सत्यमेव जयते

MILITARY ENGINEER SERVICES

STANDARD SCHEDULE OF RATES

2009

PART I - SPECIFICATIONS

COMPILED UNDER THE ORDERS OF
LIEUTENANT GENERAL GAUTAM DUTT, VSM
ENGINEER-IN-CHIEF

A GOVERNMENT OF INDIA PUBLICATION

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FOREWORD

This Standard Schedule of Rates (SSR) replaces the Standard Schedule of Rates 1991 (Part I) Specifications. This part will be applicable with Part - II Rates 2004 edition and subsequent editions thereof till revision.

IS specifications and Codes of Practice, now cover a much wider range of building materials and construction techniques. Provisions made in the IS Specifications and codes of Practice have been considered and incorporated in the SSR to the extent they are applicable. In this edition of SSR, some of the specifications have been elaborated while others have undergone considerable change(s) as compared to the previous editions of the SSR. New sections covering HVAC, Lifts, EOT Cranes, Sewage Treatment Plant, Solar Water Heater, Fire Fighting and Detection System, Incinerator, Rain Water Harvesting have been included for the first time, which should be useful.

This publication will be a very useful and informative compendium of IS Specifications for use by ground executives and I am sanguine, it will guide all executives and staff in achieving improved standards of working.

Gautam Dutt

New Delhi
01.05.2009

(Gautam Dutt)
Lt Gen
Engineer-in-Chief

PREFACE

1. The Standard Schedule of Rates - Part - I; Specifications, (SSR Part - I) was last revised in 1991. Though, the SSR Part - II (Rates) was being regularly updated but task of updating of SSR Part - I, could not be undertaken due to one reason or the other. Therefore, there was a long felt need of updating it particularly with the advent of new construction material, technological advances and revision of various codal provisions. The task has been completed and the publication is being issued as SSR Part- I, 2009.

2. This task was initiated during Sep 2007 and services of many experienced officers have been utilized for its completion, who have endeavoured to put in their best efforts and knowledge. Besides updating the existing specifications, a large number of new additions have been made to make the SSR more comprehensive and exhaustive.

3. This treatise would be quite useful to all those who are associated with preparation of estimates, making of contracts, execution of works and arbitration proceedings etc. Despite due care taken in preparation of this treatise, some errors may have crept in. In case, any omissions are noticed, the same may be brought to the notice of Joint Director General (Contracts), Military Engineer Services, Engineer-in-Chief's Branch, Integrated HQ of Ministry of Defence (Army), Kashmir House, Rajaji Marg , New Delhi-110011 for updation.

4. We would welcome suggestion for improvement and modification. SSR Part - II is also planned to be issued shortly.

New Delhi
01.05.2009

(Brajesh Kumar)
Maj Gen
Director General of Works

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REGISTER OF AMENDMENTS

Amendment Number	Reference letter	Reference clause of SSR amended	Dated signature of individual amending the schedule (with name in block letters)	Amendment Number	Reference letter	Reference clause of SSR amended	Dated signature of individual amending the schedule (with name in block letters)
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MILITARY ENGINEER SERVICES

STANDARD SCHEDULE OF RATES 2009

(PART I-SPECIFICATIONS)

[Hereinafter referred to as the "S.S.R."]

SECTION 1
GENERAL RULES

1.1 General

These general rules shall be applicable to all Sections of SSR Part I Specifications and Part II Rates to the extent the context permits and are intended to supplement the provision in the particular section. In case of any discrepancy, the provision in the particular section shall take precedence.

1.2 Interpretations

The Engineer-in-Chief, Army Headquarters, shall be the sole deciding authority as to the meaning, interpretations and implications of various provisions of SSR. His decision in writing shall be final and binding on all concerned.

1.3 Definitions

The following terms and expressions in the SSR shall have the meaning or implication hereby assigned to them unless mentioned otherwise elsewhere :

(a) Stores, M.E.S. Stores	(1)	When used in connection with the materials included in the appropriate Schedule of a contract for issue by the M.E.S. the place of issue mentioned in that Schedule.
	(2)	In cases other than those mentioned in (1) above any M.E.S. stores or place of deposit within the Contract Area or the nearest M.E.S. Store at the discretion of the Engineer-in-Charge, unless a particular Store is mentioned in the Contract.
(b) Best		With the reference to quality of material and workmanship, when possible, the standard required shall be specified in preference to the expression "Best". The word"Best" when used shall mean that in the opinion of the G.E. there is no superior malerial/ article and workmanship obtainable in the market and trade respectively.
(c) Local		The word "local" when used with reference to material/ article shall mean the best (at the discretion of G.E.) of its kind available and used in the locality (i.e. within a distance of 40 km from the boundary of the site of work,unless specified to the contrary in the tender documents).
(d) Site		The 'land(s) and/ or other place(s) on, in, into or through which work is to be executed under the

		contract, or any adjacent land, path or street which may be allotted or used for the purpose of carrying out the contract.
(e)	M.D. Premises	The term 'MD Premises' or 'premises' where used in the SSR means any premises (whether owned by Government of India or otherwise) on which work is carried out under the supervision of the M.E.S.
(f)	Contractor	The individual or firm or company, whether incorporated or not, undertaking the works and shall include the legal personal representatives of such individual or the person comprising such firm or company, or the successors of such individual or firm or company and the permitted assigns of such individual or firm or company.
(g)	Approved/ Directed	The approval or direction of the CWE or GE or person deputed by him for the particular purpose.
(h)	Indicated/ As indicated	As shown in drawings, particular specifications works order or deviation order, etc.
(i)	Specially Ordered	Separately ordered in writing for the particular item(s) only in addition to the usual Works Orders, Requisitions etc.
(j)	I.S.	The specifications and Codes of Practice issued by the Bureau of Indian Standards
(k)	Month	A calendar month.
(l)	M.D.	Government of lndia (Ministry of Defence).
(m)	M.E.S.	The Military Engineer Services.
(n)	C.E.	The Chief Engineer concerned.
(o)	C.W.E.	The Commander Works Engineer concerned.
(p)	G.E.	The Garrison Engineer concerned.
(q)	EIC	The Engineer-in-Charge, appointed by the GE to supervise the works or part of the works.

1.4 Abbreviations

The following abbreviations, wherever they appear in the SSR shall have the meaning or implication hereby assigned to them :-

(1)	Air Break	....	A.B.
(2)	All-Aluminium Conductor	....	A.A.C.
(3)	Alternating Current	....	A.C. or AC
(4)	Aluminium Conductor **Steel** Reinforced	....	A.C.S.R.
(5)	Average	....	avg.
(6)	Bayonet Cap	....	B.C.
(7)	Cab Tyre Sheathed	....	C.T.S.
(8)	Centimetre	....	cm
(9)	Cord Grip	....	C.G.
(10)	Cubic	....	cu
(11)	Cubic Centimetre	....	cm^3/cu cm

(12)	Cubic Metre	------	m^3/cum
(13)	Degree Centigrade or Celcious Temperature	------	C^o
(14)	Diameter	------	dia
(15)	Direct Current	------	DC
(16)	Double Pole	------	DP
(17)	Edison Screw	------	ES
(18)	etcetera	------	etc.
(19)	exceeding	------	exc.
(20)	Figure	------	Fig.
(21)	for example	------	e.g.
(22)	Goliath screw	------	G.S.
(23)	gram	------	g
(24)	High Tension	------	HT
(25)	Indian Army Form Works	------	IAFW
(26)	Iron Clad	------	IC
(27)	Iron Clad Triple Pole	------	ICTP
(28)	Kilogram	------	kg
(29)	Kilolitre	------	kl
(30)	Kilometre	------	km
(31)	Kilovolts	------	KV
(32)	Kilovolt Amps	------	KVA
(33)	Labour only	------	L.O.
(34)	Litre	------	l
(35)	Long Way Mesh	------	LWM
(36)	Low Tension	------	LT
(37)	Material and Labour	------	M&L
(38)	Metre	------	m
(39)	Milimetre	------	mm
(40)	namely	------	viz.
(41)	not exceeding	------	n.exc.
(42)	number(s)	------	No.
(43)	Paper Insulated Lead Covered	------	PILC
(44)	Paper Insulated Lead Covered Armoured	------	PILCA
(45)	Plain Cement Concrete	------	PCC
(46)	Polyvinyl-Chloride	------	PVC
(47)	Quintal	------	q
(48)	Reinforced Cement Concrete	------	RCC
(49)	Rupee/Rupees	------	Re/Rs
(50)	Shade Carrier Single Core	------	SC
(51)	Short Way Mesh	------	SWM
(52)	Single Pole	------	SP
(53)	Square	------	sq
(54)	Square metre	------	$m^{2/}$sqm
(55)	Supply and fix or Supplied and fixed	------	S&F
(56)	Teak Wood	------	TW
(57)	that is	------	i.e.
(58)	Triple Pole	------	TP
(59)	Tonne	------	t
(60)	Tough Rubber Sheathed	------	TRS
(61)	Under Ground	------	UG

(62) Vulcanised India Rubber ------ VIR
(63) Weather-Proof ------ WP

1.5 Specifications of Materials - Indian Standard Specifications

1.5.1 In the SSR, Specifications of materials which have been specified to conform to Indian Standard, have been partially reproduced from the relevant Standards. These partial reproductions have been made to only indicate specific requirements where alternative choices are mentioned in the IS and to bring out some of the quality characteristics for ready reference. The specifications in the relevant Standard shall however be followed, unless it is specifically mentioned that a particular requirement of the relevant Standard is dispensed with or is varied and the extent thereof is mentioned.

1.5.2 Where any IS referred to in the SSR is amended, or is revised, or supersedded or is merged into another IS or if split into more then one standard, either the IS referred to in the SSR or any of the subsequently amended/revised/superseded/merged/ split IS as applicable may be followed, as alternative specification. Where any particular alternative out of two or more alternatives given in an IS is adopted and this alternative also figures in the amended, revised, merged or spilt up IS the alternative specified in the SSR shall be followed.

1.6 Materials to be approved

1.6.1 All materials to be provided by the Contractor shall be brand new and in accordance with the specifications. Where specifications are not given, the materials shall conform to the quality of samples maintained in the office of GE for the purpose or as otherwise directed or approved by the GE. Samples of materials, fitting etc., shall be submitted by the contractor for the approval of GE before bulk supplies are brought on site of works.

1.6.2 The contractor shall satisfy the EIC that the materials provided by him conform to the requirement of the specifications and are as per the samples approved by the GE.Where materials are specified to comply with the requirements of an IS specifications, the contractor shall, if required, furnish the manufacturer's certificate that the materials satisfy the requirements of the IS.

1.6.3 The Contractor shall supply samples of materials allowing ample time for their testing and approval in order that if the samples supplied fail to satisfy the specified requirements there will be time to receive and test other samples before materials are required to be used.

1.6.4 Materials rejected by the EIC shall be removed forthwith by the Contractor of the premises.

1.7 Testing of Materials

1.7.1 Methods of Test

When required by the EIC, test on material shall be carried out in accordance with standard methods of tests issued by the Indian Standard Institution. Laboratory tests shall be conducted by recognised laboratories acceptable to the GE.

1.7.2 Samples for Testing

The contractor shall supply free of charge samples for testing of any material proposed to be used in the works. All expenditure required to be incurred for taking the samples packaging, conveyance etc., shall be borne by the Contractor.

1.7.3 Cost of Testing

The cost of testing shall be borne by the Contractor if the material does not conform to the specification after such tests. If the material is found acceptable, the Govt will bear the cost of such tests.

1.8 Materials Supplied by the Department

1.8.1 The materials supplied by the Department shall be deemed to be complying with the specifications.

1.8.2 Where the Contractor has any doubt regarding the quality of material issued by the Department, he may request the GE for the testing of these materials. In such case testing charges shall be borne by the Contractor if the material is found acceptable; and by the Govt. if the material is found not acceptable. All other expenditure required to be incurred for taking the samples packing, conveyance, etc., shall be born by the Contractor.

1.8.3 The contractor shall be responsible for the safe custody of all materials from the time they are issued to him by the Govt. Any breakages or damage to the materials issued free for fixing shall be made good by him to the satisfaction of the GE.

1.9 Storage of Materials

1.9.1 Materials shall be stored at site in such a way as to prevent deterioration or the loss or impairment of their structural and other essential properties. Materials which normally deteriorate during storage shall be kept constantly moving, by replacing old materials with fresh stocks. Freshly arrived materials shall never be placed over materials which had arrived earlier.

1.9.2 Protection against Atmospheric Agencies

Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric effects due to rain, sun or wind or moisture to avoid deterioration.

1.9.3 Protection against Fire and Other Hazards

Materials like timber, paints, etc., shall be stored in such way that there may not be any possibility of fire hazards. Inflammable materials and explosives shall be stored in accordance with the relevant regulations and rules so as to ensure the desired safety during storage.

1.10 Unit Weight of Building Materials

The Unit Weight of materials, unless otherwise indicated in the relevant Indian Standard for the materials, shall be reckoned as given in IS 1911 -1967 Schedule of unit weights of building materials.

1.11 Workmanship-IS Codes of Practice and Safety Codes

1.11.1 The work shall be carried out as described in the SSR and IS Codes of Practice and Safety Codes where referred to in the SSR. In case of any variation between the provision made in the SSR and the provisions of the relevant IS Code of Practice or Safety Code, provisions for the SSR shall take the precedence.

1.11.2 Where IS Code of Practice and Safety Codes have not been referred to in the SSR, the relevant standard may be followed as a guide of standard practice.

1.12 Methods of Construction, Tools, and Plants

The contractor shall employ only such method of Construction, Tools and Plant as are appropriate for the type of work.

1.13 Water

Water used whether in process of making materials or in execution of the work or for cleaning, etc., shall be clean and fresh, and free from deleterious matter and shall be obtained from an approved source.

1.14 Directions

Instructions shall be given in writing for all approved directions; no verbal instructions shall be deemed to be binding nor shall such work be measured/paid.

1.15 Alternatives

Where alternative materials, progress, etc., are specified in the S.S.R., the discretions shall rest with the contractor.

1.16 Safety in Construction

The Contractor shall take all necessary precautions and measures listed in the IS Safety Codes, in the MES Safety Codes or as directed by the EIC to ensure the safety of works/ construction and of workmen and shall be responsible for the same. The provisions of the following IS Safety Codes shall generally apply :-

I.S. NO.	*Subject*
3696 (Part 1)1987	Safety Code for scaffolds and ladders- Part 1. Scaffolds.
3696 (Part 2)1991	Safety Code -Part 2 for scaffolds and ladders.
4014 (Part 2)1967	Code of Practice for steel tubulars scaffolding; Part 2, Safety regulations for scaffolding.
4130 - 1991	Safety Code for demolition of buildings (Second revision).
5121 - 1969	Safety Code for piling and other deep foundations.
5916 - 1970	Safety Code for construction involving use of hot bituminous materials.
7293 - 1974	Safety Code for working with construction machinery.
7969 - 1975	Safety Code for storage and handling of building materials.

1.17 IS Codes

The list of IS Codes given in the beginning of each section is not exhaustive. All other codes referred in the body of particular section and in other sections relevant to the specified material and workmanship shall also be applicable and deemed included in the list.

SECTION 2

LIST OF INDIAN STANDARDS

Following is the consolidated list of Indian Standards referred to under the respective section in these specifications

IS Code.	Subject
5- 2004	Colours for ready mixed paint and enamels (Fifth revision)
8-1994	Specification for refractory bricks (First Revision)
44- 1991	Specification for Iron oxide pigments for paints (Second revision)
63- 1978	Specification for whiting for paints and putty (Third revision)
73- 2006	Specification for paving bitumen. (Second Revision)
75- 1973	Indian standard specification for Linseed oil, raw and refined (Second revision)
102- 1962	Ready mixed paint, brushing, red lead, nonsetting, priming
104- 1979	Ready mixed paint, brushing, zinc chrome, priming (Second revision)
109- 1968	Ready mixed paint, brushing, priming, plaster to IS Colour No 361, Light stone and No 631 Light grey (First revision)
110- 1983	Ready mixed point, brushing, grey filler, for enamels for use over primers
157- 1950	Ready mixed paint, brushing, acid and alkali resistant, lead free, for general purposes, to IS Colour No 446 red oxide, No 537, Signal red No 632 Dark admiralty grey and black and other colours as required
158- 1981	Ready mixed paint, brushing , bituminous, black, lead free, acid, alkali, water and heat resisting (Third revision)
159- 1981	Ready mixed paint, brushing, acid resisting for protection against acid fumes (First revision)
162-1950	Ready mixed paint, brushing , fire resisting, silicate type for use on wood colour as required.
164-1981	Ready mixed paint, brushing, for road marking for protection against acidfumes. (First revision)
195- 2005	Fireclay Mortar for Laying Fireclay Refractory Bricks - Specification (Fourth Revision)
204- (Part 1)-1991	Specification for tower bolts, Part 1, Ferrous metals, (Fifth revision)
204- (Part 2)-1992	Specification for tower bolts, Part 2, Non ferrous metals, (Fifth revision)
205- 1992	Specification for non-ferrous metal butt hinges (Fourth revision).
206- 1992	Specification for tee and strap hinges (Fourth revision)
207- 1964	Specification for gate and shutter hooks and eyes (First revision)
208- 1996	Specification for door handles (Fifth revision)

IS Code.	Subject
210- 1993	Specification for Grey Iron casting (Fourth revision)
212-1983	Specification for Crude coal tar for general use (Second revision)
217-1988	Specification for cut back bitumen (Second Revision)
218-1983	Specification for Creosote and anthracite oil for use as wood preservative(Second revision)
261- 1982	Specification for copper sulphate (Second revision)
269-1989	Specification for 33 grade ordinary Portland cement (Fourth Revision)
277- 2003	Specification for Galvanised Steel sheet (plain and corrugated) (Sixth revision)
278- 2001	Specification for Galvanised Steel Barbed wire for fencing (Third revision)
280-2006	Specification for mild steel wire for general engineering purposes (Fourth revision).
281- 1991	Specification for mild steel sliding door bolts for use with pad- locks (Third revision).
287- 1993	Recommendation for maximum permissible moisture content of timber used for different purposes (Third revision)
303- 1989	Specification for plywood for general purposes (Third revision)
325-1996	Specification for 3 phase induction motors
334-2002	Glossary of terms relating to bitumen and tar (Third Revision)
335-1993	New insulating oil for transformers and switchgear (Third revision).
341-1973	Black Japan, type A, B and C (First revision)
345-1952	Wood filler, transparent liquid
348-1981	French polish (First revision)
349-1981	Lacquer, cellulose, nitrate, clear, finishing glossy for metal (First revision)
362- 1991	Specification for parliament hinges (Fifth revision).
363- 1993	Specification for hasps and staples (Fourth revision).
364- 1993	Specification for fanlight catches (Third revision).
371-1979	Ceiling Roses (Second revision).
373- 1975	Specification for plywood for general purposes (Second revision)
383- 1970	Specification for coarse and fine aggregates from natural sources for concrete (Second Revision)
398-(Part 1) 1976	Aluminium conductors for overhead transmission purposes. Part: 1 Aluminium stranded conductors (Third revision).
398-(Part 2) 1976	Aluminium conductors for overhead transmission purposes. Part: 2 Aluminium conductors, galvanised steel reinforced (Third revision).

IS Code.	Subject
401- 2001	Code of practice for preservation of timber (Fourth revision)
412- 1975	Specification for expanded metal steel sheets for general purposes (Second revision)
419- 1967	Specification for putty for use on window frames (First revision).
423-1961	Plastic wood for joiner's filler(Revised)
426-1961	Paste filler for colour coats
427- 2005	Specification for distemper dry, colour as required (Second revision)
428- 2000	Specification for washable distemper (Second revision)
430-1972	Paint remover, solvent type, non flammable (Second revision)
431-1972	Paint remover, solvent type, flammable(Second revision)
432- (Part I) 1982	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement, Part I, Mild steel and medium tensile steel bars (Third revision)
432- (Part 2) 1982	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part-II, Hard drawn steel wire (Third revision)
444-1987	General purposes rubber water hose (Fourth revision)
451- 1999	Technical supply conditions for wood-screws (Third revision)
452- 1973	Specification for door springs rat-tail type (Second revision) .
453- 1993	Specification for double acting spring hinges (Third revision).
454-1994	Specification for Digboi type cut back bitumen (Second revision).
455- 1989	Specification for Portland Slag Cement (Fourth Revision)
456- 2000	Plain and Reinforced Concrete - Code of Practice (Third Revision)
458-2003	Specification for concrete pipes with or without reinforcement. (Fourth revision)
459- 1992	Specification for unreinforced corrugated and semi-corrugated asbestos cement sheets (Third revision)
460-(Part-I) 1985	Test Sieves : Part I Wire cloth test sieves (Third Revision)
460-(Part-2) 1985	Test Sieves : Part II Perforated plate test sieves (Third Revision)
460-(Part-3) 1985	Test Sieves : Part III Methods of examination apertures of test sieves of (Third Revision)
516-1959	Method of test for Strength of concrete.
524-1983	Varnish, finishing, exterior synthetic air drying (Second revision)
533-1998	Gum Spirit turpentine (oil of turpentine) (Second Revision)
613-2000	Specifications for Copper rods for electrical purposes (Third revision).
636-1988	Non-percolating flexible fire fighting delivery hose (Third revision)

IS Code.	Subject
640-1956	Ready mixed red oxide paint for hessian (Colour unspecified)
650-1991	Specification for Standard sand for testing of cement.
651-1992	Specification for salt glazed stoneware pipes and fittings. (Second revision).
653- 1992	Specification for linoleum sheets and tiles
654- 1972	Specification for clay roofing tiles, Mangalore pattern (Third revision).
655-1963	Specification for Metal Air ducts (Second revision)
659-1964	Safety code for Air Conditioning (Revised)
660-1963	Safety code for Mechanical Refrigeration (Revised)
661-2000	Code of practice for thermal insulation of cold storage (Third revision)
692-1994	Paper insulated lead sheathed cable for electricity supply (Third revision).
694-1990	PVC insulated cables for working voltages upto and including 1100 volts (Third revision).
702- 1988	Specification for Industrial Bitumen (Second Revision)
707- 1976	Glossary of terms applicable to timber technology and utilization (Second revision)
712- 1984	Specification for Building Limes (Third Revision)
723- 1972	Specification for steel countersunk head wire nails (First revision)
729- 1979	Specification for drawer locks, cupboard locks and box locks (Third revision).
730- 1978	Specification for Hook-bolts for corrugated sheet roofing (Second revision).
731-1971	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 volts (Second revision)
732-1989	Code of Practice for electrical wiring installations. (Third revision)
733- 1983	Specification for wrought aluminium and aluminium alloys bars, rods and sections (for general engineering purposes). (Third revision)
737- 1986	Specification for wrought aluminium and aluminium alloys sheets and strip for general engineering purposes (Third revision)
749- 1978	Specification for handloom cotton dungri cloth (First revision).
774-2004	Specification for flushing cistern for water closets and urinals (other than plastic cistern) (Fifth revision).
775-1970	Specification for cast iron brackets and supports for wash basins and sinks (Second revision).
778-1984	Specification for Gun Metal Gate, Globe and Check valves for general purposes (Fourth revision)

IS Code.	Subject
781-1984	Specification for cast copper alloy, screw down, bib taps and stop valves for water services (Third revision)
782-1978	Specification for caulking lead (Third revision)
800- 1984	Code of practice for general construction in steel (Second revision).
807-2006	Design, Erection and testing (Structural Portion) of Cranes and Hoists - Code of Practice (Second revision)
808- 1989	Dimensions for hot rolled steel beam, column, channel and angle sections. (Third revision)
809- 1992	Specification for rubber flooring materials for general purposes (First revision)
811- 1987	Cold formed light gauge structural steel section. (Revised)
814- 2004	Specification for covered electrodes for manual metal arc welding of carbon and carbon managese steel (sixth revision)
816- 1969	Code of practice for use in metal arc welding for general construction in mild steel (First revision).
818- 1968	Code of practice for safety and health requirement in electric and gas welding and cutting operations (First revision).
822- 1970	Code of procedure for inspection of welds.
848- 2006	Specification for synthetic resin adhesive for plywood (phenolic and amino plaster) (Second revision)
851- 1978	Specification for synthetic resin adhesive for construction work (non structural) in wood (First revision)
852- 1994	Specification for animal glue for general wood working purposes (Second revision)
876-1992	Specification Wood pole for over-head power and telecommunication line (Third revision).
884-1985	Specification for first-aid hose reel for fire fighting (First revision)
900-1992	Code of practice for installation and maintenance of induction motors (Second revision)
901-1988	Specification for couplings, double male and double female, instantaneous pattern for fire fighting (Third revision)
902-1992	Specification for suction hose coupling for fire fighting purposes (Third revision)
903-1993	Specification for fire hose delivery couplings, branch pipe, nozzles and nozzle spanner (Fourth revision)
907-1984	Specification for Suction Strainer cylindrical type for fire fighting purposes (Second revision)
908-1975	Specification for Fire Hydrant, Stand Post Type (Second revision)

IS Code.	Subject
909-1992	Specification for underground fire hydrant, sluice valve type (Third revision)
996-1979	Specification for single phase AC and universal motors (Second revision)
1003- (Part 1) - 2003	Specification for timber panelled and glazed shutters (Fourth revision)
1003- (Part 2)- 1994	Specification for timber panelled and glazed shutters (Part 2) window and ventilator shutters (Third revision)
1019- 1974	Specification for rim latches (Second revision).
1038- 1983	Specification for steel doors, windows and ventilators (Third revision)
1077- 1992	Common Burnt Clay Building Bricks - Specification (Fifth Revision)
1081- 1960	Code of practice for fixing and glazing of metals (steel and aluminium) doors, windows and ventilators.
1120- 1975	Specification for coach screw (First revision).
1121- Part I - 1974	Methods of test for Determination of Strength Properties of Natural Building Stone - Part I: Compressive Strength
1122- 1974	Methods of test for determination of specific gravity of natural building stones (First Revision)
1123- 1975	Methods of identification of natural building stones (First Revision)
1124- 1974	Method of Test for Determination of Water Absorption, Apparent Specific Gravity and Porosity of Natural Building Stones (First Revision)
1125- 1974	Methods of test for determination of weathering of natural building stones (First Revision)
1126- 1974	Methods of test for determination of durability of natural building stones (First Revision)
1128- 1974	Specification for Lime Stones (Slab & Tiles) (First Revision)
1129- 1972	Recommendations for Dressing of Natural Building Stones (First Revision)
1141- 1993	Specification for code of practice for seasoning of timber (Second Revision)
1148- 1982	Specification for hot rolled rivet bars (up to 40mm diameter) for structural purposes (Third revision).
1173- 1978	Hot rolled slit steel tee bars (Second revision)
1180-Part 1 - 1989	Outdoor three phase distribution transformers upto and including 100 KVA, 11KV : Part 1 Non sealed type.
1180-Part 2 - 1989	Out door type three phase distribution transformers upto and including 100 KVA, 11KV : Part 2 sealed type.
1195- 2002	Specification for bitumen mastic for flooring (Third revision).

IS Code.	*Subject*
1199-1959	Method of Sampling and Analysis of Concrete.
1203-1978	Method of testing tar and bituminous material, determination of penetration
1205-1978	Method of testing tar and bituminous material, determination of softening point
1206-Part 1 1978	Determination of Viscosity : Industrial viscosity.
1206-Part 2 1978	Determination of Viscosity: Absolute viscosity.
1206-Part 3 1978	Determination of Viscosity: Kinematic viscosity.
1208-1978	Method of testing tar and bituminous material, determination of ductility.
1212-1978	Method of testing tar and bituminous material, determination of loss on heating.
1216-1978	Method of testing tar and bituminous material, determination of solubility in carbon disulphide trichloroethylene.
1230- 1979	Specification for cast iron rain water pipes and fittings (Second revision).
1237- 1980	Specification for cement concrete flooring tiles (First revision).
1239-(Part I) 2004	Specification for mild steel tubes, tubulars and other wrought steel fittings (Part I): Mild steel tubes (Sixth revision).
1239-(Part 2) -1992	MS tubes, tubular and other wrought steel fittings, Part 2 MS tubular and other wrought steel pipe fitting (Fourth revision)
1252- 1991	Dimension of Hot rolled steel bulb angles (First revision)
1254- 1975	Specification for corrugated aluminium sheet (Third revision)
1255-1983	Code of Practice for installation and maintenance of paper insulated power cables.(upto and including 33 KV) (Second revision).
1258-2005	Bayonet lamp holders (Fourth revision).
1284- 1975	Wrought aluminium alloy bolt and screw stock for general engineering purposes (Second Revision)
1285- 2002	Specification for wrought aluminium and aluminium alloys extruded round tube and hollow sections for general engineering purposes (Third revision)
1293-2005	Specification for plugs and sockets out let of rated voltage upto and including 250 Volts and rates current upto and including 16 Amperes (Third revision).
1312-Part 4 - 1991	Solar heating - Domestic water heating system: Part 4 Determination of durability and reliability
1322- 1993	Specification for bitumen felts for water -proofing and damp proofing (Fourth revision).

IS Code.	Subject
1328- 1996	Specification for veneered decorative ply wood (Third Revision)
1341- 1992	Specification for steel butt hinges (Sixth revision).
1344- 1981	Specification for Calcined Clay Pozzolana (Second Revision)
1361- 1978	Specification for steel windows for industrial buildings (First revision)
1363- 2002(Part 1)	Hexagon head bolts, screw and nuts of product grade 'C'- Part-I, Hexagon head bolts (Size range M 5 to M 64) (Fourth revision)
1363- 2002(Part 2)	Hexagon head bolts, screw and nuts of product grade 'C'- Part-II, Hexagon head screws (Size range M 5 to M 64) (Fourth revision)
1363- 1992(Part 3)	Hexagon head bolts, screw and nuts of product grade 'C'- Part-Ill, Hexagon nuts (Size range M 5 to M 64) (Third revision)
1367- (Parts 1 to 20)	Technical supply conditions for threaded fasteners
1391-(Pt l &II) - 1992	Unitary and Split Air Conditioners (Second revision)
1445-1977	Porcelain insulators for overhead power lines with nominal voltage upto and including, 1000 volts (Second revision).
1464- 1992	Specification for clay ridge and ceiling tiles (Second revision).
1489- Part 1 - 1991	Specification for Portland Pozzolana Cement-Part 1: Flyash based (Third Revision)
1489- Part 2 - 1991	Portland Pozzolana Cement - Specifications - Part 2 : Calcined Clay Based (Third Revision)
1498- 1970	Classification of soil for general engineering purposes (First revision).
1504-1996	Specification for Beeswax Crude and Rifined (Third revision)
1520-1961	Horizontal centrifugal pumps for cold, clear and fresh water (Second revision)
1526- 1960	Sizes and Shapes for Firebricks (230mm series)
1536-2001	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage (Fourth revision)
1537-1976	Specification for vertically cast iron pressure pipes for water, gas and sewage (First revision).
1538-1993	Specification for cast iron fittings for pressure pipes for water, gas and sewage (First revision).
1542- 1992	Specification for sand for plaster (Second revision)
1545-1994	Solid drawn copper and copper alloy tubes for Condensers, Heat Exchangers (Third revision)
1554-(Part 1) 1988	Specification for PVC insulated (heavy duty) electric cables. Part: 1 For working voltages upto and including 1100 volts (Third revision).

IS Code.	*Subject*
1554-(Part 2) 1988	Specification for PVC insulated (heavy duty) electric cables. Part: 2 For working voltages from 3.3 KV upto and including 11 K.V. (Second revision).
1566- 1982	Specification for hard drawn steel wire fabric for concrete reinforcement (Second revision)
1568- 1970	Specification for wire cloth for general purposes (First revision) .
1569-1976	Capacitors for use in tubular fluorescent, high pressure mercury and low pressure., sodium vapour discharge lamp circuit (First revision).
1580- 1991	Specification for bituminous compound for waterproofing and caulking purposes (Second revision).
1592-2003	Specification for asbestos cement pressure pipes and joints (Fourth revision).
1596-1977	Polyethylene insulated cables for working voltages upto and including 1100 volts (Second revision).
1597- Part 1 - 1992	Construction of Stone Masonry - Code of Practice - Part 1 : Rubble Stone Masonry (First Revision)
1597- Part 2 - 1992	Construction of Stone Masonry - Code of Practice - Part 2 : Ashlar Masonry (First Revision)
1626-(Part 1) 1994	Specification for asbestos cement building pipes and pipe fittings. Gutter and gutters fitting and roofing fittings. Pipes and pipe fittings (Second revision).
1626-(Part 2) 1994	Specification for asbestos cement building pipes and pipe fittings. Gutter and gutters fitting and roofing fittings. Gutters and Gutters fittings. (Second revision)
1626-(Part 3) 1994	Specification for asbestos cement building pipes and pipe fittings. Gutter and gutters fitting and roofing fittings. Roofing fittings (Second revision)
1646-1997	Code of practice for fire safety of buildings (general) Electrical installations (Second revision).
1658- 2006	Specification for fibre hardboards (Third Revision)
1659- 2004	Specification for block boards (Third revision).
1678-1998	Specification for Pre-stressed concrete poles for overhead power, traction and telecommunication lines (Second revision).
1703-2000	Specification for water fittings - copper alloy float valves (Horizonal plunger type (Fourth revision).
1706-1972	Method for Determination of Resistance to Wear by Abrasion of Natural Building Stones (First Revision)
1708- (Part 1 to 18)-1986	Method of testing of small clear specimen of timber (Second Revision)
1711-1984	Specification for self-closing taps for water supply purposes (Second revision).

IS Code.	Subject
1726-1991	Specification for cast iron manhole covers and frames. (Third revision)
1729-2002	Cast iron/ductile iron drainage pipe and pipe fittings for over ground Non Pressure pipe lines socket and spigot service (Second revision)
1730- 1989	Dimensions for steel plates, sheets, strips and flats for general engineering purposes (Second revision)
1732- 1989	Dimensions for round and square steel bars for structural and general engineering purposes, (Second revision)
1734- (Part 1 to 20)-1993	Method of test for plywood (Part 1 to 20 in one voloum (Second Revision)
1777-1978	Industrial luminaire with metal reflectors (First revision).
1786- 1985	Specification high strength deformed steel bars and wires for concrete reinforcement (Third revision)
1795-1982	Specification for pillar taps for water supply purposes (Second revision)
1805- 1973	Glossary of terms relating to stones, quarrying and dressing (First Revision)
1823- 1980	Specification for floor door stoppers (Third revision).
1834-1984	Specification for hot applied sealing compound for joints in the concrete (First revision).
1837- 1966	Specification for fan-light pivot (First revision).
1838-(Part 1) 1983	Specification for preformed filler for expansion joints in concrete, non-extending and resilient type (Bitumen impregnated fibre) (First revision).
1852- 1985	Rolling and cutting tolerances for hot rolled steel products (Fourth revision)
1863- 1979	Hot rolled steel bulb flats (First revision)
1866-2000	Code of Practice for maintenance and supervision of mineral insulating oil in service equipment (Third revision).
1868- 1996	Specification for anodic coating on aluminium and its alloys (Third revision)
1879-1987	Specification for malleable cast iron pipe fittings (Second revision).
1905- 1987	Code of Practice for Structural Use of Un-reinforced Masonry (Third Revision)
1913-(Part 1) - 1978	General and safety requirements for luminaries Part I, Tubular fluorescent lamps (Second revision).
1944-(Part 1 & 2)	Code of practice for lighting of public thoroughfares (First revision).
1948- 1961	Specification for aluminium doors, windows and ventilators
1949- 1961	Specification for aluminium windows for industrial buildings

IS Code.	Subject
2016- 1967	Specification for plain washers (First revision).
2026-(Part 1) - 1977	Power transformers Part 1 (First revision).
2042-2006	Specification, for insulation bricks (Second Revision)
2046- 1995	Specification for decorative thermosetting synthetic resin bonded laminated sheets (First revision).
2062- 2006	Specification for hot rolled low, medium and high tensile structural steel (Sixth revision)
2065-1983	Code of practice for water supply in Buildings (Second revision).
2074-1992	Specification for Ready mixed paint, air drying, red oxide zinc chrome priming (Second revision)
2086-1993	Carriers and bases used in rewireable type electric fuses upto 650 volts (Third revision).
2095- Part 1 1996	Specification for gysum plaster boards: Part 1Plain gypsum plaster boards
2095- Part 3 1996	Specification for gypsum plaster boards: Part 3 Reinfroced gypsum plaster boards.
2096- 1992	Specification for asbestos cement flat sheets (First revision)
2098- 1997	Specification for asbestos cement building boards. (First Revision)
2114- 1984	Code of practice for laying in situ terrazzo floor finish (First revision)
2116- 1980	Specification for Sand for Masonry Mortars (First Revision)
2121-(Part 1 & 2) 1981	Conductor and earth wire accessories for overhead power lines, Part 1 & 2 (First revision).
2141-2000	Hot dip Galvanised stay strand (Fourth revision).
2175-1988	Specification for heat sensitive fire detectors for use in automatic fire alarm system (Second revision)
2185- Part 1 - 2005	Specification for Concrete Masonry Units - Part 1: Hollow and Solid Concrete Blocks (Third Revision)
2185- Part 2 - 1983	Specification for Concrete Masonry Units - Part 2: Hollow and Solid Lightweight Concrete Blocks (First Revision)
2185- Part 3 - 1984	Specification for Concrete Masonry Units - Part 3: Autoclave Cellular (Aerated) Concrete Blocks (First Revision)
2189-1999	Code of Practice for Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System (Third revision)
2202- (Part I)- 1999	Specification for wooden flush door shutters (solid core type), Part I plywood face panels (Sixth Revision)
2202- (Part 2)- 1983	Specification for wooden flush door shutters (solid core type) Part 2 particle board face panels and hard board face panels (Third revision)
2209- 1976	Specification for mortice locks (vertical type) (Third revision).

IS Code.	*Subject*
2215-1983	Starters for fluorescent lamps (Third revision).
2267- 1972	Specification for polystyrene moulding and extrusion material (Second revision).
2268-1994	Electric call bells and buzzers for indoor use (Third revision).
2309-1989	Code of practice for protection of buildings and allied structures against lighting (Second revision).
2312-1967	Propeller type AC Ventilation fans (First revision)
2314- 1986	Specification for steel sheet piling sections (First revision).
2315-1978	Specification for Thimbles for wire ropes (First revision).
2326-1987	Specification for automatic flushing cisterns for urinals (other than plastic cistern) (Second revision).
2339-1963	Aluminium paint for general purposes in dual containers
2366- 1983	Code of Practice for nails jointed timber construction (First revision)
2370-1963	Specification for Walk in type sectional cold rooms
2372-2004	Specification for Timber for cooling towers
2379-1990	Colour code for indentification of pipe lines (First revision).
2386-(Part-1) 1963	Methods of test for aggregate for concrete Part I particle size and shape.
2386-(Part-2) 1963	Methods of test for aggregate for concrete Part 2 Estimation of deleterious materials and organic impurities.
2386-(Part-3) 1963	Methods of test for aggregate for concrete Part 3 Specific gravity, density, voids, absorption and bulking.
2386-(Part-4) 1963	Methods of test for aggregate for concrete Part 4 Mechanical properties.
2412-1975	Link clips for electrical wiring (First revision).
2418-(Part 1 to 4) 1977	Specification for Tubular fluorescent lamps for general lighting service. : Part 1-Requirements and tests. (First revision) : Part 2-Standard lamp data sheets. (First revision) : Part 3 -Dimensions of G-5 and G-13 Bi-pin caps. (First revision) : Part IV-Go and no go gauges and G-5 and G-13 Bi-pin caps. (First revision)
2486-(Part 1) 1993	Metal fittings insulatiors for overhead power lines with nominal voltage greater than 1000 V General requirements and tests (Second revision).
2486-(Part 2)-1989	Insulator fittings for overhead power-lines with nominal voltage greater than 1000 V : Part 2 Dimensional requirements (Second revision).
2502- 1963	Code of practice for bending and fixing of bars for concrete reinforcement.
2506-1985	General requirement for Concrete Vibrates, Screed Board Type (First revision).

IS Code.	Subject
2508- 1984	Specification for Low Density Polyethylene Films (Second Revision)
2544-1973	Porcelain post insulators for systems with nominal voltages greater than 1000 volts (First revision).
2547- Part 1 1976	Specification for gypsum building plaster: Part 1 Excluding premixed light weight plaster.
2548-(Part 1 & 2) 1996	Specification for plastic water closet seats and covers - Part 1 Thermoset: Part 2 Thermoplastic, (fifth revision).
2551-1982	Danger notice plates (First revision).
2556-(Part 1) 1994	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 1: General requirements. (Third revision)
2556-(Part 2) 2004	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 2 : Specific requirements of wash down water closets (Fourth revision)
2556-(Part 3) 2004	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 3: Specific requirements of squatting pans (Fourth revision)
2556-(Part 4) 2004	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 4 : Specific requirements of wash basins. (Third revision)
2556-(Part 5) 1994	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 5 : Specific requirements of laboratory sinks. (Third revision)
2556-(Part 6) 1995	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 6 : Specific requirements of urinals and partition plates (Fourth revision).
2556-(Part 7) 1995	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 7 : Specific requirements of accessories for sanitary appliances (Third revision)
2645- 2003	Specification for Integral Cement Waterproofing Compounds (Second Revision)
2667-1988	Fittings for rigid steel conduits for electrical wiring (First revision).
2675-1983	Enclosed distribution fuseboards and cutouts for voltages not exceeding 1000volts (Second revision).
2681- 1993	Specification for non-ferrous metal sliding door bolts (Aldrops) for use with padlocks (Third revision).
2686- 1977	Specification for Cinder as fine Aggregate for use in Lime concrete (First Revision)
2690- (Part-2)-1992	Specification for burnt clay flat terracing tiles, Part II, Hand made (First revision).
2691- 1988	Specification for Burnt Clay Facing Bricks (Second Revision)
2700- 1987	Code of Practice for roofing with wooden shingle (First revision)
2713-(Part I to 3)-1980	Tubular steel poles for overhead power-lines (Second revision)
2720-(Part-5) 1985	Methods of test for soils, Part 5 determination of liquid and plastic limit, (Second Revision)

IS Code.	Subject
2720-(Part-7) 1980	Methods of test for soils, Part 7 determination of water content dry density relation using light compaction (Second Revision).
2720-Part 8: 1983	Method of Test for soils Part 8 : Determination of Water Content - Dry Density Relation using heavy compaction (Second revision)
2720-(Part-28) 1974	Methods of test for soils, Part 28 determination of dry density of soils in place, by sand replacement methods (First Revision).
2721- 2003	Specification for galvanised steel chain link fence fabric (Second revision).
2750- 1964	Specifications for steel scaffolding
2751- 1979	Code of practice for welding of mild steel bars used for reinforced concrete construction (First revision).
2835- 1987	Specification for flat transparent sheet glass (Third revision).
2911- (Part I: Sec 2)- 1979	Code for practice for design and construction of concrete piles foundation. Section 2 bored cast in situ piles (First revision).
2911- (Part 2) 1980	Code of Practice for design and construction of pile foundation : Part 2 Timber pile (First revision)
2911- Part 4 - 1985	Code of practice for design and construction of pile foundation: Part 4 Load test on piles (First Revision)
2932-2003	Specification for Enamel, synthetic, exterior, under coating and finishing (Third revision)
2952-Part 1 -1964	Method for measurement of fluid flow by means of orifice plates and nozzles Part 1: Incompressible fluids
2963-1979	Specification for copper alloy waste fittings for wash basins and sinks (First revision).
3016- 1982	Code of practice for fire precautions in welding and cutting operations(First revision)
3034-1993	Code of Practice for fire safety of industrial buildings-Electrical generating and distribution stations. (Second revision)
3043-1987	Code of practice for earthings (First revision).
3063- 1994	Specification for single coil rectangular section spring lock washers. (Second revision)
3068- 1986	Specification for Broken Brick (burnt clay) Coarse Aggregate for Use in Lime Concrete (Second Revision)
3070-(Part I)-1985	Specification for Surge arresters for Alternating Current systems, Part I-Non-linear resister type Surge arresters (Second revision).
3070-(Part 2)-1989	Lightning arresters for Alternating Current systems, Part 2 Expulsion type lightning arresters.
3070-(Part 3)-1993	Lighting arresters for AC system: Part 3 Metal Oxise arresters without gap.
3076-1985	Specification for low density polyethylene pipes for potable water supply (Second revision).

IS Code.	Subject
3087- 2005	Specification for wood particle boards of wood and other lingnocellulosic material (medium density) for general purposes (Second revision).
3097- 2006	Specification for veneered particle boards (Second revision)
3103-1975	Code of practice for industrial ventilation (First revision)
3114-1994	Code of practice for laying of CI pipes (Second revision)
3117-2004	Specification for bitumen emulsion for roads (anionic type) (First Revision).
3129-1985	Specification for Low density particle Board (First revision)
3144-1992	Mineral wool thermal insulation - methods of tests (Second revision)
3177-1999	Code of Practice for Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Work Cranes (Second revision)
3188-1980	Characteristics of string insulators (First revision).
3287-1965	Industrial lighting fittings with plastic reflectors.
3308- 1981	Specification for wood wool building slabs, (First revision).
3311-1979	Specification for waste plug and its accessories for sinks and wash basins (First revision).
3315-1994	Specification for Desert coolers (Second revision)
3323-1980	Bi-pin lamp holders for tubular fluorescent lamps (First revision).
3324-1982	Holders for starters for tubular fluorescent lamps (First revision).
3337- 1978	Specification for Bailies for general purpose (First revision)
3346-1980	Method for determination of thermal conductivity of insulation material (First revision)
3348- 1965	Specification for fibre insulation boards.
3384- 1986	Specification for Bitumen Primer for Use in Waterproofing and Damp Proofing (First Revision)
3386- 1979	Specification for Wooden fencing post (First revision)
3419-1988	Fittings for rigid non-metallic conduits (Second revision).
3427-1997	AC Metal enclosed switchgear and control gear for rated voltages above 1 KV and upto and including 52 KV (First revision).
3443- 1980	Crane rail sections (First revision)
3461- 1980	Specification for PVC asbestos floor tiles. (First revision)
3462- 1986	Specification for unbacked flexible PVC flooring (Second revision).
3480-1966	Flexible steel conduits for electrical wiring.
3489-1985	Specification for enamelled steel bath tubs (First revision).
3502- 1994	Specification for steel chequered plates (Second revision)
3536-1999	Specification for Ready mixed paint, brushing, wood primer, pink (First revision)

IS Code.	Subject
3553-1966	Watertight electric lighting fittings.
3564- 1996	Specification for door closers hydraulically regulated (Fourth revision).
3585-1966	Ready mixed paint, aluminium, brushing, priming, water resistant for wood work.
3588-1987	Specification for Electrical axial flow fans (First revision)
3589-2001	Specification for Electrically welded steel pipes for water, gas and sewage (Third revision)
3615-1967	Glossary of terms used in Refrigeration and Air Conditioning
3620- 1979	Specification for Laterite stone block for masonry (First Revision)
3622- 1977	Specification for Sand Stone (Slab & Tiles) (First Revision)
3624-1987	Specification for pressure and vacuum gauges (Second revision)
3629- 1986	Specification for Structural timber in Building (First revision)
3639-1966	Specification for Fittings and accessories for power transformers.
3670- 1966	Code of Practice for construction of timber floor (First revision)
3678-1966	Ready mixed paint, thick white, for lettering
3696- (Part 1)1987	Safety Code for scaffolds and ladders- Part 1. Scaffolds.
3696- (Part 2)1991	Safety Code -Part 2 for scaffolds and ladders.
3764- 1992	Excavation work - Safety code (First revision).
3792-1978	Guide for heat insulation of non industrial buildings (First revision)
3812- Part 1 - 2003	Pulverized Fuel Ash - Specification - Part 1 : For Use as Pozzolana in Cement, Cement Mortar and Concrete (Second Revision)
3818- 1992	Specification for continuous (piano) hinges (Third revision).
3837-1976	Accessories for rigid steel conduits for electrical wiring (First revision).
3844-1989	Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises (First revision)
3847- 1992	Specification for mortice night latches (First revision).
3854-1966	Switches for domestic and similar purposes.
3908- 1986	Aluminium equal leg angles (First revision)
3909- 1986	Specifications for aluminium unequal leg angles (First revision)
3921- 1985	Aluminium channel (First revision)
3954- 1991	Hot rolled steel channel sections for engineering purposes-dimensions (First revision)
3989-1984	Specification for centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories (Second revision).
4000- 1992	Code of practice for high strength bolts in steel structures. (First revision)
4004-1985	Application guide for non-linear resister-type surge arrestors for Alternating Current systems (First revision).

IS Code.	Subject
4014- (Part 2)1967	Code of Practice for steel tubulars scaffolding; Part 2, Safety regulations for scaffolding.
4020- (Part 1 to 16) 1998	Method of Tests: Door shutters (Third Resivion)
4031- Part 7 - 1988	Method of tests for hydraulic cement Part 7 Compressive Strength Test of masonary cement (First Revision)
4038-1986	Specification for Foot Valves for water works purposes (Second revision)
4081- 1986	Safety code for blasting and related drilling operation (First revision).
4101- Part 1 - 1967	Code of Practice for External Facings and Veneers - Part 1 : Stone Facing
4111-Part 1 -1986	Code of Practice for Ancillary Structures in Sewerage System: Manholes (First Revision)
4111-Part 2 - 1985	Code of Practice for Ancillary Structures in Sewerage System: Flushing tanks (First Revision)
4111- Part 3 - 1985	Code of Practice for Ancillary Structures in Sewerage System: Inverted Siphon (First Revision)
4111-Part 4 - 1968	Code of Practice for Ancillary Structures in Sewerage System: Pumping Stations and Pumping Mains(Rising Mains)
4111-Part 5 - 1993	Code of Practice for Ancillary Structures in Sewerage System: Tidal Outfalls
4127-1983	Code of Practice for Laying of Glazed Stoneware Pipes (First Revision)
4130- 1991	Safety Code for demolition of buildings (Second revision).
4137-1985	Code of practice for heavy duty electric overhead travelling cranes including special service machines for use in steel work (First revision)
4160-2005	Specification for Interlocking switch socket outlet (First revision).
4346-1982	Specification for washer for use with fittings for water services (First revision).
4351- 2003	Specification for steel doors frames (Second revision)
4457- 1982	Specification for ceramic unglazed vitreous acid resistant tiles (First revision)
4578-1997	Specification for Lubricating oil for refrigeration machinery (Second revision)
4615-1968	Switch socket outlets (non-interlocking type).
4648-1968	Guide for electrical layout in residential buildings.
4651-(Part 1)-1974	Code of practice for planning and Design of ports and harbours. Part 1- Site investigation (First revision)
4651-(Part 2) - 1989	Ports and harbours - Planning and design - Code of practice. Part 2- Earth pressure (First revision)
4651-(Part 3) - 1974	Code of practice for planning and design of ports and harbours. Part 3- Loading (First revision)

IS Code.	Subject
4651-(Part 4) - 1989	Code of practice for planning and design of ports and harbours. Part 4- General design considerations (Second revision)
4651-(Part 5)-1980	Code of practice for planning and design of ports and harbours. Part 5- Layout and functional requirements
4671- 1984	Expanded polystyrene for thermal insulation purposes (First revision)
4682-Part 1-1994	Code of Practice for lining of vessels and equipment for chemical purposes rubber lining (First Revision)
4710-1968	Switches and switch isolators above 1000 Volts but not exceeding 11000 Volts.
4831-1968	Recommendation on units and symbols in refrigeration
4832- Part-2 : 1969	Specification for Chemical Resistant Mortars - Part-II: Resin Type.
4832- Part-3 : 1968	Specification for Chemical Resistant Mortars - Part-III : Sulphur Type
4835- 1979	Specification for polyvinyl Acetate dispersion based adhesive for wood (First Revision)
4860- 1968	Specification for Acid Resistant Bricks
4894-1987	Centrifugal fans (First revision)
4926- 2003	Code of Practice for Ready Mixed Concrete (Second Revision)
4928-1986	Specification for delivery valve for centrifugal fire pump outlets (First revision)
4948- 2002	Specification for welded steel wire fabric for general use (Second revision)
4984-1995	Specification for high density polyethylene pipes for potable water supplies (Fouth revision)
4985-2000	Specification for unplasticised PVC Pipes for potable water supplies (Third revision)
5039-1983	Specification for distribution pillars for voltages not exceeding 1000 Volts DC (First revision)
5083-1988	Knifing stopper (Second revision)
5111-1993	Testing of refrigerant compressor (First revision)
5121- 1969	Safety Code for piling and other deep foundations.
5187- 1972	Specification for flush blots (First revision).
5216-1969 (Part 1)- 1982	Recommendation safety procedures and practices in electrical works Part 1: General (First revision).
5216-(Part II)- 1982	Recommendation safety procedures and practices in electrical works Part II: life saving techniques (First revision).
5219-(Part-I) 1969	Specification for cast copper alloy traps Part I 'P' and 'S' traps
5290-1983	Specification for Landing Valves (Third revision)
5300-1969	Porcelain guy strain insulators.
5312-(Part I) - 1984	Specification for Swing check type reflex valves (Non return) for water works purposes: Part I single door pattern.

IS Code.	*Subject*
5312-(Part 2) -1986	Specification for Non-Return Valves for water works purposes: Part 2 multidoor pattern
5317-2002	Specification for Bitumen mastic for bridge decking and roads (Second Revision).
5329-1983	Code of Practice for Sanitary Pipe work above ground for building (First Revision)
5382-1985	Specification for rubber sealing rings for gas mains, water mains and sewers (First revision).
5384- 1985	Aluminium I Beam (First revision)
5410- 1992	Specification for cement paint (First revision).
5411-(Part I)-1974	Plastic emulsion paint, Part I for interior use(First revision)
5411-(Part 2)-1972	Plastic emulsion paint Part 2, for exterior use.
5437- 1994	Specification for wired and figured glass. (First revision).
5454- 1978	Methods for Sampling of Clay Building Brick (First Revision)
5455-1969	Specification for cast iron steps for manholes.
5522-1992	Stainless steel sheets and strips for utensils (Second revision).
5523- 1983	Method of testing for anodic coating on aluminium and its alloys (First revision)
5531-1988	Specification for cast iron specials for asbestos cement pressure pipes for water, gas and sewage (Second revision).
5578-1984	Guide for marking of insulated conductors (First revision).
5613-(Part I Sec.1)-1985	Code of Practice for design installation and maintenance of overhead power lines. Lines upto and including 11 KV Section I: Design. (First revision).
5613-(Part I Sec 2)-1985	Code of Practice for design installation and maintenance of over head power lines. Section 2: Installation and maintenance. (First revision)
5640-1970	Method of test for determining aggregate, impact value of soft coarse aggregates.
5691-1970	Lacquers, cellulose, pigmented finishing, glossy
5714-1981	Specification for Hydrant Stand-Pipe for Fire Fighting (First revision)
5779-1986	Specification for burnt clay soling bricks (First Revision).
5820-1970	Precast concrete cable covers.
5916- 1970	Safety Code for construction involving use of hot bituminous materials.
5930- 1970	Specification for mortice latch (vertical type).
6165- 1992	Dimensions for Special Shapes of Clay Bricks (First Revision)
6241-1971	Method for Test for Determination of Stripping Value of Road Aggregate.
6248- 1979	Specification for metal rolling shutters and rolling grills (First revision)

IS Code.	Subject
6251-1971	Specification for shower and shower fittings for marine use.
6272-1987	Industrial cooling fans (man coolers) (First revision)
6295-1986	Code of practice for water supply and drainage in high altitudes and/ or sub-zero temperature regions (First revision)
6313- (Part-I) 1981	Anti-termite measure in building constructional measures (First revision).
6313- (Part-2) 1981	Anti-termite measure in building Part 2: Pre constructional chemical treatment measures (Second revision).
6313- (Part-3) 1981	Anti-termite measure in building Part 3: Treatment for Existing Building (Second revision).
6315- 1992	Specification for floor springs (hydraulically regulated) for heavy doors (Second revision).
6411-1985	Specification for gel coated glass fibre reinforced polyester resin bath tubs (First revision).
6445- 1985	Aluminium tee sections (First revision)
6523- 1983	Specification for Precast Reinforced Concrete Door and Window Frames (First Revision)
6533-Part 1 and 2 - 1989	Code of practice for design and contruction of steel chimneys. Part I mechanical aspects Part 2 structural aspects (First Revision)
6607- 1972	Specification for rebated mortice locks (vertical type).
6639- 2005	Specification for hexagon head bolts for general steel structures. (First revision)
6924-1973	Code of Practice for Construction of Refuse Chutes in multistoried buildings
6925-1973	Method of Test for Determination of Water Soluble Chlorides in Concrete Admixtures.
7098- (Part 1)-1988	Crosslinked Polyethylene (XLPE) insulated PVC Sheathed Cables: Part 1 For working voltage upto and including 1100 Volts. (Second revision)
7098-(Part 2)-1985	Crosslinked Polyethylene (XLPE) insulated PVC Sheathed Cables. For working voltage from 3.3 KV upto and including 33 KV (First revision).
7164-1973	Specification for Stopper
7193- 1994	Specification for Glass Fibre base Bitumen felts (First Revision)
7196- 1974	Specification for hold fast.
7205- 1974	Safety code for erection of structural steel work.
7208-1992	Code of Practice for Flocculator Devices Guidelines (First Revision)
7215- 1974	Tolerances for fabrication of steel structures.
7293- 1974	Safety Code for working with construction machinery.
7307- (Part I)-1974	Approval tests of welding procedures, Part I, Fusion welding of steel.

IS Code.	Subject
7314-1974	Glossary of terms relating to port and harbour Engineering
7328-1992	Specification for high density polythylene materials for moulding and extrusion (First revision).
7403-1974	Code of practice for selection of worm and helical gear boxes
7452- 1990	Specification for hot rolled steel sections for doors, windows and ventilators. (Second revision)
7534- 1985	Specification for sliding locking bolts for use with pad-locks (First revision).
7613-1975	Method of testing for panel type air filters for air conditioning purposes
7634-(Part 2) 1975	Code of practice for plastics pipe, work for potable water supplies: Laying and jointing polyethylene (PE) pipes
7634-(Part 3) 2003	Code of practice for plastics pipe, work for potable water supplies: Laying and jointing of PVC pipes(First revision)
7673-2004	Fire Fighting Equipment - Glossary of Terms
7740-1985	Code of Practice for Construction and Maintenance of Road Gullies (First Revision)
7861- Part 1 - 1975	Code of Practice for Extreme Weather Concreting - Part I: Recommended Practice for Hot Weather Concreting
7861- Part 2 - 1981	Code of Practice for Extreme Weather Concreting - Part II: Recommended Practice for Cold Weather Concreting
7896-2001	Data for outside design conditions for AC in summer months (First revision)
7969- 1975	Safety Code for storage and handling of building materials.
8008-(Part I) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 1 : General requirements (First revision).
8008-(Part 2) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 2 : Specific requirements for 90^0 bends. (First revision).
8008-(Part 3) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 3 : Specific requirements for 90^0 TEE (First revision).
8008-(Part 4) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 4 : Specific requirements for reducers (First revision).
8008-(Part 5) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 5 : Specific requirements for ferrule reducers (First revision).
8008-(Part 6) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 6 : Specific requirements for pipe ends (First revision).

IS Code.	Subject
8042- 1989	Specification for white Portland cement (Second revision)
8061-1976	Code of practice for design installation and maintenance of service lines upto and including 650 V
8112- 1989	43 Grade Ordinary Portland Cement - Specifications (First Revision)
8148-2003	Specification for Packaged Air Conditioners (First revision)
8183- 1993	Specification for bonded mineral wool.
8329-2000	Specification for centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage (Third revision).
8360-(Part I to 3) 1977	Specification for fabricated high density polyethylene (HDPE) fittings for potable water services: General requirements, specific requirement for 90^0 TEE bends.
8362-1977	Copper and copper alloy rolled plates for condensers
8686-1 - 1989	Cranes - Design Principles for Loads and Load Combination
8686-5 - 1992	Cranes-Design Principles for Loads and Load Combinations: Part 5: Overhead Travelling and Portal Bridge Cranes
8756- 1978	Specification for ball catches for use in wooden almirahs.
8757-1999	Glossary of terms Associated with Fire Safety
8931-1993	Specification for copper alloy fancy single taps, combination top assembly and stop valves for water services. (First revision)
8934-1978	Specification for cast copper alloy fancy pillar taps for water services.
8944- 2005	Specification for Chloropyrifos emulsifiable concentrate (First revision).
9103-1999	Concrete Admixtures - Specification (First revision).
9373-1989	Cranes and Related Equipment - Accuracy Requirements for Measuring Parameters During Testing
9381-1979	Method of Testing Tar and Bituminous materials : Determination of FRAASS breaking point of Bitumen.
9382-1979	Method of Testing Tar and Bituminous materials : Determination of effect of heat and air by thin film over test residue.
9385-(Part 2 & 3)- 1980	High voltage; Part 2 expulsion fuses and similar fuses; Part 3 Application guide
9466-1980	Viscosity classification of industrial lubricants
9523-2000	Specification for ductile iron fittings for pressure pipes for water, gas and sewage (First revision).
9527-(Part 1)-1981	Code of practice for design and construction of port and harbour structures. Part 1 - Concrete monoliths
9527-(Part 3)-1983	Code of practice for design and construction of port and harbour structures. Part-3 - Sheet pile walls
9527-(Part 4)-1980	Code of practice for design and construction of port and harbour structures. Part- 4 - Cellular sheet pile structures

IS Code.	Subject
9527-(Part 6)- 1989	Design and construction of port and harbour structures - Code of practice. Part 6 Block work
9537-(Part 2)-1981	Condition for electrial installation Part 2: Rigid steel conduit
9537-(Part 3)-1983	Condition for electrical installations Part 3 : Plain rigid conduit of insulating material.
9595- 1996	Recommendation for metal arc welding of carbon and carbon manganese steel (First revision)
9742-1993	Sprayed mineral wool insulation (First revision)
9762-1994	Specification for polythylene floats (spherical) for float valves (First revision).
9842-1994	Specification for Preformed fibrous insulation (First revision)
9899- 1981	Specification for hat, coat and wardrobe hooks.
9900-(Part 1 to 4) 1981	High Pressure mercury vapour lamps - Part 1 to Part 4
9920-(Part III)-1982	AC switches for voltages above 1000 volts. Part III Design and construction.
9921-(Part 1)-1981	Alternating current disconnectors (isolators) and earthing switches for voltage above 1000 Volts. Part 1: General and Definitions.
9921-(Part 2)-1982	Alternating current disconnectors (isolators) and earthing switches for voltage above 1000 Volts. Part 2: Ratings.
9921-(Part 5)-1985	Alternating current disconnectors (isolators) and earthing switches for voltage above 1000 Volts. Part 5: Information to be given with tender enquiries & orders.
9968-Part 1-1988	Specification for Elastomer insulated cables: Part 1 For working voltages upto and including 1100 Volts.
9968-Part 2 -2002	Specification for Elastomer insulated cables: Part 2 For working voltage from 3.3 KV upto and including 33 KV.
9972-2002	Specification for Automatic Sprinkler Heads for Fire Protection Service (First revision)
9974-(Part 1 & 2) 1981	High pressure sodium vapour lamps
10019- 1981	Specification for mild steel stays and fasteners
10028-(Part I)-1985	Code of Practice for selection, installation and maintenance of transformers : Part 1: Selection
10028-(Part 2)-1981	Code of Practice for selection, installation and maintenance of transformers : Part 2: Installation
10028-(Part 3)-1981	Code of Practice for selection, installation and maintenance of transformers : Part 3: Maintenance.
10118-(Part I)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears : Part 1: General
10118-(Part II)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears (superseding IS 3072-75 & 3106-66): Part 2 Selection

IS Code.	Subject
10118-(Part III)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears (superseding IS 3072-75 & 3106-66): Part 3 Installation
10118-(Part IV)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears (superseding IS 3072-75 & 3106-66): Part 4 Maintenance
10221-1982	Code of Practice for Wrapping and Coating of underground MS pipe lines
10342- 1982	Specification for curtain rail system.
10470-1983	Specification for Air cooled Heat Exchangers
10500-1991	Specification for drinking water (First revision)
10521- 1883	Specification for collapsible gate
10594-1983	Thermostatic Expansion valves
10609-1983	Refrigerants - numbers - designation
10617-1983 Pt 1,2, and 3	Specification for Hermetic Compressors
11096- 1984	Code of practice for design and construction of bolt jointed construction.
11101-1984	Specification for Extended Branch Pipe for Fire Brigade Use
11208-1985	Guide lines for registration of plumbers
11246-1992	Specification for Glass fibre reinforced polyester resin (GRP) squating Pans
11327-1985	Requirements for Refrigerant Condensing unit
11329-1985	Finned type heat exchangers for room air conditioners
11330-1985	Specification for Oil separators
11338-1985	Specification for Thermostats for use in refrigeration and air conditioning
11353-1985	Guide for uniform system of marking and identification of conductor and apparatus terminals.
11360-1985	Specification for smoke detectors for use in automatic electrical fire alarm system
11561-1986	Code of practice for testing of cooling towers
11722-1986	Thin walled flexible quick coupling pipes.
11883-1986	Ready mix Paint, brushing red oxide, priming for metals.
11907-1986	Recommendations for calculation of solar radiation on buildings
12027- 1987	Specification for silicone based water repellents
12234-1988	Specification for plastic equilibrium float valve for cold water services.
12288-1987	Code of practice for use and laying of ductile iron pipes.
12349-1988	Fire protection-safety signs

IS Code.	Subject
12406- 2003	Specification for medium density fibre board for general purposes (First revision)
12407-1988	Graphic symbols for fire protection plans
12432- (Part 3)	Application for spray applied insulator - Code of safety Part 3 Polyurethane/Polyisocyamurate.
12436-1988	Preformed rigid polyurethane foams for thermal insulation
12469-1988	Specification for Pumps for Fire Fighting System
12615-2004	Specification for Induction motors - Energy Efficient motors
12701-1996	Specification for "Rotational Moulded polyethylene water storage tanks. (First revision)
12753- 1989	Eletrogalvanized coatings on round steel wire-specifications.
12762-Part 2 - 1993	Photovoltaic devices Part 2 Requirement for reference solar cells
12778- 2004	Hot rolled parallel, flange steel sections for beams, columns and bearing piles dimensions and section properties. (First revision)
12817- 1997	Specification for stainless steel butt hinges (First revision).
12834-1989	Solar photovoltaic energy system: Terminology
12843- 1989	Tolerances for erection of steel structure
12866- 1989	Specification for plastic translucent sheets made from thormosetting polyster resin (glass fibre reinforced)
12867- 1989	Specification for PVC hand rail covers.
12933-Part I - 2003	Solar Flat Plate Collector - Specification - Part 1 : Requirements (Second revision)
12933-Part 2 - 2003	Solar Flat Plate Collector - Specification - Part 2 : Components (Second revision)
12933- Part 3 - 2003	Solar Flat Plate Collector- Specification - Part 3 Measuring Instruments (First revision)
12933-Part 5 - 2003	Solar Flat Plate Collector - Specification - Part 5 . Test Methods (Second revision)
12976-1990	Code of practice for solar water heating systems
13049-1991	Specification for diaphragm type (plastic body) float valve for cold water Services.
13129-Part I - 1991	Solar heating - Domestic water heating system: Part 1 Performance rating procedure using indoor test methods
13129-Part 2 - 1991	Solar heating - Domestic water heating systems: Part 2 Procedure for system performance characterization and yearly performance predication
13129-Part 3 - 1991	Solar heating - Domestic water heating systems: Part 3 Procedure for system component characterization and predication for yearly performance using component performance data

IS Code.	Subject
13204-1991	Rigid phenolic foams for thermal insulation
13205- 1991	Code of practice for the application of Polyurethane insulation by the situ pouring method.
13367- 1992	Safe use of cranes - Code of practice: Part 1 General
13473- 1992	Cranes - Vocabulary: Part 1 General
13558-Part 1 - 1992	Cranes - Controls - Layout and characteristics: Part 1 General principles
13592-1992	Specification for UPVC pipes for soil and waste discharge systems inside buildings including ventilation and rainwater system
13607-1992	Ready mix Paint, Finishing general purposes, synthetic - specification.
13703	Low voltage fuses for voltage not exceeding 1000 V AC or 1500 V DC Part 1 & Part 2
13703-(Part 1 to 4) 1993	Specification for Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V PC
13712- 2006	Ceramic tiles- definitions, classifications, characteristics and marking (First revision)
13753- 1993	Specification for dust pressed Ceramic tiles with water absorption of E> 10% Group (B III)
13755- 1993	Specification for dust pressed Ceramic tiles with water absorption of 3%< E < 6% Group (B II a)
13757- 1993	Specification for burnt clay fly ash building bricks
13801- 1993	Specification for chequered cement concrete tiles
13834- 1994	Cranes - Classification Part 1 General
13834-Part 5 - 1993	Cranes - Classification: Part 5 Overhead travelling and portal bridge cranes
13870- 1993	Cranes and lifting appliances - Selection of wire ropes: Part 1 General
13871- 1993	Specification for powder coatingss
13947-Part 1 1993	Specification for low voltage switchgear and control gear Part 1: General rules.
13947-Part 3 1993:	Specification for low voltage switch gears and control gear- Part 3 switches, Disconnectors, switch disconnectors and fuge combination unit.
13947-Part 1 to 4 -1993	Specification for low voltage switchgear and control gear
13983-1994	Specification for stainless steel sinks for domestic purposes.
14164-1994	Industrial application and finishing of thermal insulation material at temperature above 80 deg C and upto 700 deg C_O Code of Practice
14333-1996	Specification for high density polyethylene pipe for sewerage
14471-1997	Cranes and lifting appliances - Technical characteristics and acceptance documents

IS Code.	Subject
14472-Part 5 - 1997	Cranes - Information to be provided: Part 5 Overhead travelling cranes and portal bridge cranes
14473-Part 1 - 1997	Cranes - Inspections: Part 1 General
14665-(Part-1) - 2000	Electric Traction Lifts (Part-1 Guidelines for dimensions of passenger, goods, service and hospital lifts)
14665-(Part-2/Sec 1&2)	Electric Traction Lifts (Part-2 Code of practice for installation, - 2000 : operation and maintenance. Sec 1- Passenger and Goods Lifts, Sec 2-Service Lift)
14665-(Part-3/Sec 1&2)	Electric Traction Lifts (Part-3 Safety Rules, Sec 1- Passenger and - 2000 Goods Lifts, Sec 2-Service Lifts)
14665-(Part-4/	Electric Traction Lift(Part 4 components) Sec 1to9)- 2001
14665-(Part-5) - 1999	Electric Traction Lift (Part-5 Inspection Manual)
14687- 1999	Guidelines on falsework for concrete structures
14735-1999	Specification for unplasticized polyvinyl chloride (UPVC) injection moulded fittings for soil and waste discharge system for inside and outside buildings including ventilation and rain water system.
14772-2000	General requirements for enclosures for accessories for house hold and similar fixed electrical insutations.
14846-2000	Service valve for water works purposes (50 to 1200 mm size) specification.
14912- 2001	Specification for door closers, concealed type (hydraulically regulated)
14933-2001	High Pressure Fire Fighting Hose - Specification
14961-2001	Guidelines for rainwater harvesting in hilly areas by roof water collection system.
15051-2001	High Pressure Fire Hose Delivery Couplings - Specification
15105-2002	Code of Practice for Design and Installation of Fixed Automatic Sprinkler Fire Extinguishing Systems
15301-2003	Code of Practice for Installation and Maintenance of Fire Fighting Pumps
15462-2004	Polymer and Rubber Modified Bitumen
15658- 2006	Specification for precast concrete blocks for paving
IRC STANDARDS	
10-1961	Recommended practice for borrow pits for road, embankments constructed by manual operation.
19-1972	Standard specification and code of practice for water Bound Macadam.
29-1988	Specification for bituminous concrete for road pavements.
36-1970	Recommended practice for construction of earth embankments for road works.

IS Code.	*Subject*
60-1976	Tentative guidelines for the use of lime fly ash concrete as pavement base or sub-base.
88-1984	Recommended practice for lime fly ash stabilized soil base/ sub base in pavement construction
107-1992	Tentative specifications for bitumen mastic wearing courses.

SECTION 3
EARTH WORK

3.1 Indian Standards

The following IS apply to this section.

I.S No	*Subject*
1498 - 1970	Classification of soil for general engineering purposes (First revision).
2720 (Part VII) -1980	Method of test for soils, Part VII- determination of water content, dry density relation using light compaction (Second revision).
2911 (Part I: Sec 2)-1979	Code for practice for design and construction of concrete piles foundation Section 2 bored cast in situ piles (First revision).
3764 -1992	Excavation work - Safety code (First revision).
4081-1986	Safety code for blasting and related drilling operation (First revision).
6313 (Part-I) 1981	Anti-termite measure in building constructional measures (First revision).
6313 (Part-2) 1981	Anti-termite measure in building Part 2: Pre constructional chemical treatment measures (Second revision).
6313 (Part-3) 1981	Anti-termite measure in building Part 3: Treatment for Existing Building (Second revision).
8944 -2005	Specification for Chloropyrifos emulsifiable concentrate (First revision).

3.2 Classification

3.2.1 The materials to be excavated shall be classified as under

(a) **Soft or loose Soil** :- Generally any soil which yields to the ordinary application of pick and shovel or to phowara, rake or other ordinary digging implements such as vegetable or organic soil, turf gravel, soil classified under soil group SP, SC, ML, CL, OL, MI, CI, OI, MM, CH and OH having soil dry density less than 1.80 gm/cc as per IS 1498-1970. This will also include mud phuska, concrete etc.

(b) **Hard or Dense Soil** :- Soil group as per IS-1498-1970 other than covered under (a) above; gravel, cobble stone, hard shale, soft conglomerate where stone can be detached from the matrix with picks and shovels. This will also include hard core, soling of roads, path etc; macadam surface of any description (water bound, grouted, tarmac); lime concrete stone masonry in lime mortar and brick work in lime or cement mortar below ground level.

Note :- Cobble stone is rounded to angular , bulky, hard rock particle, average diameter smaller than 300 mm but retained on 80mm IS sieve.

(c) **Mud** :- A mixture of soil and water in fluid or weak solid state.

(d) **Soft or Disintegrated Rock (Not requiring blasting)**:- Rock or boulders which may be quarried or spilt with crowbars. This will also include laterite and hard conglomerate; plain cement concrete which can be broken up with crowbars or picks and stone masonry in cement mortar below ground level.

(e) **Hard Rock** :- Any rock (excluding laterite and hard conglomerate) or boulder for excavation for which blasting is required. This will also include plain cement concrete for the excavation for which blasting is required; reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level.

(f) Hard Rock (Blasting Prohibited) :- Hard rock requiring blasting as described under (e) but where blasting is prohibited for any reason and excavation has to be carried out by chiseling or any other agreed method.

3.2.2 A broad classification of soil and rock for earthwork, suitable for conditions generally occurring in practice, has been given. Further sub-classification may be done and indicated to suit the individual cases depending upon the properties of the sub-strata.

3.3 Types of Excavation

3.3.1 Rough Excavation

Excavation not requiring dressing of sides and bottom and reduction to exact levels as winning earth from borrow pits; hillside cutting etc, shall be described as 'rough excavation'.

3.3.2 Surface Excavation

Excavation exceeding 1.5m in width as well as 10 Sqm area on plan; but not exceeding 30 cm in depth shall be described as 'surface excavation'.

3.3.3 Excavation Over Areas

Excavation exceeding over 1.5m in width as well as 10 Sqm area on plan and exceeding 30 cm depth, shall be described as 'excavation over areas'.

3.3.4 Excavation in Trenches for Foundations and for Pipes, Cables etc

Excavation in Trenches for Foundations and for Pipes, Cables etc (not exceeding 1.5m in width and excavation for manholes, shafts, cess-pits, wells and the like not exceeding 10 Sqm on plan shall be described as 'excavation in trenches'.

3.3.5 Excavation in Post Holes

Excavation in independent post holes (or similar holes) each not exceeding 0.5 cum shall be described as 'excavation as post holes' and shall include return, fill in, ram and removal of surplus spoil.

3.3.6 Surface Dressings

Trimming of Natural ground, rough excavated surfaces and filled up area to remove vegetation and/or small inequalities not exceeding 15 cm deep shall be described as 'surface dressing'.

3.4 Antiquities and Useful Materials

Any finds such as relics or antiquity, coins, fossils or other articles of value shall be delivered to the EIC and shall be the property of the Government.

3.4.1 Any useful material such as boulders, stone etc obtained from the excavation shall be segregated irrespective of method and equipment used for excavation and stacked separately in regular stacks as directed by the EIC and shall remain the property of the Government. The decision of the EIC as to what is useful and what is useless shall be final and binding.

3.4.2 Any useful material, directed to be used by the Contractor in lieu of his own supply, will be charged to him at the agreed rates.

3.5 Inspection of site

The contractor shall be responsible to inspect the site of work and ascertain the nature of the ground in which excavation is to be carried out.

3.6 Site Clearance

Before the work is started, the area coming under cutting and filling shall be cleared of shrubs, vegetation, grass, bush , weed, trees and saplings not exceeding 30 cm in girth, measured at a height of one metre above ground level. Useful material shall be stacked and rubbish/ useless materials disposed off upto a distance 50 m outside the periphery of the area. Roots of trees and saplings shall be removed as described under felling of trees and the hollows filled up with earth, levelled and rammed.

3.7 Felling of trees

3.7.1 Trees exceeding 30 cm in girth when measured at the height of 1 m above ground level and which are to be cut shall be so approved in writing by the EIC and marked at site. Felling of trees shall include digging out roots upto 60 cm below the ground level or 15 cm below the formation level, whichever is lower. All holes and hollows, formed in the ground by digging out of roots shall be carefully filled up with earth, well rammed and levelled. Boulders which may interfere with the work shall be removed , after breaking down, if necessary.

3.7.2 The trunk and branches of the trees shall be cut into suitable pieces as directed. Useful materials shall be stacked at site of work as directed by EIC and shall be property of the Govt. All unserviceable material and rubbish shall be removed to a distance of upto 50m outside the periphery of the area under clearance and burnt or otherwise disposed off as directed.

3.8 Setting out and Making Profiles

3.8.1 All excavations, embankments, traverses etc, shall be set out to the true line, curve, level or slope required. The contractor shall be responsible for the accuracy of all setting out.

3.8.2 Masonry pillars shall be erected at suitable points in the area to serve as bench marks for the execution of the work. These bench marks shall be connected with any permanent bench mark. In case of filling, necessary profiles with pegs, bamboos and string or 'Burjis' shall be made to show the correct formation levels before the work is started. In case of cutting, levels may be marked by the digging pits and embedding brick bats at the required levels. The profiles and 'Burjis' shall be maintained during the execution of the work.

3.8.3 When directed , ground levels shall be taken on roughly level ground ordinarily at 15m distance. In sloping and undulating areas, levels shall be taken at lesser distance depending on ground conditions. The ground level shall be recorded in the field/ level books and plotted on plans, and signed jointly by EIC and the Contractor before the earthwork is started. The labour required for taking levels shall be supplied by the Contractor at no extra cost to the Govt.

3.9. Excavation in Different Strata

The depth or level at which the various strata are met shall be suitably recorded in field/ level books and plans, for reference and calculation of quantities of different types of soil excavated.

3.10. Surface Dressing

Uneven surfaces of the natural ground, rough excavated surfaces and filled up area where ordered shall be trimmed to an even surface, horizontal or sloping, by removing vegetation and by scrapping high patches and filling in low patches with the scraped soil to give an even and neat look to the site. The maximum depth of cutting shall not exceed 15 cm.

3.11 Rough Excavation

The locations and depths of borrow pits and the extent of hillside cutting shall be indicated by the Engineer-in-Charge. Sufficient number of tell tales or 'dead men' shall be left in position as indicated by the EIC for proper measurements of excavation. Such tell tales shall not be removed until after the measurements of rough excavation have been recorded in the measurement book.

Where practicable, borrow pits shall be drained to prevent stagnation of water in them.

3.12 Excavation Generally

3.12.1 All Excavation (except rough excavation) shall be dug to the exact dimensions and profiles as shown on the drawings or as directed by the EIC.

3.12.2 Disused foundations, drains or other obstructions met with during excavation shall be grubbed up and cleared away to the extent required.

3.12.3 Damage to the Existing Drains, Water mains, Cables etc.

During Excavation the contractor shall take particular care to avoid damage to existing drains, water mains, cables or other underground work. Where required , existing pipes, cables etc. shall be properly slung or otherwise supported.

3.12.4 Top spit and other vegetable matter shall be separated from excavated material, if so directed.

3.12.5 Bad Ground

If during excavation the contractor encounters, expansive soil or other bad ground, he shall immediately notify it to EIC for his instructions in writing.

3.12.6 Inspection and Approval

The Contractor shall notify the GE when excavation is ready for inspection. The excavation shall be inspected and passed by the GE, in writing, measurement recorded in measurement book before foundation is laid.

3.13 Excavation in Trenches and Over Areas in Soil

3.13.1 In firm soil the sides of excavation shall be kept vertical up to a depth of 1.5m from the bottom. For greater depth excavation profile may be widened or the sides sloped or shored up, depending upon the nature of soil, as ordered by the GE in writing. It shall be the responsibility of the contractor to take complete instructions from the GE, regarding the extent and manner of stepping, sloping or shoring and timbering to be done for excavations, where necessary.

3.13.2 Excavation shall be done from top to the bottom. Undermining and underpinning shall not be allowed.

3.13.3 The bed of excavation shall be formed to the required level, slope or grade and shall be made firm by watering and ramming. The side of excavation shall be dressed or trimmed. Soft defective spots shall be dug out and filled with concrete of the same mix as that of the base concrete or approved dry filling as directed by the EIC.

3.13.4 If the excavation is done to a depth greater than that shown in the drawings or directed, the excess depth shall be made good by the contractor at his own expense with the concrete of the same proportion as base concrete.

However, for excavation in drain work the excess depth shall be made good with stiff clay puddle at places where the drains are required to be pitched and with ordinary earth, properly watered and rammed, where the drains are not required to be pitched.

3.13.5 In trench excavation for pipes etc, grips shall be dug, if required, to take sockets, collars and joints of pipes.

3.14 Excavation in Trenches and Over Areas in Soft Rock.

Excavation in soft rock shall be carried out by the crowbars, pick axes or pneumatic drills. If however, the Contractor wishes to resort to blasting, he may do so with the prior written permission of the GE but no extra payment shall be made to him on this account.

3.15 Excavation in Trenches and Over Areas in Hard Rock.

3.15.1 Where hard rock is met with during excavation, the contractor will bring this to the notice of GE, in writing, and obtain his written instructions whether further excavation in hard rock should be carried out and if so, whether excavation shall be done by blasting or by chiseling where blasting operations are prohibited or are not considered practicable by the GE. Blasting shall not be normally done within 200m of an existing structure, unless specifically permitted by the GE, in writing.

3.15.2 During excavation in rock by blasting the lowest 150mm of the strata shall be blasted with light charges so as not to shatter or weaken the underlying rock on which the foundation will be actually laid.

3.15.3 In trenches and drains, where blasting is not otherwise prohibited, the excavation in hard rock shall be carried out by blasting and to obtain the correct section of the trenches/ excavation of the rock may be chiseled. In such cases the whole of excavation shall be treated as having been done by blasting.

3.15.4 The bottom surface of the excavation in rock shall be made as level and true as possible prior to laying concrete; and any small irregularities shall be filled in with concrete of the same mix as specified for foundations at no extra cost to the Govt.

3.15.5 In case excavation is done to depths greater than those required, the excess depth shall be made up with foundation grade cement concrete.

3.16 Blasting of Rocks

3.16.1 The contractor shall obtain licence from the District Authorities, where applicable, for undertaking blasting work and for obtaining and storing the Explosive as per Explosive Rules 1940, revised up to date. The Contractor shall purchase explosives, fuses, detonators only from the licensed dealers. He will be responsible for their safe custody and shall maintain an appropriate account of the explosive materials. The EIC or his authorized representative shall have access to check the Contractor's stock of explosive.

3.16.2 Precautions

Blasting operations shall be carried out under careful supervision of a responsible authorized person preferably during certain specified hours. Only trained person shall be employed. The blasting time shall be notified in advance to the surrounding areas.

All precautions shall be taken to avoid accidents and to ensure safety of workers, public and property during blasting operations. Red flags shall be prominently displayed around the area to be blasted and all the people on work except those who actually light the fuses, shall withdraw to a safe distance of not less than 200m from the blast.

All the procedures and safety precautions for the use of explosives, drilling and loading of the explosives before and after shot firing and disposal of explosives shall be taken by the Contractor as detailed in IS-4081-1986, Safety code for blasting and related drilling operations. The EIC shall be informed by the contractor of all cases of misfires, their causes and the steps taken in that direction.

3.17 Bailing/Pumping of water

All water that may accumulate in excavations during the progress of work from rains, subsoil water, springs or any other cause shall be bailed, pumped out or otherwise removed. The foundations shall be kept dry during excavation and laying of foundations. Pumping shall be done directly from the foundation trenches or from a sump outside the excavation as necessary in such a manner as to preclude the possibility of movement of water through any fresh concrete or masonry and washing away parts of concrete or mortar. No pumping shall be allowed during laying of concrete or masonry and for a period of at least 24 hours thereafter unless it is done from a suitable sump separated from concrete or masonry by effective means. Pumping shall be done in such a way as not to cause damage to the work or adjoining property by blows, subsidence etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structure nearby.

3.18 Protection

The contractor shall protect the excavation from the effect of frost, other damage and shall make good such damage to the satisfaction of EIC. Fencing and other precautions such as red flags and red lights at night etc. as necessary for protection against risk of accidents due to open excavation shall be provided. While carrying out excavation near a building, care shall be taken to see that proper shoring etc, as required is provided so as not to adversely affect the foundation of adjacent building.

3.19 Filling Excavated Earth in Foundation Trench, in Plinth and Under Floor etc.

3.19.1 Earth

The earth used for filling shall be free from salts, organic or other deleterious matter. Highly expensive soils like black cotton soil shall not be used, unless so specified. All clods of earth exceeding 50mm shall be broken or removed. Earth obtained from borrow pits and surplus earth from excavation, if any , shall be directly used for filling and double handling avoided.

3.19.2 Filling sides of Trenches

As soon as the work in foundation has been completed and measured, the space around the foundation masonry in trenches shall be cleared of all debris, brickbats etc. and filled with earth in layers not exceeding 250mm, each layer being watered, rammed and compacted before the succeeding one is laid. Earth shall be rammed with iron rammer where feasible and with the butt ends of crowbar where rammer cannot be used.

3.19.3 Filling Plinth, Under Floor and Hard standing etc

Filling shall be started from the lowest level in regular horizontal layers each not exceeding 250mm in depth. Each layer shall be compacted by ramming with rammers of 7 to 10 Kg weight. Earth filling shall be adequately watered for achieving maximum compaction. Special care shall be taken to compact the filling at the junctions of the floors with walls and columns. The top surface of the filling shall be neatly dressed level or to a slope or grade as directed.

3.19.3.1 In large floors, like factory floors, hangars, hard standing etc, where indicated, each layer of earth filling shall be compacted by the mechanical means such as by sheep foot roller or by hand roller or by power roller to 90 to 95 percent of standard Proctor's density under optimum moisture conditions.

3.20. Filling in Trenches for Pipes, Drains, Cables etc.

3.20.1 Material for Filling

Earth used for filling shall be free from salts, organic or other deleterious matter. All clods of earth exceeding 50mm shall be broken or removed. Unless otherwise indicated, where the excavated material is mostly rock, the rock fragment shall be broken into pieces not bigger than 150mm size and mixed with fine material consisting of decomposed rock, moorum or earth as available, so as to fill up the voids as far as possible and then the mixture used far filling.

3.20.2 Filling Trenches

Filling in trenches for pipes and drains shall be commenced only after the joints and drains have been tested and passed by the EIC in writing.

3.20.3 Where the trenches are excavated in soil, the filling shall be done with earth on both the sides simultaneously and on top of pipes in layers not exceeding 250mm thick, watered, rammed and compacted; taking care that no damage is caused to the pipe below.

3.20.4 In case of excavation in rock, the filling up to a depth of 300 mm above the crown of pipe shall be done with fine material such as earth, moorum or pulverized decomposed rock according to the availability at site, in the same manner as described for trenches excavated in soil. The remaining filling shall be done with rock fragments mixed with fine material as available to fill up the voids, watered, rammed and compacted, in layers not exceeding 250mm thick. Particular care shall be taken in a back-filling to avoid future troubles from bursts and leakage due to differential settlement.

3.21. Moorum, Red Bajri Shingle and Sand Filling in Foundation, Plinth and in Floors

3.21.1 Moorum or Red Bajri

Moorum/ Red Bajri shall be obtained from approved pits and quarries of disintegrated rocks containing silicious material and natural mixture of clay of calcareous origin. These shall not contain any admixtures of ordinary earth. Red Bajri shall be dark red in colour consisting of coarse grains, free from mica and other foreign matter. Size of moorum/Bajri shall vary from dust to 40 mm gauge.

3.21.2 Sand

Sand shall be clean, free from dust, organic and other extraneous matter. It shall not contain more than 5 percent of clay/silt.

3.21.3 Shingle

Shingle shall be clean and free from foreign matter and obtained from river or nullah beds. Shingle of all in size ranging from 40mm down to 4.75 mm gauge shall contain a sufficient proportion of fine material to fill all interstices and ensure binding when consolidated.

3.21.4 Filling

Filling shall be done in a manner similar to earth filling in plinth except that thickness of individual layer shall not exceed 15 cm. Shingle or ballast filling shall be blinded with earth before ramming/consolidation. The surface of the compacted moorum, red bajri, sand or shingle shall be dressed to the required level, grade or slope. In the case of moorum and sand filling , surface shall be flooded with water for at least 24 hours, surface allowed to dry and then compacted and graded.

When the filling in floors etc, has nearly dried, any developing cracks shall be tapped and a thin layer of the same material as used for filling and earth in case of shingle filling shall be spread over the surface evenly and tapped in.

3.22 Embankments and Traverses

3.22.1 Clearing of site

Prior to commencement of earthwork, the site shall be cleared of all obstructions and vegetation including trees, roots, undergrowth, grass, rubbish etc. All stumps shall be cut down below ground level as specified under 'Felling of Trees'.

3.22.2 Embankments for roadworks etc, shall be set out true to alignment, gradient, camber super elevation etc, as indicated or as directed by the EIC.

3.22.3 Compacting Original Grounds

Original ground shall be compacted as much as reasonably possible by rolling or by other means like tamping where rolling is not feasible. All empty pockets or depressions left in the soil as a result of clearing and grubbing operation shall be filled and compacted. Any unsuitable materials occurring in the embankment foundations shall be removed and replaced with approved materials.

3.22.4 Where an embankment is to be placed on steep sloping ground, the surface of the ground shall be benched in step or broken up in a manner that the new materials would bond with the existing surface.

3.22.5 Embankments work shall not proceed unless the foundations have been inspected by the EIC for satisfactory conditions and approved.

3.22.6 Earth for Filling

Only approved earth shall be used in the embankment. All clods of earth exceeding 50mm shall be broken or removed. Soils having laboratory maximum dry density of less than 1.44 gm/cc are ordinarily unsuitable and shall not be used unless specifically approved in writing by the GE. Similarly soils having maximum dry density of 1.52 gm/cc are ordinarily considered not suitable for use in embankments exceeding 3m in height or in embankments of any height subject to long periods of inundation. The work shall be so executed that the best available earth is saved for the top portion of the embankment. Where highly expansive clays exhibiting marked swell and shrinkage properties are indicated to be used in filling, these shall be deposited at the bottom of the embankment and no such material shall be placed in the top 50 cm portion of the embankment below the sub-grade.

3.22.7 Placing Soil

Earth shall be deposited in layers not exceeding 25 cm. When a sheep foot roller is used, the thickness of the loose layer shall not exceed the length of the stamping foot by more than 5 cm. For adequate compaction the embankment shall be constructed in uniform layers spread over the entire width of embankment. Successive layers shall not be placed unless the layers under construction have been thoroughly compacted to satisfy the specified requirements.

3.22.8.Compaction

Each layer shall be thoroughly compacted with sheep foot and/or power road roller of weight not less than 8 tonne till the soil behaves as an elastic material and gets compressed under the load of the roller. In location where consolidation by power roller is not possible, manually or mechanically operated rammers shall be employed for compaction. The embankment shall be finished to the lines, grade and cross section as directed.

3.22.9 Where specified, the compaction of earth filling in embankments shall be carried out under optimum moisture conditions, so as to obtain at least 95 percent of Standard Proctor density for each layer. Dry density shall be determined in accordance with IS-2720 (Pt VII)-1980. Method of tests for soils (Part VII)- Determination of water content-dry density relation using light compaction. The moisture content of each layer of soil at the time of compaction should be from 1% above to 2% below the optimum moisture content. Highly expansive clays (such as black cotton soils) where specified to be used, shall be compacted at a moisture content of 3 -4 percent above the optimum to a density not exceeding 90% of Standard Proctor's density.

3.22.10 Drainage

At all times during construction, the top of the embankment shall be maintained at such a cross fall as will shed water and prevent ponding.

3.22.11 Allowance for Settlement

To allow for subsequent settlement of embankment, the finished level of the embankment shall be set higher than the specified level by 1-2 percent of the height of the embankment.

3.22.12 Compaction Control

Proper record of compaction tests carried out shall be maintained. Density measurements shall be done at the rate of 1 test per 500-1000 Sqm of the compacted area, except where otherwise indicated.

3.23 Subsidence and Shrinkage

The contractor shall make good all subsidence and shrinkage in all earth fillings, embankments, traverses etc, during execution of work and thereafter until the expiry of defect liability.

3.24 Timbering/Planking and Strutting

3.24.1 When the depth of a trench in a soft but firm soil exceeds 1.5 metres, stepping, sloping and / or planking and strutting of sides shall be done as ordered, in writing, by the GE. In the case of loose and slushy soils, the depth at which these precautions are to be taken shall be determined by the GE according to the nature of the soil.

3.24.2 It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of trenches from collapse. Regarding the necessity or otherwise of timbering or any other safety measure, the Contractor shall be responsible to obtain the decision of the GE, in writing, failing which the Contractor shall be liable for any damage caused due to non-adoption of proper timbering or other safety measure.

3.24.3 Deep excavation shall be inspected by EIC after every rain, storm or other hazard increasing occurrence and protection against slides and cavings shall be increased, if necessary.

3.24.4 Planking and strutting shall be 'close' or 'open' type depending on the nature of soil and depth of trench. The type of planking and strutting shall be as decided by the GE. Where distinctly different types of soil strata are encountered, each strata shall be treated separately as required by its characteristics.

3.24.5 Timbering shall be of sufficient strength to resist earth pressure and ensure safety from slips, damage to the property or injury to person. Where excavation has also to stand vibrations from adjacent machinery, vehicles, railroads, blasting and other sources, additional bracings shall be provided. Generally the specifications and sizes and spacing of sheeting, wales and struts used for timbering for different depths of trench shall be as given in IS 3764-1992 Safety Code for excavation work. Shoring shall extend 30 cm above the vertical sides.

3.24.6 The withdrawal of timbering shall be done very carefully to prevent collapse of the sides of excavation and any damage to the work executed in the excavated area. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried unless ordered by the GE, in writing to be left permanently in position.

3.25 Under-reamed Pile Bores

3.25.1 Boring and Under-Reaming

The ground shall be roughly levelled and the position of the piles marked. Bore holes shall be made by earth augers or any other suitable boring tool. In case of manual boring, an auger boring guide shall be used to keep the bores vertical or to the desired inclination and in position. After the bore is made to the required depth enlarging of the bore shall be carried out by means of an under-reaming tool 2 to 2.5 time the diameter of the bore, as directed by the EIC.

3.25.2 For double and multi under-reamed piles boring shall first be made to a depth as required for the first under -reaming. After completing the first under-reaming, the bore shall be further extended by augering to the depth required for the second under-reaming and the process repeated.

3.25.3 In grounds with high water table and having unstable pile bores, boring and under-reaming shall be carried out using a suitable drilling fluid as directed by the GE in writing. For boring, normal spiral or modified augers and under-reaming tool having arrangement to avoid back suction shall be used. Where the drilling fluid is used the hole shall be cleaned of all soil cuttings before concreting.

3.25.4 Control of Alignment

The pile shall be bored and under-reamed as accurately as possible vertical or to the specified batter. As a general guide the permissible positional deviation shall not be greater than 75mm or D/4, whichever is less at the level of bottom of pile cap and shall not exceed 2 percent (about 1^{o}) from the specified inclination (D is the diameter of the stem). Where the deviation in the alignment of the bore is more than that specified, corrective measures as approved, shall be taken at the contractor's cost in the form of increasing pile size, provision of extra reinforcement in the piles, additional piles etc.

3.25.5 In case it is not possible to make pile bore or it is required to be abandoned due to site obstructions or otherwise, the Contractor shall be allowed payment for the abandoned bore hole excavated and its refilling.

3.26 Preconstruction Anti-termite Chemical Treatment.

3.26.1 Chemical

Following chemical conforming to the relevant IS specification in water emulsion shall be applied uniformly at the prescribed rate in all stages of treatment:-

Chemical	Concentration by weight percent	
	For mound treatment	For soil treatment
Chloropyriophos emulsifiable concentrates conforming to IS 8944 - 2005	1.00	1.00

3.26.1.1 Concentration of the chemical as emulsifiable concentrate is indicated on the sealed containers. For obtaining the specified concentration, chemical shall be diluted with water in the required quantity before it is used. Graduated containers shall be used for the dilution of the chemical. For example, to dilute chemical of 20 percent concentration, 19 parts of water to one part of the chemical shall be added to achieve 1(one) percent concentration.

3.26.2 Mound Treatment

If termite mounds are found within the plinth area of the building these shall be destroyed by pouring chemicals in to the mounds at several places, after breaking open the earthen structure and making holes with crow-bars at the rate of 4 litres of chemical emulsion per cubic metre of mound.

3.26.3 Condition of Formation

Barrier shall be complete and continuous under the whole of the building/structure to be protected. All foundations shall be fully surrounded by and in close contact with the barrier of treated soil. On loose, sandy or porous soils where loss of treating solution through piping or excessive percolation is likely to occur, preliminary moistening to fill the capillary spaces in soil may be done.

3.26.4 Time of Application

Soil treatment should start when foundation trenches and pits are ready to take mass foundation concrete. Laying of foundation concrete should start when the chemical emulsion has been absorbed by the soil and the surface is quite dry. Treatment should not be carried out when it is raining or when the soil is wet with rain or subsoil water. This applies also in the case of treatment to the filled earth surface within the plinth area before laying the sub-grade for the floor.

3.26.5 Disturbance

Once formed, treated soil barriers shall not be disturbed. If, treated soil barriers are disturbed, immediate steps shall be taken to restore the continuity and completeness of the barrier system.

3.26.6 Treatment of Masonry Foundation and Basement

The bottom surface and the sides (upto a height of about 300mm) of excavations made for masonry foundations and basements shall be treated with the chemical at the rate of 5 litres per square meter surface area.

After the masonry foundations and the retaining wall of the basements come up, the backfill in immediate contact with the foundation structure shall be treated at the rate of 7.5 litres per square meter of the vertical surface of the sub-structure for each side. If water is used for ramming the earth fill, the chemical treatment shall be carried out after the ramming operation is done by rodding the earth at 150 mm centres close to the wall surface and working the rod backward and forward parallel to the wall surface and spraying the chemical emulsion at the above dosage. After the treatment, the soil should be tempted in place. The earth is usually returned in layers and the treatment shall be carried out in similar stages. The chemical emulsion shall be directed towards the masonry surfaces so that the earth in contact with these surfaces is well treated with these chemical.

3.26.6.1 Treatment for RCC Foundations and Basements

The treatment shall start at a depth of 500mm below the ground level except when such ground level is raised or lowered by filling or cutting after the foundations have been cast. In such cases the depth of 500mm shall be determined from the new soil level resulting from the filling or cutting mentioned above, and soil in immediate contact with the vertical surfaces of RCC foundations shall be treated at the rate of 7.5 litres per square metre.

3.26.7 Treatment of Top surface of Plinth Filling

The top surface of the filled earth within plinth walls shall be treated with chemical emulsion at the rate of 5 litres per Sq metre of the surface before the sand bed/hard core of sub-grade is laid. If the filled earth has been well rammed and the surface does not allow the emulsion to seep through, holes upto 50 to 75 mm deep at 150mm centres both ways may be made with 12mm dia mild steel rods on the surface to facilitate saturation of the soil with the chemical emulsion.

3.26.8 Treatment at Junctions of the Wall and the Floor

Special care shall be taken to establish continuity of the vertical barrier or inner wall surfaces from ground level upto the level of the filled earth surface. To achieve this, a small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor (before laying the sub-base) and rod holes made in the channel upto the ground level 150mm apart and the iron rod moved backward and forward to break up the earth and chemical emulsion poured along the channel at the rate of 7.5 litres per Sq metre of the vertical wall or column surface so as to soak the soil right to bottom. The soil should be tamped back in to place after this operation.

3.26.9 Treatment of Soil along External Perimeter of Building

After the building is complete but before laying plinth protection, holes shall be made in the soil with iron rods along the external perimeter of the building at intervals of about 150mm and depth 300mm and these holes shall be filled with chemical emulsion at the rate of 7.5 litres per Sq metre of vertical surface of perimeter of the external wall.

3.26.9.1 Treatment of Soil under apron along external perimeter of building

Top surface of the consolidated earth over the apron to be laid shall be treated with chemical emulsion at the rate of 5 litres/Sq metre of the vertical surfaces before the apron is laid. If consolidated earth does not allow emulsion to seep through, holes upto 50 to 75 mm deep at 150mm centre both ways may be made with 12mm diameter mild steel rod on the surface to facilitate saturation of soil with chemical emulsion.

3.26.10 Treatment of Soil Surrounding Pipes and Conduits

When pipes and conduits enter the soil inside the area of the foundations, the soil surrounding the point of entry shall be loosened around each such pipe or conduit for a distance of 150mm and to a depth of 75mm before treatment is commenced. When they enter the soil external to the foundations, they shall be similarly treated unless they stand clear of the walls of the building by about 75mm for a distance of over 300mm.

3.26.11 Safety Precautions

The chemical used for treatment are poisonous and hazardous to health. Therefore, necessary safety precautions shall be taken in handling and use of the chemicals and emulsions.

3.27 Hard Core

3.27.1 Hard core shall be of hard broken stones or boulders, quarry waste, gravel, bricks of old broken concrete, as indicated. Material for hard core shall be hard,tough, clean and free from dust and other deleterious matter. The material for hard core shall be well graded for providing a dense and compact sub-grade. Where the gravel or concrete rubble, etc, are not well graded, it shall contain sufficient fine material for its proper compaction.

3.27.2 Unless otherwise indicated, materials for hard core shall be broken to gauge not exceeding 63mm. Hard core of gauge upto 100mm may be specified and used when laid in hard standing and pavements where power roller is used for consolidation.

3.27.3 Brick aggregate shall be from well burnt or slightly over burnt bricks and shall not contain any appreciable solution of sulphate content when used on a wet side.

3.27.4 Coarse ungraded gravel and rock may be used as a base layer for hard core exceeding 15cm thick covered by a layer of well graded material.

3.27.5 Concrete rubble shall be clean and suitably graded. Care shall be taken with rubble from general building demolition which may contain mixtures of material.

3.27.6 Hard core filling shall be spread and levelled in layers not exceeding 15cm thick, watered and well rammed or rolled where indicated.

3.28. Filling in Soakage Pits

Loose filling in soakage pits shall be of any material specified for hard core as indicated and shall be of hard stuff broken to gauge 80mm to 150mm. Loose filling shall be topped with aggregate of the same material but of 40 to 80 mm gauge as ordered.

3.29. Filling Behind Retaining Walls, etc.

3.29.1 The layer of back fill immediately against the retaining walls, etc. shall consist of broken stones or boulders, hard brick bats or other granular material as indicated.

3.29.2 Materials for hand packing shall be of gauge exc 63mm and not exc 300mm and shall be carefully selected for shape, filled and packed by hand to the required profile and in such a manner to produce a mass with as few voids as possible. Interstices shall be filled solidly with hand spalls where directed.

3.29.3 The remainder of the back fill shall be rammed in 150mm layers sloping a ways and down wards from the back of the wall. In wet situations, a continuous drain of loose stones shall be made and connected with the horizontal weep holes, as directed.

3.30. Bored cast in-situ Piles

3.30.1 The ground shall be roughly levelled and position of pile marked. The boring shall be done with or without the use of temporary casing as indicated.

3.30.2 The sides of bore-holes shall be stabilized with aid of temporary casing or with the aid of drilling mud of suitable consistency as indicated.

3.30.3 The equipment and accessories shall depend upon the type of bored pile chosen for the job consideration of sub soil strata, ground water condition , type of founding material.

3.30.4 Boring operation shall be done by a rotary or precussion type drilling rigs using direct mud circulation or reverse mud circulation method as indicated. In soft clays and loose sand bailer and chisel method may be used. The size of cutting tool shall be as per IS-2911 (Part I Section 2).

3.30.5 Use of drilling mud in stabilizing sides of bore hole where specified shall have properties as defined in Appendix A to IS 2911 (Part -I : Sec 2).

3.30.6 The pile shall be so drilled that it shall not deviate more than the limit specified vide clause 7.1.2 of IS 2911 (Part -I : Sec 2).

3.30.7 In case of deep excavation adjacent to piles proper shoring or other suitable arrangement shall be done to guard against lateral movement of soil stratum or releasing the confirming soil stress.

3.31 Post Construction Anti-Termite Chemical Treatment

3.31.1 Chemicals

3.31.1.1 Chloropyriophos emulsifiable concentrates conforming to IS 8944 -2005 shall be used as per concentration indicated in IS code.

3.31.1.2 Oil or Kerosene based solution of Chloropyriophos 1.0% (by weight) concentration shall be used for treatment of wood or wood based products.

3.31.2 Inspection and Examination of Termites

3.31.2.1 Before undertaking any type of Treatments a thorough inspection shall be carried out of the structure based on guidelines as indicated in IS 6313 (Part-3).

3.31.3 Method of Treatment (By Chemicals)

3.31.3.1 Soil Treatment

Treating along outside of foundation. The soil in contact with external wall of building shall be treated with chemical as indicated as per clause No 4.3.1.1 of IS - 6313 (Part-3) and 4.3.1.2 of IS 6313 (Part-3) as indicated.

3.31.3.2. Treatment of Soil under Floor

The treatment shall be provided on the entire plinth area of the building on ground floor as per clause No 4.3.1.3 of IS 6313 (Part 3).

3.31.3.3 Treatment of Voids in masonry

The movement of termites through masonry walls may be arrested by drilling holes in the masonry walls, as laid down in clause 4.3.1.5 of IS 6313 (Part 3).

3.31.3.4 Treatment of points of contact of wood work

The work shall be done as per clause No 4.3.1.6 of IS 6313 (Part 3).

3.31.3.5 Treatment of Wood Work

The wood work which is slightly damaged and which do not need replacement shall be treated as per clause 4.3.2.2 of IS 6313 (Part 3).

3.31.3.6 Treatment of Electrical Fixtures

If infestation in Electrical fixture is noticed, the cover of switch boxes shall be removed and inside of such boxes shall be treated with chemical as per clause 4.3.3 of IS 6313 (Part 3).

SECTION 4
CONCRETE

4.1 Indian Standards

The following IS apply to this Section :

I. S. No.	*Subject*
383 - 1970	Specification for coarse and fine aggregates from natural sources for concrete (Second Revision)
455 -1989	Specification for Portland Slag Cement (Fourth Revision)
456 - 2000	Plain and Reinforced Concrete - Code of Practice (Third Revision)
516 - 1959	Method of test for Strength of concrete.
712 - 1984	Specification for Building Limes (Third Revision)
1199 - 1959	Method of Sampling and Analysis of Concrete.
1344 - 1981	Specification for Calcined Clay Pozzolana (Second Revision)
1489 - Part 1 - 1991	Specification for Portland Pozzolana Cement-Part 1: Flyash based (Third Revision)
1489: Part 2 - 1991	Portland Pozzolana Cement - Specifications - Part 2 : Calcined Clay Based (Third Revision)
2185 - Part 1 - 2005	Specification for Concrete Masonry Units - Part 1: Hollow and Solid Concrete Blocks (Third Revision)
2185 - Part 2 - 1983	Specification for Concrete Masonry Units - Part 2: Hollow and Solid Lightweight Concrete Blocks (First Revision)
2185 - Part 3 - 1984	Specification for Concrete Masonry Units - Part 3: Autoclave Cellular (Aerated) Concrete Blocks (First Revision)
2386 - Part 1 - 1963	Method of test for aggregates for concrete: Part 1 partice size and shape.
2645 - 2003	Specification for Integral Cement Waterproofing Compounds (Second Revision)
2686 - 1977	Specification for Cinder as fine Aggregate for use in Lime concrete (First Revision)
2911 - Part 4 - 1985	Code of practice for design and construction of pile foundation: Part 4 Load test on piles (First Revision)
3068 - 1986	Specification for Broken Brick (burnt clay) Coarse Aggregate for Use in Lime Concrete (Second Revision)
3812 - Part 1 - 2003	Pulverized Fuel Ash - Specification - Part 1 : For Use as Pozzolana in Cement, Cement Mortar and Concrete (Second Revision)
4031-Part 7 - 1988	Method of tests for hydraulic cement Part 7 Compressive Strength Test of masonary cement (First Revision)
4926 - 2003	Code of Practice for Ready Mixed Concrete (Second Revision)
6523 - 1983	Specification for Precast Reinforced Concrete Door and Window Frames (First Revision)
7861 - Part 1 - 1975	Code of Practice for Extreme Weather Concreting - Part I: Recommended Practice for Hot Weather Concreting
7861 - Part 2 - 1981	Code of Practice for Extreme Weather Concreting - Part II: Recommended Practice for Cold Weather Concreting
8112 - 1989	43 Grade Ordinary Portland Cement - Specifications (First Revision)

MATERIALS

4.2 Lime

Lime shall conform to IS 712 : 1984 Specifications for Building Limes. Class of lime shall be as indicated. Building Limes are classified as follows :-

Class A	-	Eminently hydraulic lime used for structural purposes.
Class B	-	Semi-hydraulic lime used in plastering, white washing etc. and with addition of pozzolonic material for masonry mortars.
Class C	-	Fat lime used for finishing coat in plastering, whitewashing etc. and with addition of pozzolonic material for masonry mortars.
Class D	-	Magnesium lime used for finishing coat in plastering whitewashing etc.
Class E	-	Kankar lime used for masonry mortars.
Class F	-	Silicons dolomatic lime used for under coat and finishing coat of plaster.

4.2.1 Lime for mortar in lime concrete shall be eminently hydraulic, where such a lime is not available, other limes as specified or approved by the GE, may be used after addition of burnt clay pozzolana.

4.2.2 Quick lime shall be supplied in the form of lumps and not as powder. Soon after delivery lump lime shall be separated from powder and all under burnt/over burnt lumps and the powder removed. Quick lime shall not be used directly in the work and shall invariably be slaked before use.

4.2.3 Hydrated lime shall be supplied in suitable containers such as jute bags lined with polythene etc. preferably containing 50 Kg of lime. The bags shall bear marking the class of lime, weight, date of manufacture and the brand name.

4.2.4 Lime shall be stored in weather proof sheds. All lime that shows signs of air slaking, setting, damage by water or moisture, admixture of foreign matter or any other impurities shall be rejected.

4.3 Cement

The cement used shall be of 43 grade Ordinary Portland cement conforming to IS 8112 : 1989 or Portland Pozzolana Cement, conforming to IS : 1489 - Part 1 : 1991 - Specification for Portland Pozzolana Cement, Part 1 Flyash based. Cement bags shall bear ISI certification mark and date of manufacture. Mixing of OPC and PPC shall not be allowed . However with the approval of GE, different buildings can have different type of cement.

4.3.1 Storage

Cement in bags shall be stored in dry waterproof sheds to protect the cement from dampness and to minimise warehouse deterioration. Cement shall be stored over wooden planks to be placed over a dry platform that preferably shall be at least 20 cm higher than ground level. The storing shall be done in a manner so as to prevent deterioration due to moisture or intrusion of foreign matter. The cement bags shall not be piled against the wall. A space of 60 cms all round shall be left between the walls and the piles. Bags shall be piled off the floor on wooden planks. Bags shall be kept close together in the pile to reduce circulation of air as much as possible and shall not be piled more than ten bags high to avoid lumping under pressure. The width of pile should not be more than about 3M. For extra safety during the monsoon the pile shall be completely enclosed by a waterproof membrane such as polythene, tarpaulin etc. Each consignment of the cement shall be stacked separately to permit easy access for inspection & facilitate removal. Cement shall be used in the order in which it is received. It shall be ensured that tested and untested cement are segregated and stored separately with distinct identification.

4.4 Aggregates from Natural Sources

4.4.1 Quality of Aggregates

Aggregates from natural sources shall consist of (crushed or uncrushed) stones, gravel and sand or combination thereof conforming to IS 383 : 1970 Specifications for coarse and fine aggregates from natural sources for concrete. They shall be hard, strong, dense, durable, clean and free from veins and adherent coatings and free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky and elongated pieces shall be avoided. Aggregates shall be obtained from approved sources as indicated.

4.4.2 Deleterious Materials

Aggregates shall not contain any harmful material, such as pyrites, coal, lignite, mica, shale or similar laminated material, clay, alkali, organic impurities, soft fragments, sea shells, etc., in such quantities as to affect the strength or durability of the concrete. Aggregates to be used for reinforced concrete shall not contain any material liable to attack the steel reinforcement. Aggregates which are chemically reactive with alkalies of cement shall not be used in cement concrete.

4.4.3 Limits of Deleterious Material

The maximum quantities of deleterious materials in the aggregates shall not exceed the limits laid down in IS 383 : 1970

4.4.3.1 If the quantities of deleterious materials in the aggregates exceed the limits mentioned above, the aggregates shall be washed in fresh and clean water to the satisfaction of Engineer-in-Charge before use.

4.4.3.2 Use of sea sand shall not be allowed for any description of mortar, plastering, precast concrete blocks or slabs, concrete above foundations, or in any location wherein its use is considered by the GE, as detrimental to strength, appearance, etc. In localities where sea sand is available and its use specified, adjustment, if any to rates, in SSR shall be clearly indicated. Rates in SSR are for use of other than sea sand.

4.4.4 Aggregate Crushing Value

The aggregate crushing value shall not exceed 45 percent for aggregates used for concrete other than for wearing surfaces and 30 percent for concrete for wearing surfaces such as runways,roads and pavements.

4.4.5 Aggregate Impact Value

As an alternative to aggregate crushing value, the aggregate impact value shall not exceed 45 percent by weight for aggregates used for concrete other than for wearing surfaces and 30 percent by weight for concrete for wearing surfaces such as runways, roads and pavements.

4.4.6 Aggregate Abrasion Value

The abrasion value of aggregate, using Los Angeles machine shall not exceed the following values :-

(a) For aggregates to be used in concrete for wearing surfaces - 30 percent
(b) For aggregates to be used in other concrete - 50 percent

4.4.7 Size and Grading of Aggregate

4.4.7.1 Graded Coarse Aggregate

Nominal size of graded stone aggregate or gravel shall be 40, 20 or 12.5 mm as specified. For any one of the nominal sizes, the proportion of other sizes is determined by the method prescribed in Appendix 'A' in accordance with following table :-

TABLE 1

IS Sieve Designation	Percentage passing for graded of nominal aggregate size		
	40 mm	20 mm	12.5 mm
1	2	3	4
80 mm	100	-	-
63 mm	-	-	-
40 mm	95-100	100	-
20 mm	30-70	95-100	100
12.5 mm	-	-	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

4.4.7.2 Fine Aggregate (Sand)

The grading of fine aggregate shall be within the limits given in the following table and shall be described as fine aggregate Grading Zone I,II,III & IV. Where the grading falls outside the limits of any particular grading zone of sieves other than 600 micron I.S. Sieve, by a total amount not exceeding 5 percent, it shall be regarded as falling within that Grading Zone. This tolerance shall not be applied to percentage passing the 600 micron I.S. Sieve or to percentage passing any other sieve size on the coarser limit of Grading Zone I or the finer limit of Grading Zone IV.

TABLE 2

IS Sieve Designation	Percentage passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
1	2	3	4	5
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Note 1 : For crushed stone sands the permissible limit on 150 micron I.S. Sieve shall be increased to 20 percent. This does not affect the 5 percent allowance, as already permitted, applicable to other sieve sizes.

Note 2 : Fine aggregate conforming to Grading Zone IV shall not be used in reinforced concrete, unless tests (which) shall be recorded have been made to ascertain the suitability of proposed mix proportions and prior written approval of GE for use of such fine aggregate is obtained.

4.4.7.3 All-in-Aggregate

Grading of all-in-aggregate shall be within the limits given in the following table :-

TABLE 3

IS Sieve Designation	Percentage passing for All-in-Aggregates of nominal size	
	40 mm	20 mm
1	2	3
80 mm	100	-
40 mm	95-100	100
20 mm	45-75	95-100
4.75 mm	25-45	35-50
600 micron	8-30	10-35
150 micron	0-6	0-6

Note : For carrying out tests on all-in-aggregates, the fractions passing through 4.75 mm IS Sieve and the fractions retained on 4.75 mm IS Sieve shall be first separated and these shall comply with the requirements (except grading) specified for fine aggregate and coarse aggregate respectively.

4.5 Broken Brick Coarse Aggregate

Broken brick coarse aggregate shall be prepared from well burnt or over burnt bricks and shall conform to IS 3068 : 1986 - Specification for Broken Brick (burnt clay) Coarse Aggregate for Use in Lime Concrete. It shall be free from under burnt particles and adherent coatings of soil or silt. Flaky or elongated pieces shall be avoided. The aggregate shall be free from dust which shall be removed by screening over 4.75 mm IS Sieve.

4.5.1 Brick aggregate shall not contain any harmful materials such as clay, unburnt or under burnt particle, alkali, soft fragments, organic impurities, etc. in such quantity as to affect adversely the strength and durability of concrete.

4.5.2 Aggregate impact value shall not exceed 50 percent. Water absorption for the aggregate after 24 hour immersion in cold water shall not exceed 25 percent. Water soluble matter shall not exceed 1 percent.

4.5.3 Brick aggregate shall be of grading as under :-

TABLE 4

IS Sieve Designation	Percent passing by weight
80 mm	100
40 mm	90-100
20 mm	45-75
4.75 mm	-

4.6 Cinder Aggregate for use in lime concrete

Cinder aggregate shall conform to IS 2686 : 1977 - Specification for Cinder Aggregates for Use in Lime Concrete. Cinder aggregate shall be class A of well burnt furnace residue obtained from furnaces using only coal as fuel. It shall be clean and free from clay, dirt, wood, ash or other deleterious matter. The content of sulphate shall not exceed one percent when expressed as sulphur tri-oxide.

4.6.1 Loss on Ignition

The percentage loss of mass on ignition shall not exceed 10 percent.

4.6.2 Grading

The average grading of cinder aggregate shall be as under :-

TABLE 5

IS Sieve Designation	Percent passing
10 mm	100
4.75 mm	80
2.36 mm	60
1.18 mm	40
600 micron	30
300 micron	25
150 micron	16

4.7 Burnt Clay Pozzolana (Surkhi)

Burnt clay pozzolana shall conform to IS 1344 : 1981 : Specification for Calcined Clay Pozzolana. It shall be made by calcinations of suitable clay and grinding the resulting product or by grinding well burnt or slightly under-burnt bricks to fineness as laid down as per requirement for grade II lime as per IS 1344 : 1981.

4.7.1 Surkhi shall be stacked on a hard surface so as to prevent admixture of clay, dust and other foreign matter. It shall also be protected from rain and dampness and kept under adequate covering.

4.8 Water Proofing Compound

Integral water proofing compound shall conform to the requirements of IS 2645: 2003 - Specification for Integral Cement Waterproofing Compounds.

4.9 Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalies, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. The PH value of water shall generally be not less than 6.

Note :- Potable water is generally considered satisfactory for mixing concrete.

4.9.1 Sea Water

Mixing and curing of concrete with sea water is not recommended because of presence of harmful salts in sea water. Where however indicated, sea water may be used for mixing or curing plain concrete or reinforced concrete in constructions which are permanently under sea water.

4.9.2 Water found satisfactory for mixing is also suitable for curing concrete. However, water used for curing should not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or iron compound is objectionable.

WORKMANSHIP

4.10 Lime Concrete

4.10.1 Preparation of Lime Mortars

(1) Lime mortar also includes mortars of lime and sand with the addition of pozzolana. Lime mortar mix shall be designated by the relative proportions of lime putty and sand (dry) or lime putty, sand (dry) and pozzolanic material where use of pozzolanic material is indicated. In case sand used is moist, necessary allowance shall be made for bulking.

(2) *Lime* :- Lime shall be supplied either in the form of factory-made dry hydrated lime powder or in the form of quick lime.

Slaking quicklime :- The lumps of quicklime for slaking shall be broken to size between 50 and 100 mm. Medium and slow slaking lime may be broken to size smaller than 50 mm for expeditious slaking. The slaking tank, shall first be cleaned for all unslaked stones of lime and other materials left over from previous slaking. The slaking of quicklime shall be preferably done continuously in higher tank and resultant milk of lime allowed to flow through a sieve into the lower tank where it will mature into putty. The tank shall be filled with water to a depth 25 to 30 cm. Quicklime shall be gradually added to water so as to cover the entire bottom of the tank to about half the depth of water. While quicklime is being added to water, it shall be constantly stirred so as to break up the lumps and aid the slaking process with minimum cooling of the mix. No part of the lime shall be allowed to get exposed above water. When the temperature of water reaches near boiling point, addition of lime and water be made in small quantities with constant stirring so as to maintain the required temperature. The operation shall be continued until the requisite quantity of lime has been slaked. In case of class A lime boiling water shall be added to achieve this. After the slaking is apparently over, stirring shall be continued for some more time to make sure that the whole of the lime has been fully slaked.

The slaked lime shall be allowed to stand undisturbed in the tank where only one tank is used or run into lower tank and allowed to mature into lime putty. The manufacturing period shall be not less than three days in the case of class C and E lime but not more than two days in case of class B, D and F lime and not more than one day in the case of class A lime. The putty obtained shall not be allowed to stiffen or dry till it is used.

(3) Mixing of Lime Mortars

(a) *Using Lime Putty* :-

Lime putty and sand in the specified proportions shall be mixed with or without the addition of water on a dry waterproof platform or in a mixer. The mix shall be fed into a mortar mill with the required addition of water. The mortar shall be raked continuously during grinding particularly in the angular edges of the mortar mill. Water may be added during grinding as required but care shall be taken not to add more water than to bring the material being mixed to the working consistency. The mixing shall be done till every particle of aggregate is coated uniformly with the cementous material.

For mixing lime pozzolana mortars, lime putty shall first be mixed with pozzolana in specified proportion and ground in the mortar mill with addition of required quantities of water. Sand shall then be added to the mix and the mixing and grinding repeated till every aggregate particle gets coated uniformly with the cementous material.

(b) *Using Dry Hydrated Lim*e :-

Where factory made dry hydrated lime conforming to IS 712-1984 is used, the grinding of the lime and sand in mortar mills is not necessary. In this case mixing of the ingredients shall be done preferably in mechanical mixer. For small jobs dry hydrated lime and sand in specified proportion shall be mixed dry first, on a water tight platform by hand mixing and then the mortar shall be hoed back and forth for 10 to 15 minutes with addition of required quantity of water. Similarly in the case of lime mortars made with pozzolana, the dry hydrated lime and pozzolana shall first be intermixed and then the procedure of mixing with sand and water shall be adopted as mentioned above. In case of mechanical mixing the mortar shall be mixed atleast three minutes after addition of water.

(4) *Time for Use of Lime Mortars*

Lime mortars shall be used as soon as possible. If eminently hydraulic lime (Class A) is used, the mortar shall be used within four hours after mixing or grinding in mortar mill. Lime mortars made with pozzolana are hydraulic and shall be used within 24 hours of mixing or grinding.

(5) *Precautions in the Use of Lime Mortars :-*

Prepared lime mortars shall be kept damp and shall not be allowed to go dry. Partly set or dried mortar shall not be re-tempered for use.

4.10.2 Preparation of Lime Concrete

Lime concrete shall be prepared by mixing 100 parts of 40 mm nominal size cinder stone or brick aggregates, as indicated with 40 parts of lime mortar of the specified mix. The proportioning of aggregates to mortar shall be done by volume. In case class B (semi hydraulic), class C (fat) or class D (magnesium) limes are used in lieu of class A lime (eminently hydraulic) for making lime concrete, fine aggregates shall consist of sand (dry) and pozzolonic material such as surkhi or cinder in the specified proportions.

(1) *Mixing* :-

For mixing small quantities of lime concrete, hand mixing or hand-operator mixer may be adopted, whereas for big jobs mechanical mixer may be employed.

(2) *Hand Mixing* :-

Mixing shall be done on a clean, water-tight platform. The coarse aggregate shall first be stacked to an even surface on the platform. The required quantity of ground lime mortar or when permitted by Engineer-in-Charge a dry mix of hydrated lime, sand and/or surkhi mixed by a shovel separately, shall be evenly spread over the coarse aggregate and the whole is thoroughly mixed. The required quantity of water shall be applied with a sprinkler over the top surface and mixing continued by turning it over several times, until all the particles of aggregates are covered with mortar and concrete of uniform appearance and consistency is obtained.

(3) *Machine Mixing* :-
Saturated, surface dry coarse aggregate shall first be fed into the mixer. The required quantities of ground lime mortar or where permitted by Engineer-in-Charge, a dry mix of hydrated lime, sand and surkhi, dry mixed by a shovel separately, shall then be added to the mixer. Part of water shall thereafter be added and the contents mixed. The remaining quantity of water shall then be finally added and the contents mixed well. The total time of mixing shall not be less than 2 minutes, and should be sufficient to ensure uniform mixing of required consistency.

(4) Only that much quantity of concrete shall be mixed which can be laid in position within two hours after mixing. The concrete shall preferably be placed in position immediately after mixing has been completed. Compaction of concrete shall be completed within four hours of adding water.

4.10.3 Laying Lime Concrete in Foundations and Under Floors

(1) The subgrade shall be properly wetted and rammed before concreting is started.

(2) The concrete shall be laid carefully in position (not thrown from a height) while quite fresh, in layers not exceeding 15 cm in thickness. Care shall be taken while placing the concrete that segregation of aggregate particles and mortar does not take place. Each layer shall be thoroughly rammed and consolidated before succeeding layer is placed. During laying and consolidation, concrete shall be kept free from mixing with leaves, straw, dirt and other deleterious matter.

(3) Heavy rammers shall be used and ramming continued until a skin of mortar completely covers the surface. Iron rammers shall weigh 4.50 to 5.50 Kg. Square rammers preferably be used for compaction of edges. Alternatively surface vibrators may be used. No water shall be added during ramming. Where joints in the same layer are unavoidable, the end of each layer shall be sloped at an angle of 30 and made rough to ensure proper bond with new concrete. The surface of each completed layer shall be watered, roughened and cleaned by wire brushing or any other suitable means before the next layer is laid over it. Where vertical joints occur in an upper and a lower layer they shall be atleast 600 mm apart horizontally.

(4) The mixing and ramming shall go on continuously, throughout the whole building. When this is not practicable, unfinished layers of concrete shall break joints as described.

(5) For large areas, where the thickness of the foundation concrete to be laid and compacted is 150 mm or more, a needle vibrator shall be used to compact the mass of concrete till wet mortar just appears at the top surface of the layer to be compacted.

4.10.4 Curing

After laying and compaction has been completed, lime concrete shall be cured for the first 48 hours by covering it with wet Hessian and for a further period of not less than 10 days by spreading wet sand or gunny bags and watering frequently in moderate quantities.

4.10.5 In case of lime concrete in foundation, no brick work shall be laid on concrete for a period of atleast seven days after laying or till such period the Engineer-in-Charge directs is necessary.

4.10.6 Lime Concrete in Haunches of Arches

The concrete of specified mix proportions shall be laid to the required thickness and level in layers not exceeding 100 mm in thickness. Compaction and ramming shall be continued till wet mortar just appears at the top surface of the layer to be consolidated. The surface shall be continuously cured for not less than 21 days in the manner specified for lime concrete in foundations.

4.11 Plain and Reinforced Cement Concrete

4.11.1 Cement Concrete

Cement concrete shall be of the specified grade or volumetric mix, as indicated. Cement concrete and reinforced cement concrete shall be provided in accordance with IS: 456-2000, Code of Practice for Plain and Reinforced Concrete, except otherwise stated.

TABLE 6
GRADES OF CONCRETE

Group	Grade Designation	Specified Characteristic Compressive Strength of 150 mm Cube at 28 days in N/mm^2
1	2	3
Ordinary Concrete	M10	10
	M15	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
High Strength	M60	60
Concrete	M65	65
	M70	70
	M75	75
	M80	80

4.11.2 Concrete Mix Proportioning

Where concrete is specified by its grade, i.e. characteristic strength, determination of proportions of cement, aggregates and water to attain the required strength shall be made by designing the concrete mix (Design Mix concrete) or by adopting a nominal concrete mix (Nominal Mix concrete), as indicated.

TABLE 7
MINIMUM CEMENT CONTENT, MAXIMUM WATER-CEMENT RATIO AND MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH NORMAL WEIGHT AGGREGATES OF 20 MM NOMINAL SIZE

SI No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content Kg/m^3	Maximum Free Water Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content Kg/m^3	Maximum Free Water Cement Ratio	Minimum Grade of Concrete
1	2	3	4	5	6	7	8
(i)	Mild	220	0.60	-	300	0.55	M20
(ii)	Moderate	240	0.60	M15	300	0.50	M25
(iii)	Severe	250	0.50	M20	320	0.45	M30
(iv)	Very Severe	260	0.45	M20	340	0.45	M35
(v)	Extreme	280	0.40	M25	360	0.40	M40

Notes :-

(i) Cement content prescribed in this table is irrespective of the grade of cement. The additions such as fly ash or ground blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolana and slag specified in IS : 1489 (Part 1) and IS : 455 respectively.

(ii) Minimum grade for plain concrete under mild exposure condition is not specified,

(iii) The above minimum cement content and maximum water cement ratio apply only to 20 mm nominal maximum size aggregate. For other sizes of aggregate, these should be changed as per Table 6 of IS : 456 : 2000.

4.11.2.1 Design Mix concrete

Where indicated the design mix concrete shall be procured from the ready mix plants conforming to the requirements of IS : 4926 : 2003 - Specification for Ready Mixed Concrete (Second Revision).

Otherwise the concrete mix shall be designed from the institution as indicated to produce the grade of concrete having the required workability and the characteristic strength not less than that specified.

4.11.2.2.1 Ready Mix Concrete

The ready mix concrete shall be of grade as indicated and shall be procured only from the ready mix concrete plants as indicated.

1. Supply and Placing of Ready Mix Concrete

(i) Responsibility of in-place quality of ready-mix concrete shall be ensured by contractor.

(ii) The contractor shall give in writing his requirement of a particular batch of concrete to the supplier.

(iii) The ready-mix concrete manufacturer/supplier shall, along with each batch of concrete delivered to the contractor, give him a concrete delivery ticket. The supplier shall give copies of all such delivery tickets to the Engineer-in-Charge for his record and also shall get duplicate copies of all such delivery tickets duly received and signed from the contractor.

(iv) Ready mix concrete as supplied by the manufacturer and as placed by the contractor shall in no way be different from the specifications of concrete as approved by the Engineer-in-Charge.

2. Transportation

Fresh concrete can be transported to the placement area by any of the methods as indicated below.

(a) Mixer trucks

(b) Stationery truck bodies with or without agitators.

(c) Buckets hauled by trucks.

3. Cleaning

Before loading concrete in either truck mixer, open bodied trucks or buckets, the containers shall be thoroughly cleaned, washed and dried, so that there is no water or moisture in the container which may effect the designed water content of the concrete.

4. Placing Concrete by Pumping Methods

(i) Concrete conveyed by pressure through either rigid pipes or flexible hoses and discharged directly into the desired area is termed as pumped concrete.
(ii) Method of applying pressure to concrete is by pumps. Pumps to be used shall be either of the two types as mentioned below :-
   (a) Piston type pumps
   (b) Squeeze pressure type pumps

Compressed air pressure pumps shall not be used in the works.

4.11.2.2 Nominal Mix Concrete

Nominal mix concrete may be used for concrete of grades M 5, M 7.5, M 10 and M 15. The proportions for nominal mix concrete shall be as given below :-

TABLE 8

Grade of concrete	Total quantity of dry aggregates by mass per 50 Kg of cement, to be taken as the sum of the individual masses of fine and coarse aggregates (Maximum). Kg	Proportion of fine aggregate to coarse aggregate (by mass)	Quantity of water per 50 Kg of cement (Maximum)
1	2	3	4
			Litre
M5	800	Generally 1 :2	60
M7.5	625	but subject to	45
M10	480	an upper limit	34
M15	350	of 1:1-1/2 and a lower limit of 1:2.1/2	32

Notes :

1. The proportion of the fine aggregate to coarse aggregate should be adjusted from the upper limit to lower limit progressively as the grading of the fine aggregate becomes finer and the maximum size of coarse aggregate becomes larger. Graded coarse aggregates shall be used.
2. In the case of vibrated concrete the limit of water cement ratio may be reduced.
3. The quantity of water used in the concrete mix for RCC work should be sufficient, but not more than sufficient, to produce a dense concrete of adequate workability for its purpose, which will surround and properly grip all the reinforcement. Workability of concrete should be controlled by maintaining a water cement ratio that is found to give a concrete which is just sufficiently wet to be placed and compacted without difficulty with the means available.

4.11.2.3 If nominal mix concrete made in accordance with the proportions given for a particular grade does not yield the specified strength, such concrete shall be classified as belonging to the appropriate lower grade. Nominal mix concrete proportioned for a given grade shall not, however, be placed in higher grade on the ground that the test strengths are higher than the minimum specified.

4.11.2.4 Volumetric Mix Concrete

For volumetric mix concrete, the proportions of cement and aggregates are defined by bulk. Volumetric mix shall be designated as 1:2:4, 1:3:6 etc. ; the figures denote the relative proportions of cement, fine-aggregate in dry condition and graded coarse aggregate respectively. If fine aggregate is moist, necessary allowance shall be made for bulking. To determine bulk, 50 Kg of cement shall be taken as equal to 0.035 Cum. Quantities of fine and coarse aggregates shall be determined by volume separately and accurately in proper gauge boxes. The gauge boxes shall be of such dimensions that 50 Kg of cement forms a unit. The equivalent size of a box for 50 Kg cement bag will measure 45 x 35 x 25 cm internally. Consolidations of aggregates in the gauge boxes by ramming or shaking shall not be allowed.

4.11.3 Batching

In proportioning design mix concrete, the quantity of both cement and aggregates shall be determined by weight. Water shall be either measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean serviceable condition and their accuracy periodically checked.

4.11.3.1 In case uniformity in the materials used for concrete making has been established or where weigh-batching is not practicable, the proportioning may be done, if so permitted by the GE, in writing by volumetric batching, provided periodic checks are made on weight/volume relationships of the materials.

4.11.3.2 The material shall be stock piled for several hours, preferably a day before use. The grading of coarse and fine aggregates shall be checked as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge to ensure that the specified grading is maintained.

4.11.3.3 Where the aggregates supplied are not graded, different sizes shall be blended in right proportions; the different sizes being stacked in separate stock piles.

4.11.3.4 Water cement ratio shall be maintained at its correct value.

4.11.3.5 No substitutions in the materials used on the work or alterations in the established proportions except as permitted in 4.11.3.1 shall be made without additional test to show that the quality and strength of concrete are satisfactory.

4.11.4 Workability of concrete

The concrete shall be of adequate workability for the placing condition of the concrete and proper compactions with the means available. Suggested ranges of values of workability of concrete for some placing conditions, measured in accordance with IS 1199-1959, are given below :-

TABLE 9

Placing conditions	Degree of workability	Values of Workability
1	2	3
Concreting of shallow sections with vibration	Very low	20-10 seconds vee-bee time OR 0.75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10-5 seconds vee-bee time OR 0.80-0.85 compacting factor
Concreting of lightly reinforced sections without vibration, or heavily reinforced section with vibration	Medium	5-2 seconds vee-bee time OR 0.85-0.92 compacting factor OR 6-25 mm slump for 12.5 mm aggregate OR 25-75 mm slump for 20 mm aggregate
Concreting of heavily reinforced section without vibration	High	Above 0.92 compacting factor OR 75-125 mm slump for 20 mm aggregate

4.11.5 Mixing

Concrete shall be mixed in a mechanical mixer. The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete shall be re-mixed. The mixing time may be taken as 1-1/2 to 2 minutes.

4.11.5.1 In exceptional circumstances such as work in remote areas or when the quantity of concrete work is very small, hand mixing may be permitted by the Engineer-in-Charge subject to adding of 10 percent extra cement. When hand mixing is permitted, it shall be done on a clean water tight platform and care shall be taken to ensure that mixing is continued until the concrete is uniform in colour and consistency.

4.11.6 Form Work

4.11.6.1 General

The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings. All forms shall be sufficiently watertight to prevent leakage of mortar. Forms shall be so constructed as to be removable in sections. One side of column forms shall be left open and the open side filled in board by board successively as the concrete is placed and compacted except when vibrators are used. Formwork shall be provided as specified in Section 7- Woodwork.

4.11.6.2 Cleaning and Treatment of Forms

All rubbish particularly chippings, shavings and sawdust shall be removed from the interior of the forms before the concrete is placed. The formwork in contact with the concrete shall be cleaned and thoroughly wetted or treated with an approved composition to prevent adhesion between formwork and concrete. Care shall be taken that such approved composition is kept out of contact with the reinforcement.

4.11.6.3 Stripping Time

Forms shall not be struck until the concrete has attained a strength at least twice the stress to which the concrete may be subjected at the time of removal of formwork. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing of the work. Where so required formwork shall be left longer. In normal circumstances and where ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods: For other cement stripping time shall be as indicated

TABLE 10

(a)	Walls, columns and vertical faces of all structural members	2 days
(b)	Slabs (props left under)	3 days
(c)	Beam soffits (props left under)	7 days
(d)	Removal of props under slabs (1) Spanning upto 4.5 m (2) Spanning over 4.5 m	 7 days 14 days
(d)	Removal of props under beams and arches (1) Spanning upto 6 m (2) Spanning over 6 m	 14 days 21 days

In case of bad weather these periods may be increased at the discretion of Engineer-in-Charge.

The number of props left under, their sizes and deposition shall be such as to be able to safely carry full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

4.11.6.4 Removal of Formwork

Formwork shall be removed in such a manner as would not cause any shock or vibration that would damage the concrete. Before removal of soffits and props concrete surface shall be exposed to ascertain that the concrete has sufficiently hardened.

4.11.6.5 Where the shape of the element is such that formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

4.11.7 Assembly of Reinforcement

Reinforcement shall be bent and fixed as specified in Section 10-Steel and Iron work. All reinforcement shall be placed and maintained in the position shown in the drawings during concreting. Crossing bars shall not be tack welded for assembly of reinforcement, unless otherwise indicated.

4.11.7.1 Tolerance on Placing of Reinforcement

Unless otherwise directed, reinforcement shall be placed within the following tolerance :-

(a) For effective depth 200 mm or less +10 mm

(b) For effective depth more than 200 mm +15 mm

The cover shall in no case be reduced by more than one third of the specified cover or 5 mm, whichever is less.

4.11.7.2 Welded Joints or Mechanical Connectors

Welded joints in reinforcement may be used where indicated/directed but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of the bars connected.

4.11.8 Cover to Reinforcement

4.11.8.1 Reinforcement shall have concrete cover and the thickness of such cover (exclusive of plaster or other decorative finish) shall be as follows, unless otherwise indicated:

(a) At each end of reinforcing bar, not less than 25 mm or less than twice the diameter of such bar.
(b) For a longitudinal reinforcing bar in a column, not less than 40 mm nor less than the diameter of such bar. In the case of columns of minimum dimension of 200 mm or under, whose reinforcing bars do not exceed 12 mm, a cover of 25 mm may be used.
(c) For longitudinal reinforcing bar in a beam, not less than 25 mm nor less than the diameter of such bar.
(d) For tensile, compressive, shear, or other reinforcement in a slab, not less than 15 mm nor less than the diameter of such bar; and
(e) For any other reinforcement, not less than 15 mm nor less than the diameter of such bar.

4.11.8.2 Increased cover thickness may be provided when surfaces of concrete members are exposed to the action of harmful chemicals, acid vapour, saline atmosphere, sulphurous smoke etc., and such increase of cover may be between 15 mm and 50 mm beyond that specified in 4.11.8.1 as indicated.

4.11.8.3 For reinforced concrete members, totally immersed in sea water, the cover shall be 40 mm more than that specified and for members, periodically immersed in sea water, the cover of concrete shall be 50 mm more than that specified in 4.11.8.1.

4.11.8.4 In all cases the cover shall not exceed 75 mm.

4.11.9 Transporting

Concrete shall be transported from the mixer to the formwork as rapidly as possible by methods which will prevent the segregation or loss of any of the ingredients and maintaining the required workability. During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted.

4.11.10 Placing

The concrete shall be deposited as nearly as possible in its final position to avoid re-handling. The concrete shall be placed and compacted before setting commences and should not be subsequently disturbed. Methods of placing should be such as to preclude segregation. Care shall be taken to avoid displacement of reinforcement or movement of formwork. The concrete which is deposited or otherwise disturbed after initial set commences shall be immediately removed from the site.

4.11.10.1 Before placing the concrete in trenches or on sub-grade or sub base, the sub-grade/ sub base shall be cleaned of all injurious or foreign matter, watered and well consolidated, if necessary.

4.11.10.2 The final layer of concrete shall be laid to such levels and falls as may be directed.

4.11.10.3 When concrete has to be removed to any depth below 1.5 m, it shall be conveyed in suitable receptacles or by chute. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly finished with water before and after each working period, the water for this purpose shall be discharged outside the formwork.

4.11.11 Compaction

Concrete shall be thoroughly compacted and fully worked around the reinforcement, around embedded fixtures and into the corners of the formwork. Mechanical vibrators shall preferably be employed for compacting concrete except where rodding and tamping is permitted by Engineer-in-Charge. Over vibration or vibration of very wet mixes is harmful and shall be avoided; under vibration is also harmful.

4.11.11.1 Where vibration is to be applied externally, the design of formwork and the deposition of vibrators shall be such as to ensure compaction and to avoid surface blemished.

4.11.12 Construction Joints

Concreting shall be carried out continuously upto the construction joints the position and arrangement of which shall be as indicated or directed.

4.11.12.1 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted. For vertical joints neat cement slurry at the rate of 2.50 Kg of cement per Sqm shall be applied on the surface before it is dry. For horizontal joints surface shall be covered with a layer of mortar about 10 to 15 mm thick composed of cement and sand mortar in the same ratio as the cement and sand in the concrete mix. The layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing of concrete.

4.11.12.2 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, a layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against old work; particular attention being paid to corners and close spots; work thereafter shall proceed in the normal way.

4.11.13 Curing

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by covering with layer of sacking, canvas, Hessian or similar materials or a layer of sand or by ponding for at least seven days from the date of placing of concrete. Approved curing compounds may be used in lieu of moist curing with the permission of Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

4.11.14 Protection

The concrete shall be carefully protected after it is laid against the action of frost and shielded from exposure to sun to avoid rapid drying. Care shall be taken to protect the concrete from all shaking and other disturbances during construction. No traffic shall be allowed on the finished concrete surface for at least 7 days. This period may be increased or decreased at the discretion of Engineer-in-Charge.

4.11.15 Inspection

Immediately after stripping the formwork, all concrete shall be carefully inspected for any defective work and defects either removed or made good before the concrete has thoroughly hardened.

4.11.16 Exposed Surfaces

4.11.16.1 The contractor shall use proper formwork so that the concrete in contact with forms on removal of formwork presents an even surface. Concrete while being poured against formwork shall be adequately tamped, or vibrated where directed, so that fines are drawn towards the surface and honey combing is avoided.

4.11.16.2 Exposed surfaces of concrete shall be finished in any of the following manner as indicated :-

(a) Concrete Finished Fair and Even in Forms
Exposed surfaces after striking off formwork shall be such as to present a fair and even surface and shall not be plastered. The surface shall be presentable without any further treatment. Any irregularities and protruding formwork marks shall be removed and minor honeycombing made good with cement and sand mortar 1:3. Lines along the formwork joints may however show.

(b) Concrete Finished Fair and Even by Plastering
Exposed surfaces of concrete after striking off formwork shall be plastered with cement and sand mortar 1:3, 5mm thick and finished fair and even.

(c) Upper surfaces of concrete floor slabs, roof slabs, chajjas, cantilevers etc. shall be formed to such levels and falls as indicated and shall be finished with a wooden float to an even surface to receive further treatment or with a steel trowel to an even and smooth surface, where no further treatment is indicated.

(d) Upper surfaces of concrete cills, copings and similar items shall be worked up with a steel trowel to an even and smooth surface.

(e) Concrete surfaces of columns, beams, bands and similar items in a wall face shall be plastered along with wall face where the wall face is indicated to be plastered.

4.11.16.3 Exposed surfaces of concrete which are indicated/required to be plastered shall be roughened with wire brushes and hacked out closely immediately after removal of formwork.

4.11.17 Sampling and Testing of Concrete

4.11.17.1 Samples from fresh concrete shall be taken as per IS 1199-1959. Method of sampling of concrete and cubes shall be made, cured and tested at 28 days in accordance with IS 516-1959, Method of test for strength of concrete.

Note :- For relatively small and unimportant building or structure in which quantity of concrete is less than 15 cum, the strength test may be waived. The GE's decision as to whether building or structures are relatively small and unimportant or not, shall be final and binding.

4.11.17.2 Where indicated, tests on beams for modulus of rupture at 72 + 2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength test for a quicker idea of the quality of concrete. In all cases the 28 days compressive strength alone shall be the criterion for acceptance or rejection of the concrete.

4.11.17.3 Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for such purpose as to determine the strength of concrete at 7 days or to check the testing error.

4.11.17.4 Test Strength of Samples

The test strength of the sample shall be the average of the strength of three specimen. The individual variation shall not be more than +15 percent of the average.

4.11.17.5 Acceptance Criteria

(i) Compressive strength

The concrete shall be deemed to comply with the strength requirements when both the following conditions are met :-

(a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in Col 2 of Table 11

(b) Any individual test result complies with the appropriate limits of Col 3 of Table 11.

(ii) Flexural Strength

When both the following conditions are met, the concrete complies with the specified flexural strength.

(a) The mean strength determined from any group of four consecutive test results exceeds the specified characteristic strength by at least 0.3 N/mm^2.

(b) The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2.

TABLE 11

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm^2	Individual Test Results in N/mm^2
1	2	3
M15	> f_{ck} + 0.825 x established standard deviation (rounded off to nearest 0.5) N/mm^2 or f_{ck} + 3 N/mm^2 whichever is greater	> f_{ck} - 3 N/mm^2
M 20 or above	> f_{ck} + 0.825 x established standard deviation (rounded off to nearest 0.5) N/mm^2 or f_{ck} + 4 N/mm^2 whichever is greater	> fck - 4 N/mm^2

Note :- In the absence of established value of standard deviation, the value of standard deviation of 3.5 for M10 & M15 concrete, 4.0 for M20 & M25 concrete and 5.0 for M30 to M50 concrete respectively may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation

(iii) Quantity of Concrete Represented by Strength Test Results

(a) The quantity of concrete represented by a group of four consecutive test results shall include the batches from which the first and last samples were taken together with all intervening batches.

(b) For the individual test result requirements given in Col 2 of Table 11 or in item (b) of (i) above, only the particular batch from which the sample was taken shall be at risk.

(c) Where the mean rate of sampling is not specified, the maximum quantity of concrete that four consecutive test results represent shall be limited to 60 m3

4.12 Waterproof Concrete

Where indicated, cement concrete shall be waterproofed by adding integral water proofing compound conforming to IS 2645-2003 : Specification for Integral Waterproofing compounds at the time of making concrete as per the manufacturer instructions. The quantity of waterproofing compound shall be as indicated but in no case be less than the quantity recommended by the manufacturers and not exceeding 3 percent by weight of cement.

4.13 Cast in situ Shell Roofing

4.13.1 Edge members and end frames shall be concreted before the casting of shell. Full thickness of shell shall be concreted in one operation. The position of construction joints shall be as indicated.

4.13.2 Concreting may be done in panels of convenient dimensions and shape. In case of singly curved shells, the panels shall be laid parallel to the curved edge; each panel shall be started at the lowest level and worked upwards, In case of doubly curved shells, the arrangement of panels shall be as indicated. Concrete shall be finished to the correct curve as set by template. This may be done with continuously or by alternate method. Thickness of shell shall be regulated using templates of corresponding thickness. The thickness of shell shall also be accurately checked at typical points in between the thickness guides/templates.

4.13.3 Impression vibrators shall be restricted to edge members except in the case of thickened portion of shell, where the depth is sufficient to accommodate these vibrators.

4.13.4 Proper arrangements shall be made to avoid displacement of steel during placing of concrete by providing walkways above the level of finished concrete and supported so as to avoid disturbance of the reinforcement.

4.13.5 Construction Joints

Construction joints shall invariably be along the curve. They shall preferably be located along a line of zero shear stress, as for example, along the directrix at mid-span. The construction joints shall be finished in such a way that new concrete will effectively bond with the old. When the work is commenced the next day, the joints shall be cleaned with wire brushes and slushed with cement slurry. The surface of the concrete shall be finished with wooden floats. The proportions of the shell that are already cast shall be effectively protected from exposure to sudden rains by means of tarpaulins and similar coverings.

4.13.6 Curing

As soon as the concrete has sufficiently hardened to prevent damage to it, it shall be wet cured for period of at least 10 days.

4.13.7 Removal of Forms

The process of de-centering shall be gradual and without shock. The de-centering procedure to be actually adopted shall be subject to the designers approval. Generally the centering of shell may be removed at the end of 14 days and de-centering the bottom shuttering of edge members and the end frames may be done at the end of 21 days. By casting the latter a week in advance of shell, it will be possible to strike the centering of the shell, the edge members and the end frames on the same day.

4.14 Grouting under Stanchion Bases, Grillages, etc.

Grouting under stanchion bases, grillages etc., shall be done with cement mortar grout not leaner than cement mortar 1:2, mixed to dry or fluid consistency as directed. The mortar shall be poured to completely fill the space below the stanchion base or grillage.

4.15 Holes, Chases, Mortices etc.

Every endeavour shall be made to avoid the necessity of cutting away any concrete work after it has been cast. Wood fillets, plugs, iron sleeves etc., shall be placed in position in the formwork before the concrete is cast to form all necessary chases, mortice holes, and holes for pipes etc.

4.16 Work in Extreme Weather Conditions

Concreting during hot or cold weather shall be done as per the procedures set out in IS:7861 (Part I)-1975 : Code of practice for extreme weather concreting; Part I Recommended practice for hot weather concreting, or IS 7861 (Part II)-1981 : Code of practice for extreme weather concreting; Part II Recommended practice for cold weather concreting.

4.16.1 Hot weather concreting

Any operation of concreting done at atmospheric temperature above 40°C or any operation of concreting where temperature of concrete at the time of its placement is expected to be beyond 40°C shall be termed as hot weather concreting. Some of the procedures and precautions for concreting during hot weather given in IS-7861 (Part I) are as follows :-

(a) Temperature of aggregates, water and cement shall be maintained at the lowest practical levels so that the temperature of the concrete is below 40°C at the time of placement.

(b) Cement hydration, temperature, loss of workability and loss of entrained air increase with passage of time after mixing. Thus the period between mixing and delivery shall be kept to an absolute minimum. Delivery of concrete shall be coordinated with the rate of placement to avoid delay in delivery.

(c) Placing and finishing :- Forms, reinforcement and subgrade shall be sprinkled with cool water just prior to placement of concrete. The area around the work shall be kept wet to the extent possible to cool the surrounding air and increase its humidity, thereby reducing temperature rise and evaporation from the concrete. When temperature conditions are critical, concrete placement may be restricted to evenings when temperatures are lower and evaporation is less.

(d) Concrete shall be placed inlayers thin enough and in areas small enough so that the time interval between consecutive placements is reduced and vibration or other working of the concrete will ensure complete union of adjacent portions. If cold joints tend to form or if surfaces set and dry too rapidly or if plastic shrinkage cracks tend to appear, the concrete shall be kept moist by means of frog sprays wet burlap, cotton mats, or other means. Fog sprays, applied shortly after placement and before finishing, have been found to be particularly effective in preventing plastic shrinkage cracks when other means have failed.

(e) All placement procedures shall be directed to keep the concrete as cool as practicable and to ensure its setting and hardening under temperature conditions which are reasonably uniform and under moisture conditions which will minimize drying. Concrete shall reach the forms at temperature not higher than 40^0C.

(f) Protection and Curing :- Immediately after consolidation and surface finish, concrete shall be protected from evaporation of moisture without letting ingress of external water, by means of wet (not dripping) gunny bags, Hessian cloth, etc. Once the concrete has attained some degree of hardening sufficient to withstand surface damage (approximately 12 hours after mixing), concrete shall be wet cured for periods not less than 10 days. Continuous curing is important because volume changes due to alternate wetting and drying promote the development of surface cracking.

(g) Wind breakers shall be provided as far as possible.

4.16.2 Cold Weather Concreting

Any operation of concreting done at atmospheric temperatures below 5°C or any operation of concreting where the temperature of concrete at the time of its placement is expected to be below 5°C shall be termed as cold weather concreting. Some of the procedures and precautions recommended as given in IS:7861 (Part II) for concreting during cold weather are as follows :-

(a) At low temperature i.e. when the temperature is below 5°C but does not fall below freezing point :-
   (1) The formwork shall be kept in position longer or use rapid hardening cement.
   (2) Top of the concrete shall be covered with insulating material.
   (3) If steel formwork is used, it shall be insulated.
   (4) Concrete shall be delivered to the point of placing at not less than 5°C.

(b) When frost occurs at night only and is not severe :-
   In addition to the above precautions, following precautions shall be taken :-
   (1) All formwork shall be insulated.
   (2) Concrete shall not be placed against a frozen subgrade or against reinforcement or forms covered with snow or ice.
   (3) Concrete shall be placed quickly and insulated.

(c) When there is severe frost day and night :-
   In addition to the above precautions, following precautions shall be taken :-
   (1) Water and, if necessary, the aggregates shall be heated.
   (2) Concrete shall be delivered to the point of placing at not less than 10^0C placed quickly and insulated, or concrete delivered to the point of placing at not less than 5°C placed quickly and continuous heating provided to the concrete.

(d) Heating of aggregates shall be such that frozen lumps, ice and snow are eliminated and over-heating avoided. At no point shall the aggregate temperature exceed 100^0C; the average temperature of aggregate for an individual batch shall not exceed 65^0C. The heating of aggregates to temperature higher than 15^0C is rarely necessary with mixing water at 60^0C .

   If the coarse aggregate is dry and free of frost and ice lumps, adequate temperature of fresh concrete can be obtained by increasing the temperature of only the sand, which will seldom have to be higher than about 40^0C, if temperature of mixing water is 60^0C.

(e) Water having temperature upto boiling point may be used provided the aggregate is cold enough to reduce the temperature of the mixing water and aggregate to appreciably less than 38^0C . This temperature should not normally exceed 25^0C.

   To avoid the possibility of the flash set when either water or aggregate is heated to a temperature in excess of 40^0C, water and aggregate shall be mixed together in the mixer in such a way that the high temperature of one or the other is reduced before cement is added. The heated water shall come into direct contact with aggregate first and not in contact with cement.

(f) Use of Admixtures :- Admixtures or accelerators shall not normally be used to lower the freezing point of concrete.

(g) Before any concrete is placed, all ice, snow and frost shall be completely removed and the temperature of all surfaces to be in contact with new concrete shall be raised to as close as may be practical to the temperature of fresh concrete that is to be placed thereon.

(h) Protection :- During cold weather, all concrete surfaces shall be covered as soon as the concrete has been placed, to keep the heat in and prevent freezing. Clean straw blankets about 50 mm thick, sacking tarpaulins, expanded polystyrene, plastic sheeting and waterproof paper can all be used in conjunction with air gap as an insulation.

(j) During placement of concrete, tarpaulin or other readily movable coverings supported on frame work shall follow closely the placing of concrete, so that only a small length of finished slab are exposed to outside air at any time.

(k) Curing :- During periods of freezing or near freezing conditions, water curing is not necessary. When protective measures are to be discontinued, the surface temperature of the concrete shall be gradually adjusted to the air temperature.

(l) Removal of Forms :- Recommended minimum time in days for stripping formwork to normal structural concrete using Ordinary Portland Cement are given below :-

TABLE 12

Structural Member	Cold weather air temperature about 3°C	Normal weather air temperature about 16°C
Beam sides, walls and columns	5	1
Slabs (Props left under)	7	3.5
Beams (Props left under)	14	7
Removal of props to slabs	14	7
Removal of props to beams	28	14

(m) Removal of forms using Rapid hardening Portland Cement are as under :-

TABLE 13

Structural Member	Cold weather air temperature about 3°C	Normal weather air temperature about 16°C
Beam sides, walls and columns	3	1
Slabs (Props left under)	4	2
Beams (Props left under)	8	4
Removal of props to slabs	8	4
Removal of props to beams	16	8

4.16.3 Record

During cold and hot weather concreting a record of date, time, outside air temperature, temperature of concrete at the time of placing, general weather conditions (calm, windy, clear, cloudy etc.) and relative humidity shall be maintained. The record shall include temperature at several points on the concrete surface, corners and edges in sufficient number to show highest and lowest temperatures of the concrete. To control the hardening process it is necessary to measure the temperature of concrete at placing, at the time of applying the protection and three times each day until resistance to freezing has been obtained. The temperature shall also be taken of the parts of concrete where stress will appear on removal of forms.

4.17 Under-water Concreting

4.17.1 When it is necessary to deposit concrete under water, the methods, equipment, materials and proportions of the mix to be used shall be submitted to and approved by the GE, in writing, before the work is started. In no case shall such concrete be considered as “Design Mix Concrete”.

4.17.2 The concrete shall contain at least 10 percent more cement than that required for the same mix placed in the dry condition, the quantity of extra cement, varying with conditions of placing, shall be specially ordered in writing by the GE. The volume or mass of the coarse aggregate shall be not less than one and half times not more than twice that of the fine aggregate. The materials shall be so proportioned as to produce a concrete having a slump of not less than 100 mm, and not more than 180 mm.

4.17.3 Forms or coffer-dams shall be sufficiently tight to ensure still water if practicable, and in any case to reduce the flow of water to less than 3 m per min through the space into which concrete is to be deposited. Forms or coffer-dams in still water shall be sufficiently tight to prevent loss of mortar through the walls. Dewatering by pumping shall not be done while concrete is being placed or until 24 hours thereafter.

4.17.4 Concrete shall be deposited continuously until it is brought to the required height. While depositing, the top surface shall be kept as nearly level as possible and the formation seams avoided. The concrete may be laid by tremie; drop bottom bucket, etc., as approved by Engineer-in-Charge.

4.17.5 To minimize the formation of laitance great care shall be exercised not to disturb the concrete as far as possible, while it is being deposited.

4.18 Concreting in Sea Water

4.18.1 Concrete in sea-water or exposed directly along the sea-coast shall be atleast M 15 grade in the case of plain concrete and M 20 in case of reinforced concrete. Use of slag or pozzolana cement is advantageous under such conditions. Special attention shall be given to the design of mix to obtain the densest possible concrete; slag, broken brick, soft limestone, soft sandstone, or other porous or weak aggregates shall not be used.

4.18.2 Precast concrete members shall be well-cured and hardened, without sharp corners, and shall have trowel-smooth finished surfaces free from crazing, cracks or other defects, plastering should be avoided.

4.18.3 Construction joints shall be provided only where indicated. No construction joints shall be allowed within 600 mm below low water-level or within 600 mm of the upper and lower planes of wave action.

4.18.4 In reinforced concrete structures, care shall be taken to protect the reinforcement from exposure to saline atmosphere during storage and fabrication.

4.19 Concreting in Aggressive Soils and Water

To minimize the chances of deterioration of concrete from harmful chemical salts, the level of such harmful salts in concrete coming from the concrete materials, that is cement, aggregates, water and admixtures, as well as by diffusion from the environment should be limited. Generally the total amount of chlorides (as Cl) and the total amount of soluble sulphates (as SO) in the concrete at the time of placing should be limited to 0.15 percent and 4 percent by weight of cement respectively.

4.20 Precast Reinforced Concrete-Generally

4.20.1 Precast reinforced concrete articles such as columns, fencing posts, door and window frames, lintels, chajjas, copings, cills, shelves, slabs, louvers, etc. shall be of the grade or mix as indicated and cast in forms or moulds. The forms shall be of timber or of steel for better finish. Provision shall be made in the forms and moulds to accommodate fixing devices such as nibs, clips, hooks, bolts and forming of notches and holes. The contractor may precast the units on a cement or steel platform which shall be adequately oiled provided the surface is of the same standard as obtained in the forms. Each unit shall be cast in one operation.

4.20.2 Concrete shall be proportioned, mixed, placed and thoroughly compacted by vibration or tamping to give a dense concrete free from voids and honeycombing.

4.20.3 Precast articles shall have a dense surface finish showing no coarse aggregate and shall have no cracks or crevices likely to assist in disintegration of concrete or rusting of steel or other defects that would interfere with the proper placing of the units or to impair the strength or the performance of construction. All angles of the precast units with the exception of the angles resulting from the splayed or the chamfered faces shall be true right angles. The arises shall be clean and sharp except those specified or shown to be rounded. The wearing surface shall be true and out of winding. On being fractured, the interior of the units shall present a clean, homogeneous appearance.

4.20.4 The longitudinal reinforcement shall have a minimum cover of 12 mm or twice the diameter of the main bar, whichever is more, unless otherwise directed.

4.20.5 Curing

After placing, the concrete shall be adequately protected during setting and in the first stages of hardening from shocks and from the harmful effects of sunshine, drying winds and cold. The concrete shall be cured for at least 7 days.

4.20.6 Maturing

From the date of casting, the precast articles shall be matured for 28 days before erection or being built in.

4.20.7 Concrete shall have sufficient strength to prevent damage to units when first handled.

4.20.8 Marking

Precast articles shall be clearly marked to indicate the top of member and its location and orientation in the structure. While the concrete is still green, each unit shall be marked with the date of casting.

4.20.9 Precast units shall be stored, transported and placed in position in such a manner that they will not be over stressed or damaged.

4.21 Precast Reinforced Concrete Door and Window Frames

4.21.1 Concrete

RCC frames shall have a dense surface finish showing no coarse aggregate. It is preferable to use a vibrating table for compaction, alternatively a shutter vibrator may be used. Small defects may be removed by rubbing with Carborundum stone before erection of the frame. Plastering or touching up shall not be done under any circumstances. Tolerances on cross section shall be + 3 mm.

4.21.2 Casting

The entire frame may be cast complete in one piece or each of the vertical and horizontal members of the frame may be cast separately to assembled into the complete frame at site. When the frame is cast in separate parts, one of the reinforcing bars of the vertical members of the frame shall be kept projecting so as to tenon into the corresponding hole in the horizontal member. The holes in the horizontal member for taking the projecting reinforcement from the vertical members shall be slightly larger than the bar diameter to facilitate easy insertion of the projecting bar. After assembly at site the holes shall be grouted with cement and sand slurry 1:2.

4.21.3 Mould

The mould for casting shall preferably be of steel to ensure better surface finish of the cast frame. Provision shall be made in the mould to accommodate fixing devices for hinges and the hold fasts. If required, suitable rebates may be provided to act as plaster groove.

4.21.4 Arrangements for Fixing of Hinges to Frames

Suitable arrangements for fixing of hinges shall be provided in the frame by any one of the following methods as directed. These arrangements are detailed in IS 6523-1983 : Specification for precast reinforced concrete door and window frames.

(a) Hardwood Block fixture :- Hardwood blocks of well seasoned teak or other suitable timber 150 mm long, 45 to 50 mm x 30 to 40 mm in cross section, one block for each of the hinge, shall be fixed in position with 6 mm mild steel bolts, nuts and washers, after the frame has been cast, cured and matured. After tightening the nuts, the bolt heads and the nuts shall be suitably covered with hard wood fillets, finished flush with concrete surfaces of the frame.

(b) Hinge Directly attached to Frame :- L type flap hinge may be attached directly to the frame with the help of 6 mm dia mild steel bolt and nuts.

(c) Hinge Welded to Frame :- The hinge may be welded to 3 mm thick mild steel flat embedded in the frame.

4.21.5 Arrangements for Door and Window Frames

Suitable arrangements shall be provided in the frame for receiving tower bolt, sliding bolts and other door and window fixtures as indicated.

4.21.6 Erection

When a three piece frame is used, the vertical members shall be held with top member placed over them, the whole frame plumbed and firmly supported till the concrete around the holdfasts in the masonry has properly set and hardened. Cement and sand slurry 1:1.5 shall be used in grouting the joints between the vertical and horizontal members of door frame. In case where four members are used, the bottom members shall be first placed in position and other erected on this base. Alternatively, chemical loading system such as epoxy resin may be used.

4.22 RCC Fencing Posts

4.22.1 Fencing post may be rectangular or square, of uniform section throughout their length or tapering on two sides or tapering on all four sides as indicated. The tolerance on cross section shall be + 3 mm.

4.22.2 Cover

The longitudinal reinforcement shall have a minimum concrete cover of 20 mm or twice the diameter of the main reinforcement whichever is greater. For posts and struts to be used in coastal areas, the minimum concrete cover for the longitudinal reinforcement shall be increased to 25 mm.

4.22.3 RCC posts shall be cast with holes as indicated through which the fencing wires would pass. The holes may be formed by inserting steel rods, slightly greased, horizontally through the holes in the divisions of the forms/mould and withdrawing them before the concrete sets too hard. Holes shall have a uniform diameter 10 mm or as directed. They shall present a reasonably smooth surface.

4.22.4 Where fencing wire is to be tied to the fence post using cast in metal projections or clips, these shall be embedded in the fence post along the centre line of the post at right angle to one face of post during casting. Inner ends of the hook or clip shall be bent or hooked to prevent extraction. The slips shall be sufficiently robust and strong, to withstand service conditions and repeated fixing and unfixing of wires. A single wire clip shall not be used for this purpose.

4.23 Hollow Concrete Block Masonry

4.23.1 Hollow Concrete Blocks

Shall conform to the requirements of IS 2185 (Part I)-2005 : Specifications for hollow concrete blocks except with regard to the mix of cement concrete and sizes of aggregates which shall be as indicated. Hollow blocks shall be sound, free from cracks, broken edges honey combing and other defects that would interfere with the proper placing of blocks or impair the strength or performance of construction. The water absorption shall not be more than 10% by mass when the specimen is completely immersed in it. The hollow concrete blocks shall be grade "A" and of minimum average compressive strength as indicated, Mix also shall be as indicated.

4.23.2 Dimensions

Concrete blocks, hollow (open or posted cavity) or solid shall be referred to by its nominal dimensions. The term "nominal" means that the dimension includes the thickness of the mortar joint. Actual dimension shall be 10 mm short of the nominal dimensions.

The nominal dimensions of concrete block shall be as follows.

Length .... 400, 500 or 600 mm
Height .... 200 or 100 mm
Width ....50,75, 100, 150, 200, 250 or 300 mm.

In addition, the block shall be manufactured in half lengths of 200, 250 or 300 mm to correspond to be full lengths.

The nominal dimensions of the units are so designed that taking account of the thickness of mortar joints, they will produce wall lengths and heights which will conform to the principles of modular co-ordination.

4.23.3 Tolerance

The maximum variation in the dimension shall be not more than + 3 mm for height and breadth and + 5 mm for length.

4.23.4 The total width of cavity in any block measured horizontally at right angles to the face of the block as laid in the wall shall not exceed 65 percent of the total breadth (that is the overall dimension of the block at right angle to the face of the block as laid in wall) of the block. The volume of the cavity in the block, shall not exceed 50 percent of the gross volume of block.

The shell and web thickness of block shall however be in no case less than the values given in table below :-

TABLE 14

Minimum Face shell and web thickness - All dimensions in millimeters			
Nominal Block width	Face shell thickness Minimum	Thickness of Web Minimum	Total web thickness per course in any 200 mm length of walling Minimum
1	*2*	*3*	*4*
100 or less	25	25	25
Over 100 upto 150	25	25	25
Over 150 upto 200	30	25	30
Over 200	35	30	38

4.23.5 Surface characteristics of blocks intended to be plastered or rendered, shall be such as to provide a satisfactory bond with the plaster.

Faces of blocks shall be flat and rectangular, opposite faces shall be parallel and all arises shall be square. The ends of the blocks which form the vertical joints may be plain butt unless tongue and grooved or double ends are indicated.

4.23.6 The blocks shall be cured in an immersion tank or in a curing yard and shall be kept continuously moist for at least 21 days. When the blocks are cured in immersion tank, the water of the tank shall be changed at least every four days. Steam curing of blocks may be adopted provided the requirements of pressure and non-pressure steam curing are fulfilled.

After curing, the blocks shall be dried in shade before being used on the work. They shall be stacked with voids horizontal to facilitate through passage of air. The blocks shall be allowed to complete their initial shrinkage before they are laid in a wall.

4.23.7 Construction of Masonry

For single storeyed buildings, the hollows of blocks in the foundations and basement masonry shall be filled up with sand and only the top foundation course shall be of solid blocks. But for two or more storeyed buildings solid concrete blocks shall be used in foundation courses, plinth, and basement walls, unless otherwise indicated. If hollow blocks are used, their hollows shall be filled up with cement concrete 1:3:6 using 12.5 mm nominal size aggregates.

4.23.8 Wetting of Blocks

Blocks need not be wetted before or during laying in the walls. In case the climatic conditions so require, the top and the sides of the blocks may only be slightly moistened so as to prevent absorption of water from the mortar and ensure the development of the required bond with the mortar.

4.23.9 Laying

Blocks shall be laid in mortar, as indicated and thoroughly bedded in mortar, spread over the entire top surface of the previous course of blocks to a uniform layer of not less than 10 mm in thickness and not more than 12 mm.

All courses shall be laid truly horizontal and all vertical joints made truly vertical, Blocks shall break joints with those above and below for not less than quarter of their length. Precast half length closers (and not cut from full size blocks) shall be used. For battered faces, bedding shall be at right angles to the face unless otherwise directed. Care shall be taken during construction to see that edges of blocks are not damaged.

4.23.10 Provisions for Door and Window Frames

A course of solid block masonry shall be provided under doors and window openings (or a 10 cm thick precast concrete sill-block under windows). The solid course shall extend for at least 20 cm beyond the opening on either side. For jambs of very large doors and windows either solid concrete blocks shall be provided or, if hollow units are used, the hollows shall be filled in with concrete of mix 1:3:6 using 12.5 mm nominal size aggregates.

4.23.11 Provision of Roof

The course immediately below the roof slab shall be built with solid blocks. The top of the roof course shall be finished with a layer of cement and sand mortar 1:3, 10 mm thick and covered with a thick coat of white wash or crude oil, to ensure free movement of the roof.

4.23.12 Intersecting Walls

When two walls meet or intersect and the courses are to be laid up at the same time, a true masonry bond between at least 50 percent of the units at the intersection is necessary. When such intersecting walls are laid up separately, pockets with 20 mm maximum vertical spacing shall be left in the first wall laid. The corresponding course of the second wall shall be built into these pockets.

4.23.13 Piers

The top course of block in the pier shall be built in solid blocks. Hollow concrete blocks shall not be used for isolated piers, unless their hollows are specified to be filled with cement concrete.

4.23.14 Fixtures, fittings, etc. shall be built into the masonry in cement and sand mortar 1:3 while laying the blocks where possible. Hold-fasts shall be built into the joints of the masonry during laying.

Holes, chases, sleeves, openings, etc. of the required size and shape shall be formed in the masonry with special blocks while laying, for fixing pipes, service lines, passage of water, etc. After service lines, pipes etc. are fixed, voids left, if any, shall be filled up with cement concrete 1:3:6 type C_o and neatly finished. Construction details specified for brick masonry which have not been specified herein shall apply to hollow blocks masonry to the extent applicable.

4.23.15 Finishes

Renderings shall not be applied to the walls when these are wet. Joints for plastering or pointing, as specified shall be raked to a depth of 10 mm. Joints on internal faces, unless otherwise indicated, shall be raked for plastering. If the internal faces of masonry are not to be plastered the joints shall be finished as the work proceeds or pointed flush where indicated.

4.24 Concreting of Under-reamed Piles

4.24.1 Under-reamed piles shall be cast soon after the bore holes are ready.

4.24.2 Reinforcement for the under-reamed piles shall be made up into cages, sufficiently well wired to withstand the handling without damage. The reinforcement shall have a clear cover of 40 mm. End cover at the base of the piles shall be not less than 75 mm and more than 100 mm.

4.24.3 After lowering reinforcement cage, concrete shall be placed through a funnel so as to fill the entire volume of the pile-bore without the formation of voids. Concrete shall be compacted by thorough rodding, care being taken that it does not scratch the sides of the bore hole or displace, or distort the reinforcement. Mechanical vibrators shall not be used. The portion of the piles above the ground surface shall be cured for seven days.

4.24.4 Under water concreting shall be carried out by displacement method and a tremie pipe of diameter not less than 15 cm having suitable protective arrangement at the lower end, may be used. The minimum pile stem diameter for under water concreting shall be 25 cm.

4.24.5 For batter piles, concreting shall normally be done with a chute or tremie depending upon inclination and site conditions.

4.24.6 Finishing Pile Heads

The top of the pile shall be brought up above the finished level to permit all laitance and weak concrete to be removed and to ensure that it can be properly keyed into the pile cap. The minimum distance of keying of pile into pile cap shall be 50 mm. Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete. The clear cover between the reinforcement in pile cap from the top of the pile shall not be less than 10 mm. The reinforcement in the pile shall be exposed for a sufficient distance to permit it to be adequately bonded in the pile cap. For piles with capping beams these provisions may not apply.

4.24.7 Pile Caps

The clear cover for the main reinforcement from the bottom of the cap shall be not less than 60 mm. The reinforcement from the pile shall be properly tied to the pile cap.

4.24.8 Load Test

4.24.8.1 Where indicated, minimum two number initial load tests shall be carried out on test piles to establish the settlement at working load and to determine the ultimate load capacity, etc. Where load tests on test piles is not indicated, load tests on minimum two working piles shall be carried out, but not to determine the ultimate load capacity.

4.24.8.2 The number of routine tests on working piles as a check and to assess the settlement at working load shall be carried out on half percent to two percent of piles as required depending on site conditions. Load test on working piles may be carried out on a single pile or a group of piles as directed by the GE.

4.25 Reinforced Concrete Work in Water Retaining Structure

4.25.1 Special care shall be taken to get the most suitable grading of aggregates so as to produce the densest possible concrete. Mix proportion shall be as indicated. Water cement ratio shall be controlled consistent with the requirements of workability to produce impervious concrete.

4.25.2 The concrete between the reinforcement and the formwork on the water face shall be well compacted and the board joints tight, so as to produce a structure free from honey-combing or pores. External vibrators viz. vibrators at the rate of one vibrator per 2.5 M^2 of shutter area may be used to produce a compact concrete with a dense skin which shall not however contain an excess of cement. Wherever it is not possible to use shutter vibrator, pin vibrator shall be used after the approval of Engineer-in-Charge.

4.25.3.1 All vertical, horizontal construction and expansion joints in water retaining structures shall be located and executed as shown in the drawings and no deviation shall be permitted without the specific permission of Engineer-in-Charge. Where day's work joints are formed whether horizontally or vertically, they shall be rebated as called out on drawings. Care shall be taken to remove from the earlier lift over all loose pieces of gravel, stone chips, wooden chips, country nails or any other foreign materials. All laitance shall also be thoroughly removed. If necessary, the face of the old concrete shall be well hacked to expose the aggregate and after washing the surface, a thin coat of mortar or grout (1 cement : 1 sand) shall be applied immediately before resuming concreting.

4.25.3.2 Water bar installation along the joints shall be done by embedding one half of the water bar in each side of the joints by suitable jigs/supporting arrangements between the adjacent sections of the concrete as per the manufacturer's specifications and directions of the Engineer-in-Charge. Water bars shall be properly aligned and placed in position during embedding. To achieve the continuity of the water bar all along the joint at crossing and at change of alignment, the water stops shall be welded (in T, X or L shapes as the case may be) as per manufacturer's specifications and directions of Engineer-in-Charge. Suitable jigs manufactured out of reinforcing bars may be used for fixing the water bars.

4.25.3.3 Fittings

Pipes and other fittings passing through the walls and bottom shall be well embedded in the concrete and shall be provided with normal puddle flanges. Openings in the walls, and floor slabs if any shall be provided as per the relevant drawings.

4.25.4 Curing

Concrete in water retaining portion shall be cured minimum for 21 days.

4.25.5 Hydraulic Testing

Structure shall be tested strictly in accordance with IS:3370 (Part I) for water tightness. For underground tank, the total maximum drop in water surface level over seven days shall not exceed 40 mm.

4.26 Bored Cast in Situ Concrete Piles

4.26.1 After the boring has reached to required depth, the steel reinforcement shall be lowered in position keeping uniform cover all round. The bore shall be flushed with fresh bentonite slurry through tremie pipe. Freshly prepared concrete of mix as specified shall be lowered by using tremie pipe into bore hole and the temporary support shall be slowly withdrawn to ensure the concrete fills the bore properly. The top of the pile shall be finished neat and leveled properly. In case piles are exposed to free water or the concreting is done under water drilling or mud using method other than tremie, 10% extra cement over the cement required for the specified mix shall be used.

4.26.2 Tremie Method Concreting

In addition to the normal precaution to be taken in tremie concreting, the following requirements are particularly applicable to the use of tremie concrete in pipes.

(a) The concrete should be coherent, rich in cement (not less than 370 Kg/m^3) and of slump not less than 150 mm.

(b) When concreting is carried out under water a temporary casing should be installed to the full depth of the bore hole into the concrete as it is placed. The temporary casing may not be required near the top when concreting under drilling mud.

(c) The hopper and tremie should be a closed system embedded in the placed concrete, through which water cannot pass.

(d) The tremie should be large enough with due regard to the size of aggregate. For 20 mm aggregate the tremie pipe should be of diameter not less than 200 mm, aggregate more than 20 mm shall not be used.

(e) The first charge of concrete should be placed with a sliding plug pushed down the tube ahead of it or with a steel plate of adequate charge to prevent mixing of concrete and water. However, the plug should not be left in the concrete as a lump.

(f) The tremie pipe should always penetrate well into the concrete with an adequate margin if safety against accidental withdrawal of the pipe is surged to discharge the concrete.

(g) The pipe should be concreted wholly by tremie and the method of deposition should not be changed part way up the pile, to prevent the laitance from being entrapped within the pile.

(h) All tremie tubes should be scrupulously cleaned after use.

4.26.3 Normally concreting of the piles should be uninterrupted. In the exceptional case of interruption of concreting; but which can be resumed within 1 or 2 hours, the tremie shall not be taken out of the concrete. Instead it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting should be resumed by introducing a little richer concrete with a slump of about 200 mm for easy displacement of the partly set concrete.

If the concreting cannot be resumed before final set of concrete already placed, the pile so cast may be rejected or accepted with modifications.

4.26.4 In case of withdrawal of tremie out of the concrete either accidentally or to remove a choke in the tremie, the tremie may be re-introduced in the following manner to prevent impregnation or scum lying on the top of the concrete already deposited in the bore.

4.26.5 The tremie shall be gently lowered on to the old concrete with very little penetration initially. A vermiculite plug should be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm should be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing the laitance/scum. The tremie will be pushed further in steps making fresh concrete sweep away laitance/scum. When tremie is buried in bed about 60 to 100 cm concreting may be resumed.

4.26.6 During installation of bore cast-in-situ piles the convenience of installation may be taken into account while determining the sequence of piling in a group.

4.26.7 Concrete in piles shall be built above cut off level by at least 50 cm to facilitate chipping and removing all laitance of bentonite/soil mixed with concrete and weak concrete and finished to cut-off level as specified.

4.26.8 Initial load test

Where indicated minimum two number load test shall be carried out as per IS 2911 (Part IV)-1984. The load shall be applied by means of a hydraulic jack with pressure gauge held against rolled steel joist on suitable frame by means of anchor pile or any other suitable loaded platform.

4.26.9 Routine Test

The routine test on working pile shall be carried out as per IS 2911 (Part IV). The test shall be carried out upto one and half time the designed load or total displacement attained a value of 12 mm or 40 mm in case of single pile or group of piles respectively whichever is earlier.

APPENDIX A

1 DETERMINATION OF PARTICLE SIZE

1.1 In order that the sieves shall not be overloaded, care must be taken to ensure that the maximum sieve loads shown below are not exceeded at the completion of sieving.

TABLE 1

IS Sieves	Maximum weight for	
	45 cm dia sieve	30 cm dia sieve
	Kg	Kg
45 mm	10	4.5
40 mm	8	3.5
31.5 mm or 22.1 mm	6	2.5
16 mm or 12.5 mm	4	2
10 mm	3	1.5
5.6 mm	2	1.0
4.75 mm	1.0	0.5
3.35 mm	-	0.30

1.2 The sample weight taken will thus normally require several operations on each sieve. Each sieve should be shaken separately over a clean tray or receiver until no more than a trace passes, but in any case not less than 2 minutes. Material should not be forced through the aperture but hand placing is permitted. A light brush should be used with fine sieves. The cumulative weight passing each sieve should be calculated as a percentage of the total sample weight to the nearest whole number.

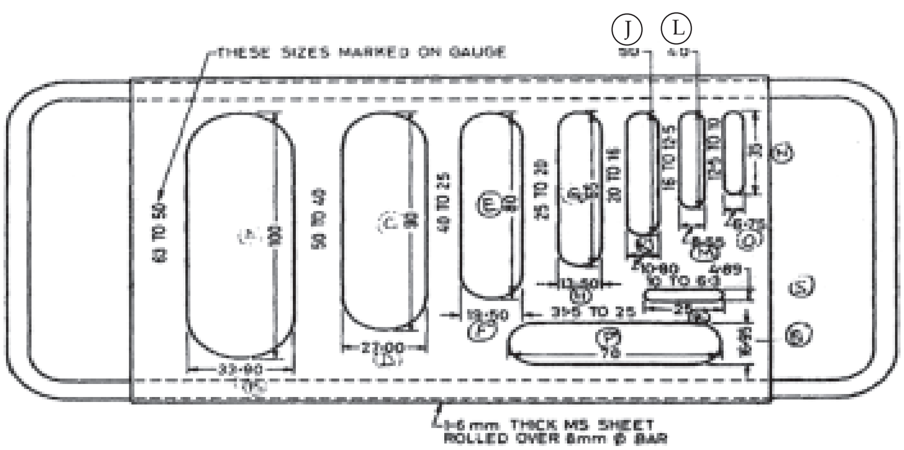
2. DETERMINATION OF FLAKINESS INDEX (IS : 2386 : Part 1 : 1963)

2.1 Apparatus

The apparatus shall consist of the following :-

(i) *Balance* :- The balance shall be of sufficient capacity and sensitivity and shall have an accuracy of 0.1 percent of the weight of test sample.

(ii) *Metal Gauge* :- The metal gauge shall be of the pattern shown in figure below.



All dimensions in millimetres

(iii) *Sieves* :- IS Sieves of sizes shown in table below.

TABLE 2

Passing through IS Sieve	Retained on IS Sieve	Thickness Gauge (mm)	Length Gauge (mm)
1	2	3	4
63 mm	50 mm	33.90	-
50 mm	40 mm	27.00	81.0
40 mm	25 mm	19.50	58.5
31.5 mm	25 mm	16.95	-
25 mm	20 mm	13.50	40.5
20 mm	16 mm	10.80	32.4
16 mm	12.5 mm	8.55	25.6
12.5 mm	10 mm	6.75	20.2
10 mm	6.3 mm	4.89	14.7

2.2 Sample

A sufficient quantity of aggregate shall be taken to provide minimum number of 200 pieces of any fraction to be tested.

2.3 Procedure

(i) *Sieving:*- The sample shall be sieved in accordance with the method described in IS with the sieves specified in table above.

(ii) *Separation of Flaky Material:*- Each fraction shall be gauged in turn for thickness on a metal gauge of the patterns shown above. Or in bulk on sieves having elongated slots. The width of the slot used in the gauge shall be of the dimensions specified in Col 3 of table shown above for the appropriate size of material.

(iii) *Weighing of Flaky Material:*- The total amount passing the gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.

2.4 Reporting of Result

The flakiness index is the total weight of the material passing the various thickness gauges or sieves, expressed as a percentage of the total weight of the sample gauged.

3. TEST FOR SURFACE MOISTURE

3.1 Take a sample of wet aggregate and weigh it (A). Then place it in a frying pan and gently apply heat, meanwhile stirring with a glass rod until the surface moisture disappears. This is apparent when the aggregate loses its shining wet appearance and becomes dull, or when it just attains a free running condition. The saturated surface-dry material is then weighed (B). Continue the heating until the moisture is evaporated and weigh the sample (C). The surface moisture is then calculated as follows :-

$$\text{Surface moisture} = 100 \times \frac{A-B}{C}$$

It is expressed as a percentage of dry aggregate.

4. SLUMP TEST

4.1 Apparatus

Mould shall consists of a metal frustum of cone having the following internal dimensions :-

Bottom diameter	20 cm
Top diameter	10 cm
Height	30 cm

The mould shall be of metal other than brass and aluminium of at least 1.6 mm thickness. The top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction by the test. A mould provided with a suitable guide attachment may be used.

Tamping rod shall be of steel or other suitable material 16 mm in diameter 60 mm long and rounded at one end.

4.2 Procedure

4.2.1 The internal surface of the mould shall be thoroughly cleaned and free from superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth horizontal, rigid and non absorbent surface viz. levelled metal plate. The operator shall hold the mould firmly in place while it is being filled with test specimen of concrete. The mould shall be filled in four layers, each approximately one quarter of height of mould. Each layer shall be tamped with twenty five strokes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and for the second and subsequent layers shall penetrate into the underlying layer. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded, the concrete shall be struck off with trowel or the tamping rod, so that the mould is exactly filled. Any mortar which shall leak out between the mould and the base plate shall be cleaned away. The mould shall be removed from the concrete immediately after filling by raising it slowly and carefully in a vertical direction. The moulded concrete shall then be allowed to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of specimen.

4.2.2 The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

4.3 Result

The slump shall be recorded in terms of the millimetres of subsistence of the specimen during the test. Any slump specimen which collapses or shears off laterally gives incorrect result. If this occurs, the test shall be repeated with another sample.

4.3.1 The slump test shall not be used for very dry mixes as the results obtained are not accurate.

5. CONCRETE CUBE TEST (IS 516 : 1959)

5.1 One sample (consisting of six cubes 15x 15x 15 cm) shall be taken for every 20 Cum or part thereof of concrete work ignoring any part less than 5 Cum or as often as considered necessary by the Engineer-in-Charge. The test of concrete cubes shall be carried out in accordance with the procedure as described below.

5.2 Mould

5.2.1 The mould shall be of size 15 cm x 15 cm x 15 cm for the maximum nominal size of aggregate not exceeding 40 mm. For concrete with aggregate size more than 40 mm, size of mould shall be specified by the Engineer-in-Charge, keeping in view the fact that the length of size of the mould should be about four times the size of aggregate.

5.2.2 The mould for test specimens shall be made of non-absorbent material and shall be substantially strong enough to hold their form during the moulding of test specimens. They shall not vary from the standard dimensions by more than one percent. The moulds shall be so constructed that there is no leakage of water from the test specimen during moulding. All the cube moulds for particular site should, prior to use, be checked for accuracy and geometric form and such test should atleast be made once a year.

5.2.3 Each mould shall be provided with a base plate having a plane surface and made of non-absorbent material. This plate shall be large enough in diameter to support the moulds properly without leakage. Glass plates not less than 6.5 mm thick or plain metal not less than 12 mm thick shall be used for this purpose. A similar plate shall be provided for covering the top surface of the test specimen when moulded.

5.3 Sample of concrete

5.3.1 Sample of concrete for test specimen shall be taken at the mixer or in the case of ready mixer or in the case of ready mixed concrete from the transportation vehicle discharge or as directed by Engineer-in-Charge. Such samples shall be obtained by repeatedly passing a scoop or pail through the discharge stream of concrete. The sampling operation should be spread over evenly to the entire discharging operation. The samples thus obtained shall be transported to the place of moulding of the specimen. To counteract segregation, the concrete shall be mixed with a shovel until it is uniform in appearance.

The location in the work of the batch of concrete thus sampled shall be noted for further reference. In case of paving concrete, samples shall be taken from the batch immediately after deposition of the subgrade. At least five samples shall be taken from different portion of the pile and these samples shall be thoroughly mixed before being used to form the test specimen. The sampling shall be spread as evenly as possible throughout the day. When wide changes occur during concreting, additional samples shall be taken if so directed by the Engineer-in-Charge.

5.4 Preparation of Test Specimen

5.4.1 The interior surfaces of the mould and base plate shall be lightly oiled before the concrete is placed in the mould. The samples of concrete obtained as described under the test specimen shall be immediately moulded by one of the following methods as indicated below :-

5.4.2 When the job concrete is compacted by manual methods, the test specimen shall be moulded by placing, the fresh concrete in the mould in three layers, each approximately one third of the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mould as the concrete there slides from it, in order to ensure a uniform distribution of concrete within the mould. Each layer shall be rounded 35 times with 16 mm rod, 60 cm in length, bullet pointed at the lower end. The strokes shall be distributed in uniform manner over the cross section of the mould and shall penetrate into underlying layer. The bottom layer shall be rodded through its depth. After the top layer has been rodded, the surface of the concrete shall be struck off with a trowel and covered with a glass plate atleast 6.5 mm thick or a machined-plate. The whole process of moulding shall be carried out in such a manner as to preclude the change of the water cement ratio of the concrete, by loss of water either by leakage from the bottom or over flow from the top of the mould.

5.4.3 When the job concrete is placed by vibration and the consistency of the concrete is such that the test specimens cannot be properly moulded by hand rodding as described above, the specimens shall be vibrated to give a compaction corresponding to that of the job concrete. The fresh concrete shall be placed in mould in two layers, each approximately half the volume of the mould. In placing each scoopful of concrete the scoop shall be moved around the top edge of the mould as the concrete there slides from it, in order to ensure a symmetrical distribution of concrete within the mould. Either internal or external vibrators may be used. The vibration of each layer shall not be continued longer than is necessary to secure the required density. In compacting the first layer the vibrators shall not be allowed to rest on the bottom of the mould. The surface of the concrete shall then be struck off with a trowel and covered with a glass or steel plate as specified above. The whole process of moulding shall be carried out in such a manner as to preclude the alteration of water-cement ratio of the concrete by loss of water, either by leakage from the bottom or over flow from the top of the mould.

5.5 Curing and Storage of Test Specimen

5.5.1 In order to ensure reasonably uniform temperature and moisture conditions during the first 24 hours for curing the specimen and to protect them from damage, moulds shall be covered with wet straw or gunny sacking and placed in a storage box so constructed and kept on the work site that its air temperature when containing concrete specimens shall remain 22^0C to 33^0C. Other suitable means which provide such a temperature and moisture conditions may be used.

5.5.2 The test specimen shall be removed from the moulds at the end of 24 hours and stored in a moist condition at a temperature within 24^0C to 30^0C until the time of test. If storage in water is desired, a saturated lime solution shall be used.

5.6 Testing

The specimens shall be tested in accordance with procedure as described below :-

5.6.1 The tests shall be made at the age of concrete corresponding to that for which the strengths are specified.

5.6.2 Compression tests shall be made immediately upon removal of the concrete test specimen from the curing room i.e., the test specimen shall be loaded in damp condition. The dimensions of the test specimens shall be measured in mm accurate to 0.5 mm

5.6.3 The metal bearing plates of the testing machine shall be placed in contact with the ends of the test specimens. Cushioning materials shall not be used. In the case of cubes, the test specimens shall be placed in the machine in such a manner that the load is applied to sides of the specimens as cast. An adjustable bearing block shall be used to transmit the load to the test specimen. The size of the bearing block shall be the same or slightly larger than that of test specimen. The upper or lower section of the bearing block shall be kept in motion as the head of the testing machine is brought to a bearing on the test specimen.

5.6.4 The load shall be applied axially without shock at the rate of approximately 140 Kg. per Sq. cm. per minute. The total load indicated by the testing machine at failure of test specimen shall be recorded and unit compressive strength is calculated in Kg. per Sq. cm. using the area computed from the measured dimensions of the test specimen. The type of failure and appearance of the concrete shall be noted.

SECTION 5
BRICK WORK

5.1 Indian Standards

The following IS apply to this section :

I.S No.	Subject
195 : 2005	Fireclay Mortar for Laying Fireclay Refractory Bricks - Specification (Fourth Revision)
702 : 1988	Specification for Industrial Bitumen (Second Revision)
1077 : 1992	Common Burnt Clay Building Bricks - Specification (Fifth Revision)
1526 : 1960	Sizes and Shapes for Firebricks (230mm series)
1580: 1991	Bituminous Compounds for Waterproofing and Caulking Purposes - Specification (Second Revision)
1905 : 1987	Code of Practice for Structural Use of Un-reinforced Masonry (Third Revision)
2116: 1980	Specification for Sand for Masonry Mortars (First Revision)
2386 : Part-2 : 1963	Methods of Test for Aggregates for Concrete - Part-2 : Estimation of Deleterious Materials and Organic Impurities.
2508 : 1984	Specification for Low Density Polyethylene Films (Second Revision)
2691 : 1988	Specification for Burnt Clay Facing Bricks (Second Revision)
2750: 1964	Specifications for steel scaffolding
3384 : 1986	Specification for Bitumen Primer for Use in Waterproofing and Damp Proofing (First Revision)
3696: Part I: 1987	Safety code for scaffolds and ladders, Part-I Scaffolds
3812 (Part 1) : 2003	Specification for fly ash for use as pozzolana and admixture (First Revision)
4832 : Part-2 : 1969	Specification for Chemical Resistant Mortars - Part-II: Resin Type.
4832 : Part-3 : 1968	Specification for Chemical Resistant Mortars - Part-III : Sulphur Type
4860 : 1968	Specification for Acid Resistant Bricks
5454 : 1978	Methods for Sampling of Clay Building Brick (First Revision)
6165 : 1992	Dimensions for Special Shapes of Clay Bricks (First Revision)
13757: 1993	Specification for burnt clay fly ash building bricks

MATERIALS

5.2 Cement

Cement shall be as specified in Section 4-Concrete.

5.3 Lime

Lime shall be as specified in Section 4- Concrete.

5.3.1 Eminently hydraulic, semi-hydraulic and Kankar limes corresponding to Class A, Class B and Class E & F of IS : 712 : 1984 are suitable for use in masonry mortars; whereas fat limes corresponding to Class C requires mixing of burnt clay pozzolana (surkhi) or other pozzolonic materials.

5.4 Sand of Masonry Mortars

Unless otherwise indicated, sand for masonry mortars shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these conforming to IS-2116-1980 : Specification for Sand for Masonry Mortars (First Revision). Sand shall be hard, durable, clean and free from adherent coatings and shall not contain clay and impurities such as iron pyrites, alkalies, salts, coal, mica, shale or similar laminated or other materials exceeding the specified limits.

5.4.1 The maximum quantities of clay, fine silt and fine dust in sand shall not be more than 5 percent by mass. Organic impurities shall be below that obtained by comparison with the standard solution specified in 6.2.2 of IS : 2386 : Part-2 : 1963 : Methods of Test for Aggregates for Concrete - Part-2 : Estimation of Deleterious Materials and Organic Impurities.

5.4.2 Use of sea sand shall not be allowed for any description of mortar in which its use is considered to be detrimental to the strength, appearance or the dryness of the work. In localities where sea sand is available and its use in certain items is permissible, the intention to allow use of sea sand shall be indicated.

5.5 Surkhi

Surkhi shall be as specified in Section 4- Concrete.

5.6 Common Burnt Clay Building Bricks

5.6.1 Common burnt clay building bricks (here-in-after termed as bricks) shall conform to the requirements laid down in IS : 1077 : 1992, Common Burnt Clay Building Bricks -Specification (Fifth Revision). The class of bricks (based on minimum average compressive strength) viz. 3.5 (or 35), 5 (or 50), 7.5 (or 75), 10 (or 100), 12.5 (or 125) or 15 (or 150) in N/mm^2 (or Kg/cm^2) as mentioned below, shall be as indicated.

Class Designation	*Average compressive strength not less than*	
	N/mm^2	*Kgf/cm^2 (Approx)*
15 (or 150)	15.0	150
12.5 (or 125)	12.5	125
10 (or 100)	10.0	100
7.5 (or 75)	7.5	75
5 (or 50)	5.0	50
3.5 (or 35)	3.5	35

5.6.2 Each class of bricks shall be further divided into two sub Classes A & B based on tolerances and shape. For example the bricks of classification 7.5 shall have Sub Classification 7.5A and 7.5B.

5.6.2.1 Sub class A bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour. Sub class 'B' bricks may have slightly distorted and round edges provided no diffculty shall arise on this account in laying of uniform courses.

5.6.3 Dimensions

Size of bricks shall be as indicated. Standard of bricks are as under :-

Type of Bricks	*Nominal Size*	*Actual Size*
Modular Bricks	20x10x10cm	19x9x9 cm
Modular Brick tiles	20x10x5 cm	19x9x4 cm
Old size Bricks (FPS)	9x4.5x3 inches or 23x11.3x7.5 cm or 25 x 12.5 x 7.5 cm	9x4-3/8x2-3/4 inches
Old size bricks tiles (FPS)	9x4.5x2 inches or 1.5 inches 23x11.3x5 cm or 4 cm 25x12.5x5 cm or 4 cm	9x4-3/8x1-3/4 inches or 1-3/8 inches

5.6.4 Tolerance

The permissible tolerance on the dimensions of the bricks, unless otherwise indicated, shall be + 3 Percent for Sub Class A bricks and + 8 Percent for Sub Class B bricks. To verify conformity within tolerance limit, twenty whole bricks selected at random from the stack shall be arranged upon a level surface successively for measuring the length, width and height, in contact with each other and in a straight line.

5.6.5 General Quality

Bricks may be hand or machine moulded and shall be made from suitable soil. They shall be free from cracks, flaws and nodules of free lime. Bricks of 7.5 and 10 cm thickness (height) shall be moulded with frog 1 to 2 cm deep on one of its flat faces. Bricks of 4 cm or 5 cm height and those made by an extrusion process may not be provided with frogs.

5.6.6 Compressive Strength

The compressive strength of any individual brick shall not fall below the minimum average compressive strength specified for corresponding class of brick.

5.6.7 Water Absorption

The average water absorption of bricks, after immersion in cold water for 24 hours shall not be more than 20 percent for bricks upto Class 12.5 and 15 percent for higher class of bricks .

5.6.8 Efflorescence

The rating of efflorescence of the bricks shall not be more than moderate for bricks upto Class 12.5 and slight for higher class.

5.6.9 Handling and Storage of Bricks

Bricks shall not be dumped at site. They shall be stacked in regular tiers on even ground as they are unloaded to minimize breakage and defacement of bricks. Bricks selected for facing and any particular purpose/situation of use shall be stacked separately.

5.7 Clay Fly Ash Bricks

The clay fly ash bricks shall conform to IS : 13757 : 1993 : Specification for burnt clay fly ash building bricks. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with free lime and organic matter. The bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length, 40 mm in width and 10 to 20 mm deep on one of its sides. If made by extrusion process, the bricks may not be provided with frogs. Fly ash shall conform to grade 1 or grade 2 of IS : 3812 : 1981 : Specification for fly ash for use as pozzolana and admixture (First Revision).

5.8 Facing Bricks

Burnt clay facing bricks shall be Class II bricks conforming to IS : 2691: 1988 - Specification for Burnt Clay Facing Bricks (Second Revision). Facing bricks shall be of uniform colour, even texture and shall be free from cracks, flaws and nodules of free lime. These shall be thoroughly burnt and shall have plain rectangular faces with parallel sides and sharp, straight, right angled edges.

5.8.1 The average compressive strength of Class II facing bricks shall not be less than 75 Kg/Sq. cm. Water absorption after 24 hours immersion shall not exceed 15 percent. Efflorescence rating shall be NIL. Warpage shall not exceed 2.5 mm.

5.8.2 Dimensions and Tolerance

Size of facing bricks shall be as indicated. The permissible tolerance on the length and width/thickness of bricks shall be + 5 and + 3mm respectively. Tolerance on the thickness of brick tiles shall be + 2mm.

5.9 Purpose Moulded Bricks

The dimensions of the special shapes of bricks such as closers, bullnose bricks, copings, corner bricks, plinth bricks and chimney or well type bricks, where indicated shall be as detailed in IS : 6165 : 1992 - Dimensions for Special Shapes of Clay Bricks (First Revision).

5.10 Fire Bricks

Fire Bricks shall be moulded from fire clay burnt at a high temperature. They shall be compact, dense, tough, evenly burnt throughout; of homogeneous texture and free from cracks and other flaws; of sufficient mechanical strength for the purpose; and regular in size and shape. These shall be of approved make.

5.10.1 Sizes and shapes of fire bricks shall conform to IS : 1526 : 1960 - Sizes and Shapes for Firebricks (230mm series), unless otherwise indicated. The dimension of normal size rectangular brick is 230 x 113 x 75mm. All wedge, radial or other shaped bricks shall be purpose moulded and not cut from rectangular bricks.

5.11 Fire Clay Mortar

Fireclay mortar of the required grade shall conform to IS : 195 : 2005 - Fireclay Mortar for Laying Fireclay Refractory Bricks - Specification (Fourth Revision), and shall be evenly ground and of such quality and plasticity as would enable to be spread satisfactorily with a trowel when tempered with adequate amount of water. No particles in fireclay shall be so large as to be retained on IS sieve 2.80mm.

5.12 Acid Resistant Bricks

Acid resistant bricks shall conform to IS : 4860 : 1968 - Specification for Acid Resistant Bricks and shall be Class I or Class II as indicated.

5.12.1 Dimensions

Acid resistant bricks shall be 230x114x64mm size, unless otherwise indicated. Permissible tolerance on length, width and thickness/height shall be + 3.5, + 2.0 and + 1.0mm respectively. Warpage shall not exceed 2.5mm.

5.12.2 Finish

Acid resistant bricks, when manufactured, shall appear fine grained in texture, dense and homogenous. The bricks shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility.

5.13 Chemical Resistant Mortars

Mortars for laying acid resistance bricks shall be resin type or sulphur type as required. Resin type mortar shall conform to IS : 4832 : Part-2 : 1969 - Specification for Chemical Resistant Mortars - Part-II : Resin Type. Sulphur type mortar shall conform to IS : 4832 : Part-III: 1969 - Specification for Chemical Resistant Mortars - Part-3 : Sulphur Type. The type of the chemical resistant mortar shall be suitable for the purpose and as recommended by the manufacturers.

Note 1 : The resin mortars have fairly good resistance to non oxidizing mineral acids and poor resistance to oxidizing mineral acids. They are fairly resistant to inorganic alkalis.

Note 2 : The sulphur mortars have good resistance against most of the acids except concentrated oxidizing acids but have very poor resistance to alkalies.

5.13.1 Storage

The mortars shall be stored in a clean and dry place prior to use. The mortar shall not deteriorate on storage. The resins shall be stored away from open flame with containers tightly closed. The resins could generally be stored without deterioration at 27°C + 2°C for periods not exceeding the values given below. The filler or resin that has become wet shall not be used.

Resin	*Periods*
Phenolic	3 months
Furane	12 months
Epoxy	12 months
Polyster	3 months
Cashew nut shell liquid	9 months

5.14 Soil for Mud Mortar

The soil shall be free from vegetable roots, gravel (of particle size greater than 2mm) and coarse sand. Other coarse materials shall not exceed 10 percent by weight. The soil shall also be free from harmful and efflorescent salts. The plasticity index of the soil shall be between 9 and 12. Soils shall have clay content from 10 to 20 percent.

Note : *Soil should be visually checked for sulphate attack. The soils which show white patches on the surfaces, suffer from sulphate attack.*

5.15 Polythene Film

Polythene film for water proofing shall comply with IS 2508 :1984 - Specification for Low Density Polyethylene Films (Second Revision). The film shall be black in colour and shall contain not less than 2.0 percent of carbon black of an average particle size 0.01 to 0.02 microns, well dispersed in mass.

5.16 Bituminous Bonding Material

The bonding material shall be blown bitumen conforming to IS 702 : 1988 - Specification for Industrial Bitumen (Second Revision).

5.17 Bitumen Primer

Primer shall conform to IS : 3384 : 1986 - Specification for Bitumen Primer for Use in Waterproofing and Damp Proofing (First Revision).

5.18 Water

Water used for making masonry mortars shall be clean and free from injurious amounts of deleterious materials. Potable water is generally considered satisfactory for use in masonry mortar.

WORKMANSHIP

5.19 Masonry Mortars

5.19.1 Proportioning

Mortars shall be of the mix as indicated. The mixes specified are by volume. Mix proportions of lime mortars and cement mortars specified are in the proportions of lime/cement to dry sand. Mix proportions of cement lime mortars specified are in the proportions of cement : lime : dry sand. In the case of lime mortar using fat lime (Class 'C') Pozzolana (surkhi) shall replace sand or a part of sand as directed. If moist sand is used, necessary allowance shall be made for bulking.

Cement and hydrated lime shall be measured by weight; 50 Kg of cement shall be taken as equal to 0.035 Cum to determine bulk. Unit weight of dry hydrated lime shall be taken as 700 Kg per cum. The quantity of water to be added to the mortar shall be such that the working consistency is obtained. Excess water shall be avoided.

5.19.2 Preparation of Cement Mortar

Mixing shall be done preferably in a mechanical mixer. If done by hand, mixing operation shall be carried out on a clean water tight platform. Cement and sand shall be mixed dry in the required proportion to obtain a uniform colour. The required quantity of water shall then be added and the mortar hoed back and forth for 5 to 10 minutes with additions of water to a workable consistency. In the case of mechanical mixing, the mortar shall be mixed for at least three minutes after addition of water. Cement mortar shall be freshly mixed for immediate use. Any mortar which has commenced to set shall be discarded and removed from the site.

5.19.3 Preparation of Lime Mortar

Lime putty shall be prepared as described in Section 4 - Concrete. Putty and sand in the specified proportion shall be mixed with or without the addition of water on a dry waterproof platform or in a mixer. The mix shall then be fed into a mortar mill with the required addition of water. The mortar shall be raked continuously during grinding, particularly in the angular edges of the mortar mill. Water may be added during grinding as required, but care shall be taken not to add more water than to bring the material being mixed to the working consistency. The mixing shall be done till every particle of aggregate is coated uniformly with the cementing material. When factory made dry hydrated lime is used for making lime mortar, grinding of the lime and sand in mortar mill is not necessary.

5.19.3.1 Where pozzolana is used in the mortar, the pozzolana shall first be mixed with the lime in the specified proportions and ground in a mortar mill with addition of required quantity of water. Sand shall then be added to the mix and the mixing and grinding repeated till every aggregate particle gets coated uniformly with the cementing materials.

5.19.4 Preparation of Composite (Gauged) Mortars

Where coarse sand is used, the lime putty and the sand in the required proportions shall, after preliminary mixing on a water tight platform with necessary addition of water, be ground in a mortar mill taking care to rake up continuously the mortar particularly at the corners, and also adding water as and when required during grinding. This mix shall then be transferred to a mechanical mixer to which the required quantity of cement is added and the contents mixed for atleast three minutes. Where fine sand is used, the mixing operations shall be done in the same manner except that grinding may be omitted for the preliminary mixing of lime putty and sand.

If the mixture of lime putty and sand is not used immediately for mixing with cement, it shall be kept protected from drying out till the time of use.

Where adding water finally in the mortar during mixing operations, it shall be ensured that it is added only to the extent necessary for obtaining working consistency for the mortar and not more.

5.19.5 Preparation of Mud Mortar

The dry soil shall be reduced to fine powder and mixed with water in a pit. The soil mix shall be allowed to mature for a period of about 7 days. During this period, it shall be worked up at intervals with feet and spader so as to get pugged into a homogeneous mass free from lumps and clods. The consistency of the mortar shall be adjusted by taking it on a trowel and observing how it slides off the face of the trowel. The mortar shall readily slide off, but at the same time shall not be so wet as to part into large drops before falling.

5.19.6 Time of Use of Mortars

Mortars with cement as an ingredient shall be used as early as possible after mixing, preferably within half an hour from the time water is added to the mix or at the latest within one hour of its mixing.

5.19.6.1 Lime mortars shall be used as soon as possible subject to the following provisions :-

(a) Lime mortars made with eminently hydraulic lime (Class A) shall be used within four hours after grinding.
(b) Mortars which have semi-hydraulic lime (Class B) or fat lime (Class C) and pozzolana as ingredients, shall be used within 24 hours from the time of mixing of the mortar.

5.19.7 Workability of Masonry Mortars

The working consistency of the mortar is usually judged by the worker during application. The water used shall be enough to maintain the fluidity of the mortar during application, but at the same time it shall not be excessive leading to segregation of aggregates from the cement.

5.20 Setting Out

All brick work shall be set out and built to the respective dimensions, thickness and heights, as indicated.

5.21 Scaffolding

Scaffolding shall be strong to withstand all dead, live and impact loads which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work, overhand work shall not be allowed.

5.21.1 For exposed brick facing double scaffolding having two sets of vertical supports shall be provided. For brick work which is to be plastered over, single scaffolding may be provided. In single scaffolding one end of the putlogs shall rest in the hole provided in the header course of brick masonry. Not more than one header for each putlog shall be left out. Such holes shall not be allowed in the case of pillars or narrow masonry portions between openings which are less than one metre in width or are immediately under or near the structural member supported by the walls. The holes left shall be made good on removal of scaffolding to match with the facework/ surrounding area.

5.21.2 Timber or bamboo scaffolds shall be erected in accordance with the provisions contained in IS-3696 (Part I) -1987. Safety code for scaffolds and ladders, Part-I Scaffolds, to ensure safety of workmen and others. Steel scaffolding shall be erected in accordance with the provisions contained in IS-2750-1964, Specifications for steel scaffolding and relevant provisions of IS 3696 (Part-I)-1987.

5.22 Soaking of Bricks

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When bricks are soaked, they shall be removed from the tank sufficiently early so that at the time of laying, they are skin-dry. Such soaked bricks shall be stacked on a clean place, where they are not again spoiled by dirt, earth etc.

Note I: The period of soaking may be easily found at site by a field test in which the bricks are soaked in water for different periods and then broken to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in the construction work.

Note II: If the bricks are soaked for the required time in water that is frequently changed the soluble salts in the bricks will be leached out and subsequent efflorescence will be reduced.

5.23 Laying

All loose materials, dirt and set lumps of mortar which may be lying over the surface in which brick work is to be freshly started, shall be removed with a wire brush and surface wetted slightly. Bricks shall be laid on a full bed of mortar. When laying, the bricks shall be properly bedded and slightly pressed with handle of trowel so that the mortar can get into all the pores of the brick surface to ensure proper adhesion. All the joints shall be properly flushed and packed with mortar so that no hollow spaces are left. Care shall be taken to see that the required quantity of water is added to the mortar at the mixing platform to obtain required consistency. Addition of water during laying of the course shall not be permitted. In case of walls two brick thick and over, the joints shall be grouted at every course in addition to bedding and flushing with mortar.

5.23.1 While using old size bricks (FPS conventional bricks) top course of all plinths, parapets, steps and top of walls below roof slab or floor slab shall be laid with bricks on edge, applicable in case of traditional bricks unless directed otherwise. Care shall be taken that the bricks forming top courses and ends of wall are properly keyed into position.

5.23.2 Bricks shall be laid with frog up. However, when the top course is exposed, bricks shall be laid with frog down, care shall be taken to fill the frogs with mortar before embedding the bricks in position.

5.23.3 All quoins shall accurately be constructed and the height of courses checked with storey rods as the work proceeds. Acute and obtuse quoins shall be bonded, where practicable, in the same way as square quoins; obtuse quoins shall be formed with squint showing a three quarter brick on one face and quarter brick on the other.

5.24 Bond

All brick work shall be built in English Bond, unless otherwise indicated. Half brick walls shall be built in stretcher bond. Header bond shall be used for walls curved on plan for better alignment. Header bond shall also be used in foundation footings, stretchers may be used when the thickness of wall renders use of headers impracticable. Where the thickness of footings is uniform for a number of courses, the top course of the footings shall be of headers.

5.24.1 Half or cut bricks shall not be used except where necessary to complete the bond.

5.24.2 Overlap in stretcher bond is usually half brick and is obtained by commencing each alternate course with a half brick. The overlap in header bond which is usually half the width of the brick is obtained by introducing a three quarter brick in each alternate course at quoins. In general, the cross joints in any course of brick work shall not be nearer than a quarter of brick length from those in the course below or above it.

5.25 Uniformity

The brick work shall be built in uniform layers; corners and other advanced work shall be raked back. No part of a wall during its construction shall rise more than one metre above the general construction level, to avoid unequal settlement. Parts of walls left at different levels shall be properly raked back. Toothing may be done where future extension is contemplated but shall not be used as an alternative to raking back.

5.25.1 For half brick partition to be keyed into main walls, indents shall be left in the main walls.

5.26 Alignments and Perpends

The walls shall be taken truly plumb or true to the required batter, where specified. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in the alternate courses shall come directly one over the other. Quoins, jambs and other angles shall be properly plumbed as the work proceeds. The maximum permissible tolerances in masonry shall be as under :-

(a) Deviation from vertical within a storey per 3m height	6mm
(b) Deviation from vertical in the total height of a building	12.5mm
(c) Deviation of bed joints from horizontal	
(i) in any length upto 12m	6mm
(ii) in any length over 12m	12.5mm total

5.27 Thickness of Joints

Thickness of joints shall be such that four courses and three joints taken consecutively shall measure as follows unless otherwise specified:

(i) Old size brick - Equal to four times of actual thickness plus 4cm
(ii) Modular brick -Equal to 39 cm

In cases of soakage pits, cesspools, manholes and the like, the thickness of joints upto 15mm may be adopted. Where brick work to match the existing work, the joints shall be of the same thickness as in the existing work.

5.28 Striking Joints

Where no pointing, plastering or other finish is indicated, the green mortar shall be neatly struck flush. Where pointing, plastering or other finish is indicated, the joints shall be squarely raked out to a depth not less than 10mm for plastering and 15mm for pointing.

5.29 Protection against damage

Care shall be taken during construction that edges of jambs, cills, heads etc. are not damaged. In inclement weather, newly built work shall be covered with gunny bags or tarpaulin so as to prevent the mortar from being washed away.

5.30 Curing

The brick work shall be constantly kept wet for at least seven days, except in the case of brickwork with mud mortar for which no such curing shall be done. In case of fat lime mortar, curing shall commence two days after the laying of masonry and shall continue for seven days.

5.31 Facing

In case of walls one brick thick and under, at least one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plane.

5.31.1 For exposed brick work, selected bricks of the specified class shall be used for the face work. Where however, use of facing bricks is indicated, brick walls shall be faced with facing bricks. No rubbing down of brick work shall be allowed.

5.31.2 Brick walls shall be plastered, pointed or otherwise finished, as indicated. Joints of external faces of brick walls in foundation upto 15 cm below ground level and of internal faces of brick walls in foundation and plinth below sub floor level shall be struck flush when the mortar is green, as the work proceeds.

5.32 Cleaning

Face of brick work shall be cleaned on the same day it is laid and all mortar droppings removed.

5.33 Brickwork Curved on Plan

Brick work curved on plan to a radius exceeding 6m shall be built as described for general brick work but where the inner radius is 6 metre or less, all courses shall be of header with bricks roughly cut to the radius or with wedge shaped joints, unless otherwise indicated.

5.34 Architectural Features

5.34.1 Architectural brick work shall be laid integral with brick work so as to form proper bond with the main work and in such a way that the main structure is not weakened. In corbels, over sailing courses etc. no course shall project more than one fourth of the brick length beyond the course immediately below. In such cases, all bricks shall be laid as headers. The bricks shall be purpose made where specified or cut and dressed to the required shape wherever necessary. Mitres and stops to splayed bull nosed, rounded or moulded angles, rebates etc. shall be provided as required or directed.

5.34.2 In important works a special template (wooden or steel) shall be prepared as per drawing to guide the laying of bricks in moulded work. Where plastering is specified, the template shall be prepared taking into account the thickness of plaster.

5.34.3 Cornices

These shall not ordinarily project by more than 15 to 20 cm and this projection shall be obtained by projecting each brick course by not more than one fourth of the brick length.

5.34.4 Corbelling shall be brought roughly to shape by plastering with the specified mortar. The moulding shall then be finished straight and true with the help of templates when the mortar is still green. Where a single course corbel is required for the support of some structural part, the horizontal projection of the corbel shall not exceed the least of the following :

(a) One half of the built-in part of the corbel;
(b) One half of the height of the corbelling; and
(c) One third the thickness of supporting wall, or 10 cm whichever is more.

5.34.5 Brick Coping and Cills

Bricks in coping and cills in external walls shall be slightly tilted for weathering as directed. Where brick copings and cills are projecting beyond the face of the wall, drip throating shall be provided where indicated.

5.35 Construction Details

5.35.1 Chases, Rebates, Reveals, etc.

Chases, rebates, reveals, etc shall be formed in wall as required to receive frames, floors, pipes, conduits, corrugated sheets etc. as required or indicated.

5.35.2 Beam Filling

Beam filling shall be executed to the full thickness of the walls by cutting and fittings brick work around ends of rafters, joists, etc., and leaving air-space where directed and making good in mortar as for adjacent brick work.

5.35.3 Bedding Wall Plates, etc.

Wall plates lintels, templates, cover stones etc. shall be bedded in the same mortar as for adjacent brickwork unless otherwise indicated and finished to match brick work. Walls shall be leveled and prepared to receive wall plates, etc., as required.

5.35.4 Fixing of Wooden Frames

Timber doors and windows frame shall be fixed as the brick work proceed without gap between the masonry and the frames. The doors and windows frames may also be fixed in prepared opening at contractor's option. Fixing shall be done generally with hold fasts securely embedded in the brick work. The chases shall later be filled up with cement and sand mortar (1:3) or concrete (1:2:4) type B-O in case of bigger chases. Hold fasts shall be fixed in the brick work for the specified length and then turned up at the end into a cross joint. Hold fasts shall be given with protective coat of bitumen to avoid rusting. Wooden faces in contact with brick work shall be treated with good preservative as indicated.

5.35.5 Fixing of Metal Frames

Metal frames shall be fixed into prepared openings and not built in as the walls go up. Steel doors and windows shall be fixed in the opening as described in Section 10 : Steel and Iron work.

5.35.6 Bedding Roof Tiles, Corrugated Sheets etc.

Roof tiles, sheets, etc., butting against parapet walls, etc., shall be solidly bedded in chases formed in the walls and finished with a neat weather fillet as specified on the upper side and pointed on the underside. Tiles and sheets overlapping tops of walls shall be solidly bedded and pointed on exposed edges, as required. Bedding and pointing shall be in the same mortar as for adjacent work, unless otherwise indicated.

5.35.7 Building in or Cutting and Pinning in and Pointing

Cills, threshold, steps, landings, corbels, lintel heads, purlins, ends of joists, etc. shall be built in or cut and pinned into brick work in mortar as for adjacent work, facing properly made good and pointed as required to match adjacent work.

5.35.8 Holes for Pipes etc.

All necessary holes for pipes, air flues, ventilators etc. and mortices, where required for dowels, bolts, etc. shall be cut or framed as work proceeds and grouted in cement and sand mortar 1:3 or cement concrete 1:2:4 as required and made good.

5.35.9 Provision for Services Installations

To facilitate taking service lines later without inordinate cutting of completed work, sleeves and chases shall be provided during the construction itself.

5.35.10 Fastening and Fixing Stocks

All holdfasts, securing bolts and other fixings for fittings etc., shall be securely built in as the work proceeds. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.

5.35.11 Setting Gratings, Soot Doors, etc.

Vents shall be formed in brick walls. Doors, fire bricks and grates, etc., of sizes as indicated, shall be built in as the work proceeds.

5.35.12 Preparing Tops of Existing Walls

Where necessary the existing walls shall be prepared by removing off the top portions, levelling the surfaces, sweeping, cleaning and keeping wet for two days before building the new work upon them.

5.35.13 Levelling upon Girders

Rivetted tops of girders shall be leveled with cement mortar (1:3) before brickwork is built upon them.

5.35.14 Bearing of Floors, Roofs, etc.

Tops of walls bearing the edges of RCC floors, roof slabs, beams or lintels shall be finished with a layer of cement mortar (1:4), 15mm thick and the plastered surface white washed; unless otherwise indicated. Where the bottom of slab does not coincide with the level of brick course after cement plaster, the level shall not be made up with cut bricks. The gap shall be made up either by increasing the thickness of slab at bearmg or where feasible by using brick tiles, so that the bearing is directly on the plaster layer.

5.35.15 Weather Fillets

These shall be square, rectangular, trapezoidal or triangular in section with edges rounded if directed, finished even and smooth in the mortar as indicated. Filleting shall include making all mitres and stops.

5.36 Vertical Reinforcement in Masonry

Vertical reinforcement at the corners and junctions of walls and jambs of openings, doors, windows etc. shall be provided as indicated. Reinforcement may be of mild steel bars or deformed bars or TMT bars and shall be embedded in cement mortar or cement concrete cover as indicated. The reinforcement shall be properly embedded in the plinth masonry, foundations and roof slab or roof band and passing through the lintel bands in all the storeys. Bars in different storeys may be welded or suitably lapped.

5.37 Half Brick Walls-Reinforced

The bricks shall be laid in stretcher bond in cement and sand mortar (1:4) or as indicated. Lime mortar shall not be used. The reinforcement may be in the form of mild steel flat or round bars or deformed bars or TMT bars as indicated and as described in Section 10-Steel and Iron work and Section 4-Concrete. The diameter of bars or thickness of flats shall not exceed 8mm. The reinforcement shall be used in every third or fourth course of the brick work as indicated. They shall be securely anchored at their ends where the partitions bond. The inlaid steel reinforcement shall be completely embedded in mortar. Overlaps in reinforcement, if any, shall be not less than 30 cm. The cover that is the mortar interposed between the reinforcement bar and brick shall be not less than 6mm. The mortar covering the direction of joints shall be not less than 15mm.

5.38 Honey Comb Brick Work

Half brick thick walls shall be built throughout in stretcher bond keeping holes of rectangular shapes or of the shapes as directed. One brick thick walls shall be of whole bricks throughout, laid as headers. Bricks shall have a minimum bearing of 40mm for half brick and 20mm for one brick thick walls on either side. The thickness of joints shall be 10mm + 3mm. The joints shall be finished flush when the mortar is green or shall be squarely raked and pointed with cement and sand mortar (1:3) where indicated.

5.39 Cavity Walls

5.39.1 Cavity walls of the specified thickness shall be set centrally on the base. The cavity shall be not less than 4 cm and not more than 8 cm. The two leaves shall be tied together with wall ties; not less than five ties shall be provided per Sqm of the wall area. The lower portion of the cavity shall be filled with lean concrete upto a few centimeters above the existing ground level. The top of concrete filling shall be sloped with weep holes at 1 m intervals along the outer leaf of the wall.

5.39.2 Unless otherwise indicated, wall ties shall be of 20 x 3mm galvanized mild steel flats, 20 cm long, twisted through 180° in the middle and fish tailed at ends. The ties shall be given a coat of bitumen paint before building in. They shall be securely embedded in cement mortar.

5.39.3 Bricks shall be laid very carefully to leave the cavity free from mortar droppings. Two leaves of the wall shall be raised simultaneously and uniformly. The position of wall ties shall be predetermined so as to have uniform spacing.

5.39.4 The cavity shall be made free from rubbish and mortar droppings by means of a timber batten 25mm thick and width about 12mm less than the cavity resting over the ties. The batten may be lifted by means of wires attached. Openings at the base opposite each run of cavity, shall be left so as to permit raking and cleaning out the cavity on completion. The openings shall be bricked up afterwards to conform with the surrounding work.

5.39.5 The jambs of the openings, doors or windows shall be built solid by means of headers which shall be suitably bonded with main cavity wall leaves. The cills of the windows shall be of brick headers. The lintel shall cover full width of the wall and the bearing of the lintel shall be sufficiently strong and solid. The top of the cavity wall shall be built of at least two solid courses of bricks. Where a non-load bearing cavity wall finishes under RCC beams, this provision may be omitted.

5.39.6 The ventilation of cavity may be done by use of gratings where indicated. The duct opening which extends through the two leaves of the wall, shall be sealed at the top, bottom and the two sides where it passes across the cavity.

5.39.7 Unless otherwise indicated, the cavity shall extend at least two courses below the damp proof course which shall be independent in the inner and outer leaves.

5.40 Brick Arches (See Fig. 1)

5.40.1 Centering

All arches shall be formed on a well constructed centering. The centering shall be sufficiently rigid so that with full load coming on it, the correct curvature and shape of the arch is maintained. To ensure continued accuracy of the centres, templates, moulds and profiles etc shall from time to time, be tested by comparing with full size drawings laid out on the platform.

5.40.1.1 When a number of arches in adjacent spans are to be constructed, the number of centering shall be adequate to ensure the stability of the arches and the supporting structure at the time of striking the same.

5.40.1.2 For arches of about lm span, centering shall consist of honey comb brick work/timber framework made to shape and supported on planks of sufficient strength. The planks shall be suitably held in position. For spans larger than 2 m, timber centering shall be used and shall be provided with hardwood wedges for slackening the centres. Steel centering of adequate strength may be used in lieu. Sand boxes shall be used for slackening for spans over 6 metres.

5.40.1.3 Centering shall not be struck before one week after the completion of the arch. When using lime mortar centres may be generally slackened within 24 hours after completion of the arch. Care shall be taken that the centres are not slackened while the mortar in the joints is still so soft that it may be squeezed out, but at the same time, the centres shall be slackened while the mortar is moist so as to allow the arch to compress itself and bring all the joints to fair bearing.

5.40.2 Circular Arches

These shall be either plain arches, built in half brick concentric rings using uncut bricks with break-joints; or gauged arches, using bricks cut or moulded to proper shape. The arch work shall be carried up from both ends simultaneously and keyed in the centre. The bricks shall be flushed with mortar and well pressed into their position so as to squeeze out a part of their mortar and leave the joint thin and compact. The thickness of joint shall be not less than 5 mm nor more than 15mm.

5.40.2.1 After the arch is completed, the haunches shall be loaded by filling up the spandrels upto the crown level of the arch. Care shall be taken to load the haunches on the two sides of the spandrels uniformly.

5.40.2.2 Where the arch is to be pointed the face bricks shall be cut to proper shape or moulded. These shall be laid with radial joints to the full depth of arch. The voussoirs shall break joint with each other. Radial joints shall be perpendicular to the tangent to the curve of the arch at each point at right angle to the face.

In multiple arches the key brick stone shall not be inserted in any one arch until the adjacent arch or arches have been at least 25 percent constructed so as to counteract the end thrust.

5.40.2.3 The bricks of the spandrel wall at their junctions with the extrados of arch shall be cut to fit the curvature of the arch. In all cases centre line of the brick faces shall be radially placed.

5.40.3 Flat Arches

These shall be gauged arches of bricks cut or moulded to proper shape. The extrados shall be kept horizontal and the intrados shall be given slight camber of 1 in 100 of the span. Bricks shall be laid with radial joints to the full depth of arch and voussoirs breaking joints with each other. The arch work shall be carried up from both ends simultaneously and keyed into the centre. The thickness of joints shall not exceed 3mm.

5.40.4 Skew backs

Bricks forming skew backs shall be cut so as to give proper radial bearing to the end voussoirs.

5.40.5 Face joints shall be raked back by 12mm where plastering or pointing is specified. The joints shall be struck flush as the work proceeds where plastering or pointing is not specified. Defects in dressing shall not be covered up by excessive use of mortar, nor shall the use of chips be allowed.

5.41 Retaining Wall

Retaining wall shall be built as indicated in the specified mortar with beds perpendicular to the exterior face. The laying of bricks shall generally comply with the requirements specified for general brick work.

5.41.1 Unless otherwise indicated/directed, weep holes, 50mm to 75mm square shall be provided at about every 2m vertically and horizontally, the lowest weep hole being about 30 cm above the ground level. Weep holes shall have sufficient fall to drain out the water quickly. The inlet of all weep holes shall be surrounded by loose stones as directed.

5.42 Damp Proof Course

5.42.1 Damp proof course (DPC) shall consist of a layer of cement concrete or cement mortar of the proportions and thickness as indicated. In the case of solid walls, piers etc, the DPC shall run the full width of walls just below it. Damp proof course shall run without a break throughout the length of wall, even under door or other opening.

5.42.2 The surface of masonry on which the damp proof course is to be laid shall be leveled flushed up with mortar and properly prepared. Cement concrete and cement mortar shall be, where indicated, admixed with integral water proofing compound in the specified proportion as per the manufacturers' instructions. Cement concrete or cement mortar on laying, shall be thoroughly compacted to dense impervious mass and cured for atleast seven days. The upper surface and sides which are not exposed shall be finished fair and even and exposed surfaces finished fair and smooth and flush with the masonry surface unless otherwise indicated.

5.42.3 A sandwich layer of polythene film in the damp proof course shall be provided where indicated. Bitumen primer shall be applied to the prepared surface at 0.3 to 0.5 Kg per Sqm by brushing till the surface is properly impregnated and allowed to dry for 6 to 12 hours or till the solvent oil in the primer evaporates completely. The polythene film shall then be carefully laid on the primed surface and firmly but carefully pressed down with the help of gunny cloth so as to prevent any damage to the film. The next length shall be similarly laid down with proper end overlap and firmly pressed. The overlaps shall be carefully sealed with hot bitumen applied over the upper surface of lower layer of polythene film. Over stretching of the film at the time of laying shall be avoided.

5.42.3.1 The laying of the film shall be immediately followed by subsequent treatment. If the film is left exposed it may cause wrinkles in the film which may possibly lead to damage. Where polythene film is to be carried over from horizontal to vertical surface it shall be over a fillet and properly protected.

Bitumen coat on DPC, where indicated, shall be of blown type bitumen of the required grade complying with IS 702 : 1988 - Specification for Industrial Bitumen (Second Revision). The bitumen shall be at temperature slightly higher than the softening point to make it workable. The concrete/mortar surface shall be thoroughly cleaned and mopped dry before applying bitumen. The bitumen shall be applied at the rate of 1.50 Kg per square meter, to a uniform thickness and the surface shall be blinded with clean dry sand at the rate of 0.05 cubic metre per square metre.

5.43 Well Sinking

Excavation (including allowance for working space) shall be carried out in the ordinary way down to the water table or to the level beyond which the soil cannot stand without support. At this point the curb (wooden or reinforced cement concrete or steel) shall be placed and firmly embedded. The steining shall then be built on the curb till it is 2m or so above ground. The earth inside shall be scooped out and the cylinder gradually sunk till its top has very nearly reached the ground level. Another 2 to 3 m of steining shall then be added till the required depth is attained. To assist in the sinking, the well shall be weighted with iron rails or gunny bags filled with sand supported on a timber platform in which opening shall be left for working dredgers, etc. Great care shall be taken to ensure the vertical sinking of the steining. Four plumb bobs shall be suspended around the interior of the well continuously to ensure the accuracy of sinking. Should any cant develop during the sinking, it shall be immediately corrected by dredging under the high side.

To secure the curb to the steining and to prevent the lower part of the cylinder-detaching itself from the upper in a sudden descent during sinking, several vertical iron tie rods, or bolts 6m to 10m long as directed, shall be built into the steining from the bottom of curb, their upper ends being connected under the bolt heads by flat iron horizontal ring.

If the brick steining splits during the sinking and in the opinion of GE is unsound the Contractor shall dismantle the whole or part as ordered by the GE and reconstruct without extra charge.

Bricks for steining shall be moulded or cut as indicated, to template and shall be built in the bond and of the thickness and in mortar as indicated. Joints shall not exceed 10mm + 5mm in thickness. Both internal and external faces of steining shall be raked out for plastering or pointing where indicated or finished with neat flush joint as the work proceeds.

5.44 Fireplace Openings

Fireplace openings shall be built in cement mortar (1:4), unless otherwise indicated and as detailed in the drawings. Fireplace openings shall have proper throats at the entrance of flues for proper air draught.

5.45 Chimney Stacks

Chimney stacks above roof level shall be built as specified for general brickwork and to the required dimensions. At the top of chimney stack, opening shall be left in the stack to form smoke outlets and the stack covered with a capping properly bedded, as indicated. Flues shall be pargetted internally and the external face finished as for external wall face. All chimney stacks and face to all brick work of flues, where passing through timber floor and roof spaces, shall be rendered rough in cement and sand mortar (1:4) or as directed.

5.46 Pargetting Flues

All smoke flues, other than those lined with fire bricks or pipes, shall be pargetted as the work proceeds, with 20mm thick mortar consisting of 1 part lime, 2 parts sand and 1 part cow dung and well worked into all joints. Pargetting shall be slightly rounded at the joints and corners and carefully cored on completion.

5.46.1 Coring

To free the flue from all mortar droppings or other obstructions which might adhere to the lining, the flue shall be cored during construction. The core shall be composed of a sack to which a rope is attached, filled with a resilient material so that it fits the flue properly. It shall be inserted at the base of the flue and pulled through as the work proceeds. Where necessary, coring holes shall be left for inserting the core. When the flue or chimney is complete, a core shall be drawn through the flue from the bottom to the top to ensure all obstructions are removed.

5.47 Sweeping Chimneys

All flues shall be accessible and provide a free way for the flue brush. Arrangement shall be made so that soot and dust removed can be collected with a minimum of mess. Chimneys shall be properly swept clean of all soot and other obstructions.

5.48 Firebrick Work

Firebrick work shall be carefully constructed to the required thickness and shape as detailed in the drawings or as directed. All wedge, radial and other shape bricks shall be purpose made.

The laying of firebricks shall generally comply with the requirements specified for general brick walling. Firebricks shall be merely dipped in well puddled fire clay mixed with water to the consistency of paste, so that there is no appreciable thickness of joints between the fire bricks.

5.48.1 Fire Brick Lining

Shall be laid with one course of headers followed by two courses of stretchers. The outer ordinary brick work, if any, shall be built in cement and sand mortar 1:4 to correspond with this setting. Fire brick work shall be pointed in fire clay mortar. Broken brick filling shall not be permitted.

5.49 Acid Resistant Brick Work

5.49.1 Surface Preparation

The surface on which the chemically resistant bricks or tiles are to be laid, shall be free from dirt and dampness and shall be properly cured and dried.

5.49.2 Bedding and Jointing

5.49.2.1 For bedding and jointing, manufacturer's instructions shall be followed invariably.

5.49.2.2 While using resin mortars, about 6 to 8 mm thick layers of mortar shall be spread on the back of tile or brick. The two adjacent sides of the brick or tiles shall be smeared with 4 to 6mm thick mortar. The brick or tile shall be pressed into the bed and pushed against the wall or adjacent brick/tile until the joints are not more than 3mm thick. Excess mortar shall be trimmed off.

5.49.2.3 While using sulphur mortar, spacer chips with a surface area of about one cm^2 and 6mm thick, made of sulphur mortar, shall be placed under the chemically resistant bricks/tiles, 3 chips being used under each brick/tile. Between the floor and the brick/tile, molten sulphur mortar shall be poured in one or two operations avoiding air pockets, till it completely fills the joints.

The sulphur mortar shall be heated to a temperature of about 135°C, unless otherwise indicated by the manufacturer, to a black and smooth liquid with mirror bright surface and the liquid is almost as free flowing as water. The sulphur mortar must be dry at the time of use to avoid fuming. If mortar thickens on overheating, it shall be allowed to cool and stirred until it is thin; more cold mortar may be added, if necessary. Overheating for long periods may permanently damage the mortar.

5.49.3 Cleaning

In case of sulphur mortar, paraffin wax paper shall be used to cover the structural units to prevent the sulphur mortar from adhering to them. The paper shall be removed after use. In case of resin mortar, manufacturer's instructions shall be followed for cleaning of mortar from face of the masonry units before hardening.

5.49.4 Curing

Floors shall not be put to service before 48 hours of laying or as recommended by the manufacturer.

5.50 Joining Old Brickwork with New Brickwork

Joining shall be done in such a way that there shall not be any hump or projection at the joint. The thickness of each course of new work shall be made equal to the thickness of the corresponding course of the old work by adjusting thickness of horizontal mortar joints; and the wall wherever necessary shall be made exactly to the same thickness of by adjusting the thickness of vertical joints.

5.50.1 While joining brickwork built with old size bricks with modular bricks the thickness of each alternate stage of three courses of modular bricks shall be made equal to the thickness of each alternate stage of four courses of old size bricks by adjusting thickness of horizontal mortar joints in new brick work.

5.50.2 For joining new cross wall to old main walls, a number of rectangular recesses in the main wall shall be cut of width equal to the width of the cross wall, three courses in height and a half a brick in depth; a space of minimum three courses being left between the sinkings. The new cross wall shall be well bonded into the recesses to avoid any settlement.

5.50.3 In general, the height of number of consecutive courses cut in a block to form the tooth in the old work shall correspond to the height of the number of courses forming the tooth in the new work. The cutting in the old work shall be alternate blocks of equal number of courses matching to courses in the toothing.

5.51 Additions to an Old Building

While making additions to an old building, if toothing with old masonry is likely to cause cracks occurring at the junctions because of differential settlement; the new masonry shall be built with straight butt joints only for walls upto one brick thick and with a slip joint for thicker walls.

5.52 Cutting Opening in Old Walls and Forming Jambs, etc.

Opening in old walls shall be formed for doors, windows, etc. or existing openings enlarged as indicated. All serviceable bricks etc shall be cleaned and stacked for reuse or removed to store as directed and all rubbish cleared away and removed. Shoring and scaffolding, as may be required shall be provided, fixed and removed.

5.52.1 Forming jambs, etc. to openings and cutting and pinning under cills, over arches, lintels, bressummers, etc. shall be executed with old bricks or as directed old brickwork shall be cut and toothings formed to bond in new work to match the existing. Jambs shall be square or splayed and with or without reveals as indicated. Facing, plastering or pointing all round the opening, shall match the existing work.

5.53 Underpinning

All underpinning shall be executed in short lengths, as directed by Engineer-in-Charge with selected bricks laid in cement and sand mortar as indicated, well grouted at every course and carefully wedged up with approved material in cement and sand mortar to the underside of old wall or foundation.

All requisite timbering, needling, shoring etc., shall be provided and fixed to ensure the safety of the structures whilst underpinning. All disturbed work shall be made good.

5.54 Brick Edging

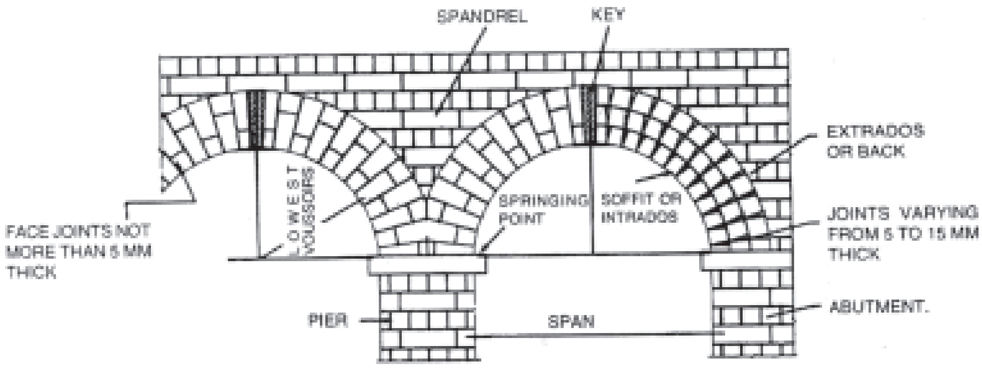
Brick edging to roads, paths, hard-standing, etc. of the specified width shall be laid on edge or on end, vertically or at the required angle as indicated. The bricks shall be laid dry and embedded in the ground to the depths as directed. The earth around the bricks shall be tamped and surplus spoil, if any, shall be removed and disposed off, as directed.

5.55 Broken Glass Coping

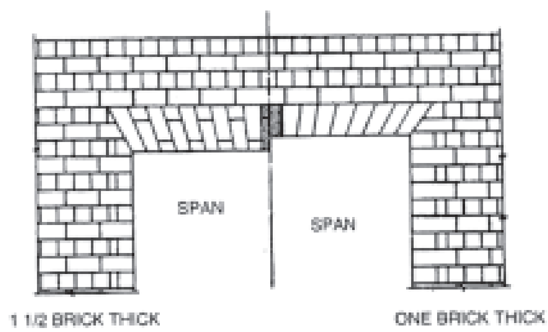
Top of walls, where so indicated shall be rendered with 25mm layer of cement mortar (1:3) or lime mortar (1:2) as required with a rounded or weathered finish and before the mortar has set, glass (of bottle or thick glass) broken to approximately 63mm gauge, shall be firmly embedded at the rate of 10 Kg of glass per square metre of rendered surface, jogged edges of the glass being left projecting.

5.56 Scaffolding

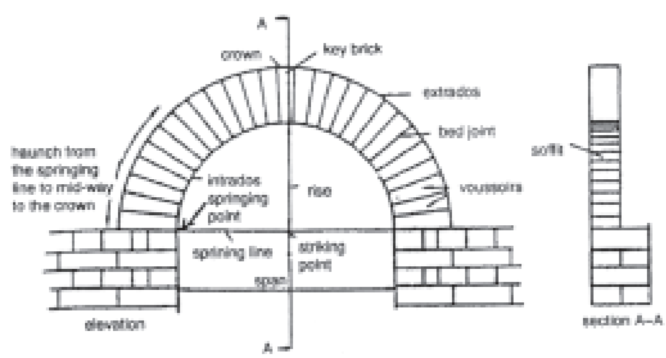
Use of tubular steel scaffolding shall be mandatory for buildings over three storey high.



CIRCULAR ARCH



FLAT GAUGED ARCH



SEMI CIRCULAR ARCH

FIG. 1 : BRICK WORK IN ARCHES

SECTION 6
STONE MASONRY

6.1 Indian Standards

The following Indian Standards apply to this section.

I.S No	*Subject*
1121 Part I - 1974	Methods of test for Determination of Strength Properties of Natural Building Stone - Part I: Compressive Strength
1122 - 1974	Methods of test for determination of specific gravity of natural building stones (First Revision)
1123 - 1975	Methods of identification of natural building stones (First Revision)
1124 - 1974	Method of Test for Determination of Water Absorption, Apparent Specific Gravity and Porosity of Natural Building Stones (First Revision)
1125 - 1974	Methods of test for determination of weathering of natural building stones (First Revision)
1126 - 1974	Methods of test for determination of durability of natural building stones (First Revision)
1128 - 1974	Specification for Lime Stones (Slab & Tiles) (First Revision)
1129 - 1972	Recommendations for Dressing of Natural Building Stones (First Revision)
1597 Part 1 - 1992	Construction of Stone Masonry - Code of Practice - Part 1 : Rubble Stone Masonry (First Revision)
1597 Part 2 - 1992	Construction of Stone Masonry - Code of Practice - Part 2 : Ashlar Masonry (First Revision)
1706 - 1972	Method for Determination of Resistance to Wear by Abrasion of Natural Building Stones (First Revision)
1805 - 1973	Glossary of terms relating to stones, quarrying and dressing (First Revision)
3620 - 1979	Specification for Laterite stone block for masonry (First Revision)
3622 - 1977	Specification for Sand Stone (Slab & Tiles) (First Revision)
4101 Part 1 - 1967	Code of Practice for External Facings and Veneers - Part 1 : Stone Facing

6.2 Stone

6.2.1 The stone shall be of the type specified such as granite, trap, other igneous rock, limestone, sand stone, quartzite, etc. and shall be obtained from the approved quarries, as indicated.

Stone shall be hard, sound, durable and free from weathering, decay and defects like cavities, crack flaw, sand holes injurious veins, patches of loose or soft materials and other similar defects that may adversely affect its strength and appearance. As far as possible, stones shall be of uniform colour and texture. Generally stone shall not contain crypto crystalline silica or chert, mica and other deleterious materials like iron oxide, organic impurities, etc.

6.2.2 In the case of stratified rocks, stones for building purposes shall be so quarried and assessed that when set in the building, the stones are laid along the plane of stratification.

6.2.3 The compressive strength and water absorption of common types of stones are given in the table below:-

Type of Stone	Water absorption percentage By weight Max.	Compressive Strength Kg/Sq cm. Min
Granite	0.50	1000
Basalt	0.50	400
Lime stone	0.15	200
Sand stone	2.50	300
Marble	0.40	500
Laterite stone	Not more than 12% by mass	35

Note 1: Test for compressive strength shall be carried out as laid down in IS : 1121 Part I - 1974, Methods of test for Determination of Strength Properties of Natural Building Stone - Part I : Compressive Strength.

Note 2: Test for water absorption shall be carried out as laid down in IS : 1124 - 1974, Method of Test for Determination of Water Absorption, Apparent Specific Gravity and Porosity of Natural Building Stones (First Revision)

Note 3: The percentage of water absorption shall generally not to exceed 5% for stones other than specified in table above.

6.2.4 Dimensions of Stones

Unless otherwise indicated , the length of stone for stone masonry shall not exceed three times the height and the breadth on base shall not be greater than three - fourth the thickness of wall. Height of stone may be upto 30cm. Minimum dimensions of stones (except slate stone) for various types of masonry shall be as given below:-

(a) Stone for random rubble masonry may be of any size and shape but shall be not less than 15 cm in any direction.
(b) Stones for squared rubble masonry shall be not less than 15 cm in length and width.
(c) Stones for block-in-course masonry shall be not less than 20 cm in breadth or height and length not less than twice the height.
(d) Stones for ashlar masonry shall be not less than 30cm in breadth and height and length not less than twice the height.
(e) Stones for cills shall be of full thickness (depth) and width. Length of stones shall be as large as available but normally not less than 90cm.
(f) Stones for lintels shall be of full thickness (depth) and length. Where some lintel of full width is not available two stones may be used to make the width.
(g) Stones for copings shall be of full thickness and width. Length of stones shall be as large as available but not less than 30 cm.
(h) Stones for kerb stone shall be of size as indicated. The length shall not be less than the height.
(i) Stones for arches, domes, and circular moulded work - the dimension shall depend on the particulars of the curve.

6.3 Laterite Stone

The laterite stone shall be compact in texture and mottled and streaked with various colours like brown, red and yellow. It shall not contain white clay or lithomarge or appreciable number of sinuousities which are deep. The blocks shall be obtained, as far as possible, from a good ferrugenous variety of laterite which hardens on exposure after it is quarried. Laterite stone shall be obtained from an approved quarry.

6.3.1 The specific gravity of the laterite stone shall be not less than 2.5. The compressive strength of the blocks to be used in masonry work shall not be less than 35 kg/sq cm in its dry condition. The water absorption after 24 hours of immersion in water shall not be more than 12 percent. Laterite stone shall be dressed soon after quarrying when it is soft enough to be cut with a pick and easy to make into rectangular blocks. After quarrying, the stone shall be allowed to season for some time before using in work.

6.4 Boulders

Boulders shall be rounded or sub-angular stones with sufficient base area to be stable. They shall be sound, hard, durable, free from laminations, seams, soft spots, cracks and other deflects. Specific gravity shall be not less than 2.5. They shall be obtained from the approved sources as indicated.

6.4.1 Boulders shall be of reasonably uniform size. The minimum dimensions at any section shall be not less than half the average dimension of stones along the longest axis. Generally, large size boulders with minimum dia not less than 15 cm shall be used in all boulder work except in hearting for bunds and thick walling where small boulders between 7 to 15 cm minimum dia may be used to the extent of 50 percent of hearting.

Note:- The minimum diameter shall mean the least diameter of the boulder across its mid - section

6.4.2 In the case of pitching, the average dimension of boulders along the longest axis shall be approximately equal the thickness of pitching.

6.5 Masonry Mortars

For masonry mortars and their constituents, refer Section 5-Brickwork. The mix of masonry mortar shall be as indicated.

6.6 Dress Stone Work

The various dressing specified shall have the following meanings.

6.6.1 Rubble

Stones of irregular shapes and sizes as quarried, with irregular angles taken off.

6.6.2 Self Faced Surfaces

Surface of stone slabs used for roofing, flooring, lintels, etc. as obtained from quarry.

6.6.3 Squared Back Surface

Means the surface shall be dressed back at right angles to the face of stone.

6.6.4 Chisel Drafted Margin

The dressing done with a drafting chisel in narrow strips of width generally 2 to 5 cm. Chisel drafted margin shall be punch dressed.

6.6.5 Hammer Dressed Surfaces

A hammer dressed stone shall have no sharp and irregular corners and shall have a comparatively even surface so as to fit well in masonry. Hammer dressed stone is also known as hammer faced, quarry faced and rustic faced. The bushing from the general wall face shall not be more than 40mm on an exposed face and 20mm on surfaces to be rendered (See Fig. 1).

6.6.6 Rock Faced Surfaces

A rock faced stone shall have a minimum of 25mm wide chisel drafted margin at the four edges; all the edges being in the same plane (See Fig. 2).

6.6.7 Rough Tooled Surfaces

A rough tooled surface shall have series of band, made by means of a plane chisel 4 to 5 cm wide, more or less parallel to tool marks all over the surface. These marks may be either horizontal, vertical or at an angle of 45°, as directed (See Fig. 3) . The edges and corners shall be square and true. The depth of gap between the surface and straight edge held against the surface shall not be more than 3mm (Rough tooled stones are used where fairly regular plane faces are required for masonry work).

6.6.8 Punched Dressed Surfaces

A rough tooled surface is further dressed by means of a punch chisel to show series of parallel ridges. The depth of gap between the surface and a straight edge held against the surface shall not exceed 3 mm (See Fig. 4). (Punched dressed stones are used where even surfaces are required)

6.6.9 Close Picked Surfaces

A punched stone is further dressed by means of a point chisel, so as to obtain a finer surface, ridges or chisel marks left over being very tiny . The depth of gap between the surface and a straight edge kept over the surface shall not exceed 1.5mm (See Fig .5.)

6.6.10 Fine Tooled Surfaces

Close picked surface is further dressed so that all the projections are removed and fairly smooth surface is obtained. The surface shall have 3 to 4 lines per centimeter width depending on the degree of hardness of stone and degree of fineness required (See Fig.6). (This type of dressing is commonly adopted for ashlar work).

6.6.11 Polished Surfaces

Polishing of stones shall be done by rubbing them with a suitable abrasive, wetting the surface where necessary with water. Alternatively polishing of stones shall be done by holding them firmly on the top of a revolving table to which some abrasive material like sand or Carborundum is fed. The final polishing shall be performed by rubber or felt, using oxide of lime (called by trade as 'putty powder') as a polishing medium.

6.6.12 Moulded

Cut to profile of a moulding with punched dressed surfaces, unless otherwise specified.

6.7 Types of Stone Masonry

6.7.1 Random Rubble Masonry

(a) **Uncoursed:-** This type of masonry is constructed of stones as they come from the quarry. The mason selects stones of all shapes and sizes, more or less at random, and places them in position to obtain a good bond, while restricting cutting of the stones to the removal of inconvenient corners with a scabbling or spalling hammer (See Fig. 7)

(b) **Brought to Courses :-** This walling is similar to uncoursed random rubble except that the work is roughly levelled up to courses at intervals varying from 30cm to 60cm in height according to the locality and the type of stone used (See Fig.8).

6.7.2 Polygonal Rubble Masonry

Stone with no pronounced stratification is roughly hammer dressed or pitched into irregular polygonal shapes, and bedded to show the face -joints running irregularly in all direction (See Fig.9&10).

6.7.3 Squared Rubble Masonry

(a) **Uncoursed:-** In this type, the stones are roughly squared as risers or jumpers and stretchers with varying heights and are laid uncoursed (See Fig.11).

(b) **Brought to Courses:-** The stones are similar to those used for uncoursed rubble but the work is levelled to courses of varying depth from 30cm to 60cm according to the locality and the type of stone used (See Fig.12).

(c) **Coursed:-** Coursed walling is built in courses which may vary in height from 10 to 30 cm but the stones in any one course are roughly squared to the same height (See Fig.13).

6.7.4 Block in Course Masonry

This is hammer faced, regular coursed masonry in large blocks (See Fig.14).

6.7.5 Ashlar/Plain Ashlar Masonry

Stone blocks of the same height in each course are used and every stone is rough tooled on all beds and joints, full and true and faces dressed as indicated (See Fig. 15).

6.7.6 Sunk or Moulded masonry

The exposed faces of each stone block are gauged, cut grooved, rebated, sunk or plain moulded as indicated . Stone blocks of same height are used in each course (See Fig.16).

6.7.7 Chamfered Masonry

In chamfered masonry, the edges are beveled to 45" for a depth of about 2.5cm. Stone blocks of same height are used in each course.

6.8 General Requirements for Stone Masonry Construction

6.8.1 All stone masonry shall be set out and built to the respective type, dimensions, thickness and heights, as indicated.

6.8.2 All labours on stone shall normally be executed when it is freshly quarried.

6.8.3 Stones shall be sufficiently wetted before laying to prevent absorption of water from mortar.

6.8.4 The natural bed of the stratified stone shall be so laid that the pressure is always perpendicular to the strata. Stone in walling, steps, coping, cills etc, shall be placed with the grain or natural bed, horizontal. In arches the grains shall be parallel to the bed or voussoirs. In projecting cornices and corbels the natural bed shall be vertical and at right angle to the face of wall.

6.8.5 The courses shall be build perpendicular to the pressure which the masonry will bear. In case of battered walls, the beds of stones and the plane of courses shall be at right angle to the batter.

6.8.6 Vertical joints shall be staggered as far as possible. In the case of squared rubble coursed masonry, block-in-course masonry and ashlar masonry, stones shall break joints, on the face for at least half the height of the course and the bond shall be carefully maintained throughout.

6.8.7 Bell shaped bond stones or headers shall not be used.

6.8.8 All necessary chases for joggles, dowels, and cramps shall be formed in the stones beforehand.

6.8.9 Stones shall be laid on a full bed of mortar. All joints shall be properly flushed and packed.

6.8.10 The walls and pillars shall be carried up truly plumb or to the specified batter.

6.8.11 No part of the wall during its construction shall rise more than 1 metre above the general construction level to avoid unequal settlement. Where there is a break in masonry work, the masonry shall be raked back in sufficiently long steps for facilitating joining of old and new work. The stepping of the raking shall not be more than 30° with the horizontal.

6.8.12 At all angular junctions, the stones in each alternatives course shall be well bonded into the respective courses of the adjacent wall.

6.8.13 In alteration work, the stones shall gauge with existing courses, unless otherwise directed.

6.8.14 Protection

Care shall be taken during construction that edges of jambs, cills, heads, etc. are not damaged. In inclement weather newly built work shall be suitably protected by covering with gunny bags or tarpaulin.

6.8.15 Curing

Masonry work shall be kept constantly moist on all faces for a minimum period of seven days. Watering shall be done carefully so as not to disturb or wash out green mortar. In the case of lime mortar, curing shall commence two days after the laying of masonry and shall continue for seven days.

6.8.16 Bond Stones

Dressing of bond stones shall be done as for other stones. In coursed masonry full surface of the bed shall be dressed. In random rubble masonry, bond stones shall be hammer dressed on the face, beds and joints and made into a squared block.

6.8.16.1 For pillars with a cross sectional area 0.25 sqm and below, the bond stones shall be a single bond stone. For pillars exceeding 0.25 sqm, either it shall be single bond stone or it shall be made up of four stones provided in two courses crossing the joint at right angles as directed by the Engineer-in-Charge. The full bond stones shall be provided one at the bottom, one at the top and remaining in-between them at courses not exceeding one metre apart center to center.

6.8.17 Plain Cement Concrete Bond Stone

Plain cement concrete bond stones of mix 1:3:6 may be provided in lieu of stone bond stones, where indicated. The size and spacing of PCC bond stones shall be as specified for stone bond stone and shall be laid on the full section of the walling in one piece.

For ashlar and coursed masonry (except retaining wall) which are not to be plastered, the bond stone shall be only stone bond stones.

6.8.18 Construction Details

For constructional details respective specifications as given in Section 5, Brickwork shall apply.

6.8.19 Scaffolding

Proper scaffolds shall be provided as specified in Section 5,Brickwork.

6.8.20 Stone Masonry in Seismic Zones

Cement mortar leaner than 1:6, composite mortar leaner than 1:2:9, lime mortar leaner than 1:3 and mud mortar shall not be used for building masonry.

6.9 Facing

6.9.1 All surface of stone masonry, unless otherwise indicated, shall be hammer dressed, with bushes from the general wall face not more than 40mm on an exposed face and 20mm on the surface to be rendered. Facing superior to hammer dressing with bushes not more than 40mm shall not be executed on masonry surface which is hidden e.g. surfaces covered with earth filling etc. The joints of hidden work shall be nearly struck flush as the work proceeds.

6.9.2 Exposed faces of wall not intended to be plastered or rendered shall be pointed as specified below, unless otherwise indicated.

(a) External faces with a neat keyed pointing in cement and sand mortar 1:4.

(b) Internal faces with a neat flush pointing in cement and sand mortar 1:4.

6.9.3 Where pointing, plastering or any other finish is indicated, all joints shall be squarely raked out to a depth not less than 15mm and properly cleaned as the work proceeds.

6.9.4 The face of the stone masonry shall be cleaned and all mortar droppings removed preferably the very day. Face work shall be washed and cleaned on completion.

6.10 Stone Masonry Construction

6.10.1 Random Rubble Masonry, Uncoursed

6.10.1.1 Dressing

Stones shall be hammer-dressed on the face, the sides and the beds to enable to come in proximity with the neighbouring stones. The bushes on the face i.e. maximum depression from a straight edge held against the dressed surface shall not be more than 40mm on an exposed face and 20mm on faces to be rendered.

6.10.1.2 Laying

Every stone shall be carefully fitted to the adjacent stone so as to form neat and close joint. Face stone shall extend and bond well in the back. These shall be arranged to break joints, as much as possible and to avoid long vertical lines of joints. Thickness of joints shall not exceed 25mm . Walls shall be levelled up at top of plinths, cill and lintel levels of openings, floor and roof levels and at top with minimum amount of chips and spalls .

6.10.1.3 Hearting Stones

The hearting or interior filling of a wall face shall consist of rubble stones not less than 15 cm in any direction, carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. The hearting shall be laid nearly level with facing and backing.

6.10.1.4 Insertion of Chips

Chips and spalls of stone shall be used wherever necessary to avoid thick mortar beds or joints and it shall be ensured that no hollow spaces are left anywhere in the masonry. Chips shall not be used below hearting stones to bring these upto the level of face stones. The use of chips and spalls shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 20 percent of the quantity of stone masonry. Spalls and pinnings may show on face.

6.10.1.5 Bond Stones

6.10.1.5.1 Through bond stones shall be provided in walls upto 60cm thick. In the case of walls above 60cm thickness, bond stones of the full thickness of wall or a set of two or more bond stones overlapping each other by at least 15 cm shall be provided in a line from face to back.

6.10.1.5.2 In case of highly absorbent types of stones (porous lime stones and sand stones etc.) single piece bond stones may give rise to dampness. For all thicknesses of such walls, a set of two or more bond stones overlapping each other by atleast 15 cm shall be provided. Length of each bond stone shall not be less than two-third of the thickness of the wall.

6.10.1.5.3 Where GE is satisfied that bond stones of suitable lengths are not available contractor shall provide precast cement concrete block of 1:3:6 type C-l using 20 mm graded stone aggregate of cross section not less than 225 Sq cm and length equal to the thickness of wall in lieu of stone bond stones,at no extra cost to the Government.

6.10.1.5.4 Bond stone shall not be less than 2 per square metre of face and staggered. No stone shall tail into a point. The bond stone shall be marked by a distinguishing letter for subsequent verification.

6.10.1.6 Quoin & Jamb Stones

The quoin and jamb stones shall be selected stones, hammer dressed. Quoin stone shall not be less that 0.01cu. m in volume. Height of quoins and jamb stones shall not be less than 15 cm. Quoin shall be laid header and stretcher alternately. Face beds and joints, where indicated shall be chisel dressed on beds and joints 5 cm and 2.5 cm respectively in case of granite or trap stone and 8 cm and 4 cm respectively in case of other stones, so that no portion of the dressed surface shall have a depression more than 6 mm from a straight edge held against the dressed surface.

6.10.1.7 Plum Stones

Vertical plums projecting about 15 to 20 cm in the courses above shall be provided at about 90 cm intervals in level beds. They shall be firmly embedded.

6.10.2 Random Rubble Masonry, Brought to Course

All requirements are the same as for random rubble masonry uncoursed, except that work in addition, shall be levelled to courses at intervals varying from 30 to 60 cm in height.

6.10.3 Polygonal Rubble Masonry, Uncoursed

All requirements are the same as for random rubble masonry, uncoursed, except that stones shall be shaped into irregular polygonal shapes and bedded to show their face joints running irregularly in all directions.

6.10.4 Polygonal Rubble Masonry, Brought to Courses

All requirements are the same as for random rubble masonry, uncoursed, except that work in addition shall be brought to courses at intervals varying from 30 to 60 cm in height.

6.10.5 Square Rubble Masonry, Uncoursed

6.10.5.1 Dressing

Face stones shall be hammer dressed on all beds and joints so as to give them approximately rectangular shape. The bushes on the face shall not be more than 20mm. The bed joints shall be chisel drafted for atleast 8cm back from the face and for the side joints atleast 4 cm. No portion of the chisel dressed surface shall show a depression of more than 6mm from a straight edge placed on it. The remaining portion of the stone shall not project beyond the surface of bed and side joints.

6.10.5.2 Laying

All bed joints shall be laid truly horizontal and all side joints shall be truly vertical. The quoin stones shall be laid stretchers and headers alternately. Thickness of joints shall not exceed 15mm. Walls shall be levelled at top of plinth, cill and lintel levels of openings, roof and floor level and top with minimum amount of chips.

6.10.5.3 Face Stones

Face stones shall tail into the work for not less than their heights and atleast one third of the stones shall tail into the work for a length not less than twice their height but not more than three fourth the thickness of wall. These shall be laid headers and stretchers alternatively.

Stone risers or jumpers and stretchers which are of varying heights are laid uncoursed and in general the risers shall not be more than 25 cm in height and stretchers shall not exceed two -thirds the height of the adjoining risers.

6.10.5.4 Hearting Stones

The hearting of the wall shall consists of flat bedded stones carefully laid on their proper beds in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10 percent of the quantity of masonry. While using chips it shall be ensured that no hollow spaces are left anywhere in the masonry.

6.10.5.5 Bond Stones

The requirements regarding through or bond stones shall be same as for random rubble masonry

6.10.5.6 Quoin and Jamb Stones

The requirements regarding quoin and jamb stones shall be same as for random rubble except that face beds and joints shall be dressed as in Para 6.10.5.1. Where indicated, the corners of each quoin shall have a chisel drafted margin 2.5 cm wide.

6.10.6 Squared Rubble Masonry, Brought to Course

All requirements are the same as for squared rubble, uncoursed, except that work in addition shall be levelled to course at intervals varying from 30 to 60cm in height.

6.10.7 Squared Rubble Masonry, Regular Course

All requirements are the same as for squared rubble, uncoursed, except that :-

(a) Face stones, quoin and jamb stones and bond stones shall be roughly squared to the same height in any one course.
(b) Height of courses shall be 10 to 30 cm. No course shall be of greater height than the course below.
(c) Bond stones shall be provided at 1.4 to 1.8 metre apart clear in every course.

6.10.8 Block-in-Course Masonry

6.10.8.1 Dressing

Every stone shall be cut to the required size and shape and rough tooled on all beds and joints so as to be free from bushing. The beds and joints, 6mm from the face, shall be fine tooled so that a straight edge can be laid along the face of the stone in contact with every point. The quoin and jamb stones shall be dressed square and corner shall be straight and vertical. All visible angles and edges shall be true and square and free from chippings. A sample of dressed stone shall be prepared for approval and kept on the work after approval of the EIC.

6.10.8.2 Bond Stones

Through bond stones shall be provided in walls upto 60 cm thick and in case of walls above 60cm in thickness, a set of two or more bond stones overlapping each other by atleast 15 cm shall be provided in a line from face to back. Each bond stone or a set of bond stones shall be provided at 1.5m to 1.8m apart clear in every course.

6.10.8.3 Faces Stones

The exposed faces shall be squared and hammer dressed on the face. The bushes on the face shall not be more than 20mm. Alternatively, exposed face shall be rock-faced, punched, close-picked or fine tooled with or without drafted margin where indicated.

6.10.8.4 Laying

The face stones shall be laid headers and stretchers alternately. The headers shall be so arranged to come as nearly as possible in the middle of stretchers above or below. Stones shall be laid in courses of 20 cm to 25 cm in height and all courses shall be of the same height. No stone shall be less in breadth than its height or less in length than twice its height.

Thickness of mortar in beds and joints shall not exceed 6mm, unless otherwise indicated.

6.10.9 Ashlar Masonry Dressing

6.10.9.1 Every stone shall be cut to required size and shape, chisel dressed on all beds and joints. The dressed surface shall not show a depth of gap more than 3mm from straight edges face on it unless otherwise indicated. In case of punched ashlar masonry, the dressing of stone shall be as mentioned above except that the faces exposed to in view shall have a fine dressed chisel draft 2.5 cm wide all round the edges and shall be rough tooled between the drafts, such that the dressed surface shall not be more than 3 mm from a straight edge placed over it.

6.10.9.2 The exposed faces and joints and other requirement shall be as per block in course masonry.

6.10.9.3 When necessary, jib crane or other mechanical appliances shall be used to hoist heavy pieces of stones and place them in correct position. They shall be handled carefully to avoid damage to edges and corners. No damaged stone shall be allowed to be used in work.

6.10.9.4 Composite Masonry

When masonry work is composite one, consisting of ashlar stone facing with a backing of either brick work, random rubble or coursed rubble, etc. the two portions shall be carried up simultaneously and carefully bonded. Specification for ashlar masonry shall apply to face work and the backing shall be governed by the appropriate specification applicable to the type of backing used.

6.10.10 Squared Rubble Masonry, Brought to Courses - Jodhpur Type

All requirements are the same as for squared rubble masonry, brought to courses, except that :-

(a) Face of stones and face beds and joints upto 25mm from the face shall be hammer dressed so that the maximum depression from the straight edge held against the surface shall not exceed 20mm .

(b) Face stones shall not be less than 15 cm in height. Face stones shall neither be narrower nor shorter than their height.

(c) Thickness of joints shall not exceed 25mm.
(d) Masonry shall be levelled to courses at interval varying from 30 to 60cm.

6.10.11 Squared Rubble Masonry, Regular Coursed - Jodhpur Type

All requirements are the same as for squared rubble masonry, brought to courses-Jodhpur type, except that:-

(a) Face stones, quoin and jamb stones and bond stones shall be roughly squared to the same height in any one course.
(b) Height of course shall not be less than 15 cm. No course shall be of greater height than the course below.
(c) Bond stones shall be provided at 1.5 to 1.8 metre apart clear in every course.

6.10.12 Squared Rubble Masonry, Regular Coursed, Secunderabad and Bangalore Type

All requirements are the same as for squared rubble masonry, regular coursed except that:-

(a) Face beds and joints shall be hammer dressed for at least 5 cm and 2.5 cm respectively so that the maximum depression from a straight edge held against the surface shall not exceed 20mm.
(b) Height of the course shall be 15 to 25 cm. No course shall be of greater height than the course below.
(c) Thickness of joints shall not exceed 25 mm.

6.11 Laterite Stone Masonry

6.11.1 Dressing

Laterite stones shall be hammer dressed into rectangular blocks so that all faces are free from waviness and unevenness, and the edges are true and square. The size shall be 390 x 190 x 190 mm with tolerance of + 5mm unless otherwise specified.

6.11.2 Laying

The dressed stones shall be laid in regular courses of not less than 15 cm height. All courses in the masonry shall be of the same height unless otherwise directed. The stones shall be laid in alternate header-stretcher fashion, alternate course of headers and stretchers or in any other suitable fashion as directed. The vertical joints shall break by atleast 65mm. No specific corner stones are necessary. Quoins may be provided, where so indicated.

6.11.3 Joints

All bed joints shall be truly horizontal and all side joints shall be truly vertical. The thickness of joints shall not exceed 15mm. Each stones shall be carefully laid in place with joints completely filled with mortar. On faces, where no plastering or pointing is required to be done, the joints shall be struck flush as the work proceeds. In other cases, joints shall be raked square to a minimum depth of 15mm by a raking tool during the progress of work while the mortar is still green.

6.12 Slate Stone Masonry

Slate stone shall be obtained from the approved quarry, as indicated, and shall not be less than 5cm thick. Slate stones shall be carefully hammered down into place with wooden mallet and solidly bedded with mortar. Chips and spalls shall be wedged in to avoid thick beds and joints of the mortar. Spalls and pinnings may show on face. Thickness of mortar in beds and joints shall not exceed 25mm. No face work shall be provided.

6.12.1 Slate stone masonry shall be built uncoursed. Walls shall be levelled up at the top of plinth, cill and lintel level of openings and at stop with minimum amount of chips and spalls. For walls upto 45cm thick 25 percent of face area shall be of bond stones. Quoin and jamb stones shall be laid headers and stretchers alternately.

6.13 Dressed Stone Work

6.13.1 Stone Cills, Copings, Shelves, Steps etc.

Stones for cills, copings, shelves, steps, corbels, cornices, etc, shall be punched dressed on the exposed faces with beds and joints rough tooled upto 6mm from the face. Unless otherwise indicated, the embedded unexposed beds and joints of self faced stone slabs need not be further dressed. Stones shall be dressed to conform to the required shape and dimensions.

6.13.1.1 Window Cills

Where window cills project beyond the wall face and are exposed to rain, drip moulding shall be provided on the underside of the outside projection, where indicated.

6.13.1.2 Stone copings shall be provided with drip moulding, where indicated.

6.13.1.3 Stone chajjas shall be punched dressed on all faces which are exposed to view and rough tooled on the other surfaces. Angles shall be true and edge lines straight. The length of slabs shall be not less than 60cm. Horizontal chajjas shall be fixed with an outer slope of 1:20.

6.13.2 Stone Moulding Work

Every stone shall be cut to the required size and shape and rough tooled on all beds and joints so as to be free from any waviness and to give a perfectly vertical and horizontal joints with the adjoining stones. The face shall be gauged, cut, chamfered, grooved, rebated, sunk or plain moulded and shall be close picked or fine tooled, as indicated. For this purpose full size layout of the moulding shall be prepared on platform from which sheet templates shall be cut and the stone dressed to templates to a uniform and fine finish. All visible angles and edges shall be true square, and free from chippings. The corner stone shall be dressed at true right angles, the corners being straight and vertical. The joints 6mm from the face shall be fine tooled or rough tooled as indicated.

6.13.3 Laying

Dressed stone work shall be laid full in mortar. The joints of the copings, etc., shall break joint with those in the masonry below. The joints in dressed stone work shall not exceed 2mm where beds and joints are fine tooled and 3mm when rough tooled.

The minimum bearing of cills inside the masonry at any point shall be 50mm.

The corbel shall not be loaded until it is fully set and sufficient masonry is constructed above.

In case of cornices and corbels the embedded length shall not be less than 1.5 times the projection unless otherwise indicated.

Copings, cornices, course of pillars, skew backs and similar works shall be secured to the adjacent stone work with dowels, cramps or joggle joints, as indicated.

6.14 Jodhpur Stone Lintels, Cills and Roofing

Stone slabs for lintels, cills and roofing shall be hard sound, durable and of uniform colour and texture and shall be obtained from an approved quarry, as indicated. These shall be sawn or split in a plane parallel to the natural bed of the stone.

6.14.1 Lintel stones shall be in one length and of full thickness. Where stone lintels of full width are not available, two stones may be used to make the width. All faces of the lintels shall be hammer dressed unless otherwise indicated. Lintels shall be set and pointed in lime mortar 1:3 or cement and sand mortar 1:6 unless otherwise indicated. Where two stones are used in a lintel these shall be joined and grouted in cement and sand mortar 1:3.

6.14.2 Roofing slabs shall be in one length and of width not less than 25cm or more than 35 cm. Slabs shall be self faced on top and bottom. The edges shall be true and square on the under side and two long edge shall be hammer dressed so that the depression from a straight edge held against the surface shall not exceed 20mm. Thickness of roofing slabs shall be as under:-

(a)	For clear span up to 2m	7.5 to 10 cm thick
(b)	For clear span exceeding 2m and not exceeding 3m .	Exceeding 10 and upto 12.5 cm. thick

6.14.2.1 Stone slabs in roofing shall be wetted with water before laying and shall be set and jointed in cement and sand mortar, as indicated. The width of joint between the two slabs shall not exceed 25mm. The joint shall be solidly filled with mortar for their full depth and neatly finished flush on the underside.

6.15 Stone Chowkats for Doors, Windows etc.

Stone for chowkats shall be obtained from an approved quarry, as indicated. The size of the vertical and horizontal members shall be as detailed or directed; the permissible tolerance on the cross-sectional dimensions of the chowkats shall be + 2 mm. The exposed faces of the chowkats including rebates shall be close picked.

6.15.1 The vertical members shall be jointed to horizontal members by mason's mortice and tennon joint and shall be embedded 15cm deep in floor. Every vertical member of door, window etc. shall have four holes for fixing bolts. Vertical members of clerestory window shall have two holes for fixing bolts. The projection of the horizontal members shall not be less than 15cm. These shall be well built into the wall at ends. Recesses and holes shall be made in chowkats for fixing hinges and bolt staples and other fixtures.

6.15.2 Stone chowkats shall be bedded and pointed in lime mortar 1:3 or cement and sand mortar 1:6 as indicated.

6.16 Stone Arches (See Fig. 17)

The stones for arch shall not be less than 25 cm on their least dimension for ashlar arch, and not less than 20 cm for rough tooled and hammer dressed stones. The stones for arches upto 600 mm in depth shall be of the full thickness of the arch ring. For arches above 600mm and upto 900 mm in depth, stones shall be laid in alternate courses of headers and stretchers, the headers being of the full thickness of ring and not more than two stretchers make up the full thickness of ring. For arches over 900 mm in depth, quoins and key stones alone need be of the full thickness of the ring.

6.16.1 Dressing

Unless otherwise indicated exposed faces of arch shall be finished as for walling. The face beds shall be rough tooled upto atleast 10cm and joints upto 6 cm in case of random, Polygonal or squared rubble masonry. For block in course or ashlar masonry face beds shall be rough tooled the full depth and joints upto at least 8 cm. The stone shall be dressed to required wedge shape so that joints are truly radial.

6.16.2 Centering shall be as specified in Section 5 Brickwork and Section 7 Wood-work. It shall be got approved by Engineer-in-Charge before commencing the masonry work. The centres (props or supports) shall not be struck before one week after the completion of the arch. Care shall be taken that the adjacent wall/arch has been built upto 2/3 of the height of the arch and haunches filled to the same height.

6.16.3 Laying

Stones shall be carried up according to the sheet template prepared for arch work. All joints shall be full of mortar. Face joints shall not be more than 5mm thick. Face joints shall be uniform throughout and squarely raked out to a depth not less than 20mm; and pointed in the specified mortar, where the arches are not specified to be plastered or otherwise finished. The pointing when finished shall be sunk from face by 5mm or finished as indicated.

6.16.4 General arrangement of stone arch shall be as shown in Figure 17.

6.17 Dry Random Rubble Masonry and Retaining Walls

6.17.1 Stone

The stones shall be knocked off so as to obtain as large bedding surface as possible. Face stones shall be hammer dressed with bushings not exceeding 40mm. The stones shall not be less than 15 cm in any direction except the packing stones. The face stone's average breadth shall not be less than the height and average length not less than 1-1/2 times the height for stones upto 20cm height and not less than 1-1/3 times the height or 30 cm whichever is more , for stones exceeding 20 cm in height. The bond stones shall be atleast 80cm long and not less than 300 sqcm in cross section at any point. Two bond stones shall be provided per sqm of front face area.

6.17.2 The stones in foundation shall be the largest available so as to have the maximum possible contact with the bed of foundation below to obtain uniform distribution of load and better prevention of sliding. The stones shall be laid closed to each other and packed in by hand. The bed of packed stones shall be at right angles to the face batter and not horizontal. The front and back face stones shall be laid alternately as headers and stretchers. The stones shall break joint with the stones below. The bond stones shall be laid in a line from front face to back over lapping each other by atleast 20 cm. The thickness of joints on the front and rear face shall not be more than 30 mm.

6.17.3 The long and high retaining walls shall be constructed in panels. Lengthwise the dry panels shall be separated from each other by constructing panels of walls 1 to 2 meters length in mortar at spacing of 10metre centre to centre or as indicated. Height -wise the panels shall be separated from each other by short height of walls about 50 cm at spacing of 3 metre or as indicated. The mix of mortar shall be as indicated.

6.18 Stone and Boulder Pitching

Stones shall be carefully hand packed in a manner to ensure a reasonably smooth surface and uniform thickness; spaces between the stones shall be minimized. Such spaces shall be wedged with spalls of suitable size, immediately following the packing of stones.

6.18.1 Ribs shall be provided at the junction of the slope with the ground and at the upper extremity of the slope. Ribs shall be rectangular in cross section with width equal to dimensions of stone along its longer axis and depth equal to depth of lining.

6.19 Stone Kerb

Kerb stones shall be not less than 45 cm in length except when required as closer or on curve; and shall be of sectional dimensions as indicated. Not more than half the depth of each stone shall be buried in ground. Kerb stones shall be hammer dressed so that the maximum depression from a straight edge held against the dressed surface shall not exceed 20mm. Where indicated, the top and exposed surfaces of sides shall be dressed so that the maximum depression from a straight edge held against the surface shall not exceed 6mm and top edge shall be chamfered not exceeding 10 cm in girth. Kerb stones shall be jointed in cement mortar 1:6 and struck flush.

6.20 Stone Veneering Facing

6.20.1 Sand Stone Slabs

Stone slabs shall be hard, sound, durable and tough, free from cracks, decay and weathering. Sand stone shall be red or white in colour as specified. The colour shall however be uniform. In case of red sand stone, white patches or streaks and in case of white sand stone, red patches or streaks shall not be allowed. Scattered spots upto lmm diameter shall however be permitted. Slabs shall be obtained from approved quarries or sources as indicated.

Transverse strength of slabs shall not be less than 70 Kg/Sq. cm. Resistance to wear shall not be greater than 2mm on the average and 2.5 mm for any individual slab, when tested in accordance with IS 1706 : 1972 : Method for Determination of Resistance to Wear by Abrasion of Natural Building Stones.

6.20.2 Lime Stone Slabs

Lime stone slabs shall be without any soft veins, cracks or flaws and shall have uniform texture. Transverse strength shall not be less than 70 Kg/Sq. cm. and shall not develop signs of spalling, disintegration of cracks.

6.20.3 Marble Slabs

Marble slabs shall be plain white marble(Makrana or Abu white or Raj Nagar Marble); white veined marble (Makrana or Abu veined); plain black marble Bhainslana; black Zebra marble(Bhainslana, Kishanagarh, Abu black, Naurnol); green marble (Baroda, Abu or Bundi); Pink plain marble (Makrana, Bar); grey marble (Kumari and Bundi); and Brown marble(Bar and Narnaul), as indicated. Marble shall be hard, sound, dense and homogeneous in texture with crystalline and coarse grains. It shall be uniform in colour and free from stains, cracks, decay and weathering. Hardness on Mho's scale shall be minimum 3. The edges of the slab and tiles shall be true. Machine cut slabs and tiles with square edges may be supplied by the contractor without any price adjustment. The contractor shall get samples of marble slabs and tiles approved by the GE for their colour and matching or mis-matching of grains.

6.20.4 Dressing

6.20.4.1 Sandstone and Lime Stones

Stone slabs be cut to the required size and shape so as to be free from any waviness and to give truly vertical and horizontal joints with the adjoining slabs. The faces those are to remain exposed in the final position as well as sides to a depth of 6mm from the face shall be chisel dressed so that no point in the finished surface varies from the straight edge by more than 1.5mm. Exposed faces may be polished where indicated. The sides which are to form joints shall be chisel dressed so that variation from a straight edge at no point exceed 5mm. No dressing shall be done at the back. The dressed slabs shall be of the thickness as specified. The tolerance in thickness shall be + 5mm upto 25mm thickness and + 5mm for the thickness above

25mm. All angles and edges those are to remain exposed in the final position shall be true, square and free from chippings.

6.20.4.2 Marble slabs shall be cut to the required size and shape and chisel dressed on all beds and joints so as to be free from any waviness and to give truly vertical, horizontal, radial or circular joints as directed. The exposed face and joints upto 12mm from the face shall be fine tooled such that the straight edge laid along the face of the slab is in contact with every point on it. These surfaces shall then be rubbed smooth. All visible angles and edges shall be true, square and free from any chippings. Beyond the depth of 12mm from the face, the joints shall be dressed with a slight splay so that the thickness of joint increases in an inverted V shape. The surface of the slabs coming in contact with the backing need not be chisel dressed. The dressed slabs shall be of the thickness as specified; tolerance on thickness shall not exceed + 3 percent.

Marble slabs in borders, jambs, cills and soffits of the openings and in shelves, cooking platforms etc., shall be in full width. Marble slabs in treads shall be in single pieces with rounded edges as directed.

6.20.5 Laying and Fixing (See Fig. 18&19)

6.20.5.1 Slabs shall be wetted before laying. They shall then be fixed with mortar in position without the use of chips or underpinning of any sort. The slabs shall be secured to each other with copper pins 75 mm long and 6 mm diameter or to the backing with cramps. Alternatively the stone may be secured to the backing by means of stone dowels of overall size 100 x 50 x 25 mm as per shape indicated in Figure 19 and the adjoining stone secured to each other by means of gun metal cramps or copper pins of specified size. Minimum one cramp/stone dowel shall be used to secure one slab to the backing.

6.20.5.2 The material for cramps shall have high resistance to corrosion under conditions of dampness and against the chemical action of mortar or concrete in which cramps are usually embedded. Cramps shall be of 25 x 6 mm and 30 cm long in case of backing of stone masonry walls and brick masonry walls thicker than 230 mm (one brick thick wall). In case of backing with brick masonry walls 230 mm or less thick or RCC members, cramps shall be of 25 x 6 mm and length as per requirement. Generally the outer length of cramp in half brick work backing shall be 115 mm and in one brick work backing it shall be 150 mm. Cramps shall be spaced not more than 60 cm apart horizontally.

6.20.5.3 Where cramps are used to hold the unit in position only, the facings shall be provided with a continuous support on which stones rest at the ground level and other storey levels, the support being in the form of projection from or recess into the concrete floor slab, or a beam between the columns or a metal angle attached to the floor slab or beams. These supports preferably be at vertical intervals not more than 3.5 m apart and also over the heads of all openings. Such support shall also be provided where there is transition from thin facings below to thick facings above.

6.20.5.4 Alternatively the cramps may be used to hold the units in position and in addition to support units thus transferring the weight of the units to the backing. Such cramps should be properly designed as per IS : 4101 : Part 1-1967. (Stone Facing)

6.20.5.5 The cramps may be of gun metal or copper alloy with zinc, nickel, lead and/or stainless steel as indicated.

6.20.5.6 The pins, cramps and dowels shall be laid in cement and sand mortar 1:2 and their samples got approved from the Garrison Engineer and kept at site.

6.20.5.7 The vertical veneers shall be carried up truly plumb. All courses shall be laid truly horizontal and all vertical joints truly vertical, unless otherwise indicated. Slabs shall break joints on the faces for at least half the height of the course unless otherwise directed. The stone shall be laid in regular courses not less than 20 cm height and all the stones shall be of the same height unless otherwise specified.

6.20.5.8 As far as possible, the backing shall be carried up simultaneously with the face work. In case of reinforced cement concrete backing, the lining shall be secured to the backing after it has set and got cured. The cramps shall be fixed at the required positions, while laying.

6.20.6 Jointing and Pointing

All joints shall be full of mortar. If any hollow grounding are detected by tapping the face stones, these shall be taken out and relaid. The face joints shall be uniform throughout. In the case of sand stone and lime stone slabs, the thickness of face joints shall not exceed 6mm. All exposed joints shall be pointed with mortar as specified. The pointing shall be sunk from stone face by 6mm or as specified and the depth of mortar shall not be less than 15 mm.

In case of marble veneering the thickness of the face joints shall be uniform, straight and as fine as possible but not more than 1.5mm; and in the face joints the top 12mm depth shall be filled with mortar specified for the pointing.

6.20.7 Curing

The work shall be kept constantly moist on all the faces for a period of atleast seven days.

6.20.8 Polishing Slabs

After the veneering work is cured, marble slabs shall be rubbed with Carborundum stones of different grades, No 60, 80 and 120 in succession, so as to give plain, true and highly smooth surface. It shall then be cleaned with a solution of oxalic acid, washed and finished clean. Where indicated, stone slabs shall be polished with Carborundum stones as specified for marble slabs.

6.21 Dholpur Stone Wall Facing

Stones shall be of 75mm deep, Dholpur stones, of approved colour and texture and hammer dressed so that the maximum depression from straight edge held against the surface shall not exceed 20mm. Stones shall be laid in straight courses about 50mm high and joined in cement and stone dust mortar 1:3 and recessed pointed with an admixture of white cement and Dholpur stone dust 1:1. The recess shall be 10mm x 20mm. Dholpur stone facing shall be properly bonded to the backing with 20mm x 12mm flat iron ties, 15 cm long, provided in every fourth course of lining at 90 cm centre to centre and shall project 50mm from the face of the wall.

6.22 Damp proof Course, Cutting Opening and Forming Jambs, Pargetting of Flues, Sweeping Chimneys, Underpinning and Well Sinking

For specification of these items of work, refer respective specification in Section 5 Brick work.

6.23 Bonding to Old Work

In alteration work, the stones shall gauge with existing courses, unless otherwise directed.

Fig 1 : Hammer Dressed Stone Surface

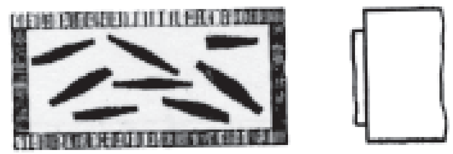


Fig 2 : Rock Faced stone Surface

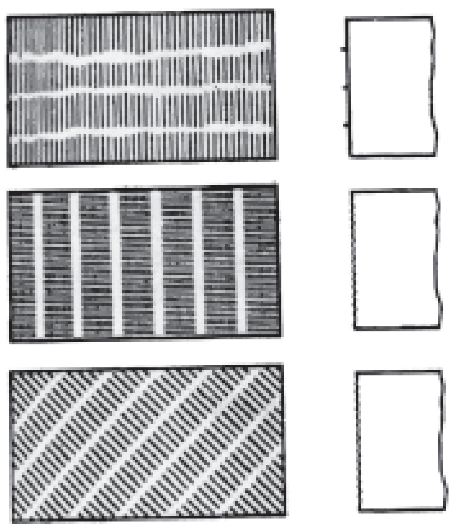


Fig 3 : Rough Tooled Stone Surface

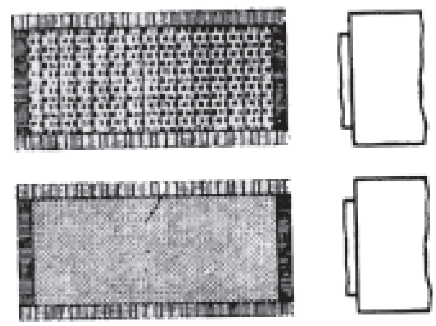


Fig 4 : Punched Stone Face Surface (Chisel drafted)

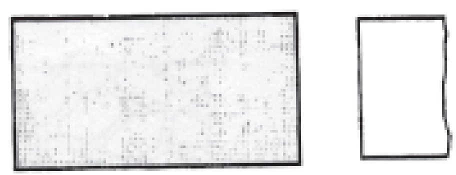


Fig 5 : Closed Plcked Stone Surface

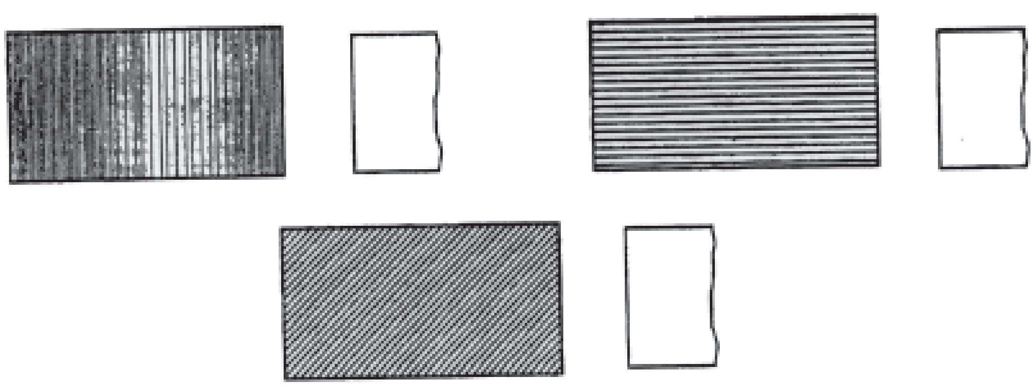


Fig 6 : Fine Tooled Stone Surface

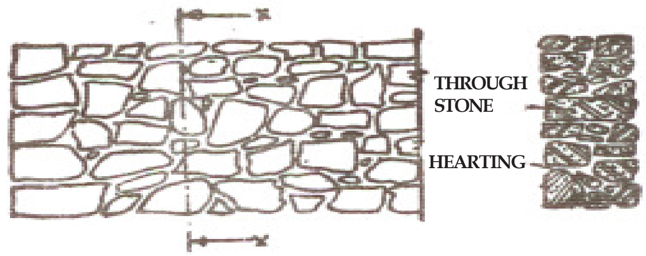


FIG.7 RANDOM RUBBLE UNCOURSED SECTION XX

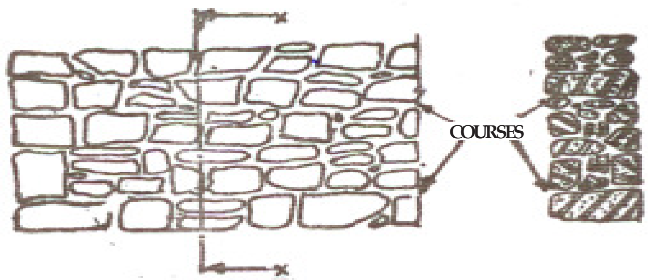


FIG. 8 RANDOM RUBBLE BROUGHT UP TO COURSES SECTION XX

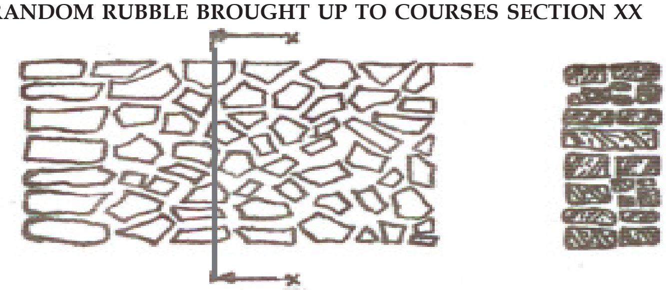


FIG. 9 POLYGONAL RUBBLE UNCOURSED SECTION XX

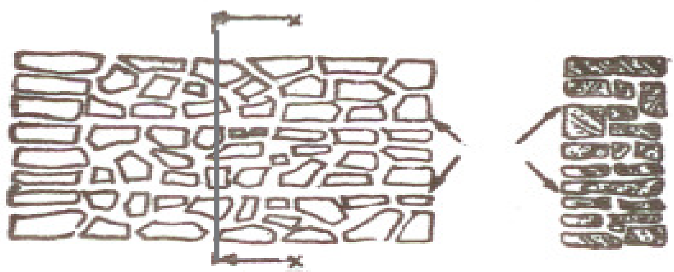


FIG.10 POLYGONAL RUBBLE BROUGHT UP TO COURSES SECTION XX

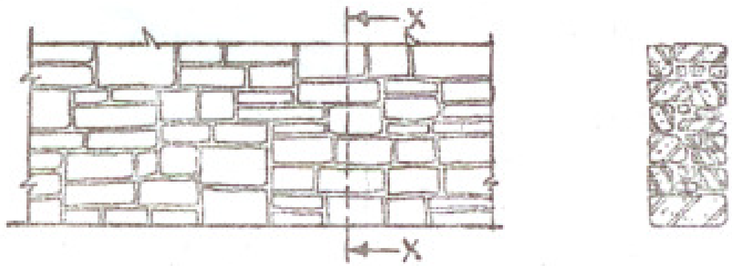


FIG.11 SQUARED RUBBLE UNCOURSED SECTION XX

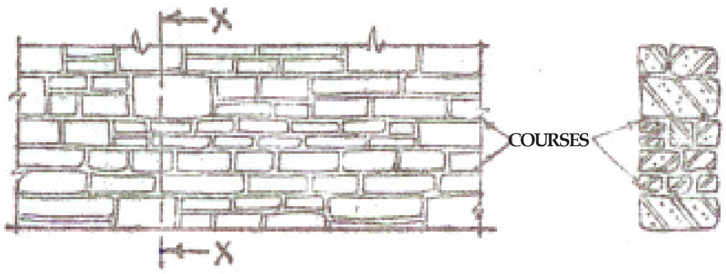


FIG.12 SQUARED RUBBLE BROUGHT UPTO SECTION XX COURSES

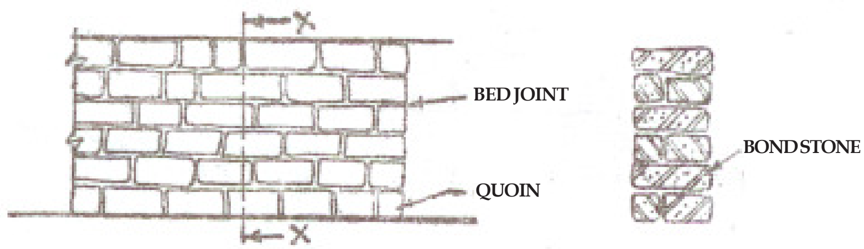


FIG.13 SQUARED RUBBLE REGULAR SECTION XX COURSED

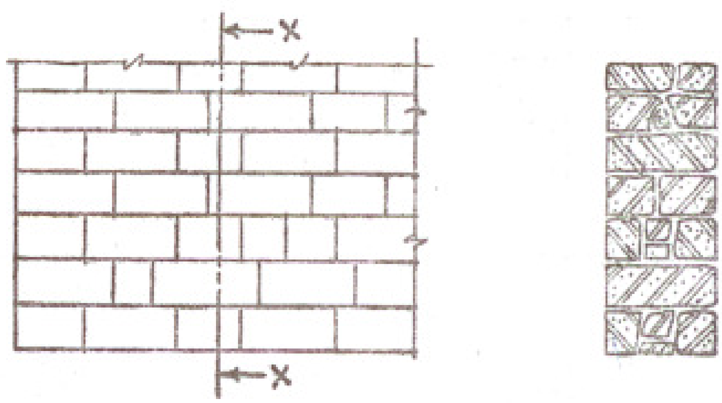
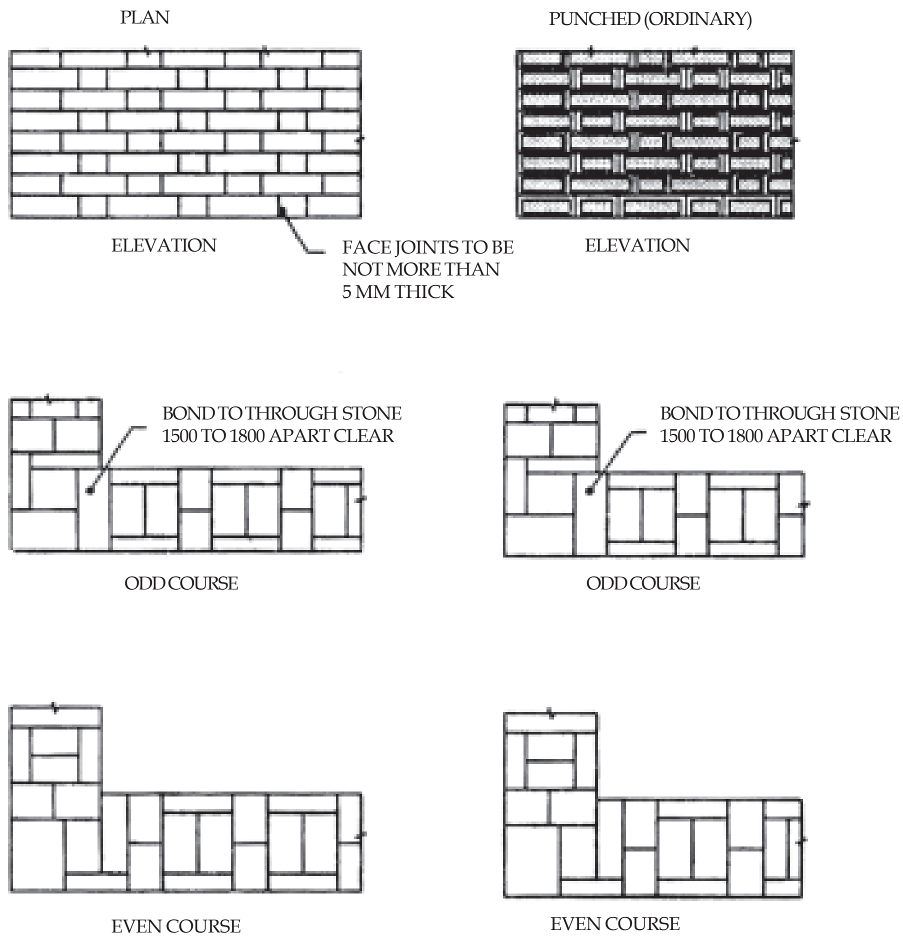


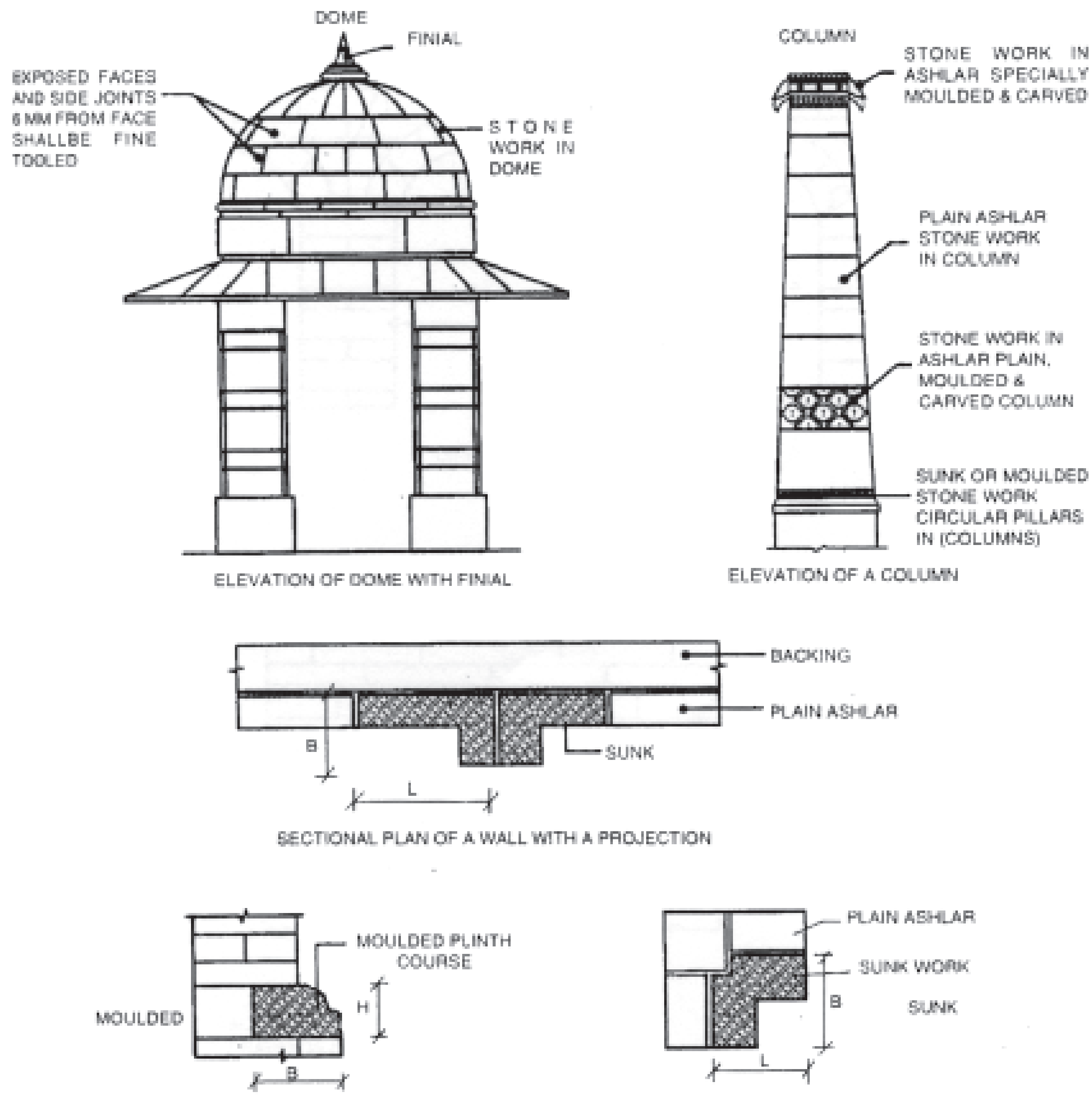
FIG.14 BLOCK IN COURSE SECTION XX

ASHLAR STONE MASONRY



All dimensions are in MM.
Drawings not to scale.

Fig 15 :Ashlar Stone Masonry - Plain and Punched



SECTIONAL PLAN OF A WALL

SECTIONAL PLAN OF A PORCH PILLLAR

DRAWINGS NOT TO SCALE.
ALL DIMENSIONS ARE IN MM.

Note : Sunk or moulded stone work shown shaded, to be measured as lxbxh

Fig 16 : Moulded, Sunk, Carved-Stone Work

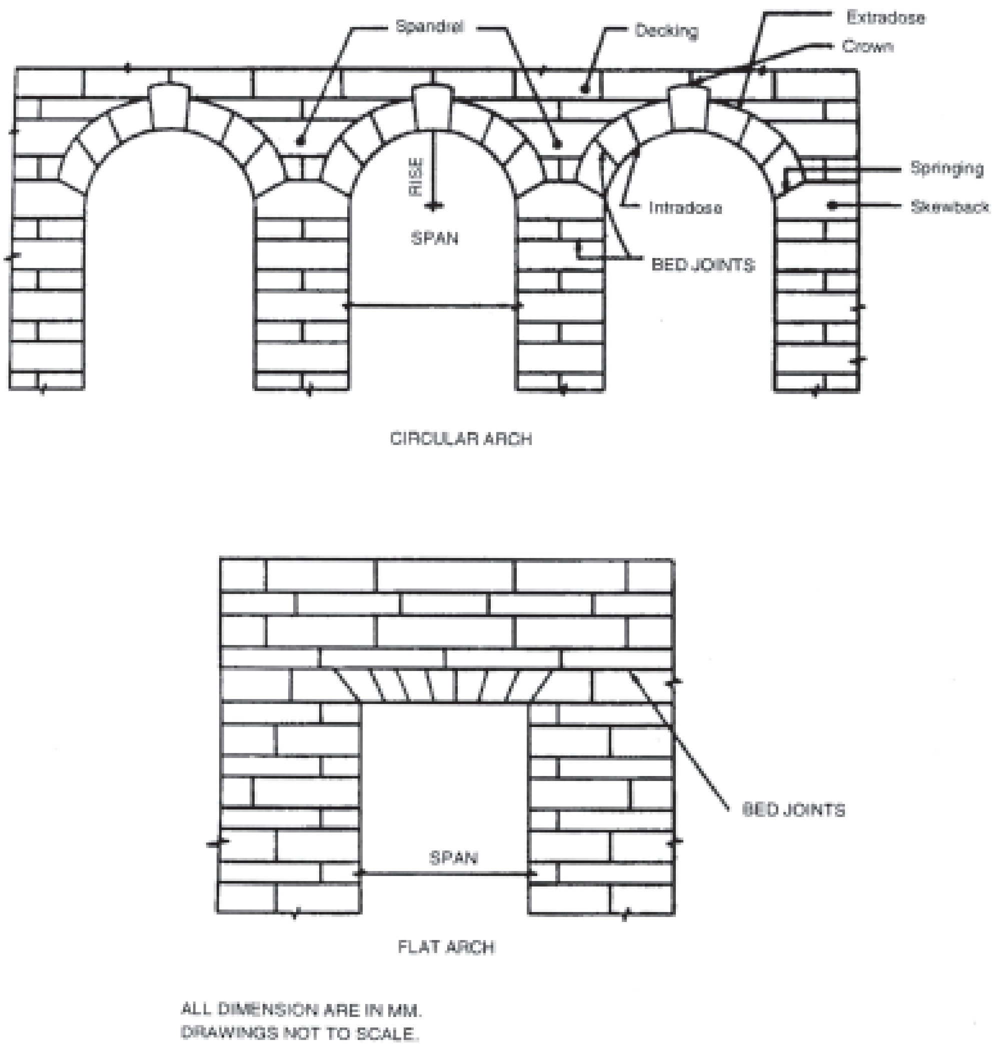


Fig 17 : Stone Work in Arches

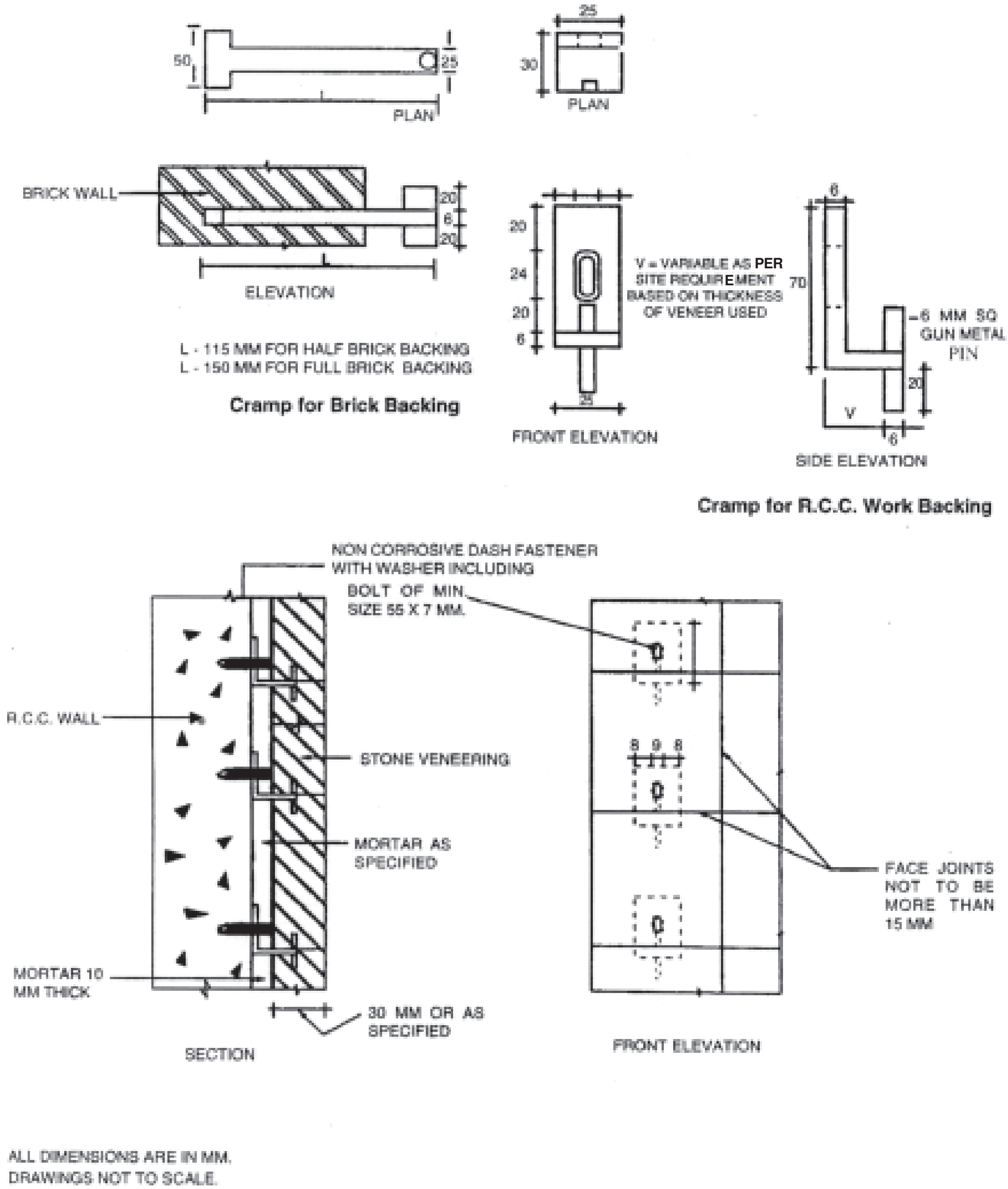


Fig 18 : Stone Veneering - Typical Fixing Arrangement

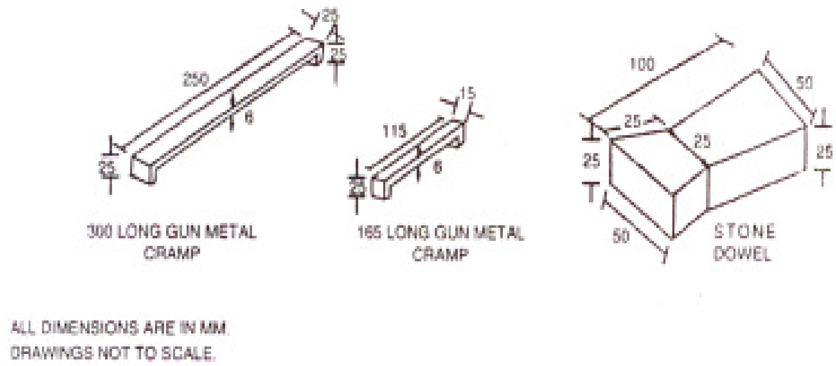


Fig 19 : Detail of Gun Metal Cramps and stone Dowel

SECTION 7
WOOD WORK (CARPENTER'S WORK)

Indian Standards :- The following IS apply to this Section.

IS No	*Subject*
287-1993	Recommendation for maximum permissible moisture content of timber used for different purposes (Third revision)
401-2001	Code of practice for preservation of timber (Fourth revision)
451-1999	Technical supply conditions for wood-screws (Third revision)
707-1976	Glossary of terms applicable to timber technology and utilization (Second revision)
723-1972	Specification for steel countersunk head wire nails (First revision)
851-1978	Specification for synthetic resin adhesive for construction work (non structural) in wood (First revision)
852-1994	Specification for animal glue for general wood working purposes (Second revision)
1141-1993	Specification for code of practice for seasoning of timber (Second Revision)
1708 (Pt 1 to 18)	Method of testing of small clean specimens of timber (Second revision)
2366-1983	Code of Practice for nails jointed timber construction (First revision)
2700-1987	Code of Practice for roofing with wooden shingle (First revision)
2911 -(Part 2) 1980	Code of Practice for design and construction of pile foundation : Part 2 Timber pile (First revision)
2911 -(Part 4) 1985	Code of Practice for design and construction of pile foundation : Part 4 Load test on piles (First revision)
3337-1978	Specification for Bailies for general purpose (First revision)
3386-1979	Specification for Wooden fencing post (First revision)
3629-1986	Specification for Structural timber in Building (First revision)
3670-1966	Code of Practice for construction of timber floor (First revision)
4835-1979	Specification for polyvinyl acetate dispersion based adhesive for wood (First revision)
11096-1984	Code of practice for design and construction of bolt jointed construction.
14687-1999	Guidelines on falsework for concrete structures

7.2 MATERIALS

7.2.1 Definitions

(a) Batten (fillet) - A piece of sawn timber whose cross-sectional dimensions do not exceed 5 cm in either direction.

(b) Beam - A structural timber generally long in proportion to its width and thickness, and used for supporting load primarily by its internal resistance to bending.

(c) Hard Wood- A conventional term used to denote the wood obtained from broad leaved trees. It has no relationship to the physical properties of hardness or strength. On account of the confusion this word might cause, its use is discouraged.

(d) Joint– A prepared connection for joining , adjacent pieces of wood , veneer etc.

(e) Dovetail Joint- A joint at the corner of two pieces in such a way that the notches made to one are fitted exactly into projections of corresponding size and shape made in the other. There are various kinds of dovetailed joints for instance , lapped dovetailed joint, wedge shaped dovetailed joints etc, joined in a way which will resist withdrawal except in the direction in which it was assembled.

(f) Mitred Joint- A joint, between two members at an angle which bisects the joining angle usually the joining faces are cut at 45 degree to format a right angle.

(g) Mortise and Tenon Joint: A joint in which the reduced end (tenon) of one member fits into the corresponding slot (mortise) in another member.

(h) Tongue and Groove Joint- A joint in which a tongue is provided on edge of one member to fit into a corresponding groove on the other.

(i) Knot: Base of a branch or limb embedded in the tree which becomes visible when it is cut.

(j) Muntin– Small horizontal or vertical dividing bars within basic framework of a window, or door subdividing and supporting the glass panes or panels of doors

(k) Rebate– A recess along the edge of a piece of timber to receive another piece or a door, sash or a frame.

(l) Seasoned Timber– Timber whose moisture content has been reduced to the specified minimum under more or less controlled processes of drying.

(m) Structural Timber– Timber used in framing and load bearing structures or timber used or intended for use in buildings where strength is the primary consideration.

(n) Plank (boarding)- A piece of sawn timber whose thickness does not exceed 5 cm and width exceeds 5 cm.

(o) Scantling- A piece of timber whose cross-sectional dimensions exceeds 5 cm but do not exceed 20 cm in both directions.

(p) Baulk- A piece of sawn timber whose cross-sectional dimensions exceed 5 cm in one direction and 20 cm in the other direction.

(q) Bailies- Thin poles in the round without bark.

(r) Wrought- The term wrought carries the same meaning as 'Planed'.

(s) Diameter of Knot– The diameter of a knot shall be the distance between two points farthest apart on the periphery of a round knot, on the face of which it becomes visible. In the case of a spike or a splay knot it shall be the maximum width of the knot visible.

(t) Fixed- Timber described as 'fixed' shall include :

(1) lapping, halving, tabling, scarfing, notching, birds-mouth cutting, splayed or beveled ends;

(2) Boring for and fixing only of bolts ;

(3) Transporting, hoisting, erecting and fixing in position;

(4) Small labours, like splays, chamfers, rounded angles and rounded nosings not exceeding 3 mm width or girth;

(5) Supplying and fixing of nails, screws; and

(6) Wastage.

(u) Framed and fixed- Timber described as "framed and fixed" shall include in addition to (1) to (6) in (t) above the following :-

(1) Framing together with mortice and tenon, tusk-tenon or dovetailed joints; and

(2) Coating framed joints with glue/adhesive or white lead where indicated, before being put together.

7.3 Timber

7.3.1 Timber

Timber shall be of good quality, well seasoned, fairly uniform in colour and texture and free from blemishes, hollow pockets and loose knots. Coniferous sawn timber (soft wood) shall be free from spiral or twisted grain, warp, any kind of decay or live insect attack and cup shakes. Non-coniferous sawn timber (hard wood) shall be free from bow, any kind of decay, live insect attack, spiral or twisted grains, splits across the grain, spring, warp, cup and shake.

7.3.1.1 Timber shall be obtained either in cut sizes or as sleepers and cut to the required sizes well in advance of the commencement of fabrication and stacked at site or work in a suitable manner for seasoning.

7.4 Defects in Timber for Structural and Carpenter's Work

7.4.1 Prohibited Defects

Timber for structural use shall not have loose grains, splits, compression wood in coniferous structural timber, heartwood rot, saprot, warp, worm hole made by powder pest beetles and pitch pockets. Knots, shakes and checks shall not be permitted in regions of maximum stress intensities nor shall they be permitted at locations where joints are to be provided.

7.4.2 Permissible Defects

The following defects are permissible :-

(a) Wanes provided they are not combined with knots and reduction in strength on account of the wanes is not more than the reduction with the maximum allowable knots.
(b) Worm holes, other than those due to powder pest beetles, located and grouped that reduce the strength of timber shall be evaluated in the same way as knots.
(c) Sap wood not more than 15 percent of the area of the section may be allowed provided it is properly treated with preservative as specified in IS 401-2001, Code of practice for preservation of timber.
(d) All other defects which do not affect any of the mechanical properties.
(e) Location and permissible limit of the size of knots, depth of checks and shakes and slope of grain shall be as applicable for Grade I structural timber as per IS 3629-1986.

7.5 Defects in Timber for Joiner's Work

7.5.1 Prohibited Defects

Timber for joiner's work shall be free from decay, fungal growth, boxed heart, pitch pocket or streaks on the exposed edges, borer holes, splits, cracks, pin holes and worm holes.

7.5.2 Permissible Defects

(a) Cross grain shall not be steeper than 1 in 15.
(b) The diameter of individual sound knot and live knot shall not exceed 25 mm and the aggregate area of the knots shall not exceed one percent of the area of the piece.
(c) Timber shall be generally free from sapwood, but traces of sapwood upto 15 percent may be allowed provided it is properly treated with preservative as specified in IS 401-2001, Code of practice for preservation of timber.

7.6 Seasoning

Timber shall be seasoned, before being planed to the required sizes, to a moisture content not exceeding the specified maximum permissible moisture content.

7.7 Moisture Content

The maximum permissible moisture content of timber for different uses, whether kiln or air seasoned, shall not exceed the limits laid down in IS 287-1993, Recommendations for maximum permissible moisture content of timber used for different purposes.

7.7.1 Tolerances

Seasoned timber (whether air or kiln dried) shall be deemed to conform to the moisture content requirements if the average moisture content of all the samples from a given lot is within + 3 percent and the moisture content of individual sample is within +5 percent of the maximum permissible moisture content for the particular end use and locality as indicated above.

7.7.2 Field Testing of Moisture Content

Moisture meters obviate the necessity of cutting test samples and yield immediate results and are particularly suited for checking of moisture content of timber in the field. This method is however not as precise and fool-proof as oven dying method. The accuracy of determination under field conditions of use after observing necessary precautions and applying the appropriate corrections to take account of timber species is not better than + 2 percent of the results obtained by oven drying method. Any dispute concerning the moisture content of timber shall be decided by recourse to the oven drying method as described in IS 287 - 1993.

7.8 Species of Timber

The species of timber to be used and their class for the purpose of pricing shall be as indicated.

7.8.1 The species of commercial timber generally recommended for carpenter's & joiner's work are listed in the following table. Class of timber mentioned in the table is solely for the purpose of pricing with reference to SSR items. In case any other species of timber not listed in the table is specified to be used, its classification for the purpose of pricing shall be as indicated.

Sl. No	Botanical Name	Standard Trade Name	Local Names	Average weight in Kg/cum at 12% moisture content	Class of timber with reference to SSR items	Remarks
1	2	3	4	5	6	7
	(a) CONIFEROUS (Softwood)					
1	Abies pindrow	FIR	morinda, pandrai, tosh, pattal, gobre, salla	450	3rd class	J & S
2	Cedrus deodara	DEODAR	deodar, kelo, kelon, diar	545	1st class	J & S
3	Cupressus torulosa	CYPRESS	devidiar, leuri, saro, surai	515	2nd class	S
4	Picea Smithiana	SPRUCE	partal, rai	480	3rd class	J & S
5	Pinus wallichiana	KAIL	kail	515	2nd class	J & S
6	Pinus insularis	KHASI PINE	diengse, dingsa, saral, uchal	515	2nd class	S
7	Pinus roxburghai	CHIR	chir, chil	575	2nd class	J & S
	(b) NON-CONIFEROUS (Hardwood)					

1	2	3	4	5	6	7
8	Acacia arabica	BABUL	babul, kikar, babla, baval, fali, jali, mashwel, karijali, karuvelam, karuvai, nallatumma, bawal	785	2nd class	S
9	Adina cordifolia	HALDU	haldu, taarksopa, rangkat, karam, kumbha, kuruma, haladwar, haldwan, heddi, yetagal, hedu, yettaga, bimbu, kadambari, manjakadambai, bandaru	675 to 705	2nd class	S
10	Albizzia lebbek	KOKKO	siris, sarin, shrin, hirih, sirish, chichola, siras, sirsul, bage, vaka, vagai, dirisinam	640	2nd class	J & S
11	Albizzia odoratissima	KALASIRIS	kala siris, kurmuru, hihand, jotikoroi, koroi, kiachalom, sirisi, chichwa, kalio-siras, bilkambi, god-hunchi, chelavagai, karuvaka, karuvagai, chinduga.	735	2nd class	J & S
12	Albizzia procera	SAFED SIRIS	safed, siris, sit, koroi, tenthra, dhala sirish, kinhai, gurer, karangro, bellati, kilai, salvagai, vellavaka, velvagai, tellachinduga	640	2nd class	J & S
13	Artocarpus chaplasha	CHAPLASH	taungpeine, cham, sam, chapalish, latore	515	2nd class	J & S
14	Artocarpus hirsuta	AINI	hebbalasu, hebhulsina, pathphanas, ainipilavu, ainipila, anjili	595	2nd class	S
15	Artocarpus lakoocha	KAKOOCH	lakoch, dahua, dao, vate	640	2nd class	S
16	Bischofia javanica	URIAM	ye padauk, kainjal, nilimara, bok, cholavenga, cholavengai, malachadayan	755	2nd class	S
17	Calophyllum species	POON	surhonni, goja, sal-hone, surahonne, punna, kathupinnai.	655	2nd class	S

1	2	3	4	5	6	7
18	Cedrela toona	TOON	tun, jatipoma, katangai, tuni, mahalimbo, bili gandhagiri, devdari,gandhagarige, chuvannagil, maavembu, galimanu	515	3rd class	J & S
19	Chukrasia tabularis	CHICK - RASSY	yin-mabin, bogapoma, laldevdari, urulu, malaveppu, madagirivembu	675	2nd class	J & S
20	Dalbergia latifolia	ROSE WOOD	satisal, kiri, sissu, shisham, biti, veeti, itti, jittegi	770 to 880	1 st class	J & S
21	Dalbergia sissoo	SISSOO	shisham tahli	770 to 785	1 st class	J & S
22	Dillenia species	DILLENIA	zinbyun, otenga, chalta, tartari, panchphal, rai, kanagol, karmal	625	3rd class	S
23	Dipterocarpus indicus	GURJAN	gurjan, challane, kalpine, yennamara, kalpayini, enney, vellayini	785	2nd class	S
24	Dipterocarpus macrocarpus	HOLLONG	hollong	735	2nd class	S
25	Gnelina arborea	GAMARI	gamari, gamhar, khamhar, gumhar, kumhar, yemane, gomari, kasmar, khamari, ghambari, siwan, shivani shiwan, kulimara, thadsal kumulu, kumilu kumil gummadi, dadsal, shivane	515	2nd class	J & S
26	Kingiodend ronpinnatum	ANJAN	anjan, eppa, karachi, karacha, acha, yepi.	850	2nd class	S
27	Hardwickia pinnata	PINEY	yennemara, chukkana payini, kolvau	625	2nd class	S
28	Hopea species	HOPEA	kiralobogi, kalhoni, bogimar iurmbogam, vellaigongu	945 to 995	2nd class	S
29	Lagerstroemia hypoleuca	PYINMA	pyinma	610	2nd class	J & S
30	Lagerstroemia lanceolata	BENTEAK	nana, nandi, bendeku, venteak, bethekku, ventheku	610 to 675	2nd class	J & S
31	Lagerstroemia parviflora	LENDI	asidh, dhauri, sidamechi, sidha, garasckre, buridhamero, senha, kaliasaia, lendia, bondarao, channangi, nanagu, peikadukkai, sida, mechi, lendia-senha	755	2nd class	S

1	2	3	4	5	6	7
32	Lagerstroemia speciosa	JARUL	ajhar, garasekre, panipatuli, holesdasal, dondara, taman, nirmaruthu, pumarudu.	625	2nd class	S
33	Madhuka indica	MAHUA	mohwa, madhkam, mahula, mahua, mahuda, ippi,	915	2nd class	S
34	Magnifera indica	MANGO	am, amb, uli, amba, mavu, mamaram, mamidi.	690	3rd class	J & S
35	Manikara species	BULLET WOOD	khirni, borsali, rayan, mugali, ranjana, wovali, bakula, elengi, nanupala, pala	895	2nd class	S
36	Messua ferrea	MESUA	gangane, nahor, nagesiar, nagkesar, nagasampigi, churul, nangal, nangu, nagakesari	995 to 1135	2nd class	S
37	Ougeinia ooienensis	SANDAN	panan,sandan, tinnas, tinsa, sannan, bandhan, pandhan, ruta, tiwas, telus, tanacn, karimuttal, tewas	850	2nd class	S
38	Palaquium ellipticum	PALI	hadasale, palvadijan	640	2nd class	J & S
39	Phoebe species	BONSUM	angari	530	2nd class	J
40	Peterocarpus dalbergioides	PADAUK	padauk	720	2nd class	S
41	Petrocarpus marsupium	B1JASAL	paisal, hid, bija, beco, hone, bibla, venga, vengai, yegi.	800	2nd class	J & S
42	Shorea robusta	SAL	sakhu, sal, sakhua, sarjam, raigala, sargi,	815 to 880	2nd class	J & S
43	Shorea assamica	MAKAI	makai	575	3rd class	S
44	Tectona grandis	TEAK	sagoon, shegun, sagwan, saguan, sagon, sag, tegu, saguvain, thega, thekinamara, theku, teku	625 to 690	1st class	J & S
45	Terminalia bialata	WHITE CHUGLAM (Silver grey wood)	safed chuglam	705	2nd class	J & S
46	Terminalia manii	BLACK CHUGLAM	kala chuglam	800	2nd class	S
47	Terminalia myriocarpa	HOLLOCK	panisaj	610	2nd class	J & S
48	Terminalia paniculata	KINDAL	honal, kindal, honagalu, pillamarudu, nallapulaga	770 to 800	2nd class	J & S

1	2	3	4	5	6	7
49	Terminalia tomentosa	LAUREL	asna, sain, aisan, asan, hatana, puccasaj, sahaja, ain, sadar, karimatti, matti, sajad, saj, banappu, karumarudu, karimarudu, nallamaddi	850 to 895	2nd class	J & S
50	Xylia xylocarpa	IURL	kongra, tangan, suria, sauria, jambe, jamba, tirwa, irul, konda, tangedu	850	2nd class	S

Note :- J for use in joiner's and carpenter's work other than structural. S for use in structural work.

7.8.2 Unit Weight

Timber having average unit weight less than 75 percent of the value given in the table shall not be permitted for use for structural purpose.

7.9 Ballies

Unless otherwise ordered, the ballies shall conform to the dimensions given below :-

Type of bailies	Diameter at the top	Diameter at the butt end
	cm	cm
1	Over 8.5 upto 12.5	Over 15 upto 20
2	Over 6.5 upto 8.5	Over 11.5 upto 15
3	Over 5 upto 6.5	Over 7.5 upto 11.5

Note : The top and butt end diameters shall be measured at the extreme ends of the ballies.

7.9.1 Ballies shall be reasonably straight that when laid horizontal in any position the centre line joining the apex and base shall not deviate from the actual axis of the ballies by more than 7.5 cm. Ballies shall be air-dried to a moisture content not exceeding 20 percent within a depth of 12 mm from the surface, when measured at 30 cm from the butt end of the bailies.

7.9.2 Ballies shall be free from cuts across the grain, live insect attack, any kind of decay (rot), pronounced spiral or twisted grain, hollow heart and dead knots exceeding 5 cm in diameter. The number, size and distribution of knots shall be such as not to weaken ballies to such an extent as to make it unsuitable for use.

Surface cracks shall not exceed 19 mm in depth and 3 mm in width for Type 1 ballies, and 12 mm in depth and 3 mm in width for Type 2 and Type 3 ballies provided they are not so numerous or so located as to impair the usefulness of the ballies. Spiral or twisted grain shall not be more than one complete twist of grain or spiral in any 6 m of length . Short crooks shall not exceed two in number per balli. Pin hole (dead infestation) shall be scattered and not concentrated, provided they are not due to powder pest beetles.

7.10 Nails

Steel wire nails shall conform to IS 723-1972, Specification for steel countersunk head wire nails. The nails shall be machine made. The head should be properly formed, chequered and concentric with the shank. The ends shall be sharp and pointed. Nails shall be plain finished.

7.11 Wood Screws

Steel wood screws shall conform to IS 451-1999, Technical supply condition for wood screws, and of the type, finish and size as required or as directed. Screws shall be cleanly finished and the heads shall be true and concentric with the shank. Slots in the head shall be clear, straight and free from burrs and central with regard to the head. Threads shall be clear and well defined. Wood screws shall be in 'self colour' condition.

7.12 Glue

Adhesives and glues for putting together joints in wood work and joinery shall conform to :-

(a) Synthetic adhesives WRB or MR grade conforming to IS 851-1978, Synthetic resin adhesives for construction work in wood; or

(b) Synthetic adhesives conforming to IS 4835-1979, Polyvinyl acetate dispersion based adhesives for wood.

WORKMANSHIP

7.13 Wood Work Generally

7.13.1 All wood work and carpenter's work shall be carried out as detailed in drawings or as directed by the EIC.

7.13.2 Species of Timber

Only the specified species of timber shall be used. For any one structural unit, only one specie of timber shall be used.

7.13.3 Sawing and Planing

Sawing shall be truly straight and square and in the direction of grains except for the members which are curved. Where indicated, the members shall be planed smooth to the full dimensions and rebated, rounded, chamfered or moulded as detailed in the drawings or directed, before they are fixed or framed and fixed. A tolerance of-2 mm and +2 mm shall be allowed in the finished cross sectional dimensions.

7.13.4 Jointing

The Contractor shall observe the following principles in forming joints:–

(a) To form joints and arrange the fastenings in such a way so as to weaken as little as possible the pieces of timber they connect.

(b) To place each abutting surface in a joint, as nearly as possible, perpendicular to the pressure it has to transmit;

(b) To form and fit accurately every pair of surfaces that come in contact.

7.13.5 Joints

Joints in timber frames shall be made carefully and accurately. Notches shall in no case remove more than the quarter of the section. All mortice and tenon, mitred, scarf and other joints shall fit fully and truly without wedging or filling and finished neatly. Framed joints shall be put together by gluing and pinned with hard wood or bamboo pins of about 10 mm dia.

7.13.6 Fabrication

Fabrication shall be done in the best possible manner and all necessary mild steel ties, straps, bolts etc., shall be fitted as indicated. Members shall be fabricated accurately so that these can be assembled without being unduly packed, strained or forced into position and when build up shall be true to shape and free from twist, kinks, buckle or open joints. Patching or plugging of any kind shall not be allowed.

7.13.7 Roof Trusses and Similar items

For roof trusses and similar items, a full size truss diagram shall be laid out on a level platform. From this diagram the templates for joints as for tenons, mortices, crafts, etc., shall be made for use in the construction of trusses etc.

7.13.8 Nailing and Screwing

The type, finish and size (length and shank dia or designation) of the nails and screws shall be as indicated or directed by EIC. Driving in screws with hammer is not permitted. The nails and screws (also bolts) shall be dipped in oil before fixing/driving. The heads of nails and screws shall be sunk and puttied or finished as directed.

7.13.9 Hoisting and placing in Position

The trusses and other framed work shall be hoisted and placed in position carefully without any damage to itself or other building work and injury to the workmen. The trusses etc., shall be braced and stayed temporarily in true position till they are permanently fixed with holding down bolts and other connecting members.

7.13.10 Surface Treatment

Woodwork shall not be painted, oiled or otherwise treated before it has been approved by the EIC. All portions of timbers built into or against or close to masonry or concrete or buried in ground shall be given two coats of hot tar, unless otherwise indicated. All junctions of rafters purlins, beams and wall plates shall be painted with a coat of primer or oiled depending upon, whether the members are painted or oiled.

7.13.11 Shrinkage

If after the wood work has been erected, any undue shrinkage is observed, the contractor shall replace or refix the same to the satisfaction of EIC.

7.13.12 Purlins

The lengthening joints in purlins shall be provided by means of steel gusset plates nailed or bolted, as indicated. The lengthening joint shall be arranged at the point of flexure, that is, within the distance of 1/5 to 1/3 of span of the purlin and staggered.

7.14 Shoring and Strutting

Walls, floors, roofs, partitions etc., where indicated or directed to be supported, shall be adequately shored to the satisfaction of the EIC. The Contractor shall be responsible for the soundness and strength of the timber used for shoring and strutting and for properly bracing and securing them to sustain the pressure to which the shoring is likely to be subjected. Shoring shall be removed only after its removal has been approved by the EIC.

Shoring shall consist of all requisite dogs, hoop iron, hooks, rakers, sole-pieces, wall pieces, braces, struts, needles, cleats, wedges and posts. Shoring shall be of suitable structural timber, clean sawn.

Racking shore may be at an angle of 60^{o} to 75^{o} with a building but 40^{o} is the best angle, if obtainable. Sole piece should be quite at right angle to the shore. The top needle should be at least 0.6 metre down from the top of the wall.

7.15 Form Work (Centering and shuttering)

7.15.1 Materials for Form Work

7.15.1.1 Propping and centering

All propping and centering should be either of steel tubes with extension or built up sections of rolled steels.

7.15.1.2 Centering/Staging

Staging should be as designed with required extension pieces as approved by EIC to ensure proper slopes, as per design for slabs/beams etc and as per levels as shown in drawings . All the staging shall be either of tubular steel structure with adequate bracings as approved or made of built up structural sections from structural steel sections.

In case of structures with two or more floors , the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

7.15.1.3 Shuttering

Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required , rubberized lining of materials as approved by the EIC shall be provided in joints.

Steel shuttering used for concreting should be sufficiently stiffened. The steel shuttering should also be properly repaired before use and properly cleaned to avoid stains, honey combing, seepage of slurry through joints etc.

7.15.2 Classification of Form Work

Formwork shall be classified depending upon the type of finish required for the concrete as under :-

(a) *Formwork for Rough Finish* :- Formwork required for the concrete surface which is either hidden from view or is specified to be separately finished with plastering or rendering.

(b) *Formwork for Fair Finish* :- Formwork required for the concrete surface which may show some joint– marks which may not be objectionable (on account of forming a pattern by itself or otherwise not objectionable), and is presentable without any further treatment.

7.15.3 General requirement

The formwork shall be rigid and so constructed as to retain the shape and dimensions of the member being cast. It shall have sufficient strength and rigidity to withstand the load of concrete, vibrations, movement of men, materials and plants and any other incidental loads without excessive deflection beyond permissible limits. Before concreting is started, the props and wedges shall be thoroughly checked to see that these are intact, and are not loose. While concreting is in progress, a constant watch shall be kept on the props and immediate remedial measures taken as soon as any of these gets loosened. Care shall be taken that props and wedges do not get loose for the minimum period specified for the removal of formwork.

7.15.4 Propping and Centering

The props shall consist of ballies, steel sections or of brick pillars laid dry or in mud mortar. Ballis shall be placed at a spacing of 1 to 1.2 meters and shall rest squarely on wooden sole plates. Double wedges shall be provided between the sole plate and the wooden prop, so as to facilitate tightening and easing of shuttering without jarring the concrete. In case brick masonry pillars are used as props, the wooden sole plate shall be provided at the top of pillar and double wedges inserted between the sole plate and the bottom of shuttering.

7.15.4.1 In case of multi-storeyed structures, the weight of concrete and formwork of any upper floor shall be suitably supported on at least two floors below the same.

7.15.4.2 In case the height of centering exceeds 3.50 metres, the props may be provided in multi-stages.

7.15.5 Shuttering

Shuttering for 'rough finish' surface of concrete may have clean sawn or wrought surfaces which come in contact with concrete surface and planed on the sides. The shuttering for 'fair finish' surface shall have wrought and smooth surfaces which come in contact with concrete surface and planed on sides. Joints shall not permit leakages of cement grout.

7.15.5.1 Form lining shall be such as would not discolour the concrete. Where steel sheet lining is provided to timber forms, it shall have, on mounting, minimum amount of kinks and other imperfections. Where metal forms are used, all bolts and nuts shall be countersunk and well ground to provide a smooth plain surface.

7.15.5.2 Where concrete is required to have a rounded edge, beveled edge or moulded edge, provision shall be made in the form itself. Opening for fan clamps and other fitting connected with services shall be provided in the shuttering as directed by the EIC.

7.15.5.3 As far as possible, clamps shall be used to hold the forms together. Where use of nails is unavoidable minimum number of nails shall be used and these shall be left projecting so that they can be easily withdrawn.

7.15.6 Surface Treatment to Shuttering

Forms shall be thoroughly cleaned of all dust, dirt, wood shavings and other matter by washing with water. The surface shall then be coated with soap solution before concreting is done. Soap solution shall be prepared by dissolving yellow soap in water to get consistency of paint. Alternatively a coat of raw linseed oil/refined pale paraffin mineral oil of approved manufacturer may be applied. Care shall be taken that the coating does not get on construction joint surface and reinforcement bars. It shall also not cause softening or permanent staining of concrete surface nor shall impede the wetting of surfaces to be water-cured. Special care shall be taken in case of small grooves. The form strips shall be oiled coated thoroughly so as to prevent swelling of the forms and consequent damages to the concrete on removal of forms.

7.15.7 Camber

The shuttering for beams and slabs shall have a camber of 1 in 250 and for cantilevers at the free end of 1/50 of the projected length or as directed by the EIC.

7.15.8 Erection or Assembly of Forms

Formwork shall be erected true to line, vertical or battered to proper slope as required and free from twist. It shall be so assembled as to facilitate easing, and removal of the various parts in proper sequence without jarring the concrete. For columns etc., where concreting is done in stages, one side of the formwork shall be made in suitable parts and shall be capable of being fixed securely and quickly in position. The complete formwork shall be inspected and approved by the EIC before placing reinforcement and laying concrete.

The formwork shall confirm to the shapes, lines and dimensions as shown on the drawings or as indicated, within the tolerance given below :-

(a) Deviation from specified dimension of cross section of column and beam.	- 6mm +12mm
(b) Deviation from dimension of footing	(See Note)
(i) Dimension in plan	- 12 mm + 30 mm
(ii) Eccentricity	02 times the width of footing in the direction of deviation but not more than 50 mm.

Note :- Tolerance apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowel

7.15.9 Striking/Removal of Forms

Forms shall be removed gently. They shall be eased carefully in order to prevent the load being suddenly transferred to concrete. The minimum period that shall elapse after the concrete has been laid and before form work is eased and removed is given in section-4: Concrete, for ordinary Portland cement.

Notes :-

1 : For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. If Portland pozzolana or low heat cement has been used for concrete, the stripping period will be increased suitably as indicated or directed by EIC.

2 : The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beams or arch as the case may be, together with any live load likely to occur during curing or further construction.

3 : For rapid hardening cement periods will be suitably decreased as indicated or directed by EIC. However for vertical side of slabs, beams and columns forms should be retained for at least 24 hrs

4 : In case of cantilever slabs and beams , the centering shall remain till structures for counter acting or bearing down have been erected and have attained sufficient strength.

5 : Proper precautions should be taken to allow for the decrease in the rate of hardening that occurs with all types of cement in cold weather and accordingly stripping time shall be increased.

6 : Work damaged through or careless removal of forms shall be reconstructed.

7.15.10 Reuse

Before reuse, the forms shall be thoroughly scraped, cleaned and joints gone over and repaired where necessary. Inside surface shall be retreated to prevent adhesion of concrete.

7.15.11 Inspection of Form Work

The completed form work shall be inspected and approved by the EIC before the reinforcement bars are placed in position.

Proper form work should be adopted for concreting so as to avoid honey combing, blow holes, grout loss, stains or discolouration of concrete etc. Proper and accurate alignment and profile of finished concrete surface shall be ensured by proper designing and erection of form work which will be approved by EIC.

Shuttering surface before concreting should be free from any defect/ deposited and fully cleaned so as to give perfectly straight smooth concrete surface. Shuttering surface should be therefore checked for any damage to its surface and excessive roughness before use.

7.15.12 Erection of Form Work (centering and shuttering)

Following points shall be borne in mind while checking during erection:–

(a) Any member which is to remain in position after the general dismantling is done , should be clearly marked.

(b) Material used should be checked to ensure that, wrong items/rejects are not used. If there are any excavations nearby which may influence the safety of form works, corrective and strengthening action must be taken.

(c) (i) The bearing soil must be sound and well prepared and the sole plates shall bear well on the ground.
  (ii) Sole plates shall be properly seated on their bearing pads or sleepers.
  (iii) The bearing plates of steel props shall not be distorted.
  (iv) The steel parts on the bearing members shall have adequate bearing areas.

(d) Safety measures to prevent impact of traffic, scour due to water etc , should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc.

(e) Bracing, struts and ties shall be installed alongwith progress of form work to ensure strength and stability of form work at intermediate stage. Steel sections (specially deep sections) shall be adequately restrained against tilting , over turning and form work should be restrained against horizontal loads. All the securing devices and bracing shall be tightened.

(f) The stacked materials shall be placed as catered for, in the design.

(g) When adjustable steel props are used , they should.
  (i) be undamaged and not visibly bent,
  (ii) have the steel pins provided by the manufacturers for use,
  (iii) be restrained laterally near each end,
  (iv) have means for centralizing beams placed in the foreheads,

(h) Screw adjustment of adjustable props shall not be over extended.

(i) Double Wedges shall be provided for adjustment of the form to the required position wherever any settlement/elastic shortening of props occurs. Wedges should be used only at the bottom end of single prop. Wedges should not be too steep and one of the pair should be tightened /clamped down after adjustment to prevent their shifting,

(j) No member shall be eccentric upon vertical member.

(k) The number of nuts and bolts shall be adequate.

(l) All provisions of the design and /or drawings shall be complied with.

(m) Cantilever supports shall be adequate.

(n) Props shall be directly under one another in multistage constructions as far as possible.

(o) Guy ropes or stays shall be tensioned properly.

(p) There shall be adequate provision for the movement and operation of vibrations and other construction plant and equipment.

(q) Required camber shall be provided over long spans.

(r) Supports shall be adequate, and in plumb within the specified tolerance.

7.16 Centering for Arches

Centering for arches shall be of steel or timber as indicated and so constructed and stayed as to remain rigid and unyielding during the construction of the work for which it acts as support.

Other materials such as bricks, etc., may be used as supports only for centering if they will serve effectively the purpose desired, subject to the approval of the EIC. In preparing centering, allowance shall be made for easing by means of wedges before striking the centering. Centering shall be set truly level, unless otherwise indicated. Centering shall not be removed without permission of the EIC.

7.17 Length of Scantling

Unless otherwise indicated, the Contractor shall supply scantlings in one piece in lengths upto 3 m. For lengths over 3 m the Contractor shall be allowed to use more than one piece. One for every extra 3 m or part thereof; and shall connect the same with proper scraf or other lengthening joints, as directed by the EIC.

7.18 Nail Jointed Timber Construction

7.18.1 Nails with blunt, tapered and diamond point are preferable for structural work. Diameter of nails shall be within the limits of 1/11 to 1/6 of the least thickness of the members to be connected. It should be such that while driving, the nails should not cause splits or cracks in the timber. The length shall be such that the nails fully penetrate through all the members to be jointed. A minimum of two nails for nodal joints and four nails for lengthening joints shall be used.

7.18.2 Spacing of nails

Unless otherwise indicated or directed, minimum distance of nails, prebore end, between the nail distance from the edge shall be as per IS 2366-1983.

7.18.3 Driving the Nails

Nails shall be driven through and through. Adjacent nails shall be driven alternately from either faces. Protruding nails shall be cut down or clenched. Where required prebore shall be drilled before driving the nails to avoid the splitting of timber. Prebore for various sizes of nails shall be as specified in IS 2366-1963.

7.18.4 Camber

The initial camber recommended in nail jointed construction is L/200 where L is the span of the truss.

7.19 Bolt Jointed Timber Construction

7.19.1 Spacing of Bolts

Unless otherwise indicated or directed, spacing of bolts shall be as per IS 11096-1984.

7.19.2 Bolting

Staggering of bolts shall be avoided as far as possible in case of members loaded parallel to grain of wood. For loads acting perpendicular to grain of wood, staggering is preferable to avoid splitting due to weather effects. The bolt holes shall be bored or drilled perpendicular to the surface involved. Bolts shall not be forcibly driven. A bolt hole of 1 mm oversize may be used as guide for pre-boring. Washer shall be used between the wood and the bolt head and between wood and the nut.

7.20 Battens for Mangalore Tile Roofing

The spacing of rafters shall not normally exceed 60 cm. The battens shall be fixed over the rafters or the boarding at the spacing indicated and nailed to the rafters/boarding with plain headed nails. The nails shall penetrate at least 2 cm into the rafters/boarding. The length of battens shall be extended with butt joints and shall be located only over the rafters. The joints of no two adjacent rows of battens shall come over the same rafter. At the eaves tilting fillet shall be fixed, unless otherwise indicated.

7.21 Nailing and Screwing of Fillets, Battens and Boards

Fillets, battens, trellis work; etc. shall be nailed, or screwed, if indicated, at every support. Boarding shall be nailed, or screwed if indicated, using two nails or screws for every board per support. Where the support is continuous, the nailing or screwing shall be done at intervals not exceeding 30 cm. As a guide, the minimum length of nails and screws shall be as under :-

For 15 mm to 20 mm thick timber .... 30 to 40 mm long.
For 25 mm to 30 mm thick timber .... 50 to 60 mm long.
For 35 mm to 45 mm thick timber .... 60 to 80 mm long.
For 50 mm thick timber.. 100 mm long.

7.22 Roof Boarding

Heading joints shall come over centre of rafters or purlins in all cases. For tiled roofs, etc., the boarding shall be laid horizontally over rafters butt jointed, well cramped up and securely nailed to rafters. When fixed direct to purlins, the boarding shall be laid diagonally with butt joints, well cramped up and securely nailed to purlins. When fixed under felt etc. the boarding shall be tongued and grooved, traversed and cleaned off after fixing, to an even surface. All nail heads shall be driven in and all exposed arises rounded off.

7.23 Weather Boarding

Weather boarding shall be 12 to 18 cm in width plain or feather edged, rebated and chamfered, hollow or V jointed with edges shot or chamfered and of thickness as indicated fixed with 60 mm long nails and neatly cut and fitted around doors, windows, etc.

7.23.1 The types of weather boarding shall be as specified. Types of weather boarding are shown in Fig. 1 to 5 at the end of the Section.

7.24 Timber Ceiling

Timber ceilings shall be provided as detailed in drawings. Unless otherwise indicated, timber boards/planks shall be 15 to 20 mm thick as indicated and width 100 to 150 mm as indicated. The longitudinal edges of the planks shall be jointed to each other in one of the following ways, as indicated :-

(a) *Butt and Beading Type :-* The planks shall be butted together with a small gap and a beading provided.
(b) *Overlap Type* :- Each plank shall overlap the adjoining plank by at least 15 mm on both sides such that any two adjoining planks are in two levels.
(c) *Half Lap Type :-* The adjoining planks shall be half lapped by 15 mm.
(d) *Tongued and Grooved Type* :- The adjoining planks shall be jointed together through tongued and grooved joint with tongue 10 mm long.

7.24.1 Fixing

The plank joints shall be parallel and in perfect line. The first plank next to the wall shall be fixed carefully and accurately very close to the wall. Subsequent planks shall be jointed up as indicated with utmost care. The longitudinal joints of the plank shall be as indicated. Heading joints shall be square butt type and shall occur under centre line of the supporting joint. The countersunk screw holes and the joints between the planks (except butt joints) shall be filled with putty or stopping.

7.24.2 The beading where indicated shall be fixed to boarding with screws of length 50 mm or equal to the overall thickness of the planks and beading whichever is larger. The overlap of the beading shall be equal on either side of the two adjoining planks. The beading shall be mitred at junctions. The spacing of the screws shall be staggered along the length so that each one is driven completely through the planks. Screws shall be countersunk and screw holes filled up with putty or stopping.

7.25 Timber Floors

Timber floors shall be provided as detailed in the drawings. Timber floor boards shall be of the species and class as indicated. Only selected quality of boards of uniform width shall be used.

7.25.1 Floor boards shall be 25 mm to 40 mm in thickness as indicated and shall not be less than 10 cm nor more than 15 cm, in width. The same width of boarding shall be maintained throughout the floor except where the width of the room is not an exact multiple of the boards; in which case the difference shall be equally adjusted between the two end boards adjacent to walls. The maximum length of the boards shall be restricted to 3 meters. The minimum length of board shall be such that the boards rest at least on three supports but in no case it shall be less than 2 metres.

7.25.2 Finish and Jointing

The boards shall be planed true on the top surface only: with edges shot, tongued and grooved rebated or rebated and filleted (with loose filet) and heading joints shall be close butt, tongued and grooved, cross tongued or secret nailed, as indicated. Heading joints shall occur over the centre line of the supporting joints/rough ground and that heading joints in adjacent boards shall not be placed over the same joist. The length of the nails and screws shall be not less than twice the thickness of the board. Where use of screw is indicated they shall not be thinner than designation 8.

7.25.3 Fixing

The joists or the rough grounds on which planks are fixed shall be checked and corrected to levels. The end boards shall be accurately fixed with the sides parallel and close to the walls. A margin of minimum 5 mm all round shall be left to allow the floor to expand. Unless otherwise indicated, each adjoining board shall be properly jointed and tightened into position and nailed, or screwed where indicated. Two nails/screws shall be used for fixing each board to the joist/rough ground at each end and one nail/screw at the intermediate joists in a zigzag manner. The screws shall be countersunk and screw holes filled with approved stopping. The junction between timber flooring and adjacent flooring shall be formed by inserting an aluminium strip at the junction. The metal strip shall be fixed to the end of the planks by screws. The flooring shall be truly level and plane. The flooring shall be planed in both directions and made perfectly even, true and smooth.

7.25.4 Finishing

The surface of the floor shall be waxed or otherwise finished as indicated. The lower face shall be treated as indicated.

7.26 Timber Fencing Posts

Fencing posts shall be provided as detailed in the drawing. The bottom ends shall be sawn square and tops shall be either tapered or sawn square as indicated or as directed.

7.26.1 Knots in the timber fencing posts shall not be more than half the cross sectional dimensions of fence posts. The number, condition and distribution shall be such as not to weaken a post to an extent to make it unsuitable for use. Surface cracks shall be permitted only upto 5 mm in depth, 1 mm in width and upto 10 cm in length. Their number and location shall not impair the usefulness of posts. Pin holes shall be well scattered and not concentrated in any area. No pin hole shall be permitted if they contain live infestation of powder pest beetles. All fence posts shall be seasoned to a moisture content not more than 18 percent. A tolerance of + 5 mm in dimensions of fence posts shall be permitted.

7.26.2 Erection

Unless otherwise indicated, fence posts shall be erected so that at least 40 cm of the butt is firmly gripped in the ground. The holes in the ground shall be as small as practicable to allow for refilling with earth which shall be well rammed. When posts are set in concrete, concrete shall be set with posts completely gripped in it and earth well rammed on all sides of concrete. The top of the concrete may be sloped away from the post in all directions.

7.27 Timber Piles

Species of timber for piles shall be as indicated. Ballies used for piling shall be specially selected and straight. The ratio of heartwood diameter to the pile butt diameter shall be not less than 0.8. Circumference less by 5 cm than that specified in 10 percent piles may be acceptable. Defects like short crooks, twists, knots etc. shall not exceed those specified for structural timber ballies.

7.27.1 Setting Out

The piles shall be set out to proper alignments, correctly centered and driven vertically or battered as indicated. In loose sand and stiff clay pile driving shall proceed outward from the centre. In the case of very soft soils driving may have to proceed from outside to inside, unless otherwise directed.

7.27.2 Driving

The pile tip shall be pointed in the form of a truncated cone or a pyramid having the end 25 cm^2 to 40 cm^2 in area and the length shall be 1-1/2 to 2 times the diameter. If the driving is to be done through hard material such as stiff clay and gravels etc., metal shoes of approved design shall be attached to the tip. To prevent splitting and reduce brooming the head of the pile shall be hoped. The heads of piles shall be further protected by provision of cushion blocks.

7.27.3 Control of Alignment

The pile shall be driven as accurately as possible to the vertical or to the specified batter. Any pile deviating from its proper alignment to such an extent that the resulting eccentricity cannot be taken care of, shall at the discretion of the EIC, be replaced or supplemented by an additional pile at no extra cost to the Govt. As a general guide, permissible positional deviation for piles shall be not greater than 75 mm from their designed position at the working level of the pile rig. In case of single pile in the column position, the tolerance shall not be more than 50 mm and shall not exceed two percent (one degree) from the specified inclination.

7.25.4 Amount of driving

Care shall be taken not to damage the piles by over driving. Any sudden change in the rate of penetration, which cannot be ascribed to the nature of the ground, shall be noted and its cause ascertained, if possible, before driving is continued.

7.27.5 Recording of Data

The recorded data shall include the following :-

(a) The diameter of the pile;
(b) The depth driven;
(c) The sequence of driving-in pile groups;
(d) The final set for the last ten blows, or as may be directed;
(e) The type and size of hammer and its stroke, or with double- acting hammers the number of blows per minute; and
(f) The type and condition of the packing on the pile head and the dolly in the helmet.

7.27.6 Cut offs and Capping

After driving pile tops shall be cut off to a true plane and shall show a solid head at the plane of cut off. Capping shall be done when the piles are in correct position.

7.28 Ballie Work

Ballies shall be fixed with notched, halved, lapped or other joints and securely fixed at crossings, joints etc. with clamps, bolts and nuts and spikes (country nails) as indicated or as directed by the EIC. In case spikes are used for firming, the large nails with a cap shall be driven through about 40 mm beyond ballies to be fixed together and the end of the nail turned back to ensure proper fastening. Squaring, packing pieces, firing etc. shall be provided to obtain level bedding, bearing, fixing, etc.

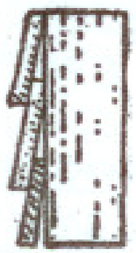
7.28.1 The ballies in truss work shall be, as far as possible, of full lengths. Where making up is considered necessary, it shall be done by half lap joints secured together with mild steel clamps of suitable length and shape and fixed with bolts and nuts.

7.29 Wooden Plugs

Wooden plugs shall be made of hardwood and shall be wedge shaped. Unless otherwise indicated or directed, the size of plugs shall be 20 mm square at one end, 25 mm square at the other end and 50 mm long. Wooden plugs shall be driven into the matrices, embedded in the holes with grout around them, if necessary, at the time of construction, generally. If plugs are fixed later, a neat hole of a size slightly longer than the size of plug shall be made and plug fixed in the hole and the surrounding space grouted with neat cement mortar. The side with the larger cross section shall be inserted inside the wall.

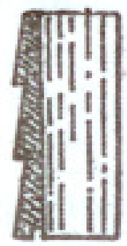
TYPES OF WEATHER BOARDING
(NOT TO SCALE)

FIG 1



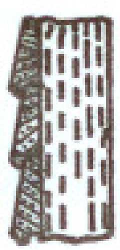
PLAIN
FEATHER EDGE

FIG 2



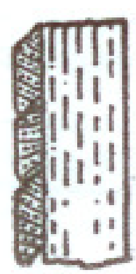
REBATED

FIG 3



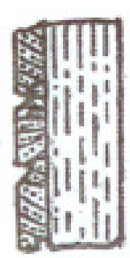
REBATED AND
CHAMFERED

FIG 4



V JOINTED

FIG 5



REBATED AND
HOLLOW JOINTED

SECTION 8
JOINERY

8.1 Indian Standards

The following IS apply to this Section :

IS No	*Subject*
303-1989	Specification for plywood for general purposes (Third revision)
737-1986	Specification for wrought aluminium and aluminium alloys sheets and strip for general engineering purposes (Third revision)
848-2006	Specification for synthetic resin adhesive for plywood (phenolic and amino plaster) (Second revision)
851-1978	Specification for synthetic resin adhesive for construction work (non structural) in wood (First revision)
852-1994	Specification for animal glue for general wood-working purposes (Second Resivion)
1003 (Part 1) - 2003	Specification for timber panelled and glazed shutters (Fourth revision)
1003 (Part 2)- 1994	Specification for timber panelled and glazed shutters (Part 2) window and ventilator shutters (Third revision)
1141-1993	Specification for code of practice for seasoning of timber (Second Revision)
1284-1975	Wrought aluminium alloy bolt and screw stock for general engineering purposes (Second Revision)
1328-1996	Specification for veneered decorative ply wood (Third Revision)
1658-2006	Specification for fibre hardboards (Third Revision)
1659-2004	Specification for block boards (First Revision)
1708 (Part 1 to 18)- 1986	Method of testing of small clear specimen of timber (Second Revision)
1734 (Part 1 to 20)- 1993	Method of test for plywood (Part 1 to 20 in one voloum (Second Revision)
2096 : 1992	Specification for asbestos cement flat sheets (First revision)
2202 (Part I)- 1999	Specification for wooden flush door shutters (solid core type), Part I plywood face panels (Sixth Revision)
2202 (Part 2)- 1983	Specification for wooden flush door shutters (solid core type) Part 2 particle board face panels and hard board face panels (Third revision)
3087-2005	Specification Particle boards of wood and other lingocelluelosic material (medium density) for general purposes (Second revision)
3097-2006	Specification for veneered particle boards (second revision)
4020 (-Part 1 to 16) 1998	Method of Tests: Door shutters (Third Resivion)
4671 : 1984	Expanded polystyrene for thermal insulation purposes (First revision)
4835-1979	Specification for polyvinyl Acetate dispersion based adhesive for wood (First Revision)
12406- 2003	Specification for medium density fibre board for general purposes (First revision)

MATERIALS

8.2 Definitions

Refer 7.2 Section 7 Woodwork.

8.3 Timber and Defects in timber

Refer 7.3 and 7.5, Section 7 Wood work.

8.4 Seasoning of Timber and Moisture Content

Refer 7.6 and 7.7 Section 7 Woodwork

8.5 Species of Timber

Refer 7.8 Section 7 Woodwork

8.6 Timber Panel

Timber panels shall be preferably made of timber of large width. The minimum width and thickness of a panel shall be 150 mm and 15 mm respectively. When made from more than one piece, the pieces shall be joined with a continuous tongue and groove joint, glued together and reinforced with metal dowels. The grains of timber panels shall run along the longer dimensions of the panels. The panels shall be designed such that no single panel exceeds 0.5 square metre in area.

8.7 Plywood Boards

Plywood shall be formed by gluing and pressing three or more layers of veneers as indicated. The veneers shall be either rotary cut or sliced and shall be sufficiently smooth to permit an even spread of glue. Face veneers may be either commercial or decorative on both sides or one side commercial and the other decorative, Plywood shall be of BWP grade or BWR as per IS:303 as indicated. Adhesive for bonding of veneers shall be synthetic resin adhesive conforming to IS - 848.

8.7.1 The thickness of all veneers shall be uniform , within a tolerance of + 5 percent. Corresponding veneers on either side of the centre one shall be of the same thickness and species. The requirement of thickness and core veneers shall be as follows:

(a) In 3 ply boards upto 5 mm thick. The combined thickness of the face veneers shall not exceed twice the thickness of centre ply.

(b) In a multiply boards, the thickness of any veneer shall not be more than thrice the thickness of any other veneer.

(c) The sum of the thickness of the veneers in one direction shall approximate to the sum of the thickness of the veneers at right angle to them and shall not be greater than 1.5 times this sum except for 3 ply as specified as (a).

8.7.2 Thickness

Plywood boards are available in thickness ranging from 3 to 25 mm . Tolerance in thickness shall be + 10% for boards upto and including 5 mm ; + 7% for boards for 6 to 9 mm, and + 5% for boards above 9 mm thickness . The boards shall be of uniform thickness and the surface of the boards shall be sanded to a smooth finish. Number of plys in plywood boards shall be as per Table below.

Thickness in mm	No of ply	Thickness in mm	No of Ply
3,4,5,6,	3	12,15,16,19	9
5,6,,8,9	5	19,22,25	11
9,12,15,16	7		

8.7.3 Moisture content of the plywood boards when tested in accordance with IS:1734 (Part 1) shall not be less than 5 per cent and not more than 15 per cent.

8.8 Particle Boards

8.8.1 Particle boards shall be of medium density and manufactured from particles of agro waste, wood or lingo-cellulose, i.e, material blended with adhesive and formed into solid panels under the influence of heat, moisture, pressure etc. The particle boards shall be flat pressed with single, three or multi layers and graded and of Type I as per Table 1 of IS : 3087. Both faces of particle board shall have sanded smooth finish.

8.8.2 Adhesive

Adhesive used for bonding shall be BWP type synthetic resin conforming to IS: 848.

8.8.3 Thickness and Tolerance

Particle boards are available in thickness ranging from 6 mm to 40 mm. Tolerance in thickness shall be + 5 % for boards upto and including 25 mm thick, and + 2.5% for boards above 25 mm thickness . Each board shall be of uniform thickness.

8.8.4 Testing

One sample for every 100 Sqm or part thereof shall be taken and testing done as per IS: 3087. However testing may not be done if the total requirement of particle boards in a work is less than 30 Sqm. All the samples tested shall meet the requirement of physical and mechanical properties of particle boards specified in relevant IS code.

8.8.5 Thickness of particle boards and adhesive used for bonding shall be as specified. Unless otherwise stated, only Type I particle boards bonded with BWP type synthetic resin adhesive shall be used.

8.9 Veneered Particle Boards

8.9.1 Veneered Particle Boards have a solid core of medium density Type I particle board(which is covered with commercial or decorative veneers on both faces or with decorative veneers on one face and commercial veneers on the other). Face veneers are bonded using adhesives under the influence of heat and pressure. Veneered particle board shall be of exterior grade (Grade I) as per IS: 3097.

8.9.2 Adhesive

The adhesive used for bonding shall be BWP synthetic resin conforming to IS: 848.

8.9.3 Thickness and Tolerance

Veneered particle boards are available in thickness ranging from 6 to 50 mm.

Tolerance in thickness shall be + 5% for boards upto and including 25 mm thick and + 2.5% of boards above 25 mm thickness. Each board shall be of uniform thickness.

8.9.4 Testing

One sample for every 100 sqm or part thereof shall be taken and testing done as per IS:3097. However, testing may not be done if the total requirement of veneered particle boards in a work is less than 30 Sqm. All the sample tested shall meet the requirements of physical and mechanical properties of veneered particles boards specified in relevant IS code.

8.9.5 Type of face veneers, thickness of veneered particle boards and adhesive used for bonding shall be as specified. Unless otherwise stated, exterior grade veneered particle board with BWP type synthetic resin adhesive shall be used.

8.10 Hard Board

8.10.1 Hard boards are generally classified into the following three types, according to their method of manufacture, density and other related mechanical and physical properties.

(a) Medium hard board: A homogenous fibre building board having a density exceeding 480 Kg/Cubic metre but not exceeding 800 Kg/Cubic metre

(b) Normal hard board: A homogenous fibre building board having a density exceeding 480 Kg/Cubic metre but not exceeding 1200 Kg/Cubic metre

(c) Tempered hard board : Hard board which has been further treated in the course of manufacture to increase its density, strength and water resistance.

8.10.2 The hard board used for paneling of door shutters, shall be of tempered quality. The thickness of hard board paneling used shall not be less than 12 mm in case of single panels shutter and 10 mm in case of two or more panel shutter. The hard board shall be regular and , unless otherwise specified shall have square edges. The lengths of the two diagonals of the boards shall not differ by more than + 3 mm per metre length of diagonal. The tolerance on length and width shall be + 3 mm and on thickness +0. 3 mm.

8.10.3 Workability

The hard boards shall not crack, split or chip when drilled, sawed or nailed perpendicular to the surface.

8.10.4 Finish

The boards shall be of uniform thickness subject to tolerance stated above. They shall be free from warp. The surface shall be flat, free from cracks and lumps and of natural colour. At least one face shall be smooth.

8.11 Block Board

8.11.1 Block Boards have a solid core made up of uniform strips of wood each not exceeding 25 mm in width laid separately, or spot glued, or otherwise joined to form a slab which is glued between two or more outer veneers. In any one block board, the core strips shall be of one species of timber only. Face veneers may be decorative or commercial on both faces or decorative on one face and commercial on the other. Block boards shall be Grade 1 (Exterior Grade) as per IS: 1659. Both surfaces of the boards shall be sanded to a smooth finish.

8.11.2 Adhesives

The adhesives used for bonding shall be BWP type synthetic resin conforming to IS: 848 for Grade I block boards.

8.11.3 Thickness and Tolerance

Block boards are available in thickness ranging from 12 to 50 mm . Tolerance in thickness shall be + 5% for boards upto and including 25 mm thick, and + 2.5% for boards above 25 mm thickness. Each board shall be of uniform thickness.

8.11.4 Testing

One sample for every 100 sqm or part thereof shall be taken and testing done as per IS: 1659. However , testing may not be done if the total requirement of block boards in a work is less than 30 Sqm. All the samples tested shall meet the requirements of physical and mechanical properties of block boards specified in the relevant IS code.

8.11.5 Type of face veneers, thickness and grade of block boards shall be as specified. Unless otherwise stated , Grade I (exterior grade) block boards bonded with BWP type synthetic resin shall be used.

8.11.6 Asbestos Cement Board

This should conform to IS: 2096. The material used in the manufacture of asbestos cement building boards shall be composed of an inert aggregate consisting of clean asbestos fibre cemented together by ordinary portland cement, rapid hardening and low heat portland cement, or blast furnace slag cement. No organic or inorganic materials shall be added to the composition. Pigments which are embodied in the asbestos cement for colouring purpose shall be of permanent colours and shall conform to the requirement. The thickness of the asbestos cement board used for panelling shall not generally be less than 6.5 mm in case of single panels shutters and 5 mm in case of two or more panel shutter. Asbestos cement building boards shall be of two classes, namely class A and class B. The thickness of class A shall be 6.5 mm and for class B 5 mm. The tolerance on thickness shall be + 0.5 mm.

8.12 Fibre Boards

8.12.1 Fibre boards shall be of medium density and manufactured from wood fibre, produced by fibreizing steamed wood under pressure, blended with adhesive and wax and formed into solid panels under controlled conditions of heat and pressure. Fibre boards are flat pressed single layers and shall be exterior grade as per IS: 12406. Both surfaces of the boards shall be sanded to a smooth finish.

8.12.2 Adhesives

The adhesive used for bonding shall be BWP type synthetic resin conforming to IS: 848.

8.12.3 Thickness

Fibre boards are available in thickness ranging from 6 to 40 mm. The tolerance in thickness shall be + 0.3 mm upto and including 9 mm thickness, and + 0.6 mm for thickness above 9 mm.

8.12.4 Testing

One sample for every 100 sqm or part thereof shall be taken and testing done as per IS 12406. However, testing may not be done if the total requirement of fibre boards in a work is less than 30 Sqm. All the samples tested shall meet the requirements of physical and mechanical properties of fibre boards specified in the relevant IS Codes.

8.12.5 Thickness of fibre boards and adhesive used for bonding shall be as specified. Unless otherwise stated, exterior grade fibre boards bonded with BWP type synthetic resin adhesive shall be used.

8.13 Nails and Screws

Refer 7.10 and 7.11 Section 7 Woodwork

8.14 Glue

Refer 7.12 Section 7 Woodwork

WORKMANSHIP

8.15 Joiner's Work Generally

8.15.1 Species of Timber

Only the species of timber indicated shall be used.

8.15.2 All exposed faces of joinery shall be planed smooth (wrought) and neatly and truly finished to the full dimensions, rebates, roundings and mouldings as indicated. Unless dimensions are indicated to be finished dimensions, a tolerance of 1 mm shall be permitted for each wrought face.

8.15.3 Jointing

The contractor shall observe the following principles in forming joints :-

(a) To cut the joints and arrange the fastenings in such a way so as to weaken as little as possible the pieces of timber they connect;
(b) To place each abutting surface in a joint, as nearly as possible, perpendicular to the pressure it has to transmit;
(c) To form and fit accurately every pair of surfaces that come in contact.

8.15.4 Joints shall be made carefully and accurately. All mortice and tenon and other joints shall fit fully and truly without wedging or filling and finished neatly. Where indicated, butt joints shall be cross tongued. The tongue shall be cut at right angles or diagonally to the grains of the wood.

8.15.5 Defective knots, when permitted on surfaces exposed to view, shall be completely bored or cut out and tightly plugged with the same timber species and properly glued in. The grains of plug shall run in the direction of the grains of piece.

8.15.6 Framing shall be done in the best possible manner. Members shall be fabricated neatly and accurately so that these can be assembled without being unduly packed, strained or forced into position and when built up shall be true to shape and free from twist or open joints. Framed joints shall be glued together and pinned with bamboo or hardwood pins.

8.15.7 All joiner's work shall be cut and framed together well ahead of their incorporation in the work but shall not be wedged up until required for fixing in position and passed by the EIC. Any portion that may warp or develop shakes or other defects shall be replaced with new before being wedged up.

8.15.8 The contact surfaces of mortice and tenon shall be glued before putting together with bulk type synthetic resin adhesive coforming to IS 851 - 1978 suitable for construction work in wood. Tongued and grooved joints shall also be properly glued together with a suitable adhesive.

8.15.9 Chowkats and other framed work shall be carefully erected and braced or stayed in the true position till built in or secured with bolts, holdfasts, pins or other connecting members.

8.15.10 If, after the joinery has been erected, undue shrinkage or bad workmanship is discovered the contractor shall forthwith replace or refix the same to the satisfaction of the EIC.

8.15.11 Where plaster finishes against frame or lining and the joint is not covered by a cover fillet or an architrave frame or lining shall be grooved for plaster as indicated.

8.15.12 The face for frame abutting the walls, lintels, and cills etc. shall be given two coats of hot tar before fixing, unless otherwise indicated.

8.15.13 The contractor shall obtain permission of the EIC, in writing, before he tars, paints, polishes or otherwise treats joinery.

8.16 Lengthening of Members

Unless otherwise indicated, the contractor shall supply members in one piece in lengths upto 3 metres. For lengths over 3m, the contractor may use more than one piece, one for every extra 3m or part thereof and shall connect the same with proper lengthening joints as directed by the EIC. The lengths of member should match.

8.17 Nailing, Screwing etc.

Nailing, screwing etc. of the various members of joinery, where necessary shall be done as directed by the EIC. When driving the screws, it is advisable that in case of hard timbers pilot holes are drilled before fixing the screw. The screws shall be driven tight fit and straight.

8.18 Timber Frames and Chowkats

8.18.1 All members of the timber frames shall be straight without any warp or bow and shall be exactly at right angles, which shall be checked from the inside surfaces of the respective members. Frames shall have smooth, well planed surfaces except the surfaces touching the walls, lintels, cills etc. which may be left clean sawn, unless it is required for straightening up or to obtain the overall sizes. Rebates, roundings and moulding etc. shall be done before the members are jointed into frames.

8.18.2 Timber frames shall have dovetail joints. The jamb post shall be through tenoned into the mortices of the transom to full width and the thickness of the tenon shall be not less than 15 mm. The tenons shall be closely fitted into the mortices without any wedging or filling and shall be pinned with hard wood or bamboo dowels not less than 10 mm dia. The depth of rebate in the frames for housing the shutters shall be 15 mm. The joints before being put together shall be glued with a synthetic adhesive conforming to IS 851-1978 or to IS 4835-1979 or animal glue conforming to IS 852-1994.

8.18.3 All door, window and ventilator frames shall be clamped together so as to be square and flat before being built in. Each assembled door frame shall be fitted with temporary cross battens.

8.18.4 The faces of frame abuting the wall, lintel, cill etc., shall be given two coats of hot tar before fixing, unless otherwise indicated.

8.19 Fixing of Chowkats and Frames

Timber frames of door, window, ventilator etc., shall be installed by 'built in method' unless indicated to be installed by 'prepared opening method'. Precautions shall be taken to fix the door frames so as to take care of the final floor level and whether the shutters open inside or outside.

8.19.1 Built in Method

Masonry or concrete in the wall shall be built after installation of the frames so that the holdfasts and pins, if any, at the bottom are well anchored into them. Suitable arrangements shall be made to hold the frame in rectangular shape and to prevent warping and distortion of frames during construction. Usually one cross batten at the middle, one cross batten at the bottom (where no cill is provided for door) and two cross battens diagonally will be necessary to hold the frame rectangular.

8.19.2 Prepared Opening Method

The clearance between the frame and opening shall be kept depending on whether the opening is externally rendered or fair faced. The frame shall be checked before fixing in position that the same is square and in the proper position. The holdfast opening and the bottom pins shall then be grouted or frames fixed as indicated. Plastering of the sides shall be done and allowed to dry before the shutters are fixed.

8.19.3 Clearing

After the plaster and grouting have dried, all splatter and marks of cement shall be removed and the frames cleaned.

8.19.4 In the case of frames without cill the vertical members shall be buried in the floor for the full thickness of the floor finish.

8.19.5 The holdfasts shall be tightly fixed to the frame by means of bolts or wood screws as indicated; the bolt hole in the frame being plugged suitably and finished neat unless otherwise indicated.

8.20 Shutters Generally

8.20.1 The types of shutters for doors, windows, ventilators, cupboards, etc., viz. panelled, glazed, wire gauzed, partly panelled and partly glazed or gauzed, ledged braced and battened, louvered etc., shall be as indicated and detailed in the drawings.

8.20.2 All members of the shutter shall be made out of one piece and shall be straight without any warp or bow. They shall have smooth, well planed surfaces at right angles to each other. The right angles of the shutters shall be checked by measuring the two diagonals from one extreme corner to the opposite one.

8.20.3 The contact surfaces of mortice and tenon and tongued and grooved joints shall be glued before putting together.

8.20.4 In the case of double leaved shutters the meeting stiles shall be rebated 20 mm or as shown on drawings. The rebating shall be splayed or square, as directed.

8.20.5 All shutters shall be finished smooth with well planed faces.

8.20.6 Tolerance in the thickness of joinery shall be + 2mm.

8.20.7 Shutters shall be of correct size and shall fit into the frames without excessive cutting at the edges. Adding of wooden strip etc., to make up the size shall not be allowed.

8.20.8 Factory Made Shutters

Where indicated the contractors shall supply panelled gauzed door and window shutters made in an approved factory. Tolerance on the width and height of factory made shutters shall be + 3 mm provided the shutter snugly fits into the frame.

8.21 Panelled, Glazed and Gauzed Shutters

8.21.1 Timber paneled, glazed and gauzed shutters shall be constructed in the form of timber frame work of stiles and rails with panel inserts of timber, plywood, block-board or veneered particle boards and medium density wood particle board as indicated in case of panelled shutters, of glass in case of glazed shutters, and of wire cloth in case of gauzed shutters.

8.21.2 Stiles and rails of shutters shall be in one piece only. Lock and intermediate rails exceeding 20 cm in width may be made out of one or more pieces of timber but the width of each piece shall not be less than 10 cm: where more than one piece of timber is used they shall be jointed with a continuous tongued and grooved joint glued together and pinned with wooden/bamboo pins.

8.21.3 Stiles and rails shall be jointed to each other by tenon and mortice joints, at right angles. Rails more than 18 cm wide shall have two tenons.

8.21.4 Muntings and glazing bars shall have mitred joints and shall be stub tenoned to the maximum depth which the size of member would permit or to a depth of 25mm, whichever is less. The thickness of each tenon shall be approximately one third the finished thickness of the member and the width of each tenon shall not exceed five times its thickness.

8.21.5 Panelled Shutters

The panels shall be fixed by either providing grooves in the stiles and rails or by beading or both, as indicated. The edges of panels shall be tongued into grooves (feather tongued in case of timber panels) to the full depth leaving an air space of 1.5 mm and the faces shall be closely fitted to the sides of groove. Mouldings to the edges of panel openings shall be scribed at the joints, where indicated.

8.21.5.1 Timber panels shall be preferably made of timber of larger width, the minimum width of panel shall be 15 cm. When made from more than one piece, the pieces shall be jointed with a continuous tongued and grooved joint glued together. The grains of timber panels shall run along the longer dimensions of panels. Unless otherwise indicated timber panels shall be flat. Thickness of flat panels, unless otherwise indicated shall be 12 mm thick or 1/3 thickness of shutter whichever is greater. Panels raised on one side shall be 2/3 thickness of shutters and panels raised on both sides shall be of full thickness of shutter. Unless otherwise indicated no single panel shall exceed 0.5 sqm in area.

8.21.5.2 Plywood panelling

Plywood panel shall be of thickness not less than 9 mm for two or more panel construction and 12 mm for single panel construction. All panels shall be made of one piece only. The plywood shall be of type AB, BWR grade conforming to IS 303-1989.

8.21.5.3 Veneered Particle Board Panelling

Panels of veneered particle board used shall be 12 mm thick using phenol fomaldehyde and made of one piece only.

8.21.5.4 Where indicated, timber panelled shutters may be provided with louvres or vision panel as detailed in the drawings.

8.21.6 Glazed Shutters

For Glazing refer Section 16. For external doors and windows, the beading, where provided, shall be fixed on the outside. Unless otherwise specified, beading shall be 15 x 10 mm and shall be secured to frames either with panel pins, or screws with cups where indicated. Exposed edges of beds shall be rounded.

8.21.7 Wire Gauzed Shutters

Wire cloth shall be securely housed into the rebates by giving a right angled bend and fixing by means of suitable staples at intervals of 75 mm. Over this wooden bead 15x15 mm shall be fixed with nails, where indicated to cover the rebate fully. The space between the beading and the rebate shall be filled with putty to give it a neat finish. Exposed edges of the beads shall be rounded.

8.22 Louvred Shutters

The framing shall be as for panelled shutters. Louvers shall be fixed at an angle with edges splayed, as directed.

8.23 Louvers Fixed to Frame

Louvers shall be fixed into the grooves 12 mm deep made in the frames. The louvers shall slope down towards the outside at a angle of 45^{o} or as indicated. The width and thickness of each louver shall be as indicated.

8.24 Standard Dimensions for shutters for Doors, Windows etc.

The rates for shutters are based on the dimensions of the various components or parts indicated below. Any variations thereon, if specially ordered shall be adjusted on the basis of other appropriate items in the SSR.

(a) Panelled, Glazed, Gauzed or Partly Panelled and Glazed shutters as for doors

(1)	Bottom	200 to 250 mm wide.
(2)	Stiles, top and freeze rails	100 to 120 mm wide.
(3)	Muntins	100 mm wide.
(4)	Glazing bar	40 mm wide.
(5)	Middle or lock rail	160 to 250 mm wide.

(b) Glazed and Gauzed shutters as for windows, ventilators, etc.

(1)	Stiles and rails	60 to 80 mm wide.
(2)	Muntins	60 mm wide.
(3)	Glazing bars	30 to 45 mm wide.

8.25 Flush Door Shutters

8.25.1 Flush door shutter shall be solid core types with block core or particle board core, as indicated, and shall conform to IS 2202 (Part I) - 1999, Specification for wooden flush door shutters (solid core type) Part I plywood face panels; except with regard to the sizes of shutters which shall be as indicated. Flush door shutters shall be non- decorative (commercial) type; or decorative type where indicated.

8.25.2 Flush door shutters shall be internally lipped. Internal lipping may be provided separately or as one piece with the frame. The width of frame including lipping shall not be less than 50mm. Where separate lipping is specifically desired it shall be so indicated. Internal lipping shall have a total depth of not less than 25 mm. Joints shall not be permitted in lipping.

8.25.3 In the case of double leaved shutters, rebating shall be splayed or square as directed. Where separate lipping is indicated, the depth of lipping at the meeting of stiles shall not be less than 35 mm.

8.25.4 Flush door shall be free from twist or warp in plane and all the four edges of the door shutter shall be square. Both the faces of the door shutter shall be sanded to a smooth even texture.

8.25.5 Tolerance on nominal thickness shall + 1.2 mm. Thickness of shutter shall be uniform through out with the variation not exceeding + 0.8 mm when measured at any two points.

8.25.6 Opening for Glazing

Where indicated, opening for glazing 25x20 cm shall be provided, which shall be lipped internally with solid timber.

8.25.7 Venetian

Venetian openings shall be provided where indicated. The width of opening shall be as indicated but shall provide for a clear space of at least 75 mm between the edges of the door and venetian opening.

8.25.8 Locks

Shutters shall be shop prepared for taking mortice locks and latches if specifically indicated.

8.25.9 Flush door shutters fixed in bath rooms and toilets shall be protected by providing aluminium sheet cover 0.5 mm thick where indicated. Aluminium sheets shall conform to IS 737 - 1986. Aluminium sheet shall be fixed to the door with chromium plated steel round headed screws conforming to IS 1284-1975 at distance not exceeding 10 cm centre to centre.

8.26 Fixing of Shutters

8.26.1 The size of the openings and the frames shall be checked and also the verticality of the side frames and the level position of the floor and the wall. Any adjustment necessary shall be made before installation of the shutters. The shutter shall be installed only after the walls on either side have dried.

8.26.2 Any transit defects or storage defects in shutter shall be filled up with a good putty. Any corner opening may be rectified by the use of glued and pressing by ‘C’ clamps. Any damage to moulding or glazing bars or other fixtures shall be rectified at site by use of similar materials.

8.26.3 Width of hinges shall suit the shutter thickness.

8.26.4 Cleats, where indicated, shall properly fit in the rebates of the chowkats to effectively stop the shutter from closing.

8.26.5 When driving screws it is advisable that in case of hard timbers pilot holes are drilled before fixing the screws. The screws shall be driven tight fit and straight.

8.26.6 Shutters shall be checked after fixing for proper location alignment and swinging. After all the fixtures have been fitted, the shutters shall be tried again for proper closure, handling and movement. Any rectification necessary shall be done.

8.26.7 Fixed Shutters

Shutters fixed in the frames shall be secured to the frames with wood screws of adequate size at intervals of not more than 40 cm, unless otherwise indicated.

8.27 Wooden panelling for wall lining & partitions

8.27.1 Rails and stiles of frame for the wooden panelling and partitions shall be fixed to each other by tenon and mortice joints. The panels of timber planks, block boards, veneered particle boards etc. as specified for wall panelling/partitions and glass for glazed partitions, shall be fixed in the grooves made in the stiles and rails or by means of rebate and beading fixed by suitable screws.

8.27.2 Wooden panels shall be made out of one or more pieces of timber not less than 12.5 cm width and also not more than 20 cm width. When made of more than one piece, planks shall be jointed together by continuous tongued and grooved joint, glued together and reinforced by means of rust proof metal dowels. The grains of solid panels shall run along the longer dimensions of the panels.

8.27.3 The exposed faces of the panelling and partitions shall be planed smooth and even.

8.27.4 Panelling shall be fixed to the wall with wooden plugs fixed into the walls at suitable intervals and screws driven through the stiles and rails or alternatively the panelling may be fixed over rough ground as indicated.

8.28 Mouldings and Architraves

Mouldings and architraves shall give a neat and presentable appearance. The finished surface shall be rubbed smooth with sand paper.

8.29 Stair case

8.29.1 Treads, Risers and Strings

Treads and strings when of more than one piece in width, shall be joined with tongued and grooved joint. Each piece of timber shall be not less than 80 mm wide on the finished face of the work. In a tread, the front piece of which the nosing is formed shall be not less than 90 mm wide.

The top of the risers shall be tongued and fitted or their full thickness housed to a minimum depth of 6 mm into the underside of the treads.

Risers and treads shall be glue-blocked with angle blocks not less than 80 mm long and 40 mm wide glued in position. The spacing between glue blocks shall not be more than 25 cm.

The lower edges of risers shall be fixed to treads with No 10 wood screws conforming to IS:451 at intervals not exceeding 25 cm. The length of screws shall be at least equal to twice the thickness of the material through which they are fixed, and in any case not less than 32 mm.

In the case of close strings, the treads and risers shall be housed to a depth of not less than 15 mm into tapered housing in the strings and securely wedged and glued, glued wedges shall be skew nailed.

Strings shall be tenoned and prepared for pinning to newels where these occur. The tenons shall be not less than 15 mm thick and 50 mm long.

Tie rods connecting the strings at suitable intervals shall be provided, where indicated.

The curved portion of riser in the lower steps may be bull nosed or semi-circular and shall be built from solid blocks; doweled, cross tongued and glued.

8.29.2 Carriage Bearers

Where carriage bearers are used they shall not be cut but the treads and risers shall be fixed on to them by means of small angle blocks.

Treads shall have rounded nosings and project 25 mm beyond the face of the riser, if without a bed mould. The shape of the front edge of the tread of any step shall properly agree with that of the riser and the nosing shall be of proper section throughout.

8.29.3 Landing

Landing shall be constructed as specified for wooden floors.

8.29.4 Newels

A newel shall be placed at every angular change of the direction of the hand-rail. Treads, risers, winders and ends of steps shall be housed into newels to a depth of not less than 15 mm. Newel posts shall be notched to landing, mortised and draw bored, where required to receive the strings, and mortised to receive the hand-rails by means of dowels.

8.29.5 Hand-rails

Hand-rails may be provided with wreaths and curve where indicated and shall be joined with a proper hand-rail screw and two dowels at each joint.

8.30 Fixing of M.S. Bar and M.S. Grills to Wooden Frames

8.30.1 For fixing M.S.bars in wooden frames of windows etc. holes shall be drilled through one member of the frame through transoms or mullions and corresponding holes 4 cm deep in the opposite member. The bars shall be cut to correct length such that they fit into the holes to their full depth and remain flush with the frame member having through holes.

8.30.2 M.S. grills shall be fixed by means of round headed bolts and nuts in the frame, when these are fixed to frames before they are built into the masonry. Where frames are already fixed in the masonry, grills shall be fixed to the frames by means of suitable wood screws.

8.31 Pelmets

8.31.1 Planks and curtain rods of specified timber shall be used, it shall be sawn in the direction of the grains. Sawing shall be truly straight and square. The timber shall be planed smooth and accurate to the full dimensions , rebates , roundings and moulding as shown in the drawings made , before assembly. Patching or plugging of any kind shall not be permitted.

8.31.2 Sides, front and top of the pelmets shall be of 12 mm planks or boards of specified quality and width unless otherwise stated . These shall project from the wall face by 15 cm or as specified , and shall be securely fixed to walls with wood screws by means of wooden plugs and 10 cm long 25 x3 mm M.S flat bent in the form of angle or by any other device approved by the EIC. The pelmet shall be provided with curtains rods and brackets or curtain rails with rollers , stop ends and brackets wooden , brass or chromium plated brass as specified. Intermediate wooden brackets shall be provided , if the front length of pelmet exceeds 1.5 metres.

8.32. Ornamental Work

The ornamental wood work shall be painted on the back with priming coat of approved wood primer before fixing the same to the grounds with screws , which shall be sunk into the wood work and their tops covered with putty. The ornamental work shall be made true and accurate to the dimensions shown in the working drawings. The fixing shall be done true to lines and levels. The planks for wall lining shall be tongued and grooved , unless otherwise specified.

8.33 Shelves

8.33.1 Shelves and vertical partitions of cupboards shall be of timber planks, fibre board, particle board, block board as indicated. Each shelf shall be a single piece and vertical partitions between two consecutive shelves shall be without any joint. Exposed edge of boards having particle board core shall be sealed with 3 mm thick single piece teak wood strips of width to the thickness of board with headless pins. The arrangement of shelves and vertical partitions shall be as per drawings or as directed by EIC.

8.33.2 Fixing

Planking for shelves shall be planed on all faces and edges. In case of boards they shall be sawn to the required size truly straight and square. Timber battens 25 x 40 mm unless otherwise specified shall be planed smooth and fixed inside the cupboard with wooden plugs and screws. Shelves shall be fixed to the battens and vertical portions shall be held in position by fixing them to the battens and shelves using screws. Teakwood strips for edging sealing of the boards shall be planed smooth and fixed with headless nails . Tolerance in width shall be + 1.5 mm and in thickness +1 mm.

8.34 SOLID PVC JOINERY

8.34.1 Materials

8.34.1.1 PVC Sheet/Plain Colour PVC Sheet Materials

PVC sheet means FREE FOAM RIGID PVC SHEETS made out of PVC Resin (suspension grade) blended with suitable chemicals and additives. The sheets shall be made by extrusion process and foamed using organic blowing agents. The sheets will be self coloured in plain shades by blending suitable pigments with PVC resin. The sheets will have silky matt surface finish free from any blistering, colour blots, creasing, pin holes etc. The density & thickness of the sheets shall be as under:-

THICKNESS in mm	**TOLERANCE** in mm	**DENSITY** Kg/m3
1 mm	0.85-1.15mm	Min 780
1.5 mm	1.35-1.65mm	Min750
2mm	1.80-2.20mm	Min 700
3mm	2.75-3.25mm	Min 700
5mm	4.65-5.35mm	Min 600

8.34.1.2 Printed PVC Sheets

Printed PVC Sheets, shall be as defined in 8.34.1.1, screen printed with suitable designs using glossy PVC ink.

8.34.1.3 Prelam PVC Sheets

Prelam PVC Sheets, shall be PVC sheet as defined in 8.34.1.1, laminated under pressure and temperature with hot stamping foil of various aesthetic veneer-like appearance. The thickness of hot stamping foil shall be 30 micron with tolerance limit + 10%. When lamination is done on one side, the other side will have either white or ivory colour.

8.34.1.4 Embossed PVC Sheets

Embossed PVC sheets shall be Prelam PVC Sheets, as defined in 8.34.1.3, with designs, ie., intricate lattice work combined with scroll work and geometrical patterns, embossed to depth ranging from 4mm to 6mm by vacuum thermoforming process.

8.34.1.5 Moulded PVC Sheets

Moulded PVC sheet shall be PVC sheet as defined in 8.34.1.1 or 8.34.1.3, vacuum thermoformed to give raised panel i.e. two panel, four panel or six panel look with moulding depth ranging from 12mm to 16mm.

8.34.1.5.1 3-D Wood Grain Moulded PVC Sheets

3-D Wood grain moulded PVC sheet shall be PVC sheet as defined in 8.34.1. with additional 3-D wood like effect suitably painted using polyurethane paint, vacuum thermoformed to give raised panel, i.e., two panel, four panel or six panel look with moulding depth ranging from 12mm to 16mm.

8.34.1.6 Solvent Cement

A composite organic chemical comprising of Cyclohexanonc, Tetrahydro flurance (THF), Methyl Ethyl Ketone (MEK) etc., in transparent liquid state, is generally used for joining PVC pipes. The solvent cement when applied on PVC sheets dissolves its surface, bonding it to the other PVC sheet permanently. The date of manufacture of solvent cement shall not be more than 6 month old.

8.34.1.7 PVC Sandwich Panel

PVC Sandwich Panel shall consist of Expanded Poly Styrene (EPS) conforming to IS 4671, of density 32 Kg/m^3 (tolerance limit + 15%) flame retardant (TF) grade of desired thickness (mm) sandwiched between two PVC sheets of 1 mm, 1.5 mm, 2 mm or 4 mm thickness using thermosetting adhesive.

8.34.1.8 PVC Insulation Panel

PVC insulation panel shall consist of Expanded Poly Styrene (EPS) conforming to IS 4671 of minimum density 15 Kg/m3 flame retardant (TF) grade of desired thickness (mm) stuck to PVC sheet of lmm, 1.5 mm, 2 mm, or 5 mm thickness using thermosetting adhesive on one side.

8.34.1.9 PVC sheet Fillet for Wall Panelling

PVC sheet fillet shall be 5mm thick & 35mm wide PVC sheets with 'U' shape groove of 2mm depth in the center. The purpose of the groove is that the head of the screw used to fix the fillet to the wall sinks into it so as to make the surface of the fillet plain.

8.34.1.10 MS Square Tube

MS Square tube shall be of size 19mm X 19mm & 15mm X 15mm of 19 gauge of required length with coat of steel primer.

8.34.1.11 MS Angle

MS Angle shall be of size 35mm X 35mm x 5mm of required length with coat of steel primer.

8.34.1.12 EPDM Rubber Gasket

EPDM Rubber gasket with bulb-type profile shall be used to make doors & windows airtight.

8.34.1.13 Decorative PVC Beading

'L' type (90^o) Decorative PVC Beading shall be of size 10mm X 10mm with wood moulding design.

8.34.2 Factory Made Solid PVC Door Shutters

8.34.2.1 Factory Made Solid Panel PVC Door Shutter

30 mm thick Factory Made Solid Panel PVC Door Shutter consisting of frame made out of MS tubes of 19 mm X 19mm for stiles, & 15mm X 15mm for top & bottom rails. MS frame shall be covered with 5mm thick heat moulded PVC sheet 'C' channel having a 5mm thick PVC sheet strip of 20 mm width stuck inside with solvent cement, forming stiles, and 5mm thick PVC sheets for top rail, lock rail & bottom rail on either side, and 10mm (5mm X 2) thick, 20mm wide cross PVC sheet as gap inset for top rail & bottom rail. Panelling of 5mm thick PVC sheet to be fitted in the MS frame welded/sealed to the stiles & rails with PVC sheet beading, and joined together with solvent cement adhesive etc. shall be complete as per direction of EIC, manufacturer's instructions and drawing. The width of stiles & rails shall be in proportion to the width of the door shutter as detailed below :-

Door width (in feet)	Stiles Size (mm)	Rails Size (mm)	Remarks
1.5'upto2'	50mm	50mm	
More than 2' upto 2.5'	50mm	75mm	
More than 2.5' upto 3'	75mm	100 mm	Gap insert of 15 mm to be provided between stiles and rails & panel.
More than 3'	100mm	125mm	

For doors of sizes larger than 17.5 sq.ft, an additional 15mm X 15mm, 19 gauge MS Square tube shall be welded to the MS frame below the top rail square tube keeping a gap of 50mm between the two MS Square tubes. In the case of double leaved shutters the meeting stiles shall be rebated 20mm as shown on drawing. The rebating shall be square, as directed.

Factory Made Solid Panel PVC Door Shutters shall conform to the below mentioned permissible limit as per testing methods provided in IS 4020

S. No	Test	Permissible Limit
01	Dimensions and squareness	Width + 3mm Height + 3mm Difference in Diagonals : Not more than 3mm
02	General flatness test	No twisting, cupping or warping shall be observed
03	Local Planeness test	Depression on all 10 points at the panel areas shall be less than 0.5mm
04	Impact indentation test (Steel ball impact test)	Indentations shall be less than 0.3mm
05	Edge loading test	Initial max. deflection shall not be more than 5mm. Residual deflection shall be not more than 0.5mm
06	Shock resistance test	Not visible damage shall be observed
07	Buckling test	Initial deflection shall not be greater than 90mm. Residual deformation after 15 minutes of unloading shall not be greater than 5mm.
08	Slamming test	No visible damages shall be observed to any part of the door.
09	Misuse test	No permanent deformation of the fixing or any other part of the door shutter in hindering its normal working shall be observed
10	Screw withdrawal resistance test	Face : 1400N Edge : 1500N

8.34.2.2 Printed Solid Panel PVC Door Shutters

Printed Solid Panel PVC Door Shutter shall be Solid Panel PVC Door as in 8.34.2.1 but made using printed PVC sheet and panel to be fitted in the MS frame welded/scaled to the stiles & rails with 5mm thick X 15mm wide PVC sheet beading on inner side of panel and decorative PVC beading of 10mm X 10mm (90^o) to be used on outer side of panel.

8.34.2.3 Single Side Prelam Solid Panel PVC Door Shutter

It shall be Solid Panel PVC Door as in 8.34.2.1 but made using Prelam PVC sheet and Single Side Prelam Panel to be fitted in the MS frame & sealed directly without beading to the front (Prelam side) stiles and rails (which shall have a 5mm 45^o bent portion) and sealed to the back (Plain colour) stiles and rails (which shall have a 10mm 90^o bent portion) using 2 nos 15mm wide X 5mm thick PVC sheet beading inside the 90^o bent beading.

8.34.2.4 Both Side Prelam Solid Panel PVC Door Shutter

It shall be Solid Panel PVC Door as in 8.34.2.1 but made using Prelam PVC sheet and stiles & rails extended by 20mm which shall be tapered in 45^o angle on either side, 5mm+2mm thick X 15mm wide PVC sheet beading on inner side, and joined together with solvent cement adhesive etc.

8.34.2.5 Fully Glazed Solid PVC Door Shutter

Fully glazed solid PVC door shutter shall be Solid Panel PVC Door as in 8.34.2.1 but with glass panel instead of 5mm PVC sheet panel. Glass panel shall be fitted externally in the clear space available between the stiles & rails and fixed with PVC sheet beading on one side and decorative PVC beading on the other side shall be nailed on the rails and stiles so that the decorative beading can be removed when required for replacement of broken glass panel.

8.34.2.6 Partly Glazed Solid Panel PVC Door Shutter

It shall be Solid Panel PVC Door as in 8.34.2.1 but the upper panel shall be glazed fitted externally in the clear space available between the stiles & rails fixed with PVC sheet/decorative beading & lower panel shall be PVC Panel.

8.34.2.7 Wire Gauzed Solid PVC Door Shutters

Wire gauged solid PVC door shutters shall be Solid Panel PVC Door as in 8.34.2.1 but panel shall be of G.I wire gauze. The wire gauze shall be wrapped on an additional 8 mm square MS Solid tube and this tube shall be welded to 19mm X 19mm MS tubes. The GI wire gauge shall be stretched to tighten firmly.

8.34.2.8 Fully Louvred Solid PVC Doors Shutters

Fully louvred solid PVC Doors shutters shall be Solid Panel PVC Door as in 8.34.2.1 but with louvred panel instead of 5mm PVC sheet panel. Louvred panel shall consist of 25mm thick heat bent PVC sheet 'C' channel with a 5mm PVC sheet of 10mm width stuck inside, on all four sides. Slanted slots shall be cut at 45^o angle in both the vertical 'C' channels at an interval of 100mm. 5mm thick PVC of width 25mm of suitable length shall be inserted in the slant cut slots and fixed with solvent cement.

If the width of Solid PVC louver door shutter is more than 2 feet (610mm) an additional vertical PVC member of width 25mm and 15mm thickness with slots cut at 45^o angle shall be fixed with solvent cement in the center of the louvred panel for support & rigidity.

8.34.3 Factory Made Solid PVC Door Frames

8.34.3.1 Solid Single PVC Door Frame

Solid PVC Door Frame shall be of the size 50 X 47 mm made out of 5mm PVC sheet. The door profile are to be reinforced with 19 X 19mm MS Square tube. EPDM rubber gasket weather seal shall be provided through out the frame. The profile shall be mitre cut at two corners and joined by inserting 2 nos of 150mm long brackets of 15 X 15mm MS square tube inside the 19mm X 19mm MS square tube and suitably screwed.

8.34.3.2 Solid PVC Double Door Frame

Solid PVC Double door frame shall be of size 50mm X 95mm made by joining 3 nos heat bent PVC Sheet 'C' Channel of 5mm thickness of sizes 35mm X 30mm X 25mm & 40mm X 35mm X 40mm & 25mm X 30mm X 35mm using solvent cement. The two side 'C' Channel shall be reinforced with MS tube of size 19mm X 19mm. All the three 'C' channel shall be fixed to flat base of 5mm PVC sheet with solvent cement. The profile shall be mitre cut at two corners and joined by inserting 4 nos 150mm long brackets of 15 X 15mm MS square tube inside the 19mm X 19mm square tubes & remaining each of them with four screws as indicated in the drawing.

8.34.4 Factory Made Solid PVC Moulded Door Shutters

8.31.4.1 Particle Board Core Solid PVC Moulded Door Shutter

28 to 30 mm thick factory made Solid PVC Moulded Door shutter shall be of 2, 4 or 6 raised panel design with solid core of particle board of 24mm thick (12mm x 2) as indicated. The particle board shall be lipped with 25mm thick baton made from PVC sheets on the stile where hinges are to be fitted. On the three other sides the lipping shall be of 15mm thick PVC baton. 2mm thick moulded PVC sheet shall be stuck on the front face of the particle board suitable prepared to accept the moulded design and 2mm PVC sheet shall be stuck on the back face of the particle board with thermosetting adhesive. The 2mm PVC sheets shall be stuck with lipping by using solvent cement.

8.34.4.2 EPS Core Solid PVC Moulded PVC Door Shutter

28 to 30mm thick factory made EPS Core Solid PVC Moulded Door Shutter shall consists of frame made out of MS tube. The core panel shall consist of 25mm thick high density EPS conforming to IS 4671, routed with design, sandwiched in between 2mm thick moulded PVC sheet on one face and 2mm PVC sheet on the other side. The door on all the edges to be sealed with lipping of 10mm (5mm X 2) thick X 25mm wide PVC sheet for three sides & 60mm wide PVC sheet for lock side. The lipping shall be bonded to the 2mm moulded/plain PVC sheet solvent cement.

8.34.5 PVC Sheet Cladding

PVC sheet shall be stuck using rubber based adhesive for cladding. PVC sheet may be heat bent, i.e., lipping to cover the edges of plywood/flush door shutter.

8.34.6 Solid PVC Partitions

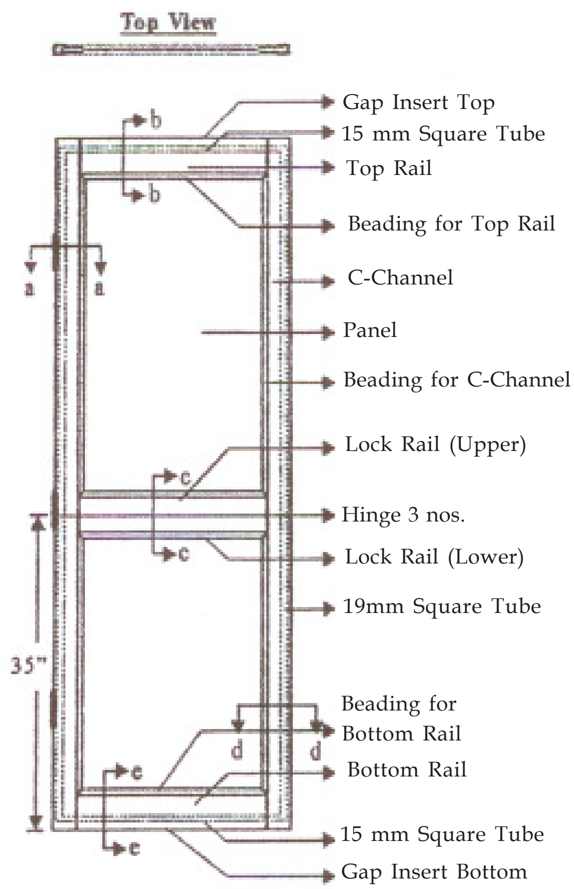
Solid PVC partitions shall consist of PVC sandwich panel of suitable thickness placed in MS angle frame work and fixed inside 'C' Channel and feathered strips made from 5mm thick PVC sheets, as indicated in detailed drawings. MS angle between the floor & ceiling height with anchor bolts at an interval of 1220 mm or as mentioned in the drawing shall be provided.

In between two MS angles PVC sheet heat bent 'C' channel of size 100 mm X 50mm with feathered edges shall be fixed with screw on the floor. In between two MS angles PVC sheet heat bent 'C' channel of size 75mm X 50mm with feathered edges shall be fixed with screw in the ceiling. The first & last MS angle should be erected such that it is inside a PVC sheet heat bent 'C' channel of size 75mm X 50mm which has been screwed on to the walls. PVC sandwich panels shall be inserted in the PVC sheet 'C' channel fixed at ground floor & ceiling and shall be stuck by using solvent cement. In between adjoining EPS sandwiched PVC partitions panel 5mm thick X 75mm width PVC sheet feathered at edges shall be stuck on front & back face using solvent cement as indicated in the detailed drawing.

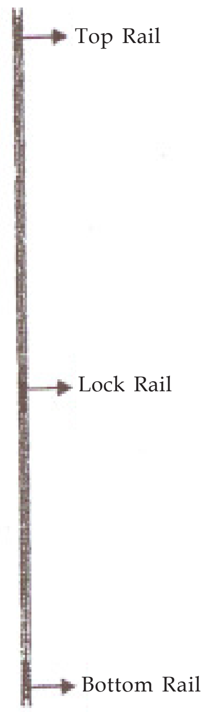
8.34.7 Solid PVC Joinery Items shall be of Approved Makes.

SOLID PVC JOINERY

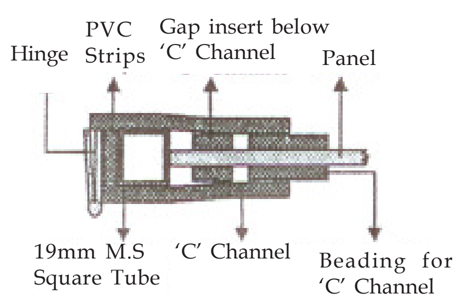
DIAGRAM SHOWING SECTION OF FACTORY MADE SOLID PANEL PVC DOOR SHUTTERS.



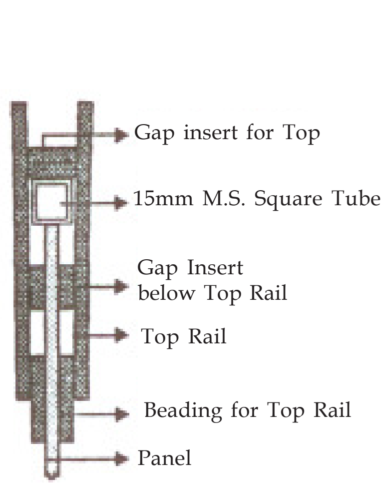
Diagrammatic Representation of 6.5′x2.5′ Door
(Scale - 1 : 25)



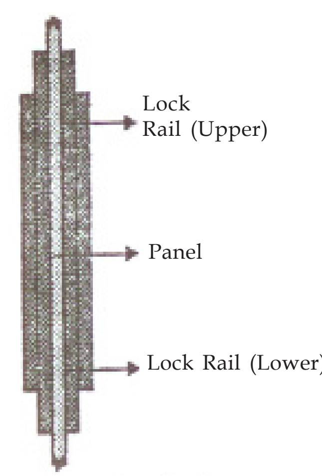
Side View



Section View (a) Stile
Sectional View (dd) is mirror image of (aa)



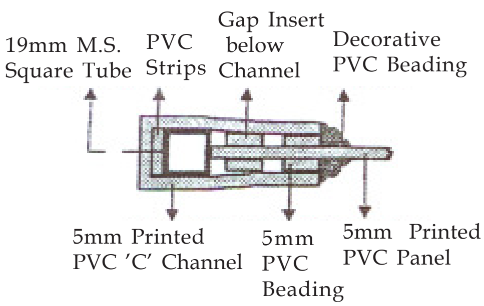
Section View (bb) Top Rail
Sectional View (ee) is mirror image of (aa)



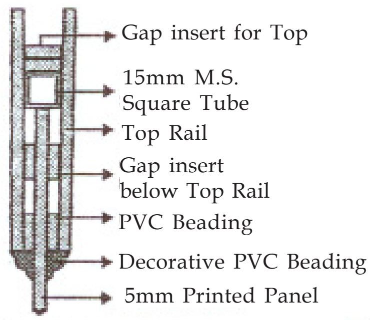
Section View (cc)
Lock Rail

(Scale 1:3)
(Note: All Dimensions are in mm)

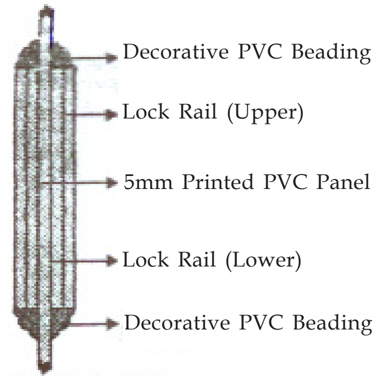
FACTORY MADE PRINTED SOLID PANEL PVC DOOR SHUTTERS



Sectional View (slite)
(Scale - 1:3)

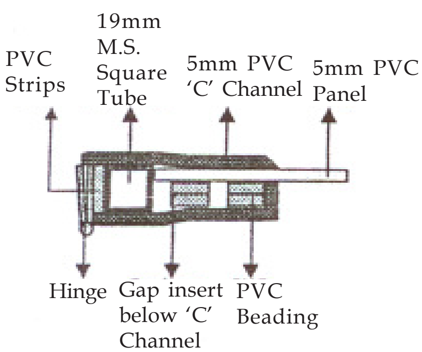


Sectional View (Rail)
(Scale - 1:3)

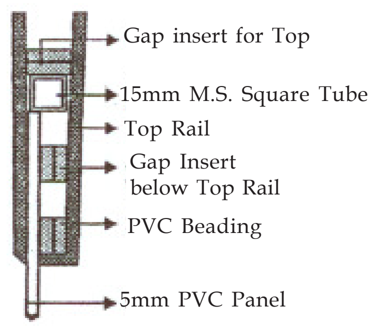


Sectional View (Lock Rail)
(Scale - 1:3)

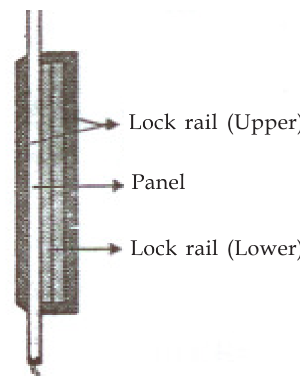
FACTORY MADE SINGLE SIDE PRELAM SOLID PANEL PVC DOOR SHUTTERS



Sectional View (slite)
(Scale - 1:3)

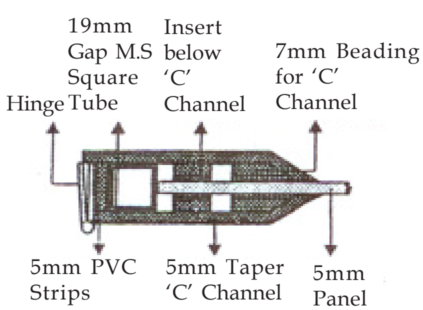


Sectional View Rail
(Scale - 1:3)

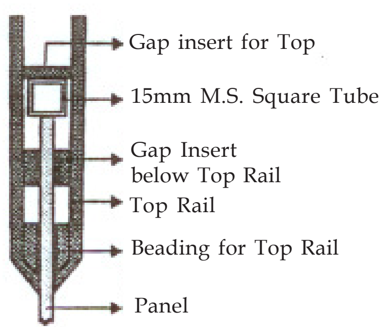


Sectional View (Lock Rail)
(Scale - 1:3)

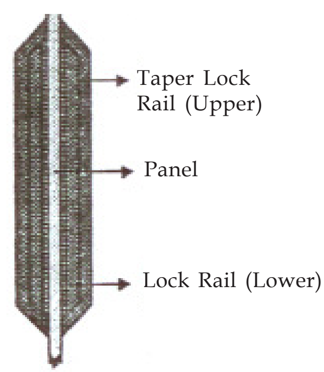
FACTORY MADE BOTH SIDE PRELAM SOLID PANEL PVC DOOR SHUTTERS



Sectional View (slite)
(Scale - 1:3)

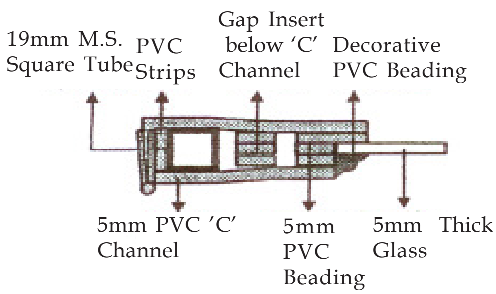


Sectional View Top Rail
(Scale - 1:3)

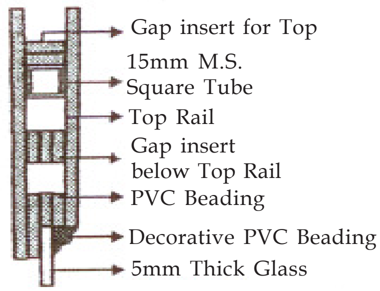


Sectional View Lock Rail
(Scale - 1:3)

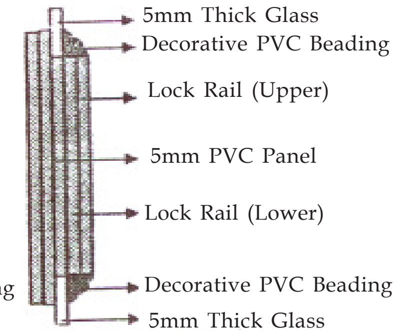
FACTORY MADE FULLY GLAZED SOLID PANEL PVC DOOR SHUTTERS



Sectional View (slite)
(Scale - 1:3)

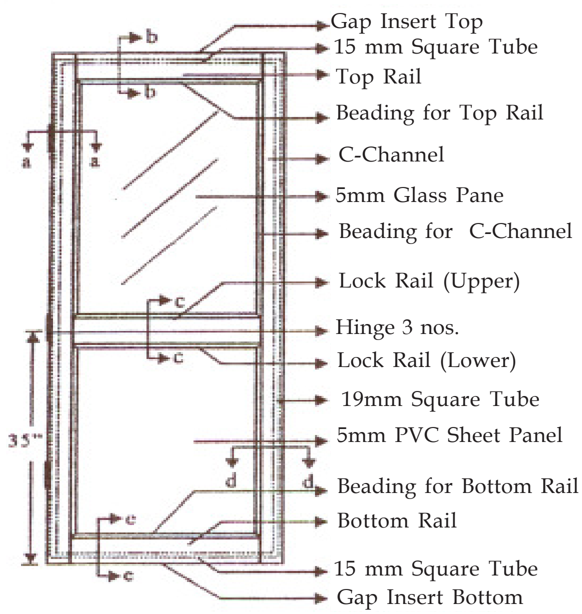


Sectional View (Rail)
(Scale - 1:3)

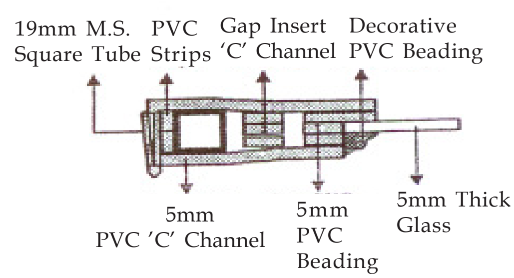


Sectional View (Lock Rail)
(Scale - 1:3)

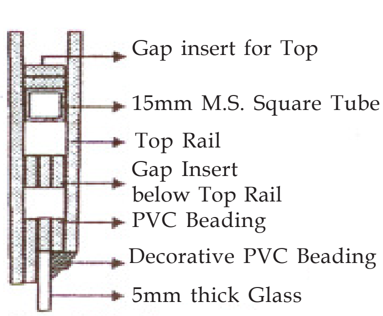
FACTORY MADE FULLY LOUVERED SOLID PANEL PVC DOOR SHUTTERS



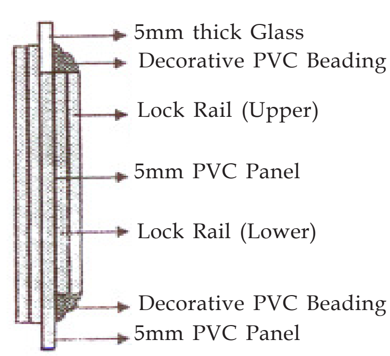
Diagrammatic Representation
of 6.5'x2.5' Door
(Scale - 1 : 25)



Sectional View (slite)
(Scale - 1:3)

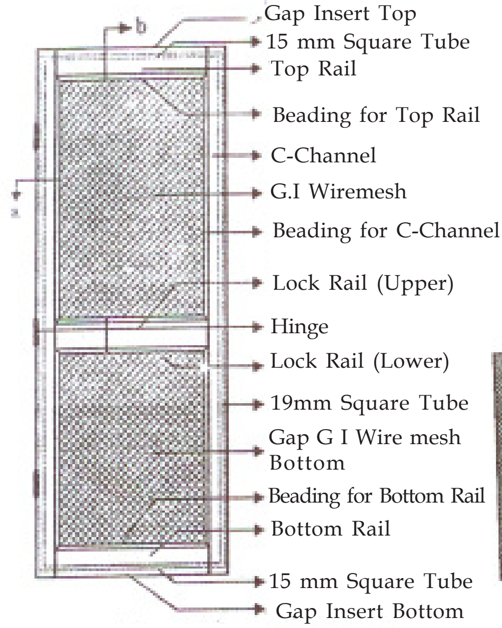


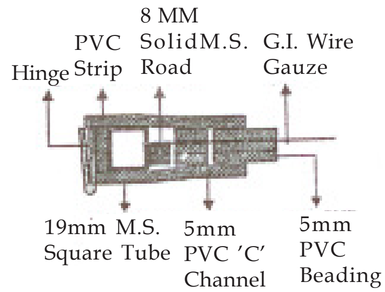
Sectional View Top Rail
(Scale - 1:3)

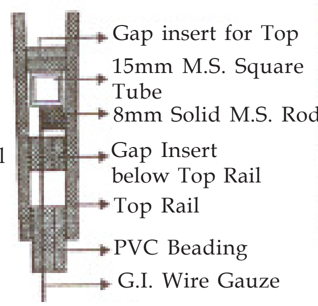


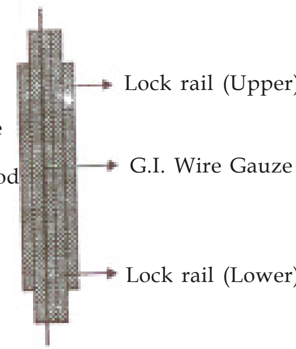
Sectional View Lock Rail
(Scale - 1:3)

FACTORY MADE WIRE GAUZED SOLID PANEL PVC DOOR SHUTTERS







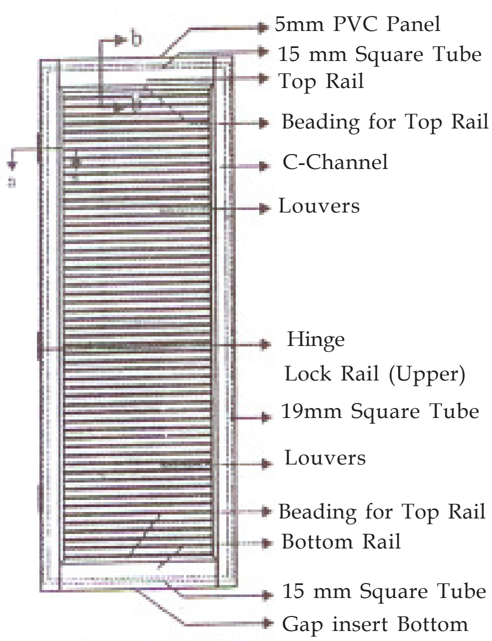


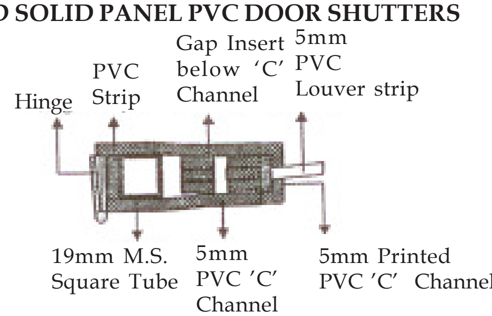
Diagrammatic Representation of 6.5′x2.5′ Door
(Scale - 1 : 25)

Sectional View (bb) Rail (Scale - 1:3)

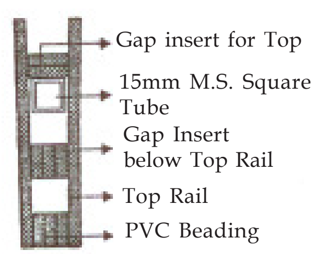
Sectional View (Lock Rail) (Scale - 1:3)

FACTORY MADE FULLY LOUVERED SOLID PANEL PVC DOOR SHUTTERS





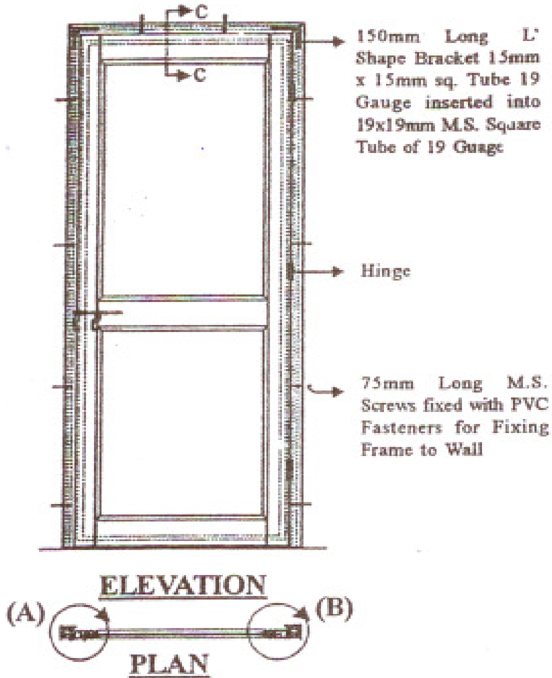
Sectional View 'aa' Slite (Scale - 1:3)



Diagrammatic Representation of 6.5′x2.5′ Door
(Scale - 1 : 25)

Sectional View 'bb' (Rail)
(Scale - 1 : 3)

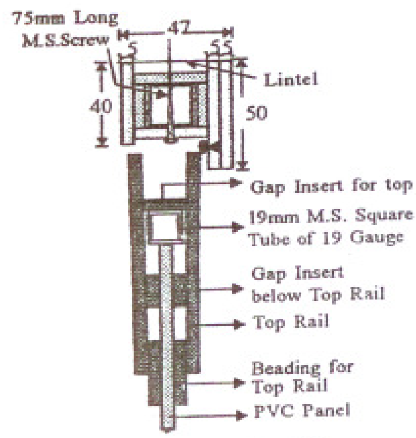
FACTORY MADE SOLID PVC DOOR FRAMES



ELEVATION

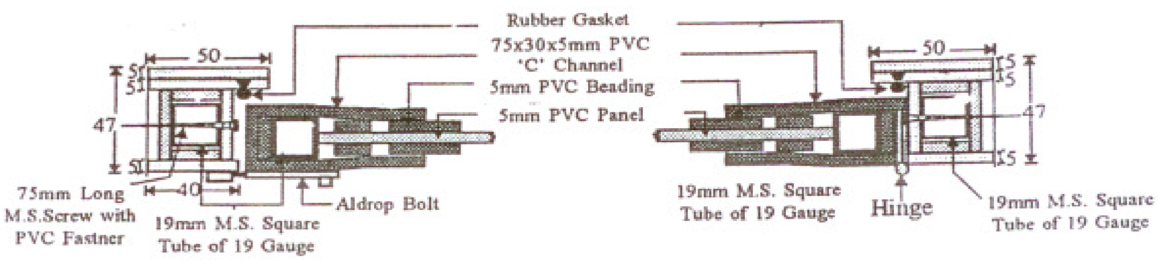
PLAN

(Scale - 1 : 25)



DETAIL AT (C)

(Scale - 1 : 3)



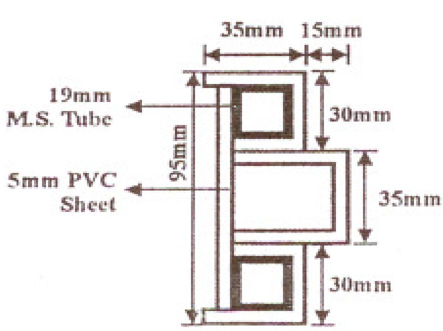
SECTIONAL VIEW

(Scale - 1 : 3)

SECTIONAL VIEW

(Scale - 1 : 3)

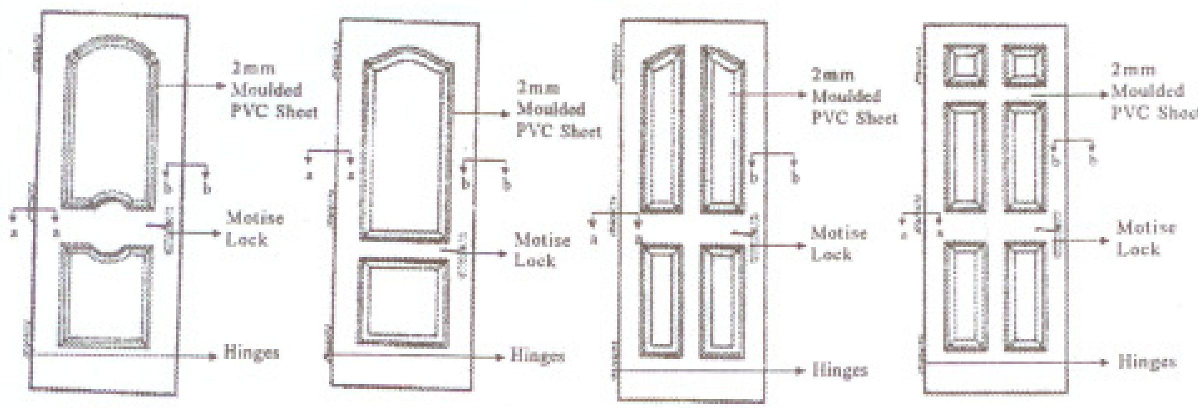
FACTORY MADE SOLID PVC DOUBLE DOOR FRAME



SECTIONAL VIEW

(Scale - 1 : 3)

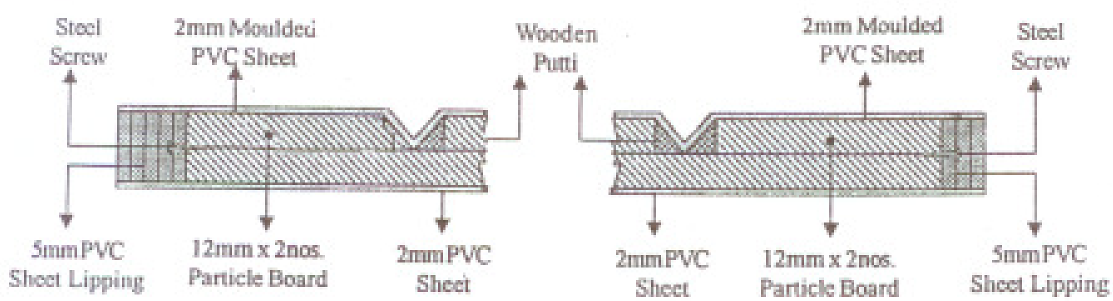
FACTORY MADE SOLID PVC MOULDED DOOR SHUTTER



2 PANELS 2 PANELS 4 PANELS 6 PANELS

Diagrammatic Representation of 6.5'x2.5' Door

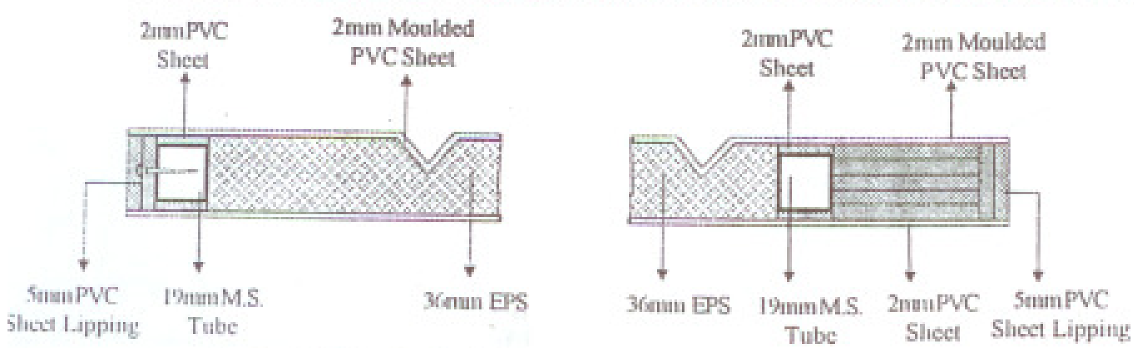
FACTORY MADE PARTICLE BOARD CORE SOLID PVC MOULDED DOOR SHUTTER



Sectional View 'aa'
(Scale - 1:3)

Sectional View 'bb'
(Scale - 1:3)

FACTORY MADE EPS CORE SOLID PVC MOULDED DOOR SHUTTER



Sectional View 'aa'
(Scale - 1:3)

Sectional View 'bb'
(Scale - 1:3)

SECTION 9
BUILDER'S HARDWARE

9.1 Indian Standards

The following IS apply to this Section

I.S. No.	*Subject*
204 (Part 1)-1991	Specification for tower bolts, Part 1, Ferrous metals, (Fifth revision)
204 (Part 2)-1992	Specification for tower bolts, Part 2, Non ferrous metals, (Fifth revision)
205-1992	Specification for non-ferrous metal butt hinges (Fourth revision).
206-1992	Specification for tee and strap hinges (Fourth revision)
207-1964	Specification for gate and shutter hooks and eyes (First revision)
208-1996	Specification for door handles (Fifth revision)
281-1991	Specification for mild steel sliding door bolts for use with pad- locks (Third revision).
362-1991	Specification for parliament hinges (Fifth revision).
363-1993	Specification for hasps and staples (Fourth revision).
364-1993	Specification for fanlight catches (Third revision).
452-1973	Specification for door springs rat-tail type (Second revision) .
453-1993	Specification for double acting spring hinges (Third revision).
729-1979	Specification for drawer locks, cupboard locks and box locks (Third revision).
1019-1974	Specification for rim latches (Second revision).
1341-1992	Specification for steel butt hinges (Sixth revision).
1568-1970	Specification for wire cloth for general purposes (First revision) .
1823-1980	Specification for floor door stoppers (Third revision).
1837-1966	Specification for fan-light pivot (First revision).
2209-1976	Specification for mortice locks (vertical type) (Third revision).
2681-1993	Specification for non-ferrous metal sliding door bolts (Aldrops) for use with padlocks (Third revision).
3564-1996	Specification for door closers hydraulically regulated (Fourth revision).
3818-1992	Specification for continuous (piano) hinges (Third revision).
3847-1992	Specification for mortice night latches (First revision).
5187-1972	Specification for flush blots (First revision).
5930-1970	Specification for mortice latch (vertical type).
6315-1992	Specification for floor springs (hydraulically regulated) for heavy doors (Second revision).
6607-1972	Specification for rebated mortice locks (vertical type).

I.S. No.	*Subject*
7196-1974	Specification for hold fast.
7534-1985	Specification for sliding locking bolts for use with pad-locks (First revision).
8756-1978	Specification for ball catches for use in wooden almirahs.
9899-1981	Specification for hat, coat and wardrobe hooks.
10342-1982	Specification for curtain rail system.
12817-1997	Specification for stainless steel butt hinges (First revision).
12867-1989	Specification for PVC hand rail covers.
14912-2001	Specification for door closers, concealed type (hydraulically regulated)

MATERIALS

9.2 Builder's Hardware Generally

9.2.1 Materials

Articles of builder's hardware (fittings) shall be of mild steel, cast iron, brass, aluminium alloy etc, as indicated. The type and size of fittings shall also be as indicated. Fittings shall be of ISI marked/approved makes as indicated.

9.2.2 Shape and dimensions

The shape and dimensions of the fittings shall conform to the shape and dimensions given in the relevant IS Specifications, unless otherwise indicated. Where however shape of fitting or its components are indicated in the relevant IS Specification, as illustrative, they are not intended to limit their design. Such fittings or components shall be provided of the shape as approved by the GE.

9.2.3 Where no IS Specifications are indicated, such fittings shall be provided equal in quality to the samples maintained by the GE or as otherwise approved and directed by him.

9.2.4 Finish

Except where otherwise specified, articles of builder's hardware shall have the following finish :-

(a) Mild Steel and cast iron fittings	:	Stove enamelled black
(b) Brass fittings	:	Finished bright or satin polished.
(c) Aluminium fittings	:	Anodised, Anodic film shall be transparent unless indicated to be dyed.

9.2.5 Manufacture

Fittings shall be well made and finished to the correct shape and size, free from surface defects and flaws and shall have smooth action. Cast fittings or components shall be free from casting and other defects. All screw holes shall be countersunk to suit the countersunk head wood screws. All burrs, sharp edges and corners shall be removed and finished smooth.

9.2.6 Screws

Unless otherwise indicated, brass articles shall be fixed with brass screws and mild steel, cast iron and aluminium articles with steel chromium plated screws or as indicated. Screws shall be of the sizes as given in the IS specification for the fitting or as required.

9.3 Tower Bolts

9.3.1 Generally

Steel tower bolts shall comply with IS 204 (Part 1)-1991, Specification for tower bolts Part 1, ferrous metals. Brass and aluminium tower bolts shall comply with IS 204 (Part 2)-1992 Specification for tower bolts Part 2, non-ferrous metals. The type and size of the tower bolts shall be as indicated. The bolts shall be bright finished, stain finished, Ni-Cr plated as per IS 1068, copper oxidized as per IS 1376 or zinc plated as per IS 1573, as indicated. Other parts shall be same finished or may also be stove enameled as indicated.

9.3.1.1 Barrel and skeleton tower bolts, wherever possible, shall have the knob integral with bolts. In case it is not possible to provide a single piece construction of bolt, the knob may preferably be fitted to the bolts with a pin or alternatively screwed and riveted to the bolts, and its shape may be round, half round spherical or conical as directed, and of robust construction.

9.3.1.2 Where diameter of bolt for particular size of tower bolts is stated in the IS as 10 or 12 mm, the bolt shall be of 10 mm dia upto size 125 mm and 12 mm dia for sizes 150mm and above.

9.3.1.3 All M.S. tower bolts made with steel 1.2 mm thick MS sheet and above shall have countersunk screw holes.

9.3.2 Ferrous Tower Bolts

Steel tower bolts shall be of the following types. Bolts shall be finished bright and other parts stove enameled black. Size of the bolt shall be indicated.

(a) Mild steel barrel tower bolts with mild steel barrel and mild steel bolt.
(b) Mild steel semi-barrel tower bolts, open cover, with mild steel sheet pressed barrel and mild steel bolt.
(c) Mild steel tower bolts riveted type with back plate and mild steel bolt and open staple.
(d) Mild steel skeleton tower bolts with steel sheet pressed plate and staple and mild steel bolt.

9.3.3 Non-Ferrous Tower Bolts

Brass and aluminium tower bolts shall be of types as given in 9.3.3.1 and 9.3.3.2. These shall be provided with a small spring and ball on the inside of the barrel for smooth working. Brass bolts and barrels shall be polished bright. Aluminium alloy bolts and barrels shall be anodized. Size of bolt shall be as indicated.

9.3.3.1 Types of Barrel Tower Bolts

(a) Brass barrel tower bolts with cast brass barrel and rolled or cast brass bolt.
(b) Brass barrel tower bolts with sheet brass barrel and rolled or drawn brass bolt.
(c) Brass barrel tower bolts with barrel of extruded sections of brass and rolled or drawn brass bolt.
(d) Aluminium barrel tower bolts with barrel and bolt of extruded section of aluminium alloy.

9.3.3.2 Types of Skeleton Tower Bolts

(a) Brass skeleton tower bolts with cast brass plate and staples and rolled or drawn brass bolt.

(b) Brass skeleton tower bolts with staples and plate of extruded sections of brass and rolled or drawn brass bolt.
(c) Aluminium skeleton tower bolts with plate, staples and bolt of extruded sections of aluminium alloy.

9.4 Flush Bolts

Flush bolts shall comply with IS 5187-1972, Specification for flush bolts. These shall be type 2 and of the following material and finish, as indicated.

(a) Brass flush bolt with cast brass body and plate and cast brass or extruded brass bolt, and steel strip spring.
(b) Aluminium flush bolt with cast aluminium alloy or extruded aluminium alloy body and plate and extruded aluminium alloy bolt and steel strip spring.

9.4.1 Brass flush bolts shall be bright finished. Aluminium flush bolts shall be anodised.

9.4.2 Flush bolts shall have smooth and easy working. When the rod is completely in its maximum bolting position, it shall be retained in that position by the spring. The length of the bolt shall be such that when the bolt is pulled down, the top of the bolt shall be flush with the top of lip face. The top of the bolt shall be given a taper of 45° to enable easy pull or push.

9.5 Sliding Door Bolts

9.5.1 Mild Steel Sliding Door Bolts

These shall be bolt type and comply with the requirement of IS 281-1991. Hasp, clips and staple plate shall be made from mild steel sheets. Sliding bolts shall be made from round mild steel bar.

Hasp, bolt, staple and clips or fixing bolts shall be copper oxidised in accordance with IS 1378 or plated with nickel or chromium in accordance with IS 1068 as indicated.

9.5.2 Non-Ferrous Metal Sliding Door Bolts

These shall comply with IS 2681-1993, Specification for non-ferrous sliding door bolts for use with padlock and shall be of the following types, as indicated :-

(a) Brass sliding door bolts with sand or die cast brass hasp staple and fixing bolt and rolled or drawn brass bolts.
(b) Aluminium alloy sliding door bolts with hasp, staple and fixing clips of sheet or extruded section and fixing and sliding bolts of extruded sections of aluminium alloy.

9.5.2.1 The sliding door bolt shall have smooth sliding action. The hasp, when not cast integral with the bolt, shall be properly secured to the bolt. Sliding bolts shall be provided with fixing bolts. Brass bolts shall have satin finish or polished. Aluminium bolts shall be anodised.

9.6 Sliding locking Bolts

These shall comply with IS 7534-1985, Specification for sliding locking bolts for use with padlocks. Locking bolt shall have smooth sliding action. Bolt shall be made from mild steel and shall be copper oxidized, electrogalvanised or stove enameled black as indicated. The plate and strap shall be firmly riveted or spot welded and shall be stove enamelled black. Locking bolt shall be Type II (with straight locking plate). Size of bolt shall be indicated.

9.7 Hinges

9.7.1 Generally

Hinges shall be well made and shall be free from flaws and defects. All hinges shall be cut clean and square. The hole for the hinge pin shall be central and square to the knuckles/boss. All sharp edges and corners shall be removed. The sides of the knuckles shall be straight and at right angles to the flap. The movement of the hinges shall be free, easy and square and working shall not have any play or shake. The hinge pin shall fit inside the knuckles firmly and riveted in the case of steel hinges, and riveted or firmly notched in the case of non-ferrous metal butt hinges and properly finished. Rivet bead shall be well formed so as not to allow any play or shake. All screw holes shall be clean countersunk, suitable for countersunk head wood screw.

9.7.2 Mild Steel Butt Hinges

Mild Steel butt hinges shall be of cold rolled mild steel and shall comply with IS 1341-1992, Specification of steel butt hinges. Steel butt hinges are classified as light weight, medium weight; broad type, square type; and heavy type I and II. Hinges shall be of medium weight, unless otherwise indicated. The pins shall be of mild steel wire. Hinges shall be finished bright with smooth surface.

9.7.3 Non Ferrous Metal Butt Hinges

Brass and aluminium butt hinges shall comply with IS 205-1992, Specification for non-ferrous metal butt hinges and shall be of cast brass, extruded brass, sheet brass or extruded aluminium alloy, as indicated. Brass hinges shall be polished bright or satin finished. Aluminium hinges shall be anodised.

9.7.3.1 In the case of brass hinges the hinge pin shall be made of mild steel; or of brass in location susceptible to atmospheric corrosion where indicated. In the case of aluminium alloy hinges, the hinge pin shall be of aluminium alloy; or of mild steel, galvanised, where indicated. The aluminium alloy hinge pin shall be hard anodised and sealed with oil, wax or lanolin.

9.7.3.2 Non-ferrous metal butt hinges shall be of the size as indicated. These are designated with length of the hinge followed with letter A,B,C,D,E and F suitable for use with 45,40,35,30,25 and 20mm thick shutters respectively suffixed with numbers 11,12,21 or 22. Lower suffixing numbers indicate heavier hinges which are recommended for shutters of larger sizes, while higher suffixing numbers indicate lighter hinges and are recommended for shutters of comparatively smaller sizes. For example, a hinge with size designation 125C11 indicates that the hinge is 125 mm in length and is suitable for 35 mm thick shutter when the size of the shutter is considerably larger.

9.7.4 Mild Steel Tee Hinges

M.S. Tee hinges shall comply with IS 206-1992, Specification for tee and strap hinges and shall be of medium type; or of heavy type where indicated. Tee hinges shall be finished stove enamelled black.

9.7.5 Parliament Hinges

Parliament hinges shall comply with IS 362-1991 Specification for parliament hinges. These shall be of mild steel and shall be finished with bright or electrogalvanised as indicated.

9.7.6 Continuous (Piano) Hinges

Continuous (Piano) hinges shall be as per IS 3818-1992, Specification for continuous (Piano) hinges. These shall be of Type II; or Type IV where indicated. These shall be of mild steel galvanised or aluminium alloy as indicated. In the case of aluminium hinges, the hinge pin shall be of aluminium and in the case of steel hinges, the hinge pin shall be of mild steel. Mild steel hinges shall be bright polished, chromium plated or copper oxidized finish as indicated. Aluminium hinges shall be anodised.

9.7.7 Double Acting Spring Hinges

Double acting spring hinges shall conform to IS 453-1993 Specification for double acting spring hinges. These shall be of the following type as indicated.

(a) Mild steel double acting spring hinges with steel wire spring.
(b) Brass double acting spring hinges with phosphor bronze wire spring.

9.7.7.1 Mild steel hinges shall be finished stove enamelled black. The steel wire spring shall be electrogalvanised or copper plated. Brass hinges shall be finished bright.

9.7.7.2 Double acting spring hinges shall work smoothly when fitted to swing doors. The hinges shall hold the door vertical in its normal closing position.

9.7.7.3 Blank hinges for use alongwith double acting spring hinges shall also conform to IS 453- 1993.

9.7.8 Door Springs Rat-Tail Type

These shall conform to IS 452-1973, Specification for door springs, rat-tail type and shall be of mild steel or brass as indicated. In the case of mild steel door springs, casing, tail rod, spindle cap and base plate shall be stove enamelled black. Spindle, roller plate and roller shall be bright finished . Brass door spring shall be bight finished. Spring for both mild steel and brass door spring shall be of mild steel wire, copper oxidized or electro galvanised as indicated.

9.7.9 Stainless Steel Butt Hinges

Stainless Steel butt hinges shall be of stainless steel and shall comply with IS 12817-1997, Specification stainless steel butt hinges. Stainless steel butt hinges are classified as light weight, medium weight, heavy weight and unequal flap hinges. Hinges shall be of medium weight, unless otherwise indicated. Grade of stainless steel for flap and pin shall be as per IS. Unless otherwise indicated, hinges shall be naturally finished bright with smooth surface without chemical coating. The stainless steel hinges are rust proof and especially useful in high moisture area.

9.8 Latches

Latches shall be supplied left handed or right handed depending on the type of door to which they are fitted and as directed.

9.8.1 Rim Latches

These shall comply with Type 1 of IS 1019-1974, Specification for rim latches. They shall be of mild steel, brass or aluminium alloy as indicated. Locking pin shall also be provided to facilitate locking from one side. In the case of mild steel rim latches, the body, striking box, spindle and back plate shall be of mild steel; the latch bolt, follower, locking pin, knobs and disc shall be of brass. In the case of brass and aluminium alloy latches, body striking box and back plate and disc shall be of brass and aluminium alloy respectively. All other component shall be of brass. Spring for mild steel, brass and aluminium rim latches shall be of steel wire. Spring type lever handles may be provided in lieu of knobs where indicated. When the knob/lever handle of the latch is tuned, the latch bolt shall draw smoothly into the body. Mild steel rim latches shall be finished stove enamelled black. Brass latches shall have bright or satin finish. Aluminium latches shall be anodised.

9.8.2 Mortice Night Latch

This is a mortice lock having a single spring bolt withdrawn from the outside by key and from inside by a handle and with an arrangement whereby the lock can be prevented from being opened by its key from outside while the night latch is used from inside the room. Mortice night latches shall conform to IS-3847-1992, Specification for mortice night latches. These shall be mild steel, brass or aluminium alloy as indicated. Various components shall be as described for mortice Locks (vertical type). Mild steel body shall be given protective coating such as painting. Face plate and striking plate shall be finished smooth and polished bright or satin. Where so indicated face plate and striking plate shall also be chromium plated; where aluminium alloy is specified, it shall be anodized. Face plate shall be provided in front of case plate.

9.8.3 Mortice Latch (Vertical type)

Mortice latch (vertical type) shall conform to IS 5930-1970, Specification for mortice latch (vertical type). These latches shall be capable of being operated both from inside and outside and shall be provided with a thumb turn knob fitted on the handle plate in order to close the door from inside. The latches shall be of mild steel or brass or aluminium alloy as indicated. Various component shall be as described for mortice Locks (vertical type). Mild steel body shall be given protective coating such as painting. Face plate and striking plate shall be finished smooth and polished bright or satin. Where so indicated face plate and striking plate shall also be chromium plated; where aluminium alloy is specified, it shall be anodized. Face plate shall be provided in front of the case plate. Size of latch shall be as indicated.

9.9 Locks

9.9.1 Generally

Number of levers shall be as indicated. The locks shall be supplied with two keys. The keys shall be of stainless steel with stout brass label (oval or circular) attached thereto. The labels shall be engraved with the word 'MES' on one side and the number of building or room on the other side. In addition each key shall be provided with a split ring of approved pattern and size. Where more than one lock is provided, no key of the lock shall fit any other lock supplied. Master key in duplicate shall be supplied in case of more than six locks are provided in the same building. All components of the lock and keys shall be finished smooth to minimise frictional resistance in the working. The size of lock shall be indicated.

9.9.2 Mortice Locks (Vertical type)

These shall conform to IS-2209-1976, Specification for mortice lock (vertical type). These shall be of mild steel, brass or aluminium as indicated. No. of lever shall also be as indicated.

9.9.2.1 The various components of mortice locks shall be as under:

Components	Mild steel lock	Brass lock	Aluminium lock
Body Body cover	Mild Steel	Cast brass or sheet brass	Aluminium alloy cast or sheet
Cast plate Face plate	Mild Steel	Cast brass or sheet brass	Aluminium alloy sheet
Striking plate lever	Mild Steel	Cast brass or sheet brass	Aluminium alloy sheet
Locking bolt and latch bolt	Mild Steel	Extruded brass	Extruded brass
Follower	Malleable iron	Cast brass	Aluminium alloy
Lever spring & latch spring	Steel wire	Phosphor bronze	Phosphor bronze
Key	Stainless steel	Stainless steel	Stainless steel

9.9.2.2 The lock shall be made easy-working with lever and shall be capable of being opened with the key from both inside and outside. Depth of the body shall not exceed 15 mm. Face plates shall be provided in all locks. Mild steel body shall be given a protective coating such as painting. Brass body shall be finished bright. Aluminium alloy body shall be anodised. Face plate and striking plate shall be finished smooth, and finished bright for brass and mild steel locks; and anodised for aluminium locks.

9.9.3 Rebated Mortice Locks

These shall conform to IS 6607-1972, Specification for rebated mortice locks (vertical type). These shall be of mild steel, brass or aluminium as indicated. Material for various components of rebated mortice locks and their finish shall be as described for mortice locks (vertical type).

9.9.4 Drawer Locks and Cupboards Locks

Drawer Locks and Cupboards Locks shall be of Grade 2(light) quality and shall conform to IS 729-1979, Specification for drawer locks, cupboard locks and box locks. The size of locks shall be 40, 50, 65 or 75 mm as indicated.

9.9.4.1 These shall be with brass or aluminium body, as indicated with a minimum of four levers. For brass locks the body, cover plate, body plate and striking plate, shall be of cast brass or brass sheet; key, key pivot pin, lever pivot pin, lever spring fulcrum pin of stainless steel. For aluminium locks, the body cover plate, body plate and striking plate shall be of aluminium alloy pressure die casting or aluminium alloy sheet; key of mild steel; key pivot pin, lever pivot pin, lever spring fulcrum pin of stainless steel. For both brass and aluminium locks, the locking pin, locking in both plate, locking bolt and lever shall be of cast brass and lever cover plate of brass sheet and lever spring of phosphor bronze wire. Brass locks shall be finished bright and those of aluminium shall be anodised.

9.10. Hasps and Staples

These shall conform to IS 363-1993 Specification for hasp and staples. These shall be of the following types as indicated:-

(a) Mild steel hasp and staple- wire type
(b) Mild steel hasp and staple-safety type
(c) Brass hasp and staple- safety type
(d) Aluminium alloy hasp and staple- safety type

9.10.1 Hasp and staples shall be well made and free from defects. The hinge pin shall be of mild steel in the case of mild steel hasp and staples, and of mild steel or brass in the case of brass or aluminium hasps and staples, as indicated. The movement of the hinge shall be free, easy and square and shall not have any play or shake. The hasps shall fit the staples correctly. The staple, except in the case of cast one, shall be riveted properly to its plate. The hinge pin for the safety type hasp shall be riveted and rivet head properly formed and finished. Screw holes shall be clean and counter sunk to suit countersunk head wood screws.

9.10.2 Mild steel hasps and staples shall be stove enamelled black. Brass hasps and staples shall be finished bright and covered with clear lacquer. Aluminium alloy hasps and staples shall be anodised.

9.11 Handles

These shall conform to IS-208-1996, Specifications for door handles. These shall be of the following types, as indicated. Continuous plate shall be provided in handles.

(a) Cast iron or malleable cast iron.
(b) Mild steel pressed oval.
(c) Cast brass
(d) Brass fabricated handles
(e) Cast Aluminium
(f) Aluminium alloy fabricated handles.

9.11.1 Door handles shall be finished smooth. When the grip portion of handle is joined with base piece by mechanical means, the arrangement shall be such that assembly handle shall have adequate strength. Cast iron, malleable cast iron and Mild steel door handles shall be finished stove enamelled black. Brass handles shall be with bright polished finish. Aluminum handles shall be anodized.

9.12 Fanlight Pivots

These shall conform to IS 1837-1966, Specification for fanlight pivots. These shall be of the following types, as indicated:-

(a) Mild steel pivots.
(b) Brass pivots
(c) Aluminium pivots

Mild steel pivots shall be finished bright with a smooth surface. Brass pivots shall be finished bright. Aluminium alloy pivots shall be anodised.

9.13 Fanlight Catches

These shall conform to IS 364-1993, Specification for fanlight catch and shall be of the following types, as indicated :-

(a) Cast brass fanlight catches with brass body, mild steel hinge pin and spring of steel wire.
(b) Aluminium alloy fanlight catches with aluminium alloy body, aluminium alloy hinge pin and spring of steel wire.
(c) Mild steel fanlight catches with mild steel sheet body, mild steel hinge pin and spring of steel wire.

9.13.1 The movement of the plunger shall be smooth, easy and square. The heads of the riveted hinge pin shall be well formed and shall allow the catch to function without any friction or undue play.

9.13.2 Brass fanlight catches shall be with bright polished finish. Aluminium alloy fittings shall be anodised. Steel fittings shall be stove enamelled black.

9.14 Ball Catches

These shall comply with the requirements of IS 8756-1978, Specification for ball catches for use in wooden almirahs. The ball shall be of steel 8mm in diameter and polished bright. Spring shall be of steel wire. Catch shall be of cast brass with SI No.(ii) of Table 1 of IS Code. The striking plate shall be of brass sheet with minimum thickness of 0.5 mm. The body and striking plate shall be finished bright. Ball catches shall have smooth and easy working. When almirah door is in closed position, it shall be retained in that position by the spring action of the brass catch. The door shall open when it is pulled to open.

9.15 Floor Door Stoppers

These shall conform to IS 1823-1980, Specification for floor door stoppers. These shall be of the following types, as indicated:-

(a) Aluminium alloy pressure die cast body and tongue with hard drawn steel spring.
(b) Brass cast body and tongue with hard drawn steel spring.

9.15.1 The door stopper shall be well made and shall have smooth action. The body or housing of the door stopper shall be cast in one piece and it shall be fixed to the cover plate by means of brass or aluminium screws. The spring shall be fixed firmly to the pin. The tongue which would be pressed while closing or opening of the door shall be connected to the lower part by means of copper pin. On the extreme end, a rubber piece shall be attached to absorb shocks due to the pulling action of the door.

9.15.2 The exterior of the brass door stopper, which will be in flush and above the floor, shall be finished bright or satin and exterior of aluminium stopper shall be anodised.

9.16 Door Closers (Hydraulically Regulated)

9.16.1 Door Closers (Hydraulically Regulated) exposed type

These shall comply with IS 3564-1995, Specification for door closer (Hydraulically regulated) and shall be of designation 2 suitable for door weighting 36 to 60 Kg or designation 3 suitable for doors weighting 61 to 80 Kg as indicated. Door closers shall have cast iron body or aluminium alloy body, as indicated. Materials of other parts shall be as per IS. Closers shall be universal type suitable for both anticlockwise and clockwise doors, without any change in parts of the closers. Closers shall be Bottle type (Type A) or Tubular type (Type B) as indicated.

Door closers with cast iron body shall be painted and finished with lacquer. In case of aluminium body closer shall be anodised.

9.16.1.1 The surface of the closer shall be clean, without sharp edges, free from cracks burrs, dents or any other visible surface defects. The door closer shall not allow any signs of leakage under working conditions. The closing time shall be easily adjustable by means of regulating screw between 5 to 20 seconds.

9.16.2 Door Closers (Hydraulically Regulated) concealed type

These shall comply with IS 14912-2001. Specification for door closers, concealed type (Hydraulically regulated) and shall be of designation 2 suitable for door weighting up to 60 Kg or designation 3 suitable for doors weighting 61 to 80 Kg as indicated. Door closers shall have aluminium alloy body, as indicated. Materials of other parts shall be as per IS. Closers shall be universal type suitable for both anticlockwise and clockwise doors, without any change in parts of the closers. In case of aluminium body closer shall be anodized.

9.16.2.1 The body shall be secured in the hole in the door frame with screws on the holding plate. In case width of frame is equal to width of door closer, a set of plates shall be provided to cover the body from both surface of the door panel with the help of screws. The surface of the closer shall be clean, without sharp edges, free from cracks burrs, dents or any other visible surface defects. The door closer shall not allow any signs of leakage under working conditions. The closing time shall be easily adjustable by mans of regulating screw between 5 to 20 seconds.

9.17 Floor Springs (Hydraulically Regulated) for heavy doors

These shall comply with IS 6315-1992, Specification for floor springs (Hydraulically regulated) for heavy doors suitable for doors weighting up to 125 Kg. These shall be single action or double action type as indicated. Foundation box, main body and half cover shall be of minimum 1.25 mm thick mild steel sheet or aluminium alloy sheet or brass sheet as indicated. Top cover shall be of minimum 2 mm thick aluminium alloy sheet or 1.25 mm thick brass sheet as indicated. Materials of other parts shall be as indicated in IS. The floor springs shall operate smoothly and easily without undue delay during opening and closing operation. The closing time shall be easily adjustable by suitable device between 3 to 20 seconds. The floor springs shall be free from all mechanical defects, sharp edges, and any other visible surface defects. The cover sheet, shoe and top centre shall be polished or electroplated as indicated. Mild steel parts shall be given phosphating treatment and thereafter two coats of enamel paint.

9.18 Hold fast

These shall comply with IS 7196-1974 specification for hold fast. These shall be of minimum 5 mm thick mild steel flats conforming to IS 1731 and shall be given a coat of bitumen and sanded. Size and dimensions shall be as indicated.

9.19 Hat, Coat and Wardrobe Hooks

These shall comply with IS 9899-1981, Specification for Hat, Coat and Wardrobe Hooks. These shall be of mild steel sheet, aluminium alloy (sheet/die cast/extruded section) or brass (sheet/cast) as indicated. The hooks shall be manufactured in one piece and shall be well made and free from all defects. They shall either be screwed or riveted to back plate or may be solid cast along with back plate. Mild steel hooks shall be stove enameled black and brass hooks shall be finished bright. Aluminium hooks shall be anodised.

9.20 Gate and Shutter Hook and Eyes

These shall conform to IS 207-1964. Specification for gate and shutter hooks and eyes, and shall be of the following types as indicated:

(a) Mild steel hooks and eyes Type I
(b) Hard drawn brass hooks and eyes Type 1
(c) Aluminium anodised hooks and plates Type 2

9.20.1 The hook shall snugly fit in the eye. Steel and brass hooks, eyes and plates shall be finished bright. Aluminium hooks, eyes and plates shall be anodised.

9.21 Curtain Rails

These shall conform to IS 10342-1982 Specification for curtain rail system. These shall be of the following types as indicated. Size shall be as indicated.

(a) Pressed mild steel sheet curtain rails.
(b) Aluminium alloy (sheet/die cast/extruded section) curtain rails.

Curtain rails of the specified size shall be supplied with rings and brackets for fixing. Two brackets for fixing to walls or pelmets shall be supplied. For rails exceeding 50 cm in length, one additional bracket shall be provided for every 50 cm. The mild steel rail and brackets shall be chromium plated and aluminium alloy rails shall have anodised finish. Rollers shall be provided one roller per 15 cm length of curtain rail.

9.22 Finger Plates

Finger plates shall be of transparent plastic sheets or aluminium alloy sheets as indicated 200 mm to 300 mm long, 80 mm to 100 mm wide and 1 mm thick unless otherwise indicated. Plastic laminated sheets shall be of colour and pattern as directed and aluminium plates shall be anodised.

9.23 Kicking Plates

These shall be of galvanised mild steel sheet lmm thick fixed with galvanized wood screws, with washers at 300 mm centres around.

9.24 Towel Rails

These shall be of the following hollow tube types, as indicated; size, thickness shall be as indicated:-

(a) Brass towel rails, chromium plated.

(b) Aluminium alloy towel rails, anodised.

9.24.1 Towel rails shall be D Type with flanged ends for fixing to the background. Alternatively brackets with sockets suitable for a fixing to the background shall be provided.

9.25 Wire Cloth

9.25.1 Galvanised Mild Steel Wire Cloth

Wire cloth shall comply with IS 1568-1970, Specification for wire cloth for general purposes. Wire shall be of galvanised mild steel and the cloth shall conform to the following dimensions.

Average width of aperture mm	Nominal diameter of wire mm
1.40	0.63
1.18	0.56
1.00	0.56

Wire cloth shall be regularly woven with a number of equally spaced parallel wires in both warp and weft directions to produce uniformly square meshes or openings. The wire cloth shall be properly selvedged by one or more wires in each edge.

9.25.2 Aluminium Alloy Wire Cloth

These shall be of 0.45 mm nominal diameter anodized aluminium wire and average width of aperture shall be 1.40mm unless otherwise indicated.

9.25.3 Stainless Steel Wire Cloth

These shall be of 0.36 mm nominal diameter stainless steel wire and average width of aperture shall be 1.40mm unless otherwise indicated.

9.26 PVC Handrail Covers

These shall conform to IS 12867-1989, Specification for PVC handrail covers. These are generally made in widths to match desired width of metal strips. Size and colour shall be as indicated. Bright colours other than black fade in course of time when installed exposed to outdoor weather therefore only black colour PVC handrail covers shall be provided for outdoor exposed use, unless otherwise indicated.

WORKMANSHIP

9.27 Generally

All builders' hardware shall be fixed to joinery in a secure and efficient manner. Special attention shall be given to the size and fixing of screws to ensure that the screws are driven (and not hammered) tight and the heads of the screw do not protrude.

9.28 Hinges

All hinges except T or strap hinges shall be countersunk into the edge of timber joinery and frames to a depth equal to the thickness of the leaf of the hinge.

9.29 Fanlight etc.

When fanlights or windows are centre hung, fanlight pivots shall be fixed slightly off the centre so that the fanlights and windows may normally remain in the open position.

9.30 Metal Sockets

These shall be provided to all tower bolts and sliding bolts where the bolts enter brick, stone, or concrete. These shall be securely fixed flush with the surface into mortices and cemented. Mortice plates over holes shall be provided where the shoots enter wood.

9.31 Oiling

All lock, bolts, springs and other items of builder's hardware with moving parts shall be properly oiled and handed over in working condition on completion.

9.32 Woven Wire Cloth

When fixed in panels of door, window or opening shall be secured into the rebates of stiles and rails or frames and fixed with beads. Edges of the wire cloth shall be bent over heads and the bead pressed well into the angle of the rebate to hold the wire cloth on two faces.

9.33 Wire Netting Galvanised

When fixed to wood frames, shall be fixed with staples at intervals not exceeding 30cm. Wire netting shall be tightly stretched during fixing to prevent sagging. Authorised joints shall be sawn together with 15cm over-lap with 1.6mm annealed wire.

9.34 PVC Handrail Covers

Method of installation of PVC handrail covers shall be as indicated in Annex D of IS 12867.

SECTION 10
STEEL, IRON AND ALUMINIUM WORK

10.1 Indian Standards

The following IS apply to this section.

I.S. No.	*Subject*
210-1993	Specification for Grey Iron casting (Fourth revision)
277-2003	Specification for Galvanised Steel sheet (plain and corrugated) (Sixth revision)
278-2001	Specification for Galvanised Steel Barbed wire for fencing (Third revision)
280-2006	Specification for mild steel wire for general engineering purposes.(Fourth revision)
412-1975	Specification for expanded metal steel sheets for general purposes (Second revision)
432 (Part I) 1982	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement, Part I, Mild steel and medium tensile steel bars (Third revision)
432(Part 2) 1982	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement Part-II, Hard drawn steel wire (Third revision)
733-1983	Specification for wrought aluminium and aluminium alloys bars, rods and sections (for general engineering purposes). (Third revision)
737-1986	Specification for wrought aluminium and aluminium alloys sheet and strip for general engineering purposes (Third revision)
800-1984	Code of practice for general construction in steel (Second revision).
808-1989	Dimensions for hot rolled steel beam, column, channel and angle sections. (Third revision)
811-1987	Cold formed light gauge structural steel section. (Revised)
814 -2004	Specification for covered electrodes for manual metal arc welding of carbon and carbon managese steel (sixth revision)
816-1969	Code of practice for use in metal arc welding for general construction in mild steel (First revision).
818-1968	Code of practice for safety and health requirement in electric and gas welding and cutting operations (First revision).
822-1970	Code of procedure for inspection of welds.
1038-1983	Specification for steel doors, windows and ventilators (Third revision)
1081-1960	Code of practice for fixing and glazing of metals (steel and aluminium) doors, windows and ventilators.
1148-1982	Specification for hot rolled rivet bars (up to 40mm diameter) for structural purposes (Third revision).
1173-1978	Hot rolled slit steel tee bars (Second revision)
1252-1991	Dimension of Hot rolled steel bulb angles (First revision)
1285-2002	Specification for wrought aluminium and aluminium alloys extruded round tube and hollow sections for general engineering purposes (Third revision)

I.S. No.	*Subject*
1361-1978	Specification for steel windows for industrial buildings (First revision)
1363-2002 (Part 1)	Hexagon head bolts, screw and nuts of product grade 'C'- Part-I, Hexagon head bolts (Size range M 5 to M 64) (Fourth revision)
1363-2002 (Part 2)	Hexagon head bolts, screw and nuts of product grade 'C'- Part-II, Hexagon head screws (Size range M 5 to M 64) (Fourth revision)
1363-1992 (Part 3)	Hexagon head bolts, screw and nuts of product grade 'C'- Part-Ill, Hexagon nuts (Size range M 5 to M 64) (Third revision)
1367 (Parts 1 to 20)	Technical supply conditions for threaded fasteners
1566-1982	Specification for hard drawn steel wire fabric for concrete reinforcement (Second revision)
1730-1989	Dimensions for steel plates, sheets, strips and flats for general engineering purposes (Second revision)
1732-1989	Dimensions for round and square steel bars for structural and general engineering purposes, (Second revision)
1786-1985	Specification high strength deformed steel bars and wires for concrete reinforcement (Third revision)
1852-1985	Rolling and cutting tolerances for hot rolled steel products (Fourth revision)
1863-1979	Hot rolled steel bulb flats (First revision)
1868-1996	Specification for anodic coating on aluminium and its alloys (Third revision)
1948-1961	Specification for aluminium doors, windows and ventilators
1949-1961	Specification for aluminium windows for industrial buildings
2016-1967	Specification for plain washers (First revision).
2062-2006	Specification for hot rolled low, medium and high tensile structural steel (Sixth revision)
2314-1986	Specification for steel sheet piling sections (First revision).
2502-1963	Code of practice for bending and fixing of bars for concrete reinforcement.
2721-2003	Specification for galvanised steel chain link fence fabric (Second revision).
2751-1979	Code of practice for welding of mild steel bars used for reinforced concrete construction (First revision).
3016-1982	Code of practice for fire precautions in welding and cutting operations(First revision)
3063-1994	Specification for single coil rectangular section spring lock washers. (Second revision)
3443-1980	Crane rail sections (First revision)
3502-1994	Specification for steel chequered plates (Second revision)
3908-1986	Aluminium equal leg angles (First revision)
3909-1986	Specifications for aluminium unequal leg angles (First revision)
3921-1985	Aluminium channel (First revision)
3954-1991	Hot rolled steel channel sections for engineering purposes-dimensions (First revision)
4000-1992	Code of practice for high strength bolts in steel structures. (First revision)

I.S. No.	Subject
4351-2003	Specification for steel doors frames (Second revision)
4948-2002	Specification for welded steel wire fabric for general use (Second revision)
5384-1985	Aluminium I Beam (First revision)
5523-1983	Method of testing for anodic coating on aluminium and its alloys (First revision)
6248-1979	Specification for metal rolling shutters and rolling grills (First revision)
6445-1985	Aluminium tee sections (First revision)
6639-2005	Specification for hexagon head bolts for general steel structures. (First revision)
7205-1974	Safety code for erection of structural steel work.
7215-1974	Tolerances for fabrication of steel structures.
7307(Part I)-1974	Approval tests of welding procedures, Part I, Fusion welding of steel.
7452-1990	Specification for hot rolled steel sections for doors, windows and ventilators. (Second revision)
9595-1996	Recommendation for metal arc welding of carbon and carbon manganese steel (First revision)
10019-1981	Specification for mild steel stays and fasteners
10521-1883	Specification for collapsible gate
12753 - 1989	Eletrogalvanized coatings on round steel wire-specifications.
12778-2004	Hot rolled parallel, flange steel sections for beams, columns and bearing piles dimensions and section properties. (First revision)
12843- 1989	Tolerances for erection of steel structure
13871 - 1993	Specification for powder coatingss

CAST IRON WORK

10.2 Cast Iron Work

Casting shall be cast iron of grade FG 150 conforming to IS:210-1993, Specification for grey iron casting. The casting shall be sound, clean and free from porosity, blow holes, hard spots, cracks, hot tears, cold shuts (i.e. irregularities due to casting at too low a temperature), distortion, sand and slag inclusion and other harmful defects. They shall be well dressed and fettled; accurately moulded in accordance with the pattern/drawing and shall be of uniform thickness except where the design necessitates variation. Abrupt changes in the section of adjoining members shall be rounded and internal angles finished with an angle fillet. No welding or repairs shall be carried out, unless otherwise indicated.

10.3 BLANK

10.4 Structural Steel Work

Structural steel shall conform to any of the following grades of steel, as indicated:-

(a) Structural steel E 250(Fe 410W quality A, B or C) conforming to IS 2062-2006, Specification for hot rolled low, medium and high tensile structural steel.

(b) Structural steel E 165(Fe 290) conforming to IS 2062-2006, Specification for hot rolled low, medium and high tensile structural steel.

10.4.1 Structural Steel E 250 (Fe 410W quality A, B or C)

It is intended to be used for all types of structures including those subjected to dynamic loading and where fatigue, wide fluctuation of stresses, reversal of stresses and great restrain are involved; e.g. residential buildings, office building, platform roofs, foot over bridges, transmission towers, crane gantry girders, road bridges etc. This steel can be used for all types of riveted/welded construction. "C" quality steel is supplied with low temperature properties.

10.4.2 Structural Steel E 165 (Fe 290)

It is intended for general purposes such as door and window frames, window bars, grills, steel gates, hand rails, fencing posts, tie bars etc.

10.4.3 Freedom from Defects

All finished steel shall be well and cleanly rolled to the dimensions, sections, and masses specified. The finished material shall be reasonably free from cracks, surface flaws, laminations, rough/jagged and imperfect edges and all other harmful defects. Minor surface defects may be removed by the manufacturer by grinding provided that the thickness is not reduced locally by more than 4 percent with a maximum of 3mm.

10.4.4 Structural steel of different sections, sizes and lengths shall be stacked separately. For each classification of steel separate areas shall be ear-marked. Steel shall be marked with distinct painting marked for easy identification.

All steel shall be so stored that is is always at least 15cm above the ground level. In case of long storage suitable protective measures shall be taken to prevent scaling and rusting.

10.4.5 Dimensions

Nominal dimensions of rolled products shall be as per following IS:-

Products	Relevant IS
Beam, column, channel and angle section	808
Tee bars	1173
Bulb angles	1252
Plates, strips and flats	1730
Round and square bars	1732
Bulb flats	1863
Sheet piling sections	2314
Channel sections	3954
Track Shoe sections	10182 (Parts 1 & 2)
Parallel beam and column sections	12778

10.4.6 Tolerances

Rolling and cutting tolerances shall be as per IS 1852.

10.5 Chequered Plates

Chequered plates shall be as per requirements given in IS-3502-1994, Specification for steel chequered plates. Pattern of chequered plates shall be as directed. Unless otherwise indicated, minimum bead height shall be 0.8 mm. Plates shall be cleanly rolled and shall be reasonable free from harmful surface defects such as cracks, surface flaws, imperfect edges, etc. Thickness of chequered plates specified shall be exclusive of the raised portion.

10.6 Rivets

Rivets used for fabrication in general building construction shall be made out of mild steel rivets bar conforming to IS 1148-1982, Specification for hot rolled steel rivet bars (upto 40mm diameter) for structural purposes. Rivets shall have snap head, flat counter sunk head, rounded counter-sunk head or pan head as indicated or directed by EIC.

Rivet bars shall be well and cleanly rolled and shall be free from such surface and internal flaws as would be detrimental to the end use of the material.

10.7 Bolts Nuts and Washers

10.7.1 Bolts and nuts shall be conforming to the relevant requirements given in the following IS specifications.

(a) IS 1363-2002 (Parts 1 to 3)	Specification for hexagon head bolts, screws and nuts of product grade 'C' (Size M 5 to M 64)
(b) IS 1367 (Parts 1 to 20)	Technical supply conditions for threaded fasteners.
(c) IS 6639-2005	Specification for hexagon head bolts for general steel structures.

10.7.2 The heads shall be forged in one piece with the bolts and the nuts shall be neatly made with the hole truly in the centre. The threads shall be full, true and deep. The heads and nuts shall be hexagonal unless square heads and nuts are specially indicated. Bolts and nuts shall be cleanly finished and shall be sound and free from defects which may affect their serviceability. Bolts and nuts shall be suitably protected against corrosion.

10.7.3 Washers

Plain washers shall be of steel conforming to IS 2016-1974, Specification for plain washer. Spring washer shall conform to IS 3063-1994, Specification for single coil, rectangular section spring washers for fasteners. The washer shall be free from cracks, burns, pits or other defects. The hole shall be reasonably concentric with the outer periphery. All sharp edges shall be removed.

10.8 Electrodes

Electrodes for metal are welding of mild steel shall be as per IS 814-2004, Specification for covered electrodes for metal are welding of structural steel. Joints in materials above 20 mm thick and all important connections shall be made with low hydrogen electrodes. The mechanical properties of the weld deposit shall be such as to satisfy all the requirements such as tensile strength, elongation and impact strength of the parent metal.

10.9 Workmanship Generally

Structural steel work riveted, bolted or welded shall be carried out described in IS 800-1984, Code of practice for use of structural steel in general building construction.

10.9A Straightening and Bending

All material shall be straight and if necessary, before being worked shall be straightened and flattened by pressure, unless required to be curvilinear form and shall be free from twists. Straightening of steel by hammer blows is not permitted. All bending and cutting shall be carried out in cold condition, unless otherwise directed, in such manner as not to impair the strength of the metal.

10.10 Cutting and Machining

Member shall be cut mechanically by saw or shear or by oxyacetylene flame. All sharp rough or broken edges and all edges of joints which are subjected to tensile or oscillating stresses shall be grounded. No electric metal arc cutting shall be allowed. All edges cut by oxyacetylene, pores shall be cleaned of impurities and slag prior to assembly cutting tolerance shall be as follows:-

(a) For member connected at ends ± lmm.
(b) Elsewhere ± 3 mm.

10.10.1 When compression members depend on contact surfaces for stress transmission, then ends of columns, caps and bases together with gussets, angles and channels (after riveting/welding together) shall be accurately machined so that the parts connected butt over the entire surfaces of contact. Columns at bases or at caps or at butt joints need not be machined.

10.11 Holes

All holes shall be accurately marked and drilled. Holes through more than one thickness shall preferably be drilled together after the members are assembled and tightly clamped or bolted together. In such cases, if required these parts shall be separated after drilling and burrs removed. For thickness of materials less than 16 mm the holes may be punched 3mm less in diameter than the required size and may be reamed to the full diameter after assembly. Finished holes for rivets and black bolts shall be not more than 1.5mm (2.0 mm for rivets and bolts of diameter more than 25mm) in diameter larger than the diameter of rivets and bolts passing through them. All matching holes for rivets shall be so prepared that a gauge 1.5 mm or 2 mm (as the case may be) less in diameter than the diameter of hole can pass freely through the members assembled for riveting. Holes other than those required for close tolerance may be punched full size through material not over 12mm thick.

10.11.1 All holes shall have their axis perpendicular to the surface bored through. Holes through two or more members shall be truly concentric. No rivet or bolt hole shall be nearer the edge of the member than a distance equal to its own diameter. Holes shall not be formed by gas cutting process.

10.12 Assembly

10.12.1 Laying Out

Steel structure shall be laid out on a level platform to full scale and to full size or in parts as shown on working drawings or as directed by EIC. Wooden templates 12mm to 19mm thick or metal sheet templates shall be made to correspond to each member and part, rivet holes shall be marked accurately on them and drilled. The templates shall be laid on the steel members and holes for riveting and bolting marked on them. The ends of the steel members shall also be marked for cutting. The base of steel column and the position of anchor bolts shall be carefully set out.

10.12.2 The component parts shall be assembled in such a manner that they are neither twisted no otherwise damaged and shall be so prepared that the specified cambers, if any, are provided. All box sections shall be sealed so as to prevent the access of moisture to the inside of the members.

10.12.3 Assembly shall be done by using assembly fixtures, jigs and stands which facilitate high quality assembly with proper safety. Mis-alignment and distortion of parts after assembly shall not be allowed; only thoroughly straightened parts free from burrs, grease, rust etc shall be allowed for assembly.

10.12.4 Temporary connection of parts during assembly shall be done in the following way:-
(a) For welded structures joining shall be done by means of tack weld, fastening devices and fixtures.

(b) For riveted and bolted structures joining shall be done by adequate number of bolts. If tack welding is permitted, in such cases the same shall be removed after the work is over.

(c) For riveted structures in which holes are to be drilled after assembly, joining shall be done by appropriate fixtures.

10.12.5 Tack welding shall be done on the side and along the line of the weld. Tack weld dimension shall be minimum. Tack welding shall be carried out with similar electrodes as the final welding and the tacks shall completely fuse with the final weld metal.

10.12.6 In case splicing is necessary; the individual members shall be spliced first before assembly and before final welding with other members.

10.12.7 For riveted structures, members shall be well tightened by assembly bolts in every third hole. Maximum distance between bolts shall not exceed 500 mm. To prevent stiffening drift pins shall be used 30 percent of the assembly bolts. After tightening, the gap between members to be jointed shall be checked by 0.2 mm thick feeler gauge which should not go inside by more than 2mm, looseness of bolts shall be checked by tapping with a test hammer.

10.13 Riveting

Riveting shall be done by pneumatic riveting or hydraulic riveting equipment Riveting of diameter less than 10mm may be fitted cold. In cold riveting the rivets are driven with the aid of powerful pneumatic or electrical clamps and the holes filled with sufficient tightness. However where such facilities are not available, hand riveting may be permitted by the EIC.

10.13.1 Members to be riveted shall be properly pinned, or bolted and rigidly held together while riveting. Rivets shall be heated uniformly throughout the length without burning or excess scaling and shall be of sufficient length to provide ahead of standard dimension. They shall, when driven, completely fill the holes and if counter-sunk the countersinking shall be fully filled by the rivet. Any protusion of counter-sunk head shall be dressed off flush. All loose, burnt and badly formed or otherwise defective rivets shall be cut out and replaced before the structure is loaded. The heads of rivets shall be central to shanks and shall grip the assembled members firmly. In cutting out rivets, care shall be taken so as not to injure the assembled members. Caulking or recupping shall not be permitted.

10.14 Bolting

Bolt heads and nuts shall be of such length as to project one clear thread beyond the nuts when fixed in position, and these shall fit in the holes without any shake. The nuts shall fit in the threaded ends of bolts properly.

10.14.1 Round washes shall be placed under the heads and nuts of permanent bolts. Maximum two washers for one nut and one for each bolt head shall be used. Bolt threads shall be outside the limits of joining members and unthreaded portion of bolt shall not be outside the washer.

10.14.2 Where there is risk of the nuts being removed or becoming loose due to vibration or reversal of stresses, these shall be secured from slackening by the use of lock-nuts or spring washers, as directed by the EIC.

10.14.3 Bolts, nuts and washers shall be thoroughly cleaned and dipped in double boiled linseed oil before use.

10.14.4 Quality of tightening of bolts shall be inspected by taping them with a hammer. The bolt shall not be shaken or shifted.

10.14.5 The bolts shall be tightened starting from centre of the joint towards the edge.

10.15 Welding

10.15.1 Welding shall be done by metal are process unless otherwise permitted by the GE, in writing, in accordance with IS-816-1969, Code of practice for use of metal are welding of general construction in mild steel, and IS 9595-1996, Recommendation of Metal Arc Welding of carbon and carbon manganese steel, regarding workmanship welding method, welding procedure with suitable electrodes are wire flux, combinations, quality of welds, correction of weld faults etc.

10.15.2 Preparation of Members for Welding

10.15.2.1 Assembly of structural members shall be made with proper jigs and fixtures to ensure correct positioning of members (angles, axis, nodes etc.)

10.15.2.2 Sharp edges, rust of cut edges, notches, irregularities and fissures due to faulty cutting shall be chipped or ground or filed over the length of the affected area, deep enough to remove faults completely.

10.15.2.3 Edge preparation for welding shall be carefully and accurately made so as to facilitate a good joint.

10.15.2.4 Generally no special edge preparation shall be required for members under 8mm thick.

10.15.2.5 Edge preparation (beveling) denotes cutting of the same so as to result in V,X,K or U seam shapes as per IS-9595.

10.15.2.6 The members to be assembled shall be clean and dry on the welding edges. Under no circumstances shall wet, greasy, rust or dirt covered parts be assembled. Joints shall be kept free from any foreign matter, likely to get into the gaps between members to be welded.

10.15.2.7 Before assembly, the edges to be welded as well as adjacent areas extending for at least 20 mm shall be cleaned (until metallic polish is achieved).

10.15.2.8 When assembling members proper care shall be taken of welding shrinkage and distortions, as the drawing dimensions cover finished dimensions of the structure.

10.15.2.9 The elements shall be got checked and approved by the EIC before assembly.

10.15.2.10 The permissible tolerances for assembly of members preparatory to welding shall be as per IS 9595.

10.15.2.11 After the assembly has been checked temporary tack welding in position shall be done by electric welding, keeping in view finished dimensions of the structure.

10.15.2.12 Preheating of members to be joined to be carried out as per standards wherever necessary.

10.15.3 Butt Welds

The form of joint, angle between fusion faces, gap between parts and the welding procedure shall be such that the welded joint shall comply with the design requirements. The ends of butt joints in plate shall be welded so as to provide full throat thickness. In the gas-welded condition, the weld face shall be proud of the surface of the parent metal. Where a flush surface is required, the excess metal shall be dressed off. Where no dressing is to be carried out, the permissible weld profile shall be as specified in the relevant IS.

10.15.4 Fillet Welds

A fillet weld as deposited shall be not less than the specified dimensions indicated as throat thickness and/or leg thickness taking into account penetration process or partial penetration. For concave fillet welds the actual throat thickness shall be not less than 0.7 times the specified leg length. For convex fillet welds, the actual throat thickness shall be not less than 0.9 times the specified leg length.

10.15.5 Preparation of Joint Faces

If preparation or cutting of material is necessary, this shall be done by shearing, chipping, grinding, machining, thermal cutting or thermal gouging. When shearing is used the effect of work hardening shall be taken care of to ensure that there is no cracking of the edges. Removal of 1 mm to 2 mm from a cut face normally eliminates the layer of hardness.

10.15.6 Fusion Faces

Fusion faces and adjacent surfaces shall be free from cracks, notches or other irregularities which might be the cause of defects or would interfere with the deposition of the weld. They shall also be free from heavy scale, moisture, oil, paint, any other substances which might affect the quality of weld or impede the progress of welding.

10.15.7 Assembly for Welding

Jigs and manipulators should be used, where practicable, so that the welding can be carried out in the most suitable position. Jigs shall maintain the alignment with the minimum restraint so as to reduce the possibility of lock in stresses.

10.15.8 Alignment of Butt Joint

The root edges or root faces of butt joints shall not be out of alignment by more than 25 percent of the thickness of the thinner material for material upto 12mm thick or by more than 3 mm for thicker material. For certain applications closer tolerances may be necessary for proper alignment.

10.15.9 Fit up of Parts jointed by Fillet Welds

The edges and surfaces to be jointed by fillet welds shall be in as close contact as possible since any gap increases the risk of cracking but in no case should the gap exceed 3 mm.

10.15.10 Tack Welds

Tack welds shall be not less than the throat thickness or leg lengths of the root run to be used in the joint. The length of the tack weld shall not be less than four times the thickness of the thicker part or 50mm whichever is smaller. If smaller tack welds are desired, these shall be so indicated.

Where a tack weld is incorporated in a welded joint, the shape of the tack shall be suitable for incorporation in the finished weld and it shall be free from cracks and other deposition faults.

10.15.11 Protection from Weather

Surface to be welded shall be dry. When rain or snow is falling or during periods of high wind, necessary precautions shall be taken for outdoor welding. Warming shall be carried out at all ambient temperatures below 10° C.

10.15.12 Inter-Run Cleaning

Each run of weld bead and each layer of weld shall be thoroughly cleaned of slag, spatters, etc, before depositing subsequent bead or weld with particular reference to thorough cleaning of toes of the welds. Visible defects such as cracks, cavities and other deposition faults, if any, shall be removed to sound metal before depositing subsequent run of layer of weld.

10.15.13 Welding Procedure

10.15.13.1 Welding shall be carried out only by fully trained and experienced welders as tested and approved by the EIC.

10.15.13.2 Qualification tests for welders as well as tests for approval of electrodes will be carried out as per IS:823. The nature of test for performance qualification for welders shall commensurate with the quality of welding required on the work as judged by the EIC.

10.15.13.3 The steel structures shall be automatically, semi-automatically or manually welded.

10.15.13.4 Welding shall be done only after the checks shown under clause 10.15 have been carried out.

10.15.13.5 Welding Procedures and Tests for welders shall be conducted as per IS:9595 and approved by the EIC.

10.15.13.6 The welder shall mark with his identification mark on each element welded by him.

10.15.13.7 When welding is carried out in open air, steps shall be taken to protect the places of welding against wind or rain. The electrodes wire and part being weld on shall be dry.

10.15.13.8 Before beginning the welding operation each joint shall be checked to assure that the parts to be welded are clean and root gaps provided as per IS-9595.

10.15.13.9 For continuing the welding of seams discontinued due to some reasons the end of the discontinued seam shall be melted in order to obtain a good continuity. Before resuming the welding operation the groove as well as the adjacent parts shall be well cleaned for a length of approximately 50mm.

10.15.13.10 For single butt welds (in V, 1/2 V or U) and double butt welds (in K, double U, etc) the re-welding of the root butt is mandatory but only after the metal deposition on the root has been cleaned by back gouging or chipping.

10.15.13.11 The welding seams shall be left to cool slowly. The Contractor shall not be allowed to cool the welds quickly by any method.

10.15.13.12 For multi-layer welding, before welding the following layer, the formerly welded layer shall be cleaned metal bright by light chipping and wire brushing. Backing strips shall not be allowed.

10.15.13.13

The order and method of welding shall be so that :-

(a) No unacceptable deformation appears in the welded parts.

(b) Due margin is provided to compensate for contraction due to welding in order to avoid any high permanent stresses.

10.15.13.14 The defects in welds must be rectified according to IS :9595 and as per instruction of EIC.

10.15.14 Approval and Testing of Welders

The Contractor shall satisfy the EIC that the welders are suitable for the work upon which they will be employed.

10.15.15 Weld Inspection

10.15.15.1 The weld seams shall satisfy the following :

(a) Shall correspond to design shapes and dimensions.

(b) Shall not have any defects such as cracks, incomplete penetration and fusion under cuts, rough surfaces, burns, blow holes and porosity etc beyond permissible.

10.15.15.2

During the welding operation and approval of finished elements, inspections and tests shall be made as shown in Table I below -

EXTENT OF INSPECTION AND TESTING

Sr. No.	Inspection of Test	Coverage	Procedure	Evaluation and remedy of defects
1.	Inspection of weld seam appearance	All welds	Naked eye or lens	All faulty welds shall be rectified.
2.	Checking of sizes	At least one for each weld seam	Ordinary Measuring instruments (rule templates)	Should faulty weld be found, all welds shall be checked and all defects shall be rectified.
	Mechanical Test for welding procedures, performance & electrodes		As per IS : 9595	As per IS : 9595

10.15.15.3 The mechanical characteristics of the welded joints shall be as in IS: 9595.

10.15.16 Quality of Welds and Corrections

Welded joints shall be free from defects that would impair the service performance of the construction. All welds shall be free from incomplete penetration, incomplete fusion; slag inclusion, burns, unwelded craters, undercuts and cracks in the weld metal or in the heat affected zone, porosity, etc. Unacceptable undercutting shall be good by grinding. In case of shrinkage cracks, cracks in parent plate and crater, defective portions shall be removed down to sound metal and re-welded. Whenever corrections necessitate the deposition of additional weld metal, electrode of a size not exceeding 4mm may be used. Rectification of welds by caulking shall not be permitted.

10.15.17 Cleaning

All welds shall be cleaned of slag and other deposits after completion; till the work is inspected and approved, painting shall not be done.

10.15.18 Plaining of Ends

10.15.18.1 Plaining of ends of member like column ends shall be done by grinding where so specified.

10.15.18.2 Plaining of butt welded member shall be done after these have been assembled and the edges be removed with grinding machine or file.

10.15.18.3 The following tolerances shall be permitted on members that have been plained:

(a) The length of member having both end plained max $\pm$ 2mm with respect to design.

(b) Level difference between plained surface = 0.3mm.

(c) Deviation between plained surface and member axis=max 1/5000.

10.15.19 Safety and Health

The Contractor shall ensure that the safety requirements and health provisions laid down in IS : 818-1968, Code of Practice for safety and health requirements in electric and gas welding and cutting operations, are complied with during welding operations. The Contractor shall also provide equipment for eye and face protection during welding as laid down in IS: 1179-1967. Fire precautions shall be taken in accordance with IS 3016-1982, Code of practice for fire precautions in welding and cutting operations.

10.16 Erection

10.16.1 Erection works shall be performed in accordance with the general construction schedule. A scheme shall be worked before the commencement of the erection which shall also contain rules for safety precautions as detailed in IS:7205-1974, Safety Code for erection of structural steel work.

10.16.2 Anchor bolts for fastening of steel structures shall be set in designed position and grouted along with foundations. Alternatively anchor bolts should be provided in the concrete foundations with bolt boxes and anchor channels for the purpose of flexibility and grouted after final alignment and levelling of column.

10.16.3 The gaps between the bearing surface of foundation and bottom of the structures to be erected, shall be filled properly by cement grouting. Grouting shall be done after the verification and proper positioning of the structures but before encasing the structures with concrete if specified.

10.16.4 Damaged structural members shall be examined and rectified or replaced as directed.

10.16.5 The erected parts of the structure shall be stable during all the stages of erection; and structural elements to be erected shall be stable and strong to bear erection loads.

10.16.6 Working on the already erected structures is permitted only after they are finally fixed. Erection of structures of each tier high structures shall be executed only after the relevant fastening of lower tier by the permanent or temporary fastening devices as per schedule of execution of work and certified for safety.

10.16.7 The joint and mating surface including the mating planes, strips and filler or spacers shall be cleaned of dust, rust and water.

10.16.8 Erected structural members shall be firmly fastened by bolts and drifts, permanent or provisional tacking crossing bars and so on before the erection crane hook is removed.

10.16.9 The trusses shall be lifted only at nodes. The trusses above 12m span shall not be slinged at the apex as it will develop compression stresses in the bottom tie member. It shall be lifted by slinging at two mid points of rafters, which shall be temporarily braced by a wooden member of suitable section. After the trusses are placed in position ,purlins and wind bracings shall be fixed as soon as possible. The end of truss which faces the prevailing winds shall be fixed with holding down bolts and the other end kept free to move. In case of small truss of span say upto 12 m the free end of the truss shall be laid on steel plate as per design and the holes for holding down bolts shall be made in the form of oblong slot so as to permit the free movement of the truss end. For large spans, the free end of the truss shall be provided with suitable rocker and roller bearing where indicated.

10.16.10 Erection Joints

While erecting, holes to be riveted shall be fitted with temporary bolts and drifts of diameters equal to those of the holes. It is necessary to install drifts for accurate matching of holes. Number of bolts and drifts shall not be less than 40 percent of total number of holes. Forces applied to drifts shall be same as approved for rivets. Number of drifts shall be 10 percent of number of holes.

10.16.11 The number, size and length of tack welds in erection joints bearing erection forces shall be as indicated . For the erection joints which do not bear the erection forces the length of tack welds shall be minimum 10 percent of the designed weld length of the joint.

10.16.12 Welding, riveting and final fastening of permanent bolts shall be done only after the inspection of the structural elements for their positions. Head bolts and nuts shall perfectly be in touch with the surface of structures and washers.

10.16.13 Tolerance Allowed in Erection

10.16.13.1 Building without crane

The maximum tolerance for line and level of steel structure shall be ± 3.00 mm on any part of the structure. The structure shall not be out of plumb more than 5.00 mm on each 10 metre section in height and not more than 8.00 mm per 30 metre section. This tolerance shall apply to all parts of structure unless otherwise specified.

10.16.13.2

Tolerance allowed in erection of steel structure containing cranes shall be as per following table :-

TABLE

Component	Table	Tolerance Allowed
Main Columns and Roof Posts	(a) Shifting of column's axis at foundation level with respect to building line : (i) In longitudinal direction (ii) In lateral direction	 ± 5 mm ± 5 mm
	(b) Deviation of both major column axis from vertical between Foundation and other member connection levels: (i) For a column upto and including 10M height, (ii) For a column greater than 10 M but less than 40 M height	±5.00 mm from true vertical ±5.00 mm from true vertical for any 10M length measured between connection levels but not more than ±8.00 mm for 30 M length
	(c) For adjacent pairs of columns across the width of the building prior to placing of truss.	±5.00 mm on true span
	(d) For any individual column deviation of any bearing or resting level from levels shown on drawings.	± 5.00 mm
	(e) For adjacent pairs of columns either across the width of buildings or longitudinally level difference allowed between bearing or seating level supposed to be at the same level.	± 5.00 mm
Truss	(a) Deviation at centre of span of upper chord member from vertical plane running though centre of bottom chord. (b) Lateral displacement of top chord at centre of span from vertical plane running through centre of supports.	1/500 of the span or 10mm whichever is less. 1/250 of depth on truss of 20mm whichever is less.

STEEL REINFORCEMENT

10.17 Steel Reinforcement for Concrete

Steel reinforcement shall be of mild steel plain bars, high strength deformed bars manufactured by thermo mechanical treatment process (TMT), steel wire fabrics and of grade/ types as indicated.

10.17.1 Mild Steel plain bars shall be of grade I or grade II as indicated and conforming to IS 432 (Part 1)-1982, Specification for mild steel and medium tensile steel bars. Alternatively mild steel bas shall be of grade E 250 conforming to IS 2062.

10.17.2 High strength deformed bars shall be produced by thermo mechanical treatment process (TMT) and shall be of grade Fe 415, Fe500 or Fe 550 as indicated meeting all requirements conforming to IS 1786-1985 Specification for high strength deformed bars and wires for concrete reinforcement.

10.17.3 Fabric reinforcement shall conform to IS 1566-1982, Specification for hard drawn steel wire fabrics for concrete reinforcement. The wire used in manufacture of fabric shall be hard drawn steel wire conforming to IS-432 (Part 2) and suitable for welding.

10.17.4 Tolerance on size of Reinforcement Bars

The tolerance on diameter of the mild steel bars will be ± 0.5 mm for bars upto and including 25 mm dia with a total margin of 1 mm, and ± 0.75 mm for bars above 25mm dia with total margin of 1.5mm. The tolerance on the diameter in the case of coiled round bars shall be ± 0.5mm upto and including 12 mm diameter with a total margin of lmm. Measurement shall be taken at point sufficiently away from the ends ensuring exclusion of heavy ends.

10.17.5 Tolerance on Weight

The tolerance on weight of plain and deformed round shall be ±4 percent with a total margin of 8 percent for bars upto and including 8 mm diameter, and ± 2.5 percent for bars over 8mm diameter with a total margin of 5 percent.

Tolerance on weight of fabric reinforcement shall be ± 6 percent.

10.17.6 Freedom from Defects

All finished bars shall be well and cleanly rolled to the dimensions and weight specified. These shall be sound and free from cracks, surface flaws, laminations and rough, jagged and imperfect edges and other defects and shall be finished in a workmanlike manner.

10.17.7 Steel reinforcement shall be stored as to prevent distortion and corrosion. Any reinforcement that has deteriorated or is considered defective by the EIC shall not be used in the work. Bars of different classification, sizes and lengths shall be stored separately to facilitate use in such sizes and lengths as to minimise wastage in cutting from the standard lengths.

10.18 Bends and Hooks Forming end Anchorages

Ends of plain round mild steel bars shall be bent to radius of not less than 2 diameter and the straight portion beyond the curve shall not be less than 4 diameter unless otherwise indicated. In the case of deformed bars, bends shall be made to radius of 4 times the diameter of the bar and straight portion beyond the curve shall not be less than 4 diameter, unless otherwise indicated. Ends of deformed bars are not bent to form hooks.

10.18.1 In the case of binders, stirrups, links, etc, the straight portion beyond end of the curve at the end shall be not less than 8 times the nominal size of the bar.

10.18.2 Bars specified to be formed to radii exceeding those given in table X of IS 2502-1963, Code of practice for bending and fixing of bars for concreting, need not be bent but the required curvature may be obtained during the placing.

10.18.3 Bending of Bars

Bars shall be bent to shape cold except that bars larger than 25 mm in size may be bent hot at cherry red heat (not exceeding 850^{o} C). Hot bar shall not be cooled by quenching. A bar which shows any sign of cracks at a bend shall be rejected.

10.19 Splicing

Where bars required are longer than those carried in stock, splices shall be provided as far as possible, away from the section of maximum stress and be staggered. Lap splices shall be considered as staggered if the centre to centre distance of the splices is not less than 1.3 times the lap length calculated as described in clause 10.19.2. The use of short length bars shall not be permitted. IS 456-1978, Code of practice for plain and reinforced concrete recommends that splices in flexural members should not be at section where the bending moment is more than 50 percent of the moment of resistance; and not more than half the bars shall be spliced at a section.

10.19.1 Lap Splices

Lap splices shall not be used for bars larger than 36mm dia, larger diameter bars may be welded, in cases where welding is not practicable , lapping of bars larger than 36 mm dia may be permitted in which case additional spirals shall be provided around the lapped bars.

10.19.2 Lap length including anchorage value of hooks for bars in flexural tension shall be not less than development length (calculated as per clause 26.2.1 of IS 456) or 30 diameter whichever is greater and for direct tension shall be not less than two times development length (calculated as per clause 26.2.1 of IS 456) or 30 diameter whichever is greater. Lap length in compression shall be not less than development length in compression (calculated as per clause 26.2.1 of IS 456) or 24 diameter whichever is greater. When bars of two different diameters are to be spliced the lap length shall be calculated on the basis of diameter of the smaller bar. Other provisions of IS 456 shall also be followed.

10.19.3 End bearing splices shall be used only for the bars in compression. The ends of the bars shall be square cut and concentric bearing ensured devices.

10.19.4 When larger diameter bars have to be welded to avoid congestion rather than lapped for splicing, the method of welding shall be as directed. The location of staggered welds at heights or position shall be convenient for welding.

10.19.5 Spiral Reinforcemcnt

Spirals shall be provided with one and a half extra turns at both top and bottom. Where necessary to splice the spiral it shall be done by a lap of one and a half turns or by shop welding.

10.20 Placing and Fixing of Bars

Reinforcement shall be placed in position as per detailed design drawing and shall be secured at that position. In case of delay occuring between fixing of reinforcement and concreting, the position of the reinforcement shall be checked prior to concreting. Bars crossing each other shall be screwed by binding wire (annealed) of size not less than 0.9mm, and conforming to IS 280-2006, Specification for mild steel wire, in such a manner that they will not slip over each other at the time of fixing and connecting. Every compression bar shall be tied at least in two perpendicular directions.

10.20.1Cover Blocks

Cover blocks generally of cement mortar shall be used to ensure the required cover for the reinforcement . The mortar or concrete used for the cover blocks or rings shall be not leaner than the mortar or concrete in which they would be embedded.

10.20.2 Spacers

Where multiple rows of reinforcement are provided distances between successive rows shall be properly maintained while concreting by providing suitable spacer bars.

10.20.3 Placing Reinforcement

All mill scale, loose or scaly rust, oil and grease or any coating that will destroy or reduce bond shall be thoroughly cleaned off the steel reinforcement with a stiff wire brush or other approved means before it is placed in forms. Steel reinforcement when placed in the forms shall be properly braced, supported, or other-wise held firmly in position so that placing and ramming/ vibrating of concrete does not displace it.

10.20.4. It shall be ensured that all reinforcement can be properly placed. Congestion of steel shall be avoided at points where members intersect.

10.20.5 Tolerance in placing of Reinforcement

Unless otherwise indicated, reinforcement shall be placed within following tolerance.

(a) For effective depth 200 mm or less = ± 10mm
(b) For effective depth more than 200 mm = ± 15mm
(c) The cover shall in no case be reduced by more than 1/3 of specified cover or 5mm whichever is less.

10.21 Steel Wire Fabric Reinforcement

Hard drawn steel fabric shall conform to IS 1566-1982, Specification for hard-drawn steel wire fabric for concrete reinforcement, mesh size, weight, size of wire for square and oblong welded wire fabric shall be indicated. The fabric shall be formed by spacing the main and the cross wire, which shall be fixed at the point of inter-section by electric welding. Since fabric is supplied in long rolls it is rarely necessary to have a joint of the main wires. In structural slab laps in regions of maximum stress shall be avoided. When splicing of welded wire fabric is to be carried out, lap splices of wire fabric is to be carried out, lap splices of wires shall be made so that overlap measured between the extreme cross wires shall be not less than the spacing of cross wires plus 10 cm. For edge laps a lap of 5 cm shall be provided.

10.22 Welding of Reinforcement

Welding of bars where indicated or agreed to by the GE, in writing, in lieu of lapping shall be done in accordance with IS-2751-1979. Code of practice for welding of concrete construction. Welding in general shall be done as described for structural steel work.

10.22.1 Bars upto and including 20mm dia shall be lap welded and those larger than 20mm dia shall be butt welded. In case of lap welds, the length of lap shall be five times the dia or 100 mm which is greater. The throat thickness shall not be less than 3mm for bars upto 16mm dia and 5mm for bars over 16mm dia and upto 20mm dia.

10.22.2 Butt Welding

Where it is not possible to rotate bars for welding in flat position the axis of the bars shall be horizontal and the respective axis of welds shall be vertical. The edge preparation for inclined bars shall be such that welding is done only on sides. All the bars to be butt welded shall be aligned and set up in position with their axis in one straight line. This may be done in a jig or by means of a clamp or by using guides. Rotation of the bars shall be avoided, until they are adequately welded.

10.22.3 Lap Welding

Edge preparation is not necessary for lap welds.

10.22.4 Finish

The profile of the welds shall be uniform, slightly convex and free from overlap at the toes of the welds. The weld face shall be uniform in appearance throughout its length. The welded joint shall be free from undercut. The joints in the weld run shall be as smooth as practicable and shall show no pronounced hump or crater in the weld surface. The surface of the weld shall be free from porosity, cavities and trapped slag.

10.23 Steel Rolling Shutters

Steel rolling shutters shall be of approved make and shall conform to the requirement of IS 6248-1979 Specification for metal rolling shutters and rolling grills. The size of the rolling shutters (denoted by clear width and clear height) shall be as indicated. The position of fixing of the rolling shutter shall be as indicated viz inside or outside or within jambs; with projecting or embedded guide channels and above or below the soffits.

10.23.1 Rolling shutters shall be self-coiling type with or without ball bearings or gear operated type with bevel gear box and crank handle or operated by a chain wheel and a hand chain as indicated. These types are :-

(a) Self-Coiling Type Shutters (Push Pull Type or Manual type) are used up to a maximum of about 8 sq.m clear area without ball bearings and up to a clear area of about 12 sq.m with ball bearings.

(b) Gear-Operated Type Shutters (Mechanical Type) shall be fitted with ball bearings. These are used up to a maximum of about 25 sq.m clear area, if operated by a bevel gear box and crank handle and upto a maximum of about 35sq.m clear area, if operated by chain mounted directly on the worm shaft.

10.23.2 Curtain

The curtain shall be built up of inter-locking lath sections formed from cold rolled steel strips 0.9 mm thick for shutters upto 3.5 m width and 1.20 mm thick for shuters 3.5 m and above in width unless otherwise specified. The lath section shall be rolled so as to have interlocking curls at both edges and a deep corrugation at the centre with a bridge depth of not less than 12mm. Each lath section shall be continuous single piece without any welded joint. When interlocked, the lath sections shall have a distance of 75mm between rolling centres, unless otherwise specified. Each alternate lath section shall be fitted with malleable cast iron or mild steel clips securely riveted at either ends.

10.23.3 Lock Plate

A fabricated lock plate of riveted construction made of mild steel sheet of not less than 3.15 mm thickness, reinforced with mild steel angle section of not less than 35x35x5mm size at the bottom, shall be interlocked with bottom most lath section of curtain so as to provide contact against the cill, when closed. The lock plate shall be fitted with sliding bolts with arrangement for locking with pad locks and also pulling handles of mild steel, one handle for widths upto 2.5m, and two handles for widths of above 2.5m. Pulling handle shall be fixed on both the interior and exterior side of the lock plate.

10.23.4 GuideChannels

The guide channels shall be of mild steel deep channel section and of rolled, pressed or built up construction. Thickness of sheet shall not be less than 3.15 mm. The curtain shall project into the guide channel at least 40 mm upto 3.5m width and 60 mm for greater widths. There shall be a clearance of 10mm minimum between the guide wall and the end clips of the curtain. Minimum depth of the guide channels shall be as under:-

Clear width of shutter	Depth of guide Channels
Upto 3.5 m	65mm
3.5 m and upto 8 m	75mm
8 m and above	100mm

Width of guide channel shall be 25mm for the lath section with bridge depth about 12mm and 32 mm for the lath section with bridge depth about 16 mm.

Each guide channel shall be provided unless otherwise specified, with a minimum of three fixing cleats or supports for attachment to the walls or column by means of bolts or screws. The spacing of cleats shall not exceed 0.75 m. Alternatively, the guide channels may also be provided with suitable dowels, hooks or pin for embedding in the walls.

The guide channels shall be attached to the jambs, plumb and true, either in the over-lapping fashion projecting fashion or embedded in grooves, depending on the method of fixing. The guide channels shall have a box welded on at the bottom to conceal the end of the sliding bolt, when fixed on side.

10.23.5 Bracket Plate

It shall be fabricated out of mild steel sheet of 3.15 mm minimum thickness in case of manually operated shutters, and 6mm minimum thickness in case of mechanically operated rolling shutters. The minimum size of bracket plate for different heights of rolling shutters shall be as per IS. The bracket plate may be of hexagonal square or circular contour. In the case of manually operated shutter, extra tying of the bracket plate to the guide channel shall be provided by means of a square bar not less than 20mm size. An angle iron 40x40x6mm split at one end shall be firmly riveted or welded at the top line of the bracket. The angle shall extend at least 20 cm from the edge of the bracket plate. This angle shall be grouted firmly into the wall with the split end of the angle well buried in concrete .

A stopper made out 40x6mm M.S. flat is bolted on to the square bar so that the lock plate may be arrested from going beyond the limit.

10.23.6 Roller

Recommended sizes of pipes for suspension shafts for various width of rolling shutter are as follows :-

Width	Size of Pipe (Nominal bore)
Upto 2m	32 mm
Upto 3m	40 mm
Upto 6m	50 mm

The suspension shaft shall be provided with steel or preferably cast iron pulleys and helical wire spring or flat spiral springs for counter balancing the weight of the shutter adequately. When the width of shutter is greater than 3.5 m the pulleys shall be interconnected with a cage formed out of MS flats of at least 32x6mm and MS dummy ring made of similar flats so that the torque is distributed uniformly. In such cases self aligning two row-ball bearings shall be provided with special cast iron casting at the extreme pulleys at either ends, where indicated. The caging ring shall have a minimum spacing of 15 cm and there shall be at least 4 nos. flats running throughout the length of the roller.

10.23.7 Hood Covers

Hood covers shall be made of mild steel sheet 1.0mm thick. They shall be hexagonal square or circular contour depending on the conotur of the bracket plate. The cover shall be properly stiffened with angle/flat stiffeners at top and bottom edges. The hood covers shall be fixed to the bracket plate.

10.23.8 Gears, Worms etc.

All gears, worms etc, used in the assembly of the rolling shutters shall be machine cut. Worm gear wheel shall be of high grade cast iron or mild steel. The worms shall be of mild steel.

10.23.9 Safety Devices

For width upto 2.5m a properly fabricated and reinforced bottom lock plate shall be provided to give protection. For width above 2.5 m in addition, both anchoring rods and central hasp and staples shall be provided. The pipes for the anchoring rods shall be embedded in the cill so as not to project above the cill surface. Anchoring rods shall be provided at the rate of one per extra 2.5 m width or a part thereof above a clear width of 2.5 m. The hasp shall be grouted on the ground so as to be level with the cill.

10.23.10 Wicket Doors

Where indicated, wicket door of 600 x 1200mm size for ordinary use and 900x1800 mm size for large installations shall be provided in the rolling shutters. The wicket door shall be of robust construction and shall be fitted with a good lever lock operated by key, lockable both from in side and outside. The wicket doors shall be erected in such a way as not to foul with the main rolling shutters when opening or closing. The wicket door shall be swing clear of the opening before the rolling shutter is raised or lowered.

10.23.11 Safety Lever Locks

Where indicated one pair of safety lever locks may be fitted on either ends of the bottom lock plate.

10.23.12 Rolling Grill

In situation where certain amount of ventilation combined with safety is required, for example transformer room, substation etc, the rolling shutter may have a small rolling grill portion either at top or at bottom or at both places as indicated. The height of grill portion shall be maximum of 0.5 m. Rolling grill shall be built of cold rolled steel sheet links of 0.9 mm thickness assembled on tubes or rods. Grill may also be manufactured out of 8 mm dia MS round bars. Design of grill shall be as indicated.

10.24 Collapsible Steel Gates

10.24.1 Collapsible steel gates shall be of approved design and make and top hung. These shall be with single or double leaves as indicated.

10.24.2 Rolled steel channels for vertical supports, flats for crossing, and tee and flats for top and bottom runner shall be mild steel conforming to IS 2062-2006. Roller wheels shall be of grey iron casting generally conforming to grade FG 150 of IS 210-1993 and shall be capable of taking the weight of the gate. Rivets used shall not be less than 6mm and shall be of snap headed type. Other fittings such as folding stoppers, fixing hold fasts, locking cleats, brass handles on both sides and cast iron rollers shall be of approved design and size.

10.24.3 The dimensions and other particulars shall generally be as under, unless otherwise indicated. The dimensions given are normally for a collapsible gate of maximum height of 3m .

(a) MS Channel = Hot rolled medium channel 18x9x3mm.
(b) Flats for crossings = 18x5 mm.
(c) Tee and flats for top and bottom runners with a minimum web of 40x12mm and flange of 40x6mm.
(c) The distance from centre to centre of channel pickets = 10 cm.

10.24.4 The bottom and top runners are fabricated separately with necessary holding fixtures for burying in the ground or fixing in the lintel respectively. The gates shall be provided with locking arrangement so that locking with padlock can be done.

10.24.5 Collapsible gates may be fixed under the lintels or fixed on outside/inside of the wall as indicated. Gates shall be fixed moveable on top and bottom channels with swinging arrangements on either side. Single leaf collapsible gate can be with single panel collapsible at right or left end. Fixing of collapsible gates shall be carried out in a workman like manner, the gate shall open and close smoothly and easily, the bottom runner shall be sunk level with floor. The gate shall be cleaned of all rust and mill scales etc. The wheel shall be fitted with ball bearing for width of opening more than 1.5m.

10.25 Steel Doors, Windows and Ventilators

10.25.1 Steel doors, windows and ventilators shall comply with IS 1038-1983, Specification or steel doors, windows and ventilators; except with regard to sizes, which shall be as indicated; and shall be of approved make. Rolled steel sections for fabrication shall conform to IS 7452-1990.

10.25.2 Fabrication

Both fixed and opening frames shall be constructed of sections mixed at corners. The corners of frames shall be welded to form a solid fused welded joint. All frames shall be square and flat. The process of welding adopted may be flash butt welding or any other suitable method which complies with the requirements listed in the IS. Subdividing bars of the units shall be tenoned and riveted to the frames. Casements shall be fitted to their frames so as to provide continuous contact to weathering on the inside and outside and shall be secured in closed position by the fittings which shall have been properly adjusted. Windows and doors may have holes in the web of bars other than those required during manufacture and fixing. Fixing lugs shall have standard slot of 8mm wide for MS screw of 6 mm dia and 12 mm long with square nuts.

10.25.3 For fixing steel hinges, slots shall be cut in the fixed frame and the hinges inserted inside and welded to the fame. The hinges shall be projecting type and not less than 65mm and not more than 75mm wide. The hinge pin shall be of electro-galvanised steel of suitable thickness. Where indicated, friction hinges shall be provided for side hung windows.

10.25.4 Side hung shutters

The handles for side hung shuters shall be of steel or of hot pressed brass, where indicated and shall be mounted on a steel handle plate. Thickness of handle shall not be less than 3 mm for mild steel and brass. The handle shall have a two point nose which shall engage with a steel/brass striking plate on the fixed frame in a slightly open position as well as in a fast position. The boss of the handle shall incorporate a friction device to prevent the handle from dropping under its own weight and the assembly shall be so designed that the rotation of the handle may not cause it to unscrew from the pin. The strike plate shall be so designed and fixed in such a position in relation that with the latter bearing against its stop, there shall be adequate tight fit between the casement and the outer frames.

10.25.5 In cases where non-friction type hinges are provided, the windows shall be fitted with peg stays which shall be of steel and shall be 300 mm long with steel peg and locking brackets riveted or welded to the fixed fames. Side hung casement fitted with friction hinges shall not be provided with peg stays.

10.25.6 Top Hung Ventilator

Steel butt hinges for top hung ventilators shall be riveted to fixed frame or welded to it after cutting a slot in it. Hinges to the opening frame shall be riveted or welded and cleaned off. Top hung casements shall be provided with a peg stay with three holes which when closed shall be held tightly by the locking bracket. The locking bracket shall either be fitted to the fixed frame or to the window.

10.25.7 Centre Hung Windows and Ventilators

Centre hung windows and ventilators shall be hung on two pairs of brass cup pivots, riveted to the inner and outer frames of the window to permit the window to swing to an angle of approximately 85 degree. The opening portion of the window shall be so balanced that it remains open at any desired angle under normal weather conditions. A brass spring catch shall be fitted in the centre of the top bar of the centre hung window and shall close into a mild steel or malleable iron catch plate. A brass cord pulley wheel in galvanized mild steel or malleable iron bracket shall be fitted at the cill of the window.

10.25.8 Door

Steel hinges unless otherwise indicated, shall be 50 mm projecting type. The hinge pin shall be of electrogalvanised steel. A mortice lock with not less than 4 levers shall be provided in the door where indicated. In the double leaf shutter concealed bolts at the top and bottom shall be of steel.

10.25.9 Weather Bar

Where fixed light occurs over external opening shutter, a push fit weather bar shall be provided.

10.25.10 Position of Holes

Outer frames shall be provided with fixing holes centrally in the web of the section.

10.25.11 Composite Units

Composite units shall consist of two or more units of doors, windows and ventilators jointed together with coupling sections made from MS sheet 1.6m thick and of dimensions given in the IS. Mastic cement shall be applied between the junctions with the coupling sections to make the joints the watertight.

10.25.12 Fixing steel Doors, Windows or Ventilators

Steel doors, windows or ventilators shall be fixed into prepared opening. They shall not be built-in as the walls go up. In case of brick work holes for fixing the lugs or holdfasts shall be cut 5 cm square and 5 cm to 10 cm deep, unless it is possible to put slotted lugs into joints. In the case of concrete or stone masonry, fixing lugs are recommended to be embedded in the masonry during construction at the appropriate places. Steel door, window and ventilator units shall be checked to ensure that they are square and working satisfactorily. The unit shall then be set in its opening by using wooden wedges at jambs, head and cill and shall be plumbed. The frame shall be squared and true and free from any warp and twist. The unit shall be put in position and the lugs screwed on tight. Every hole in the frame need not be fixed with a lug: some holes are incidental to manufacture and are not necessarily fixing holes. Lugs shall be placed in the specified position and then grouted into their holes with cement sand mortar 1:3; wedges round the frame shall be left in position until this cement has hardened and the lugs firmly set in. The gap between unit and surround shall then be filled with cement mortar 1:3. When fixing to flush surround without rendering, the 3 mm clearance round the frame shall be pointed with cement mortar 1:3. The plaster shall be applied to surrounds after the lugs have firmly set talking care to keep plaster clear of hinges and not to bring it too close to the opening frame of casement. Before applying the rendering, the joint of unit and mortar shall be pointed from the outside. Other details of fixing and the fixing procedure for composite doors, windows and ventilators shall generally be as described in IS 1081-1960, Code of practice for fixing and glazing of metal (steel & aluminum) doors, windows and ventilators.

10.26 Steel windows for industrials Buildings

Steel windows for industrial buildings shall confirm to IS: 1361-1978 Specification for steel windows for industrial buildings except with regard to size of opening which shall be as indicated, and shall be of approved make. Rolled steel sections shall conform to IS 7452-1990.

10.26.1 Fabrication

Corners of fixed and opening frames shall be welded to form solid fused welded joints. The process of welding adopted may be flash butt welding or any other suitable method which complies with the requirements listed in the IS. All frames shall be square and flat. Tee sections for glazing shall be tenoned and riveted to the frames and where they intersect the vertical tie shall be broached and the horizontal tee threaded through it, and the intersection closed by hydraulic pressure.

10.26.2 Centre-hung ventilators shall be mounted on a pair of brass cup pivots consisting of an inner and an outer cup, permitting the swinging of the ventilator through an angle of at least 85 degree and so balanced that the ventilator shall be capable of remaining open in any desired position under normal weather conditions.

10.26.3 Centre-hung ventilators shall be provided with a pulley (consisting of a brass pulley-wheel in a mild steel or malleable iron bracket) in the centre of the bottom section of the ventilator, and attached with steel screws. They shall also be provided with a mild steel or malleable iron cord-eye riveted or welded to the bottom inner frames section of the ventilator in a position corresponding to that of the pulley.

10.26.4 Centre-hung and bottom-hung ventilators shall have a bronze (gun metal) spring catch in the centre of the top section of the ventilator suitable for operation by hand or pole (and by cord in the case of centre hung ventilators). This spring catch which shall be screwed to the frame with brass screws, shall close a mild steel or malleable iron catch plate riveted or welded to the outside of the outer ventilator frame section.

10.26.5 Bottom-hung and top hung ventilators shall be hung on strong hinges made of steel or malleable iron.

10.26.6 Bottom-hung ventilators shall be provided with pair of standardized steel or malleable iron folding side arms to limit the opening of the ventilators. When the ventilators is closed, these side arms shall be invisible.

10.26.7 Top hung ventilators shall be provided with a 30 cm peg stay of steel mounted on a jaw bracket of mild steel lugs malleable iron, welded or riveted to the bottom inner ventilator section and locking into a locking bracket of similar material welded or riveted to the bottom outer inner or other ventilator section and with a standardized steel peg welded or riveted to the bottom outer ventilator section.

10.26.8 Outer frames shall be provided with fixing fittings for the fixing holes. These maybe slotted reversible lugs (hold fasts) complete with countersunk steel nuts and bolts for fixing to brickwork; with wood screws for fixing to wood plugged concrete or stone; steel screws, or mild steel clips with steel nuts and bolts for fixing to steel.

10.26.9 For coupling window frames with members specified to form composite windows, countersunk steel and cone-nuts, of suitable length and in the quantities specified for fixing, shall be provided.

10.26.10 Composite windows shall be dispatched unassembled, but complete with necessary coupling components. In composite windows each coupling member will increase the overall height or width by 20 mm, maximum which includes manufacturing tolerances.

10.27 Pressed Steel Frames for Wooden Doors/Window Shutters

10.27.1 Steel frames for wooden shutters shall be pressed out of cold rolled mild steel sheets of 1.25 mm or 1.60 mm thickness as indicated and shall comply with requirements of IS 4351-2003, Specifications for steel door frames. Cold rolled mild steel sheet shall conform to IS 513. The size, type (profile) and dimensions of the frames shall be as indicated. Tolerance in the size of frames shall not vary by more than ± 2 mm. The tolerance over the profile size shall be ± 1 mm. Steel frames shall be of approved make.

10.27.2 Frames shall be either painted with two coats of ready mixed paint or power coated (conforming to IS 13871) as indicated.

10.27.3 Frames shall be filled with PCC 1:3:6.

10.28 Tee or Angles iron Door, Window and Ventilators Frames

Tee or angles iron frames shall be made from mild steel tee or angle sections of the size as indicated. Steel shall be of grade E-165 confirming to IS- 2062-2006. The frame shall be fabricated in sections which have been cut and mitered. The corners of the frames shall be butt welded to form a true right angle. All frames shall be square and flat. Requisite number of holes shall be made in the frames for fixing of fittings. Nuts shall be welded to the frame. Frames shall be fixed in the masonry opening with lugs or any other arrangements as indicated.

10.29 Steel Sheeting, Plain and corrugated

Galvanized steel sheet, plain or corrugated shall comply with the requirement of IS 277-2003, Specification for galvanised steel sheets, plain or corrugated. The grade of galvanizing shall be as indicated. Sheets are galvanized as under:-

Grade of coating	Minimum average mass of coating (Total both sides) (Triple spot test) gm/m2
600	600
450	450
350	350
275	275
220	220
200	200
180	180
120	120

10.29.1 The following are recommended grades of zinc coating for the various thickness of sheets:-

Thickness	Grade of coating
0.18 to 0.28mm (both inclusive)	200
0.30 to 0.55mm (both inclusive)	220
0.63 to 1.0mm (both inclusive)	275
Above 1.0 mm	350

Note:- The recommended thickness for roofing application in IS is 0.63 mm and corresponding recommended grade of coating is minimum 275 gm/m2.

10.29.2 Plain sheets shall be reasonably flat and free from twist. Corrugated shall be free from twist or buckle and shall have uniform corrugation, true in depth and pitch, and parallel to the sides of the sheets. The tolerance on weight of an individual sheet shall be ±10% and tolerance on bundle of sheet shall be ± 5%.

10.30 Steel Sheet Pipes

Gutters, pipes, fittings and accessories shall be made with welted or welded seams as indicated; sound and mechanically strong throughout their length. The pipes fitting etc. shall be true, smooth and circular in cross section. The ends shall be smoothly finished, free from burrs and sharp edges and shall be square to their respective axis. At one end of each pipe, bend or elbow, a spigot shall be formed by means of a 6 mm dia swage 40 mm from the end. The spigot end shall be slightly tapered to fit tightly into the non-spigot end of pipe. Pipes, bends, elbows etc. upto 100mm dia shall be of sheeting one mm thick, those exc. 100 mm dia and n exc 200 mm dia shall be 1.25 mm thick and those exc 200 mm dia shall be 1.60 mm in thickness.

10.30.1 Gutters, trough and similar work shall be cut of one piece in the cross section. Joints in the length shall be watertight and made by telescoping one piece into the other for 15 cm and securing with solder, red lead cement or bitumen mastic compound. Gutter bolts 6 mm dia shall be provided in addition, as directed.

10.31 Mild Steel Wire

Mild steel wire for fencing, mattresses shaped nets, etc. shall be galvanized and shall confirm to IS 280-2006, Specification for mild steel wire for general engineering, purpose. All finished steel wire shall be well and cleanly drawn. Wires shall be sound and free from splits, surface flaws, rough jagged and imperfect edges and other harmful surface defects. Zinc coating shall be smooth, even and bright. Galvanised coating of steel wire shall conform to the requirements as laid down for medium coated wire in IS 4826, hot dipped galvanized coatings on round steel wires or IS 12753, electrogalvanised coatings on round steel wires. Fixing arrangement be as directed.

10.32 Barbed Wire

Galvanised steel barbed wire for fencing shall confirm to IS 278-2001, Specification for galvanized steel barded wire for fencing. The galvanized barbed wire shall be manufactured from galvanized mild steel wire conforming to IS 280-2006, Galvanised coating of steel wire shall conform to the requirements as laid down for medium coated wire in IS 4826, Hot dipped galvanized coatings on round steel wires. The barbed wire shall consist of two line wire 2.24 mm nominal dia, one or both containing 2 mm dia barbs at 75 mm centre to centre and weighing 97 to 106 Kg per Km. The barbs shall have a length of not less than 13 mm and not more than 18 mm. The points shall be sharp. The line and point wires shall be circular in section, free from scales and other defects and shall be uniformly galvanized. The line wire shall be in continuous lengths and shall not contain any welds other than those in the rod before it is drawn.

10.32.1 Barbed wire shall be stretched and fixed in specified number of rows and diagonals. The diagonals wires will be interwoven with horizontal wires by fixing the old rows of wires, then the diagonal cross wires and lastly the even rows of wires. The barbed wires shall be held to the RCC posts by means of GI staples fixed to wooden plugs or GI binding wire tied to 6 mm bar nibs fixed while casting the posts. The barbed wire shall be fastended to the ballies/timber posts by means of GI staples, driven into the post. Turn buckles and straining bolts shall be used at the end posts where indicated.

10.33 Welded Steel Wire Fabric

Wire fabric for general use such as fencing, window grills etc, shall conform to IS: 4948-2002, Specification for welded steel wire fabric for general use. Welded wire fabric shall be made of mild or stainless steel wires as indicated. Mild steel wire shall conform to IS 280 and stainless steel wire shall conform to grade X 04 Cr 17 Ni 12 Mo 2 or X 04 Cr 18 Ni 10 of IS 6528. Mild steel wire shall have anti corrosive treatment such as pickling followed by painting, phosphating and painting, hot dip galvanizing where indicated. The longitudinal and transverse wire shall be securely connected at every intersection by process of welding. Wire fabric shall be rust proof and free from injurious defects. The mesh size and the size of wires shall be as indicated. Steel wire fabric in each panel shall be in one whole piece. Wire fabric shall be fixed with wooden beads or MS flats as indicated.

10.33.1 The welded steel wire fabric in fencing shall be stretched, fixed to the posts by means of GI staples fixed to wooden plugs or GI Binding wire tied to 6 mm bar nibs, fixed while casting the posts 25 cm apart or as indicated.

10.34 Chain Link Fence

Chain link fence shall be made of galvanized wire and shall conform to IS:2712-2003, Specification for galvanized steel wire chain link fence fabric. The mesh wire and line wire of the fabric shall be manufactured from galvanized steel wire conforming to IS 280:2006 having zinc coating of type heavy as laid down in IS 4826, Hot dipped galvanized coatings on round steel wires or IS 12753, Electrogalvanised coatings on round steel wires. Tensile strength of wires shall be within 400 to 500 MPa. Dia of wire and the length of side of the mesh of chain link fence and the dia of line wire shall be as indicated. The wires shall be free from scale, irregularities, imperfections, flaws, sand splits and other defects. Zinc coating shall be smooth, even and bright. Chain link in fencing shall be fixed to the fencing posts as indicated or directed.

10.35 Fan Clamps

Circular cast iron box ceiling fan clamps shall be fixed during the laying of RCC slabs. The sizes of the box shall be 10 cm overall dia. 75 mm height, with rim thickness of 5 mm. Bottom and top lid shall be 1.5mm thick mild steel sheet with its top surface hacked for proper bonding with the concrete. Lid shall be screwed to the box. Fan clamps shall be made of 12 mm dia mild bar bent to shape with its ends bent as directed.

10.36 Expanded Metal Steels

Expanded metal sheets shall conform to IS: 412-1975, Specification for expanded metal steel sheets for general purposes and shall be free from flaws, joints, welds broken stands, laminations and other harmful surface defects. The size of diamond mesh of expanded metal dimensions of strands and weight shall be as indicated. Expanded metal in panels shall be in one whole piece in each panel as far as stock size permits and shall be fixed as directed.

10.37 Anodised Aluminium Doors, Windows, Ventilators, Partitions, Composite units etc.

(a) Sizes and types of aluminium sections given in IS 1948-1961 are rarely available in market, therefore sections manufactured by reputed firms shall be used for fabrication as indicated. Chemical and mechanical properties of sections shall comply with requirements given in IS 733-1983, Specification for wrought aluminium and aluminium alloys bars, rods and sections, IS 737-1986, Specification for wrought aluminium and aluminium alloys sheet and strip for general engineering purposes and IS 1285-2002, Specification for wrought aluminium and aluminium alloys extruded round tube and hollow sections for general engineering purposes.

(b) Aluminium sections and fittings shall be anodized and minimum average thickness of anodizing (coating of anodizing) on all aluminum section and fitting shall be 15 micron and shall conform to IS: 1868- 1996, Testing of anodizing coating shall be in accordance with IS:5523-1983

(c) Joining of sections, providing fittings, lugs, method of fixing etc shall be as per IS 1948-1961.

(d) Aluminium Doors, Windows, Ventilators, Partitions, Composite units etc. shall have matt, scratch-brush or polished finish as indicated.

(e) Glazing:- Glass panes shall be as indicated. Unless otherwise indicated, fixing of glass panes shall be done with aluminium beading with CP brass or stainless steel screws spaced not more than 10 cm from each corner and intermediate not more than 20 cm apart. When glass panes are fixed with aluminium beading having mitred joints, epoxy resin or silicon sealant shall be applied between glass panes and sash bars and also between glass panes and beading. Aluminium beading shall also be from firm of sections used for fabrication of aluminium Doors, Windows, Ventilators, Partitions, Composite units etc. Joints shall be filled with PVC/neoprene felt, cleats etc as indicated.

(f) Paneling:- Panels shall be of decorative plywood, prelaminated particle board, aluminium etc as indicated. The panels shall be cut to correct size with minimum 12 mm portion being inserted in the frame and shall be fixed firmly with CP brass or stainless steel screws. The joints between panels and members shall be sealed with epoxy resin or silicon sealant. Joints shall be filled with PVC/neoprene felt, cleats etc as indicated.

(g) PVC protected sheeting shall be used while fixing the frame of doors, windows, ventilators etc to avoid damages, scratches etc.

10.38 Anodised Aluminium Frame Work (snap grid) for false ceiling Work

10.38.1

(a) Materials:-

(i) Aluminium sections incorporated in frame work shall conform to IS 733, IS 737 and IS 1285.

(ii) The snap grid consist of anodized aluminium main/cross tee of size as indicated.

(b) Workmanship:-

(i) Snap grid frame work shall be fixed to ceiling with supporting hanger consisting of 6mm dia mild steel rod, J bolts with necessary bolts, nuts and washers all as manufacturer's instruction.

(ii) The main and cross tees shall be jointed at junction/crossings with anodized aluminium angle bracket of size as indicated, if not indicated it shall be 15mmxl5mmx1.5mm, weighing 0.12 Kg per running metre, fixed with sutiable mild steel, bolts nuts and washers, all as per manufacturer's instructions.

(iii) The snap grid (main/cross tee section) shall be supported at ends all along the wall with anodized aluminium angle of size as indicated, if not indicated it shall be 40mmx25mmx2mm, weighing 0.36 Kg per running metre.

(iv) Size of the snap grid shall be as indicated.

(v) PVC protected sheeting shall be used to avoid scratches, damage to the framework while fixing to ceiling.

10.39 Pre engineered steel Building structure (PEB structure)

10.39.1 Structural Members

10.39.1.1 Frame: Primary (Build-up) sections shall be fabricated from hot rolled steel plates conforming to ASTM A 572M Grade 50 or equivalent with minimum yield strength of 345 MPa. Flanges shall be welded to the web by a continuous single side fillet weld deposited by an automatic submerged arc welding process. The Built up frame shall be shot blast & primed with one coat of primer paint applied as per Section - 17: Painting.

OR

10.39.1.2 Hot rolled sections shall confirm to ASTM A36 M Grade 36 or equivalent with minimum yield strength of 250 MPa where indicated.

10.39.1.3 Galvanized secondary members shall be cold-formed from steel coils conforming to ASTM A 653M Grade 65 or equivalent, with zinc coating to Z275 designation (275 g/m^2) on both surfaces & having a minimum yield strength of 450MPa.

10.39.2 Roofing panel

Monolithic roofing system shall be factory pre-punched profiled sheet of nominal 600mm effective cover width with two major corrugations, 50 mm high (80 mm including seam). The flat of the panel shall contain cross flutes 430 mm on the pan centre perpendicular to the major corrugations over the entire length of the panel. The feed materials shall be manufactured from 0.60 mm Base Metal thickness (BMT), min. 345 MPa yield strength coated with hot dip metallic Aluminium / Zinc alloy coating, Zincalume as 150 gms/sqm total on both sides of Aluminium (55%) & Zinc (43.50%) & Silicon (1.50%) conforming to ASTM792M or AS1397. The steel manufacturer's test certificate for the chemical and mechanical properties of steel shall be submitted for approval by the Engineer-in-Charge prior to installation. The sheet shall have brand marking of the manufacturer on the back of the sheet at every 1mc/c for conforming genuinity of the material. Specially designed roof clips shall be used to hold roof panels to the supporting sturctural member. The clip is designed to move freely in both directions to take care of thermal expansion and contraction. The supporting structural member (galvanized purlins) shall be factory pre-punched as per design requirements. Panel side laps shall be field-seamed by roof runner seaming machine which is self-propelled and portable electrical lock-seaming machine. The machine field forms the final 180 degrees of a 360 degree double - lock standing seam, all side lap sealant shall be factory applied butyl rubber hot metal sealant. The insulation shall be vinyl membrane supported fiberglass blanket of thickness 50 mm with density 12kg/m^3 (or as per design requirement) shall be approved by GE. The panel end lap shall be joined by mean of a two piece clamped connection consisting of a bottom reinforcing plate and top panel strap. Manufacturers recommended specially designed ridge capping, flashing, trims, gutter and down pipe shall be used for fixing roof system which shall be approved by Engineer-in-Charge. Scrubolt type fastener shall be used for fixing roof system as per manufacturer's recommendation.

10.39.3 Wall Panels

Panels shall be roll formed from nominal 0.45mm base metal thickness of minimum yield strength of 550 MPa, coated with an aluminum / zinc alloy (i.e. Zincalume Steel), (min 150 gm/m^2 total on both side), conforming to Australian standard AS1397, pre-painted with Colorbond steel quality paint. The paint finish thickness shall have a total coating thickness of nominal 35 μm, comprising of nominal 20 μm on exterior face and nominal 5 μm reverse coat on interior face over nominal 5 μm epoxy primer coat on both surfaces of approved colour shade by GE. The steel manufacturer's test certificate for the chemical and mechanical properties of steel shall be submitted for approved by the Engineer -in -Charge prior to installaton. The sheet shall have brand marking of the manufacturer giving product details on the back of the sheet at every 1 meter c/c for conforming genuinity of the material.

10.39.4 Profile dimensions

Trapezoidal type profile sheet shall have 1015 mm effective cover width, nominal 28mm deep ribs with subtle squae fluting in the five pans at nominal 203mm centre to centre. The end rib shall be designed for anti-capillary action, to avoid any seepage of water through the lateral overlap.

OR

shall be of Rib profile of 900 mm effective cover width, min 35 mm deep ribs at pitch of min. 300 mm centre to centre distance with two stiffeners between ribs where indicated.

10.39.5 Trims & Gutters

Wall flashing and trims (gable, corner, framed opening, accessories, etc.) shall be manufactured from same color, finish and thickness as wall panels. Roof flashing and trims (parapet flashing, transition trims, expansion joint trims and ridge caps) shall be manufactured from same color, finish and thickness as roof panels. Eave gutters and downspouts shall be cold formed from same material as wall panels. Water resistant louvers shall be manufactured from high strength ZINCALUME steel or COLORBOND steel.

10.39.6 Protection accessories

Protection net shall be provided as per manufacturer's recommendation :

Note : The contractor shall prepare the shop drawings based on the drawings supplied by the GE. These shall be submitted in five sets sufficiently in advance for approval of Garrison Engineer.

10.39.7 Accessories

(a) **Anchor bolts** shall be manufactured from rods conforming to ASTM A 36M Grade 36 or equivalent with minimum yield strength of 240 MPa and an ultimate strength of 400 MPa.

(b) **Bracing rods**, used in sidewalls of buildings supporting cranes shall be solid plain round steel bars conforming to ASTM A36M or equivalent with minimum yield strength of 240 MPa.

(c) **Flange braces** used to stabilize the inner flanges of main frame columns and rafters shall be 50mm x 50mm x 4mm steel angles conforming to ASTM A 36M (or equivalent) with minimum yield strength of 240 MPa.

(d) **Roof Fixing Clip**: Specially designed roof clips shall be used to hold roof panels to the supporting structure member. The clip shall be design to move freely in both direction to take care of thermal expansion and contraction. The supporting structural member (Galvanized Purlin) shall be factory pre-punched as per design requirements.

(e) **Panel Endlap**: The panel lap shall be joined by means of a two-piece clamped connection consisting of a bottom reinforcing plate and a top panel strap as per manufacturers recommendations and approved by concern authority. All other special accessories shall also be factory fabricated including flashing, ridge cap, gutter, downpipe or any other covering shall be as per manufacturer’s recommendations.

(f) **Sealant**: Special grade of silicon non-hardening, neutral cure type of approved make and grade shall be applied at all side laps and endlaps (with flowable mastick) as per manufacturer’s recommendation and approval by Engineer-in-Charge.

(g) **Bead mastic** shall be an extruded elastomeric butyl rubber based sealant supplied in rolls on silicon release paper conforming to Federal Specification TT-C-1796 A Type II Class B (or equivalent)

(h) **Flowable mastic** (caulking sealant) shall be a neutral cure silicone rubber sealant that is chemically inert and non corrosive, UV resistant and suitable for exterior applications against weathering and rainwater. When cured it is non-toxic and shall be able to accommodate high thermal and shrinkage changes in structural movement joints.

(i) **Foam closures** shall match the panel profile. They shall be made of expanded polyurethane or similar material.

(j) **Fasteners**: The panel clip shall be fastened to structural members with Scrubolt fastener as per manufacturer's recommendation. The size of the fastener shall be as per the manufacturers' recommendation and as approved by GE.

(k) **Insulation**: The insulation shall be vinyl membrane supported fiberglass blanket of thickness 50 mm with density min 12 kg/m^3 (or as per design requirement) shall be approved by concern authority.

10.39.8 Erection and Fixing:

Note: the erection and fixing has to be done through approved steel Builder of Manufacturer of PEB structure.

(a) The installation shall be done in, accordance with the standard practices as specified by the manufacturer and as approved by the Engineer-in-Charge. All sheets and accessories must be stored and finally erected without any damage

(b) The contractor shall be required to submit design calculation in support of the proposed profile of the sheet and standard loading etc. to the satisfaction of Accepting Officer The contractor shall also submit methodology for fixing and also a maintenance manual for routine maintenance.

(c) Special flashing, ridge capping and trims shall be fixed as per manufacturer's recommendation. The shape and girths shall be as per design requirement and shall be as approved by the Engineer-in-Charge.

(d) Panel clips shall be positioned by matching the hole in the clip with the factory-punched holes in the secondary structural members.

(e) Panel shall be positioned and properly aligned by matching the factory punched holes in the panel end with the factory punched holes in the eave structural member and by aligning the panel with the panel clip

(f) Panel sidelap shall be field-seamed by a self-propelled and portable electrical lock-seaming machine. The machine field forms the final 180 degrees of a 360 degree double-lock standing seam; all side lap sealant shall be factory applied.

(g) Panel endlap, when required, shall be at least 150mm sealed with neutral-cure sealant and fastened together by clamping plates. Sealant shall contain hard nylon beads which prevent it from flowing out due to clamping actions. The panel lap shall be joined by means of a two-piece clamped connection consisting of a bottom reinforcing plate and a top panel strap. The panel endlap shall be located directly over, but not fastened to, a supporting secondary roof structural member and be staggered, so as to avoid a four panel lap splice condition.

(h) The contractor shall ensure that panel erector is familiarized with the erection procedure and all the supporting members are straight, level and true (according to AISC) before starting panel erection. Panels shall be erected according to approved shop drawings.

10.39.9 Skylight Translucent sheeting

The panel shall be nominal 1.5 mm thick, composed of a translucent, thermosetting polyester resin with a thoroughly impregnated glass fiber reinforcing mat with or without an integrally bonded translucent film on the weathering face. The profile should match for fixing the translucent sheeting. The profile and properties shall be approved by Engineer-in-Charge before installation.

SECTION 11
ROOF COVERING & WATER PROOFING TO ROOFS

11.1 Indian Standards

The following IS apply to this section:

I.S. No.	*Subject*
73-2006	Specification for paving bitumen (Second revision).
459-1992	Specification for unreinforced corrugated and semi-corrugated asbestos cement sheets (Third revision)
654-1972	Specification for clay roofing tiles, Mangalore pattern (Third revision).
702-1988	Specification for industrial bitumen (Second revision).
723-1972	Specification for steel countersunk head wire nails (First revision).
730-1978	Specification for Hook-bolts for corrugated sheet roofing (Second revision).
737-1986	Specification for wrought aluminium and aluminium alloy sheet and strip for general engineering purposes (Third revision).
1120-1975	Specification for coach screw (First revision).
1230-1979	Specification for cast iron rain water pipes and fittings (Second revision).
1254-1975	Specification for corrugated aluminium sheet (Third revision)
1322-1993	Specification for bitumen felts for water -proofing and damp proofing (Fourth revision).
1464-1992	Specification for clay ridge and ceiling tiles (Second revision).
1626(Part 1)-1994	Asbestos cement building pipes and pipe fittings (Second revision).
1626(Part 2)-1994	Asbestos cement gutters and gutter fittings (Second revision).
1626(Part 3)-1994	Asbestos cement roofing fittings (Second revision).
2645-2003	Specification for integral cement water proofing compound. (Second revision)
2690 (Part-2)-1992	Specification for burnt clay flat terracing tiles, Part II, Hand made (First revision).
3384-1986	Specification for bitumen primer for use in water proofing and damp proofing (First revision).
7193-1994	Specification for Glass Fibre base Bitumen felts (First Revision)
12432(Part 3)	Application for spray applied insulator - Code of safety Part 3 Polyurethane/ Polyisocyamurate.
12866-1989	Specification for plastic translucent sheets made from thormosetting polyster resin (glass fibre reinforced)
13205-1991	Code of practice for the application of Polyurethane insulation by the situ pouring method.
13592-1992	Specification for UPVC pipes for soil and waste discharge systems including ventilation and rain water system.

MATERIALS

11.2 Plain and Corrugated Steel Sheets
Refer Section 10- Steel and Iron Work.

11.2.1 Corrugated Aluminium Sheets
Aluminium corrugated sheets shall be made in alloy and temper confirming to alloy No. 31000-H4.40800 H4 or 51300 H4 as indicated and specified in IS-737-1986. Specification for wrought aluminium and aluminium alloy, sheet the profile shall be general purpose sheet or industrial sheet as indicated. The profile shall confirm to IS-1254-1975. Specification for corrugated aluminum sheets, and strip. The corrugation shall be uniform and parallel to the side of the sheet. The type of finish shall be as indicated. Ridge covering shall be of plain sheet of same quality as that of corrugated sheet.

11.2.2 Corrugated and Semi-corrugated Asbestos Cement Sheets
AC sheets shall comply with IS 459-1992; Specification for unreinforced corrugated and semi-corrugated asbestos cement sheet and shall not be pigmented . AC sheets shall have a rectangular shape, smooth surface on the exposed side, a good appearance and shall be free from visible defects. The corrugations shall be true and regular. The edges of the sheets shall be straight and clean. Ridge covering and other AC accessories shall be of the same quality as of the sheets.

11.3 Galvalume Sheet Roofing
Galvalume sheet shall be 0.50mm thick (total coated thickness), 550 Mpa minimum, yield strength. It shall be coated with hot dip alloy of 55% Aluminium 43.5% Zinc 1.5% Silicon and finished with resin coat on both surfaces @ 150 gm/sqm of coating (total both surfaces) having overall width and laid width as specified and shall be fixed using hot dip galvanized, self drilling and self tapping screws neoprene and EPDM washers. Penetrations and laps in sheet shall be sealed by using proper sealant profile. HDPE fillers shall be provided wherever required to close voids between sheets, sheet & fasteners etc.

11.3.1 Fixing system shall be as per manufacturers instructions and shall be safe against effects of Wind velocity.

11.3.2 Galvalume Sheet Wall Cladding
Galvalume Sheet for wall cladding shall be same as for roof and shall be fixed with 8mm and 30mm deep trapezoidal profile sheeting fixed with self trapping fasteners.

11.3.3 Roofing Accessories
Roofing accessories ie. Corner piece apron, eaves/valley gutters, hoopers, ridges, sheet floor connectors etc shall be of galvalume sheet and of size shape as specified.

11.4 Fasteners for Steel Sheet, Aluminium Sheets and Asbestos Cement Sheets
L-types and J-type hook bolts and nuts, mushroom head roofing bolts and nuts, and bituminous felt and steel washers shall conform to IS 730-1978. Specification for Hook-bolts for corrugated sheet roofing. Steel bolts, nuts and washers shall be galvanised. However washers for aluminium sheet shall be of plain aluminium sheet of same quality as that of corrugated sheet.

11.4.1 Coach screws shall conform to IS 1120-1975, Specification for mild steel square or hexagon head coach screws with gimlet points.

11.5 Mangalore Pattern Roofing Tiles

The tiles shall conform to the requirements of IS 654-1972; Specification for clay roofing tiles, Mangalore pattern. Roofing tiles shall be of class 'AA'. These shall be made from suitable soil of even texture and shall be well burnt. They shall be free from irregularities such as twists, bend, cracks and laminations. The tiles shall be free from impurities like particles of stone, lime or other foreign material visible to the naked eye either on the surface or on the fractured face of the tile, obtained by breaking the tile. However occasional particles upto 2mm in size may be permissible.

11.5.1 When struck, the tile shall give a characteristic ringing sound and when broken the fracture shall be clean and sharp at the edges.

11.5.2 Tiles shall be of uniform colour. When the tiles are placed on either face on a plane surface, the gap at the corners shall be not more than 6mm. The minimum overlap shall be 60 mm lengthwise and 25 mm widthwise.

11.6 Ridge and Ceiling Tiles

Ridge and ceiling tiles for use with Mangalore Pattern roofing tiles shall conform to IS 1464-1992, Specification for Clay ridge and ceiling tiles. These shall be of class 'AA' quality and shall comply with physical requirements as described for roofing tile- Mangalore Pattern.

11.6.1 Ceiling tiles shall be double lug type and the length of lug shall not be more than 20 cm. Thickness of ceiling tiles shall not be less than 10mm throughout excluding ornamentals etc. Ceiling tiles shall be of length to suit, the gauge of battens used for roofing tiles and shall have an ornamental pattern on the underside when exposed to view.

11.6.2 When a ridge tile is placed on horizontal plane, the triangle formed in elevation by producing the inner faces of the tile shall have a base of 265 mm and height of 100mm with a tolerance of + 5 mm . Thickness of ridge tiles shall be not less than 10mm. The length of ridge tiles shall suit the length of roofing tiles.

11.7 Flat Terracing Tiles

Burnt clay flat terracing tiles shall be hand made conforming to IS 2690 (Part 2)-1992, Specification for burnt clay flat terracing tiles, Part II Hand-made. The size of the tiles shall be as indicated. The tolerance in length, width and thickness of tiles shall be + 3 percent. The terracing tiles shall be made from good soil of even texture and shall be uniformly well burnt. These shall be uniform in shape and sizes and shall be free from irregularities such as finish, bends, cracks and particles of stones.

11.7.1 Tiles shall have minimum compressive strength of 75 Kg/sq cm or as indicated. Water absorption shall not exceed 20 percent by weight. The warpage for tiles shall not exceed in any direction by two percent, unless otherwise indicated.

11.8 Stone Slabs for Roofing

Stone slabs shall be of granite, sand stone including quartzite or lime stone, as indicated. They shall be obtained from approved sources as indicated.

11.8.1 Stone slabs shall be hard, even, sound, durable and of uniform colour and texture and shall be without any soft veins, cracks and flaws. Stone slabs shall be rectangular in shape, not less that 0.2.sq.m. each in area and shall be of uniform thickness. The thickness of slab at every point shall not be less than the nominal thickness specified, subject to a minimum of 30 mm.

11.8.2 The width or length of the slabs shall be uniform to suit the guage of supporting members. The slabs shall be self faced on top and bottom and shall be rough tooled on the edges to atleast 12 mm depth from the underside. Dressed edges shall be true and square. The remaining depth of edges shall be dressed so that the thickness of joint does not exceed 25 mm at any point.

11.9 Soil for Mud Phuska

The soil for mud Phuska shall be free from gravel (of particle size greater than 2 mm),vegetable matter and fine Kankar particles. Other coarse material shall not exceed 25 percent by weight . The soil shall also be free from harmful and efflourescent salts. The plasticity index of the soil shall be between 10 to 15 percent.

Note 1:- Generally soil suitable for brick making is suitable for mud Phuska also.

Note 2:- Soils collected from localities afflicted by white ants may not be suitable.

11.10 Soil for Mud Plaster and Mud Mortar

The soil shall be free from vegetable roots, gravel (of particle size greater than 2mm), and coarse sand. Other coarse material shall not exceed 10 percent by weight. The soil shall also be free from harmful and efflourescent salts. The plasticity index of the soil shall be between 9 and 12 percent.

11.11 Lime Concrete for Terracing

11.11.1 Lime shall be class 'C (fat lime) and shall conform to specification as given in Section 4- Concrete.

11.11.2 Burnt clay Pozzolona shall be from well burnt bricks or clay and shall conform to specification in Section 4 - Concrete.

11.11.3 Brick aggregate shall conform to specification in Section 4- Concrete but the grading shall be as under :-

I.S. Sieve Designation	*Percentage Passing*
25 mm	100
20 mm	90-100
10 mm	25-55
4.75 mm	0-10

11.12 Bitumen, etc. for Waterproofing

11.12.1 Bitumen Primer

Primer shall conform to the requirements of IS 3384-1986, Specification for bitumen primer for use in waterproofing and damp-proofing and shall be made from the same grade of bitumen as used in bonding.

11.12.2 Bonding Material for Waterproofing (felt work)

It shall consist of industrial type bitumen conforming to IS 702-1988, Specification for industrial bitumen, or residual bitumen conforming to IS 73-1992 . Specification for paving bitumen, selected to withstand local conditions of prevailing temperature and gradient of roof surface. Penetration of bitumen shall not exceed 40.

11.12.3 Nails for fixing roofing felts shall be galvanised, 20 mm long and with round extra large head with a diameter of 11 mm and shall conform to IS 723-1972, Specification for steel counter-sunk head wire-nails.

11.13 Bitumen Felts for Water Proofing

Bitumen felts shall be of the types as indicated and shall comply with IS 1322-1993, Specification for bitumen felts for water proofing and damp proofing. The finished material shall be free from visible external defects such as holes, oil patches, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations. Total weight of finished bitumen felts shall not be less than the following :-

Description	*Total weight in dry condition per 10 Sq.m of the finished bitumen felt with mica dusting powder in Kg; Min*
(a) Bitumen felts with fibre-base	
(i) Type 1-Self finished felt (for waterproofing), Grade 1 Conforming to IS - 1322	21.9
(ii) Type 2 -Self finished felt (for waterproofing), Grade 2 Conforming to IS-1322	30.8
(b) Bitumen felts with Hessian base ;	
(i) Type 3-Self finished felt (for waterproofing), Grade 1 Conforming to IS-1322	22.3
(c) Glass Fibre Base Felts	
(i) Glass fibre base bitumen felts Type 2 Grade I conforming to IS 7193-1994	18.0
(ii) Glass fibre base bitumen felts Type 2 Grade II conforming to IS 7193-1994	25.0

11.14 RMP Sheets

Red mud waste and PVC are combined in the ratio of 25% : 75% to form RMP.

Structural/Mechanical/Physical Quality of RMP Sheets

Tensile strength	:	500Kg/cm^2 (minimum)
Charpoy impact strength	:	5.88 Joule/cm^2
Impact strength	:	no failure
Brittleness temp	:	60°
Opacity test value (tested) as per IS : 4985-1981	:	Nil
Elongation at break	:	54.28%
Tensile modulous	:	3100 Kg/cm^2
Flexural strength (at 5% strain)	:	769 Kg/cm^2
Thickness	:	As indicated

11.15 Matting

All matting shall be new, of the best quality used locally, and as per samples kept in the office of GE. All the edges shall be properly bound. Matting shall be of any of the following type as indicated.

(a) Reeds or bamboo (beaten flat), woven closely.
(b) Bamboo strips or flat leaf from leaves of palm.
(c) Khajur, Mazri,etc. and woven closely.
(d) Whole reeds, pattal, sirki,sirkanda bound or laced tightly together with string, reeds or sirki stalks; shall be well seasoned, dried, skinned and generally of uniform size.

11.16 Thatch

Thatch shall be best quality straw of wheat or barley or similar material used locally new, fresh and well selected, so as to be clear and free from thorns, seeds, etc. The poolas or bundles shall be at least 1 m in length and shall be opened out, shaken up lightly and stems of lengths smaller than 85 cm and other small loose stuff shall be removed by rough combing with hand rake. The straw shall then be slightly sprinkled with water, lightly beaten and poolas reformed from clean straight straw before laying on roof.

11.17 Bamboos

Bamboos shall be of mature growth, free from splits, weevil rot, borer holes or other defects. Bamboos of 35 mm girth and over shall be semi solid with fibre content not less than 75 percent of cross sectional area.

11.18 Cast Iron Rain Water Pipes & Fittings.

11.18.1 Cast Iron Pipes

Pipes shall conform to IS : 1230 -1979 Specification for cast iron rain water pipes and fittings. Pipes and fittings shall be true, smooth and cylindrical, their inner and outer surfaces being as nearly as practicable concentric. These shall be sound and uniform castings, free from laps, pin holes or other imperfections and shall be neatly finished and carefully fitted both inside and outside. The ends of pipes shall be reasonably square to their axes.

11.18.1.1 C.I rain water pipes shall be of the dia specified in the description of the item and shall be in full length of 1.8 metre including socket ends of the pipes, unless shorter lengths are required at junctions with fittings. The pipe lengths shall be in each case be with socket. The pipes shall be supplied without ears unless otherwise indicated.

11.18.1.2 The pipes supplied shall be factory painted (with a tar base composition) both inside and outside which shall be smooth and tenacious.

11.18.1.3 Every pipes shall ring clearly when struck all over with a light hand hammer. When shorter pipes are cut from full length they shall be cut with a hacksaw. The sizes, weights, sockets and tolerances of pipes shall be as shown in Table 1.

TABLE-1
DIMENSIONS AND WEIGHT OF C.I RAIN WATER PIPES

Nominal sizes of pipes (Internal diameter in mm) PIPE	*50*	*75*	*100*	*125*	*150*
1. (a) External diameter in mm Tolerance in mm	53 ±3	79 ±3	104 ±3.50	130 ±3.50	156 ±4.00
(b) Thickness in mm Tolerance in mm	3.00 ±1	3.00 ±1	3.00 ±1	3.00 ±1	4.00 ±1
(c) Nominal weight of 1800 mm long pipe without ears in Kg Tolerance in weight Tolerance in length in mm	7.50 (-) 10% ± 13.00	11.00 (-)10% ± 13.00	14.00 (-)10% ± 13.00	20.00 (-)10% ± 13.00	26.00 (-) 10% ± 13.00

Nominal sizes of pipes (Internal diameter in mm)	*50*	*75*	*100*	*125*	*150*
2. SOCKET					
(a) Internal diameter in mm Tolerance in mm	63 ±3.00	89 ±3.00	114 ±3.00	139 ±3.00	167 ±3.00
(b) Thickness in mm Tolerance in mm	4.00 ± 1.00	4.00 ±1.00	4.00 ±1.00	4.00 ±1.00	4.00 ±1.00
(c) Internal depth in mm Tolerance in mm	60 ± 10	65 ± 10	65 ± 10	75 ± 10	75 ± 10

Notes: 1. All dimensions are in mm.
2. Pipes weighing more than the nominal weight may be accepted provided they comply in every other respect with the requirements of this standard.
3. The above table applies only to water pipes fixed on wall face.
4. For pipes and fittings which are to be embedded in masonry, specifications shall correspond with those of pipes for soil, waste and vent pipes.

11.18.2 Fixing and Jointing.

11.18.2.1 Pipes shall be either fixed on face of wall or embedded in masonry, as required in the description of the item.

11.18.2.2 Plain pipes (without ears) shall be secured to the walls at all joints with M.S. holder bat clamps. The clamps shall be made from 1.6 mm thick galvanized M.S Sheet of 30mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semi-circular pieces, hinged with 6mm dia M S bolt on one side and provided with flanged ends on the other side with hole to fit in the screw bolt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long 10 mm diameter M.S bar , riveted to the ring at the center of one semi circular piece. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm in 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20mm nominal size) for which necessary holes shall be made in the wall, so as to facilitate cleaning and painting of pipes.

Note : Where G.I sheet clamps are not provided, M.S sheet clamps of 3mm thick and 20mm wide shall be used for making the clamps.

11.18.2.3 The pipes shall be fixed perfectly vertical or the lines as directed. The spigot of the upper pipe shall be properly fitted in the socket of the lower pipe such that there is a uniform annular space for filling with the jointing material. The annular space between the socket and the spigot shall be filled with a few turns of spun yarn soaked in neat cement slurry. These shall be pressed home by means of caulking tool. More of spun yarn shall be wrapped if necessary and shall be rammed home. The joint shall then be filled with stiff cement mortar 1:2 (1 Cement: 2 fine sand) well pressed with caulking tool and finished smooth at top at an angle of 45 degree sloping up. The joints shall be kept wet for not less than 7 days by tying a piece of gunny bag, four fold, to the pipe and keeping it moist constantly.

11.18.2.4 Where pipes are to be embedded in masonry, these shall be fixed in masonry work as it proceeds. In such cases care shall be taken to keep the pipes absolutely vertical or to the line as directed by the Engineer-in-Charge. The pipe shall have surrounding of 12mm minimum thickness of mortar on every portion of the external surface. The mortar shall be of the same mix as is used in the masonry. The joint shall be caulked with lead as soon as the next length of pipe is placed in position. The open end (socket end) of the pipe shall be kept closed till the next length is fitted and jointed, to prevent any brick bats or concrete or pieces of wood falling in and choking the pipe.

The depth of lead from the lip of socket shall be 25 mm minimum. In case of 100mm dia. 75mm and 50mm pipes, the quantity of lead required per joint shall be 1.00 Kg , 0.66 Kg and 0.50 kg respectively for purpose of reckoning theoretical consumption.

In order to ensure that required quantity of lead is poured in to the joint and to control wastage of lead, at the beginning, three or four samples shall be made and the quantum of lead per joint approved by the Engineer-in-Charge.

The actual consumption of lead should be within + 5% of the approved sample job subject to the provision that a variation of + 20% shall be allowed over the theoretical quantity of lead due to dimensional tolerances allowed as per Indian Standards. This variation includes allowances of wastage also.

11.18.2.5 The spigot end shall butt the shoulder of the socket and leave no gap in between. The annular space between the socket and the spigot will be first well packed in with spun yarn leaving 25mm from the lip of the socket for the lead. The joint shall then be lead caulked.

11.18.3 Cast Iron Fittings for Rain Water Pipes

C.I fittings such as bends of various degrees, heads, offsets of different projections, branches and shoes shall conform to IS : 1230.

Bends shall be of the nearest standard degrees as actually required at site. Heads shall be of the flat or corner type as required. Offsets shall be of the projection as specified. Branches shall be single or double and shall be of the nearest standard degree as actually required. Standard shoes shall be of overall vertical length, 180 mm for 75mm dia., 205mm for 100 mm dia and 275mm for 150 dia sized pipe from top of socket to lowest tip of shoe. Shoes of longer lengths if used shall be in lengths from top of socket to lowest tip of shoe of 300 mm, 375mm, 450 mm or 600 mm, as actually required at site.

11.18.3.1 Dimensions

The fittings shall be of the diameter as specified.

The thickness of the fittings and details of spigots and sockets shall be same as those of the corresponding size of straight pipes. The fittings shall be supplied without ears unless otherwise specifically mentioned. The fittings shall be factory painted with a tar basis composition both inside and outside which shall be smooth and tenacious. Every fittings shall ring clearly when struck all over with a light hard hammer. The fittings shall be of standard size and their individual weights shall conform to the weights given in the Table 2.

TABLE 2
WEIGHT OF C.I RAIN WATER PIPE FITTINGS

S.No	*Description*	*75mm dia (weight in kg)*	*100mm dia (weight in kg)*	*150mm dia (weight in kg)*	*Unit*
1.	Bends (Plain)	3.20	4.50	9.10	Each
2.	Offset (Plain)				
	(a) 55 mm projection	2.70	5.00	8.20	Each

S.No	Description	75mm dia (weight in kg)	100mm dia (weight in kg)	150mm dia (weight in kg)	Unit
	(b) 75 mm projection	3.20	5.50	9.10	Each
	(c) 115mm projection	4.10	5.90	9.50	Each
	(d) 150 mm projection	4.50	6.40	10.40	Each
	(e) 225mm projection	5.00	7.30	11.80	Each
	(f) 300 mm projection	6.00	8.60	12.70	Each
3.	Branches (Plain)				
	Single	5.00	7.30	14.50	Each
	Double	6.80	10.00	19.10	Each
4.	Standard Shoes (Plain)	3.20	4.10	8.60	Each
5.	Longer Shoes (Plain)				
	(a) 300 mm	3.20	5.00	-	Each
	(b) 375 mm	4.10	5.50	-	Each
	(c) 450 mm	5.50	6.40	-	Each
	(d) 600 mm	7.30	8.60	-	Each
6.	Heads	6.40	6.80	11.30	Each
7.	Extras:				
	(a) For ears cast on any fitting short pipes	0.90	0.90	1.35	Each
	(b) For inspection doors fitted or any fitting	1.80	1.80	2.25	Each

Note : 1. The above table applies only to rain water fittings which are part of pipe lines fixed wall face. Permissible tolerance in weight of fittings shall be 5%.

2. For fittings to be used with pipe lines to be embedded in masonry, specifications shall correspond with those of pipe fittings of soil, water and vent pipes.

11.18.3.2 Fixing and jointing shall be as specified in 11.18.2.

11.18.3.3 Finish shall be as specified in 11.18.2.5.

11.19 Asbestos Cement Rain Water Pipes, Gutters, Fittings and Roofing Fittings

These shall comply with IS 1626-1994 (Part I and II) and IS 1626 (Part III) 1994. Part I covers specification for asbestos cement building pipes and pipe fittings, Part II covers for gutters and gutter fittings (spigot and socket type) and Part III covers for roofing fittings. The pipes shall be straight and the ends of pipes, gutters and fittings shall be finished square to their axis. Pipes, gutters and fittings shall be true and smooth; their inner and outer surfaces shall be as nearly as practicable, concentric. They shall be in all respects sound, homogeneous and free from impurities, other imperfections , and visible defects.

11.19.1 Dimensions

A.C rain water pipes shall be of the diameter as specified. The pipes are available in lengths of 0.5m, lm, 1.5m, 2m and 3m excluding the depth of socket. The pipes shall be fixed in lengths of 3 metres as far as possible. The thickness of pipes and tolerances on their thickness shall be as shown in table 3 below.

TABLE 3
THICKNESS OF PIPES AND PIPE FITTINGS AND TOLERANCES ON THICKNESS

Nominal diameter of pipe and pipe fittings in mm	*Thickness of pipe or pipe fittings in mm*	*Tolerances on thickness in mm*
50	6.5	+ 1.0
60	6.5	+ 1.0
80	8.0	+ 1.0
100	8.0	+ 1.0
150	9.5	+ 1.5

11.19.2 Fixing and Jointing

Pipe shall be secured to face of the wall, below all joints by standard holder bat G.I. clamps. The bat clamps shall consist of a cast iron base with a projecting "1" shaped lug, to the web of which the two semi-circular halves of the 1.8 mm thick G.I sheet clamp or 3 mm thick M.S. clamps are bolted. The base of the holder bat clamp shall be screwed on a pair of wooden plugs fixed in the wall with screws of designation No. 18 of slotted counter sunk head wood screws driven through the holes in the base. The screws shall be not less than 75 mm long for 80 mm diameter pipes and 100 mm long for 100 mm dia pipes. The plugs shall be fixed in the wall to a depth of 15 cm, in cement mortar 1:2 (1 cement : 2 fine sand) centrally to the holes. In the case of the bat clamps and with their front face projecting to such a length from the brick face that when the bat clamp is fixed, the outer face of its base shall be 11 x 5 cm wide at face increasing to 16 x 7 cm width at rear and shall be 7 cm deep through out. The bat clamps shall be well galvanized.

11.19.2.1 The spigot of the upper pipe shall be properly fitted into the socket of the lower pipe, such that there is uniform, annular space for filling with the jointing material. One-third depth of this annular space between socket and spigot shall be filled in with spun yarn soaked in bitumen such as cut back bitumen of approved quality and properly pressed with caulking tool. The remaining 2/3rd depth of the depth of the joint shall be filled in with stiff cement mortar 1:2: (1Cement : 2 coarse sand) and shall be pressed with caulking tool and finished smooth at top at an angle of 45 degree slopping up. This will be cured for a period of 7 days by tieing a piece of gunny bag, four fold, to the pipes and keeping it wet.

11.19.2.2 The finished pipe line shall be truly vertical or to lines and slopes as directed and shall be at a uniform distance of 40mm from the finished face of the wall.

11.19.3 Asbestos Cement Pipe Fittings

The term fittings means A.C. specials such as bends of various degrees, heads, offsets of different projections, branches and shoes. The general specifications for these shall conform to those described in 11.19. These shall confirm to IS : 1626 (Part 1) and shall be of approved manufacturer.

11.19.3.1 Dimensions

The fittings shall be of the type, diameter and size as specified. The thickness of the fittings and details of spigots and sockets shall be the same as those of the corresponding size of straight pipes. The fittings shall be of standard size and their individual thickness and tolerance on thickness shall be as per table 3. The fittings shall also conform to IS : 1626 (Part-1).

11.19.3.2 Fixing and Jointing

The specifications for A.C. Pipes in para 11.19.2 shall also apply to fittings.

11.20 Unplasticized Polyvinyl Chloride (UPVC) Rain Water Pipe and Fittings.

U.P.V.C. Pipes

Pipes shall conform to IS 13592 : 1992 (Type A). The internal and external surfaces of the pipes shall be smooth and clean and free from grooving and other defects. The end shall be clearly cut and shall be square with the axis of the pipe. The end may be chamfered on the plain sides. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible provided the wall thickness remain within the permissible limit.

11.20.1 Colour of Pipe

Surface colour of the pipes shall be as specified.

11.20.2 Marking

Each pipe shall be clearly and indelibly marked with the following information at intervals not more than 3 metre.

(a) Manufacturer's name or trade mark,.
(b) Nominal outside dia of pipe,
(c) Type 'A'
(d) Batch number

The pipes may also be marked with standard mark.

11.20.3 Dimensions

UPVC rain water pipes shall be of the dia, as specified and shall be in nominal lengths of 2,3,4 or 6 metres either plain or with sliding/grooved socket, unless shorter lengths are required at junctions with fittings. The sizes, weights, sockets and tolerances of pipes shall be as shown in Table 4,5,6 & 7. Tolerances on specified length shall be + 0.10mm.

TABLE 4
DIMENSIONS OF PIPES

(All dimensions in mm)

Nominal Outside Diameter	Mean Outside Diameter		Outside Diameter at any Point		Wall Thickness S Type A	
	Min	Max	Min	Max	Min	Max
75	75.0	75.3	74.1	75.9	1.8	2.2
100	110.0	110.4	108.6	111.4	2.2	2.7

TABLE 5
MINIMUM WALL THICKNESS OF SOCKETS ON PIPES

(All dimensions in mm)

Nominal Outside Diameter	*S 2 Min Type A*	*S 3 Min Type A*
75	1.6	1.0
110	2.0	1.2

TABLE 6
DIMENSIONS FOR SLIDING SOCKETS

(All dimensions in mm)

Nominal Outside Diameter	*Socket Depth, C*	*Mean Inside Diameter of Socket at Midpoint, Dl*	
		Min	*Max*
75	40.0	75.1	75.3
110	48.0	110.1	110.4

TABLE 7
DIMENSIONS OF GROOVED SOCKET

(All dimensions in mm)

Nominal Outside Diameter	*Inside Diameter of Socket, D1*		*Inside Diameter of Beading, D2*		*Length of Beading and Neck A*	*Neck of Socket B*	*Length beyond beading C*
	Min	*Max*	*Min*	*Max*	*Min*	*Max*	*Min*
75	75.3	76.2	84.5	85.5	20	5	35
110	110.4	111.3	120.3	121.3	26	6	32

11.20.4 Fixing and Jointing

Pipes shall be either fixed on face of wall or embedded in masonry as specified.

Plain pipes shall be secured to the walls at all joints with PVC pipe clips by means of 50 x 50 x50 mm hard wood plugs, screwed with M S Screws of required length including cutting brick work and fixing in cement mortar 1:4 (1 cement: 4 coarse sand). The clips shall be kept about 25mm clear off finished face of wall, so as to facilitate cleaning of pipes.

Pipes shall be fixed perfectly vertical or to the lines as directed. The pipes shall be fitted to fittings with seal ring conforming to IS:5382 allowing 10mm gap for thermal expansion.

11.20.5 Installation in Wall/Concrete

The walls/concrete slots should allow for a stress free installation. Pipes and fittings to be inserted into the slots without a cement base, have to be applied first with a thin coat of PVC solvent cement followed by sprinkling of dry sand (medium size) and then allowed to dry. The process gives a sound base for cement fixation. This process is repeated while joining PBVC material to CI/AC materials.

11.20.6 Fittings

Fittings used shall be of the same make as that of the PVC pipes and shall have a minimum wall thickness of 3.2mm. The fittings shall be supplied with grooved socketted ends with square grooves and provided with Rubber Gasket conforming to IS: 5382. The plain ends of the fittings should be chamfered. The fittings shall be joined with the help of Rubber lubricant.

Note: These pipes shall be used only in shaft or unexposed location to avoid damage to these pipes due to willful act.

11.20.7 Sheet Metal Gutters

Sheet metal gutters shall be of mild steel sheets, black or galvanized as indicated. The thickness of sheet shall be as specified, but not less than 1.25 mm. Metal sheet gutters shall be of ogee type, half round type, valley or eaves type as required. Where indicated gutters may be stiffened with stays, the spacing of stays usually should not exceed 40 cm. Stays of tubular pattern, if used, shall be soldered in position on to the gutter. All joints shall be lapped and soldered for at least 40 mm in the direction of flow. The jointing faces of sheet metal gutters shall be primed with solder to ensure running of the jointing metal. Soldering of the joint throughout the full girth of the gutter and to the full extent in the lap shall be ensured. Jointing may also be done by proper welding of the joining faces or by providing a lap joint adequately riveted to obtain a leak proof joint.

WORKMANSHIP

11.21 Roofing Generally

Particular care shall be taken in providing good workmanship in the construction of roofs, specially the vulnerable points mentioned below to ensure that the finished roof is water-tight without any leakage, under all weather conditions.

(a) Filling of side joints of flat terrace tiles, bricks, stone slabs etc with mortar.
(b) Joints between roof and parapets, chimney stacks, etc.
(c) Rain water outlets.
(d) Waterproofing treatment.
(e) Drilling of holes in corrugated and semi-corrugated sheets.
(f) Avoiding cracks in fragile articles such as asbestos cement sheets, tiles, etc, due to careless handling and fixing.
(g) Sealing joints of gutters, hip and ridge coverings, etc.

11.21.1 Sloping roofs shall be secured with suitable wind ties where indicated. These shall be fixed with the same hook bolt which secure the sheets to the purlin. To allow for expansion and contraction, holes in wind ties shall as slotted, if so directed.

11.21.2 The slope of the finished top of flat roofs shall be as specified or indicated in the drawings.

11.22 Corrugated Steel Sheeting

11.22.1 Spacing of Purlines

The spacing of purlines shall be as indicated but shall not exceed the following :-

Thickness of steel sheet	*Maximum spacing of purlins C/C*
1.00 mm	**2.00 m**
0.80 mm	1.80 m
0.63 mm	1.60 m

Ridge purlins shall be fixed 75 mm to 115 mm from the apex of the roof, that is from the bolt point.

11.22.2 Laps

The sheets shall be laid with minimum end lap of 150 mm and side lap of two corrugation as indicated. The side and end laps may be increased to avoid cutting of sheets, if the GE agrees thereto. The above minimum end lap of 150 mm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end laps shall be 200 mm.

11.22.3 Laying and Fixing of Sheets

The sheets shall be laid on the purlins or other structural members as indicated, to a true plane. With the lines of corrugations truly parallel or normal to the sides of the area to be covered, unless otherwise required as in special shaped roofs.

11.22.3.1 Sheet shall be fixed to the purlins or other structural members with coach screws, round headed 6 mm dia , 65 to 75 mm long or galvanized J or L hook bolts and nuts, 8 mm diameter with bitumen and G I limpet washers filled with white lead as directed. The length of the hook bolt shall be varied to suit the particular requirements. The bolts shall be sufficiently long so that after fixing they project above the top of their nuts not less than 12 mm. The grip of J or L hook bolt on the side of the purlin shall be not less than 25mm. There shall be a minimum of three coach screws hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 300 mm.

11.22.3.2 Where slopes of roofs are less than 1:2 ½ (1 vertical to 2-1/2 horizontal) or where indicated sheets shall be joined together at the side laps by galvanized iron bolts and nuts 25x6 mm size, each bolt with a bitumen and a GI limpet washer or a GI limpet washer filled with white lead. The spacing of these seam bolts shall not exceed 20 cm.

11.22.3.3 Sheeting on steel bearers, where indicated, shall be riveted together with 6 mm dia galvanized wrought iron rivets and galvanized plain round washers (two to each rivet), at intervals not exceeding 20 cm for the side laps, and on every corrugation (staggered) for the end laps. The sheets may be riveted in sets of 9 to 12 on the ground and then hoisted in position. Care shall be taken in riveting that the sheet is well supported underneath and no indentation is made on the upper surface. Rivets shall be tightened and drawn closely and the heads spread evenly and equally.

11.22.3.4 All holes for bolts, rivets, drive screws, etc., shall be made in the crown of corrugations and shall be drilled (and not punched). The holes in the washers shall be of the exact diameter of the hook bolt or the seam bolt. The nuts shall be tightened from above to give a leak proof roof.

11.22.3.5 When the sheets are indicated to be painted after erection, the laps shall be painted before erection.

11.22.3.6 Sheets shall not generally be built into gables and parapets. They shall be bent up along the side edges close to the wall and the junction shall be protected by suitable flashing or bitumen mastic 'gola' as indicated.

11.22.4 Ridges and Hips

Ridges and hips shall be covered with ridge and hip sections with a minimum 150 mm lap on either side over the roofing sheets, and shall be properly bent to shape and fixed. The end laps of the ridges and hips and between ridges and hips shall also be not less than 150 mm.

11.22.4.1 Ridges and hips shall be fixed to the roof members with coach screws 6 mm dia or 8 mm dia GI hook bolts and nuts and bitumen and GI limpet washers which fix the sheets to the purlins. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on either side. If this is not possible extra hook bolts shall be provided. The end lap of ridges and hips shall be joined together by galvanized iron seam bolts 25x6 mm size each with a bitumen and a GI washer. There will be at least two such bolts in each end lap. Laps shall be set in red lead. The edges of the ridges and hips shall be straight when fixed end to end and their surfaces should be plain and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

11.22.5 Valley and flashings

Valley and flashings of plain sheeting shall be of width and thickness as specified and bent to shape and fixed. They shall lap with the corrugated sheets not less than 150 mm width on either side. The end laps of valleys and flashing shall also be not less than 150 mm and painted with red lead.

11.22.5.1 Valley sheets shall be fixed to the roof members below, with the same 8 mm dia Gl hook bolts and nuts and bitumen and GI limpet washers which fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of the valley pieces, on either side. If this is not possible extra hook bolts shall be provided. The edges of valleys and flashing shall be straight from end to end. The surfaces shall be true and without bulges and depressions.

11.22.5.2 Flashing shall be well and properly tucked into joints of brickwork of masonry, secured with hardwood wedges and the joints finished neatly to match the adjoining work.

11.23 Aluminum corrugated sheeting

11.23.1 Spacing of purlin

The spacing of the purlin shall be as indicated but shall not exceed the following :-

Thickness of Aluminum sheeting	*Max spacing of the purlin*
0.56 mm	1.52 m
0.71mm	1.67 m

Ridge portion shall be fixed at the same spacing as in the case of steel sheeting.

11.23.2 Laps

The sheeting shall be laid with minimum end lap of 150 mm and side lap of two corrugation.

11.23.3 Laying and fixing of sheeting

Laying and fixing shall be similar to steel sheeting with two corrugation side laps. However side laps are to be stitched together by galvanized iron bolts and nuts 25x6 mm size with bitumen and aluminum washer. The spacing of these screw bolts shall not exceed 20 cm.

11.23.4 All holes for bolts, driver screws etc. shall be made in the crown of corrugations and shall be drilled (and NOT punched). The holes in the washer shall be of the exact diameter of the hook bolts or screw bolt. The nut shall be tightened from above to give a leak proof.

11.24 Asbestos Cement Sheeting Corrugated and Semi-Corrugated

11.24.1 Spacing of purlins

The spacing of purlins shall be as indicated, but shall not exceed 1.4 m for roof covering and 1.7 m for side cladding for 6mm thick sheets. Ridge purlins shall be fixed 75 mm to 115 mm from the apex of the roof, that is from the bolt-point.

11.24.2 Laps

11.24.2.1 Corrugated Sheets

The sheets shall be laid with a side lap of half corrugation. The end laps in sheets shall be as indicated but not less than 150 mm. The contractor may increase end lap to avoid cutting sheets, etc, but no extra payment shall be made for the additional sheeting so fixed . As far as possible, the side lap shall be sheltered from the prevailing wind direction. The overhang at eaves, measured as the length of sheet from its lower end to the centre of bolt holes, shall be indicated but not more than 300 mm for 6 mm thick sheets.

Wherever four corners of sheets overlap, two of them shall be mitred in order to secure a prefect fit . In order to avoid undue width of flashing, the sheets should finish at abutments, as far as possible, with an upturned edge.

11.24.2.2 Semi-Corrugated Sheets

Laps shall be provided as described in 11.24.2.1. above for corrugated sheets except that the side lap shall be of one corrugation; the left hand small corrugation of each sheet being covered by the right hand large corrugation of the next sheet.

11.24.3 Sawing and Drilling

Sheets shall be cut with a wood saw. Holes in the sheets shall be drilled (2 mm larger than the diameter of the fixing bolts) through the crown of the corrugation ; they shall on no account be punched. Holes for fixing for the sheeting shall be drilled in the centre of the end lap of sheets to suit the purlins, that is, on the centre line of the purlins if these are of timber and square head coach screws are used; or as close as possible to the back of the purlins if J or L bolts are used. No hole shall be nearer than 40 mm to any edge of a sheet. As far as possible, holes shall be drilled on the roof with the sheeting laid in position.

11.24.4 Fixing Accessories

(1) Galvanised iron 'J' type hook or cranked hook bolt and nut bearing on galvanized iron washer and bitumen washers shall be used for fixing sheets on angle iron purlins.
(2) Galvanised iron 'L' type hook bolt and nut bearing on galvanized iron washer and bitumen washer shall be used for fixing sheets on M. S. joists, timber or precast concrete purlins.
(3) Galvanised iron coach screws bearing on galvanized iron washer and bitumen washer shall be used for fixing sheets on timber purlins.
(4) Galvanised iron roof bolts and nuts bearing on galvanized iron flat washers and bitumen washers shall be used for stitching on the sheets, ridge cappings, ventilators, north light curves, etc.

11.24.4.1 Fixing bolt and coach screw shall not be less than 8 mm diameter. The nuts of the hook and crank bolts and heads of coach screws shall bear on galvanized iron washers (flat, curved or diamond pattern) which in turn shall bear on bituminous felt washers, (rounded or diamond pattern corresponding to the shape of galvanized iron washer). The length of J bolt or crank bolt shall be 75 mm longer than the depth of the purlins for single sheet fixing and 90 mm longer than the depth of the purlin where two sheets overlap or where ridges or other accessories are to be fixed .The minimum length of coach screws for timber purlins shall be 110 mm. The galvanized iron flat washer shall be 25 mm in diameter, 1.6mm thick and bitumen washer shall be 35 mm in diameter and 1.5 mm thick, with hole to suit the required size of fixing accessory. The number and length of bolts and the number of bitumen and galvanized iron washer for fixing asbestos cement sheets shall be as under :-

SI No	*Situation*	*No of bolts and Bitumen; washers and galvanized iron washers*	*Length of bolt*
I	Corrugrated Sheets.		
	1. (a) At horizontal (end) laps of sheets (b) At eaves when filler pieces are used. (c) At ridge when corrugated sheets and ridge pieces are secured by the same bolt.	Twice the number of sheets in one horizontal course	Depth of purlin plus 90 mm
	2. (a) At eaves when filler pieces are not used. (b) At ridge when corrugated sheet and ridge pieces are not secured by the same bolts.	Twice the number of sheets in one horizontal course.	Depth of purlin plus 75 mm
	3. At intermediate purlins where horizontal laps do not occur	Twice the number of sheets in one horizontal course.	Depth of purlin plus 75 mm
II	Semi-corrugated sheets.		
	1. (a) At horizontal (end) laps of sheets	(Short-bolts) the number of sheets in one horizontal course plus two.	Depth of purlin plus 75 mm
	(b) At eaves when filler pieces are used. (c) At ridge when sheets and the ridge pieces are secured by the same bolt.	(Long-bolts) the number of sheets in one horizontal course less one.	Depth of purlin plus 90 mm

SI No	*Situation*	*No of bolts and Bitumen; washers and galvanized iron washers*	*Length of bolt*
	2. (a) At eaves when filler pieces are not used. (b) At ridge when sheets and ridge pieces are not secured by the same bolt.	Twice the number of sheets in one horizontal course plus one.	Depth of purlin plus 75 mm
	3. At intermediate purlins where horizontal laps do not occur.	The number of sheets in one horizontal course plus one.	Depth of purlin plus 75 mm

11.24.5 Laying the Sheets

Asbestos cement sheets shall be laid with smooth side upwards, from left to right or from right to left depending upon the prevailing wind direction, starting at the eaves. If laid from left to right, the first sheet shall be laid uncut, but the remaining sheets in the bottom rows shall have the top left hand corners cut or mitred. The sheets in the second and other intermediate rows shall have the bottom right hand corner of the first sheet cut, all other sheets, except the last sheet, shall have both the bottom right hand corner and top left hand corner cut. The last sheet shall have only the top left hand corner cut. The last or the top row sheets shall have the bottom right hand corner cut with the exception of the last sheet which shall be laid uncut. If the sheets are laid from right to left the first sheet shall be laid uncut and the remaining procedure reversed.

11.24.6 Fixing of Sheets

Nuts or screws shall be tightened lightly at first and then fully tightened. On no account shall the fixing screws or the nuts on fixing bolts be screwed down too tightly and care shall be taken not to deflect sheets at the intermediate purlins in an attempt to make the sheet bear on such purlins. Men working on roof shall invariably use cat ladder or plank to avoid damages to the sheets.

In the case of corrugated sheets one bolt or screw shall be used on each side on the side lap. In the case of semi-corrugated sheets one bolt or screw shall be used in every side lap corrugation at the verges and at one of the two intermediate corrugations on each sheet. When the sheets are supported on intermediate purlins an additional fixing bolts shall be provided through each side lap corrugation only.

Ridge capings shall, as far as possible , be secured to the ridge purlins by the same bolt which secure the sheeting.

Accessories shall be fixed as per the manufacturer's instructions.

Expansion joints shall be provided where indicated, as per manufacturer's instructions.

11.25 Mangalore Pattern Tile Roofing

11.25.1 The tiles shall be laid from the eaves towards the ridge properly interlocked according to the design of the tile. The tile shall be laid either directly over the battens or over an undercover.

The tiles shall be laid by breaking joint, that is, the left channel of the upper tile shall lie in the right channel of the below and shall fit closely one to another, the catches resting fully against battens or undercover. Rows shall be even, straight and parallel to the ridges. The hips and ridges of the roof shall be covered with the ridge tiles which shall be edge bedded in the mortar, as indicated, finished with pointing to match with the colour of the tiles. If the courses of roof tiles adjacent to the hip or to the ridge do not finish exactly underneath the ridge tiles, either purpose made tiles or tiles cut to suitable shapes may be used. While finishing joints, gaps in the troughs of the roof tiles at the ridge or hip, if large enough shall be neatly packed watertight using mortar. At eaves the lower most course of the tiles shall overhang the tilting fillet by a distance sufficient to ensure that the rain water discharges clear off the eaves.

11.25.2 Where a layer of ceiling tiles is to be laid as under cover , the ceiling tiles shall be laid over the battens and the Mangalore pattern tiles shall be laid over them with appropriate interlocking between the tiles in the two layers.

11.25.3 The finished slope of the roof shall be uniform from ridge to eaves. The eaves line and the ridge line shall be perfectly straight, horizontal and parallel to each other.

11.25.4 The Joints between hip and ridge tiles shall be grouted with mortar so as to be leak-proof Mild Steel galvanized sheet saddle not less than 45 sq cm shall be used underneath such junctions as additional protection against leakage.

11.25.5 Eaves tiles shall be tied to the battens or other roof elements by means of galvanized wire 1.6 mm dia. Alternatively, where indicated eaves tiles shall be screwed by using GI screws with GI and bitumen washers fixed in the crest between channels of eaves tiles and reaching at least 25 mm into the wood support below.

11.25.6 In the case of chimney stacks and other similar features, full tiles shall be used around them and taken into the masonry. Unless otherwise indicated cement concrete 1:2:4 benching shall be provided to cover the intersection between the top edge of the tiling and any projection through the roof as directed by the EIC. Where indicated GI sheet flashing or bitumastic benching may be provided as a cover in lieu of cement concrete benching.

The flashing shall be tuned against the projection and dressed down over the tile. The flashing shall be well tucked into either the joints in masonry or grooves in concrete as the case may be and shall be wedged and pointed.

11.25.7 Unless otherwise indicated, the tiles shall be let into the wall to a depth of not less than 50 mm and drip moulding at about 100 mm height above the roof surface or benching or bands as indicated shall be provided and joints between the roof and the wall shall be grouted with a waterproofing cement mortar 1:3.

11.25.8 Tiles required to be pointed, plastered or set in lime or cement mortar or requiring filling of ends with lime mortar shall be soaked in water for two hours before use and kept well watered for at least seven days after laying and application of the mortar.

11.25.9 All broken tiles and mortar dropping shall be removed and the work left neat and tidy.

11.26 Mud Phuska

11.26.1 Preparation of Mud Phuska

The soil shall be stacked in required quantities in about 30 cm high stacks over a level ground and the top surface divided into suitable compartments by bunding. The estimated quantity of water corresponding to optimum moisture content shall be added about 12 hours before the use and allowed to soak. The stacks of soil shall then be worked up to ensure proper distribution of moisture at the time the soil is to be used.

11.26.2 Preparation of Mud Plaster

The dry soil shall be reduced to fine powder and mixed with water in the pit, adding wheat straw 6% by mass and cow dung 12%by mass. The mixture be allowed to rest for a period not less than 7 days. During this period it shall be pugged manually using spades if necessary to get a homogeneous mass free from lumps and clods.

11.26.3 Preparation of Mud Mortar

Mud mortar used as bedding under brick tile layer shall be prepared in the same manner as mud plaster but without any addition of fibrous reinforcing material and building material. The mud mortar may be used without any maturing period.

11.26.4 Leeping Plaster (Gobri Leeping)

This shall be prepared by mixing soil which is free from coarse sand with approximately equal volume of cow dung and adding the required quantity of water. The mixture shall be worked to a homogeneous mass.

11.26.5 Laying

11.26.5.1 The mud phuska shall be laid in loose layers of thickness not more than 15 cm , to the proper slope and rammed manually with wooden rammers and thapies so as to obtain maximum density. The surface shall then be allowed to dry for a period of not less than 24 hours. If any cracks appear, these shall be filled with a grout of cow dung used in the leeping plaster.

11.26.5.2 Over mud phuska, a mud plaster shall be laid to a total thickness of not less than 25 mm, in a single coat or two coats of 15 mm and 10 mm, the latter being preferable. Each coat of plaster shall be allowed to dry; haircracks, if any , shall be filled with gobri leeping. The surface shall be checked for slope and evenness with a straight edge and spirit-level and made up where necessary by application of plaster.

11.26.5.3 When the surface of mud plaster had dried, a thin coat of leeping plaster shall be applied to a thickness of not less than 3mm and finished with trowel or float. The surface shall be allowed to dry. When haricracks appear, they shall be filled with gobri leeping.

11.26.5.4 Paving with Brick Tiles

Where tile paving finish is indicated, brick terracing tiles shall be laid directly over the mud plaster and no leeping plaster shall be provided. Brick tiles shall be laid flat on a thin layer of mud mortar to give a level surface. The tiles shall be laid close to each other and the thickness of joints shall be not less than 6 mm and not more than 15 mm. It shall be ensured while laying the tiles that the mud mortar rises vertically in the joints to a height of about 15 mm. The brick tile work shall be allowed to dry for a period of 24 hours before grouting of joints. The joints shall be grouted flush with cement and sand mortar (1:3) mixed with crude oil 5 percent by weight of cement. The surface of the finished roof shall be kept wet for a period of not less than 7 days. The completed brick tile surface shall be checked for evenness and slope.

11.27 Lime Concrete Terracing

11.27.1 Preparation of Lime Concrete

One part of slaked lime and two parts of surkhi by volume shall be mixed on a watertight platform. This shall then be sprinkled with the required quantity of water and shall be well ground in a mortar mill, or using mechanical grinders. Hand pounding may be done for small quantities. Burnt brick aggregate shall be soaked thoroughly in water for a period not less than six hours before use in the concrete mix. The lime concrete shall be prepared by thoroughly mixing the aggregate and lime-surkhi mortar in the proportion of 2- ½ : 1 by volume. 12 Kg of washing soap and 4 Kg of alum dissolved in water shall be added to each cubic metre of lime concrete. The lime concrete shall be used in the work within 36 hours of the preparation of lime mortar.

11.27.2 Laying

11.27.2.1 The roof surface shall be wire brushed and cleaned of all dust and foreign matter. Where indicated, a coat of blown grade bitumen conforming to IS : 702-1988 shall be evenly applied at the rate of 1.2 Kg per sq.m.

11.27.2.2 Laying of lime concrete shall be started from a corner of the roof and proceeded diagonally toward centre and other sides considering the slopes required for draining the rain water smoothly. Unless otherwise indicated, average thickness of the lime concrete shall not be less than 10 cm and the minimum thickness not less than 7.5 cm. After the lime concrete is laid, it shall be initially rammed with a rammer weighing not more than 2 Kg and further consolidation shall be done using wooden thapies. The beating shall be carried out by mazdoors who will sit close together, and beat the surface lightly and in rhythm and move forward gradually. The beating shall be carried on for atleast seven days until the hand beater makes no impression on the surface and rebounds readily from it when struck. During compaction by hand beating, the surface shall be sprinkled liberally with lime water and small proportion of jaggery solution (prepared by mixing 3 Kg of jaggery and ½ Kg of Bael fruit to 100 liters of water in Northern parts of the country, or a solution prepared by soaking in water dry nuts of Terminalia Chebula). For preparing the solution of Terminalia Chebula (Kadukkai), the dry nuts shall be broken to small pieces and allowed to soak in water. A solution shall be made of 600 g. of Kadukkai, 200g. of jaggery and 40 liters of water (sufficient for 10 sq.m of roof) and brewed for 12 to 24 hours. The resulting liquor shall be decanted and added to lime water. On completion of beating, the mortar coming out on the top shall be trowelled with the addition of jaggery solution, if necessary, and finished smooth. The finished surface shall be even and to slope as directed.

If the surface during the process of compaction becomes so uneven that the water stands in pools the surface shall be pricked up and fresh lime concrete spread and consolidated as is necessary so as to ensure proper slopes and levels are maintained, with adequate bonding between old and new concrete by sprinkling requisite quantity of lime water (1 part of putty and 3 to 4 parts water) with sugar solution as specified above.

11.27.2.3 The lime concrete after compaction shall be cured for 6 days or until hardens by covering with a thin layer of grass or straw which shall be kept wet continuously.

11.27.2.4 Special care shall be taken to properly consolidate the concrete at its junction with the parapet wall. Unless otherwise indicated, all along the junction of the roof surface with the masonry of the vertical wall, a fillet of lime concrete as directed, shall be laid and finished smooth.

11.27.3 Brick Tile Roof Finish

Brick tiles shall be laid on lime mortar 1:3 or cement mortar 1:6 bed, 15 mm thick. The brick tiles shall be immersed in water for two hours before being used. The side joints shall be not less than 6mm thick, and not more than 12 mm and set full in mortar. Before the work dries up completely, the joints shall be raked out and pointed with cement sand mortar 1:3 mixed with crude oil which shall be 5 percent by weight of cement. The joints shall be well rubbed over with a thin bar trowel and excess mortar scrapped off until the surface of the pointing attains the black polish and becomes hard. As the work proceeds, it shall be kept thoroughly wetted until the mortar has set firm and hard. The finished surface of the terrace shall be cured with water for a period not less than 7 days.

Unless otherwise indicated, where brick paving is provided, angle fillet 75 mm radius, of the lime concrete all along the junction of the roof surface with the walls (parapet and other walls) shall be laid after the brick paving has been laid. Plastering of the masonry Parapet wall, where indicated shall be done only after brick tiles and angle fillet have been laid.

11.28 Stone Slab Roofing Over Joists

Stone slabs shall be placed over the joists, the bearing of the slabs over the joists shall be half the width of the joists. The size and thickness of slabs shall be as indicated. The even surface of the slabs shall be kept downwards. The slabs shall be sent in rows close to each other in lime or cement sand mortar as indicated. The gap between the slabs shall not be more than 25 mm at any point. Joints shall be filled with lime or cement sand mortar as indicated for their full depth and neatly finished on top and underside.

11.28.1 Lime Concrete Finish

Where indicated lime concrete finish to the specified thickness shall be laid over the stone slab roofing to the proper slope, consolidated and cured as specified under lime concrete terracing.

11.29 Repairing of Cracks in Old Terraced Roofs

The cracks shall be cleaned out and in the case of large ones, the uneven and broken edges shall be trimmed to form V shaped cuts, at least 6 mm wide on top. When repairing is indicated in cement, the cracks shall be thoroughly flooded with water, water allowed to soak in cracks, grouted with cement and sand slurry 1:3 and repaired cracks cured for at least seven days. When repairing is indicated with bitumen mastic the cracks shall be absolutely dried and cleaned, and filled solidly with a hot mixture of blown grade bitumen and sand 1:1 by weight. The filler shall be well filled into the cracks with the edge of a trowel and left flush with the surface of roof. Repaired cracks shall cause no ridges across the direction of the slope of roof.

11.30 Matting

Matting shall be laid with side and end laps of atleast 150 mm and securely tied to the supports with approved string (such as munj, coir, fibre, etc.), at intervals of not more than 60 cm . Second layer of matting, if indicated, shall be laid breaking joints with the first layer. When fillets of wood or bamboo are used for securing matting as in partitions, etc., the fixing shall be done with nails driven through fillets. If so directed, all cut edges shall be properly bound to prevent fraying.

11.31 Thatching

The poolas or bundles of thatch shall be carried to the bamboo jaffri on the roof without disarranging the stems and the operation of laying the thatch shall begin from the eaves upwards. The thicker (bottom) end of the poolas shall be kept downwards, poolas shall be placed touching each other with their length parallel to the sides of the roof and shall then be opened and spread so that the thickness at the eaves is slightly more than 75 mm. The straw shall then be roughly levelled. As each new poola is laid, the edge of the straw already in position shall be slightly lifted up and the new straw shall be pushed underneath by 2 to 3 cm, in order that adjacent poolas are lapped together and a compact and unbroken joint is made between the two. The straw shall be gently beaten as it is laid and shall be consolidated in to a firm mass.

11.31.1 When the eaves row of poolas has been laid, a bamboo split into half shall be laid on top at about 30 cm up from the eaves, parallel to it and tied down with ' munj ban' or strings, pressing the straw under. Munj ban and strings used for tying shall first be dipped in coal tar or a bituminous composition and dried.

11.31.2 The second and subsequent rows of poolas shall be taken in hand in exactly the same manner tying each poola to the supports and securing each row with split bamboo fillets. Each row of fillets shall be placed at 30 cm intervals and shall be concealed by the lower edge of pool as directly above.

11.31.3 The process of laying shall be repeated working upwards towards the ridge till the entire roof is covered, the surface being occasionally beaten gently, consolidated and combed down with hand rake to preserve straight line from top to bottom and to keep each stem in its place. The completed thickness of this covering shall be 75 mm.

11.31.4 Every effort shall be made to ensure that the bundles of straw mingle together effectively at the edges as the life of the thatched roof depends very largely on the way the joints are made. The verges of the roof shall be laid with a double thickness of the straw to strengthen the edges and to throw the water away from the gable on to the roof. A split bamboo shall be tied along the verges also.

11.31.5 The top of the roof shall be finished off by laying bundles of straw longitudinally along the ridge, these being tied on as before and being laid in just sufficient thickness to form a substantial (but not bulky) foundation for the crown of thatch. The apex shall then be covered in by placing the final row of poolas with their centre exactly across the top of the ridge and bending the ends down on either sides so that they can be tied to bamboo foundation. The angle on the top shall not be so acute as to buckle the straw. The eaves and verges shall then be trimmed by cutting off the loose ends of the straw in a straight line with long scythe by a sawing action. Finished roof surface shall lie evenly without rises and hollows and shall not sink perceptibly under the weight of a person.

11.31.6 Subsequent 75 mm covering shall be laid in manner exactly similar to the first covering to produce the thickness of 150 mm or 225 mm as indicated, but fillets shall be fixed (at 30 cm centre) only on top of finished thickness and not on each 75 mm thick layer.

11.32 Bamboo work

String for fixing bamboos shall be new stout good quality munj ban or other equal and approved. It shall be tarred and dried, if so directed. All tying shall be done tightly and securely with sufficient turns of the string joints in the length shall be formed by laps of about 75 cm tied spirally with double string.

11.32.1 Bamboos shall be securely tied (or nailed or wired, if so indicated) at all intersections, to all supports at specified intervals and to bamboos alongside each other at intervals not exceeding 1 metre. Where indicated, bamboo work shall be dipped in a bath of crude oil before fixing or oiled in position after fixing as directed.

11.33 Gutters

11.33.1 Gutters shall be laid with a minimum fall of 1 in 150, which should be increased where possible. The gutters shall be true to line and slope. Gutters shall be laid with the requisite accessories such as drop ends stop ends, nozzle angles and union clips as directed. The size of the outlet of drop ends and nozzles shall, be the same as the size of rain water pipes into which they discharge.

11.33.2 Joints in the gutters shall be made watertight.

11.33.3 Unless otherwise indicated, gutters shall be supported with a bracket close to the socket and another in the centre of the gutter. Plain ended gutter shall be supported with a bracket on either side of each joint. For gutters of large size, one extra supporting bracket in the centre of the gutter shall be fixed.

11.33.3.1 Brackets shall be fabricated from mild steel flats of the size as indicated. Where the brackets are fixed to the side of rafters they shall be fixed with 40 x 3 mm flats bent to shape and fixed rigidly to the sides of rafters with 3 nos. 10 mm dia bolts, nuts and washers. The bracket shall overlap the rafter not less than 30 cm and connecting bolts shall be 115 mm centres.

11.33.3.2 Where the brackets are to be fixed to the purlins, these shall consist of 50x3 mm MS flats bent to shape with one end turned at a right angle and fixed to the purlins face with a 10 mm dia bolt, nut and washer. The perpendicular over-hang portion of 50x3 mm bracket shall be stiffened by another 50x3 mm flat bent to right angle shape with its longer leg connected to the bracket with 2 numbers 6 mm dia MS bolt, nuts and washers and its shorter legs fixed to the face of purlins with one number 10 mm dia bolt, nut and washer. The over-hang of the vertical portion of the flat iron bracket from the face of the purlins shall not exceed 225 mm.

11.33.3.3 The requisite slope in the gutters shall be given in the line of bracket. The brackets shall be placed at not more than 90 cm centres for AC gutters and 75 cm for sheet metal gutters.

11.33.4 Jointing and fixing of AC Gutters

11.33.4.1 Spigot and socket ends of gutters or 'socketed eaves ornamental' or socketed half round type gutters and their accessories shall be connected together at their laps with one row of 8 mm dia GI bolts and nuts, each bolt and nut provided with a pair of bitumen and a pair of GI washers. The gap between the socket and spigot shall be packed with approved plastic roofing compound, flanged on both sides with 6.35 mm dia asbestos rope. The connecting GI bolts shall be then tightened so that the lapped joints become leak proof. The outer faces of the packed asbestos rope shall not be farther than 6 mm from the edges of the spigot and socketed ends. Where both ends of gutters and/or their accessories to be connected together are spigot ends they shall be laid as butt joints with 1.5 mm gap in between over union clips (loose socket pieces). The union clips shall be connected to the two butt ends of the gutter or other sections with two rows (one row per end of 8 mm dia GI bolt and nut, each bolt and nut being provided with a pair of bitumen and a pair of GI washers). The gap between the union clips and butt ends of gutter sections or accessories shall be packed with plastic roofing compound flanged with edges of 6.35 mm dia asbestos rope as before. The whole joint shall be made leak proof by tightening the bolts.

11.33.4.2 The ends of "plain ended eaves or boundary wall" type gutters and ' plain ended valley type gutters' and their accessories shall be laid with butt joints over union clips and connected together in the same manner as for socketed and spigoted end gutters.

11.33.4.3 Fixing

The gutters shall be fixed to the brackets with 2 numbers 8 mm dia GI seam bolts and nuts, each bolt and nut being equipped with a pair of bitumen and GI washers. These connecting bolt shall normally be above the water line of the gutters.

11.33.5 Jointing and Fixing of Steel Gutters

11.33.5.1 Use of Stays

Unless otherwise indicated, steel sheet gutters upto 1.25 mm thick shall be stiffened with stays at spacing not exceeding 40 cm. Stays of tubular pattern shall be soldered in position in the gutter.

11.33.5.2 Jointing

All joints shall be lapped and soldered for at least 40 mm, in the direction of flow; the jointing faces shall be primed with solder to ensure running of the jointing metal. Soldering of the resulting joint through the full girth of the gutter and to the full extent in the lap shall be ensured. Jointing may be done by press folding (welting) of the jointing faces.

11.33.5.3 Fixing

Gutters upto 100 mm size shall be fixed by screws inserted through alternate stays and those above 100 mm size shall be fixed by screws inserted through every stay. The screws shall not be less than 2.6 mm dia and not shorter than the nominal thickness of the gutter plus 25 mm. Screws shall not be hammered into place. Fixing of gutters by this method shall not be done when facial board is less than 25 mm in thickness.

11.34 Rain Water Pipes

11.34.1 Rain water pipes and fittings shall be of cast iron, asbestos cement and UPVC and of diameter, size and type as indicated. The pipes shall be fixed in full length, unless shorter lengths are required at junction with fittings.

11.34.2 Joints shall be water tight

11.34.3 The pipes and fittings shall be fixed in vertical alignment, unless otherwise indicated.

11.34.4 Cast iron pipes and fittings shall be secured to walls at all joints and AC pipes and fittings below all joints with mild steel holder bat clamps or with cast iron holder bats weighing to 2 Kg. each, according to size and shape conforming to IS 1729-1964 and fixed to walls with concrete blocks.

11.34.5 Mild steel clamps shall be made from 1.6 mm thick sheeting of 30 mm width bent to the required shape and size unless otherwise indicated, so as to fit tightly on the socket of the pipe, when tightened with screw bolts. The clamp shall be provided with a hook made out of 275 mm long 10 mm diameter MS bar riveted to the ring at the centre of one semi-circular piece. The clamps shall be fixed to the wall by embedding their hooks in cement concrete blocks 100 x 100 x 190 mm., 1:2:4 mix. The clamps shall be kept about 30 mm clear of finished face of wall, so as to facilitate cleaning and painting pipes.

11.34.6 Joining of Cast Iron Pipes

Cast iron pipes when fixed to walls shall be jointed with cement joints and when embedded in the masonry wall, the pipes shall be jointed with lead joints; unless otherwise indicated.

11.34.6.1 The spigot of the upper pipe shall be properly fitted in the socket of the lower pipe such that there is a uniform annular space for filling with the jointing material. The annular space between the spigot and socket shall be filled with a few turns of spun yarn soaked in cement slurry or blown grade bitumen. These shall be pressed home by caulking tools. More skeins of yarn shall be wrapped if necessary, and shall be rammed home. The joint shall then be filled with stiff cement and sand mortar 1:2 well pressed with caulking tools and finished smooth at top at an angle of 45° sloping up. The joints shall be cured for 7 days.

11.34.6.2 Where the pipes are embedded in masonry, these shall be fixed in the masonry as the work proceeds. The pipe shall have a minimum surround of 12 mm thick cement mortar at every portion of external surface. The mortar shall be of the mix as used in masonry work. The length shall be caulked in with lead as soon as the next length of pipe is placed in position. The open and (socket end) of the pipe shall be kept closed till the next length of pipe is fitted and jointed, to prevent any brickbat or concrete or pieces of wood falling in and choking the pipe. The spigot end shall butt the shoulder of the socket and leave no gap in between. The annular space between the socket and spigot will be first well packed in with spun-yarn leaving 25 mm from the lip of the socket for the lead. The joints shall then be lead caulked as described under jointing of cast iron soil, waste and vent pipe.

11.34.7 Jointing AC Pipes

Spigot of AC Pipes and fittings shall be properly fitted into the socket of the lower pipe such that there is uniform annular space for filling with the jointing material. One third depth of annular space between the socket and the spigot shall be filled with spun-yarn soaked in bitumastic jointing compound and shall be pressed home by means of a caulking tool. The remaining 2/3rd depth of the joint shall be filled with stiff cement and sand mortar 1:2 and shall be pressed with caulking tool and finished smooth at top at an angle of 45° slopping up.

11.34.8 Pipes shall be kept clear of any falling debris to avoid choking. All holes etc. made for fixing the pipes shall be made good to match the existing.

11.35 Translucent Sheets

The translucent sheet shall be clean translucent variety with minimum total light transmission 75% i.e. diffusion classification II as per table 4 of IS Code 12866-1989. The sheet shall be corrugated, matching with corrugated profile of A.C. sheet as per I.S. 459 or corrugated steel sheet profile according to IS 277- 1985 or corrugated aluminium sheet profile according to IS 1254-1975 as indicated. The minimum thickness shall be 1.1 mm as per IS Code. The sheets shall be fixed as per manufacturer instructions and there shall be no leakage of water through joints and fixture.

11.36 RMP Corrugated Sheeting

The spacing of purlins shall be as indicated but shall not exceed the following.

Thickness of RMP sheeting	Maximum spacing
2 mm	1.1 metres

The ridge shall be fixed in the same spacing as in the case steel sheeting.

Laps :- The sheeting shall be laid with minimum end lap of 150 mm with side lap of two corrugation.

Laying and Fixing of sheets :- The laying and fixing of sheet shall be same as steel sheeting and accessories shall be as per manufacturers' instructions.

11.37 Water Proofing Treatment to roofs

11.37.1 Water Proofing Treatment on Roof Slabs by Applying Cement Slurry mixed with Armoucrete or Tapecrete, Second Layer of Fibre Glass Cloth.

11.37.2 Preliminaries to be Attended

(i) Before taking up the waterproofing work the construction of parapet walls etc, including finishing should be completed in all respects.

(ii) Similarly, the ancillary items like haunches, khurras, grooves to tack the fibre cloth layer, fixing up of all down-take pipes, water pipes and electric conduits etc. should be completed and no such work should be allowed on the area to be treated during the progress of water proofing treatment or even later.

11.37.3 Preparing Surface

There is no necessity of hacking the surface but the surface to be treated shall be cleaned including chiseling the extra mortar sticking to the surfaces etc.

11.37.4 Preparing cement Slurry

(i) Preparation of slurry is most important factor. The consistency of the slurry should be just that of oil paint and the quantity of slurry prepared should be such as to cover the calculated and desired area with just one coat of application and for that it is essential to calculate the correct quantity of water to be mixed in the prescribed quantity of cement per sqm area.

(ii) This can be done only by trial and error method by preparing few samples with prescribed quantity of cement and applying over few patches each of say 1/2 sqm area and thus the required quantity of water per sqm area can be decided say X litres per sqm.

(iii) On deciding the correct quantity of water required per sqm area the required quantity of slurry should be prepared which can be applied over the desired surface within 1/2 an hour of mixing with 0.488 kg of grey cement + 0.253 kg of Armoucrete or Tapecreate + X litres of water per sqm area and the required quantity of slurry thus prepared should only be used for first application.

11.37.5 Fibre Glass Cloth

The fibre glass cloth shall be of approved proprietary brand and shall be thin, flexible uniformly bonded mat composed of chemically resistant borosilicate glass fibre distributed in random open porous structure bonded together with a thermosetting resin (Phenolic Type).

11.37.6 Application of Slurry as First Layer

The First layer shall be applied with painting brushes over the specified and dampened area with slurry prepared as given in clause 11.37.4 very carefully including the corners, holes on the surfaces and joints of pipes in concrete etc. and the application should continue at least upto 150 mm height of fixtures of pipes from the surface. The surface on application shall be air cured for just 4 hours.

For projected pipes, slurry shall be applied just up to 100mm height instead of 150mm height as prescribed. Also the slurry shall be applied up to a height of 300mm on parapet walls and also the groove on top where the fibre glass cloth has to be tucked.

11.37.7 Spreading Fibre Glass Cloth

(i) Immediately on applying the slurry on a sufficiently workable area when the slurry applied is still green the fibre glass as specified shall be spread evenly on the surface without any kink and pressed to see that no air spaces exist. The fibre glass cloth shall be taken up to a height of 300 mm on parapet walls and tucked in the groove specially prepared at that height.

(ii) A minimum overlap of 100mm width shall be provided when the fibre cloth has to be joined. The joining of 100mm overlap shall be done with the same slurry used for the application on surface as first layer. The fibre cloth shall also be extended up to a height of 100mm over pipes projecting from the surface.

11.37.8 Preparing Cement Slurry Mixed with Sand for Third Layer

(i) The quantity of water required to prepare slurry which can cover one Sqm area of the surface to be treated shall be calculated as described in clause 11.37.4 and consider this quantity as say X litres/sqm.

(ii) On deciding the correct quantity of water required, the slurry shall be prepared by mixing 1.289 Kg of grey cement + 0.67 kg of Armoucrete or Tapecrete + 1.289 Kg of coarse sand + X litres of water. All above quantities are for preparing slurry to cover 1 sqm surface. Therefore, the required quantity of slurry for the area to be covered within 1/2 an hour shall be prepared.

(iii) The consistency of the slurry shall be such that in one application with a brush 1.5mm thickness of slurry can be coated on the fibre glass cloth surface.

11.37.9 Applying Final Coat of Slurry

(i) The slurry specially prepared as explained above shall be applied evenly on the entire surface covered with fibre glass cloth so that a layer of 1.5mm thickness of slurry is formed.

(ii) The application of slurry shall be continued over the 300mm portions of parapet wall and also the portion tucked in the groove on top.

(iii) The entire surface shall be allowed for air curing for 4 hours and later the surface shall be cured with clean water for 48 hours.

(iv) On completion of curing the grooves where the fibre glass cloth is tucked shall be closed neatly with cement mortar mixed with water proofing compound.

11.38 Integral Cement based Water Proofing treatment including preparation of surface as required for treating roofs, balconies, Terraces etc with Brick Bat Coba.

11.38.1 Preliminaries to be Attended

The preliminaries to be attended before taking up the work shall be exactly same as described in clause 11.37.2.

11.38.2 Preparing the Surface

It would be advantageous to roughen the surface by scraping the surface when the slab is being cast, however the surface need not be hacked. In case the slab is already cast and surface fairly finished, the same shall be cleaned neatly of all mortar droppings, loose materials etc.

11.38.3 Blending Cement/Water with water Proofing Compound

(i) Whenever the water proofing compound is to be used, it is advantageous to blend the same with cement if the water proofing compound is in powder form and if the same is in liquid form the required quantity of water blended with water proofing compound alone should be used for preparing slurry/mortar.

(ii) The water proofing compound to be used shall conform to IS:2645 and be of reputed brand with a clear ISI marked on the container which should be in the form of sealed tins or closed packets.

(iii) The correct quantity of water proofing compound to be used per 50 Kg grey cement shall be as prescribed by the manufacturer on the tins/packets literature. However, not more than 3% of water proofing compound shall be used per 50 Kg of grey cement.

(iv) Blended cement with water proofing compound or water mixed with liquid water proofing compound shall be used to prepare slurry/mortar.

11.38.4 Preparing of Slurry

(i) The quantity of water required to prepare the slurry with 2.75 Kg of cement to painted over an area of 1 sqm shall be calculated exactly as described in clause 11.37.4 para (i) and (ii). Consider this quantity of water as x litres per sqm.

(ii) Depending upon the area of surface that has to be covered, the required quantity of slurry should be prepared using 2.75 Kg blended cement + x litres of water per sqm area to be covered, taking particular care to see that only that much quantity of slurry shall be prepared which can be used within 1/2 an hour of preparation.

11.38.5 Application of Slurry under Base coat

(i) The slurry prepared as explained above shall be applied over the dampened surface with brushes very carefully, including the joints between the floor slab and the parapet wall, holes on the surfaces and joints of pipes in masonry/concrete.

(ii) The application of the slurry should continue up to a height of 300 mm over the parapet wall and also to the groove as shown in Fig 11.1. The slurry should also be applied up to a height of 150 mm over pipe projection etc.

11.38.6 Laying Base coat 20mm thick

Immediately after the application of slurry and when the application is still green, 20mm thick cement plaster as base coat with cement mortar 1:4 (1 blended cement: 4 coarse sand) shall be evenly applied over the concrete surface taking particular care to see that all corners and joints are properly packed and the application of the base coat shall be continued up to a height of 300 mm over the parapet wall as shown in Fig 11.1.

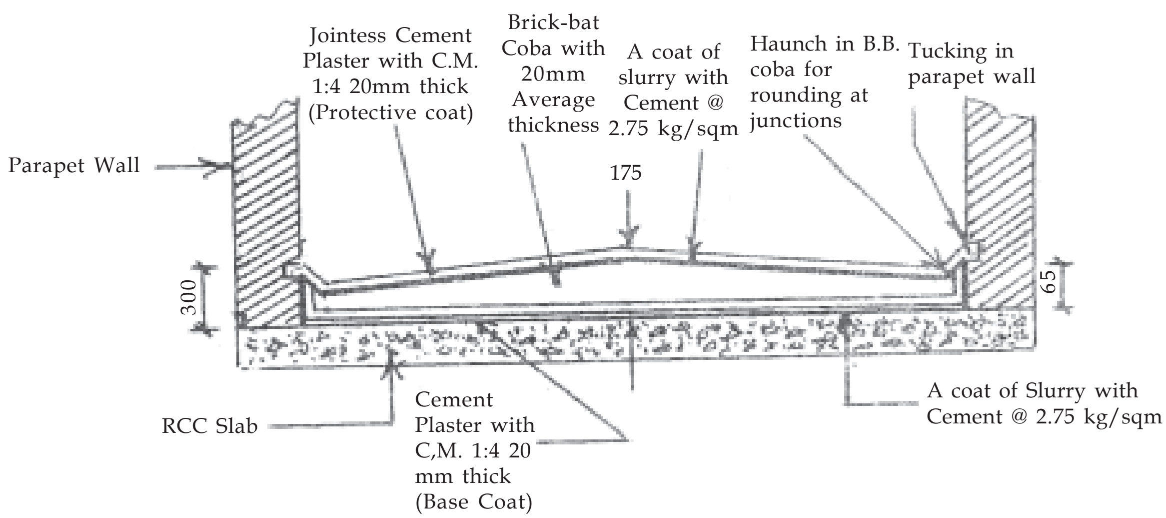


Fig. 11.1: Integral cement based water proofing treatment with Brick- bat Coba over a RCC slab

11.38.7 Preparing Brick-bat Concrete Mix

(i) Brick bat of size 25mm to 100mm out of over burnt bricks shall be used for the purpose of brick bat coba.

(ii) Depending upon the area of concrete surface to be covered the calculated quantity of brick bats to cover the area shall be heaped for mixing. Cement mortar 1:5 (1 blended cement: 5 coarse sand) shall be prepared separately of half the quantity of brick bats, collected by volume.

(iii) The bricks bats shall be properly dampened for six hours before the cement mortar is added. The materials shall be thoroughly mixed by adding some water if needed and the homogenous mix thus prepared should only be used. Under no circumstances dry brick bats should be mixed with the mortar.

11.38.8 Laying Brick bat Coba

(i) When the base coat takes initial set or preferably on the subsequent day the brick bat coba after mixing as specified above shall be laid to required slope/gradient. To ensure fixing up of proper level/gradient correct level points should be fixed with brick bat coba mix only and the brick bat coba shall be laid to the top of level points. The surface of brick bat coba shall be finished neatly to proper slope.

(ii) The haunches/gola at the junction of parapet wall and the roof shall be formed only with brick bat coba as shown in Fig 11.1

(iii) In case the brick bat coba is laid on the base coat immediately on initial set there will be no necessity of applying cement slurry over the base coat before laying the brick -bat coba. However, if the brick bat coba is to be laid on the subsequent day, cement slurry prepared as described in clause 11.38.4 shall be applied over the top surface of the base coat, then only the brick bat coba shall be laid.

11.38.9 Application of Slurry Over Brick-bat Coba

Immediately on laying brick-bat coba i.e when the initial set takes place, or at least on the subsequent day cement slurry prepared as per clause 11.38.4 shall be applied on the surface of brick -bat coba. The application of slurry shall be the same as described in clause 11.38.5 which should cover the haunches/gola, and the remaining small portion of parapet wall and also inside the groove as shown in the figure.

11.38.10 Laying Finishing Layer (Protective Coat)

(i) Immediately on applying the cement slurry over the surface of the brick bat coba and when the slurry applied is still green, a 20 mm thick layer of cement plaster, without leaving any joints shall be applied with cement mortar 1:4 (1 blended grey cement : 4 coarse sand) over the entire surface including the haunches/gola and the small portion on the parapet wall. The groove in the parapet wall over the haunches shall also be filled neatly packing the mortar firmly in the groove.

(ii) The surface of the finishing layer (protective coat) shall be neatly finished with cement slurry prepared as per clause 11.38.4. The finished surface shall be allowed to dry for a while till a string mark can easily be made on the surface, when 300mm x 300 mm square marks shall be made over the entire surface.

11.38.11 Curing and Testing the Treatment

The entire surface thus treated shall be flooded with water by making kiaries with weak cement mortar, water shall be made to remain on the roof slab for a minimum period of two weeks during which it can be observed if there are any leakage or not.

Brick bat coba shall be provided as specified, however recommended average thickness is 120mm and minimum at Khurra as 65 mm.

11.39 Water proofing with Bitumen Felts

11.39.1 Water proofing treatment with self finished felt shall be four courses or six courses

Four course water proofing treatment with self finished felt is a normal duty treatment suitable for buildings where the cost of roof treatment is required to be restricted.

Six course water proofing treatment with self finished felt is heavy duty treatment suitable for important structures.

11.39.2 Materials

11.39.2.1 Self finished felt (as given in Appendix A and B) : The self finished felt shall be of brand and manufacture conforming to the type and grade specified. This shall be one of the following types :

(a) Type 2 grade 1 is a glass fibre base bitumen felt conforming to IS : 7193
(b) Type 2 grade 1 is a fibre (Vegetable or animal) base felt conforming in all respect to IS :1322
(c) Type 2 grade 2 is a fibre (Vegetable or animal) base felt conforming in all respect to IS :1322
(d) Type 3 grade 1 is Hessian base felt conforming in all respect to IS :1322.

11.39.2.2 Bonding Materials: This shall consist of blown type petroleum bitumen conforming to IS :702 or residual petroleum bitumen conforming to IS :73 or mixture thereof. The bonding material shall be so selected as to withstand the local condition of temperature and gradient satisfactorily. The penetration of bitumen used shall not exceed 40 in any case. Suitable residual type petroleum bitumen is of penetration 30/40 (IS grade S-35).

Generally, blown type petroleum bitumen of S-90 shall be used for the base and intermediate layers of bonding material and for flashing, while residual petroleum bitumen with higher penetration and low softening point shall be used for the finishing layer. Suitable blown type petroleum bitumen is of IS grade 85/25 of approved quantity.

Where proprietary brands of bonding materials are proposed to be used by the contractor they shall conform in all respects to the specifications in the preceding paras.

Table showing the quantity of Bonding materials to be used over per Sqm Area of surface to be treated for different course, in four course and six course treatment.

	Ist course kg/sqm	*3rd course kg/sqm*	*5th course kg/sqm*
I. Four course treatment	1.45	1.45	-
II. Six course treatment			
(a) With type 3 grade 1 hessian base self finished bitumen felt	1.45	1.20	1.45
(b) With felts other than type 3 grade 1 hessian base	1.45	1.20	1.70

11.39.2.3 Stone Grit and Pea-sized Gravel: Stone grit shall be as specified and shall be 6mm and down size. Where pea-sized gravel is used it shall be hard, round and free from dust, dirt etc. The stone grit or pea-sized gravel shall not be spread over vertical and sloping faces of flashings and at drain mouths. At these places the surface shall be painted with two coats of bitumeneous solution.

The quantity of stone grit or pea-sized gravel required for the final course of four or six course treatment with Hessian base self finished bitumen felt type 3 grade 1 shall be 0.006 cum. For six course treatment with felt other than type 3 grade 1, the stone grit or pea sized gravel at 0.008 cum per sqm shall be used.

11.39.3 Preparation of surface

11.39.3.1 The surface to be treated shall have a minimum slope of 1 in 120. This grading shall be carried out with, cement concrete or cement plaster with coarse sand, as ordered, to the average thickness required and finished smooth. The correct method of executing the item of grading is explained in clause 11.42 with Figures 11.7, 11.8,11.9 and 11.10.

11.39.3.2 Junctions between the roof and vertical faces of parapet walls, chimneys etc. shall be cased by running triangular fillets 7.5 x 7.5 cm size in cement concrete. At the drain mouths, the fillets shall be suitably cut back and rounded off for easy application of water proofing treatment and easy flow of water. Cement concrete shall be 1:2:4 mix (1 cement :2 coarse sand:4 graded stone aggregate 20mm Nominal size).

11.39.3.3 In existing roof where gola and drip course are provided at the junction of roof and vertical face of parapet wall, chimney stacks etc., these shall be dressed suitably and finished smooth so as to ensure an easy and gradual turning of the flashing.

11.39.3.4 While the grading of roof surface is being done, it shall be ensured that the outlet drain pipe have been fixed and mouth at the entrance have been eased and rounded off properly for easy flow of water.

11.39.3.5 When any pipe passes through the roof to be treated, angular fillet of shape shown in Fig 11.6 shall be built around it for the water proofing treatment to be taken over it.

11.39.3.6 For carrying over and tucking in the water proofing felts into the parapet walls, chimneys stack etc. a horizontal groove 6.5 cm deep, 7.5 cm wide section with its lower edge at not less than 15 cm above the graded roof surface shall be left on the inner face of the same during construction if possible as shown in Figs 11.3, 11.4 and 11.5. When such groove has not been left, the same shall be cut out neatly and the base at rear of the groove shall be finished smooth with cement plaster 1:4 (1 cement: 4 coarse sand).

11.39.3.7 Tucking in the water proofing felt will be required where the parapet wall exceeds 45 cm in the height from the graded surface. Where the height is 45 cm or less, no groove will be required as the water proofing treatment will be carried over the top of the parapet wall to its full thickness. In the case of low dividing walls of height 30 cm or less, outlets therein shall be cut open for full height and the bottom and sides shall be rendered smooth and corners rounded.

11.39.3.8 Where expansion joints are left in the slab, the provision of dwarf walls and/or RCC slabs for covering them and finishing the surface smooth shall be made.

11.39.3.9 The graded surface of the roof and concrete fillets and the faces of walls shall be thoroughly cleaned with wire brushes and all loose scales etc. removed. The surface shall then be dusted off. Any crack in the roof shall be cut to 'V section, cleaned and filled up flush with cement mortar slurry 1:4 (1 cement :4 coarse sand) or blown type petroleum bitumen of IS grade 85/25, or approved quality conforming to IS :702.

11.39.4 Priming Coat

Priming coat shall be as specified in clause 11.40.1.1

11.39.5 Underlay

Where a floating treatment of water proofing with self finished bitumen felt is required i.e. where water proofing treatment is required to be isolated from the roof structure, a layer of bitumen saturated felt (underlay) shall be spread over the roof surface and tucked into the flashing groove. No bonding material shall be used below the underlay in order to keep the underlay free of the structure. The adjoining strips of the underlay shall overlap to a minimum of 7.5 cm at sides and 10 cm at ends. The overlaps shall be sealed with the same bonding material as used for the self finished felt treatment.

The underlay shall be of type 1 saturated felt conforming to IS: 1322 in all respect and having a total minimum weight of the finished bitumen felt in dry condition with mica dusting powder @ 6.8 kg per 10 sqm. The roll shall not be damaged or cracked on being unrolled on a fairly smooth and flat surface.

Fig 11.2 shows typical method of providing underlay. The four course water proofing treatment is shown in Fig 11.3 and six course water proofing treatment as shown in Fig 11.5.

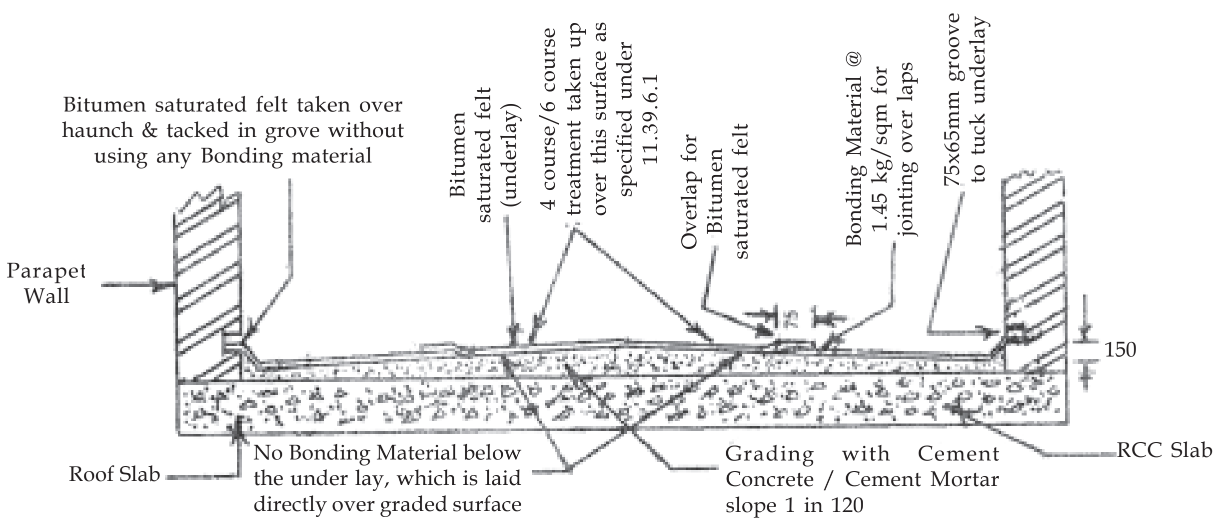


Fig. 11.2 : Method of Laying "underlay" (Clause 11.39.5)

It should be clearly noted that no bonding material is to be laid below the underlay but the "Initial Layer" i.e the first layer of the bonding material either for the four course treatment or for the six course treatment shall be laid directly over the underlay considering the same as the base of the four course/six course water proofing treatment.

Note: The underlay should be provided over the graded surface only when specified. Underlay is proposed only in very rare cases and not at all for the regular water proofing treatment works.

11.39.6 Treatment

11.39.6.1 The water proofing shall consist of a four or six course treatment, specified in the work, each layer of bonding materials, self finished bitumen felt or stone grit or pea sized gravel being counted as a course.

11.39.6.2 The choice of a four or six course treatment will depend on the climatic condition, the importance of the building, the durability required, cost and other relevant considerations.

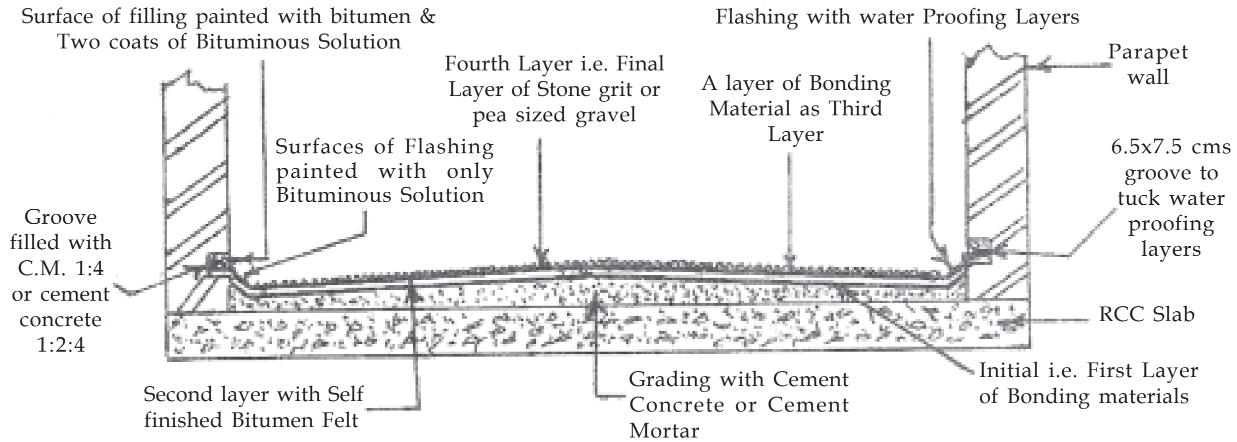


Fig. 11.3 : Four Course Water Proofing Treatment (Clause 11.39.6.3)

11.39.6.3 A four course treatment shown in Fig 11.3 and 11.4 shall consist of following layers :

(i) Initial layer of bonding material applied hot at specified weight per unit area.

(ii) 2nd layer of self finished bitumen felt of specified brand and manufacturer conforming to the type and grade given.

(iii) Third layer of bonding material

(iv) Final layer of stone grit of pea sized gravel spread at specified volume of material per unit area.

Note: In this case the layer of stone grit or pea gravel is not provided

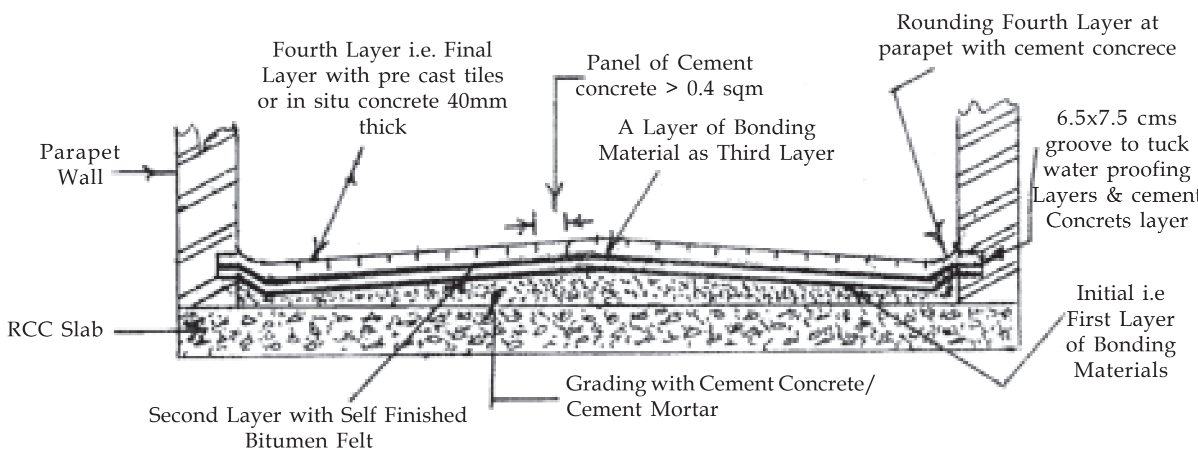


Fig. 11.4 : Four Course Water Proofing Treatment (Clause 11.39.6.3 and 11.39.7.10)

11.39.6.4 In a six course treatment, shown in Fig 11.5 the first, second and third layer shall be the same as in the four course treatment. The fourth and fifth layer shall consist oj self finished felt and bonding material respectively. The sixth layer shall consist of stone grit or pea sized gravel.

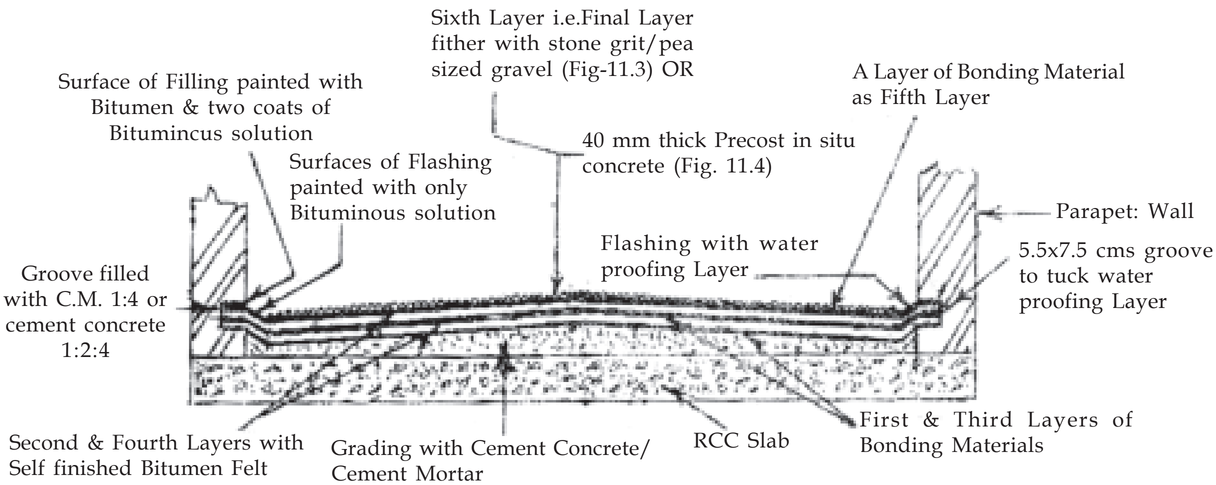


Fig. 11.5 : Six course water proofing treatment (Clause 11.39.6.4 and 11.39.7.10)

11.39.6.5 The primer or underlay shown in Fig 11.2 where required to be provided shall not count against the number of courses specified.

11.39.7 Laying

11.39.7.1 Bitumen bonding material of required grade shall be heated to the working temperature specified for the particular grade by the bitumen manufacturers and conveyed to the roof in buckets or pouring canes in weighed quantities.

Suitable working temperature for different grades of bitumen are as under :-

(i) Blown type petroleum bitumen of IS grade 85/25 180 degree C

(ii) Residual type petroleum bitumen of penetration 30/40 180 degree C (IS grade S-35).

11.39.7.2 Drain outlets shall be given a four or six course treatment as specified for the roof in the manner specified for the flat roof surface. Water proofing treatment shall be carried out into the drain pipe or outlets by atleast 10 cm. The water proofing treatment laid on the roof surface shall overlap the upper edge of the water proofing treatment in the drain outlets by at least 10 cm.

11.39.7.3 The self finished felt shall be cut to the required length, brushed clean of dusting material and laid out flat on the roof to eliminate curls and subsequent stretching. The felt shall normally be laid in length at right angles to the direction of the slope and laying shall be commenced at the lowest level and worked upto crest. The felt shall not be laid in single piece of very long lengths as they are likely to shrink ; 6 to 8 m are suitable lengths. The roof surface shall be clean and dry before the felt treatment is begun. Each length of felt shall be laid in position and rolled up for a distance of half its length. The hot bonding materials shall be poured on the roof across the full width of the rolled felt as the later is steadily rolled out and pressed down. The pouring shall be so regulated that the correct weight of bonding material per unit area is spread uniformly over the surface. Excess bonding material that gets squeezed out at the ends, shall be levelled up as laying proceeds. When the first half of the strip of felt has been bonded to the roof, the other half shall be rolled up and then unrolled on the hot bonding material in the same way. Subsequent strips shall also be laid in the same manner. Each strip shall overlap the preceding one by at least 7.5 cm at the longitudinal edges and 10 cm at the ends. All overlaps shall be firmly bonded with hot bitumen. Streaks and trailings of bitumen near edges of laps shall be levelled by heating the overlap with a blow lamp and levelling down unevenness.

The third layer of bonding material in the four course treatment shall be carried out in a similar manner after the flashing has been completed.

11.39.7.4 In a six course treatment the third and fourth layers of bonding material and self finished felt shall be laid in the manner already described, taking care that laps in the felt are staggered from those in the second layer. The fifth layer of bonding material shall be carried out after the flashing is done (See Fig 1L5)

11.39.7.5 High Parapet wall, Chimney Stacks etc: Felts shall be laid as flashings wherever junctions of vertical and horizontal surfaces occur. Longitudinal laps shall be 10 cm. The lower layer of flashing felt in a six course treatment shall overlap the roof water proofing by not less than 20 cm while the upper layer shall over lap the roofing felt by 10 cm. The minimum overlap of the flashing felt in four course specification over the roofing felt shall be 10 cm.

The flashing shall consist of the same four or six course treatment as for the roof except that the final course of stone grit or pea-sized gravel shall be replaced by an application of bituminous solution of approved quantity in two coats on the vertical and sloping faces only, of the flashing as shown in Fig 11.3 and 11.5. The overlaps along the length of flashing shall stagger with those in the second layer of flashing felt (in a six course treatment and with the joints in the roof felt).

The upper edge of the flashing felt shall be well tucked into the flashing grooves in the parapet, chimney stacks etc. to a depth of not less than 6.5cm. Corresponding application of bonding material shall also be made. The flashing treatment shall be firmly held in place in the grooves with wood edges at intervals and the grooves shall be filled up with cement mortar 1:4 (1 cement : 4 coarse sand) or cement concrete 1:2:4 (1 cement: 2 coarse cement: 4 graded stone aggregate 6mm nominal size) and surface finished smooth with the rest of the wall. The cement work shall be cured for 7 days. When dry, the exposed plaster joints of grooves shall be painted with bitumen and two coats of bituminous solution shall be applied on the vertical and sloping surface of flashing (See Fig 11.3,11.4 and 11.5).

After the top flashing felt layer has been fixed, the penultimate layer of bonding material shall be applied over the roofing felt and the horizontal overlaps and vertical and sloping surfaces of the flashings at the specified rate. Stone grit or pea-sized gravel shall then be spread uniformly over the hot bonding material on the horizontal roof surface at the specified quantity per unit area and pressed into it with a wooden roller.

11.39.7.6 Low Parapet Walls: Where parapet walls are of height 45 cm or less, bitumen felt flashing shall be provided in the same manner as for flashing in the case of high parapet walls except that the upper edge shall be carried upto the full height of the wall and taken across the top of the parapet and down on the external vertical faces to a minimum distance of 5 cm (see Fig 11.6).

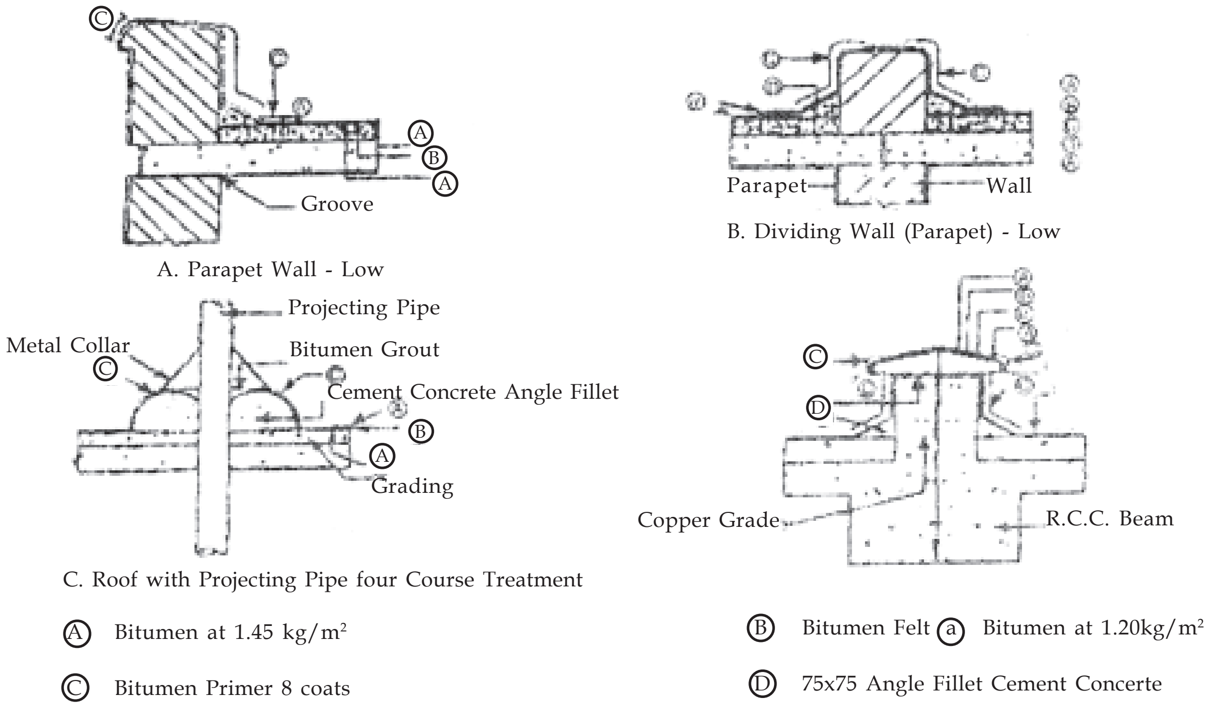


Fig. 11.6 : Water proofing

11.39.7.7 Low Dividing Walls: Where low dividing walls or inverted beams are met with, the same shall be covered with a four or six layer treatment as for the main roof, the latter bearing carried down both sides of the wall and overlapping the roofing treatment as in the case of flashing of high parapet walls (see Fig 11.6).

Drain outlets where formed in the low dividing walls, shall be given water proofing treatment of the same number of courses as specified for the flat roof surface. The bottom and sides shall be so treated that all overlaps are in the direction of flow of drainage.

11.39.7.8 Expansion Joints: Where the expansion joints are provided in the slabs, the joints and their cover slabs shall be suitably treated with water proofing. A typical sketch of an expansion joint with the RCC slabs on either side of the joint turned vertically up and covered with precast RCC cover slabs as given in Fig 11.6. The cover slabs shall cover the vertical turned up dwarf walls by not less than 7.5 cm and are provided with throatings on their underside along their length. The water proofing treatment shall be taken upto the sloping junction fillets and the vertical faces of the walls to the underside of the cover slabs. The cover slabs are given the water proofing treatment like the roof slabs, after the cross joints between adjacent cover slabs are first sealed with 15 cm width of roofing felt struck to them with bitumen. The water proofing treatment shall be carried down the sides of the cover slabs to their full thickness. Care shall be taken to see that overlaps, if any, in the roofing over the cover slabs stagger with the joints between cover slabs.

11.39.7.9 Pipes: Where vertical pipe outlets are met with, 7.5 x 7.5 cm fillets of cement concrete of the type and section shown in Fig 11.6 shall be provided and flashing of four or six course treatment, same as for the roofing treatment shall be laid.

The upper edge of the flashing shall be laid down forward and butted against the pipe and annular depression so formed shall be filled with hot bitumen. A circular metal collar in the shape of an inverted truncated cone shall be fixed on the pipe to throw off the rain water clear of the flashing.

11.39.7.10 Terrace: Where roof surface are expected to be used, precast cement concrete tiles or 40mm thick cement concrete shall be laid on the water proofing treatment as shown in Fig 11.4. In such cases, the final course of stone grit or pea sized gravel shall not be laid in the water proofing treatment. Cement concrete in situ flooring shall be laid in panel not exceeding 0.4 square metre each.

11.40 Water Proofing with glass Fibre Tissue Reinforced Bitumen

In-situ water proofing treatment of roofs with glass fibres tissue reinforced bitumen shall be of five course, seven-course or nine-course type as specified. In selecting the combinations of layers of glass fibre tissue membrane, consideration shall be given to the type and construction of buildings, climatic and atmospheric conditions and the degree of permanence required. Five-course treatment is a normal duty treatment suitable for moderate rainfall conditions (less than 50 cm), seven-course treatment is a heavy duty treatment suitable for severe conditions of rainfall (50 to 150 cm) and nine-course treatment is extra heavy duty treatment suitable for very heavy conditions of rainfall (more than 150 cm).

11.40.1 Materials

11.40.1.1 Bitumen Primer: The primer shall conform to the requirements laid down in IS:3384. Unless otherwise specified, each coat of bitumen primer shall be applied at the rate of 0.40 kg per square metre of the surface area.

11.40.1.2 Glass Fibre Tissue: The glass fibre tissue shall be thin, flexible, uniformly bonded mat composed of chemically resistant borosilicate staple glass fibre distributed in a random open porous structure, bonded together with a thermosetting resin (phenolic type) and reinforced with continuous filament glass yarn at 10mm pitch in the longitudinal direction. The minimum weight of the tissue shall be 50 gm per square metre and the nominal thickness shall be 0.50 ± 0.1mm. The minimum tensile strength of the tissue shall be 45 kg/150mm width in the longitudinal direction.

11.40.1.3 Bonding Material: This shall consist of blow type bitumen conforming to IS: 702 or residual bitumen conforming to IS :73 heated to the correct working temperature. The penetration of the bitumen shall not be more than 40 when tested in accordance with IS :1203. Unless otherwise specified, each coat of bonding material shall be of blow type bitumen of grade 85/25 heated to a working temperature of 180 degree C and applied at the rate of 1.60 kg per square metre of the surface area.

11.40.1.4 Surface finish: Surface finish shall depend upon whether the roof is flat or sloping and whether the terrace is accessible or not. Pea sized gravel, stone grit, burnt clay tiles, cement concrete flooring tiles, broken pieces of ceramic glazed tile or bitumen based aluminous mastics may be used as specified. Pea size-gravel/stone grit, where specified, shall be spread at the rate of 0.006 cubic metre per square metre of the surface area. Materials used for surface finish shall be dry and free from dust.

11.40.2 Preparation of Surface

The preparation of the surface shall be done as specified in 11.39.3 except water proofing felt wherever mentioned shall mean glass fibre tissue. To ensure good adhesion between the structural surface and water proofing treatment, suitable methods to dry the surface shall be adopted wherever necessary.

11.40.3 Treatment

11.40.3.1 The water proofing treatment shall be five, seven or nine-course as specified. The first coat of bitumen primer, each coat of bonding material, each layer of glass fibre tissue and the top of surface finished shall be counted as a course.

11.40.3.2 A five course treatment shall consist of the following :-

(i) First coat of bitumen primer
(ii) Second coat of bonding material
(iii) Third layer of glass fibre tissue
(iv) Fourth coat of bonding material
(v) Fifth and top most layer of surface finish as specified.

11.40.3.3 In seven-course treatment, the first four courses shall be the same as for five course treatment. The fifth course shall be a layer of glass fibre tissue. The sixth course shall be a coat of bonding material and the top most seventh course shall be of specified surface finish.

11.40.3.4 In nine course treatment, the first six courses shall be the same as for seven course treatment. the seventh course shall be layer of glass fibre tissue, the eight course shall be a coat of bonding material and the top most ninth course shall be of specified surface finish.

11.40.4 Laying

Laying shall be done as specified in 11.39.7 except that the glass fibre tissue shall be used instead of self finished felt and the first course shall be a coat of bitumen primer followed by subsequent courses as per the treatment required.

11.41 Applying Bitumenous Solution Primer on Roof and or Wall surface

11.41.1 Preparation of the Surface

The surface to be painted shall be cleaned with wire brushes and cotton or gunny cloth. All loose material and scales shall be removed and dusted off.

11.41.2 Application

As specified or required by the Engineer-in-Charge under slightly damp conditions, priming coat consisting of a bitumen primer conforming to IS:3384 is applied with a brush on the roof and wall surface at 0.24 litres per sqm to assist adhesion of the bonding materials (i.e. bitumen).

11.42 Grading Roof for Water Proofing Treatment

11.42.1 Grading with Cement Concrete 1:2:4

11.42.1.1 Materials

Cement, coarse sand and graded stone aggregate 20mm nominal size, shall be used as specified in the item.

The specifications for the materials and method of preparation of concrete shall conform in general to the specification given in cement concrete chapter.

11.42.1.2 Laying

(i) Before laying cement concrete for grading the level marking (Thiya) to the required slope/gradient shall be made only with cement concrete on the surface of the slab at suitable spacing with the help of string and steel tape (Measuring tape) so that the mason can lay the concrete to the required thickness, slope/gradient easily in between the two level markings.

(ii) On getting the level markings approved by the Engineer-in-Charge the surface should be sprinkled with thick cement slurry and the concrete should be laid carefully, without throwing from height, in predetermined strips.

(iii) As no vibrator can be used for consolidating such small depths, the concrete should be consolidated by specially made wooden tamping beams operated by two labours on two ends. After the tamping is done the surface should be finished to required slope/ gradient with wooden trowels without leaving any spots of loose aggregates etc.

(iv) The cement concrete that is mixed must be laid in position, within half an hour of its mixing with water; therefore, every time small batches shall be mixed i.e. a quantity which can be laid within half an hour. In case any quantity of concrete remains unused for more than half an hour the same should be rejected and removed from site.

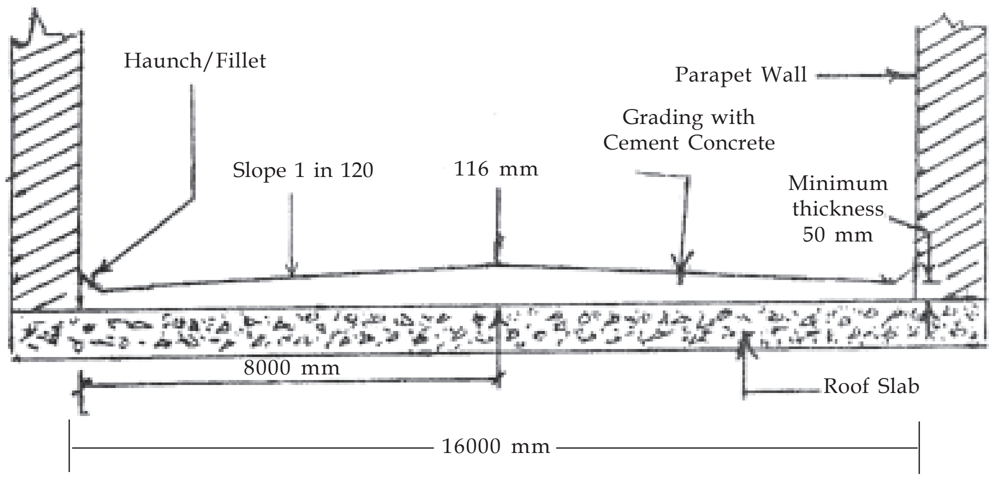


Fig. 11.7 : Grading Roof Slab with Cement Concrete with details of thickness to be provided for specified gradient, position of Haunches/Fillets

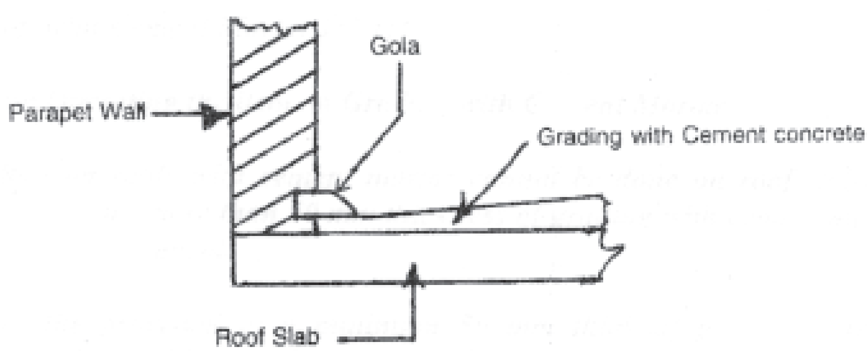


Fig. 11.8 : Position of Gola in the Work of Grading Roof Slabs

11.42.1.3 Finishing

The slope of finished terrace shall not be more than 1 in 120 unless a steeper slope is expressly permitted by the Engineer-in-Charge in writing.

The minimum thickness of the concrete at it junction with Khurra or parapet shall be 5 cm. The concrete shall be rounded at the junction of roof slab and parapet. It is desirable to provide a haunch/gola/fillet at the junction of the parapet wall and the roof slab as shown in Fig 11.7 and 11.8.

The finished concrete surface shall present a smooth surface with concrete slopes and uniform rounding wherever they are provided. The concrete should be free from cracks. Excess trowelling shall be avoided.

11.42.1.4 Thickness

The average finished thickness of the laid concrete over the entire area shall conform to the average thickness specified or as shown in Fig 11.7

11.42.1.5 Curing

Curing shall be done either by spreading straw/hessian cloth over the graded surface, keeping the same wet for full 10 days or flooding the graded area with water by making kiaries with weak cement mortar, keeping the water over the surface for full 10 days. Occasional curing by simply spraying water now and then shall not be permitted under any circumstances.

Notes for Preparation of Surface

(i) If the RCC slab is to be treated with water proofing treatment which would need grading the surface of the roof, then the same shall be made rough in the initial stages only when the concrete laid is still green. This can be easily done by scratching the surface with a scratching tool immediately after finishing the slab. However the surface should not be hacked.

(ii) In case the grading is to be done over the slab which is already cast and attained it's full strength, then the only alternative to roughen the surface is not by hacking with a hacking tool but treating the surface with spatter dash key.

(iii) The method of preparing the surface for grading prescribed above shall be followed for executing any type of grading.

11.42.2 Grading Roof with Cement mortar 1:3/1:4

11.42.2.1 Limitations on Operating the item on Grading with Cement Mortar

(i) Grading on roofs with cement mortar cannot be done on roof slabs of large width/length as laying more than 50 mm thickness of grading with cement mortar shall not be stable and economical.

(ii) Unlike the provision of a minimum 50 mm thick of grading with Cement concrete, the minimum thickness for grading with cement mortar shall be just 20mm to 25mm as it is not desirable to increase the maximum thickness more than 50 mm.

(iii) Therefore, the maximum length/width that can be achieved with this restriction of thickness is the length/width that can be covered with cement mortar. Recommended width shall be 6m if the slope of grading is in two directions as shown in Fig 11.9 and 3m in case the slope is in one direction.

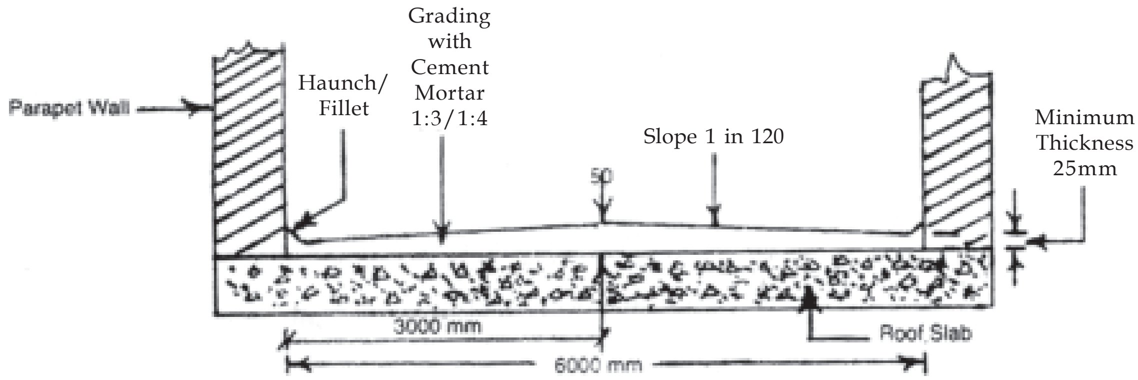


Fig. 11.9 : Grading with Cement Mortar 1:3/1:4 and Maximum Width of Roof Slab that can be covered

(iv) Thus, the grading with cement mortar can be used for slabs of smaller spans, cantilevers, chajjas, balconies etc. as shown in Fig 11.10

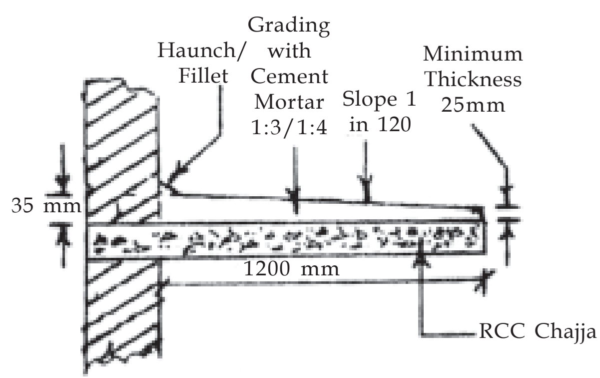


Fig. 11.10 : Grading with Cement Mortar 1:3/1:4 over RCC Chajja

11.42.2.2 Materials

Cement and coarse sand shall be as specified in chapter of Cement Concrete.

11.42.2.3 Cement Mortar

Cement mortar 1:3 (1 cement: 3 coarse sand)/l:4 (1 cement: 4 coarse sand) shall be specified in chapter of Cement Concrete.

11.42.2.4 Preparing the Surface

The surface shall be prepared exactly as described in clause 11.42.1.5

11.42.2.5 Laying

Same as described in clause 11.42.1.2, except the cement mortar shall be tamped with wooden and steel trowel and surface finished with steel trowel.

11.42.2.6 Finishing

(i) The slope of finished surface shall not be more than 1 in 120 unless a steeper slope is specified in the item of work or ordered by the Engineer-in-Charge in writing.

(ii) The finished surface of the grading shall present a smooth surface with correct slopes and uniform roundings wherever they are provided. The mortar surface shall be free of cracks. Excess trowelling shall be avoided.

11.42.2.7 Thickness

(i) The minimum thickness of cement mortar grading at the junction with khurra or parapet wall shall be 20 mm to 25mm. The cement mortar shall be rounded at the junction of roof slab and parapet. It is desirable to provide a haunch/gola/fillet at the junction of parapet wall and the roof slab.

(ii) The maximum thickness that shall be adopted for grading with cement mortar shall be 50mm. It is not at all desirable to lay the cement mortar grading for greater thickness and in that case it is advised to go in for grading with Cement Concrete.

(iii) The average thickness shall be as shown in Fig 11.9 and 11.10.

11.42.2.8 Curing

Curing for the grading with cement mortar shall be done exactly as described in clause 11.42.1.5.

11.43 Water Proofing Treatment with APP (Atactic Polypropylene)

11.43.1 In-situ water proofing treatment of roofs with APP (Atactic Polypropylene) modified polymeric membrane shall be five course, seven course type as specified. In selecting the combinations of layer of APP membrane, consideration shall be given to the type and construction of buildings, climate and atmospheric conditions and the degree of permanence required. Five course treatment is a normal duty treatment suitable to moderate rainfall conditions (less than 50 cm), seven course treatment is a heavy duty treatment suitable for severe condition of rainfall (50 to 150 cm) and seven course treatment with APP modified polymeric membrane 2.00 mm thick and weight 3.00 kg/sqm, suitable for very heavy condition of rainfall (more than 150 cm).

11.43.2 Materials

11.43.2.1 Bitumen Primer

The primer shall conform to the requirements laid down in IS :3384. Unless otherwise specified, each coat of bitumen primer shall be applied at the rate of 0.40 kg per square metre of the surface area.

71.43.2.2 Atactic Polypropylene modified polymeric membrane

It is a polymeric water proofing membrane manufactured to high standards. It is five layered APP modified polymeric membrane with centre core as 20 mircron HMHDPE/100 micron HMHDPE High Molecular High Density Polyethylene Film, this centre core is the heart of the membrane and protects against water and moisture. The centre core is sandwiched on both sides by high quality polymeric mix with properties of high softening point, high heat resistance and cold resistivety to make it ideal for all water proofing treatment. The polymeric mix is protected on both sides with 20 micron HMHDPE film. This is available in variable thickness and weights, usually width is 1.0m.

Important physical and chemical parameter of the membrane shall be as given in Table for guidance.

Centre Core	Film	Thickness	Weight
20 micron HMHPDE	20 micron HMHPDE	1.5mm	2.25 kg/sqm
100 micron HMHPDE	20 micron HMHPDE	2.00mm	3.00kg/sqm

Where proprietary brands Atactic Polypropylene modified polymeric membrane is proposed to be used by the contractor, they shall conform in all respects to the specification in the preceding paras and manufacturered by the firms specified.

11.43.2.3 Bonding Material

This shall consist of blown type bitumen conforming to IS :702 or residual bitumen conforming to IS: 73 headed to the correct working temperature. The penetration of the bitumen shall not be more than 40 when tested in accordance with IS:1203, unless otherwise specified each coat of bonding material shall be of blown type bitumen of grade 85/25 heated to a working temperature of 180 degree C and applied @ 1.20 Kg per square metre of the surface area.

11.43.3 Surface Finish

Surface finish shall be with brick tiles of class designation 100 grouted with cement mortar 1:3 (1 cement : 3 fine sand) with 2% integral water proofing compound by weight of cement over a 15mm thick layer of cement mortar 1:3 (1 cement : 3 fine sand) and finished neat, as shown in Fig 11.11.

11.43.4 Preparation of Surface

The preparation of surface shall be done as specified in 11.39.3 except that water proofing felt wherever mentioned shall mean Atactic Polypropylene modified membrane. To ensure good adhesion between the structural surface and water proofing treatment, suitable method to dry the surface shall be adopted where necessary.

11.43.5 Treatment

The water proofing treatment shall be five, seven course as specified. The first coat of bitumen primer, each coat of bonding material, each layer of Atactic Polypropylene modified Polymeric membrane and the top layer of surface finish shall be counted as a course.

A five course treatment shall consist of the following :-

(i) First coat of bitumen primer
(ii) Second coat of bonding material
(iii) Third layer ofAPP modified polymeric membrane of specified thickness and weight.
(iv) Fourth coat of bonding material
(v) Fifth and top most layer of surface finish as specified.

In seven-course treatment, the first four courses shall be the same as for five course treatment. The fifth course shall be a layer ofAPP modified polymeric membrane. The sixth course shall be a coat of bonding material and the top seventh course shall be specified surface finish.

11.43.6 Laying

Laying shall be done as specified in clause 11.39.7.1 to 11.39.7.9 except that APP modified polymeric membrane shall be used instead of self finished felt and the first course shall be a coat of bitumen primer followed by subsequent course as per treatment required. The method of laying different courses is shown in Fig 11.11.

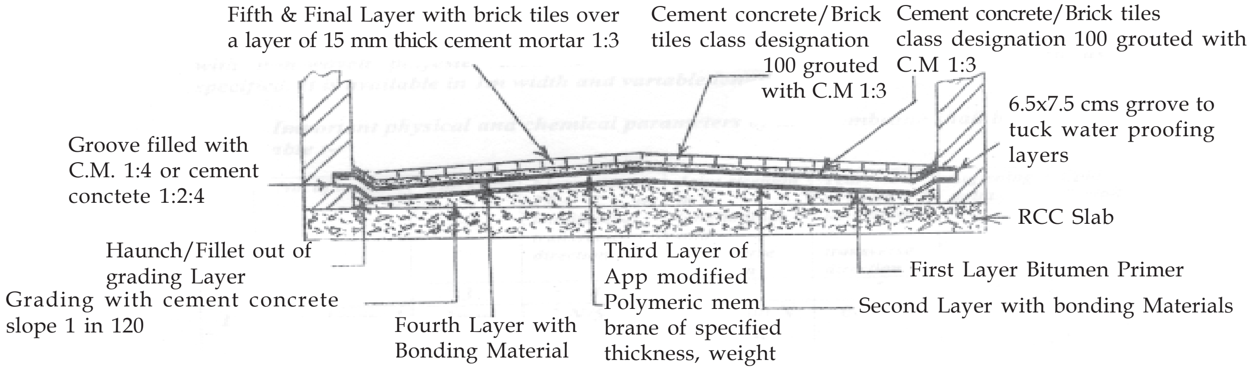


Fig : 11.11 : Five course water proofing treatment with APP modified polymeric membrane of specified weight, thickness

11.44.1 Atactic Polypropylene Polymer modified prefabricated five layer water proofing membrane shall be of thickness as specified. In selecting thickness of membrane due consideration shall be given to the type and construction of building, climate and atmospheric condition and permanence required. Five layered treatment 2.00 mm thick with glass fibre is with a normal duty treatment suitable for pitched roofs. Five layered 3.00 mm thick with glass fibre matt treatment is suitable for moderate condition of rainfall (50 to 100cm) and five layered 3.00 mm thick with non-woven polyester matt treatment is suitable for heavy condition of rainfall (more than 150cm).

11.44.2 Materials

11.44.2.1 Bitumen Primer

Bitumen primer for bitumen membrane manufactured by the same manufacturer shall have density at 25° C in the range of 0.87-0.89 kg/litre and viscosity of 70-160 CPS primer shall be applied at the rate of 0.40 litre/sqm.

11.44.2.2 Atactic Polypropylene Polymer modified prefabricated membrane

It is a polymeric water proofing membrane manufactured to high standard. This shall be one of the following types :-

(a) 2mm thick with glass fibre matt
(b) 3mm thick with glass fibre matt
(c) 3mm thick with non -woven polyester matt

It is prefabricated five layered black finish water proofing membrane comprising of centre core of 50 to 60 gsm glass fibre matt/170 gsm non-woven polyester matt sandwiched on both sides by APP polymer modified bitumen which is protected on both sides by 20 micron thermofusible polyesthylene sheet. Composite thickness of the membrane including all five layers shall be 2/3mm with glass fibre matt and 3 mm with non-woven polyester matt manufactured by reputed manufacturer and as specified. It is available in lm width and variable length.

Important physical and chemical parameters of the membrane shall be as given in the table :-

Sl. No.	*No. of layers*	*Thickness*	*Elongation at 23° C in longitudinal transverse direction*	*Joint strength in longitudinal and Transverse direction*	*Tear strength in longitudinal and transverse direction*	*Softening point*	*Cold Flexibility*
1	2	3	4	5	6	7	8
1.	Five layered reinforced with fibre glass	2mm	3 N/5 cm	350/300 N /5cm	60/80N	150^0	-2°
2.	Five layered reinforced with fibre glass	3mm	3.3 N/5 cm	350/300 N/5 cm	60/80 N	150°	-3^0
3.	Five layered reinforced with non-woven polyester matt	3mm	40/50N/ 5cm	650N/450N /5cm	300/ 250N	150^0	-2^0

When tested in accordance with ASTM, D-5147 where proprietary brand Atactic polypropylene modified black finished is proposed to be used by the contractor they shall conform to all respects to the specification in the preceding paras. However, contractor should get the work done through authorized applicator.

11.44.3 Preparation of Surface

The surface to be treated shall have a minimum slope of 1 in 100 or as specified, as far as applicable provision specified in clause 11.39.3 shall apply for preparation of surface except for pitched roof where surface shall be cleaned off any loose paint etc. To ensure good adhesion between the surface and water proofing treatment suitable method to dry the surface shall be adopted where necessary. All hair line cracks in the surface should be filled with the approved sealant.

11.44.4 Treatment

The water proofing shall consist of prefabricated five layered 2mm/3mm membrane as shown in Fig 11.12. The choice of 2mm or 3 mm membrane will depend on the type of roof i.e. pitched or flat and importance of building, durability, cost etc.

11.44.5 Laying

Bitumen primer of required grade shall be applied to the prepared roof, drain and any other surface wherever polymer modified membrane is to be laid over the primery coat the five layered water proofing membrane shall be laid using Butane torch and sealing all joints and preparing the surface complete.

Drain outlets shall be given same treatment as specified for the roof in the manner specified for the flat roof surface. Water proofing treatment shall be carried into the drain pipe or outlets by atleast 10 cm. The water roofing treatment laid on the roof surface shall overlap the upper edge of the water proofing treatment in the drain outlets by at least 10 cm.

The APP polymer modified prefabricated water proofing membrane shall be cut to the required length. Water proofing membrane shall normally be laid in length at right angles to the direction of the slope and laying shall be commenced at the lowest level and worked upto crest. APP water proofing membrane shall be laid in 6 to 8m lengths. The roof surface shall be cleaned and bitumen primer shall be applied in the correct quantity, over this specified water proofing membrane shall be laid with butane torch after allowing 24 hours for primer to dry. Each strip shall overlap the preceding one by at least 10 cm at the longitudinal edges and 15 cm at the ends. All overlaps shall be firmly bonded with bitumen primer and levelled by heating the overlaps with butane torch.

If the roof is accessible the treatment is protected by brick tiles laid over a 12mm thick cement mortar bedding and joints sealed with cement mortar or plain cement concrete.

High parapet walls, chimney stacks etc : APP water proofing membrane shall be laid as flashing wherever junction of vertical and horizontal surfaces occur, longitudinal laps shall be 10 cm. The upper edge of flashing membrane shall be well tucked into the flashing grooves in the parapets, chimney stack etc. to a depth of not less then 6.5 cm; corresponding applications of primer coat shall also be made. The flashing treatment shall be firmly held in the grooves and it shall be sealed with the approved sealant after terminating the membrane.

Low Parapet walls: Where parapet walls are of height 45 cm or less APP water proofing membrane flashings shall be provided in the same manner as for splashing in the core of high parapet walls except that upper edge shall be carried upto the full height of the wall and taken right across the top of the parapet and down on the external vertical faces to a minimum distance of 5 cm.

Low Dividing Walls: Where low dividing walls or inverted beams are met with, the same treatment shall be provided as for the main roof, the lateral bearing carried down both sides of the wall and overlapping the roof treatment.

Drain outlets where formed in the low dividing walls, shall be given water proofing treatment same as for the main roof.

Expansion Joints: Where the expansion joints are provided in the slabs, the joints and their cover slabs shall be suitably treated with water proofing treatment. For general guidance refer para 11.39.7.8

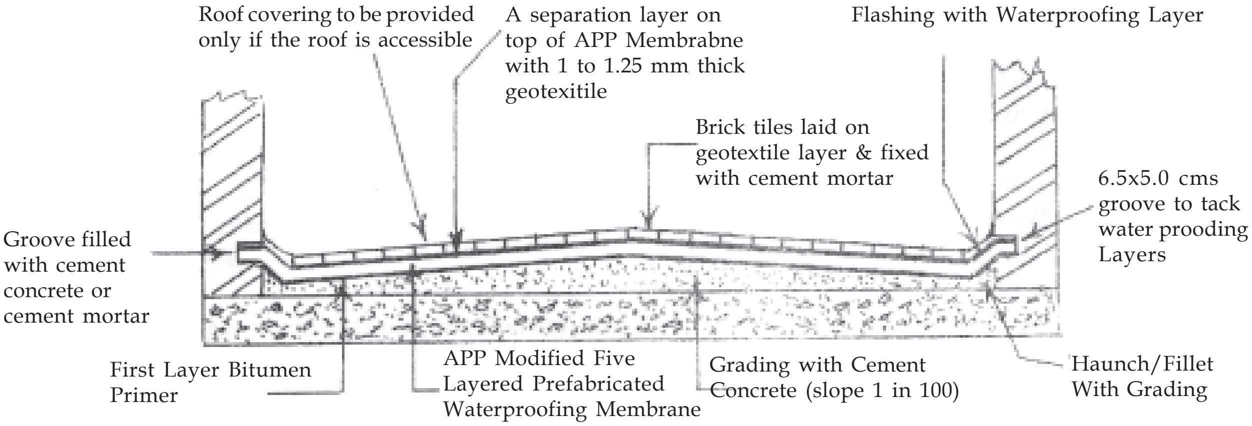


Fig 11.12: Water-proofing with APP modified Five layered Prefabricated water proofing membrane

11.45 Extra for covering of Atactic polypropylene modified prefabricated water proofing membrane with Geotextile

11.45.1 If the water proofing treatment of flat roof has been done with APP modified layered membrane and the roof is accessible, a separation layer on top of membrane should be laid before any protected treatment is done. Brick tiles in cement mortar or 25 mm thick cement concrete 1:2:4 shall be laid as final layer as shown in Fig 11.12 above.

11.45.2 Geotextile 120 gm non woven 100% polyester of thickness 1 to 1.25 mm manufactured by a company of repute is used.

11.45.3 Geotextile of the specified thickness is bonded to the water proofing membrane with intermittent touch by heating the membrane by Butane torch as per manufacturers recommendations.

11.46 Composite Roof insulation and water proofing - with Rigid Polyurethane Foam:
30 mm thick jointless sprayed foam (Fig 11.13 and 11.14).

11.46.1 Composite roof insulation and water proofing treatment serves the purpose of water proofing and roof insulation. It is strong light weight treatment, thereby reducing the dead weight on the building.

Efficient thermal insulation reduces heat to travel and therefore air conditioning losses are quite less.

This treatment can be applied to flat surface and is ideal for pitched roof, where very high disbonding stresses (such as leeward wind forces) are to be countered by the insulation curved, corrugated and irregular surfaces. Apart from external use, spray foam can be applied internally as long as building is suitable, having easy, convenient access for application and good ventilation. The foam can be sprayed on the underside of roofs on suspended floors and on the inner surface of walls.

Although this forms a weather resistance membrane, in addition final coating is required as an additional protection against sun rays. Liquid applied polyurethane foam should adhere strongly to any surface and should not sag, buckle while in use.

11.46.2 Materials

11.46.2.1 Polyurethane Foam:

Rigid Polyurethane Foam shall conform to IS:13205. A rigid cellular plastic material formed by catalysed reaction between polyisocynate and a plyhydroxyl compound (Polyol) with foaming agent which is normally a Chlorofluorocarbon gas. The foam shall be composed substantially of urethane linkages which are basically straight chain structures.

Salient properties of polyurethane foam for guidance are given below :-

Density = 42 ±2 kg/m^3	Thermal Conductivity = 0.023 W/mk(design)
Compressive strength =300 kpa	Water absorption (7 days) =0.2 kg/m^3
Tensile Strength = 280 kpa	Temperature limit = 100 degree C (Max)
Shear Strength =210 kpa	
Closed Cell content = 92% vol	

There are two methods of application of polyurethane foam

(i) In-Situ Pouring Method: A method adopted for complicated shapes for minimizing the number of joints or for strengthening the structures to be insulated by pouring (or injecting). This is also known as foam on foam or layer by layer application of rigid foam insulation. This is useful for thermal insulation of storage tanks, vessels, columns, piping, flanges, valves etc.

(ii) In-Situ Spray Method: This method is applicable for insulating large areas in short time where PUR foam system is sprayed on the surface to be insulated to form a foam insulation.

11.46.2.2 Isothane EMA

Elastomeric membrane is a liquid applied coating. It is urethane prepolymers based which cures by reaction with atmospheric moisture to give a continuous film which is rubbery and elastic. It contains leafing aluminum which gives excellent U.V resistance. It shall have higher viscosity than a conventional paint and is designed to give a high build film. It can be applied with brush and should not be diluted.

It cures to a permanently flexible, seamless membrane, which by virtue of its chemical reactivity in wet state has good adhesion as a base course to a wide range such as asphalt roofing, slates, tiles, asbestos concrete, brick, wood, glass and metals. Unlike traditional bitumen based product, it should not become brittle due to age or exposure to ultra violet radiation or weathering. It should not be effected by extremities of temperature variation.

Coverage rate varies with the texture, porosity of the surface. On average coverage of Isothane special primer shall be 6-10 m^2/litre and that of Isothane EMA @ 1 Kg/m and shall provide an adequate film thickness of lmm.

For guidance salient properties are given below :-

Specific gravity	1-18
Solid % min	95
Application limit	0- 70° C
Approximate Dry time (20 degree, 50% RH)	12-20 Hrs. touch dry 7 days full cure
Elongation %	= 500
Tensile strength	=2.07 Mn/mm^2
Accelerated weathering	= No appreciable deterioration (12000 Hrs)
Resistance to ultraviolet rays, hydrolysis, and industrial environment	= Excellent
Resistance to mechanical damage	= Good
Storage/Shelf stability	— 9 months

It shall be stored in a cool, covered and well ventilated space. Under no circumstance should the drum be kept in open or water be allowed to come in contract with the chemicals. Unnecessary opening of can should be avoided. Once opened it starts to cure and form skin. The cure skin should be removed to use the material below.

11.46.2.3 Handling of Foam System

Material should be stored as stated above and as per the instruction of chemical supplier. The supply shall be taken in sealed commercial container bearing the label of manufacturer with the following information.

(i) Indication of source of manufacture
(ii) Name of contents
(iii) Net weight of contents
(iv) Lot or batch number
(v) Recommended storage temperature range
(vi) A caution label indicating strict instruction for handling and storage temperature range,
(vii) Mixing instructions
(viii) Expiry date or shelf life and recommended maximum pot-life after opening of container.

11.46.2.4 Surface Finish

If the roof is not accessible, First coat urethane based Isothane Elastomeric water proofing membrane (EMA) over the entire surface @ 0.5 Kg/sqm is applied on P.U. foam. Second coat Isothane EMA @0.5 Kg/sqm is applied on the First coat.

If the surface is accessible brick tiles in cement mortar 25mm thick plain cement concrete 1:2:4 (1 cement : 2 coarse sand : 20 mm nominal graded stone aggregate) shall be laid in chequered 2.5 m x 2.5 m panels with 24 SWG X $^{3}/_{4}$" chicken wire mesh interposed in between and finished smooth. All joints between the panels shall be sealed with polymerised mastic.

11.46.3 Preparation of Surface

As far as applicable provision specified in 11.39.3 shall apply for preparation of surface. Roof slab should be free from all protrusion and depression having proper slope and free flow of water. Remove all loose materials by vigorous brushing by wire mesh if necessary. Surface should be thoroughly dry, any moisture is to be dried.

11.46.4 Treatment

11.46.4.1 Composite roof insulation and water treatment shall consist of a four course treatment or with a wearing course of brick tiles or 25mm thick plain cement concrete 1:2:4 , as specified.

11.46.4.2 The choice of four course or with a wearing treatment shall depend whether roof is inaccessible/accessible.

11.46.4.3 A four course treatment shall consist of the following

(i) Polyurethane primer
(ii) 2nd layer of 30 mm thick Rigid polyurethane foam
(iii) 3rd layer (first coat) or urethane based isothane Elastomeric water proofing membrane
(iv) Final layer (2nd coat) of isothane EMA.

For accessible roof a wearing course of 25mm thick cement concrete 1:2:4 shall be laid as final layer over the four courses treatment mentioned above.

11.46.5 Laying

11.46.5.1 Over the cleaned surface apply polyurethane primer over the entire area @ 5-6 sqm/litre. 2nd layer of 30mm thick Rigid Polyurethane Foam conforming to IS :13205 with density of foam being 40-45 Kg/m^3. This is a seamless and monolithic treatment. Application of rigid/poly urethane by spray eliminates separate fixing procedure. Foam is sprayed with the help of two component Gusmer machine which are capable of maintaining the mix ratio within ± 2% accuracy and controlling the temperature at precisely the optimum range. 3rd layer (first coat) of isothane EMA elastomeric membrane coating @ 0.50 kg/sqm is applied, average maximum thickness of 0.50 mm. Before laying this layer fill cracks and voids with mastic sealant if required.

4th layer (2nd coat) of isothane EMA : The first coat should be touch dry in 12 to 48 hours (in some conditions this might be delayed) and the 2nd coat of isothane @ 0.5 kg/sqm should be applied average maximum thickness of 0.5 mm with 24 hours to ensure good adhesion. Due to some reason or otherwise if it is not possible to lay 2nd coat within 24 hours of laying of first coat, prime the entire surface with special primer and allow to dry before 2nd coat is laid within 4 to 8 hours. An overlap of 150mm shall be provided. Total thickness of first and 2nd coat shall not be diluted.

All completed works shall be cleaned to remove any spills of chemicals. Aromatic hydrocarbon solvent should be used to clean equipment.

If the surface is accessible the treatment is protected by bricks tiles in cement mortar or 25mm thick plain cement concrete with 24 SWG X $^3/_4$″ chicken wire mesh interposed in between as per the recommendation of execution agency.

11.46.5.2 High Parapet Walls

Water proofing layer shall be laid as flashing wherever junction of vertical and horizontal surface occur.

11.46.5.3 Low Parapet Walls

Where parapet walls are of height 45 cm or less the same treatment as for the main roof shall be carried out and taken right across the top of parapet and down on the external vertical faces to a minimum distance of 5 cm.

Low dividing walls, drain outlets: Where low dividing walls or inverted beams are met with, the same treatment shall be provided as for the main roof.

Expansion Joints : Where expansion joints are provided in slabs, the joints and their cover shall be suitably treated with water proofing treatment.

11.46.6 Precautions

Precautions to be taken while handling volatile chemical substances

(i) Protective work clothes
(ii) Safety glasses preferably with side protection
(iii) Protective gloves which are impermeable to liquid
(iv) Chemical resistant work shoes
(v) Water containers and dispensers to wash parts of the body which may accidentally be exposed to spills
(vi) Bottles of eye cleansing lotion in case of accidental splashing to the eyes of personnel
(vii) Clothes should not be allowed to get saturated with chemicals, in case it happens, proper washing be carried to prevent the remote possibilities of skin contact and irritation caused thereby. Work place must be ventilated at all times.

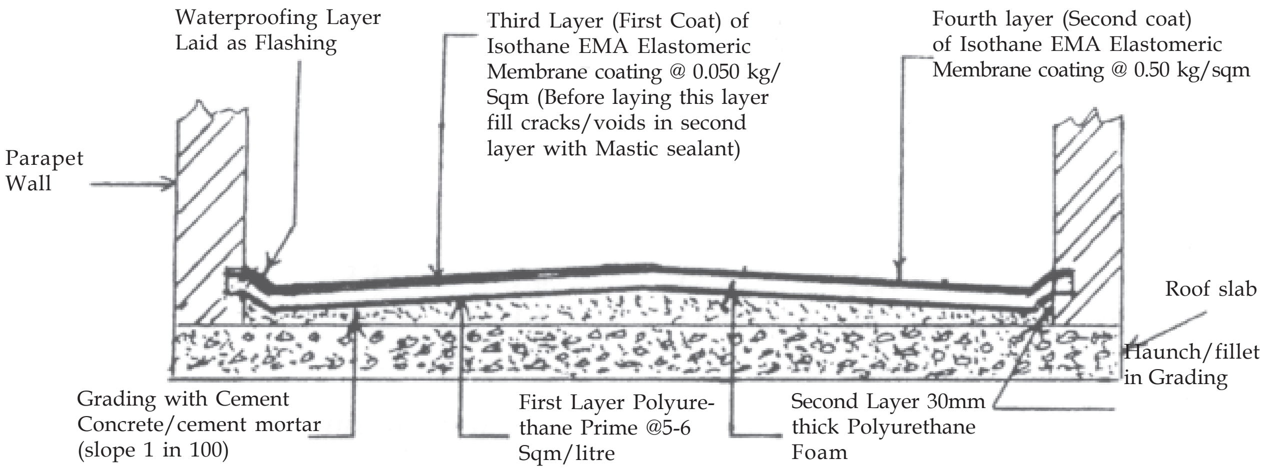
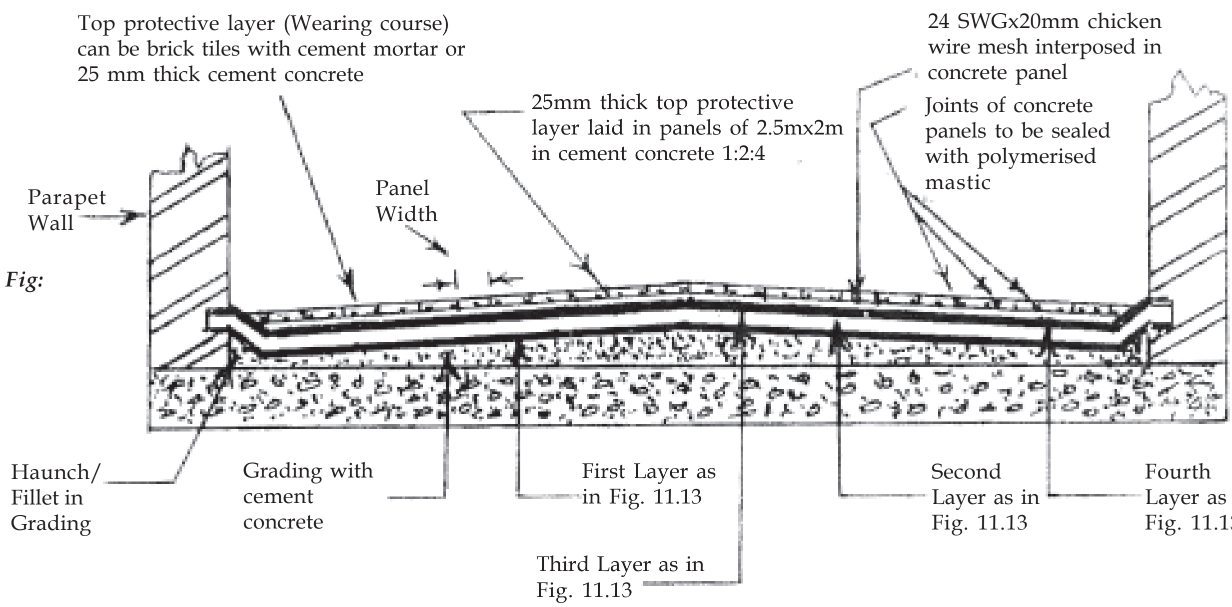


Fig: 11.13: Insulation/Water- proofing with ployurethane foam over roofs for which no Access is provided

Fig:



11.14: Insulation/Water-proofing with polyurethane foam over roofs for which access is provided.

Appendix 'A'

BITUMEN FELT (FIBRE HESSIAN BASE)

A-l Weights

The weights of the ingredients used in the manufacture of bitumen felt per 10 sqm shall not be less than those specified in Table 8.

TABLE 8
MINIMUM WEIGHTS OF BITUMEN FELTS

SI. No.	Type of felt: Fibre base	Untreated Base Kg	Saturant Kg	Coatant Kg	Bitumen content Kg	Total weight of the finished bitumen felt in dry condition with mica dusting powder Min Kg
(i)	Type 2 Grade 1	5.0	5.7	10.7	11.9	21.9
(ii)	Type 2 Grade 2 Hessian Base	4.0	4.5	21.8	17.1	30.8
(iii)	Type 3 Grade 1	2.3	1.8	17.7	12.1	22.3
(iv)	Type 3 Grade 2	2.3	1.8	31.8	20.2	36.4

Note: 1. The weight of the untreated base shall be taken as in the dry condition.
2. Includes allowance for 0.5 Kg minimum mica dusting powder in dry condition.

A-2 Sampling

A-2.1 All the rolls of the same type and grade and from the same batch of manufacture, in one consignment shall constitute a lot.

The conformity of the lot to the requirements of the standard shall be determined on the basis of inspection and tests carried out on the samples selected from the lot.

The number of rolls to be taken from the lot shall depend upon the size of the lot and shall be in accordance with table 9.

TABLE-9
SAMPLE SIZE

No. of rolls in the lot	*No. of rolls to be selected in the sample*	*Permissible no. of defective rolls*	*Sub-sample sizes, no. of rolls to be selected.*
1	2	3	4
Upto 100	5	0	2
101 to 150	8	0	3
151 to 300	13	0	4
301 to 500	20	1	5
501 to 1000	32	2	6
1001 to 3000	50	3	8
3001 and above	80	5	10

Note:1. All the rolls taken as per column 2 shall be inspected for width, length and visible external defects.
2. The rolls taken as per column 4 shall be tested for breaking strength, pliability, storage sticking, heat resistance, water absorption and pressure head.

These rolls shall be taken at random from the lot, and in order to ensure randomness of selection, random number tables may be used. In case random number tables are not available, the following procedure may be adopted for the selection of the rolls.

Starting from any roll in the lot count them as 1,2, 3.... r and so on, in one order. Every rth roll thus counted may be selected till the requisite number of rolls for the samples is obtained, r being the integral part of N/n, where "N" is the number of rolls in the lot and "n" the number of rolls to be selected in the samples.

A-2.2 From each of the rolls one piece 3m long and the full width of the felt shall be cut out for preparing test specimens. The first 2m of the roll shall not be selected for this purpose. The lengths of felt so selected shall be free from abnormal defects and shall be truly representative of the whole consignment. The selected piece of felt shall be dispatched without breakage or distortion, wrapped up in water proof paper or other similar materials so as to cause no damage to the material during transit. In case the material has stuck together, no heat shall be applied to separate the layer but the whole roll shall be sent for testing and the fact shall be reported.

A-3 Tests

The samples, when tested as per IS :1322 shall conform to the requirements given in Table 10.

TABLE 10

Sl. No.	Type of Felt	Breaking strength Kg Wrap way	Breaking strength Kg Weft way	Pliability test	Storage sticking test	Heat Resistance test	Pressure head test	Water absorption test Max.
1.	Type 2 (all grades)	95	60	(i) The roll shall not show cracks on unrolling	The test pieces shall be examined after cooling	The test pieces shall show no sign of melting of the bitumen compound	The test pieces shall show no sign of leakage	5.0%
				(ii) Consider any surface rupture exceeding 5mm in length as failure	After release of the load, the layers of felt shall be capable of being separated without damaging the coatant in any way			
2.	Type 3 (all grades)	135	90	(i) The roll shall not show cracks on unrolling	The test pieces shall be examined after cooling	The test pieces shall show no sign of melting of the bitumen Compound	The test pieces shall show no leakage	2.0%
				(ii) Consider Surface rupture exceeding 5mm in length as failure	After release of the load, the layers of felt shall be capable of being separated without damaging the coatant in any way			

Criteria for conformity

The lot shall be considered to be in conformity with the requirements of the standard if the following condition are satisfied :-

(a) The number of rolls found defective with respect to width, length and visible external defects do not exceed the corresponding number given in column 3 of table 9.

(b) From the observed values of breaking strength, the average X and the range R are calculated for each direction (that is, warp way and weft way) separately and the value of the expression X-0.6 R is found to be greater than or equal to the applicable specified value.

Note: 1. Average X is the value obtained by dividing the sum of the observed values by the number of observed values.

Note: 2. Range R is the difference between the maximum and minimum in a set of observed values.

(c) For all the other characteristics (except breaking strength) all the test pieces satisfy all the requirement of the characteristic individually.

Appendix 'B'

GLASS FIBRE BASE BITUMEN FELT
(Clause 11.39.2.1)

B-l Weight

The weight of the ingredients used in the manufacture of glass fibre felts for 10 square metre shall not be less than those specified in Table 11.

TABLE 11
MINIMUM WEIGHT OF BITUMEN GLASS FIBRE BASE FELT
For 10 Square Metre

S.No	Type of felt	Untreated base (Kg)	Treated base surfacing material (Kg)	Coatant condition (Kg)	Total weight in dry including (Kg)
1.	Type 2 Grade 1	0.4		15.3	18.0

B-2 Sampling

All the rolls of the same type and grade and from the same batch of manufacture, in one consignment shall constitute a lot. The conformity of the lot to the requirements of this standard shall be determined on the basis of the inspection and test carried out on the samples selected from the lot. The number of rolls to be selected from a lot shall depend upon the size of the lot and shall be in accordance with

TABLE 12
TABLE 12 SAMPLE SIZE AND CRITERION OF CONFORMITY

No. of rolls in the lot	*No. of rolls to be selected in the sample*	*Permissible no. of defective rolls*	*Sub-sample size, no. of rolls to be selected.*
1	2	3	4
Upto 100	5	0	2
101 to 150	8	0	3
151 to 300	13	0	4
301 to 500	20	1	5
501 to 1000	32	2	6
1001 to 3000	50	3	8
3001 and above	80	5	10

Note:1. All the rolls taken as per column 2 shall be inspected for width, length and visible external defects.

2. The rolls taken as per column 4 shall be tested for breaking strength, pliability, storage sticking, heat resistance, water absorption and pressure head.

These rolls shall be taken at random from the lot and in order to ensure randomness of selection, random number tables may be used. In case random number tables are not available, the following procedure may be adopted for the selection of the rolls.

Starting from any roll in the lot count as 1, 2, 3...........r and so on, in one order. Every rth thus counted may be selected till the requisite number of rolls for the sample is obtained, r being the integral part ofN/n, where N is the number of rolls in the lot and n the number of rolls to be selected in the sample.

From each of these rolls one test sample 3m long and the full width of the felt shall be cut out for preparing test specimens. Test samples shall not be taken from damage portion of the rolls, if any, the required number of test specimens shall be taken from each of the test sample and subjected to the corresponding tests.

B-3 Tests

The samples, when tested as per IS :7193 shall conform to the requirements given in Table 13.

TABLE 13
REQUIREMENTS OF GLASS FIBRE FELTS

SI. No.	*Type of Felt*	*Minimum breaking strength Kg*		*Pliability test*	*Storage sticking test*	*Pressure head test*	*Heat Resistance test*	*Water absorption test Max.*
		Wrap way	*Weft way*					
1.	Type 2 Grade I	50	30	(i) The roll shall not show cracks on unrolling	The test pieces shall be examined after cooling	The test pieces shall show no sign of melting of the bitumen compound	The test pieces shall show no sign of leakage	2.0%
				(ii) Consider any surface rupture exceeding 5mm in length as failure	After release of the load, the layers of felt shall be capable of being separated without damaging the coats in any way			

B-4 Criteria for conformity

The lot shall be considered to be in conformity with the requirements of the standard if the following conditions are satisfied :-

(a) The number of rolls found defective with respect to width, length and visible external defects, do not exceed the corresponding number given in column 3 of table 12.

(b) From the observed values of breaking strength, the average X and the Range R are calculated for each direction (that is, warpway and weftway) separately and the value of the expression X-0.6 R is found to be greater than or equal to the application specified value.

Note: 1. Average X is the value obtained by dividing the sum of the observed value by the number of observed value.

2. Range R is the difference between the maximum and minimum in a set of observed values.

(c) For all the other characteristics (except braking strength), all the test pieces satisfy all the requirements of the characterstics individually.

SECTION 12
CEILINGS AND LININGS

12.1 Indian Standards

The following IS apply to this section :

IS No.	*Subject*
373-1975	Specification for plywood for general purposes (Second revision)
451-1999	Technical supply conditions for wood screws, (Third revision).
723-1972	Specification for steel countersunk head wire nails (First revision).
749-1978	Specification for handloom cotton dungri cloth (First revision).
848- 2006	Synthetic resin adhesive for plywood. (Phenolic and Aminoplastic)
1328-1996	Specification for veneered decorative plywood (Third revision).
1658-2006	Specification for fibre hard-boards (Third revision).
1659-2004	Specification for block boards (Third revision).
2046-1995	Specification for decorative thermosetting synthetic resin bonded laminated sheets (First revision).
2095 Part 1 1996	Specification for gysum plaster boards: Part 1Plain gypsum plaster boards
2095 Part 3 1996	Specification for gypsum plaster boards: Part 3 Reinfroced gypsum plaster boards.
2098-1997	Specification for asbestos cement building boards. (First Revision)
2547 Part 1 1976	Specification for gypsum building plaster: Part 1 Excluding premixed light weight plaster.
3087-2005	Specification for wood particle boards of wood and other lingnocellulosic material (medium density) for general purposes (Second revision).
3097-2006	Specification for veneered particle boards, (Second revision)
3129-1985	Specification for low density particle board.
3308-1981	Specification for wood wool building slabs, (First revision).
3348-1965	Specification for fibre insulation boards.
8183-1993	Specification for bonded mineral wool.
12406-2003	Medium density fibre board for general purposes.

12.2 Asbestos Cement Building Boards

AC Building boards shall conform to the requirements of Class B of IS-2098-1997 Specifications for asbestos cement building boards. 4 mm thick building boards are not covered by IS 2098; these shall be of approved make. Building boards shall have natural colour.

12.2.1 Finish

Building Boards shall be free from visible defects that impair appearance or serviceability. The surface of the boards shall be of uniform texture. Boards shall have nearly trimmed edge and shall be square at the corners.

12.2 Tolerance

Tolerance on the thickness of boards shall not exceed ± 0.5 mm.

12.3 Fibre Insulation Boards

Fibre insulation boards shall conform to the requirements of IS 3348-1965. Specification for fibre insulation boards. The boards shall be ordinary type except where flame retardant type is indicated. The mean density of the boards shall not exceed 0.4 gm/cu.cm. Flame retardant boards may be treated on one face or both the faces, as indicated.

12.3.1 In the case of flame retardant boards on one face only, the face which is treated shall be clearly marked.

12.3.2 Tolerance

Permissible tolerance on the thickness of the fibre insulation board shall be as under: -

12 mm, thick boards	: ± 0.75 mm
18 mm thick boards	: ± 1.0 mm

12.4 Particle Boards for Insulation Purposes

Particle boards for insulation purposes shall conform to the requirement of IS 3129- 1985, Specification for particle board for insulation purposes. Boards shall have either flame retardant chemical mixed during manufacture or shall be impregnated with a solution of flame retardant chemical. The density of the board shall not exceed 0.4 gm/cu.cm and shall not vary from board to board by more than ± 10 percent

12.4.1 The permissible tolerances on the nominal thickness of finished boards shall be as follows: -

For boards upto 25 mm thick	: ± 0.8 mm
For boards above 25 mm thick	: ± 1.0 mm

12.4.2 Accoustic Tiles:

Particle board for insulation purposes may also be used for accoustic purposes where indicated or directed. Accoustic tiles shall be perforated, if so indicated.

12.5 Wood-Wool Building Slab

Wood-wool building slabs shall be light weight slabs, type 1 conforming to the requirements of IS 3308-1981, Specification for wood wool building slabs. Cement used for bonding the wood wool shall be magnesium oxychloride cement, unless otherwise indicated.

12.5.1 The slabs shall be of uniform thickness with rectangular parallel faces and shall have clean reasonably square edges and shall be of uniform texture. The weight of individual slab of 2x0.5 m size shall be as follows:

15mm	5-5.5 kg
25mm	10-11 kg
40mm	12-12.5 kg
50mm	15-16 kg
75mm	20-22 kg

12.5.2 The permissible tolerance on the thickness of the slabs shall be ± 2 mm.

12.6 Medium Density Fibre Board

Medium density fibre board shall conform to the requirement of IS 12406-2003. Grade of the board shall be as indicated.

Exterior grade phenol formaldehyde	EGSB
Interior grade	IGSB

Thickness of the board shall be indicated

12.7 Decorative laminates

Decorative Laminates shall be type 1 having only one side bearing the decorative surface and the other side being roughened or given appropriate treatment to promote adhesion to the base and shall conform to the requirements of IS 2046-1995, Specification for decorative thermosetting synthetic resin bonded laminated sheets. IS 2046 does not cover 1 mm thick decorative laminates which when specified, shall be of approved make.

12.7.1 The type of surface finish colour and pattern shall be as directed. The sheets shall be reasonably free from local deformation. Since sheets may vary slightly in colour and appearance, the sheets for any one scheme shall be matched.

12.7.2 Tolerance

Tolerance on thickness of sheets shall not exceed ± 0.25 mm.

12.7.3 Sheets shall not split or crack when sawn, milled, drilled and tapped.

12.8 Gypsum Plaster Board

Gypsum plaster board shall conform to IS 2095-1996 Part 1 or 2 as indicated. The type of board shall be well board or base board as indicated. The thickness shall be indicated. The board shall be square edge board or tapered edge board as indicated.

12.9 Bonded Mineral Wool

The material shall be mineral wool made from rock slag or glass, as indicated processed from molten state into fibrous form and bonded with a suitable binder and shall conform to the requirements of IS 8183-1993, Specification for bonded mineral wool. The slabs, unless otherwise indicated, shall be supplied unfaced. Where indicated mineral wool slabs shall be covered with polythene based Hessian/Glass cloth or GI wire netting on one or both faces to meet the particular requirement.

12.9.1 The bulk density of the material excluding facing shall be 48 Kg/Cu.m as indicated, specified for Group I for maximum recommended hot face temperature upto 250^{0}C. For any particular product the variation from the manufacturer's declared value for bulk density calculated at the nominal thickness shall not exceed± 15 percent.

12.9.2 The shot content shall not be more than the values given below. Any shot present in the bonded mineral wool shall not be greater than 5 mm in any direction.

IS Sieve	Shot content, Percent by Mass, Max
500 micron	5
250 micron	15

12.9.3 The material shall be rated as incombustible and shall not contain more than 0.6 percent of sulphur.

12.9.4 Bonded mineral wool shall not show any mould or bacterial growth. The material shall not cause corrosion of the surface on which it is applied, and shall not suffer visible deterioration of the fibrous structure when heated to the maximum recommended temperature of use.

12.9.5 Tolerance

Dimensional tolerance for thickness shall be - 2 mm. An excess in thickness is permitted.

12.9.6 Plywood

Plywood shall conform to the requirements of IS 373-1975, Specification for plywood for general purposes. Plywood shall be of grades BWP (boiling water proof) or BWR (boiling water resistant), as indicated. The quality requirement of each face of the plywood as given in Table 1 of the IS, shall not be inferior than type B. Along with the thickness of plywood, the number of plies shall also be indicated.

12.10 Plywood

Plywood boards shall be uniform thickness and free from warp and cracks. The faces of plywood boards shall be reasonably smooth with face veneers of uniform thickness. The edges of the boards shall be trimmed square.

12.10.1 Tolerance

Permissible tolerance on the thickness of plywood boards shall be as under: -

For boards upto 5 mm thick	± 10 percent
For boards from 6 mm to 9 mm thick	± 7 percent
For boards exceeding 9 mm thick	± 5 percent

12.11 Decorative Plywood

Decorative plywood shall be of type I quality conforming to IS 1328-1996, Specification for veneered decorative plywood. Decorative plywood shall have decorative veneers of the specified species of timber and on one or both the faces, as indicated.

12.11.1 The adhesive for bonding of veneers shall be synthetic resin adhesive conforming to IS 848-1974.

12.11.2 Tolerance

Permissible tolerances on the thickness shall be as under:-Positive: 10 percent of nominal thickness. Negative: 5 percent of nominal thickness.

12.12 Block Boards

Block Boards shall conform to the requirements of IS 1959-2004, Specification for block boards. Block boards shall be of grade I quality, exterior grade or grade 2 quality, interior grade and of decorative type or commercial type as indicated. In case of decorative type it shall be indicated if one or both the faces shall have decorative face veneer. Strips of wood in the core may be laid separately or glued or otherwise jointed.

12.12.1 Block boards shall be flat and square. Both faces of block board shall be sanded to a smooth even surface. Block boards shall be uniform in thickness within the tolerances specified.

12.12.2 Tolerance permissible on the thickness of block boards shall be ± 5 percent for boards upto 25 mm thickness and ± 2.5 percent for boards above 25 mm thickness.

12.13 Particle Boards

Particle boards shall conform to the requirements of IS 3087-2005, Specification for wood particle boards (medium density) for general purposes. Adhesive used for bonding purposes shall be phenol formaldehyde as indicated.

12.13.1 Particle boards may be either flat pressed single layer type or flat pressed three layer type, unless a particular type has been indicated. In case of three layer particle boards the construction shall be well balanced about the central plane. In the case of single layer particle board the particles shall be uniformly distributed.

12.13.2 Particle boards shall be of uniform thickness and uniform density throughout the board. Both faces of particle board shall have sanded smooth finish.

12.13.3 Density

Mean density of the boards shall be between 500 to 900 kg/cu.m. The density shall not vary from one board to another by more than 10 percent of the mean density.

12.13.4 Particle boards shall not crack *or* split when drilled, sawed *or* nailed perpendicular to the surface.

12.13.5 Tolerance

Tolerance permissible on the thickness of particle boards shall be ± 5 percent for boards upto 25 mm thick and ±2.5 percent for boards above 25 mm thick.

12.14 Veneered Particle Boards

Veneered particle boards shall conform to the requirements of IS :3097-1980, Specification for veneered particle boards. The boards shall be of interior *or* exterior grade with solid core, and shall be general purpose type or decorative type, as indicated. In case of decorative type it shall be indicated if one *or* both faces shall have decorative face veneer. Face veneers of commercial type veneered particle boards shall not be inferior than exterior grade phenol formaldehyde.

12.14.1 Finish &Tolerance

Finish and tolerance permissible on the thickness of veneered particle boards shall be same as specified under 'Block boards'.

12.15 Reeds for In-Situ Walling

Reeds may be of Ekra, Khagra, Nal or Sarkanda, or as indicated. Reeds shall be cut from mature plant, which have their sheaths firmly attached and shall be free from rot or decay and of approved quality. The reeds shall be cut to the required length and spread out in sun until all the moisture is dried out.

12.16 Cloth for Ceiling and Lining

Dungri cloth shall conform to the requirement of IS 749-1978, Specification for handloom cotton dungri cloth, grey. The weight of the dungri cloth shall be 330 gm/sq.m. The cloth shall be thoroughly washed before use to free it from chemicals, Otherwise after being whitened it may turn black.

12.16.1 Hessian shall be No.l (11 porters 12 shots) weighing 320 gm/sq.m. *or* as indicated.

12.17 Nails & Screws

Nails shall conform to IS 723-1972, Specification for steel countersunk head wire nails. The nails shall be diamond pointed. Screw shall be conform to IS 451 :1999 Technical supply conditions for wood screws. Special nails recommended by the manufacturer, if any, shall be invariably used.

12.18 Plaster of Paris (Gypsum Anhydrous Tiles) Ceiling Board

Plaster of Paris (Gypsum Anhydrous) tiles shall be made from Gypsum Anhydrous conforming to IS 2547: Part 1-1976 reinforced with Hessian cloth. The thickness of tiles shall be 12 mm *or as* indicated.

Workmanship

12.19 Material

The type of boarding etc. in ceiling and lining, their thickness/density and finish shall be as indicated.

12.20 Fixing Generally

12.20.1 When handling, boards and sheets shall be carried on edge and not flat to prevent buckling and cracking.

12.20.2 Before fixing, the boards shall be conditioned to the humidity of the atmosphere by stacking them loosely on edge for a period of 24 hrs to 48 hrs so that air can have free access to both sides of each sheet during the period. Hardboards shall be conditioned as specified under 'Fixing Hardboard'.

12.20.3 Before fixing the boards, sheeting tiles, etc. to the framework, the framework shall be checked with regard to the level, position and vertically of its outside surface and for proper fixtures and joints.

12.20.4 Boards, sheeting, tiles etc. shall be checked for correct sizes, squareness of adjacent sides and laying patterns.

12.20.5 Boards shall be cut to the required size and to conform to the pattern of panels as directed. Each panel shall be in one whole piece. The board should be sawn with the face-side up and a fine and even edge obtained. The joints in the boards shall be with the square or slightly rounded edges as directed. The edges shall be lightly sandpapered to make them smooth.

12.20.6 Fixing

Unless otherwise directed, boards shall be fixed with length parallel to all joints, centered over framing members. Where the joints are to be covered, the boards shall be closed butt jointed or spaced 3 to 6 mm apart as per manufacturer's instructions or as indicated. Where joints are to be left exposed, the boards shall be butt jointed with a minimum clearance of 3 mm or as directed. The boards shall be supported and held tight to the background with timber pieces, these being marked outwards as the fixing proceeds. The boards are first fixed to the intermediate framing member proceeding from the center of the boards outwards, the edges being fixed last.

12.20.7 Where boards are fixed with nails, they shall be countersunk into the boards with suitable punch. Care shall be taken in driving the nails that the boards/sheets are not marked by hammer blows.

12.20.8 The screws shall be rustless and oiled before fixing.

12.20.9 Finishing

The exposed side of the board fixed in ceiling shall be truly level and plane except in the case of sloped ceiling and truly vertical when fixed in wall lining without any local bulges or sags. The joints shall be truly parallel and/or perpendicular to the walls. The width of joints shall be uniform.

Care shall be taken to ensure that the boards are not dirtied and uniformity of the colour of the boards is not spoilt during the fixing operations. Ceiling boards and wall linings, when fixed, shall present a neat and uniform appearance.

12.21 Fixing of AC Building Boards

12.21.1 Asbestos cement building boards shall be fixed to the wooden frame-work with wood screws, care shall be taken to avoid rigid fixing as this may cause cracking when the supporting structure expands or shrinks. Holes in the boards shall be drilled and on no account be punched. No holes shall be nearer than 12 mm to the edge of the board. The board shall be butt jointed and fixed with screws at 15 cm to 20 cm intervals at edges and 30 cm intervals in middle. Screws shall be countersunk and covered by Plaster of Paris. Alternatively a gap of 3 to 6 mm shall be kept between the adjoining edges of the sheets where indicated.

12.21.2 The joints in the board shall be covered with wooden beading or AC cover strips, as indicated. The beading or the cover strip shall be screwed along the central line of the joints. The spacing of the screws shall be 15 to 20 cm centres.

12.22 Fixing of Insulation Building Boards

12.22.1 Insulation boards shall be fixed invariably as per the manufacturer's instructions; Where such instructions are not given, the method of fixing shall be as follows. Where joints are to be covered the boards shall be spaced 3 to 6 mm apart. Where joints are to be left exposed, the sheets shall be butt laid with their edges abutting in moderate contact, but without having to force them into place.

12.22.2 Where the joints are to be left exposed the outer row of nails shall be placed at 10 cm centres and about 12 mm from the edge of the sheet. Along the line of intermediate support the nails shall be spaced 20 cm apart. Nails in the outer rows on either sides of joint shall be paired and not staggered.

12.22.3 Where the joints are to be covered with beading, felt headed (clout) nails shall be used instead of lost head nails. The spacing of the nails in the interior rows in boards shall be 20 cm centres. In the outer rows at edges to be covered by beading, the nails shall be spaced at 20 cm centres in each row but which the nails staggered. The beading shall then be fixed over the sheets with screws at 20 cm centres in each row with screws in the two rows staggered and passing through beading, sheet and framing.

12.23 Fixing of Hardboards

12.23.1 The length of the screws shall be 25 mm for 3 to 6 mm thick board and 30 to 35 mm for 8 to 12 mm thick board.

12.23.2 Open joints may be covered with wooden beading or plain cover strips cut from the boards as indicated. The cover strips shall be screwed along the central line of the joints, so that the fixing of screws pass through the open joints. The spacing of screws shall be at 15 cm to 20 cm centres.

12.23.3 Uncovered joints may be chamfered or otherwise finished as directed.

12.24 Fixing of Plywood, Block board, Particle Board and Veneered Particle Board.

12.24.1 Decorative veneers shall be matched or mismatched to achieve a decorative effect in colour, figure and grail. Where directed decorative veneers shall be matched to particular design, for example quartered, centered, diamond or V matched or shall be arranged to form a group to give an overall general effect. The pattern and figure matching shall be decided, put on paper and boards preferably numbered for their positions. Any board so required shall be cut to the required plan.

12.24.2 The boards shall be carefully lifted and fixed to the frame-work with wood screws. All the edges shall be fixed to the frame members by screws spaced 7.5 cm center for 4 mm to 6 mm thick plywood, for thicker boards, the center to center spacing of screws may be at about 15 times the thickness. The screws shall have a clearance of 10 mm from the edge line. At the line of intermediate support, the screws shall be fixed at center to center spacing not exceeding 25 times the thickness. All the screws shall be countersunk. The screws shall be fixed starting from one corner and extending to both sides to fix the board flat and level. The length of the screws shall be as follows:

(a) For boards up to 7 mm thick	-	25 mm
(b) For boards above 7 mm upto 12 mm thick	-	35 mm
(c) For boards above 12mm thick	-	Thickness +20 mm

12.24.3 The joints, if left open, shall be filled with painter's putty and brought to level or may be cut to "V" shape. They may also be left open, bevelled or parallel grooved using plane and chisel or grooving cutter. The boards may also be pre-cut and edges rounded before fixing. In the case of decorative boards, the joints may be coloured to match the general colour and pattern of the ceiling boards. Alternatively the open joint shall be covered by a beading or strips as indicated.

12.24.4 Finishing

The boards after fixing shall be finished by paper-sanding, where necessary.

12.25 Fixing of Decorative Laminates

Decorative laminates shall be fixed to the base with approved adhesives as per manufacturers' instructions.

12.26 Bonded Mineral Wool

Mineral wool blankets shall be friction fitted within framework over the ceiling board or behind the wall lining as per manufacturer's instructions.

12.27 Fixing Cloth Ceiling and Lining

The cloth shall be damped, stitched over the framework and fastened with tacks on the outside. Panels of the framework shall not exceed 1.5x1.5 m in size, unless otherwise indicated. Wooden beading shall be fixed to framework, with screws at 20 cm centres.

12.28 Fixing Cover Fillets and Beading

Unless otherwise specified, cover fillets and beading shall be fixed centrally over the butt joints between the two boards with screws in two rows on either side of the joints. The spacing of the screws in each row shall be about 20 cm centres. The screws shall pass through the cover fillets beading, the boards and into the timber frame work, with a minimum grip of 25mm in the latter. Where the cover strip beading is to be fixed to the board above for ornamental purposes there being no frame work scantling above, then the beading shall be fixed with screws which shall be driven through the full depth of the board and spacing of screws shall be 20 cm centres.

The screws should be oiled before insertion and in no case be hammered in. The screws shall be driven countersunk slightly below the surface of the cover fillet/beading.

12.28.2 The junction of the cover fillet/beading shall be fully mitred or partly mitred as directed by the EIC. Where joints are to be fully mitred, both the longitudinal as well as cross beading shall be the exact length as required by the panel arrangements. Where the joints are of the partly mitred variety and the length of cover fillet / beading in one direction can run continuously over more than one panel then the minimum length of beading shall be 1.8 m. Joints shall come at the corners of the panel and not in the middle of a panel side.

12.28.3 Cover fillets/beading shall be fixed so that there is absolutely no gap left between the cover fillet/beading and the ceiling board/wall lining in the joint faces. The cover fillet/beading lines shall be absolutely Straight and parallel. The plane of the underside of the cover fillet/ beading shall be uniform.

12.29 Reed Walling

12.29.1 Grooves shall be made in the timber frame to a depth of not less than 15 mm and the reeds shall be slipped into to the grooves one by one. The reed walling so formed shall be stiffened by means of double bamboo slips, 25 mm wide and not less than 6 mm thick, spaced at intervals of not more than 40 cm apart. One slip shall be attached on each side of the reed and tied together by means of same slip and further strengthened by tying with 0.9 mm mild steel wire (annealed) at 45 to 60 cm apart One stiffening clip shall be placed with in a distance of 8 cm of all the battens.

12.29.2 Reeds shall be fixed with just sufficient space of one centimetre between each other so that the mortar applied on one side for finishing penetrates to the other side to form a key for plaster. All vertical timbers the walling shall be recessed with grooves 4 cm wide and 1.5 cm deep and plaster forced into the groove so that there is no gap between the groove and the plaster when the plaster sets and dries.

12.29.3 Reeds shall be relatively dry prior to application of plaster.

12.30 Plaster of Paris Ceiling Work with Tiles

12.30.1 Preparation of Plaster of Paris Tile

Tiles of Plaster of Paris reinforced with Hessian cloth shall be prepared on glass or smooth surface in suitable sizes as indicated. The maximum size of tiles shall be limited to 600mm. In each direction wooden forms of height equal to the thickness of tiles shall be placed on a true level and smooth surface such as a glass sheet.

The section of form sides shall be such that the edge of the tiles shall be provided with a neatly formed camber alround of 5 mm width and 8 mm depth, unless the tiles are to be provided with cover fillets over joints in which case the edges of the tiles shall be truly square. Plaster of Paris shall be evenly spread into the form upto about half the depth and Hessian cloth weighing not less than 230 gms per square meter shall be pressed over the Plaster of Paris layers. The ends of the Hessian cloth shall be turned over at all edges to form a double layer to a width of 50 mm. The Hessian cloth shall be of an open webbed texture so as to allow the plaster below and above to intermise with each other and form an integral hole. The form shall then be filled with Plaster of Paris which shall be uniformly pressed and then wire out to an even and smooth surface. The tile so moulded shall be allowed to set initially for an hour or so and then removed from the form and allowed to dry and harden for a week. A good tile after drying and hardening shall give a ringing sound when struck. The tiles shall be true and exact to shape and size and with clean and regular chambers. The exposed surface shall be truly plane and smooth.

12.30.2 Fixing of Plaster of Paris Tiles

12 mm thick Plaster of Paris tiles shall be fixed to the cross battens of the ceiling frame with 40 mm brass screws at a spacing not exceeding 20 *cm centre to centre* on all edge. The tiles shall be laid with their edges in just close position to the adjoining tiles without any gap in between. The line of screws shall not be less than 15 mm away from the edges of the tiles. The screws shall be slightly countersunk into the tiles. Holes for screws shall be drilled. The counter sunk heads of screws shall be covered up With Plaster of Paris and smooth finished.

12.30.3 Where surface unbroken by visible joints is required, the joints sealed with Plaster of Paris shall be trowelled smooth so that the whole surface appears as one without any joints. Nothing extra shall be paid for this closing of joints.

12.31 Gypsum Hard Board

(a) False Ceiling :- The board shall be carefully lifted and fixed to the frame work with screws @ 230 cm center to center as per manufacturing instructions.

(b) Joints between the junctions flush with requisite compound, paper tapes and primer suitable for gypsum plaster board as recommended by manufacturer.

12.32 Panelling

12.32.1 Teak Wood Panelling

The thickness of panel shall be 16 mm upto a width 40 cm and 19 mm for a greater width. Solid wood panels shall be made out of one or more pieces of timber of one or more pieces of timber of not less than 12.5 cm in width. In order to avoid warping, splitting and cracking, normally pieces not exceeding 20 cm in width should be used. When made from more than one piece, the pieces shall be joined with continuous tongued and grooved joint plugged together and reinforced with metal dowels. The grains of the solid panels shall run along with longer dimensions of the panel. The finished work with a tolerance of + 1 mm in thickness may be allowed.

12.32.2 Block Board Panelling

This panelling shall be decorative or non-decorative (Paintable) type as per design and thickness specified. These shall be specified in details of the type and construction of core The specification in general shall confirm to IS: 2202 (Part 1) and 2202 (Part 2)

12.33 Wall Lining

Specified timber shall be used and it shall be sawn in the direction of the grains. Sawing 'shall be truly straight and square. The timber shall be planed smooth and accurate to the full dimensions, rebates, roundings and mouldings, as shown in the drawings made, before assembly. Patchings or plugging of any kind shall not be permitted except as provided.

12.34 Solid PVC Wall Lining, Partition, Ceiling

12.34.1 Material

Material shall be as described in Section 7 : Joinery.

12.34.2 PVC Sheet Cladding

PVC sheet shall be stuck using rubber based adhesive for cladding. PVC sheet may be heat bent. i.e. lipping to cover the edges of plywood/flush/flush door shutter

12.34.3 Solid PVC Wall Lining

Solid PVC Wall Lining shall consist of PVC sheet stuck with solvent cement on PVC sheet paneling fillets as per direction of E1C & manufacturer's instruction. Rectangular or circular pillars or other insets in the wall shall be covered using heat bent PVC sheet to ensure heat bending of the PVC sheet at the required angle: suitable groove shall be cut in the PVC sheet if required. Two PVC lining sheets shall be stuck adjacent to each other after leaving a gap of 2mm. If so desired strips of 5 mm thick PVC sheet of width 75 mm feathered at the edges can be stuck at the places where two PVC sheets are joined, using solvent cement. Broader arrangement shall be as shown in drawings at the end of this Section.

12.34.4 Insulated PVC wall Lining

Insulated PVC wall lining shall consist of PVC insulated panels having wall thickness of 2 mm PVC sheet and the desired thickness of EPS (dependent on the insulation required) screwed into the wall using screws of adequate length. The screws shall be placed at a distance of 150mm and shall be 25 mm from the edge of the insulated panel on all sides of the panel. Strips of 5 mm thick PVC sheet of width 75 mm feathered at the edges shall be stuck at the places where two panels are joined so as to cover the screws of both the panels, using solvent cement. 90^0 heat bent strips of 5mm thick PVC sheets of width 75mm x 75 mm feathered at the edges shall be stuck at wall joints/pillars etc. Broader arrangement shall be as shown in drawings at the end of this Section.

12.34.5 Solid PVC Partitions

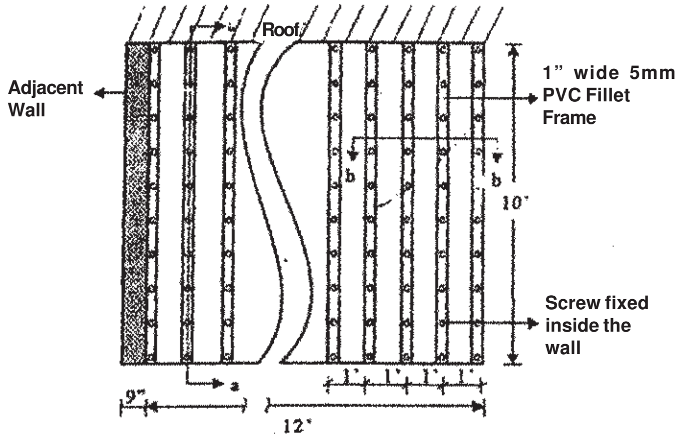
Solid PVC partitions all consist of PVC sandwich panel of suitable thickness placed; in MS angle frame work and fixed inside 'C' Channel and feathered strips made from 5 mm thick PVC sheets, as indicated in drawings given at the end of this Section. MS angle between the floor & ceiling height with anchor bolts at an interval of 1220mm or as mentioned in the drawing shall be provided. In between two MS angles PVC sheet heat bent 'C' channel of size 100 mm x 50 mm with feathered edges shall be fixed with screw on the floor. In between two MS angles PVC sheet heat bent 'C' channel of size 75 mm x 50mm with feathered edges shall be fixed with screw in the ceiling. The first & last MS angle should be erected such that it is inside a PVC sheet heat bent "C" channel of size 75mm x 50mm which has been screwed on to the walls. PVC sandwich panels shall be inserted in the PVC sheet 'C' channel fixed at ground floor & shall be stuck by using solvent cement. In between adjoining EPS sandwiched PVC partitions panel 5mm thick x 75mm width PVC sheet feathered at edges shall be stuck on front & back face using solvent cement as indicated in the drawings given at the end of this Section.

12.34.6 Solid PVC Insulation Panel For False Ceiling

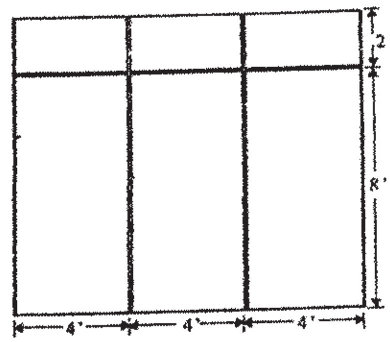
Solid PVC insulation panel having wall thickness of 1 mm PVC sheet and EPS of desired thickness as indicated depending on insulation required shall be placed in false ceiling grid made of Aluminum/GI/MS as indicated in drawings given at the end of this Section.

12.34.7 Solid PVC Joinery items shall be of Approved Makes

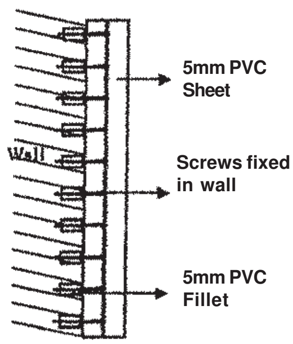
SOLID PVC WALL LINING



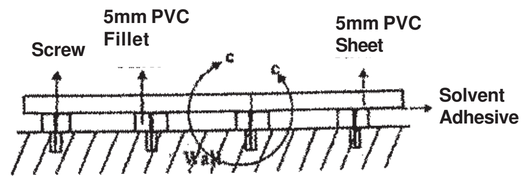
Without Panelling Sheet



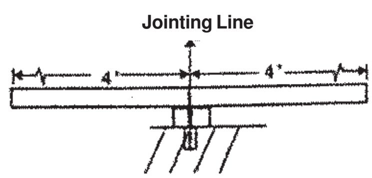
With Panelling Sheet



Sectional View (aa)

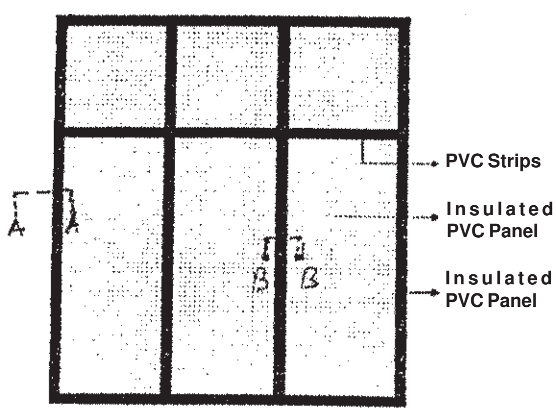


Sectional View (bb)

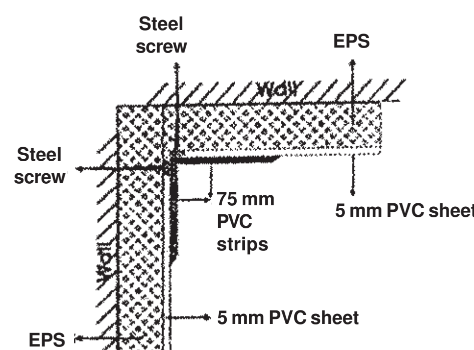


View 'cc'

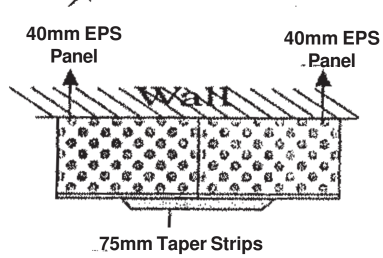
SOLID PVC INSULATED WALL LINING



Solid PVC Insulaled Wall Lining

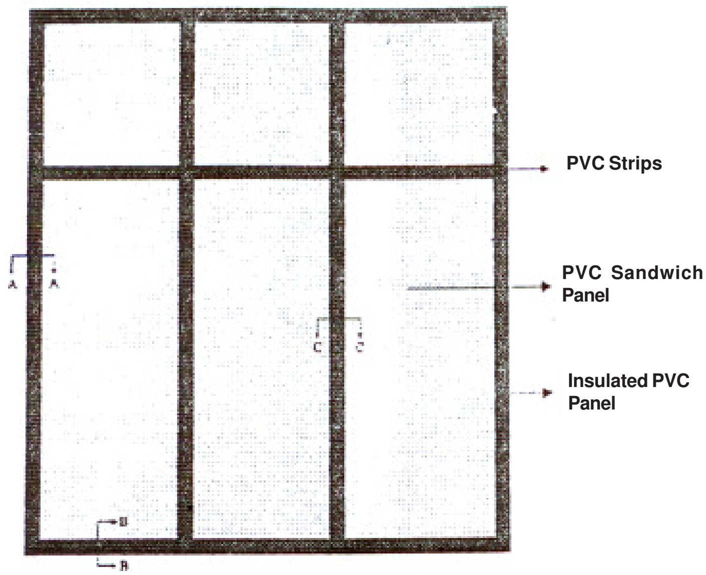


Sectional View 'AA'



Sectional View 'BB'

SOLID PVC WALL LINING



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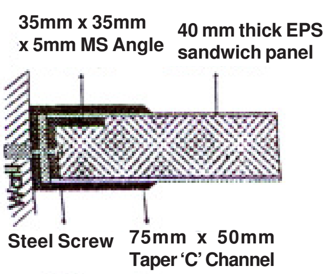

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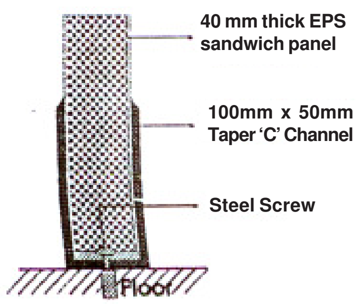

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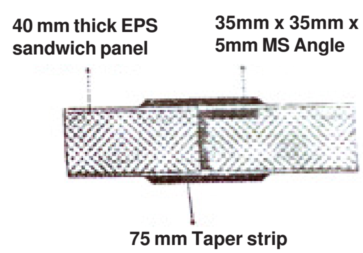
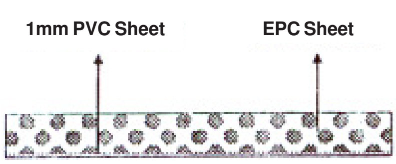
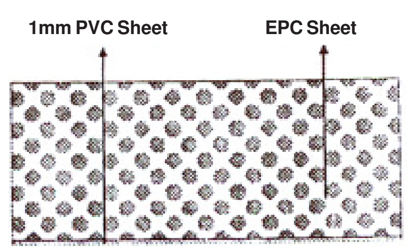


Sectional View 'CC'

SOLID PVC INSULATION PANEL FOR FALSE CEILING



10mm Insulation Panel for False Ceiling



40mm Insulation Panel for False Ceiling

SECTION 13
FLOOR FINISHES AND PAVING

13.1 Indian Standards

The following IS apply to this section :-

I.S No	Subject
653-1992	Specification for linoleum sheets and tiles
809-1992	Specification for rubber flooring materials for general purposes (First revision)
1195-2002	Specification for bitumen mastic for flooring (Third revision).
1237-1980	Specification for cement concrete flooring tiles (First revision).
1580-1991	Specification for bituminous compound for waterproofing and caulking purposes (Second revision).
2114-1984	Code of practice for laying in situ terrazzo floor finish (First revision)
2508-1984	Specifications for low density polytheylene films (Second revision).
3461-1980	Specification for PVC asbestos floor tiles. (First revision)
3462-1986	Specification for unbacked flexible PVC flooring (Second revision).
4457-1982	Specification for ceramic unglazed vitreous acid resistant tiles (First revision)
8042-1989	Specification for white Portland cement (Second revision)
13712-2006	Ceramic tiles- definitions, classifications, characteristics and marking (First revision)
13753-1993	Specification for dust pressed Ceramic tiles with water absorption of E> 10% Group (B III)
13755-1993	Specification for dust pressed Ceramic tiles with water absorption of 3%< E < 6% Group (B II a)
13801-1993	Specification for chequered cement concrete tiles
15658-2006	Specification for precast concrete blocks for paving

MATERIALS

13.2 Cement

Cement shall be ordinary Portland cement conforming to IS 269-1989 or Portland blast furnace slag cement conforming to IS 455-1989 or Portland pozzolana cement conforming to IS 1489-1991, as specified in Section 4 Concrete.

13.2.1 White Cement

White cement shall conform to IS 8042-1989. Specification for white Portland cement.

13.3 Lime

Lime for mortar for marking lime concrete shall be class B or C conforming to IS 712, as specified in Section 4-Concrete.

13.4 Aggregates

Coarse and fine aggregates for cement concrete and granolithic concrete shall conform to IS 383-1970, as specified in Section 4 Concrete.

13.4.1 Aggregates for granolithic concrete shall consist of crushed granite, basalt, trap or quartzite. The aggregate crushing value shall not exceed 30 per cent. The grading of aggregates shall be as given below :-

IS Sieve Designation	Percentage by weight passing IS sieve		
	Coarse Aggregate	Fine Aggregate	
		Zone 1	Zone 2
12.5	90 to 100		
10	40 to 85	90 to 100	90 to 100
4.75	0 to 10	60 to 95	75 to 100
2.36		30 to 70	55 to 90
1.18		30 to 70	55 to 90
600 micron		15 to 34	35 to 59
300 micron		5 to 20	8 to 30
150 micron		0 to 10	0 to 10

13.4.2

Sand for mortar for laying slab/tiles shall conform to IS 2116-1980 as specified in Section 5-Brick work.

13.5 Marble Aggregate

Marble Aggregates shall be calcites, dolomites or serpentines or calcitic or dolomitic marbles and shall be of the following grades, as indicated :

Grade No.	Size in mm
0	2 to 4
1	4 to 7
2	7 to 10

13.5.1 Marble Powder

Marble powder shall pass through IS sieve 300 micron.

13.6 Brick Coarse Aggregate

Brick Coarse aggregate for use in lime concrete shall be as specified in Section 4 Concrete.

13.7 Surkhi (Burnt Clay Pozzolana)

Surkhi for use in lime concrete shall be as specified in Section 4-Concrete.

13.8 Pigments

Pigments shall conform to the requirements of Appendix 'A' of IS 2114-1984, Code of practice for laying in situ terrazzo floor finish. The proportion of the cement and pigment by weight for various colours of matrix in terrazzo work shall be as indicated in the table below :

Colour	Pigment	Proportion of Pigment	Proportion of ordinary Port-land Cement	Proportion of white Cement
Red	Red Oxide of iron	1	15 to 20	Nil
Black	Carbon Black	1	25 to 40	Nil
Bottle green	Green chromium oxide	1	15 to 30	Nil
Pink	Red Oxide	1	Nil	100 to 300
Cream	Yellow oxide of iron	1	Nil	100 to 400
Yellow	Yellow oxide of iron	1	Nil	25 to 75
Light Green	Green chromium oxide	1	Nil	50 to 150
French Grey	-	Nil	1 to 2	1
Fawn	Yellow oxide of Iron	1	6	4

13.9 Surface Hardening Solution

Sodium silicate shall be of approved quality having a density of 84° Twadill (Specific gravity 1.24)

13.10 Abrasives

Metallic hardeners in the topping of floors and paving for increasing abrasion resistance shall be Ironite, Hardonate, Ferronite or other equal and approved metallic floor hardeners.

13.11 Bricks

Bricks for flooring shall have a compressive strength of at least 75 Kg/Sq cm and shall be of sub class A or B as indicated. Bricks shall conform to IS 1077-1992 as specified in Section 5-Brickwork.

13.12 Sand Stone Slabs

The stone slab shall be hard, even, sound, durable, tough, regular in shape, of uniform colour and free from soft veins, cracks and flaws, decay and weathering. Stone slabs shall be obtained from approved quarries as indicated. The slabs shall have transverse strength not less than 70 Kg/Sq cm and resistance to wear shall not be more than 2mm. In case of red sand stone white patches or streaks and in case of white sand stone, red patches or streaks shall not be allowed. However, scattered spots upto 10mm diameter will be permitted. The slabs shall be cut along planes parallel to natural bed of stone. The slabs shall not be less than 0.1 Sq metre in area. The slabs used in any one room shall be of uniform size. Thickness shall be as specified, with a permissible tolerance of + 3mm.

13.12.1 Marble Stone Slab and Tile

Marble stone slab and tile shall be as per requirement listed in the section 6-Stone Masonry. The slab shall not be less than 0.21 Sq metre in area. The slab/tile used in any one room shall be uniform. The thickness shall be as specified with permissible tolerance of + 3%.

13.12.2 Lime Stone Slab and Tile

The slab/tile shall be hard, even, durable, sound, tough, regular in shape, of uniform colour and free from soft veins, cracks, flaws, decay and weathering. In case polished stone slabs are indicated, these shall be of the fine grained stone capable of taking good polish. Stone slabs shall be obtained from approved quarries as indicated. The slabs shall have transverse strength not less than 70 Kg/Sq. cm and shall not develop signs of spalling, disintegration or cracks. The slabs shall not be less than 0.1 sq m in area and tiles not less than 25cm x 25cm. Slabs and tiles used in any one room shall be of uniform size. Thickness shall be as specified, with a permissible tolerance of + 5mm.

13.13 Stone Setts

Stone for the setts shall be of the best quality, granite, trap, basalt, or quartzite as indicated. Stones shall be obtained from the approved quarries as indicated. Use of sedimentary stone shall not be permitted. Stone setts shall be approximately rectangular in shape, 200mm to 250mm long, 150mm to 200mm wide and 150mm deep, with a tolerance of plus or minus 12mm. Edge stones shall be 250mm to 300mm long, 150mm to 200mm wide and depth not less than 450mm.

13.14 Ceramic Glazed Tiles

13.14.1 Ceramic Glazed wall tiles shall be of Ist quality and shall conform to IS :13753. The surface of tiles and components can be smooth, profiled, decorated or finished, glossy, matt or semi-matt as indicated. The tiles shall be flat true to shape, sound and free from flaws and other manufacturing defects. The top surface of the tiles shall be glazed. The underside of the tiles shall be free from glaze in order that the tiles may adhere properly to the base. The glaze shall be uniform in quality and shall be free from welts, chips, craze, crawling or other imperfections, detracting from appearance when viewed at a distance of one meter. The texture and colour of tiles shall be as indicated. Tiles shall be of sizes as indicated. If not indicated size of tile shall be 200mm x 300 mm. The thickness shall be as specified by the manufacturer but in no case it shall be less than 6mm.

13.14.2 Ceramic Glazed floor tiles shall be of Ist quality and shall conform to IS :13755. The surface of tiles and components can be smooth, profiled, decorated or finished, glossy, matt or semi-matt (anti skid) as indicated. The tiles shall be flat true to shape, sound and free from flaws and other manufacturing defects. The top surface of the tiles shall be glazed. The underside of the tiles shall be free from glaze in order that the tiles may adhere properly to the base. The glaze shall be uniform in quality and shall be free from welts, chips, craze, crawling or other imperfections, detracting from appearance when viewed at a distance of one meter. The texture and colour of tiles shall be as indicated. Tiles shall be of sizes as indicated. If not indicated size of tile shall be 300mm x 300 mm. The thickness shall be as specified by the manufacturer but in no case it shall be less than 7mm.

13.15 Vitrified Porcelain Tiles

13.15.1 Vitrified polished porcelain floor tiles shall be of Ist quality. These vitrified tiles are classified under group B1a of the International Standard for ceramic tiles ISO: 13006. Tiles shall be hard, dense, impervious and frost resistant. Water absorption of tiles shall be less than 0.5% and flexural strength (Modulus of Rupture) shall be more than 35 N/Sqmm. Vitrified polished porcelain floor tiles shall be provided of sizes, colour, shades, texture and designs as indicated and if size not indicated it shall be 600mm x 600 mm/ 605 x 605 mm. The thickness shall be as specified by the manufacturer but not less than 10mm.

13.15.2 Heavy duty vitrified unpolished porcelain floor tiles for exterior use shall be of Ist quality. Heavy duty vitrified tiles shall be acid and alkali resistant, weather proof, anti skid and abrasion resistant as per International Standard for ceramic tiles ISO :13006 and EN 176 requirement. These tiles shall comply with the following requirements:-

(a) Water absorption<2%
(b) Flexural Strength>35 N/Sqmm
(c) Moh's Hardness>6
(d) Abrasion resistance<204mm.

Heavy duty vitrified tiles shall be of sizes, colour, texture and designs as indicated but size if not indicated it shall be of 300mm x 300 mm . The thickness shall be as specified by the manufacturer.

13.16 Plain Cement Concrete and Terrazo Flooring Tiles

13.16.1 Plain cement concrete tiles, coloured cement concrete tiles and terrazzo tiles; and specials shall conform to IS 1237-1980 specification for cement concrete flooring tiles. Plain and coloured cement concrete tiles shall be general purpose type and shall be manufactured by pressure process. Thickness of wearing layer in case of plain and coloured cement concrete tiles shall not be less than 5mm . The thickness of wearing layer of terrazzo tiles shall be 6mm for chips of sizes varying from smallest to 6mm or smallest to 12mm and shall be 7mm for chips of sizes from smallest to 20mm.

13.16.2 Unless otherwise directed, the wearing face of the terrazzo tiles shall be mechanically ground and filled. The wearing face shall be plane, free from projections, depressions and cracks (hair cracks not included) and shall be reasonably parallel to the back face of the tiles. All angles shall be right angles and all arises shall be sharp and true. The colour and texture of the tiles shall be uniform throughout its thickness. Tiles shall be 200mm x 200mm x 20mm thick or 250mm x 250mm x 22mm thick, plain, coloured or terrazzo finish with marble chips of size and shade, as indicated. Tiles in treads shall be 40mm thick and bull nosed. The tolerance on thickness of tiles shall be plus 5mm but shall not exceed 3mm in case of any one delivery.

13.17 Chequered Cement Concrete and Terrazo Flooring Tiles

13.17.1 Chequered cement concrete tiles, coloured chequered cement concrete tiles and chequered terrazzo tiles shall conform to IS 13801-1993 specification for Chequered cement concrete tiles. Chequered tiles shall be with the centre to centre distance of chequers not less than 25mm and not more than 50mm, the groove in chequers being uniform and straight with the depth of grooves not less than 3mm. Tiles shall be manufactured by pressure process. Thickness of wearing layer measured from top of the chequers shall not be less than 6mm.

13.17.2 Unless otherwise directed, the tiles shall be supplied with initial grinding and grouting of the upper layer. The upper layer of the tiles shall be free from projections, depressions and cracks, holes, cavities and other blemishes. The edges of the tiles may be rounded. All angles shall be right angles and all arises shall be sharp and true. The colour and texture of the wearing layer shall be uniform throughout its thickness. The size of Chequered Tiles shall be 200mm x 200mm x 22mm thick or 250mm x 250mm x 22mm thick or 300 x 300mm x 25mm thick as indicated. The tolerance on length or breadth of tiles shall be +1mm and tolerance on thickness of tiles shall be +5mm. In addition the difference in thickness between the thickest and thinnest tile in the sample shall not exceed 3mm.

13.18 Precast Interlocking Paver blocks

Precast concrete Paver blocks shall conform to IS 15658:2006, Specification for Precast concrete blocks for paving. Paver blocks shall be sound and free from cracks or other visual defects. The tolerance on length or breadth of paver blocks shall be +2mm and tolerance on thickness of tiles shall be +3mm. Water absorption shall not be more than 6 percent by mass. Shapes shall be triangular, Zigzag, Haxagon or other shape as indicated. Colour of paver blocks shall be as indicated or as decided by GE. Thickness and grade of concrete of paver blocks is decided based on intensity of traffic, which is as under (Refer Table 1 of IS 15658):-

Traffic Category	Paver block Thickness	Grade of concrete
Light Traffic	60mm	M-35
Medium Traffic	80mm	M-40
Heavy Traffic	100mm	M-50

13.19 Linoleum Flooring

13.19.1 Linoleum shall comply with the requirements of IS 653-1992, Specification for linoleum sheets and tiles. There shall be adequate adhesion between the composition and the Hessian backing. The surface shall be smooth, uniform, free from indentations and protrusions, streaks and marks. The thickness and size shall be as indicated. The mean thickness shall not vary by more than 0.1 mm from the specified thickness. Linoleum shall be plain, moiré or jaspe, or marbled type, as indicated. Colour and shade shall be as approved by the GE.

13.19.2 The adhesive used for laying linoleum floors shall be vegetable and casein glues, gum spirit adhesives, bitumen rubber emulsion or bitumen rubber solution as approved by EIC.

13.20 Rubber Flooring

13.20.1 Rubber sheets or tiles for flooring shall conform to IS 809-1992, Specification for rubber flooring materials for general purposes. The rubber flooring shall be with fabric backing or fabric insert with topping type ‘A’ plain or marbled or type ‘B’ ribbed or fluted, as indicated and of colour as directed.

13.20.2 The rubber flooring materials shall be of first class workmanship, satisfactorily vulcanized, free from sulphur boom and objectionable odour and blisters, cracks, and embedded foreign matter. There must be no porosity on the surface or throughout the thickness of the sheet. The surface finish of the flooring shall be either glossy or matt as indicated. The base stratum may be of any colour. The underside of the floor covering shall be either furnished with a cloth impression or be buffed smooth. The edges and ends shall be cut true and square. The colour of the flooring shall, be not permanently affected by cleaning with water and washing soap or by treatment with a suitable floor polish. The colour of the flooring shall not bleed into an adjacent piece of rubber.

13.20.3 The thickness of the flooring shall not differ at any point by more than + 0.5 mm or – 0.2 mm from the thickness specified. The thickness and size of rubber sheets and rubber tiles (200mm, 300mm or 500mm square) for floors shall be as indicated. In the case of fabric insert type rubber flooring, the thickness of wearing stratum shall be at least 1mm; where the total thickness of flooring is more than 2.5mm, thicker wearing surface is recommended.

13.20.4 The adhesive as recommended by the manufacturer should be used; the manufacturer shall also indicate the precautions to be taken while using the adhesive.

13.21 PVC Flooring

PVC Floor covering shall be unbacked homogeneous flexible PVC flooring conforming to IS 3462-1986, Specification for unbacked flexible PVC flooring. The flooring shall have a uniform wearing surface. The colour and also the pattern, marbling or mottling, if present shall extend through the full thickness of the flooring. The colour and the pattern shall match as approved by the GE. PVC floor covering shall be in form of sheets/roles or tiles of the thickness and sizes as indicated. The permissible tolerance on thickness shall not be more than 0.15mm.

13.22 PVC Asbestos Floor Tiles

PVC asbestos tiles shall conform to IS 3461-1980, Specification for PVC asbestos floor tiles. The tiles shall be plain or mottled as directed. Plain tiles shall have the colour uniformly distributed throughout the tiles. Mottled tiles shall have the colours distributed at random through out the thickness of the tiles. The material shall not develop any toxic effect in service and shall not give any disagreeable odour. Permissible tolerance on thickness shall be + 0.15mm.

13.23 Acid Resistant Tiles

Acid resistant tiles shall conform to IS 4457-1982, Specification for ceramic unglazed vitreous acid-resistant tiles. The tiles shall be of vitreous ware and free from deleterious substances and shall be unglazed. The finished tile when fractured, shall appear fine grained in texture, dense and homogeneous. The tiles shall be sound, true to shape, flat and free from flaws and other defects. The size and thickness of tiles shall be as indicated. The tolerance on thickness and warpage shall not exceed 2.0mm. The compressive strength shall be 700 Kg/sqcm. The loss in weight when tested for acid resistance shall not exceed 1.5 percent.

13.23.1 Chemical Resistant Mortars

Chemical resistant mortars shall be as specified in Section 5-Brickwork.

13.23.2 Wear Resistance Tile Flooring

This shall be of ceramic material and shall be acid/alkali resistant. The hardness shall be over 7 when checked with Moh's scale with a compressive strength of 1500Kg/sqcm. The water absorption shall be less than 2%. Thickness of tile shall be as indicated.

13.24 Polythene Film

Polythene film shall comply with IS 2508-1984, Specification for low density polythene films. The film shall be black in colour and shall contain not less than 2.5 + 0.5 percent of carbon black. The film shall be uniform in colour, texture and finish. The film shall be free from pinholes and substantially free from undispersed raw materials, streaks, particles of foreign matter and other visible defects such as holes, tears and blisters. The edges shall be free from cracks and cuts.

13.24.1 Bitumen for Damp Proofing

Bitumen shall conform to IS 1580-1991, Specification for bituminous compounds for waterproofing and caulking purposes.

WORKMANSHIP

13.25 Flooring Generally

13.25.1 Before the flooring work is taken up, the following operations shall have been completed :-

(a) The completion of all preliminary operations, such as laying of services affecting the laying of floors; and
(b) Plastering of all inside walls, ceiling and outside walls and fixing of door and window frames in place. All heavy work in the room may be completed.

13.25.2 The thickness of each course or layer constituting the floor shall be as specified or indicated.

13.25.3 The floors shall be laid to levels or falls as indicated or as directed by the EIC. The surface shall be finished to a reasonably true plain surface. The desired slope for proper drainage shall be provided in the sub-floor and subgrade.

13.25.4 Floors shall not sound hollow when tapped.

13.25.5 All points of level from the finished floor surface and outlets shall be clearly marked and outlet openings made before hand.

13.25.6 In the case of suspended floor slabs any slope in the floor finish shall be given in the structural concrete itself. The surface of the floor slabs shall be kept rough to provide an adequate bond for the topping.

13.25.7 Unless otherwise directed, the joints shall be of uniform thickness, perfectly straight throughout the length of a row, with rows parallel to each other. Transverse joints shall be at right angles to longitudinal joints; to avoid sympathetic cracks likely to be induced in the adjoining panel the joints shall not be staggered. The pattern of laying the floor units viz. straight, diagonally or to herring bone or any other pattern shall be as directed by the EIC.

13.25.8 Where full size tiles can not be fixed these shall be cut/sawn to the required size and then edges rubbed smooth to ensure straight and true joints.

13.25.9 Tiles fixed in the floor adjacent to the wall shall enter plaster, skirting or dado to a minimum depth of 10mm.

13.25.10 Mortars

Cement, Lime and composite mortars shall be made as detailed in Section 5-Brickwork. The quantity of water added shall be the minimum to give sufficient plasticity and workability for laying. A high water cement ratio will produce a screeded bed with a high drying shrinkage and shall be avoided.

13.25.11 Unless otherwise specified, bedding layer of mortar for laying floor units, where specified shall be not less than 15mm.

13.25.12 Mortar in joints shall be restricted to the width of joints and any smearing of mortar on the surface of floor on either side of joint shall be removed immediately. The finished surface of mortar in joints shall be flush with the floor surface.

13.25.13 Preparation of Sub-grade

The ground or earth filling shall be thoroughly compacted so that there are no loose pockets left any where in the whole area.

13.25.14 Preparation of sub-base

Before laying lime concrete or cement concrete sub-floor, the surface of sub-base such as hard-core shall be thoroughly compacted and cleaned of all dirt, dust, loose particles and any other deleterious materials.

13.26 Lime Concrete in Sub-Floor, Base or Sub Base

Lime concrete of the specified mix in sub-floor or sub-base, etc. shall be mixed, laid and cured as specified for lime concrete in foundations in Section 4-Concrete.

13.26.1 Before laying the lime concrete, the surface of sub-base shall be thoroughly cleaned of dirt, dust etc. and surface well wetted. On the clean damp surface of sub base, lime concrete shall be spread between forms, if necessary, thoroughly tamped and levelled. The top surface shall be left rough to provide an adequate bond for the topping.

13.26.2 Lime concrete shall be allowed to set for seven days before floor finish of topping layer is laid.

13.27 Cement Concrete Sub-floors, Base or Sub Base

Cement concrete of the specified mix in sub-floor base or sub-base etc., shall be mixed as specified in Section 4-Concrete, and shall be laid, compacted and finished as specified under Cement Concrete Flooring. The top surface shall be broomed to have adequate bond with the topping. Flooring shall be commenced within 48 hours of laying the concrete sub floor etc, failing which the surface of the sub-floor, etc,. shall be roughened with steel wire brushes, wetted by sprinkling water and smeared with a coat of cement slurry at 3 kg per sq.m.

13.28 Stone Slab Flooring

13.28.1 Dressing of Stone Slabs and Tiles :-

(a) Rough Dressed Slabs :-Every slab shall be cut to required size and shape. The top surface of the slabs and tiles may be self faced or rough chisel dressed so that the dressed surface shall not be more than 6mm from the straight edge placed on it. The edges of depressions or projections shall be chisel dressed in a slant so that the surface does not have sharp unevenness. The side shall be chisel dressed to half the depth so that the dressed edge shall, at no place, be more than 3mm from a straight edge butted against it. Beyond this depth the sides may be dressed slightly splayed so as to form an inverted 'V' shaped joint with adjoining slab. The surface shall be reasonably true and plain and all the angles and edges shall be true, square and free from chippings. Where slabs are used for nosing, the exposed edges shall be rough tooled to full depth and cut to a uniform thickness.

(b) Fine dressed slabs :-All joints upto half the depth and exposed faces shall be fine tooled so that a straight edge placed on it is fully in contact with it.

(c) Polished Slabs :-Every slab shall be machine cut or hand cut to the required size. Hand cut slabs shall be first fine tooled as specified for fine dressed slab and then table rubbed before paving, to obtain a perfectly true surface free from chisel marks. Machine cut slabs shall have fine tooled dressing on all sides to full depth. Machine cut slabs may be supplied with polished (one cut) surface on top.

13.28.2 Laying of Stone Slabs

13.28.2.1 Slabs shall be washed clean before laying. The bedding mortar of the specified mix, shall be spread under each slab, Slab shall be then laid on top, pressed so that all hollows underneath get filled and surplus mortar works up through the joints. The slab shall be tapped with a wooden mallet and brought level and close to the adjoining slab with thickness of joint not exceeding 10mm in the case of rough dressed slabs and 3mm in the case of fine dressed slabs. After laying each slab, surplus mortar on the surface of slabs shall be cleaned off and joints finished flush. Subsequent slabs shall be laid in the same manner. In case slabs are specified to be pointed, the joints shall be left raked out uniformly to a depth not less than 10mm, when the mortar is still green. The surface of the flooring, as laid, shall be true to levels and slopes, as directed by the Engineer-in-Charge. Slab which are fixed in the floor adjoining the wall shall enter not less than 12mm under the plaster, skirting or dado. The junction between wall plaster and floor shall be finished neatly and without waviness.

13.28.2.2 In case of polished slab flooring, after paving, the slabs shall be polished first by grinding with Carborundum stone of 120 grit and second cut with 220-250 grit stones as described for terrazzo flooring. Joints shall be very fine; thickness of joints shall not exceed 1.5mm.

13.28.2.3 The flooring shall be cured for 14 days. Any unevenness existing between the edges of slabs at joints shall be removed by chiselling in a slant. No patching up on the edges shall be permitted and the slabs with chipped or badly dressed edges shall be replaced. The finished floor shall not sound hollow when tapped with wooden mallet.

13.29 Stone Sett Paving

Stone setts shall be set on the prepared surface of the base concrete over a bedding layer of cement and sand mortar 1:3, 20mm thick, with joints not exceeding 20mm in width. The joints shall be grouted with cement and sand mortar 1:2 with an admixture of metallic hardener such as Ironite, Hardonate or other approved hardener, 5 percent by weight of cement or as recommended by the manufacturers and joints struck off as the work proceeds. Stone setts shall be laid in section not exceeding 1.2metre long in herring bone pattern or any other suitable pattern as indicated separated by two rows of stone setts laid across the road or paving with the longitudinal axis of the stone setts parallel to the length of the road. Edge stones shall also be laid with their longitudinal axis parallel to the length of road.

13.30 Brick Flooring

13.30.1 To reduce excessive suction, the bricks before being laid shall be soaked in clean water and then allowed to drain until they are surface dry.

13.30.2 The bricks shall be laid flat or on edge in plain, diagonal, herring bone or other suitable patterns as indicated. Damaged bricks shall not be used. Broken bricks shall not be used in flooring except for closing a line.

13.30.3 Bricks shall be laid on a bed of mortar not less than 15mm thick spread evenly over the sub-base. Mix of mortar shall be as indicated. Each brick shall be properly bedded and set by gentle tapping with handle of trowel or wooden mallet. The sides of bricks shall be smeared with mortar before the next brick is laid and pressed against it. On completion of a portion of flooring the vertical joints shall be fully filled with mortar from the top. The surface of the flooring during laying shall be frequently checked with a straight edge at least 2 meter long so as to obtain a true surface with the required slope. In case of flat brick flooring, bricks shall be laid with frog down. When laid flat in plain courses the units shall be bonded to break joints at half the length of the bricks.

13.30.4 Thickness of joints shall be between 8 to 10mm. The joints shall be flush pointed in cement and sand mortar 1:3 or as indicated after being raked out 10mm deep while the mortar is still green.

13.30.5 Curing

The flooring shall be kept wet for at least 7 days after completion. In case of lime or cement lime mortar curing shall commence two days after the laying and shall continue for seven days.

13.31 Dry Brick Flooring/Paving

The bricks without soaking in water shall be laid dry, flat or on edge, as indicated on a layer of sand, 25mm thick, laid to required slope on the subgrade. The bricks may be laid in plain, diagonal, herringbone or other suitable pattern as indicated. After laying the bricks, the joints shall be filled with fine sand. Where indicated, joints shall be flush pointed to a depth of 15mm in cement and sand mortar 1:3.

13.32 Cement Concrete Flooring Cast in situ

13.32.1 Size of Panels

The floor topping shall be divided into suitable panels. Size of the panel is governed by the thickness of floor finish, the type of construction (monolithic or separate), local conditions of temperature, humidity and the season in which flooring is laid. Generally no dimension of a panel shall exceed 4m in case of floor topping laid monolithically with the base concrete and 2m in case of floor topping laid separately on a hardened base. In case of ground floors, topping panel may synchronize with that of the base concrete. Length of a panel shall not exceed one and a half times its breadth. The exact dimensions of the panels shall be as directed by EIC.

13.32.2 Formwork to sides of Concrete Flooring

Forms shall be provided as specified in Section 7-Wood work. Where glass or aluminium dividing strips are provided, form work may not be provided. The boarding/battens shall be fixed in position with their top at proper level, giving slope where required. The flooring shall butt against the masonry of the wall. Before being laid in position, the form or screed strips shall be preferably coated with a thick coat of lime wash.

13.32.3 Joints

Construction joints between bays of the floor finish need only be plain, untreated, vertical butt joints and shall be placed over any joint in the base.

13.32.4 Floor Finish Laid Monolithically with the Base Concrete

1. Laying the Sub-Floor or Base :-
   The area to be paved shall be divided into suitable panels. Before placing the base concrete, the sub-base shall be properly wetted. The concrete of the specified mix shall then be deposited between the screed strips, thoroughly tamped and the surface screeded uniformly. The surface shall be finished rough to provide adequate bond for the topping.
2. Laying the Floor Finish or Topping :-
   On the clean, green surface of the base concrete, the topping of the specified mix shall be placed in position as soon as possible but generally not later than two to three hours of laying the base concrete. The topping shall then be thoroughly tamped or vibrated struck off level and the surface floated with a wooden float to a fair and even surface. The surface shall be tested with a straight edge and mason's spirit level to detect any inequalities in the surface which if any, shall be made good immediately. Where indicated, dividing strips shall be provided for effective separation of panels. The mix for the topping shall be stiff enough to prevent accumulation of any excess water or laitance on the surface.

The base concrete and the topping shall be laid in alternate panels, the intermediate panels being filled in after one to two days as directed. The screed strips shall be removed the next day after the concrete has been deposited in the panels; the edges of panels shall be examined for any honeycombing or undulation which, if found, shall be repaired straight and smooth by cement mortar. If the intermediate panels are not to be filled the next day, the screed strips shall then be cleaned and put back against the edges of panels till the concrete in the alternate panels is to be deposited. When the concrete is being compacted in new panels, care shall be taken to avoid damage to the panels already laid.

If dividing strips are provided, the base concrete and the topping may be laid in all the panels simultaneously.

13.32.5 Floor Finish Laid Separately on Hardened Concrete Base

13.32.5.1 Laying the Base Concrete

The base concrete may be deposited in the whole area at a stretch. Before placing the concrete, the sub-base shall be properly wetted and rammed. The concrete shall then be deposited between the forms, where provided, thoroughly tamped and the surface finished level with the top edges of the forms. The surface of base concrete shall be left rough to provide adequate bond for the topping. Two or three hours after the concrete has been laid in position, the surface shall be brushed with a hard brush to remove any scum or laitance and swept clean so that the coarse aggregate is exposed.

13.32.5.2 Laying the Topping

13.32.5.2.1 The surface of base concrete shall be thoroughly cleaned of all dirt, loose particles, caked mortar dropping and laitance, if any, by scrubbing with coir or steel wire brush. Where the concrete has hardened so much that roughening of surface by wire brush is not possible, the entire surface shall be roughened by chipping or hacking. Before laying the topping, the surface shall be soaked with water, at least for twelve hours and surplus water shall be removed by mopping immediately before the topping is laid in position.

13.32.5.2.2 The forms shall be fixed over the base concrete dividing it into suitable panels. Before placing the concrete mix for topping, neat cement slurry at the rate of 3 Kg/sq m shall be thoroughly brushed into the prepared surface of the base concrete just ahead of the finish. The topping shall then be laid, thoroughly tamped or vibrated, the surface floated with a wooden float to a fair and even surface. The surface shall be tested and finished as specified for laying of topping laid monolithically with base concrete.

13.32.6 Laying the Topping in Two Layers

Where the topping is to be laid in two layers, the surface of the concrete in the under-layer of topping shall not be finished smooth with a trowel but left rough after tamping it and levelling it with screed board.

13.32.7 Floor Topping Laid Over Concrete Sub-Floor or Base

Before laying the topping, surface of lime concrete shall be thoroughly cleaned and prepared as specified for base concrete. Immediately before spreading the concrete for topping, the surface shall be brushed with a layer of neat cement slurry at the rate of 3 Kg per Sq m. The topping whether in single or two layers shall then be laid, thoroughly compacted and surface floated with a wooden float, tested and finished as specified for floor finish laid separately over hardened concrete.

13.32.8 Finishing the surface fair smooth

Where an even smooth surface is indicated, the surface, after being floated with a wooden or steel float, shall be finished with a steel trowel. Finishing operations shall start shortly after the compaction of concrete and shall be spread over the period of one to six hours depending upon the temperature and atmospheric condition. The surface shall be trowelled three times at intervals so as to produce an uniform, hard and closed knit surface. Immediately after laying, only just sufficient trowelling shall be done to give a level surface. Excessive trowelling in the earlier stages shall be avoided as this tends to work a layer rich in cement to the surface. Sometime after the first trowelling and after a duration depending upon the temperature and atmostpheric condition, the surface shall be retrowelled to close any pores in the surface, and to bring to surface and scrap off any excess water in concrete laitance (it shall not be trowelled back into the topping). The final trowelling shall be done well before the concrete has become too hard but at such a time that considerable pressure is required to make any impression on the surface. Spreading and trowelling of a rich mix of dry cement and fine aggregate on to the surface shall not be permitted.

Where the surface is to be finished with a steel trowel using extra cement, it shall be clearly indicated.

13.32.9 Spike Rolling, etc

Spike rolling to concrete surface where indicated shall be executed with a suitable roller to produce indentations, whilst the concrete is green. Expanded metal impressions, where indicated, shall be made on the floor surface while green by pressing expanded metal of the mesh as directed to a depth of 3mm and removing the same carefully.

13.32.10 Curing

Immediately after the flooring surface is finished, it shall be protected from rapid drying and strong sunlight. As soon as the surface has hardened sufficiently to prevent damage to it, it shall be kept continuously moist for at least fifteen days by means of wet gunny bags or 50mm thick layers of damp sand spread over the surface or pooling water on the surface. During this period the flooring shall not be exposed to any traffic. Regular traffic on the floor shall be allowed only after 28 days.

13.33 Polished Coloured Concrete Floor

13.33.1 The surface of cement concrete floor, when indicated to be coloured, shall be finished with a thin topping not less than 3mm thick; consisting of one part of cement to two parts of sand, coloured with the addition of approved mineral pigment of required colour; thoroughly mixed with cement, when dry. The quantity of pigment shall be such as to produce the required shade. The coloured top layer shall be laid monolithically with the concrete.

13.33.2 The surface shall be air-cured for a duration of 12 to 18 hours. It shall then be cured by allowing water to stand in pools over it for not less than 2 days before hand grinding and seven days before machine grinding.

13.33.3 Grinding and polishing may be done by hand or by machine. In hand grinding and polishing, the first cut shall be made with carborundum stone 60 grit size and plenty of water. After the first cut, the surface shall be thoroughly washed to remove all grinding mud and covered with a grout of cement using the same coloured cement as in the original mix in order to fill the pin holes that appear after cutting. The surface shall be again wet cured for ten days. The final cut shall then be carried out with Carborundum stone of 320 to 400 grit size. After the final cut, the surface shall again be washed clean and rubbed hard with felt and slightly moistened oxalic acid powder, at the rate of five grams of oxalic acid powder per sq m of floor area. The following day, the floor shall be wiped with moist rag and dried with a soft cloth.

13.34 Granolithic Concrete Floors

The proportion for the granolithic concrete floor topping shall be 1:1:2 (Cement : fine aggregate : Coarse aggregate) by volume. Mixing, laying, finishing and curing, etc,. shall be carried out as specified for cement concrete flooring. Granolithic concrete shall be preferably laid monolithic with the base concrete.

13.35 Sodium Silicate Treatment

The concrete surface shall be clean, dry and free from grease. The dressing shall be applied about seven days after the completion of curing. The first dressing shall be with sodium silicate diluted in the ratio of 1 part of silicate to 4 part of water (by volume). Second dressing with dilution of 1:3 and the third of 1:2. The surface shall be allowed to dry thoroughly between each application and any glazed patches which appear shall be removed by scrubbing with stiff fibre brushes and water, before the next coat is applied. The floor shall be washed with hot clean water after the third dressing and the floor is dried.

13.36 Wear Proof Topping

For light or heavy duty floors, metallic floor hardener and cement shall be thoroughly mixed to an even colour in dry state in the proportion recommended by the manufacturer. This mixture shall be mixed with crushed granite/ basalt/trap as indicated (6mm and down) in the proportion 1:2 by volume. Requisite amount of water shall then be added to form a workable mixture.

13.36.1 New Work

The topping of the thickness as indicated, shall be laid while the underlying surface is green. When the initial set has taken place, the surface shall be trowelled even and smooth with a steel trowel. Dry cement or mixture of dry cement and sand, shall not be sprinkled directly on to the surface with the object of absorbing moisture or for stiffening the mix. The final trowelling shall not be commenced until such time as the surface has so hardened that pressure with a finger ceases to make any indentation. The topping shall be kept damp with wet sacks or sand, for 7 days before putting to use.

13.36.2 Old Work

The old concrete surface shall be cut and removed to a depth as indicated, generally of not less than 50mm, and all loose particles and dust cleared away. The cleared surface shall then be soaked with water for at least 12 hours before the topping is laid. Surplus water, if any, shall be mopped up and neat cement grout shall be thoroughly worked into the surface. While the grout is wet, the layer of cement concrete (1:2:4) Type B-1, shall be laid followed by wear proof topping, as described above.

13.37 Precast Cement Concrete Slab Flooring

13.37.1 Cement Concrete of the specified mix shall be mixed precast in forms or mould and cured as specified for precast articles in Section 4-Concrete. Unless otherwise indicated, the size of slabs shall not exceed 0.5 Sq m nor be less than 0.1 Sq m. Slabs used in any one room shall be uniform in size and of thickness as indicated. The top surface of slabs shall be finished fair and smooth (using additional cement where indicated) whilst the concrete is green in forms. Exposed edges shall be perfectly fine, square and well defined.

13.37.2 The slabs shall be bedded and jointed in cement and sand mortar (1:6) and pointed in cement and sand mortar (1:4). The thickness of bedding mortar shall be not less than 15mm and thickness of joints shall not exceed 6mm.

13.38 Terrazo Cast-in-Situ in Floors, Skirtings and Dados

13.38.1 Size of Tarrazo Panel

The Floor, both while laying the under layer and the topping shall be divided into panels not exceeding 2 Sq m. The joints shall be so located that the longer dimension of any panel does not exceed 2m. The panels, where indicated shall be separated by means of dividing strips. However, where butt joints are provided, the bays shall be laid alternately allowing for an interval of at least 24 hours between the laying of adjacent bays.

13.38.2 Mixing of Materials

1. Cement for making matrix for Terrazo topping shall be ordinary Portland cement (with no pigment) or coloured cement made by mixing ordinary Portland cement with pigments, or with white cement or by mixing white cement with pigments depending on the colour of the terrazo finish, as indicated. With a view to avoid variation in colour, the complete quantities of cement and pigment required for one operation shall be mixed at the beginning of work and stored properly.

2. Where different coloured chips are used, they shall first be well mixed in required proportion of various colours and sizes.
3. The proportion of cement and marble powder shall be 3 parts of cement and 1 part of marble powder by weight. For every part of cement and marble powder mix, the proportion of aggregates, by volume, shall be 1.75 parts for aggregates of 1 to 7 mm and 1.5 parts of 7 to 15mm. The cement shall be mixed thoroughly in dry state with marble powder. The binder so obtained and the marble chips shall then be mixed dry together.
4. The mixing, if done manually, shall preferably be done in a trough or tub. While mixing the aggregate, care shall be taken not to get the materials into a heap. The material shall be kept, as far as possible in an even layer during mixing.
5. After the materials have been thoroughly mixed in the dry state, water shall be added in small quantities, preferably in fine spray, while the materials are being worked until proper consistency is obtained. The mixture shall be plastic but not so wet that it will flow.
6. The mix shall be used in the work within half an hour of the addition of water during preparation.

13.38.3 Spreading the Underlayers

1. Dividing strips, where indicated, shall be glass, aluminium or plastic as indicated and shall be fixed on the base to the exact surface level of floor so as to divide the surface of the base into the required arrangement of panels. Aluminium dividing strip shall have protective coating of bitumen. The thickness of strip shall be as indicated but not less than 1.5mm. Where dividing strips are not used, screed strips shall be fixed on the base, properly leveled to the correct height to suit the thickness of floor.
2. Before spreading the underlayer, the base shall be cleaned of all dirt, laitance or loose material and then well wetted with water without forming any water pools on the surface. It shall then be smeared with cement slurry at the rate of 3 kg of cement per sq. m just before the spreading of underlayer.
3. After application of cement slurry, the underlayer of cement concrete of mix as indicated shall be spread and leveled with a screeding board to leave slightly rough surface.

13.38.4 Laying Terrazo Topping

1. Terrazo topping, of the thickness, as indicated, shall be laid, while the underlayer is still plastic, but it has hardened sufficiently to prevent cement from rising to the surface; this is normally achieved between 18 to 24 hours after the underlayer has been laid. A cement slurry @ 2.5 Kg per sq m, preferably of the same colour as the topping shall be brushed on the surface immediately before the laying is commenced.
2. The terrazzo mix shall be placed on the screed bed (underlayer) and compacted thoroughly by tamping or rolling and trowelled smooth. Excessive trowelling in early stages shall be avoided. Care shall be taken that cement does not get worked up to the surface which will produce a finish liable to crack and will also necessitate more grinding of surface to expose the marble chips.
3. The surface shall then be rammed in order to consolidate the terrazzo; it is not sufficient just to float lightly as this would cause depressions which have to be filled with mortar. A piece of smooth marble stone of size 15cm x 15cm x 2.5cm may be advantageously used for ramming. Following the rammer, a trowel may be used. Internal and external angles may be rounded upto 25mm radius, where directed.
4. Work on Borders and Decorative Designs : Borders and decorative designs shall be laid before the main body of the flooring. They shall be laid and finished in the same manner as flooring.

13.38.5 Curing

The surface shall be left dry for air-curing for duration of 12 to 18 hours. It shall then be cured by allowing water to stand in pools over it for a period of not less than two days, before commencement of hand grinding and 7 days before commencement of machine grinding. Precautions shall also be taken to prevent the floor from being subjected to extreme temperature.

13.38.6 Grinding

The grinding shall be done by machine or by hand where machine grinding is not feasible such as in skirting, dados, treads etc. First grinding shall be done with carborundum stone of 60 grit size, the second with 80 grit size, the third with 120 to 150 grit size and the fourth with 320 to 400 grit size. Between each grinding the surface shall be washed clean and grouted with neat cement grout of cream like consistency using the same coloured cement as in the original mix and allowed to dry for 24 hours (except 12 hours in lieu of 24 hours after the third grinding) and then wet cured for four days. After the final grinding the surface shall again be washed clean and rubbed hard with felt and slightly moistened oxalic acid powder, at the rate of 5 gm of oxalic acid powder for one sq m of floor surface.

13.38.7 Just before completion, the floor shall be washed clean with dilute oxalic acid solution and dried. Floor polishing machine fitted with felt or Hessain bobs shall then be run over it until the floor shines.

13.38.8 Where wax-polished surface is indicated, the wax-polish shall be sparingly applied with soft linen on the clean and dry surface. Then the polishing machine fitted with bobs shall be run over it. Clean saw-dust shall then be spread over the floor and polishing machine again applied, mopping up surplus wax and leaving glossy surface. Care shall be taken that the floor is not let slippery.

13.38.9 Before commencement of terrazzo work, a sample slab shall be laid by contractor at his expense, and got approved by the GE in respect of colour and shade of terrazzo, grade and colour of marble aggregate to be provided.

13.39 Cement Concrete Tile and Terrazo Tile Flooring

13.39.1 Cement Mortar Screed

The screed bed for laying cement concrete and terrazzo tiles shall be of cement and sand mortar 1:4 in the case of floors and cement and sand mortar 1:3 in the case of skirtings and dados. The base shall be cleaned of all scum, laitance or plaster droppings or any other loose foreign matter. It shall be properly wetted without allowing any water pools on the surface. The mortar shall then be evenly spread over the base for two rows of tiles and about three to five meters in length. The top of mortar shall be kept rough so that cement slurry can be absorbed. The thickness of the bedding shall be not less than 15mm at any place.

13.39.2 Laying of Tiles

1. Laying of tiles shall commence by the time the bedding becomes sufficiently hard to offer rigid cushion for the tiles. Neat cement slurry of honey-like consistency shall be spread over the mortar bed, over such an area at a time as would accommodate about 20 tiles. The tiles shall be fixed in this grout one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall not exceed 1.5mm in width.
2. After the tiles have been laid in a room or the day's laying work is completed, the surplus cement slurry and the joints shall be cleaned and washed fairly deep with the help of a broom stick. It shall be seen that the cement slurry is cleaned before it sets hard.

3. The day after tiles have been laid, the joints shall be filled with cement grout of the same shade as the colour of the matrix of the tiles.
4. Tiles which are fixed in the floor adjoining the wall shall go about 10mm under the plaster or skirting or dado. For this purpose, the wall plaster may be left unfinished by about 50mm above the level of the proposed finished flooring, skirting or dado and the unfinished strip may be plastered later on after the tiles are fixed.
5. After fixing, the flooring shall be kept moist and allowed to mature undisturbed for seven days so that the bedding and joints set properly. After this, it may be used for light traffic. Heavy traffic shall not be allowed on the floor for at least 14 days after fixing the tiles.
6. Wherever big areas of floors are to be tiled, the level of the central portion of the floor shall be kept about 10mm higher than the level marked at the wall.

13.39.3 Grinding and Polishing

1. Grinding and polishing of the tiles shall be commenced only after the floor as well as the joints have properly set but in no case earlier than 14 days of laying.
2. Grinding shall preferably be done using a machine except for skirting and dados. Chequered or grooved tiles shall be polished by hand.
3. For grinding terrazzo tile flooring, the first grinding shall be with Carborundum stone of 48 to 60 grit. When floor is rubbed even and the chips show uniformity it shall be cleaned with water making bare all pin holes. Grouting in the same shade is then briskly applied so that all pin holes are properly filled in. The grout shall be kept moist for a week for proper setting. Thereafter, the second grinding operation with Carborundum of 120 grit is commenced. The floor is grouted again to fill in fine pin holes. After curing for a week, the floor is left with this protective film till other works are completed. Final grinding is done with Carborundum of 220 to 350 grit using plenty of water. When surface is rendered smooth it is washed with water. After wards oxalic acid powder is vigorously applied with machine fitted with Hessian bobs to bring out shine. Floor is then washed clean and dry linen applied to suck- in- moisture.

   Where indicated, wax polish shall finally be applied mechanically with clean Hessian bobs. Superfluous wax is moped-up with saw dust to prevent slipperiness. Saw dust may be allowed to remain on the surface till occupation. This will protect the surface and help to increase luster. When saw dust is spread, water should not be spilled as this is likely to leave stains on the polished surface.
4. In the case of plain cement and coloured cement tiles, the process of polishing shall be the same as described for terrazzo tiles except that initial grinding with Carborundum stone 48 to 60 grit is not necessary.

13.39.4 Tile Skirting and Dado

Tile skirting and dado shall be fixed only after laying the tiles in the floor. The portion of the wall to be covered with skirting and dado shall be left unplastered. The wall surface shall be evenly and uniformly covered with about 10mm thick backing of cement and sand mortar 1:3. However in the case of skirting, the tiles may be directly fixed without application of backing as a separate course. Before the backing mortar has hardened, the back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile gently tapped against the wall with a wooden mallet. The fixing shall be done from the bottom of the wall upwards. All the tile faces shall be set in conformity with one another and shall be truly vertical.

Tiles shall be ground and polished as for flooring by hand. Precast treads and risers for staircase shall be laid and polished as for flooring.

13.39.5 The finished floor, skirting and dado shall have an even smooth and shining surface. Joints shall be in correct alignment. After laying the floor shall be allowed to remain clean and free from cement, oil, paint, distemper, plaster dropping and all materials likely to stain or spoil the tiles.

13.39.6 Marble Stone Slab and Tile Flooring and Skirting

Every slab/tile shall be machine cut to required size and shape. The top surface tile/slab before laying shall be machine polished. The laying grinding and polishing shall be similar to that of kota stone flooring and skirting.

13.40 Ceramic Glazed tiles flooring / Ceramic Glazed wall tiles in dado and Skirting

13.40.1 Bedding

The screed bed for laying Ceramic Glazed floor tiles shall be of cement and sand mortar 1:4. Bedding over which the tile shall be laid shall not be less than 10mm at any place. Tiles shall be soaked in water before laying.

13.40.2 Laying

Base concrete or RCC slab shall be cleaned and wetted. The bedding shall then be laid evenly over the surface, tamped and corrected to desired levels and allowed to harden enough to offer a rigid cushion to tiles. Before laying the tiles, cement slurry of honey like consistency at 3 kg/sq m shall be applied over the bedding. At a time area to accommodate about twenty tiles shall be applied with cement slurry. Tiles shall then be washed clean and fixed in the grout one after the other, each tile being gently tapped in its position till it is properly bedded and in level and line with adjoining tiles. The joints shall be as thin as possible but not exceeding 1.5mm wide. The ceramic tiles shall be set, jointed with cement slurry and pointed in neat coloured cement to match the colour of tiles. The surface shall be cured for seven days and then washed clean.

In the cases of skirting and dado, the wall surface shall be covered with about 10mm thick plaster of cement and sand mortar 1:3 and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal lines. The back of tiles shall be buttered with cement paste and set on bedding mortar. The tiles shall be gently tapped in position one after the other. Top of skirting or dado shall be truly horizontal and the joints vertical or as per required pattern. Joints shall be flush pointed with white cement with pigment to match the colour of tiles.

13.41 Vitrified Porcelain Tiles flooring

13.41.1 Bedding

The screed bed for laying Vitrified Porcelain Tiles shall be of cement and sand mortar 1:4. Bedding over which the tiles shall be laid shall not be less than 10mm at any place.

13.41.2 Laying

Base concrete or RCC slab shall be cleaned and wetted. The bedding shall then be laid evenly over the surface, tamped and corrected to desired levels and allowed to harden enough to offer a rigid cushion to tiles. Before laying the tiles , tiles shall be washed and then applied fine cement slurry on the back of the tile to ensure full and proper bedding. Tiles shall then be placed on bedding, each tile being gently tapped with rubber hammer in its position till it is properly bedded and in level and line with adjoining tiles. Use of spacers is recommended for uniformity in joints and better finish. Remove the residual cement or jointing material immediately by a wet sponge. After 24 hours when the tiles are properly set and cured, fill the joint gaps with joint filler as per recommendation of manufacturer. The joint gap shall be filled by spreading joint filler paste in the spaces between the tiles with the help of rubber trowel. Clean the tiles surface immediately with the help of wet sponge .

Vitrified Porcelain Tiles can be laid in flooring over Base concrete or RCC slab directly by using suitable chemical adhesive as per manufacturers instructions if so indicated.

13.42 Linoleum Flooring

The linoleum shall be laid either loose or fixed to the sub-floor by means of a suitable adhesive as indicated.

13.42.1 Loose Spreading

Linoleum shall be kept at a temperature of not less than 20° C for at least 48 hours before it is unrolled. It shall be laid out flat for several days before it is cut to size because, after being unrolled, it shrinks in length and expands in width. As the humidity in the room is usually greater than that at which the linoleum is rolled, it absorbs moisture and being unrestrained expands. When two widths of linoleum meet, they shall be left with one overlapping the other until expansion has stopped and then cut to fit.

13.42.2 Fixing

Where fixing of linoleum is indicated, the base shall be even and dry. The base over which the linoleum is to be fixed shall be thoroughly cleaned free from dust and dirt, chemicals, oils, paints or grease. There is no need to wait for expansion to occur because the adhesive restrains movement.It shall be cut closely to size and fitted loose on the floor. One-half of the sheet is turned back into the centre and adhesive is spread on both floor and linoleum and allowed to become tacky. After an interval of time appropriate for the adhesive used, the linoleum shall be rolled on to the floor, with a 70 Kg linoleum roller working from the centre to the walls. If necessary, the linoleum may be loaded with sand bags at various points until the adhesive has gripped.The operation shall be repeated for the other half.

13.42.3 Finishing

Any adhesive contaminating the face of the flooring shall be removed as soon as possible and in any case within the setting time. When the flooring has been securely fixed, it shall be cleaned with soap and warm water. The surface shall be wax polished where so indicated.

13.43 Rubber Sheet and Tile Flooring

13.43.1 Before commencing the laying operations, it shall be ensured that base concrete or mortar is even, clean and dry. The layout of the rubber flooring on the sub-floor to be covered shall be marked with guidelines. The rubber flooring shall be first laid for trial without using the adhesive according to the required layout. The adhesive shall be applied by using a notched trowel to the sub-floor and to the back side of the rubber sheet or tile flooring. When set sufficiently for laying, the adhesive shall be tacky to the touch, but shall not mark the fingers. In general, the adhesive will require about half an hour for setting, it should not be left after setting for too long a period as the adhesive properties will be lost owing to dust film and other causes. Care shall be taken while laying the flooring that condensation does not take place on the surface of the adhesive. It is preferable to avoid laying under high humidity conditions.

13.43.2 When the adhesive is just tack free, the rubber flooring sheet shall be carefully taken and placed in position from one end onward slowly so that the air will be completely squeezed out between the sheet and the background surface. After laying the sheet in position, it shall be pressed with suitable roller to develop proper contact with the sub-floor. The next sheet with its backside applied with the adhesive shall be laid to edge with the sheet already laid and fixed in exactly the same manner as the first sheet. Care shall be taken that sheets are laid close to each other with minimum gap between joints. The alignment shall be checked after laying of each row of sheet is completed. If the alignment is not perfect, the sheets may be trimmed by using a straight edge.

13.43.3 The tiles shall be fixed in exactly the same manner as the sheets. It is preferable to start laying of the tiles from the centre of the area. The tiles shall always be lowered in position and pressed firmly on to the adhesive for full contact with the background surface. The tiles shall not be slid as it may result in adhesive being squeezed up between the joints. Any undulations noticed on the rubber flooring surface shall be rectified by removing and relaying the tiles after thorough cleaning of the under side of the affected tiles. The adhesive applied earlier in such places shall be thoroughly removed by using proper solvents and the surface shall be cleaned to remove the traces of solvents used. Work shall be constantly checked against guidelines to ensure that all the four edges of adjacent tiles meet accurately.

13.43.4 Any adhesive contaminating the face of the rubber flooring before it hardens shall be removed as the work proceeds, without smearing the adjacent surfaces. In case a solvent is used care shall be taken so that the solvent does not cause any damage to the rubber.

13.43.5 A minimum period of 24 hours shall be given after laying the rubber flooring for developing proper bond of the adhesive. During this period, the flooring shall not be put to service. When the flooring has been securely fixed, it shall be cleaned with a wet cloth, soaked in warm soap solution (two spoons of soap in 5 liters of warm water), and then washed with clean water.

13.43.6 Where indicated, rubber flooring shall be polished with a wax emulsion polish. Polishes containing organic solvents which are injurious to rubber shall not be used. The floor shall be thoroughly cleaned, dried and made free from oil and grease. The polish shall be spread lightly and evenly over the surface with a clean pad of cotton or similar material. It is important not to rub polish into the flooring. A second application shall be made in the same manner, but approximately an hour shall elapse between the applications. The polish shall be left to dry for approximately 30 minutes, depending on the atmospheric conditions and the polish employed. Polish shall be rubbed gently with a soft dry cloth until a high luster is obtained.

13.43.7 The work of laying rubber flooring shall be executed by a specialist firm approved by the GE. The workmanship shall be of a high order.

13.44 PVC Flooring

PVC sheets and tiles shall be laid in the same manner as described for 'Rubber sheet/tiles flooring'.

13.45 PVC Asbestos Tile Flooring

PVC Asbestos tiles shall be laid in the same manner as described for 'Rubber sheet/tile flooring'.

13.46 Acid Resisting Tile Flooring

Acid resisting tiles shall be laid in the same manner as described for 'Acid resisting brickwork' in Section 5-Brickwork'.

13.47 Kota Stone Flooring

13.47.1 Stone Slabs

The slab shall be of selected quality, hard, sound, dense and homogeneous in texture, free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness as indicated and they shall be of uniform colour.

The slabs shall have the top (exposed) face polished before being brought to site. Before starting the work, Contractor shall get the sample of slabs approved by the Engineer-in-Charge.

13.47.2 Dressing of Slabs

Every slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane. For staircase treads, single piece slab to full length and width of treads shall be provided. The nosing shall be rounded off and two parallel grooves ten by ten (10mm x 10mm) immediately behind the nosing edge shall be provided to avoid skidding. Square or circular holes shall be made carefully to accommodate M.S. Baluster in position

13.47.3 Preparation of Surface and Laying

13.47.3.1 Sub-grade concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:3 (1 Cement : 3 Coarse Sand). The thickness of screed shall be indicated.

13.47.3.2 The slabs shall be laid in the following manner :-

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness as indicated. The slab shall be washed and cleaned before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4 kg of cement per square metre. The slab to be paved shall be lowered gently back in position bedded in level. Subsequent slabs shall be laid in the same manner and joints between adjacent slabs shall be as thin as possible and run in straight line. After each slab has been laid, surplus cement grout coming out of the joints of the slabs shall be cleaned off. The surface of the flooring as laid shall be true to levels, lines and shapes as instructed by the Engineer-in-Charge.

13.47.3.3 Slabs which are fixed in the floor adjoining the wall shall enter not less than twelve (12) mm under the plaster skirting or dado. The junction between wall plaster and the floor shall be finished neatly and without waviness.

13.47.4 Curing, Polishing and Finishing

13.47.4.1 The floor shall be kept wet for a minimum period of seven (7) days. The surface shall thereafter be ground evenly with machine fitted with fine grade blocks (No. 120). The final grinding with machine fitted with the finest grade grit blocks (No. 320) shall be carried out the day after the first grinding described above or before handing over the floor, as ordered by the Engineer-in-Charge.

13.47.4.2 For small areas or where circumstances so require, hand polishing may be permitted in lieu of machine polishing after laying. For hand polishing the following Carborundum stones shall be used.

1st grinding	-	Medium Grade Stone (No. 8)
Final Grinding	-	Fine Grade (No. 120)

13.47.4.3 In all other respects, the process shall be similar as for machine polishing.

13.47.4.4 After the final polish, oxalic acid shall be dusted over the surface at the rates of thirty three (33) gms. per square metre sprinkled with water and rubbed hard with pad of wooden rags. The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

13.47.4.5 If any slab is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with wooden mallet.

13.48 Use of Epoxy Mortar for Laying Tile Flooring on Existing Floors

13.48.1 Material

1. Primer :- Primer shall be as specified.

2. Sand :- Normally sand for concrete use will be used passing through 10 guage mesh.

3. Surface treatment :- The existing surface shall be roughened by chemical etching and then cleaned by water. When the surface is dry, it shall be wire brushed to have rough, dry and clean surface for the application of primer.

4. Primer Coat :- One/Two brush coat as specified of epoxy mixture of thickness 6mm shall be applied on the pre treated surface. The ratio of the constituent of the epoxy shall be of 2:1 using araldite GY 257 and Hardener HY 830/850.

5. Bedding mortar shall be of the following composition :-

Araldite GY 257	100 part by weight
Hardner HY 830	45 parts by weight
Hardner HY 850	15 Parts by weight
Quartz sand	400 to 600 parts by weight

6. Pointing Mortar :- The pointing mortar shall be of the following composition :-

Araldite GY 250	100 parts of weight
Hardner HY 830	45 parts by weight
Hardner HY 850	15 parts by weight
Quartz sand	400 Parts by weight

13.48.2 The method of application and use shall be as per manufacturer's instruction.

13.49 Wear-Resistance Flooring by Use of Vaccum Dewatering Method and Power Trowelling Method with a Skim Floater

1. Cement shall be laid between the steel forms and a precast concrete rail acting as a stop end and also rail to be used for surface vibration. The preparation and laying of concrete shall be all as per clause 13.32.5. Thickness and mix of the concrete shall be as indicated.
2. The concrete thus laid shall be vibrated with poker vibrator. During poker vibration, proper compaction of coarse aggregate fine aggregate, and cement shall be obtained. The surface will then be finished in level with the help of surface vibrator to give a dense level surface of concrete.

3. Vacuum dewatering method will be used to remove excess water from the laid concrete and filter pad and suction mat shall be laid on the freshly laid concrete which will not allow cement paste to flow out, and the suction pump are then started immediately to remove the excess water. The suction time normally is 20 to 30 minutes. This vacuum process will enable to remove 15 to 25% of water content making the surface hard enough to enable to carry the floating operation.
4. The top surface after removal of mat shall be floated with a mechanical skim floater with trowelling blade to enable the top surface to grind and give a uniform water resistance surface on top. Under no circumstances neat cement be sprinkled directly on concrete surface to absorb bleed water as surface scaling may occur later. Similarly water should not be applied between trowelling operations as it may cause surface weakness. Minimum two passes shall be carried out. The surface shall then be watered and cured as per clause 13.32.10.

SECTION 14
PLASTERING AND POINTING

14.1 Indian Standards

The following IS apply to this Section :

I. S. No.	*Subject*
1542-1992	Specification for sand for plaster (Second revision)

14.2 Definitions

(a) The term 'plastering' shall cover all type of rough or fair finished plastering, rendering, floating and setting coat or finishing coat, screed, etc., in mud, lime, cement lime or cement mortar.
(b) "Dubbing out" shall mean filling in hollows in the surface of wall and roughly leveling up irregular or out of plumb surfaces prior to rendering.
(c) "Rendering" or "rendering coat" shall mean the plaster coat, which is applied following the "Dubbing out" or the final coat in case of one coat work.
(d) "Floating coat" shall mean the second coat in a three coat plaster work, to bring the rendering coat to a true and even surface before the setting or finishing coat is applied.
(e) 'Setting or Finishing coat' shall mean final coat in a two or three coat plaster work.
(f) Thickness of plaster shall mean the minimum thickness at any point on a surface. This does not include thickness of dubbing out.
(g) The term "even and fair" as referred to finishing of the plastered surface shall mean a surface finished with a wooden float.
(h) The term "even and smooth" as referred to finishing of the plastered surface shall mean a surface levelled with wooden float and subsequently smoothed with a steel trowel.

MATERIALS

14.3 Cement

Cement shall be ordinary Portland cement or Portland blast furnace cement or Portland pozzolana cement as specified in Section 4-Concrete.

14.4 Lime

Lime shall be semi-hydraulic lime class B or fat lime class C conforming to IS 712-1984. Refer Section 4-Concrete.

14.5 Sand

Unless otherwise indicated, sand for plastering and pointing shall conform to IS 1542-1992, Specification for sand for plaster. The sand shall consist of natural sand, except where crushed stone sand or crushed gravel sand or a combination of any of these are indicated. The sand shall be hard, durable, clean and free from adherent coating and organic matter and shall not contain any appreciable amount of clay balls. Sand shall be obtained from approved sources.

14.5.1 Deleterious Materials

Sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal, mica shade or similar laminated materials, soft fragments, shells and organic impurities in such quantities as to affect adversely the hardening, the strength and the durability or the appearance of the plaster or applied decoration or to cause corrosion of metal lathing or other metal in contact with plaster. 'The maximum quantities of clay, fine silt, fine dust shall be not more than 5 per cent by weight. Organic impurities in the sand shall not exceed the following limit : -

"that the colour of the liquid is below that indicated by comparison with the standard solution specified in 6.2.2. of IS 2386 (Part-2)-1963 ".

14.5.2 The particle size grading of sand for plaster and pointing work shall be as under, unless otherwise specified to conform to the sample maintained by the GE for the purpose :-

IS Sieve designation	Percentage passing by weight
10 mm	100
4.75mm	95-100
2.36mm	95-100
1.18mm	90-100
600 microns	80-100
300 microns	20-65
150 microns	0-5

Note 1 :-Where the grading falls outside the limits of grading zones of sieves other than 600 micron IS sieve by a total amount not exceeding 5 percent, it shall be regarded as falling within the grading. This tolerance shall not be applied to percentage passing the 600 microns IS sieve or to percentage passing any other sieve size on the finer limit.

Note 2 :-Sand whose grading falls outside the above limits shall be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of sand particles.

14.6 Aggregates

All aggregates other than sand shall conform to IS 383-1970, Specification for coarse and fine aggregates from natural sources for concrete. Refer Section 4-Concrete.

14.7 Integral Water Proofing Compound

Refer Section 4-Concrete.

14.8 Soil for Mud Plaster and Mud Mortar

Refer Section 5-Brickwork

14.9 Metal lathing

Metal lathing shall be of wire netting or expanded metal as indicated.

14.10 Lime putty (Neeru),

Lime putty shall be obtained by slaking fat lime with fresh water and sifting it. The slaking shall be done as specified under Masonry Mortars in Section 5-Brickwork, Putty shall be kept moist until used and the quantity prepared at a time shall not be more than that can be consumed in 7 days.

14.11 Water

Water used for mixing and curing shall be clean, free from deleterious matter and also from unusual proportions of dissolved salts. Sea water or tidal astuary or brackish water shall not be used. Water fit for drinking is normally suitable.

14.11A White Cement based Wall Care Putty

White Cement Based Wall Care Putty shall be of approved make and shall be water resistant.

Workmanship

14.12 Scaffolding

Where possible, independent scaffolding shall be used to obviate the subsequent restoration of masonry in put log and other breaks in the work. Stage scaffolding shall be provided for ceiling plaster.

14.13 Preparation of Mortar for Plastering and Pointing

14.13.1 Lime Mortar

Mortar for lime plaster and pointing shall be prepared as described in Section 4-Concrete, except that mortar is ground in a mortar mill for atleast 180 revolutions. Finally chopped jute or coconut fibre shall be added to the mortar, at the rate of 1 Kg of jute to one cubic meter of mortar, while grinding. Where the quantity of mortar required is small EIC to warrant the use of mill, the mixing and grinding shall be done as directed by the EIC. Lime mortar remaining unused for over 72 hours shall be rejected. All lime mortar after grinding shall be kept damp by covering with wet sacks or any other means and shall not be allowed to go dry.

14.13.2 Cement and Cement Lime Mortars

These shall be prepared as described in Section 5-Brickwork. These shall be made in small quantities as required and applied within 30 minutes of mixing.

14.13.3 Proportioning of Mixes

All mixes specified are by volume. Proportioning of lime shall be done as volume of lime putty and when measurement is done of hydrated or dry slaked lime, then quantity shall be such as to yield the required volume of lime putty.

14.14 Preparation of Background for Application of Plaster

14.14.1 Cleanliness

All dirt, dust and other foreign matter on masonry and laitance on the concrete surfaces shall be removed by watering and brushing as required. If the background contains soluble salts, particularly sulphates, the application of plaster shall be done only after the efflorescence of the salts is complete and the efflorescence is completely removed from the surface. In case of old work crumbled and damaged parts shall be cut out and patched. Any trace of algae or moss formation shall be removed.

14.14.2 Joints in brickwork, stone masonry and hollow block masonry shall be raked out to a depth of not less than 10 mm as the work proceeds. Local projections in brickwork and masonry beyond the general wall face shall be trimmed off where necessary.

14.14.3 Roughness

Smooth surfaces of in-situ concrete walls and ceilings etc. shall be roughened by wire brushing, if it is not hard; and by hacking or bush hammering if it is hard, to provide for proper adhesion. Projecting burrs of mortar because of gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushes. In addition concrete surface shall be pock marked with a pointed tool at spacing of about 50 mm, the pocks made to be not less than 3 mm deep.

14.14.4 Suction Adjustments

Adequate drying intervals shall be allowed between the erection and plastering to bring the surface suitable for suction adjustment. High rate of suction makes the plaster weak, porous and friable. The wall shall not be soaked but only damped evenly before applying the plaster. If the surface becomes dry in spots, such areas shall be moistened again to restore uniform suction. Excessive water leads to failure of bond between the plaster and the background.

14.14.5 Evenness

Any local unevenness must be levelled and projections removed to avoid variance in the thickness, of plaster.

14.14.6 Immobility

Differential movements between the background and the plaster due to moisture change, temperature change, structural settlement, deflection, etc. cause cracks. The major part of such movements shall be allowed to set in before the plaster is applied.

14.14.7 Precaution against discontinuity in background

All straight cut groove through the plaster at the junction of wall to ceiling may be provided where directed.

14.14.8 Holes left in the wall after removing scaffolding, shall be filled up with the respective masonry and the patch plastered up true and in conformity with rest of the wall so that no sign of patch work shows out.

14.15 Blank

14.16 Plastering - Generally

14.16.1 The type and mix of mortar for plastering, the number of coats to be applied, and surface finish of the plaster and the background to which the plaster is to be applied shall be as indicated.

14.16.2 The mortar for dubbing out and rendering coat shall be of the same type and mix. Dubbing out may be executed as a separate coat or alongwith the rendering coat.

14.16.3 Plastering operations shall not be started until all necessary fixtures such as door and window frames, mantle pieces are completed and all pipes and conduits to be embedded have been installed and surfaces to be plastered have been passed by the EIC.

14.16.4 Protection

All existing work and fittings that are likely to be damaged in the application of plastering shall be protected. Care shall be taken to avoid, as far as possible, the splashing of mortar on to the finished surfaces such as joinery, paintwork and glazing, all such splashes shall be cleaned off immediately.

14.16.5 Screeds 15 x 15 cm shall be laid vertically and horizontally not more than 2 m apart to serve as guides in bringing the work to an even surface.

14.16.6 Plastering shall be done from top to bottom and care shall be taken to avoid joints in continuous surface.

14.16.7 Maintenance of Proper Time Intervals

To avoid break down of adhesion between successive coats, drying shrinkage of first coat shall be allowed to be materially completed before a subsequent coat is applied.

14.16.8 All corners, arises angles, junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering of corners, arises and junctions shall be carried out with proper templates to the required size. Plastering of cornices, decorative feature etc. shall normally be completed before the finishing coat is applied.

14.16.9 In suspending the work at the end of the day, the plaster shall be cut clean to the line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scraped clean and wetted with lime putty or cement slurry before plaster is applied to the adjacent area.

14.16.10 Partially set and dried mortar shall not be retampered for use.

14.16.11 Cleaning on Completion

On completion all work affected by plastering and pointing shall be left clean; special care shall be taken when removing any set mortar from glass and joinery, etc. to avoid damaging their surface.

14.16.12 Trueness of Plastering System

The finished plaster surface shall not show any deviation more than 4 mm when checked with straight edge of 2 m length placed against the surface.

14.17 One Coat Plaster Work

Mortar shall be firmly applied to the masonry walls and well pressed into the joints forcing it into surface depressions to obtain a permanent bond. The plaster shall be laid **in** a little more than the required thickness and levelled with the wooden float. On concrete walls, rendering shall be dashed on to roughened surface to ensure adequate bond. The dashing of rendering coat shall be done using a strong whipping motion at right angles to the face of walls. The surface shall be finished even and fair, unless indicated to be finished even and smooth.

The surface of the dubbing out, if carried out separately, shall be left rough or scored to provide key for the plaster coat

14.18 Two Coat Plaster Work

14.18.1 First Coat

The first coat of the specified thickness shall be applied in a manner similar to one coat plaster work. Before the first coat hardens, the surface of the cement and cement lime plasters shall be scored to provide key for second coat. In case of lime plasters the surface shall be beaten with edges of wooden thapies and close dents shall be made on the surface, to serve as a key to the subsequent coat. The rendering coat shall be kept damp for atleast two days. It shall then be allowed to become thoroughly dry.

14.18.2 Second Coat

Before starting to apply second coat, the surface of the rendering coat shall be damped evenly. The second coat shall be completed to the specified thickness in exactly the same manner as the one coat plaster work.

14.19 Three Coat Plaster Work

14.19.1 First coat of the specified thickness shall be applied as specified for first coat of two coat plaster work.

14.19.2 Second Coat (Floating coat)

Before starting to apply the second coat, the surface of the rendering coat shall be damped evenly. The second coat shall be applied to specified thickness and brought to a true and even surface and then roughened to provide bond for the finishing coat The second coat shall be kept damp for atleast 2 days and then allowed to become dry.

14.19.3 Finishing Coat

Before starting to apply the finishing coat, the second coat shall be damped evenly. Mortar shall be applied from top to bottom, wherever possible, in the operation to eliminate joining marks. The surface shall be finished as specified for one coat plaster work.

14.20 Neeru Finish

After applying and finishing the undercoats and before they set the finishing coat of specially prepared lime putty about 1.5 mm thick shall be applied. It shall be well polished with a trowel.

14.21 Sand Faced Plaster

After the undercoat of cement and sand mortar 1:4, not less than 10 mm thick, has been applied and finished, the final coat of cement and sand mortar 1:4 shall be applied to a thickness not less than 5 mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture; care being taken that the tapping is even and uniform.

14.22 Roughcast Finish

After applying the under coat of cement and sand mortar 1:3 not less than 10 mm thick and while it is still in plastic state the roughcast mixture consisting of crushed stone or fine gravel aggregate (which is generally of size between 6 to 12 mm depending on the texture required) mixed with coarse sand and cement in the ratio of 1: 1: 1 shall be applied and finished even. The mix of cement and sand shall be made slightly wetter than normal for rendering to ensure that larger aggregates are thoroughly covered.

14.23 Dry Dash Finish

A rough finish rendering coat of cement and sand mortar 1:3 shall be laid on to a thickness of not less than 10 mm and shall be lightly pressed over to straighten it. The aggregate used for dashing viz crushed stones or pebbles of suitable size generally from 10 to 20 mm, shall be well washed, drained and thrown wet on to the rendering coat while it is still plastic, rough covering material being partially embedded in the surface. To insure satisfactory bond between the dashing and the mortar the aggregate may be lightly tapped into the mortar with wooden float or the flat of a trowel.

14.24 Curing

Each coat shall be kept damp continuously for at least two days. Moistening shall commence as soon as the plaster has hardened sufficiently and is not susceptible to injury. The water shall be applied preferably by using a fine fog spray. Soaking of wall shall be avoided, and only as much water as can be readily absorbed shall be used. Excessive evaporation on the sunny or wind ward sites of buildings in hot dry weather shall be prevented by hanging mattings or gunny bags on the outside of the plaster and keeping them wet.

14.24.1 After the completion of finishing coat, the plaster shall be kept wet for at least seven days and shall be protected during that period from extremes of temperature and weather.

14.25 Water Proofing Plaster

Integral water proofing compound shall be mixed with cement in the proportion indicated by weight. When not indicated it shall be 3% by weight of cement. Care shall be taken to ensure water proofing material gets well and integrally mixed with cement and does not run out separately when water is added.

14.26 Mud Plaster

14.26.1 Preparation of Mud Mortar

Mud mortar and leeping shall be prepared as described in Section 11 Roof Covering.

14.26.2 Application

The mortar shall be firmly applied to the prepared surface, to a thickness not less than 25 mm unless otherwise indicated and finished with a wooden float to a fair and even surface and allowed to dry. Cracks that appear during drying shall be filled in with a grout of gobri and clay in equal proportions.

14.26.3 When the plaster surface has dried, leeping plaster shall be applied to thickness not less then 3 mm and finished with a trowel to a smooth and even surface. The surface shall be allowed to dry and hair cracks, if any shall be filled with gobri and clay grout and finished with trowel.

14.27 Metal lathing

Lathing shall be tightly stretched before nailing and secured with 25 mm galvanised steel staples at 20 cm centres, if the studding is of wood and with 0.90 mm iron tying wire if the studding is of steel. Edges of lathing shall be lapped 50 mm at the sides and wired together with 1.25 mm tying wire. Overlaps shall not occur at angles or curves. End laps shall occur only at supports. Before plastering the surface of metal lathing shall be brushed over with thin cement slurry.

14.27.1 Plastering to lathing shall be carried out in two coats. The first coat shall be applied stiff on both the sides of the lathing and levelled with wooden float. The surface shall then be protected and cured as directed by EIC. After the First coat has set and dried, the finishing coat to a thickness as indicated shall be applied. Too much pressure shall not be used in applying plaster to lathing to guard against its deflection.

14.28 Repairs to Plastered Surfaces Cutting

14.28.1 Cutting

The mortar of the patch where the existing plaster has cracked, crumbled or sounds hollow when gently tapped on the surface, shall be removed. The patch shall be cut out, to a square or rectangular shape at the position marked on the wall. The edges shall be under-cut slightly to provide a dovetailed key for the catch plaster.

14.28.2 Preparation of Surface

The masonry joints which become exposed after removal of the old plaster shall be raked out to a minimum depth of 12 mm in the case of brick work and 15 mm in the case of stone work. The raking shall be carried out uniformly with a raking tool and loose mortar dusted off. The surface shall then be thoroughly washed with water, and kept wet before plastering is commenced.

Concrete surfaces, shall be thoroughly scrubbed with wire brushes after the plaster had been cut out. The concrete surface shall be pock marked with a pointed tool, at spacing of about 50 mm, the pocks made being not less than 3 mm deep, to ensure a proper key for the plaster. The mortar shall be washed off and the surface cleaned of all oil, grease etc, and well wetted before the plaster is applied

14.28.3 Application of Plaster

The mortar of the specified mix shall be used. The method of application shall be the same as described for single coat plaster work. The surface shall be finished even and flush with the old surrounding plaster. All roundings necessary at junctions of walls ceilings etc. shall be carried out carefully and neatly.

14.28.4 Protective Measures

Doors, windows, floors, articles of furniture, etc, and such other parts of the building shall be properly protected from being splashed upon. Splashings and drops if any shall be removed and the surface cleaned.

14.29 Pointing

The type and mix of mortar for pointing and the type of pointing shall be as indicated.

14.29.1 Raking out joints

14.29.2 Joints of new brick work or block or stone-masonry shall be raked out (without damaging the brick work or masonry) when the mortar is green to such a depth that the minimum depth of new mortar measured from either the sunk surface of the finished pointing or from the edge of the brick block shall not be less than 10 mm. The raked out Joints shall be well wetted before application of mortar.

14.29.3 Application of Mortar and Finishing

The mortar shall be pressed firmly into the raked out joints, with a pointing trowel according to the type of pointing required. The mortar shall not spread over the corners, edges or the surfaces of the masonry. When pointing is air dry, it shall be rubbed smooth with the trowel and shall then be finished with proper tool. The surface of masonry shall be cleaned of all mortar.

14.29.4 Pointing on Random Rubble / Polygonal Rubble Stone Masonry

The pointing shall follow the natural irregularities in line and surface of stones.

14.29.5 Types of Pointing

14.29.5.1 Flush Pointing

The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the bricks, tiles, blocks or stones so as to give a smooth appearance. The edges shall be neatly, trimmed with a trowel and straight edge.

14.29.5.2 Struck Pointing (Weather-Struck pointing (see Fig 1 & 2)

The mortar shall first be pressed into the raked out joints. The top of the horizontal joints shall be neatly pressed back about 3 mm or as directed by EIC with the pointing tool so that the joint is sloping from top to bottom. The vertical joints shall be pressed back to form a semi-circular or V -groove of the same width as the horizontal joints.

14.29.5.3 Keyed Pointing (Ruled Pointing) (See Fig 3)

Keyed or ruled pointing shall be done by first finishing the joints as for flush pointing and then ruling off the horizontal and vertical joints with a round edged tool to form narrow semi-circular grooves in proper alignment.

14.29.5.4 Raised Pointing (Masons V Joints and Bastard Tuck) (See Fig 4 & 5)

Raised pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm in depth. The pointing shall be finished to a smooth but hard surface.

14.29.5.5 Recessed Pointing (Sunk Pointing) (See Fig 6)

The mortar shall be neatly pressed back to about 3 mm or as directed with the pointing tool. The vertical joints shall be pressed back similarly to match the horizontal joints.

14.29.6 Curing

The pointing shall be kept wet for seven days. During this period it shall be suitably protected from all damages.

WEATHER STRUCK POINTING **KEYED POINTING**

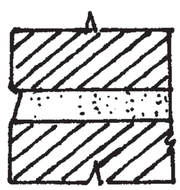


FIG: 1
Horizontal
Joint

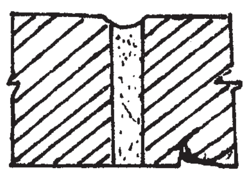


FIG: 2
Vertical
Joint

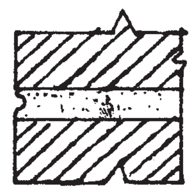


FIG: 3
Keyed
Joint

RAISED POINTING **RECESSED POINTING**

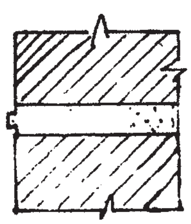


FIG: 4
Bastard
Tuck
Joint

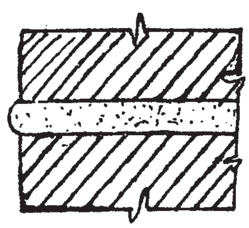


FIG: 5
Mason's
Joint

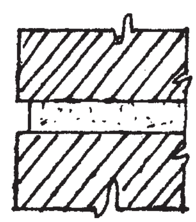


FIG: 6
Recessed
Joint

SECTION 15
WHITE WASHING, COLOUR WASHING AND DISTEMPERING

15.1 Indian Standards

The following IS apply to this section:-

IS NO	*Subject*
44-1991	Specification for Iron oxide pigments for paints (Second revision)
63-1978	Specification for whiting for paints and putty (Third revision)
261-1982	Specification for copper sulphate (Second revision)
427-2005	Specification for distemper dry, colour as required (Second revision)
428-2000	Specification for washable distemper (Second revision)
712-1984	Specification for building limes (Third revision)
5410-1992	Specification for cement paint (First revision).
12027-1987	Specification for silicone based water repellents

Materials

15.2 Lime

Lime used for white washing shall be freshly burnt fat lime (Class 'C') or magnesium/siliceous dolomitic lime (Class 'D' or 'F'), white in colour, conforming to IS 712-1984 Specification for building limes.

15.3 Yellow and Red Ochre

The pigment for making colour wash shall conform to IS 44-1991 Specification for Iron oxide/pigment for paints. The solid lump shall be crushed to powder.

15.4 Blue Vitriol

Fresh crystals of hydrous copper sulphate (blue vitriol) shall conform to IS 261-1982 Specification for copper sulphate and shall be ground to fine powder.

15.5 Distemper, Dry

Distemper dry of required colour and shade shall be obtained ready mixed conforming to IS 427 -2005, Specification for distemper, dry. The material shall be in the form of fine dry homogeneous powder free from odour of putrefaction as such and when mixed with water.

15.6 Distemper, Oil Emulsion

Distemper of required colour and shade shall be obtained ready mixed conforming to IS 428-2000 Specification for distemper, oil emulsion. The material shall in the form of a homogeneous paste free from odour of putrefaction as such and when mixed with water.

15.7 Cement Paint

Cement paint shall comply with IS 5410-1992, Specification for cement paint colour as required. The material shall be in the powder form, free from lumps that are not friable and when mixed with required volume of water shall be suitable for use on porous surfaces of masonry, concrete, bricks and rough plaster work.

15.8 Whiting for Cloth or Hessian Ceiling

Whiting shall conform to IS 63-1978, Specification for whiting for paints. Whiting shall be well washed and finely ground.

Workmanship

15.9 Silicon based water repellants

Silicon based water repellants shall comply with requirement laid down in IS 12027-1987. It shall be Class A, B or C as indicated.

15.10 Generally

The finish to be provided viz, white washing, colour washing, distempering or painting, etc. the number of coats to be applied, and any special process or treatment to be adopted shall be as indicated.

15.10.1 No finish shall be executed until a sample of the finish to the required colour and shade has been approved by the EIC. Where more than one coat of any finish is indicated, each coat shall be approved by the EIC before the subsequent coat is applied.

15.10.2 The colour shall be of even shade over the whole surface, if it is patchy or otherwise badly applied the work shall be redone by the contractor at his own expense.

15.10.3 Protective Measures

Surfaces of doors, windows, floors, articles of furniture etc., and such other parts of the building not to be treated shall be protected from being splashed upon. Such surfaces shall be cleaned of splashes of white wash, colour wash, distemper, etc. The contractor shall be responsible for any damage to the fittings, fixture and furniture.

15.11 Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that, as far as possible, no part of scaffolding shall rest against the surface to be treated. A properly secured and well tied suspended platform (JHOOLA) may also be used. Where ladders are used, pieces of old gunny bags shall be tied at top and bottom to prevent scratches to the walls and floors. For work in ceilings, proper stage scaffolding may be erected, where necessary.

15.12 White washing and Colour Washing

15.12.1 Preparation of New Surfaces

The surfaces shall be thoroughly cleaned of all dirt, dust, mortar drops, efflorescence, chalking, grease and other foreign matter before white wash is applied.

15.12.2 Preparation of Old Surfaces

Old surfaces already white washed or colour washed shall be broomed to remove all dust, dirt and all loose scales of lime wash and other foreign matter. Where heavy scaling has taken place, the entire surface shall be scrapped clean. Old colour wash on surfaces where white wash or different colour wash is to be applied shall be entirely removed, before white wash or different colour wash is applied.

15.12.2.1 Old Surfaces Spoiled by Smoke Soot

The surface shall be scrapped with steel wire brushes or steel scrapers. The surface shall then be broomed to remove all dust and dirt and shall be washed with clean water.

15.12.2.2 Oil and Grease Spots

Oil and Grease spots shall be removed by a suitable chemical and smooth surfaces rubbed with wire brushes.

15.12.2.3 Moulds, Moss etc.

Any growth of mould, moss etc. shall be removed by scrapping with steel scrapers, or treated as directed by EIC.

15.12.2.4 Unsound Portions

All unsound portions of the surface plaster shall be removed where directed, to full depth of plaster in rectangular patches and plastered again after raking the masonry joints properly. Such portions shall be wetted and allowed to dry. They shall then be given one coat of whitewash.

15.12.2.5 Nails, Holes etc.

All unnecessary nails shall be removed and the holes, minor pittings and cracks filled with lime putty or Plaster of Paris to make the surface smooth.

15.12.3 Preparation of Whitewash

The lime shall be slaked at site and shall be mixed and stirred with about five liters of water for 1 kg of unslaked lime to make a thin cream. This shall be allowed to stand for a period of 24 hours and shall then be screened through clean coarse cloth. 1 kg of gum dissolved in hot water shall be added to every one cubic meter of lime cream. About 1.3 Kg of sodium chloride dissolved in hot water shall also be added for every 10 kg of lime for making the coating hard and rub-resistant. Small quantity of ultramarine blue (upto 3 gm per kg of lime) shall also be added to the last two coats of white wash solution and the whole solution shall be stirred thoroughly before use.

15.12.4 Preparation of Colourwash

Sufficient quantity of colour wash shall be prepared in one operation to avoid any difference in shade. The basic whitewash solution shall be prepared as described for white wash. Mineral colours not affected by lime shall be gradually added and solution stirred until the required tint is obtained.

15.12.4.1 Yellow ochre, red ochre and blue vitriol where used in the preparation, of colour wash shall be first dissolved in water. Sufficient quantity of solution enough to produce the colour of required shade shall be strained through a clean coarse cloth and the filtrate mixed evenly and thoroughly to the white wash.

15.12.5 Application of Whitewash

Whitewash shall be applied with 'MOONJ' brush or other brush to the specified number of coats. The operation for each coat shall consist of a stroke of the brush given from the top downwards, another from the bottom upwards over the first stroke and similarly one stroke horizontally from the right and another from the left before it dries. Each coat shall be allowed to dry before the next coat is applied. No portion of the surface shall be left out initially to be patched up later on. The brush shall be dipped in whitewash, pressed lightly against the wall of the container and then applied by lightly pressing against the surface with full swing of hand.

15.12.5.1 Whitewashing on ceiling should be done prior to that on walls.

15.12.5.2 For new work, unless otherwise indicated, minimum two coats shall be applied so that the surface presents a smooth and uniform finish through which the plaster does not show. The finished dry surfaces shall not show any signs of cracking and peeling and the whitewash shall not come off readily on the hand, when rubbed.

15.12.5.3 For old work, after the surface has been prepared, a coat of whitewash shall be applied over the patches and repairs. Then the specified number of coats of whitewash shall be applied over the entire surface. The white washed surface shall present a uniform finish through which the plaster patches do not show.

15.12.6 Application of Colourwash

The colourwash shall be applied as described for white wash. For colourwash on new surfaces after the surface has been prepared, the first primary coat shall be of whitewash. The specified number of coats (minimum two) of colourwash shall then be applied. The entire surface shall present a smooth and uniform finish.

To start with 0.1 sq m of the prepared surface shall be colour washed with a first coat of whitewash and subsequent coats of colour wash solution in full number of coats and the shades so obtained shall be approved before the work of colour washing is taken up in hand. It shall be noted that small areas of colourwash will appear lighter in shade than when the same shades are applied to large areas.

15.12.6.1 For colourwash on old work after the surface had been prepared, a coat of colour wash shall be applied on the patches and repairs. Then the specified number of coats of colourwash shall be applied over the entire surface. The colourwash surface shall present a uniform colour shade. No primary coat is needed for old surfaces bearing colour of the same shade.

15.12.6.2 On surface requiring a change of colour, after the surface has been prepared, a coat of whitewash shall be applied before application of specified number (minimum two) of coats of colour wash of the new shade.

15.13 Distempering with Dry Distemper

15.13.1 Preparation of New Surfaces

The surface shall be thoroughly cleaned of dust, dirt efflorescence, chalking, grease, mortar drops and other foreign matter. The surface shall be sand papered with grade I abrasive paper and dusted off to achieve an even and smooth surface. If surface so obtained is uneven, it shall be brought to a perfectly even surface by applying putty and allowing it to dry completely and then it shall be rubbed with the abrasive paper and dusted off.

15.13.2 Preparation of old surfaces

Old surface of white wash or colour wash if in good condition shall be lightly sand papered down but if in bad condition shall be removed completely by scrapping on or rubbing and allowed to dry completely, care being taken that the surface is not scratched. Old surfaces already distempered with dry distemper and required for the application of dry distemper, if in good condition shall be lightly sand papered with fine sand paper and dusted off. When the old surface is in bad condition, the entire film may be removed either by dry rubbing with sand papers or by rubbing down with water and pumice stone and allowed to dry out completely and then lightly sand papered.

15.13.2.1 Old surfaces covered by smoke, soot, having oil and grease spot, mould and moss shall be prepared as specified under white wash & colour wash except that after a portion of plaster is replaced, it shall be given a coat of dry distemper in lieu of white wash.

15.13.2.2 All the undesirable nails shall be removed and nail holes and inequalities filled with putty and allowed to completely dry. The surface shall then be rubbed down with abrasive paper grade I and dusted off.

15.13.3 Priming Coat

For distempering with dry distemper, the priming coat, where indicated shall be a coat of clearcolle composed of 1 Kg of Glue mixed with 15 litres of boiling water. The mixture shall be suitably tinted where required. Priming coat shall be applied by brushing and allowed to dry before distempering coat is given.

15.13.4 Preparation of distemper

The dry distemper shall be added to clean warm water and stirred slowly using 0.6 litres of water per Kg of distemper or proportion as specified by the manufacturer. The mixture shall be allowed to stand for at least 30 minutes before use. The mixture shall be well stirred before application to maintain an even consistency.

15.13.5 Application of distemper

The surface of priming coat, where applied shall be lightly sand papered taking care not to rub out the priming coat and then dusted off. Specified number of coats of distemper shall then be applied with proper distemper brushes in horizontal strokes immediately followed by vertical ones which together shall constitute one coat. The subsequent coat shall be applied only after the preceding coat has dried. The finished surfaces shall be even and uniform without patches, brush marks, distemper drops etc.

15.14 Distempering with Oil bound Distemper (Washable Distemper)

15.14.1 Preparation of Surfaces

Surfaces shall be prepared as specified under dry distemper. Pitting in plaster shall be made good with Plaster of Paris mixed with dry distemper of the colour to be used. The surface shall then be rubbed down again with sandpaper and made smooth. A coat of distemper shall be applied over the patches. The surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

15.14.2 Preparation of Old Surfaces

15.14.2.1 Old surfaces already dry distempered and required for applying oil bound distemper

The distemper whether in good or bad condition shall be removed completely by washing even to the last trace and allowed to dry completely. It shall then be sand papered to obtain an even and smooth surface.

15.14.2.2 Old surfaces already painted with oil bound distemper and required for painting with oil bound distemper

The surface shall be treated similarly as for the case above except that the removal of distemper in bad condition shall be done only by dry rubbing.

15.14.3 Priming Coat

Priming coat for oil bound distemper shall be whitening mixed with petrifying liquid. Newly plastered surfaces to be distempered before a period of six months shall be given a coat of alkali resistant priming paint conforming to IS - 109 - 1968 Specification for ready mix paint brushing, priming plaster to IS colour No 361 light stone and No. 631 light grey, or any other primer as specified by the manufacturer and allowed to dry for at least 48 hours.

15.14.4 Preparation of Oil Bound Distemper (Washable Distemper)

The distemper shall be thinned with water or any other prescribed thinner in the proportion of four parts of paste by weight to one part of cold water or in the proportion as specified by the manufacturers which shall invariably be followed. To obtain a better finish and longer durability Copolymer based resin glue be added to the prepared distemper solution at the rates recommended by the manufacturers.

15.14.5 Application of Washable Distemper

After the priming coat has dried, the surface shall be lightly sandpapered with zero grade abrasive paper, taking care not to rub out the priming coats and then dusted off. Prepared distemper shall then be applied with brushes in coats comprised of horizontal strokes immediately followed by vertical ones which together constitute one coat. Distempering shall always be started from ceiling down. A uniformly finished surface without patches, brush marks distemper drop etc shall be obtained.

15.14.5.1 Distemper shall be applied in dry weather with double bristled distemper brushes. The first coat shall always be of lighter tint than that required finally and the subsequent coat shall be applied only after the previous one has thoroughly dried for atleast 24 hours.

15.14.5.2 The distemper shall be thinned and prepared using prescribed thinner as per manufacturer instruction.

15.14.5.3 Workability of oil bound distemper surface shall be tested with wet cloth. Oil bound distemper shall not come out when surface is rubbed with wet cloth.

15.15 Cement Painting

15.15.1 Preparation of Cement Paint

Cement paint shall be made by adding equal volume of paint powder to water and the mix stirred to obtain a thick paste, which shall then be diluted to a brushable consistency. If the proportion recommended by the manufacturer differs, the recommendation of the manufacturer shall invariably be followed. The water mixed paint shall be kept well stirred during use and shall be applied within one hour of preparation. To prevent algae and moss growth and efflorescence, silicon base water repellant compound may be added to mixture, at the rate as recommended by the manufacturer.

The lids of cement paint drums shall be kept tightly closed when not in use, as the cement paint rapidly becomes air set.

15.15.2 Preparation of Surfaces

The surfaces shall be prepared as specified under whitewashing and colourwashing.

15.15.3 Wetting of Surface

Before applying cement paint, the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet when the paint is applied. Surfaces which readily absorb moisture shall be wetted in one operation not more than one hour before painting. Surfaces which absorb moisture slowly shall be wetted in at least two operations not less than 30 minutes apart.

15.15.4 Application of Paint

No painting shall be done when the paint is likely to be exposed to a temperature below 7° C within 48 hours after application.

15.15.5 When weather conditions are such as to cause the paint to dry rapidly, work shall be carried out 'in the shadow' as far as possible, for proper hardening of the paint film.

15.15.6 To maintain a uniform mixture and to prevent segregation, the paint shall be stirred frequently in the bucket.

15.15.7 Unless otherwise indicated, new surfaces shall be treated with minimum of two coats of cement paint of the same colour. Not less than 24 hours shall be allowed between two coats and the second or subsequent coat shall not be started until the preceding coat has become sufficiently hard to resist marking by the brush being used. In hot dry weather the preceding coat shall be slightly moistened before applying the subsequent coat. For old surfaces the treatment will be with one coat, unless two coats are indicated.

15.15.8 Cement paint shall be applied with a brush with relatively short stiff hog or fiber bristles. The paint shall be brushed in uniform thickness and shall be free from excessive brush marks. The laps shall be well brushed out.

15.15.9 On external plastered and concrete surfaces, cement paint shall be vigorously scrubbed on in such a manner as to work the paint into the voids and provide a continuous paint film free from pin holes or other openings.

15.15.10 Spray applications may be adopted only for dense concrete or interior surfaces where the paint is not required for waterproofing purposes.

15.15.11 The finished surface shall be even and uniform in shade, without patches, paints drops etc.

15.15.12 Curing

Painted surfaces shall be sprinkled with water using a fog spray two or three times a day. Curing shall be done between coats and for atleast two days following the final coat. The curing shall be started as soon as the paint has hardened so as not be to damaged by the spray, about 12 hours after the application.

15.16 Whiting cloth or Hessian Ceilings

Whitening jelly shall be prepared by mixing together 2½ Kg of whitening and 1 litre of double size, prepared from 1/4 kg glue and placed in a covered vessel with enough water to cover the mixture and left to cool until it becomes a jelly. 1 Kg of jelly mixed with water shall be used to cover 10 Sq m of surface. Whitening shall be applied to the Hessian or cloth by brush, sufficiently thick, leaving no surface uncovered.

15.17 Cement Slurry Wash

Cement shall be mixed with water to form slurry to the consistency of a good ready mixed oil paint and the slurry applied with flat brushes to form a smooth bodied opaque surface. If so directed, common salt (sodium chloride) may be added to the mixture at the rate of 1 kg per 160 litres of slurry.

15.18 Water Repellent

Preparation of water repellant, preparation of surfaces to be treated and application shall be as per IS 12027-1987.

15.19 White Cement Based Putty

15.19.1 Material

White cement based putty shall be obtained ready mixed from the approved manufacture as approved by GE. White cement based putty shall be in the form of fine dry homogeneous powder free from odors of putrefaction and when mixed with water shall have the following properties.

(a) Tensile Adhesion strength at 28 days	>	1.0 N/mm^2
(b) Compressive strength at 28 days	>	9.0 N/mm^2
(c) Initial setting time	>	100 minutes
(d) Final setting time	>	500 minutes
(e) Water retaintivity	>	98%.

15.19.2 Preparation of White Cement based putty

White cement based putty shall be made by adding 30 to 35% of water by volume strictly as per manufacturer instructions, and the mix stirred to obtain a thick uniform paste. The water mixed putty shall be kept well stirred during use and shall be applied within 2 to 3 hours of preparation.

15.19.3 Preparation of Surfaces

The surface shall be prepared as specified under white washing and colour washing.

15.19.4 Wetting of Surface

Before applying white cement based putty, the surface shall be thoroughly wetted to ensure proper covering capacity, workmanship and better sticking properties of putty.

15.19.5 Application of Putty

(a) Unless otherwise indicated, the surfaces shall be treated with two coats of putty. First coat of putty shall be applied on wet surfaces starting from the bottom of surfaces towards top and shall be applied with putty blade to maintain homogeneity of application of putty. The surface so prepared shall be allowed to dry for atleast 3 hours. After the surface becomes dry, the surface shall be gently rubbed with wet sponge or putty blade so as to remove the loose particles. Then the second coat of putty shall be applied as like first coat and the surface shall be allowed to dry completely for minimum 12 hours.

(b) After ensuring that the surface is completely dry, the surface shall be rubbed gently with waterproof emery paper greater than 500.

15.19.6 Precautions during application

15.19.6.1 Mixing of the “White Cement Putty” is very important activity and hence extreme care is required to be taken for proper and thorough mixing with hand or mechanical stirrer in order to get best results. Mixing is to be continued till a uniform paste is formed. It is important that during mixing, the required amount of water is added incrementally to “White Cement Putty” and not vice versa (do not add putty into water).

15.19.6.2. The “White Cement Putty” shall be applied over wet surface.

15.19.6.3 It is recommended not to rub the “White Cement Putty” strongly and harshly with rough emery paper. This breaks the film formed over the “White Cement Putty”, which decreases the water repellency properties.

15.19.6.4 In case of fresh concrete/mortar surface, it is recommended that two coats of white cement wash be done before application of white cement putty.

15.20 Sagol Finish

15.20.1 Material

Sagol to be used for ‘Sagol finish’ shall be what is locally called as “Gujarat sagol” and shall be obtained from the approved manufacturer as indicated or approved by GE.

15.20.2 Preparation of Surface

The surface shall be prepared as specified under white washing and colour washing.

15.20.3 Preparation of Sagol putty

Sagol shall be mixed with water to obtain a thick uniform paste as recommended by manufacturer. The water mixed sagol shall be kept well stirred during use and shall be applied within 2 to 3 hours of preparation.

15.20.4 Application of Sagol

A thin coat of 1 mm thick on dried plastered surfaces shall be applied starting from the bottom of surfaces and then moved towards the top with putty blade and homogeneity of application shall be ensured. The surface shall be finished smooth to ensure no undulations or loose particles appears on the face. The surface so prepared shall be allowed to dry for atleast 24 hours.

15.21 Acrylic Distemper

15.21.1 Preparation of Acrylic Distemper

The distemper shall be thinned with water or any other prescribed thinner in the proportion of 1 kilogram of distemper to 600 ml of water or in the proportions as specified by the manufacturers, which shall invariably be followed. Add water slowly to the paste while continuing to stir the mixture.

15.21.2 Preparation of surfaces

Surfaces shall be prepared as specified under oil emulsion distemper.

15.21.3 Priming Coat

Apply a coat of wall primer as per manufacturers instructions and allow it to dry for 6 - 8 hours. Smoothen the surface by filling dents with thin coats of wall putty and allow drying for 4-6 hours. Sand the surface with Emery paper 180 and wipe clean. Apply another coat of primer and allow drying for 6 - 8 hours. Sand the surface with Emery paper 320 and wipe clean.

15.21.4 Application of Distemper

Application of Distemper shall be done as is being done for oil emulsion distemper in minimum two coats. For Acrylic distemper the time interval shall be 3-4 hours between successive coats.

SECTION 16
GLAZING

16.1 Indian Standards

The following IS apply to this Section :

I. S. No.	*Subject*
419-1967	Specification for putty for use on window frames (First revision).
2835-1987	Specification for flat transparent sheet glass (Third revision).
5437-1994	Specification for wired and figured glass. (First revision).

16.2 Sheet Glass

Sheet Glass for glazing shall conform to IS 2835-1987 Specification for that transparent sheet glass and shall be of the following qualities:

(a) 'A' quality or selected quality (SQ) for selected glazing, where indicated.
(b) 'B' quality or ordinary quality (OQ) for glazing purposes.
(c) 'C quality or greenhouse quality (GQ) for strips for flooring.

16.2.2 Sheet glass shall be flat transparent and clear as judged by the naked eye. It may, however, possess a light tint when viewed edgewise. It shall be free from any cracks and other defects.

16.2.3 Tolerance on the thickness of glass_sheet shall be as under: Normal thickness

Normal thickness	Tolerance
2.0, 2.5, 3.0 and 4.0 mm	± 0.2 mm
4.8, 5.5 and 6.3 mm	± 0.3 mm

16.3 Wired Glass, Wired figured Glass and figured Glass

16.3.1 Wired glass, wired figured glass and figured glass shall ('Conform to IS 5437- 1994) Specification for wired and figured glass. These shall not contain any stones with cracks or stones bigger than 2 mm dia.

16.3.2 Wired glass and wired figured glass shall be of thickness 6.4 mm ± 0.4 mm. Wire mesh shall be made of steel wire 0.46 to 0.56 mm dia The pattern of mesh shall be square or diamond with wires welded or hexagonal with wires twisted. Wire mesh shall be embedded completely in the glass sheet at least one mm from the surface and shall not be exposed at any place. Wire mesh shall not contain more than three broken wires per square metre.

16.3.3 Tolerance

Tolerance on the thickness of figured glass shall be as under:

Normal thickness	Tolerance
3.0mm	± 0.3 mm
4.0 & 5.0mm	± 0.4 mm
6.0mm	± 0.5 mm

16.4 Blank

16.5 Putty

Linseed oil putty for glazing in wooden and metal surrounds or frames shall conform to IS 419-1967, Specification for putty for use on window frames. Putty shall be homogeneous paste and shall be free from dust, grit and other visible impurities. The putty after thorough working in hands shall have good plastic quality without sliminess or stickness. The putty shall work readily and smoothly under a palette knife without crumbling or cracking and after being moulded in place, it shall convert itself into cohesive mass.

16.6 Size of Glass

A clearance of 2.5 mm between the edge of glass and wood or metal surrounds and 3 mm for stone, concrete or brick surrounds shall be allowed.

16.6.1 Each pane of glass shall be one whole square; piecing shall not be allowed. Broken or damaged glass shall be hacked and replaced.

16.7 Preparation for Glazing

16.7.1 Before glazing, all opening parts shall be checked to see that they are closing correctly and frames are well bedded and not twisted in any way.

16.7.2 Rebates and grooves shall be dry and completely cleaned at the time glazing is fixed.

16.7.3 Wood Surrounds

The rebates and grooves shall be painted with one coat of primer if the surround is to be painted or primed with a medium composed of equal parts of exterior varnish and white spirit if the surround is not to be painted.

16.7.4 Steel Surrounds

The rebates and grooves shall be painted with one coat of primer. Zinc surfaces shall be primed with calcium plumbate or self-etching primer. Mordant solution shall not be used.

16.7.5 Brick, Stone, Concrete or other similar Materials

The rebates and grooves shall be sealed with an alkali resisting primer compatible with putty.

16.8 Location of Glass in Surrounds

Except for small panes not exceeding 0.2 sq.m the glass shall rest upon blocks to locate the pane properly within the surround. Blocks shall be from 25 mm to 75 mm long except at the bottom bar of vertically pivoted Windows where the block shall be not less than 150 mm long.

16.9 Glazing In Wood Surrounds

16.9.1 Glazing with putty

Sufficient putty shall be applied to the rebate so that when the glass has been pressed into the rebate, the putty between the glass and the surround (back putty) shall not be less than 1.5 mm thick and there shall also be surplus of putty squeezed out above the rebate which shall be stripped at an angle and not undercut The glass shall be secured by springs spaced not more than 450 mm apart around the perimeter of the pane. Front putty shall then be applied around the perimeter of the pane to form a triangular fillet stopping 1.5 mm short of the sight line.

16.9.2 Glazing with Beads

The glass shall be back puttied as specified under "Glazing with putty". The glass shall then be secured by springs not more than 450 mm apart around the perimeter of the frame. All beads shall be bedded against the glass and the rebates with putty. Care shall be taken to ensure that no voids are left between the glass and the beads. Beads shall be secured to frames with panel pins or screws where indicated. When panel pins are used to secure the beads, they shall be spaced at not more than 75 mm from each corner and at intervals not exceeding 230 mm. When screws are used they shall be spaced to ensure that no flexing or movement of the beads take place.

16.10 Glazing In Steel Surrounds

16.10.1 Glazing with putty

The glass shall be back puttied in the rebates as specified for glazing in wood surrounds. Where the frame size exceeds 600 X 300 mm, glass shall be secured by special spring glazing clips which shall be inserted in holes provided in the steel surrounds before applying the front putty. Where frame sizes do not exceed 600 x 300 mm spring clips may not be provided. Front putty shall then be applied around the perimeter of the pane to form a triangular fillet stopping 1.5 mm short of the sight line and neatly finished. In case of galvanised steel surrounds, to help stick to steel frame, a thin film of raw linseed oil shall be applied to the glazing rebate with cloth soiled in linseed oil.

16.10.2 Glazing with Beads

The glass shall be back puttied and secured in the rebates as specified under "Glazing with putty". Beads shall be bedded against the glass with putty and secured to frame with screws. An adequate number of screws shall be used so as to prevent flexing or movement of the beads.

16.11 Glazing direct to Stone, Concrete, Brick or other similar Materials

The glass shall be fixed with putty as in the case of wood surrounds except that springs shall not be used.

16.12 Glazing with putty Into Grooves

The glass shall be pressed into the putty previously placed in the groove. The space between the glass and the sides of groove shall be filled with putty which shall be stripped at an angle and not undercut.

16.13 Cleaning of glazing

Glass shall be washed with warm water and soap or mild detergent followed by a clean water rinse and dried with cloth or wash leather. Glass with broken or textured surface shall be cleaned with a stiff plastic or bristle brush. For removing any obstinate dirt, glass shall be polished with whiting in water or spirit. Organic solvents may be used for special purposes such as petrol or benzene for removing tar, turpentine for paint that has not dried hard and paraffin for grease. The solvent shall be carefully cleaned off the glass afterwards. Plaster or mortar splashes on the glass shall be removed with thin razor blade.

16.14 Glazing to Roof and In Vertical Cladding

Any sheeting in roof or cladding below and at the ends/sides of glazing shall be completed before glazing is commenced. Also the joints shall be raked out, chases cut and other preparations made as required to take the flashings to the glass. The sheeting above the glass shall not be laid until the glazing is fixed and top flashing laid. All structural members shall be painted before glazing is fixed.

16.15 Frosting or Obscuring

The grinding of glass shall be done uniformly and evenly so as to avoid any patchy look. The ground glass shall be thoroughly cleaned so that it does not catch stains.

16.16 Grinding, Polishing and Rounding of Edges

The edges of glass when rounded shall present a uniform and neatly finished edge.

16.17 Sun Control Polyester Film - Reflective Type

Type of Film		Sun Control Reflective:
Base		Polyester
Thickness		50 micron (200 gauge)
Colour		Bronze, Silver, Gold'
Radiant Transmittance (DIN 67507 & CIE 20) (300mm to 2500mm global)	Te	18%
Radiant Reflectance (DIN 67507 & CIE 20) (300mm to 2500 mm global)	Pe	45%
Radiant absorbtance (DIN 67507 & CIE 20) (300mm to 2500mm global)	ae	37%
UV Transmittance (280mm to 380mm)	Tuv	3%
* Total Rejected Solar heat		72%
* Total Admitted Solar heat		28%
Shading Co-efficient(Solar Factor	Sc	0.28
'U' Factor	U	0.96 Btu/(hr)(sqft) (F)

PHYSICAL PROPERTIES

Residual Shrinkage		0.3% TD, 0.7% M/D
Service Temperature		(-)70^{0}C to 130°C
Combustion Rate on Glass		Negligible
Melting Point	:	250°C
Co-efficient of Expansion	:	1.7x 10^{-5} in / in^{0}C

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16.18. Sun Control Polyester Film. Non Reflective Type

Type of Film	-		Sun control film Non reflective
Base	-		Polyester
Thickness	-	:	25 micron (100 gauge)
Colour	-	:	Bronze, Grey
Radiant Transmittance (DIN *67507 &* CIE 20) (300 mm to 2500 mm global)	Te	:	49%
Radiant Reflectance (DIN *67507*& CIE 20) (300 mm to 2500 mm global)	Pe	:	12%

Radiant absorbtance (DIN *67507&* CIE 20) (300 mm to 2500mm global)	ae	:	39%
UV Transmittance (230mm to 380mm)	Tuv	:	3%
* Total Rejected Solar heat		:	31%
* Total Admitted Solar heat		:	69%
'U' Factor		:	0.96 Btu/(hr)(sq.ft)(F)
PHYSICAL PROPERTIES			
Residual Shrinkage		:	0.3% TD, 0.7% M D
Service Temperature		:	-70^{0}C to 130°C
Combustion Rate on Glass		:	Negligible
Melting Point		:	250°C
Co-efficient of Expansion		:	1.7x 10^{-5} in / in^{0}C

16.19 Workmanship

The surface should be free from dust and oil. Sun control polyester film shall be fixed on glass as per manufacturer's instructions.

SECTION 17
PAINTING

17.1 Indian Standards

The following IS apply to this section

I.S. No.	*Subject*
5 -2004	Colours for ready mixed paint and enamels (Fifth revision)
73 - 2006	Specification for paving bitumen. (Second Revision)
75-1973	Indian standard specification for Linseed oil, raw and refined (Second revision)
102 -1962	Ready mixed paint, brushing, red lead, nonsetting, priming
104- 1979	Ready mixed paint, brushing, zinc chrome, priming (Second revision)
109-1968	Ready mixed paint, brushing, priming, plaster to IS Colour No 361, Light stone and No 631 Light grey (First revision)
110-1983	Ready mixed point, brushing, grey filler, for enamels for use over primers
157-1950	Ready mixed paint, brushing, acid and alkali resistant, lead free, for general purposes, to IS Colour No 446 red oxide, No 537, Signal red No 632 Dark admiralty grey and black and other colours as required
158-1981	Ready mixed paint, brushing , bituminous, black, lead free, acid, alkali, water and heat resisting (Third revision)
159-1981	Ready mixed paint, brushing, acid resisting for protection against acid fumes (First revision)
162-1950	Ready mixed paint, brushing , fire resisting, silicate type for use on wood colour as required.
164-1981	Ready mixed paint, brushing, for road marking for protection against acidfumes. (First revision)
212-1983	Specification for Crude coal tar for general use (Second revision)
218-1983	Specification for Creosote and anthracite oil for use as wood preservative(Second revision)
341-1973	Black Japan, type A, B and C (First revision)
345-1952	Wood filler, transparent liquid
348-1981	French polish (First revision)
349-1981	Lacquer, cellulose, nitrate, clear, finishing glossy for metal (First revision)
423-1961	Plastic wood for joiner's filler(Revised)
426-1961	Paste filler for colour coats
430-1972	Paint remover, solvent type, non flammable (Second revision)
431-1972	Paint remover, solvent type, flammable(Second revision)
524-1983	Varnish, finishing, exterior synthetic air drying (Second revision)
533-1998	Gum Spirit turpentine (oil of turpentine) (Second Revision)
640-1956	Ready mixed red oxide paint for hessian (Colour unspecified)
1504-1996	Specification for Beeswax Crude and Rifined (Third revision)

2074-1992	Specification for Ready mixed paint, air drying, red oxide zinc chrome priming (Second revision)
2339-1963	Aluminium paint for general purposes in dual containers
2932-2003	Specification for Enamel, synthetic, exterior, under coating and finishing (Third revision)
3536-1999	Specification for Ready mixed paint, brushing, wood primer, pink (First revision)
3585-1966	Ready mixed paint, aluminium, brushing, priming, water resistant for wood work.
3678-1966	Ready mixed paint, thick white, for lettering
5083-1988	Knifing stopper (Second revision)
5411 (Part 2)-1972	Plastic emulsion paint Part 2, for exterior use.
5411(Part I)-1974	Plastic emulsion paint, Part I for interior use(First revision)
5691-1970	Lacquers, cellulose, pigmented finishing, glossy
7164-1973	Specification for Stopper
11883 - 1986	Ready mix Paint, brushing red oxide, priming for metals.
13607 - 1992	Ready mix Paint, Finishing general purposes, synthetic - specification.

17.2 Paints and Allied Materials - Generally

17.2.1 All paints and allied materials shall be of quality not inferior to that required by the relevant IS Specification. Paints, etc shall be ready mixed. The colour and tints of paints, unless indicated, shall be as approved by the GE.

17.2.2 The Contractor shall inform the GE, well before he places bulk order for the materials, the names of the brands and manufacturers of paints he proposes to use in the works and submit samples thereof and obtain prior written approval of the GE.

17.2.3 The whole of the materials required for the painting work shall be obtained direct from, approved manufacturers or their authorized agents and shall be brought to the site in makers, drums, kegs, etc, with seals unbroken.

17.2.4 Compatibility of Paints

Before considering the application of undercoats and finishing coats, it shall be made sure that those selected are compatible with each other. If a non elastic finishing coat is applied over an elastic primer coat, it may lead to cracking or "alligatoring' of the finishing coat and the primary coat may become visible through cracks, in the finishing coat. Similarly if the under coat contains a strong solvent, it may attack the primer coat and lead to shrivelling (wrinkling) of the entire paint structure. As a general rule, it is safer to use primer, filler, undercoating and finishing paints made by the same manufacturer.

17.2.5 Storage of Paints

All containers of paints, thinners and allied materials shall preferably be stored in well ventilated room free from excessive heat, sparks or flame or direct rays of sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using. Materials which have become stale or fat due to improper and long storage shall not be used or mixed with usable stuff.

17.3 Painting Work Generally

17.3.1 The type of paint and allied materials to be used, the number of coats to be applied, the preparatory treatment appropriate to the surface and any special process or treatment to be adopted shall be as indicated.

17.3.2 Where more than one coat is indicated, each coat shall vary slightly in shade, undercoat being lighter than subsequent coat; and shall be approved, in writing, by EIC before the next coat is applied.

17.3.3 No painting work shall be carried out in wet and very humid weather when there is danger of dew or weather is otherwise unfavourable. No painting or any other process likely to be damaged by dust shall be carried out in windy weather.

17.3.4 Painting except the priming coat shall be taken in hand after all other builder's work is practically finished.

17.3.5 The paint in the drum shall be thoroughly mixed prior to application. The materials shall be mixed, prepared and applied strictly in accordance with the instructions or recommendations of the manufacturers except where otherwise directed by the GE. The paints shall be mixed periodically during brushing.

17.3.6 Addition of Thinners

Thinners (such as mineral turpentine) shall not be added to paints on the feeling that the consistency of the paint supplied by the manufacturer is too thick. If the paint has been manufactured to conform to the specifications, the paint shall have the correct consistency and shall not require further dilution. If there is any doubt, the viscosity of the paint may be checked. If a slight adjustment of viscosity is necessary, thinner, recommended by the manufacturer shall be used after prior approval of EIC.

17.3.7 The surface must be thoroughly dry and clean before painting work is proceeded with at all stages or processes of work. All dust, dirt, rust and grease shall be removed before painting is started. Painting shall follow immediately after pre-cleaning or pre-treatments; any contamination which may occur in the intervening period shall be removed. Every individual coat shall be properly applied, reasonably level and smooth and free from runs and holidays (minute uncovered areas).

17.3.8 Drying Time

For paint film to perform in unison, each coat of paint shall be allowed to dry sufficiently but not excessively before a subsequent coat is applied. Manufacturer's instructions for drying shall be adhered to properly.

17.3.9 Flatting down

Cutting of primer coat and undercoat shall be done to provide a key for subsequent coats. The primer coat, with or without putty, shall be dry cut and the undercoat, with or without putty for spot work, shall be wet cut with waterproof emery paper No 220/240. In the case of under coatings without putty, surface, prior to finishing coat, shall be wet cut with waterproof emery paper No 280/320. The surface shall be dry, clean and free from dust before subsequent coat is applied.

17.3.10 Appearance

The painted surface shall have a clean uniformly coloured appearance. No hair marks from the brush or clogging of paint puddles in the corner of panels, angles of moulding etc, shall be left on the work.

17.3.11 Colour

Correct colour matching shall be judged against a sample having the same type of surface as that to which the paint has been applied.

17.3.12 In painting doors and windows, the putty round the glass panes shall also be painted but care shall be taken to ensure that no paint, stains etc, are left on the glass. If stains are left these shall be removed with turpentine etc. and surface left clean. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting.

17.4 Scaffolding

The scaffolding as required shall be erected for proper execution of work. If the work can be done safely with a ladder or jhoola these may be permitted in the place of scaffolding.

17.5 Brushing of Paint

17.5.1 Generally

Clean pliable brushes free from loose bristles shall be used. Paints shall not show objectionable pulling under the brush. The brush shall be such that the paint does not show lapping streaks and works satisfactorily under it.

17.5.2 Cleaning of paint containers shall be done only with paint thinners which are compatible with the paint to be filled.

17.5.3 Brush application

While applying the paint, the brush shall be held at an angle of approximately 45 degrees to the vertical surface and several light strokes applied in the area to be painted, so as to first transfer the paint to the surface. During painting, the brush shall also be turned around through 180 degree in order to ensure that the paint on both the faces of bristles is utilized completely. The paint is then spread with gentle pressure so as to hide the surface and produce a uniform coating. Ensure that the ends and not the sides of the bristles come in contact with the surface during painting. The paint shall be applied, first using vertical strokes untill the surfaces are covered and then brushed crosswise for complete coverage with light strokes, so as to smooth outlaps and brush marks and finally laid off with vertical strokes.

17.5.4 Conditioning and Maintenance of Brush

After each day's work, the brush shall be cleaned in mineral turpentine or any other suitable thinner, ensuring that the paint and pigment are completely removed from the heel of the brush. Warm water and soap shall be used to clean the brushes used in water bound paints or emulsions.

17.6 Painting woodwork

17.6.1 Preparing New Surfaces

All wood work shall be dry and free from dust, dirt or any other extraneous material. Paint applied over discoloured sapwood is liable to become discoloured; resin from knots tends to exude through the paint. Any such unsound portions shall be cut out and replaced with sound wood. Nails shall be punched well below the surface to provide a firm key for sopping.

17.6.1.1 Flat portions shall be smoothed with abrasive paper used across the grain prior to painting and with the grain prior to straining or if the wood is to be left in its naturals colour. Mouldings shall be carefully smoothed with abrasive paper and projecting fibres left after machining shall be removed. Quirks need particular attention.

17.6.1.2 All loose knots shall be removed and the holes filled with well fitted sound timber set in red or white lead paint and securely pinned. Any knots, resinous streaks or bluish sapwood that are not large enough to justify cutting out, shall be treated with two coats of pure shellac knotting, applied thinly and extended about 25 mm beyond the actual area requiring treatment. Aluminium primer may be used in place of shellac knotting. If the area is small and the wood is not highly resinous, it is permissible, instead of applying two coats of knotting, to apply one coat slightly pigmented with aluminium powder.

17.6.2 Priming

On clean prepared surfaces, a priming coat of paint shall be applied by brushing. Unless otherwise directed, the priming coat shall be applied before the woodwork is fixed in position. In case there is already a primer coat but an unsatisfactory one, it shall be rubbed to bare wood and the surface re-primed.

17.6.3 Stopping and filling

Stopping and filling shall be done after priming.

17.6.3.1 For deep holes, stopping shall be done with plastic wood conforming to IS 423-1961, Specification for plastic wood for joiner's filler. Stopping shall be to the consistency of stiff paste and all holes, cracks and crevices, etc, shall be stopped carefully to a true and level surface.

17.6.3.2 For stopping slight irregularities of surface and shallow indentation, filler conforming to IS 426-1961, Specification for paste filler for colour coats shall be used. For enamel finishes, filler conforming to IS 110-1983, Specification for ready mixed paint brushing, grey filter, for enamels, for use over primers shall be used.

Filler coat, where indicated, shall be applied with a putty knife and subsequently rubbed down to a level surface with abrasive paper or pumice stone. The filler coat shall be of an optimum thickness and shall be allowed to fully harden and flatten before subsequent coat is applied. As many layers or filler as necessary shall be applied allowing each coat to harden and flatten before next coat is applied.

17.6.4 Under Coating

Undercoat shall be applied by brush after the surface has been primed stopped, filled and rubbed down to a smooth surface. After drying , the undercoat shall be carefully rubbed down and wiped clean before the next coat is applied.

17.6.5 Finishing Coat

The finishing coat shall be applied by brush. The extent of gloss shall be as directed by the GE. The finished surface shall be free from hair or brush marks, streaks clogging of paint, puddles in the corner or pave angle of moulding.

17.7 Clear Finishes to Wood Work

17.7.1 Filling

On hardwood , with large open vessels, filler conforming to IS 345-1952, Specification for wood filler, transparent liquid, shall be used. On fine textured wood having minute pores that do not require filling, unfilled drying oils, thin varnishes, lacquer of shellac shall be used. For special stain effect coloured fillers shall be used.

17.7.1.1 Fillers where indicated, shall be heavily applied, to the wood surface by hand using Hessian or jute rag across the grain. It may be rubbed when still wet to get better penetration. After 5 to 10 minutes it shall be wiped off by hand across the grain followed by a light wipe with the grain. The filled surface shall be dried preferably overnight and smoothened with abrasive paper. Finally wipe with a clean soft rag to remove dust and nibs.

17.7.2 Staining

17.7.2.1 Spirit Stains

Spirit Stains are solutions of spirit soluble dyes in industrial methylated spirit. They shall be applied quickly and skillfully to avoid patchy effects. If applied to damp wood the dyes in the stains are liable to be thrown out of solution and cause discolouration.

17.7.2.2 Oil Stains

Oil stains consist of solutions of oil soluble dyes in linseed oil or of insoluble semi-transparent pigments ground in linseed oil and thinned with turpentine or other solvent. Wax may be added to make the stain less penetrating if so directed by EIC. If applied to damp wood they are likely to develop a milky effect or bloom.

Note: Oil stains do not take well on certain resinous or oily woods, such as teak. These woods are pre-treated with solvents to remove the greasy matter from the surface prior to oil staining or varnishing.

17.7.2.3 Preparation of Surface for Staining

Surface to be stained shall be scrupulously clean and free from greasy finger marks. It shall be prepared by careful smoothening with fine abrasive paper used in the direction of the grain; scratches across the grain are likely to become stained darker than the rest of the surface. Small cracks or nail holes may be stopped with plastic wood or other suitable, stopping, if sprit stain is to be used. The stopping shall be rubbed down with fine abrasive paper when hard and touched with a little thinned knotting before staining. Where oil stain is to be used stopping shall preferably be done after staining, using tinted putty or wood filler.

17.7.2.4 Sizing

For sizing where indicated or directed soft wood shall be treated with hot weak size of thinned shellac varnish before staining to prevent undue absorption of stain, but excess of size shall be avoided. To control the depth of colour, however, diluted stain may be made to soak well in to the wood . Where size is used, the surface shall be allowed to dry thoroughly before staining. In general, flat surface shall be treated first and mouldings and edges the last.

17.7.2.5 Application of stains

Stains shall be applied by brushing and wiped. The stain shall be so thinned that it can be applied fairly liberally without over staining. Care shall be taken, especially, on absorbent soft woods, to stain evenly and without overlapping. Spirit stains, in particular require careful and quick application as they dry very quickly

17.7.3 Varnishing

17.7.3.1 Preparation of surfaces

Surface to be varnished shall be prepared to produce a smooth dry, matt surface stopped with transparent liquid filler. Where indicated the surface shall then be spirit or oil stained to the tint required before application of varnish. Previous coats of paint or stain, if any, shall be rubbed down lightly, wiped off and allowed to dry. All dirt and dust must be removed from the surface to be varnished and also from the neighbourhood. Damp atmoshere and draughts shall be avoided.

17.7.3.2 Old varnished surfaces shall be dusted off, sand papered smooth and wiped clean before application of varnishing. Care shall be taken to remove all grease, wax, gloss, etc from old surface.

17.7.3.3 Application

Varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with short light strokes to avoid frothing of air bubbles. It shall be allowed to flow out while the next section is being laid-in. Excess varnish shall then be scraped out of the brush and the first section is crossed, recrossed and then laid off lightly. Too much or too little varnish left on the surface will mar the appearance of the finish. The varnish, once it has begun to set, should not be retouched. The edges of varnished surfaces shall be free from runs and blobs and the finished surface shall be free from loose hair and brush marks.

Where two coats of varnish are specified, the first coat shall be a harddrying undercoating or flatting varnish; this shall be allowed to dry hard and then be flatted down before applying the finishing coat, sufficient time shall be allowed between the two coats.

17.7.4 French polishing

17.7.4.1 Material for French Polishing

Pure shellac varying from pale orange to lemon yellow colour, free from resin and dirts shall be dissolved in methylated spirit at the rate of 0.15 Kg of shellac per litre of spirit conforming to IS 348-1981, Specification for French polish. Suitable pigment shall be added to get the required colour.

17.7.4.2 Preparation of Surface

All unevenness shall be rubbed down to smoothness with sand paper and the surface shall be well dusted. The pores in the wood shall be filed with a filler made of paste of whitening in water or methylated spirit (with a suitable pigment like burnt sienna or number, if required).

17.7.4.3 Application of Polish

A pad of woolen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface should be allowed to dry and the remaining coats applied, in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have uniform texture and high gloss.

17.7.4.4 As an alternative to above specification vide clause 17.7.4.1 to 17.7.4.3. Acrylic wood finish polish may be used where indicated. The method of preparation and application shall be as per manufacturer instruction.

17.7.5 Bees wax Polishing

17.7.5.1 Materials

Wax polish shall be prepared by mixing commercial bees wax conforming to IS 1504-1996 with oil of turpentine conforming to IS 533-1998 and linseed oil conforming to IS 75-1973. The polish shall be prepared, in general, by mixing 1 kg of wax slowly heated over fire to melt and mixed with 0.5 litre of turpentine and 0.8 litre linseed oil. Polish of different consistencies are required for different wood.

17.7.5.2 Preparation of Surfaces

The surfaces shall be prepared as specified for french polishing except that no grain filling will be required, unless indicated.

17.7.5.3 Application of Wax Polish

Wax polish shall be thoroughly worked into the surface of the wood with a piece of clean and fluffless coarse cotton cloth. The wax polish must be thoroughly rubbed into the surface by shortish strokes backward and forward while considerable pressure is applied to the cloth piece. Care shall be taken that the wax is applied evenly. After well rubbing in one good coat of wax polish, the work shall be covered with a dust proof sheet (cloth for preventing dust falling on the work) and allowed to dry.

Subsequent coats shall be similarly applied, if required, till the grain appears to be well filled. The final polish shall be done with clean fluffless soft cloth using long sweeping strokes. A fine surface with an egg shell gloss should result after continued rubbing.

17.7.6 Finishing of Wood Based Materials

17.7.6.1 Ply wood

Plywood is similar to solid wood in its finishing characteristics.

17.7.6.2 Hard Board

To prevent swelling under the influence of oil paint, a coat of plastic emulsion paint thinned with water or shellac varnish shall be applied as the first coat and when dry, rubbed down with fine grade abrasive paper and followed, with required undercoating and finishing coats as for the solid wood.

17.7.6.3 Particle Board

The surface shall be filled with a thin brushable filler and finished as for solid wood.

17.7.6.4 Insulation Board

Two thin coats of plastic emulsion paint or any other water based paints shall be applied after dusting off the surface and finished as for solid wood.

17.8 Painting steel and Iron work

17.8.1 Preparing New Surfaces

The surfaces shall be thoroughly cleaned of dirt, fluxing material, other foreign matter and scrapped thoroughly with hand scraper followed by wire brushing first with coarse and then with fine wire brushes and finally sand papering the surface to remove all mill scale and rust. The surface shall then be wiped finally with mineral turpentine to remove oil, grease and perspiration left by hand marks.

Temporary rust protectives materials applied to steel sheets to protect during transport and storage shall be removed with suitable solvent as a preliminary to other preparatory treatment. Surfaces already pretreated or primed in a factory shall be carefully inspected and damaged areas shall be thoroughly degreased and cleaned off all rust and touched up.

17.8.2 Application of Mordant Solution over Galvanised Surfaces

Mordant Solution shall be composed of soft water 64 parts and copper chloride, copper nitrate, aluminium chloride and hydrochloric acid, each one part; all by weight. New galvanised surfaces and also old galvanised surfaces where ordered by the GE, shall be treated with mordant solution at the rate of about 5 litres per 100 sq m, rubbing the solution on generously with brush or a bundle of rags on a stick. After about half an hour, the surface will turn grey, any part remaining bright shall be retreated and the entire surface washed down thoroughly with clean cold water and allowed to dry before applying primer.

17.8.3 Primer Coat

Immediately after the preparation of the surfaces priming coat shall be applied by brush, working in the paint into the fine dents and ensuring a continuous film without runs and holidays.

17.8.4 Filler Coat

After the primer coat is hard dry, the surface shall be rough sanded without scratching or in any way damaging the primer coat and surface cleaned free from dust. Deep dents and scratches, if any shall be filled with paste filler using a good putty knife pressing firmly into the dents and applying in optimum layers. Each layer shall be allowed to dry hard and then cut down by wet rubbing to a smooth finish.

17.8.4.1 Where indicated, after the paste filler is hard dry, a coat of liquid filler shall be applied by brush to fill all fine dents, allowed to hard dry and then wet rubbed to a smooth finish.

17.8.5 Under Coating

An optimum coat or under coating shall be applied by brush. The film shall be allowed to hard dry, wet rubbed and cut down to a smooth finish ensuring that at no place the under coat is completely removed.

17.8.6 Finishing Coat

Finishing coat shall be applied by brush. Special care shall be taken while painting over bolts, nuts, rivets and overlaps etc.

17.9 Painting Asbestos Cement Building Products, Plaster, Concrete, Brick and Stone Surfaces

17.9.1 Preparation of Asbestos Cement Surfaces

The surface shall be cleaned by rubbing with sand paper. Any glazed area shall be roughened. Loose powdery material after rubbing shall be brushed off. Wire brushes shall preferably be avoided in cleaning operations as they often lead to difficulties from deposited particles of iron causing iron stains.

17.9.2 Preparation of Cement and Cement Concrete Surfaces

For new surfaces it is preferable the surface is left unpainted for as long as possible to allow drying. Before painting the surface shall be thoroughly brushed to remove all dirt and other foreign matter incidental to building operation.

17.9.2.1 Any loose or uneven areas or any major cracks or defects in the cement concrete or plaster background shall be cut out and made good and the repairs allowed to dry thoroughly.

Cracks may be vetted thoroughly prior to filing or priming paint may be applied to the side of cracks to avoid undue absorption of water and subsequent shrinkage and filling. Minor cracks may be filled with cement mortar. Fine cracks in lime plaster may be filled with a mixture of linseed oil putty and white lead.

17.9.3 Preparation of masonry surface

All mortar joints shall be brought to a sound condition before painting operations are started. In the case of new brick work painting shall be deferred for at least three months after completion of masonry work and longer if the weather during the period becomes unfavourable for drying. Dirt may be removed by washing with water.

17.9.4 Preparation of Surfaces Generally

17.9.4.1 Any existing paint showing extensive flaking, bleaching, or saponification (as shown by stickiness or the presence of yellow soapy runs) shall be removed by scraping and washing and the surface allowed to dry completely.

17.9.4.2 Any existing fungus or mould growth shall be completely removed. The surface shall be thoroughly scraped and rubbed down with bristle and brush sand paper and then washed down with clean water and allowed to dry.

17.9.4.3 If efflorescence appears, painting shall be deferred until it ceases. Efflorescence shall be removed by dry brushing, in no case the efflorescence salts shall be removed by washing.

17.9.4.4 Dry distempers and lime wash shall be totally removed prior to repainting. It may sometimes be necessary to wet the surface before scrapping. This shall not be over done and all surfaces shall be perfectly dry prior to the application of any priming coat.

17.9.4.5 Local defective patches shall be treated individually by removing all loose or softened paint and bringing forward the treated patches with primer and undercoating before applying a fresh coating over the whole area.

17.9.4.6 Minor defects are frequently more apparent once the priming or the first coat has been applied and if any further stopping or filling is done over the first coat, the area must be brought forward with appropriate paint to restore even porosity over the surface.

17.9.5 Priming Coat

New surfaces shall be given a priming coat of alkali resistant priming paint conforming to IS 109-1968 or any other primer as recommended by the manufacturer and allowed to dry for at least 48 hours.

17.9.6 Undercoating, stopping or filling as required, shall be carried out before the painting is done. Any crack between the plaster and wood work shall be securely filled; if such cracks are wide, caulking with hemp or similar material may be necessary to support the filling. Undercoat shall then be applied by brush. After drying the coat shall be carefully rubbed down and wiped clean before the next coat is applied.

17.9.7 Finishing Coat

Finishing coat shall be applied by brush. The extent of gloss shall be as directed by the GE.

17.10 Preparation of Old Painted Surfaces

17.10.1 If the old paint is oily and dirty, but is firm and has not disintegrated, it shall be cleaned down by washing with solution of alkaline soap and greasy spots shall be rubbed with turpentine. The surface shall then be thoroughly rinsed with clean water and rubbed down with abrasive paper or pumice stone. All holes and cracks shall be prepared for stopping by touching them with primer, when dry the stopping shall be completed.

17.10.2 In the case of steel surfaces where old paint is not deteriorated and is in good condition the underlined surface being free from corrosion the surface shall be rubbed down with sand paper. The surface shall then be wiped finally with mineral turpentine to remove grease and perspiration of hand marks etc. and then allowed to dry.

17.10.3 Removal of Paint

Where complete removal of paint is indicated or ordered in writing, old paint shall be removed either by hand scrapping or by blow lamps/flame cleaning or by paint removing chemicals, as directed.

In the case of flame cleaning, the Contractor shall be liable for all fire risks, in burning off paint from woodwork care shall be taken that wood is not burnt in spots.

17.10.3.1 Paint removing chemicals shall be used as per manufactures' instructions. After use of chemicals containing strong alkalies, a weak acid such as diluted vinegar shall be used in washing down to neutralise the alkalies.

17.10.3.2 After removal of paint the surface shall be finally sand-papered and surface cleaned of all dust.

17.11 Creosoting

17.11.1 Material

The creosoting oil shall be type I confirming to I.S.218-1983 Specification for creosote oil for use as wood preservatives.

17.11.2 Workmanship

The surface shall be cleaned of all dirt and dust, Creosote oil shall then be applied evenly to the surface at the specified rate and well brushed in so that no more creosote is absorbed and there are no hungry patches and holidays. Each subsequent coats shall be applied after the previous coat has thoroughly dried.

17.12 Tarring of Painting with Coal Tar Paint

200 gm of unslaked lime shall be added to every litre of crude coal tar for general use conforming to IS 212-1983 and heated till it begins to boil. It shall then be taken off the fire and kerosene oil added to it slowly at the rate of one part kerosene oil to six or more parts of coal tar by volume, and stirred thoroughly.

17.12.1 The surface shall be cleaned of all dirt and dust and then coal tar or coal tar paint applied evenly at the specified rate and well brushed in so that there are no hungry patches and holidays.

17.13 Oiling with Raw Linseed Oil

17.13.1 Material

The raw linseed oil shall be raw linseed oil solvent, confirming to IS 75-1973. Specification for linseed oil, Raw and Refined.

17.13.2 Workmanship

The surface shall be used papered and cleaned off. The oil shall be applied freely with brushes and spread evenly and smooth until no more oil is absorbed. Each subsequent coat shall be applied after the previous coat is thoroughly dried, in any case not before 24 hours of the application of preceding coat. The surface after completion shall not be patchy or sticky to touch, and shall present a uniform appearance.

17.14 Lettering

The type and size of letters and figures shall be as indicated or directed by EIC. These shall be stenciled or drawn in pencil and got approved before painting. They shall be of uniform size and finished neatly. The edges shall be straight or in pleasant smooth curves.

17.15 Road Marking etc

The line painting shall stand our boldly and solidly without showing signs of brush marks or surface underneath. The paint shall be Grade 2 paint conforming to IS 164-1981. Specification of ready mixed paint for Road marking and creosoting.

17.16 Wall Painting with plastic Emulsion paint

17.16.1 The plastic emulsion paint shall confirm to IS 5411 (Part 1) 1974 (Interior) or IS 5411 (Part 2) 1972 (Exterior) as indicated.

17.16.2 The surface shall be thoroughly cleaned of dust. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give smooth and even surface. Any unevenness shall be made good by applying putty made of Plaster of Paris with water on the entire surface including filing up of undulation and then sand papering the same again when surface is dry.

17.16.3 The paint shall then be applied either by brush or by roller.

17.16.4 Each coat of paint shall be allowed to dry before the next coat is applied

17.16.5 The thinning of emulsion shall be done with water and not Turpentine Oil. The quantity of water to be added shall be as per manufacturer's instruction.

17.16.6 No washing shall be done within 3 to 4 week of application.

17.16.7 Precaution

17.16.7.1 The brush shall be completely dried of Turpentine oil paint by washing with warm soap water before use.

17.16.7.2 The brushes shall be washed in water after use.

17.16.7.3 No oil based putty shall be used for filling cracks.

17.16.7.4 Splashes in floor shall be cleaned immediately.

17.17 Wall painting with Acrylic Emulsion Paint (Interior / Exterior Walls) Mateial

17.17.1 The Acrylic emulsion paint shall be of manufacturer as indicated or as approved by GE and of premium quality. The paint shall be 100% Acrylic and semi Acrylic paint shall not be used in the work.

17.17.2 Preparation of Surfaces

17.17.2.1 The surfaces to be applied with Acrylic emulsion paint shall be cleaned to remove loose dirt or dust, lichen, algae, fungi or any organic growth by use of stiff brush. Then the surface is washed well and allow water to dry. All cracks, voids and minor damages shall be patched/repaired prior to application of paint with white cement putty or with Plaster of Paris.

17.17.2.2 In case of old surfaces where excessive fungal/algal growth is observed the surface should be bio washed as per manufacturers instructions. This product is diluted in water before application as per manufacturer instructions and shall be applied with brush. The coat of bio wash shall be allowed to dry for 12-24 hours and then washed with clean water. Allow the wall to dry before it is ready for painting.

17.17.3 Primer Coat

Over this prepared surface apply a coat of acrylic primer as per manufacturer's instructions. This shall be allowed to dry for 4 to 6 hours before application of final paint.

17.17.4 Finishing Coat

Acrylic paint of premium quality 100% Acrylic shall be applied in atleast two coats as per manufacturer instructions. The Acrylic paint shall be prepared as per manufacturer's instructions by adding water in proportions as suggested. No other thinner shall be used. Paint shall be applied with brushes or roller and shall be allowed to dry for 3 to 4 hours between subsequent coat.

SECTION 18
WATER SUPPLY, PLUMBING DRAINS AND SANTIARY APPLIANCES

18.1 Indian Standards

The following IS apply to this Section :

I.S. No.	*Subject*
210-1993	Specification for grey iron casting (Fourth revision).
458-2003	Specification for concrete pipes with or without reinforcement. (Fourth revision)
650 - 1991	Specification for Standard sand for testing of cement.
651-1992	Specification for salt glazed stoneware pipes and fittings. (Second revision).
774-2004	Specification for flushing cistern for water closets and urinals (ohter than plastic cistern) (Fifth revision).
775-1970	Specification for cast iron brackets and supports for wash basins and sinks (Second revision).
781-1984	Specification for cast copper alloy, screw down, bib taps and stop valves for water services (Third revision)
782-1978	Specification for caulking lead (Third revision)
1239 (Part I) 2004	Specification for mild steel tubes, tubulars and other wrought steel fittings (Part I): Mild steel tubes (Sixth revision).
1239 (Part 2) 1992	Specification for mild steel tubes, tubulars and other wrought steel fittings (Part 2): Mild steel tubular and other wrought steel pipe fittings (Fourth revision)
1536-2001	Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage (Fourth revision)
1537-1976	Specification for vertically cast iron pressure pipes for water, gas and sewage (First revision).
1538-1993	Specification for cast iron fittings for pressure pipes for water, gas and sewage (First revision).
1592-2003	Specification for asbestos cement pressure pipes and joints (Fourth revision).
1626 (Part 1) 1994	Specification for asbestos cement building pipes and pipe fittings. Gutter and gutters fitting and roofing fittings. Pipes and pipe fittings (Second revision).
1626 (Part 2) 1994	Specification for asbestos cement building pipes and pipe fittings. Gutter and gutters fitting and roofing fittings. Gutters and Gutters fittings. (Second revision)
1626 (Part 3) 1994	Specification for asbestos cement building pipes and pipe fittings. Gutter and gutters fitting and roofing fittings. Roofing fittings (Second revision)
1703-2000	Specification for ball valves (horizontal plunger type) including floats for water supply purposes (Fourth revision)
1703 - 2000	Specification for water fittings - copper alloy float values (Horizonal plunger type (Fourth revision).
1711-1984	Specification for self-closing taps for water supply purposes (Second revision).
1726-1991	Specification for cast iron manhole covers and frames. (Third revision)

1729-2002	Cast iron/ductile iron drainage pipe and pipe fittings for over ground Non Pressure pipe lines socket and spigot service (Second revision)
1795-1982	Specification for pillar taps for water supply purposes (Second revision)
1879-1987	Specification for malleable cast iron pipe fittings (Second revision).
2065-1983	Code of practice for water supply in Buildings (Second revision).
2267 - 1972	Specification for polystyrene moulding and extrusion material (Second revision).
2326-1987	Specification for automatic flushing cisterns for urinals (other than plastic cistern) (Second revision).
2548 (Part 1 & 2) 1996	Specification for plastic water closet seats and covers - Part 1 Thermoset: Part 2 Thermoplastic, (fifth revision).
2556 (Part 1) 1994	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 1: General requirements. (Third revision)
2556 (Part 2) 2004	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 2 : Specific requirements of wash down water closets (Fourth revision)
2556 (Part 3) 2004	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 3: Specific requirements of squatting pans (Fourth revision)
2556 (Part 4) 2004	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 4 : Specific requirements of wash basins. (Third revision)
2556 (Part 5) 1994	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 5 : Specific requirements of laboratory sinks. (Third revision)
2556 (Part 6) 1995	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 6 : Specific requirements of urinals and partition plates (Fourth revision).
2556 (Part 7) 1995	Specification for Vitreous Sanitary Appliances (Vitreous China) Part 7 : Specific requirements of accessories for sanitary appliances (Third revision)
2963-1979	Specification for copper alloy waste fittings for wash basins and sinks (First revision).
3114-1994	Code of practice for laying of CI pipes (Second revision)
3076-1985	Specification for low density polyethylene pipes for potable water supply (Second revision).
3311-1979	Specification for waste plug and its accessories for sinks and wash basins (First revision).
3489 - 1985	Specification for enamelled steel bath tubs (First revision).
3989-1984	Specification for centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories (Second revision).
4127 - 1983	Code of practice for laying of glazed stoneware pipes (first revision).
4346-1982	Specification for washer for use with fittings for water services (first revision).
4984-1995	Specification for high density polyethylene pipes for potable water supplies. (Fourth revision).
4985-2000	Specification for unplasticized PVC pipes for potable water supplies. (Third revision).
5219 (Part-I) 1969	Specification for cast copper alloy traps Part I 'P' and 'S' traps
5382-1985	Specification for rubber sealing rings for gas mains, water mains and sewers (First revision).
5455-1969	Specification for cast iron steps for manholes.

5522 - 1992	Stainless steel sheets and strips for utensils (Second revision).
5531-1988	Specification for cast iron specials for asbestos cement pressure pipes for water, gas and sewage (Second revision).
6251 - 1971	Specification for shower and shower fittings for marine use.
6411 - 1985	Specification for gel coated glass fibre reinforced polyester resin bath tubs (First revision).
7328 - 1992	Specification for high density polythylene materials for moulding and extrusion (First revision).
8008 (Part I) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 1 : General requirements (First revision).
8008 (Part 2) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 2 : Specific requirements for 90^0 bends. (First revision).
8008 (Part 3) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 3 : Specific requirements for 90^0 TEE (First revision).
8008 (Part 4) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 4 : Specific requirements for reducers (First revision).
8008 (Part 5) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 5 : Specific requirements for ferrule reducers (First revision).
8008 (Part 6) 2003	Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies. Part 6 : Specific requirements for pipe ends (First revision).
8329 - 2000	Specification for centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage (Third revision).
8360 (Part I to 3) 1977	Specification for fabricated high density polyethylene (HDPE) fittings for potable water services: General requirements, specific requirement for 90^0 TEE bends.
8931 - 1993	Specification for copper alloy fancy single taps, combination top assembly and stop valves for water services. (First revision)
8934 - 1978	Specification for cast copper alloy fancy pillar taps for water services.
9523 - 2000	Specification for ductile iron fittings for pressure pipes for water, gas and sewage (First revision).
9762 - 1994	Specification for polythylene floats (spherical) for float valves (First revision).
11722 - 1986	Thin walled flexible quick coupling pipes.
12234-1988	Specification for plastic equilibrium float valve for cold water services.
12288-1987	Code of practice for use and laying of ductile iron pipes.
12701-1996	Specification for Rotational Moulded polyethylene water storage tanks. (First revision)
13049-1991	Specification for diaphgram type (plastic body) float valve for cold water Services.
13592-1992	Un-platicized polyvinyl chloride (UPCV) pipes for soil and waste discharge system inside including ventilation and rain water system-specification.
13983 - 1994	Specification for stainless steel sinks for domestic purposes.
14846 - 2000	Service valve for water works purposes (50 to 1200 mm size) specification.

MATERIALS
SUB SECTION A- WATER SUPPLY

18.2 Cast Iron pressure pipes and fittings
18.2.1 Centrifugally Cast (Spun) Iron Pipes

Shall conform to IS 1536-2001: Specification for centrifugally cast (spun) iron pressure pipes for water, gas and sewage. Spigot and socket pipes shall be of class LA, class A or class B and flanged pipes shall be Class A or Class B as indicated.

The pipes shall withstand the following hydrostatic test pressures after installation, without showing leakage, sweating or defects of any kind.

Class LA	12 Kg/cm^2
Class A	18 Kg/cm^2
Class B	24Kg/cm^2

Note : IS covers flanged pipes only up to 600 mm diameter.

18.2.2 Vertically Cast iron pressure Pipes

Shall conform to IS 1537-1976 Specification for vertically cast iron pressure pipes for water, gas and sewage. These pipes shall be of class A or Class B with spigot and socket ends or flanged ends, as indicated.

The pipes shall withstand hydrostatic test pressures as given below, without showing leakage, sweating or defects of any kind:-

Nominal Diameter	Test Pressure in Kg/cm^2			
	Spigot and socket pipes		Flanged Pipes	
	Class		Class	
	A	B	A	B
Upto and including 300 mm	20	25	20	25
Over 300 mm and upto and including 600 mm	20	25	15	20

18.2.3 Cast iron Fittings for Pressure Pipes

Shall conform to IS 1538-1993 Specification for cast iron fittings for pressure pipes for water, gas and sewage. The fittings shall withstand hydrostatic test pressures as given below, without showing leakage, sweating or defects of any kind:-

Nominal Diameter	Test Pressure in Kg/cm^2
Upto and including 300 mm	25
Over 300 mm and upto and including 600 mm	20

18.2.4 Generally

Metal used for manufacture of pipes and fittings shall be good quality cast iron not less than grade FG-150 of IS 210-1993.

18.2.4.1 Cast iron pressure pipes and fittings shall be free from warping shrinkage defects and also defects other than any unavoidable surface imperfections which result from the method of manufacturer and which do not affect the use of the pipes and fittings.

18.2.4.2 The pipes and fittings shall be such that they could be cut, drilled or machined.

18.2.4.3 In the case of spigot and socketed pipes with rubber joints, the spigot ends shall be suitably chamfered for smooth entry of the pipe in the socket fitted with rubber gasket.

18.2.4.4 In the case of flanged pipes and fittings, the flanges shall be at right angles to the axis of the pipe or the fitting and machined on face. The bolt holes shall be drilled.

18.2.4.5 Permissible tolerances on the standard mass of the pipes shall be + 5 percent and of the fittings + 8 percent except for bends and fittings with more than one branch in which case the permissible tolerance shall be + 12 percent. Pipes and fittings of heavier mass than the maximum may be accepted without any price adjustment provided the pipes and fittings comply in every other respect with the requirements of the relevant standards.

18.2.4.6 All pipes and fittings shall be coated both externally and internally with a composition having tar or other similar base. The coating shall be smooth and tenacious; and shall not scale off. The inside coating shall not contain any constituent soluble in water or any ingredient which could impact any taste or colour, whatsoever, to the potable water after sterilization and washing of the mains. In the case of imperfectly coated pipes and fitting or where coating is damaged, the coating shall be removed and pipes and fittings re-coated.

18.3 Blank

18.4 Mild Steel galvanized Tubes (Pipes) and fittings

18.4.1 Mild Steel Tubes

Shall comply with IS 1239 (Part I)-2004 specification for mild steel tube-tubulars and other wrought steel fittings, Part I mild steel tubes. These shall be hot finished welded, electric resistance welded, or high frequency induction welded pipes, galvanized, and screwed and socketed. The tubes shall be of light, medium or heavy grade as indicated. Each tube shall be supplied with one socket. The end of socket shall be chamfered internally to prevent damage to the leading thread. Tubes shall be distinguished by colour bands, light tubes with yellow, medium tubes with blue and heavy tubes with red band.

18.4.2 Tolerance

Permissible tolerance on the weight of steel tubes shall be as under:-

(1) Single tube irrespective of the quantity	(+)10 percent. (-) 8 Percent.
(2) For quantities of less than 150 m of one size	(+) 10 percent. (-) 8 Percent.
(3) For quantities of 150 m and over of one size	(+) 4 percent.

18.4.3 Tubulars and Fittings

Mild steel tubulars and other wrought steel fittings for use with mild steel tubes shall be galvanized complying with IS 1239 (Part 2)-1992 for mild steel tubulars and other wrought fittings. These may be butt welded or seamless. Fittings may alternatively comply with the requirement of IS 1879-1987, specification for malleable cast iron pipe fittings. These fittings shall be galvanized.

18.4.4 Tubes and fittings shall be cleanly finished, well galvanized in and out, reasonably straight and shall be free from scale, cracks, surface flaws, laminations and other defects. Zinc coating shall be uniformly adherent, reasonably smooth and free from such imperfections as flux, dross inclusions, bare patches, pimples, lumping, runs, rust stains and blisters. All screw threads shall be clean and well cut, the end shall be cut cleanly and square with the axis of tubes. Screwed tubes shall be taper threads while the sockets shall have parallel threads.

18.4.5 Tubes of any grade and fittings shall withstand a test hydraulic pressure of 5 MPa without showing defects of any kind.

18.5 Low Density Polyethylene (LDPE) Pipes

LDPE pipes shall conform to IS 3076-1985. Specification for low density polyethylene pipes for potable water supply. Pipes shall be smooth clean and reasonably free from grooving and other defects. LDPE Pipes shall be of pressure ratings (working pressure) 2.5, 4, 6 and 10 Kg/cm^2 as indicated.

Note :- Polyethylene and PVC pipe are designated by their outside diameter.

18.6 High Density Polyethylene (HDPE) pipe

HDPE pipe shall conform to IS 4984-1995. Specification for high density polyethylene pipes for potable water supply. The Pipes shall be smooth internal and external surfaces. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible provided that the wall thickness remains within the permissible limits. HDPE pipe shall be of pressure ratings (working pressure) as indicated. The pipes shall carry colour bands to indicate class of pipes.

Class of pipe	Working pressure Mpa	Colour
Class 1	0.2	Orange
Class 2	0.25	Red
Class 3	0.4	Blue
Class 4	0.6	Green
Class 5	1.0	Yellow

18.7 Unplasticised PVC Pipes

UPVC pipes shall conform to IS 4985-2000. Specification for Unplasticised PVC pipes for potable water supply. The pipes shall be reasonably round. Internal and external surfaces of the pipes shall be smooth and clean, reasonably free from grooving and other defects. The ends shall be cleanly cut square with the axis of the pipes, UPVC pipes shall be of pressure ratings (working pressure) as 2.5, 4.5 and 10 Kg/sq cm as indicated.

18.8 Fittings to use with LDPE and HDPE Pipes

Shall be injection moulded or fabricated type confirming to IS 8008 (Parts I to 6)-2003, Specification for injection moulded high density polyethylene (HDPE) fittings for potable water supplies or to IS 8360 (Parts I to III)-1977, Specification for fabricated high density polyethylene fittings for potable water supplies or as recommended by the manufacturers of the pipes used.

18.8.1 Fittings for Unplasticised PVC pipes shall be made of PVC or shall be as recommended by the manufacturers of the pipes used.

18.9 Caulking lead

Pig lead wool shall comply with IS 782-1978 specification for caulking lead.

18.9.1 Pig lead shall be of uniform quality, clean and free from foreign materials and shall be of uniform softness and capable of being easily caulked and driven.

18.9.2 Lead wool shall not contain any sulphur and shall not be manufactured from discarded accumulator battery plates. The lead wool shall consist of fine strands or plaited ribbons of lead. The cross section of individual strand shall be flat. The dimensions in the sectional plane shall be not less than 0.13 mm and not more than 0.9 mm and of length same as the length of the rope.

18.10 Spun Yarn

Shall be hemp and good quality. It shall be free of oil, tar or greasy substance and shall be of sterilized quality.

18.11 Rubber Gasket for Jointing

Shall comply with IS 5382-1985 specification for rubber sealing rings for gas mains, water mains and sewers. Rubber rings shall be free from extractable substance, which impart taste, smell or toxicity to water.

18.12 Lagging of Hot/Chilled water Pipes

18.12.1 Exposed Services:

18.12.2 Lagging

Material shall be of Poly-isocyanurate (PIR) foams pipe section conforming to IS 12436-1988 Type-I. The density of material shall be 32 + 2 Kg/cu.m. Pipe section shall be in two semi-circular pieces. The longitudinally meeting face shall be flat and in the same plane. Other requirements all as per above IS Code. Thickness shall be indicated.

18.12.3 For Internal & Covered Area: Material shall be preformed fibrous pipe insulation conforming to IS 9842-1994. The density of the material shall be 144 Kg/cum. The material fibre insulation shall be as per clause 3.7 of IS 9842-1994. Insulation may be covered with aluminum foil as indicated, sticking the joints with Bitumen and securing it with storn cotton twine, covering it with chicken wire mesh of 25 G and 20 mm mesh as indicated.

SUB SECTION B- PLUMBING

18.13 Plumbers Brass work: Generally

18.13.1 Fittings shall be of approved pattern, type and make and shall conform to the relevant IS Specification

18.13.2 All cast fittings shall be sound and free from laps, blow holes and pittings. External and internal surfaces shall be clean, smooth and free from sand burning: plugging stopping or patching of casting shall not be permissible. The bodies, bonnets, spindles and other parts shall be machined true to shape so that when assembled the parts are axial parallel and cylindrical with surfaces, smoothly finished and are correct in adjustment.

18.13.3 Where taps and stop valves, etc., are specified to be nickel/chrominum plated the thickness of plating shall not be less than that for the grade specified in the relevant IS Specifications. The plating shall be capable of taking high polish and shall not easily tarnish or scale.

18.13.4 Galvanisation of malleable iron and cast iorn bodies shall be done by hot dip process. Mild steel components shall be electro-galvanized.

18.14. Bib Taps and Stop Valves

18.14.1 They shall be screw down type and shall conform to IS 781-1984, (Specification for cast copper alloy screw down bib taps and stop valves for water service). A bib cock (bib tap) is a draw off tap with a horizontal inlet and free outlet and a stop cock (stop tap) is a valve with a suitable means of connections for insertion in a pipe line for controlling or stopping the flow. They shall be of specified size and shall work by means of disc carrying a renewable non-metallic washer which shuts against water pressure on a seating of right angles to the axis of the threaded spindle which operates it. The handle shall be either crutch or butterfly type securely fixed to the spindle valve shall be of the loose leather seated pattern. The cocks (taps) shall open in anticlockwise direction.

18.14.2 The bib cock and stop cock shall be polished bright. In case these are required to be nickel plated, the plating shall be of the first quality with a good thick deposit of silvery whiteness capable of taking high polish which will not easily tarnish or scale. The minimum furnished weight of bib tap and stop cock shall be as under:-

Size (mm)	Bib Taps (Kg)	Stop valve	
		Internally threaded (kgs)	Externally threaded (kgs)
15	0.40	0.33	0.40
20	0.75	0.675	0.75
25	1.25	1.18	1.30
32	-	1.68	1.80
40	-	2.09	2.25
50	-	3.70	3.85

18.15 Fancy Bib Taps and Stop Valves

They shall be of cast copper alloy screw down type and shall conform to IS 8931-1993, Specification for cast copper alloy fancy screw bib taps and stop valves for water services. They shall be of approved pattern and shall be nickel-chromium plated.

18.15.1 The minimum finished mass of fancy bib taps and stop valves shall be as under:-

Size (mm)	Fancy Bib Taps (Kg)	Stop valve (Kg)
15	0.575	0.575
20	0.900	0.900
25	-	1.590

18.16 Pillar Taps

Pillar taps shall be of brass or bronze and shall conform to IS 1795--1982, Specification for pillar taps for water supply purposes. The nominal size of pillar taps shall be 15mm or 20 mm as specified. The nominal size shall be designated by the nominal bore of the pipe outlet to which the tap is to be fitted. Casting shall be sound and free from laps, blow holes and pitting. External and internal surfaces shall be clear smooth and free from sand and be neatly dressed. The body, bonnet and other parts shall be machined true so that when assembled, the parts shall be axial, parallel and cylindrical with surface smoothly finished.

The area of water way through the body shall not be less than the area of the circle of dia metre equal to the bore of the seating of the tap. The seating of pillar tap shall be integral with the body and edges rounded to avoid cutting of washer. Pillar taps shall be nickle chromium plated and thickness of coating shall not be less than services grade No 2 of IS 4827 and plating shall be capable of taking high polish which shall not easily tarnish or scale.

Every pillar tap complete with its component parts shall withstand an internally applied hydraulic pressure of 20Kg / sq cm. Maintained for a period of 2 minutes during which period it shall neither leak nor sweat.

18.16.1 Fancy Pillar Taps

They shall be cast copper alloy and shall conform to IS 8934--1978, Specification for cast copper alloy fancy pillar taps for water services and shall be of approved pattern and shall be nickel-chromium plated.

18.16.2 The minimum finished mass of pillar taps and fancy pillar taps shall be as under:-

Type	Minimum finished mass in Kg.	
	15 mm size	20 mm size
Pillar Taps	0.960	1.758
Fancy Pillar Taps	0.665	1.030

18.16.3 Fixing of brass fitting

18.16.3.1 The fitting shall be carefully examined and cleaned off all foreign matter before being fixed. The fittings shall be fitted in the pipe lines/connection in engineering workman like manner. The joints between fittings and pipe shall be made leak-proof when tested to pressure of 17.50 Kg per sqcm.

18.17 Self closing Taps

They shall conform to IS 1711-1984, Specification for self closing taps and shall be cast iron, malleable iron casting, brass or bronze as indicated.

18.18 Washers for cold water Taps

Washers for cold water Taps shall conform to IS 4346-1982, Specification for Washers for water taps for cold water services and shall be of good quality fiber, specially selected leather or rubber asbestos composition.

18.19 Ball valves

Ball valves shall be of brass or bronze, high pressure type, and shall conform to IS 1703-2000, Specification for Ball valves (horizontal plunger type) including floats for water supply purposes. The float shall be of polyethylene. High pressure ball valve with float immersed to not more than half its volume shall remain closed against test pressure of 1.05 MPa. The minimum finished mass of ball valves exclusive of floats, and the wall thickness of floats shall be as under:-

Nominal size mm	Ball valve Kg	Wall thickness of floats mm
15	0.28	1.5
20	0.45	2.0
25	0.82	2.5
32	1.15	4.0

18.20 Waste fittings

Waste fittings shall be of brass chrominum plated and shall conform to IS 2963-1979. Specification for cast copper alloy waste fittings for wash basins and sinks. Waste fittings shall be of nominal size 32 mm for wash basins and 50 mm for sinks

18.21 Waste Plugs

Waste Plugs and its accessories shall conform to IS 3311-1979. Specification for Waste Plug and its accessories for sinks and wash basins. Waste Plugs shall be of rubber of hard and durable quality. The depth and diameter of the plug shall be such as to provide and maintain the required rigidity and water tightness. Waste plug shall have a loose shackle for anchoring plug chain. Shackle, plug chain and other metal components shall be brass or bronze chromimum plated. Chains shall be of dia not less than 1.80 mm with brazed oval links approx 13 mm in length. The overall length of the chain excluding shackle shall be not less than 30 cm. Chain stays shall be of bolt or screw type.

18.22 Traps P and S Types

Traps for wash basins, sinks and baths shall be of cast copper alloy, chromium plated conforming to IS 5219 (Part I)-1969, Specification for cast copper alloys traps, Part I, P and S traps.

18.22.1 Bottle Traps

Copper alloy traps shall be of brass with copper content not less than 56% conforming to IS 5219 (part I)-1969. The traps shall be polished or chromiuim plated as indicated. Galvanized malleable iron traps shall be of approved manufacturer. Traps for lavatory basins and sinks shall have one inspection eye, fitted with screw plug and washer, while for baths, the traps shall have branches screwed externally, one of which shall be fitted with washered cap and other with a bent tail pipe and union nut for overflow connection. A loose coupling nut shall be fitted to the inlet for coupling to the waste and the outlet shall be either plain tails for lead pipe or screwed with pipe thread and provided with union tail end pipe. The minimum depth of seal shall be 35 mm.

18.23 Cast iron Soil, Waste and Ventilating Pipes

18.23.1 They shall comply either with IS 1729-2002 Specification for sand cast iron spigot and socket, soil, waste and ventilating pipes, fittings and accessories or with IS 3989-1984, Specification for centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories as indicated. Fittings as indicated and accessories shall conform to the particular standard.

18.23.2 Pipes and fittings shall be without ears. Where pipes and fittings with ears are indicated they shall have the following projections, measured from the outer surfaces of pipe or fittings to the face of the ears.

50 and 75 mm dia	-	32 mm
100 and 150 mm dia	-	38 mm

18.23.3 Pipes and fittings shall be sound and free from defects other than unavoidable surface imperfections, which are inevitable as a consequence of manufacturing process and are in no way harmful to their use. Pipes and fittings shall be such that they may be cut, drilled or machined. Each pipe shall be tested for soundness by striking with a light hand hammer and shall emit a clear ringing sound.

18.23.4 All Pipes and fittings shall be coated externally and internally with a composition having tar or otherwise similar base. The coating materials shall have good adherence and shall not scale off. In case pipe and fittings are imperfectly coated or where the coating has not set, the coating shall be removed and the pipes and fitting re-coated.

18.23.5 The tolerance permissible on weight shall be (-) 10%. Pipes and fittings weighing more than the nominal weight may be accepted provided they comply in every other respect with the requirements of the standard, without any price adjustment.

18.23.6 Pipe nails shall be galvanized, chisel pointed, with 8 mm dia shank and 18 mm dia head. Pipe nails shall be 100 mm long for pipes upto 100 mm dia and 150 mm long for 150 mm dia pipes.

18.24 C I Cowls

Cast iron cowls shall conform to IS 3989-1984 and shall approximately weigh 1 Kg, 1.5 Kg, 2.7 Kg and 5.8 Kg for pipes of nominal diameters 50 mm, 75 mm, 100 mm and 150 mm respectively.

18.25 Nahani Traps

Cast iron Nahani traps shall conform to IS 3989-1984 and shall have outlet of nominal diameter 50 mm, 75 mm as indicated. Approximate weight of Nahani traps shall be not less than 5.50 Kg and 6.50 Kg for traps with outlet dia of 50 mm and 75 mm respectively. Nahani traps shall be provided with cast iron grating.

18.26 Floor Traps

Cast iron floor traps shall conform to IS 3989-1984 and shall have outlet of diameter 50 mm, 75 mm and 100 mm. Weight of floor traps shall be not less than 2.50 Kg, 4.8 Kg and 7.5 Kg for traps with outlet dia of 50 mm, 75 mm and 100 mm respectively. Floor trap shall be provided with cast iron grating.

18.27 Asbestos Cement Soil, Waste and Vent Pipes and Fittings

Asbestos Cement Building pipes and pipe fittings, gutters and gutter fittings and roofing fittings shall comply with IS 1626 (part I) 1994 pipes and pipe fittings. IS 1626 (part II) 1994 Gutters and Gutters fittings and IS 1626 (part III) 1994 roofing fittings. The socketed asbestos cement building and sanitary pipes and pipe fitting shall be used as rain water pipes, soil waste and ventilating pipes.

Thickness : The nominal thickness of pipes and pipe fittings shall not be less than the valves given in table 1.

Table 1 : Thickness of Pipes and Pipe Fittings and Tolerance on Thickness

Sl. No	Nominal Diameter of pipes and pipe fittings (mm)	Thickness of pipes or pipe fittings (mm)	Tolerance on Thickness (mm)
(i)	50	6.5	+ 1.0
(ii)	60	6.5	+ 1.0
(iii)	80	8.0	+ 1.0
(iv)	100	8.0	+ 1.0
(v)	150	9.5	+ 1.5

18.27A UPVC Soil, Waste and Rainwater (SWR) Drainage Pipes

18.27A.1 UPVC (SWR) pipes shall conform to IS 13592-1992 as under :

Type 'A' Pipe : For use in ventilation pipe work and rain water application.

Type 'B' Pipe : For use in soil and waste discharge system.

The size of pipes shall be indicated.

18.27A.2 Rubber rings for pipes and fittings shall conform to IS 5382-1985.

18.27A.3 UPVC (SWR) fittings shall be used as per recommendations of the manufacturer of the pipes. In case there is no IS code for the fittings, these shall generally conform to the requirements of BS 4515 DIN 19531 and DIN 19534.

18.27A.4 UPVC (SWR) pipes and fittings shall be strong, dimensionally stable and shall be free from defects.

Sub Section C-Drains And Sewerage Including Appurtenant Works

18.28 Salt Glazed Stoneware pipes, fittings and Gully Traps

18.28.1 Salt glazed stoneware pipes, fittings and gully traps shall comply with the requirement of IS 651-1992. Specification for salt glazed stoneware pipes and fittings. Pipes and fittings shall be of quality Grade 'A' or Grade 'AA' as indicated.

Note 1 : Grade 'A Pipes and fittings : Pipes which comply in every respect with the requirement of IS 651-1992 but of which only 5 percent have been submitted to hydraulic test of the manufacturer and found satisfactory, shall be classified as Grade 'A'. Fittings in this class are not subject to hydraulic test.

Note 2 : Grade 'AA' Pipes and fittings : Pipes and fittings normally forming part of a pipe line such as tapers, bends junctions, etc. which comply in every respect with the requirement of IS 651-1992 and all of which have satisfactorily passed the hydraulic test conducted by the manufacturer, shall be classified as Grade 'AA'. Such pipes and fittings shall bear the word Grade 'AA'

Note 3 : Classification of Grade A and AA does not apply to fittings which do not form part of normal pipe line such as channels and their junctions and bends, interceptors and gully traps.

18.28.2 All pipes and fittings shall be sound, free from visible defects which may affect their strength, durability and serviceability. The glaze shall be free from crazing. The pipes shall give a sharp, clear note when struck with a light hammer. The acceptance criteria shall be as per IS 650-1991.

18.28.3 Gully traps may be round or square moulded with P, Q or S type outlets as required.

18.29 Concrete Pipes

18.29.1 Reinforced concrete pipes for drains and culverts shall be non-pressure type, class NP2 or class NP3, as indicated; and shall conform to IS 458-2003. Specification for concrete pipes with or without reinforcement. Bends, junctions and specials shall be of cast iron and of suitable size.

Note : Class NP2 Pipes are recommended for culverts carrying light traffic and Class NP3 for culverts carrying heavy traffic.

18.29.2 The ends of concrete pipes shall be suitable for butt end joints. The butt ends shall be prepared for collar joint with grooves. The pipe joints shall be capable of withstanding the same pressure as the pipe.

18.29.3 Concrete pipes shall be straight and free from cracks excepting craze cracks. The ends of pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench, no opening between ends in contact shall exceed 3 mm in pipes upto 600 mm diameter and 6 mm in pipes greater than 600 mm in diameter. The outside and inside surfaces of the pipes shall be smooth dense and hard and shall not be coated with cement wash or other preparation. The pipe shall be free from defects resulting from imperfect grading of the aggregate, missing or moulding. Pipe shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

18.30 Manhole Covers and Frames

18.30.1 Manhole Covers and Frames shall be of grey cast iron and shall conform to IS 1726-1991. Specification for cast iron manhole covers and frames. These shall be of any of the following grades, types and size, as indicated.

(a) Heavy Duty (HD), Solid type double triangle or circular, for use under heavy vehicular traffic conditions.
(b) Medium Duty (MD), Solid type, circular or rectangular, for use under light traffic condition such as in footpath and cycle tracks.
(c) Light Duty (LD), rectangular types with single or double seal, for use in domestic premises or other places where they are not subjected to wheeled traffic loads.

18.30.2 Weights shall be not less than as given below:-

Grade	Type	Size of clear opening in mm	Weight of cover in kg	Weight of frame in kg
H.D.	Double triangular	500	118	111
		560	140	115
H.D.	Circular	500	85	85
		560	108	100
M.D.	Circular	500	58	58
		560	64	64
M.D.	Rectangular	610x455	80	64
LD	Rectangular Single Seal :			
	Pattern 1	610x530	23	15
	Pattern 2	610x525	15	10
	Rectangular Double Seal	610x455	29	23
	Square, single seal	455	13	7
		610	25	13
	Square, double seal	455	23	15
		610	37	18

18.30.3 Covers shall have a raised chequered design to provide an adequate non-slip grip. The rise of the chequer shall be not less than 4 mm. Covers shall have key holes and shall be provided with lifting keys. The covers used in manholes in sewer lines shall invariably bear the word 'SEWER' on the top and those used for storm water drains shall bear the word 'STORM'. These marking shall be done during casting of the covers.

18.30.4 The Covers and frames shall be cleanly cast and shall be free from air and sand holes and from cold shuts. They shall be neatly dressed. All castings shall be free from voids whether due to shrinkage, gas inclusion or other causes. The covers shall be gas tight and watertight.

18.30.5 Manholes Covers and frames shall be coated with black bituminous composition. The coating shall be smooth and tenacious.

18.30.6 The size of covers specified shall be taken as the clear internal dimensions of the frames.

18.31 Steps in Manholes

Cast iron steps shall conform to IS 5455-1969, Specification for cast iron steps for manholes. The portion of the step which projects from the wall of the manhole shall have chequered or ribbed design to provide an adequate non-slip grip. The minimum weight of cast iron steps shall be 4.50 kg each. Where indicated steps may be of mild steel flat iron or round bars. Cast iron and mild steel steps shall be coated with a black bituminous composition.

SUB SECTION D-SANITARY APPLIANCES

18.32 Sanitary Appliances

18.32.1 General

Sanitary appliances shall be of vitreous China, unless otherwise indicated and shall conform to IS 2556 (Part I)-1994. Specification for vitreous sanitary appliances, Part I. General requirements and shall be of approved make. Appliances shall be strong, of high grade and shall be coated on all exposed surface with an impervious white vitreous glaze. The glaze shall be uniform, free from craze and discolouration and shall possess an impervious surface.

18.32.1.1 Sanitary appliances shall be of one piece construction. Water closets and urinals shall have an integral flushing rim. Inside of the pans shall be regular and smooth in order to ensure efficient flush.

18.32.2 Wash Down Water Closet

Water Closet shall conform to IS 2556 (Part 2)-2004. Specification for vitreous sanitary appliances (vitreous china), part II, specific requirements for wash down water closets, and shall be of pattern 1 or 2 as indicated, and of height 390 mm and 410 mm respectively. Each closet shall have an integral trap either with P or S outlet; trap inlet depth shall be at least 75mm. Where required the closet shall have an anti-syphonage 50 mm dia vent horn on the outlet side of the trap. The serrated part of the outlet shall not be glazed externally. Each closet shall have not less than two holes for fixing to floor.

18.32.3 Squatting Pans

Squatting Pans shall conform to IS 2556 (Part 3)-2004. Specification for sanitary vitreous appliances (vitreous china), part III, specific requirements for Squatting Pans. These shall be of long pattern size 580 or 630mm or Orrisa pattern size 580x440 mm or 630x540mm as indicated. The flushing inlet shall be at the narrow end unless indicated to be provided at both the ends. Each pan shall be provided with a 100 mm dia P or S trap with or without inspection vent as directed. The trap shall be glazed inside. The inside of the pans shall be regular and smooth to ensure an efficient flush.

18.32.4 Foot Rest

They shall conform to IS 2556 (Part 7)-1995, Specification for vitreous sanitary appliances, part X, Foot Rest. The minimum size of foot rest shall be 250 x 125mm.

18.32.5 Wash Basin

Wash basin shall conform to IS 2556 (Part 4)-2004, Specification for vitreous sanitary appliances (Vitreous China) (Part-4) Specific requirements for wash basins. The basins shall be of flat back pattern, size 660x460mm (surgeons basin), 630x450mm, 550x 400mm or 450x300mm : or angle back pattern 600x480mm or 400x400mm, as indicated. Wash basin to be installed in surgeon's room and operation theater shall not be provided with soap holder recess and combined overflow.

Basins shall be provided with a single or double tap holes as indicated. A suitable tap hole button shall be supplied if the tap is not required in installation. The waste hole shall be either rebated or beveled internally with an overall dia of 65 mm and a depth of 10mm. Each basin shall be provided with 32 mm brass, chromium plated waste fitting. A slot type overflow having an area of not less than 5 sq cm shall be provided at the back of the bowl. Every basin shall have an integral soap holder recess or recesses, which shall fully drain into the bowl.

18.32.5.1 Pedestal

Glazed pedestals for wash basins shall be provided where indicated. The quality and thickness of the ware and the quality of the glaze of the pedestals shall not be less than that of the basins with which it is to be installed. They shall be suitably recessed at the back for the reception of supply and waste pipe and fittings. They shall be so constructed as to support the basins rigidly and adequately and shall be so designed as to make the height from the floor to top of the rim of basin between 750 to 850mm.

18.32.6 Sinks

Laboratory Sinks shall conform to IS 2556 (Part 5)-1994. Specification for vitreous sanitary appliances (vitreous china), part 5, specific requirements for Laboratory Sinks. The floor of sink shall gently slope towards the outlet. The waste hole shall have a minimum dia of 65 mm at the bottom to suit the waste fitting. Each sink shall be provided with a brass, chromium plated 50 mm dia waste fitting. The sinks shall have weir type over flow and their invert shall be 30 mm below the top edge.

18.32.7 Urinals

18.32.7.1 Bowl Type Urinals

Urinals basins shall be flat back or corner wall type, lipped in front and shall conform to IS 2556 (Part -6) 1995. Specification for vitreous sanitary appliances (vitreous china), part 6, Specific requirements for Urinals Section 1 Bowl type. The urinal shall be of one piece construction. Each urinal shall be provided with not less than two fixing holes on each side. Each urinal shall have an integral flushing rim of suitable type and inlet or supply horn for connecting flush pipe. The flushing rim and inlet shall be of the self draining type. The bottom of the pan shall have sufficient slope from the front towards the outlet for efficient draining. When installed, there should be no liquid left over in the bottom of the pan of urinal after flushing.

18.32.7.2 Half Stall Urinals

They shall be flat back type and shall conform to IS 2556 (Part -6) 1995. Specification for vitreous sanitary appliances (vitreous china), Part 6, Specific requirements for Urinals Sec 2, Half stall urinals. These shall be of size 580x380 x 350 mm min or 450x350x300 mm min as indicated. They shall be of one piece construction with or without an integral flushing box rim and provided with slots or alternative fixing arrangement at the flat back end.

18.32.7.3 Squatting Plate Urinals

The plates shall conform to IS 2556 (Part -6) 1995. Specification for vitreous sanitary appliances (vitreous china), part 6, Specific requirements of urinal section 3, squatting plates. They shall be of size 600 x 350 mm or 450x350 mm as indicated. Squatting plate shall be of one piece construction. Each urinal shall have integral longitudinal flushing pipe of suitable type which may be connected to flush pipe.

18.32.7.4 Stall Urinal

The stall urinal and its screens shall be of white glazed fire clay conforming to IS 771 (Part - 3 Sec 2). The stall shall be 1140 mm high and 460 mm wide with 400 mm over all depth at the base. Where specified screens which shall be 1200mm high and 15 mm thick (overall) and projecting 500 mm after suitable embedment in the wall shall be provided as directed by Engineer-in-Charge. In case of a range of two or more urinals, there shall be further division screens. The end screen shall also be suitably fixed as directed by Engineer-in-Charge. The range shall have 15 cm deep standard pattern tread plates of fire clay or black granite as specified or otherwise directed by the Engineer-in-Charge. The inside surface of the stall and its screens shall be regular and smooth throughout to ensure efficient flushing.

18.33 Partition Slabs

In case of ranges of two or more urinals partition slabs or screens of the type as indicated shall be provided between the urinals and fixed as directed.

18.33.1 Vitreous China partition slabs shall conform to IS 2556 (Part - 6) 1995 (Re-affirmed 2003). Specification for vitreous sanitary appliances (vitreous china), part VI, Specific requirements of urinals, section 4 Partition slabs. Partition slabs be of size 825 x 450 x100 mm or 675x325x85mm as indicated. Slab shall be provided with fixing arrangement at the flat back top and also with counter sunk hole at the bottom end to keep it fixed.

18.34 Flushing Cistern

18.34.1 Flushing Cistern for water closets and urinals shall be manually operated or automatic high level or low level as indicated. A high level cistern is intended to operate with a minimum height of 125 cm. and low level cistern with a maximum height of 30 cm, between the top of the pan and the underside of the cistern.

18.34.2 Manually operated flushing cistern shall conform to IS 774-2004, Specification for flushing cistern for water closets and urinals (valveless symphonic type). Cistern shall be of cast iron, pressed steel porcelain enameled or vitreous china as indicated. Automatic flushing cistern shall conform to IS 2326-1987, Specification for automatic flushing cistern for urinals.

18.34.3 The cisterns shall be free from manufacturing and other defects. All working parts shall operate smoothly and efficiently. Cistern shall be mosquito proof i.e. there shall be no clearance any where which would permit a 1.6 mm wire to pass through.

18.34.4 High level cisterns shall be provided with chain of galvanized steel or interlocked non ferrous metal and shall be of such strength as to sustain a dead load of 50 kg. With suitable handle or 'Pull' which shall be of galvanized iron or non-ferrous metal and shall be smooth and free from burrs. Low level flushing cisterns shall have chromium plated brass handle. Flushing cistern shall be supplied with brass couplings.

18.34.5 Cisterns shall operate on valveless siphon principle. The discharge rate of the cistern shall be about 5 litres in 3 seconds and there shall be no appreciable change in the force of flush, during the period of discharge. The cistern shall have a discharge capacity of 5,10 or 12.5 litres as indicated, with a tolerance of + ½ litres.

18.34.6 Cast iron cistern shall be painted two coats of black bituminous paint on the inside and with a priming coat on the outside before delivery. Flushing cisterns shall be painted on the outside, as directed.

18.34.7 Overflow pipe shall be of 20 mm dia GI pipe medium quality and shall have a non corrosive mosquito proof plastic/PVC Cover having 1.25 mm, dia perforations. The cover shall permit to be readily cleaned or renewed when necessary.

18.34.8 Ball Valves

Ball valves shall be of 15 mm nominal size and shall conform to IS 1703-2000.

18.35 Flush pipe

Flush pipe shall have a nominal internal diameter of 32 mm for high level cisterns and nominal diameter of 40 mm for low level cisterns. Telescopic flush pipe shall be made out of galvanized steel sheeting not less than 1 mm thick. A pipe clip with a rubber buffer shall be fixed to flush pipe to prevent damage either to the pipe or to the seal when the seal is raised. Flush pipes may be of polyethylene pipe, where indicated.

18.36 Plastic Water Closet Seats and Covers

These shall conform to IS 2548(part-I & II) -1996, Specification for plastic water closet seats and covers. Seats and covers shall be made of moulded synthetic materials, which shall be tough, hard with high resistance to solvents.

18.36.1 The underside of the seats may be either flat or recessed as indicated. Where the underside is flat, the seat shall be of solid moulding, where the underside is recessed the section shall be of adequate strength but shall be not less than 3 mm at any point. Covers shall be not less than 3 mm in thickness at any point. Seats and covers shall have a smooth finish and shall be free from cracks and crevices.

18.36.2 The hinging device shall be of brass or bronze, chromium plated and shall be provided with two bolts per seat.

18.36.3 Each seat shall be provided with not less than three rubber or plastic buffers of size 25x40x10 mm for full rounded seats and not less than four buffers for open front seats which shall be securely fixed to the inside of seat. Each cover shall be provided with the same number of buffers as for seats.

18.36.4 Unless other wise indicated, seats and covers shall be black in colour.

18.37 Glass Shelf

The unit shall consist of an assembly of glass shelf placed or seated on anodized aluminum angle frame. The size of shelf shall be 60x12 cm unless otherwise indicated. The shelf shall be of 5.5 mm thick sheet glass, ordinary quality with edges rounded off. The shelf shall be supported on chromium plated brass brackets which shall be fixed with chromium plated brass screw to plugs or gutties fixed in the wall.

18.38 Mirror

Mirror shall be made of selected quality sheet glass not less than 5.5 mm thick with edges rounded or beveled as indicated. It shall be free from all flaws, specks or bubbles. The glass shall be uniformly silver plated on the back, free from silvering defects. The silvering shall have a uniform protective coating of red lead paint.

18.39 Toilet paper Holder

The toilet paper holder shall be of chromium plated brass or vitreous China as indicated and of size and design as approved by the GE. It shall be fixed with chromium plated brass screws and rawls/plugs.

WORKMANSHIP

18.40 General Requirements

18.40.1 The work shall be carried out generally complying with the requirements of relevant byelaws and rules wherever in force.

18.40.2 All water supply, sanitary and plumbing installation work shall be carried out through licensed skilled plumbers.

18.40.3 All pipe work shall be laid or fixed as to be completely airtight or watertight as specified.

SUB-SECTION A-WATER SUPPLY

18.41 General Requirements

18.41.1 Changes in the diameter and in the direction of water mains shall preferably be gradual. No bend or curve in pipe line shall be made which materially diminishes or alters the cross section.

18.41.2 All water mains and services in the distribution pipes used for water supply for domestic purposes shall be thoroughly and efficiently disinfected as approved by the EIC, before putting into commission.

18.41.3 The method of laying cast iron pipes below ground level for water supply and drainage purposes is covered in IS 3114-1994 Code of practice for laying of cast iron pipes to be followed. It also includes excavation of trenches, handling and jointing of pipes, usage of anchor and thrust blocks, testing, flushing, back filling, restoration and maintenance of surface.

18.41.4 No pipe shall be laid or fixed so as to pass into, through or adjoining any sewers, scour out let or drain or any manhole connected therewith nor through any ash pit or manure pit or any material of such nature that would be likely to cause undue deterioration of the pipe, except where the laying of any pipe through such situations is unavoidable the piping shall be properly protected from contact with such soil or material by being carried through an exterior cast iron tube or by some other suitable means as approved by EIC. Any existing piping or fitting laid or fixed, which does not comply with the above requirement shall be removed and relaid/fixed in conformity with the above requirement immediately.

18.42 Excavation and Preparation of Trenches

The Trenches shall be excavated to the required alignment, size and grade as directed and detailed in Section 3 Earth work.

18.42.1 Pipes laid underground shall have adequate cover ie the pipe shall be laid at such depths that they are unlikely to be damaged by frost or traffic loads and vibrations. When a pipeline is under a roadway, normally a minimum cover of 90 cm shall be provided but it may be modified to suit local conditions.

18.42.2 Width of Trench

Width of the trench at bottom shall be such as to provide 20 cm clearance on either side of the pipe. Additional width shall be provided at position of sockets and flanges for jointing to be made properly. Trenches shall be of such extra width, where ordered, as will permit the convenient placing of timber supports planking and strutting.

18.42.3 Pipe shall not be laid in ground liable to subsidence but when such a ground cannot be avoided, special precaution shall be taken as ordered by the Engineer-in-Charge to avoid any damage to the pipes. Where pipes have to be laid on recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

18.42.4 The bottom of trench excavations shall be carefully prepared so that the barrels of the pipe when laid are well bedded for their whole length on firm surface and are true to line and gradient. Joint holes shall be made to such dimensions as will allow the joints to be conveniently made and thoroughly caulked. Where rock and large stones or boulders are encountered, the trench shall be trimmed to a depth of at least 80 mm below the level at which the bottom of the barrel of the pipe is to be laid and filled to a like depth with stones broken to pass through a sieve of 12.5 mm size and well rammed for a hard bed for pipes.

18.42.5 When roads have to be crossed, half the width shall be dug at a time and proper warning notices, signs and lights shall be displayed and watchmen posted to prevent accidents.

18.42.6 Roots of trees within a distance of about 0.5 m from the side of pipe line shall be removed or killed.

18.43 Handling of pipes

While unloading, pipes shall not be thrown down from the trucks or be dragged or rolled along the hard surfaces. Proper implements, tools and facilities such as derricks, ropes etc, satisfactory to the EIC shall be provided and used for safe handling and careful lowering of all pipes fittings, valves and hydrants into the excavation in such a manner as to prevent damage to water mains and their protective coating. Pipes over 300 mm dia shall be handled and lowered in to excavation with the help of chain pulley blocks.

18.44 Detection of Cracks in Pipes

All pipes and fittings shall be inspected carefully before being laid. Broken or defective pipes shall not be used and removed from the site of work. Pipe shall be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, confirmation may be obtained by pouring a little paraffin on the inside of the pipe at the suspected spot; if a crack is present, the paraffin seeps through and shows on the outer surface.

18.45 Preparing Pipes

The pipes shall be carefully cleared off all foreign matter before being laid. They shall be thoroughly brushed out internally with a well fitting hard brush and after laying, the open end shall be temporarily plugged to prevent ingress of water, soil etc. Precautions shall be taken to prevent flotation of the plugged pipes, should the trench become flooded.

18.45.1 Usage of Anchor and Thrust Blocks in Pipe Line

(a) **General :** High pressure mains need anchorages at dead ends and bends, as appreciable thrust occurs which tend to cause 'draw' and even blow out of joints. Where the thrust is appreciable, concrete blocks shall be provided at all points where movement may occur as indicated.

(b) **Hydrants :** The bowl of each hydrant shall be well braced against a sufficient area of unexcavated earth at the end of the trench with stone slab or concrete backing, or it shall be tied to the pipe with 50 x 6 mm M.S. flat clamp or restrained joints as indicated.

(c) M.S. Flat shall be protected against corrosion by a bituminous coating.

(d) **Pipelines :** Anchorages shall be provided as necessary to resist the tendency of the pipe to pull apart :-

  (i) At bends or other points of unbalanced pressures.

  (ii) When they are laid on steep gradients and the resistance of their joints to longitudinal (shearing stresses) is either exceeded or inadequate. They are also used to restrain or direct the expansion and contraction of rigidly jointed pipes under the influence of temperature changes or as indicated.

(e) It is advisable to avoid sharp bends above 45^0 and in soft ground it is better not to put two bends together but to separate them by at least a length of straight pipe. If the pressure is high enough to merit it and sleeve joints are being used, the joints on the bends and on two pipes either side of them shall be fully welded inside and outside, and the trench refilled with concrete to 150 mm above these pipes and bends pipes laid on steep inclines shall be anchored or transversed blocks or other precautions taken to prevent slippage and measures to overcome unbalanced pressures.

(f) Anchor or thrust blocks shall be designed in accordance with IS 5330-1984. Thrust resistance design pressure should be equal to the test pressure. Vertical and horizontal reaction backing shall be made of concrete of grade M-15 conforming of IS 456-2000.

18.46 Laying of pipes.

18.46.1 Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the line. If the pipe cannot be laid without earth entering it, a heavy, tightly woven canvas hag of suitable size shall be placed over each end and left there until the connection is to be made to the adjacent pipe. During laying operations, no tools, clothing or other materials shall be placed in the pipe.

18.46.2 Laying of pipes shall always proceed upgrade of slope if the pipes have spigot and socket joints the socket ends shall face upstream. In the case of pipes with joints to be made with loose collars, the collar shall be slipped before the next pipe is laid.

18.46.3 While laying pipes, the trenches shall be kept free from water until the material in the joints hardens. Walking or working on the completed pipe line shall not be permitted until the trench has been back filled to a height of at least 30 cm over the pipes.

18.46.4 After placing a length of pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to gradient. The pipe shall be secured in place with approved backfill material tamped under it except at the socket.

18.46.5 When the pipe laying is not in progress the open ends of pipe shall be closed by a water tight, plug.

18.46.6 Wherever the jointing material specified is cement, six or more lengths of pipe shall be laid in place ahead of each joint before such a joint is finished.

18.46.7 Permissible Deflection at socket and spigot joints : Where necessary to deflect pipe from a straight line either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted, deflection at joint shall not exceed the following: -

Lead joints	$2½^0$
Rubber joints for Nominal bore 80 to 300 mm	5^0
For Nominal bore 350 to 400 mm	4^0
For Nominal bore 450 to 750 mm	3^0

18.47 Cutting of pipe

The cutting of pipe for inserting valves or fittings shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angle to the axis of the pipe.

18.48 Jointing of Cast Iron Pipes

18.48.1 Jointing of Cast Iron spigot and socket Pipes shall be done with any one of the following joints as indicated.

(a) Run lead joint (under dry connection).
(b) Lead wool joint (under wet connection).
(c) Cement joint (where working pressure does not exceed 30 m head). As cement joints are rigid, to give some flexibility lead joints may be provided at suitable intervals, where indicated preferably at valve sections or street intersections.

18.48.2 Run Lead Joints

The spigot shall be centered in the adjoining socket by tightly caulking in sufficient turns of tarred gasket or hemp yarn to leave unfilled half the depth of socket for lead. When gasket or hemp yarn has been caulked tightly home, a jointing ring shall be placed round the barrel and against the faces of the socket. Molten pig lead shall then be poured in to fill the remainder of the socket, the lead shall then be solidly caulked with suitable tools and hammers of not less than 3 Kg weight, right round the joint to make up for the shrinkage of the molten metal on cooling and shall be preferably finished 3 mm behind the socket face. The pipes shall be perfectly dry before run lead joint are made, otherwise blow holes may occur in the lead.

18.48.2.1 The lead shall be heated to proper temperature so that when stirred it will show a rapid change of colour. Before pouring, all scum shall be removed. Each joint shall be made in one continuous pouring. Care shall be taken that no grass enters the joint. Spongy or imperfectly filled joints shall be burnt out and re-poured.

18.48.2.2 The joint runner shall fit snugly against the face of the socket and the outside of the pipe shall be dammed with clay to form a pouring lip to provide for filling the joint flush with the face and to the top of the socket.

18.48.2.3 Any deviation either in plan or elevation less than $11\text{-}1/4^0$ shall be effected by laying the straight pipes round a flat curve of such radius that the minimum thickness of lead at the face of socket shall not be reduced below 6 mm or the opening between the spigot and socket increased beyond 12 mm at any joint. A deviation about $2\text{-}1/4^0$ can be effected at each joint this way.

18.48.2.4 The quantity of lead and spun required for different sizes of pipes are given as under:-

Nominal size of Pipe	Lead/Joint	Depth of lead joint	Spun Yarn/Joint
mm	Kg	mm	Kg
80	1.8	45	0.10
100	2.2	45	0.18
150	3.4	50	0.20
200	5.0	50	0.30
250	6.1	50	0.35
300	7.2	55	0.48
350	8.4	55	0.60
400	9.5	55	0.75
450	14.0	55	0.95
500	15.0	60	1.00
600	19.0	60	1.20

Note :- A variation of 5 per cent in the specified weights is permissible.

18.48.3 Lead wool Joint

When it is impracticable or dangerous to use molten lead for joints e.g. in cases such as inverted joints or in wet conditions or in exceptional cases joints may, with the approval of the EIC, be made with caulking lead wool and yarn inserted in strings not less than 6 mm thick and the caulking repeated with each turn of lead wool or yarn. The whole of the lead wool or yarn shall be compressed into a dense mass. The joint shall then be finally finished flush with the face of the socket.

18.48.3.1 Joints made with lead wool shall comply with all the requirements specified for run lead joints.

18.48.3.2 The quantity of lead wool and spun yarn required for different sizes of pipes shall be as under:-

Nominal dia of Pipes	Lead Wool required per Joint	Depth of lead Wool or lead yarn	Spun Yarn required per Joint
mm	Kg	mm	Kg
80	0.80	19	0.10
100	0.90	19	0.15
150	1.60	23	0.25
200	2.05	23	0.35
250	2.95	25	0.55
300	3.50	25	0.70

Note :- A variation of 5 per cent in the specified weights is permissible.

18.48.4 Rubber Gasket Joint

Where joints of spigot and socket pipes are specified to be made with rubber gasket, pipes cast with spigot and socket of modified design suitable for the purpose only shall be used. Spigot of pipes and portion of sockets engaging the bulb seating shall be scrubbed of all dirt, dust, loose scales etc and wiped clean.

18.48.4.1 A thin film of an approved lubricant shall be applied to the bulb seating inside the socket. The rubber gasket, after wiping clean, shall be flexed and placed inside the socket with the bulb towards back of the socket, ensuring that the groove in the gasket is located on the retaining head in the socket and retaining head of the gasket is firmly bedded in its seating.

18.48.4.2 The chamfered portion of the spigot and the inside surface of gasket shall be lightly smeared with a thin film of lubricant. Spigot of the pipe shall be aligned and carefully entered into the socket until it makes contact with the gasket end; the joint assembly completed by boring the spigot and past the gasket (which is thus compressed) until the spigot reaches bottom of the socket. If the spigot cannot be forced home with the use of reasonable force the spigot shall be removed and the gasket, in position, examined for any bulges or displacement.

18.48.4.3 Forcing home of the spigot shall be done by using appropriate tools and tackle suitable for the purpose.

18.48.4.4 Spigot of pipes to be used when rubber joints are indicated shall have chamfered ends, when it is found necessary to cut a pipe on site, the cut end shall be chamfered carefully removing burr and sharp edges before using.

18.48.5 Cement Joint

Closely twisted spun yarn gasket of such diameter as required to support the spigot of the pipe at the proper grade and make truly concentric joints and in one piece, of sufficient length to pass around the pipe and lap at the top, shall be thoroughly saturated in cement paste. This gasket shall be laid in the socket for the lower one third of the circumference of the joint and covered with cement and sand mortar 1:1. The spigot of the pipe shall be thoroughly cleaned, inserted and carefully driven home; after which a small amount of mortar shall be inserted in the annular space around the entire circumference of the pipe and solidly rammed into the joint with a caulking tool, the mortar previously placed being driven ahead of the gasket. The remainder of the joint shall then be completely filled with mortar and beveled off at an angle of 45 degree with the outside of the pipe. In pipes of 450 mm in diameter or larger, the joint shall be pointed and smoothened from the inside while making cement joints, one lead joint shall be introduced after every ten cement joints.

18.48.5.1 The inside of the pipe shall be cleaned after the mortar sets slightly by dragging a large gunny wrapped block of wood or straw through the pipe. Care is, however necessary to see that this block is not left in the sewer when the work is interrupted or completed.

18.48.5.2 Time interval before filling pipe

Pipes laid with cement joints shall not be filled with water until a lapse of twelve hours after the last joint in any section has been made, and pressure shall not be permitted in the pipe until all joints have aged till at least 36 hours and tested thereafter for hydrostatic pressure. The pipe shall remain full of water until all tests have been made then only back filling shall be done.

18.48.6 Jointing Flanged Pipes

The jointing material used between flanges of pipes shall be compressed fiber board or rubber of thickness between 1.5 mm to 3 mm. The fiber board shall be impregnated with chemically natural mineral oil and shall have a smooth and hard surface. Its weight per sqm shall be not less than 112 gm/mm thickness.

18.48.6.1 Each bolt should be tightened a little at a time, taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable.

18.48.7 Testing of Pipe line

Before testing, trench shall be partially back filled except at joints. Completed pipe line shall be subjected to the following tests :-

(a) **Pressure test :** The field test pressure to be imposed shall be not less than the greatest of the following :

(i) One and half times the maximum sustained operating pressure.

(ii) One and haft times of the maximum pipe line static pressure and

(iii) Sum of the maximum static pressure and surge pressure subject to the works test pressure. Test shall be conducted as per IS 3114-1994.

(b) **Leakage test :** A leakage test shall be conducted concurrently with the pressure test. Leakage is defined as the quantity of water coming out of the newly laid pipe, or any valved section there of with 0.035 N/sq.mm of the specified leakage test pressure after the air in the pipeline has been expelled and the pipe has been filled with water. Pressure at which leakage test will be made shall be indicated.

$$q_1 = \frac{ND\sqrt{P}}{3.3}$$

Where

q^1 = The allowable leakage in Cum/hour

N = Number of joint in the length of the pipe line

D = Diameter in mm

P = Average test pressure during the leakage test in kg/Cm ^{2}

(c) Should any test disclose leakage greater than that specified above, the defective joints shall be remade until the leakage is within the specified allowance. When the joints are made with lead, leaking joints shall be re-caulked until watertight; when joints are made with cement or rubber gasket, such joints shall be cut out and remade.

18.48.8 Flushing and Disinfections of Mains before Commissioning : Flushing and Disinfections of Mains before commissioning shall be carried out as per clause 8 of IS 3114-1994. Code of Practice for laying Cast Iron Pipes.

18.49 JOINTING OF ASBESTOS CEMENT PRESSURE PIPES

18.49.1 The pipes shall be checked before laying for defects such as cracks, chipped ends, crushing of sides, etc.

18.49.2 Pipes and fittings such as joints flanges, joint collars, AC couplings etc to be laid in trenches must be clean from inside. The ends of the pipes shall be cleaned preferably with a hard wire brush to remove loose particles. The rubber rings shall be kept clean from grease and oil and kept away from heat and sun.

18.49.3 Laying of Pipes

The pipes shall be lowered into trenches by hand or by means of rope, as directed, and laid on an uniform bed along the whole length of pipe. The pipes shall not rest on lumps of earth or on the joints. At joints, a clearance of approximately 100 mm in depth and width equal to the length of collar plus 30mm on both sides shall be provided which shall be refilled from sides after the joint is made . Care shall be taken to prevent movement of the laid pipes.

18.49.4 Jointing of Pipes

Two types of joints shall normally be provided with Asbestos cement pressure pipes and the type of joint shall be indicated. They are :-

(a) Asbestos cement couplings with rubber sealing rings, and

(b) Cast Iron detachable joints with rubber sealing rings and bolts and nuts.

The composition of asbestos cement couplings shall be made from a thorough and homogeneous mixture of ordinary Portland cement, rapid hardening Portland cement, Portland slag cement or Portland pozzolana cement. Cast iron detachable joints shall conform to IS 8794-1988. Rubber rings used in jointing shall comply with the requirements of IS 5382-1985. If the pipes are to be used for conveying drinking water, the rings shall not affect the quality of water. The assembled joints shall be flexible and capable of with standing the specified hydraulic pressure of the pipes on which they are to be used, when the pipes are set at the maximum permissible angular deviation indicated by the manufacturer of pipes.

18.49.4.1 Cast Iron detachable joints

This type of joints shall consist of a central collar, two rubber rings, two flanges of cast iron and the required number of bolts and nuts.

One flange and rubber ring shall be placed on the end of the pipe already laid and the other flanged ring and the central collar shall be slipped on to the pipe to be assembled. The rubber ring shall be kept positioned at half the collar width less 2.5 mm from the end of the pipe already laid . The other pipe shall be brought nearer leaving a gap of 5 mm between the two pipe ends. This gap will facilitate maneuvering of deflection at joints after assembly and will take care of any expansion in the pipe line.

The collar shall then be slidded to sit square around the rubber ring on already laid pipe and then the rubber ring on the pipe to be jointed shall be rolled to sit around the collar.

The flanges shall then be moved on both ends to enclose rubber rings. The fastening bolts be inserted through the holes of the flanges, and the bolts shall be tightened alternatively and evenly for proper setting of the joints.

18.49.4.2 Asbestos cement coupling joints

This type of joints shall consist of three rubber rings and an asbestos cement coupling machined on the inside.

The rubber rings shall be seated in their respective grooves after cleaning the coupling and rubber rings. The machined ends of the pipe and end rings in the coupling shall be suitably lubricated with a soft soap solution or other lubricant which is not detrimental to rubber rings or drinking Water. Then, the assembly shall be made by pushing with a crowbar or using a pipe puller. The joints shall be made by keeping the pipe in one line. Any permissible deflection at joint shall be made only after completion of the joint.

18.49.5 All cast iron fittings shall be plain ended to suit the class and dia of pipe. Cast iron fittings are jointed by cast iron detachable joints only. Cast iron specials having flanges are jointed in the pipe line with cast iron flange adaptors having one end flanged and the other end plain ended.

18.49.6 Wherever necessary, change over from cast iron pipe to asbestos cement pipes and vice versa shall be done with the help of suitable adaptors.

18.49.7 Tests

(a) Hydraulic Pressure test IS 1592-2003. The pipes shall not indicate any loss or visible sweating on the outside surface of the pipe, when the hydraulic test pressure as given in the table below is maintained for 30 seconds. The test time may be reduced to 10 second for pipe of diameter less than or equal to 250 mm without changing the class provided that the internal pressure is increased by 10 percent.

CLASSIFICATION OF ASBESTOS CEMENT PRESSURE PIPES

Class	Hydraulic test pressure (MP_a)
05	0.5
10	1.0
15	1.5
20	2.0
25	2.5

Hydraulic working pressure shall normally be not more than 50 % of the Hydraulic test pressure defining the class.

The relationship between the bursting pressure (BP) and the hydraulic test pressure (TP) and the relationship between the bursting pressure (BP) and the normal hydraulic working pressure (WP) shall not be less than the values given in Table below :

Relationship between (BP), (TP) and normal hydraulic working pressure (WP)

Nominal Diameter mm	$\frac{BP}{TP}$	$\frac{BP}{WP}$
80 and 100	2	4
125 and 200	1.75	3.5
250 to 600	1.5	3.00

18.50 Laying and jointing of GI Pipes (External work)

18.50.1 Trenches

The width and depth of trenches for different diameter of GI pipes shall be as under:

Dia of pipe mm	Width of Trench cm	Depth of trench cm
15 to 50	30	60
65 to 100	45	75

At joints the width of trench shall be widened where necessary.

Note : Authorised width of trench as defined in SSR part II section 3 special Conditions 3.2.3 shall be modified as above for GI water mains.

18.50.2 Cutting and Threading

Where pipes have been cut or re-threaded, the ends shall be carefully filed out so that no obstruction to flow is offered. The ends of pipes shall then be carefully threaded in such a manner as will not result in slackness of joints.

18.50.3 Jointing

Screwed steel pipe shall be jointed with screwed and socketed joints using screwed fittings of wrought iron, steel or malleable cast iron. The pipes shall be cleaned and cleared of all foreign matter and any burrs from the ends of pipes removed before laying. In jointing the pipes, the inside of the socket and the screwed end of the pipe shall be oiled and rubbed over with white lead and a few strands of fine yarn or thread wrapped round screwed end of the pipe. The end shall then be screwed in the sockets tee etc. Care shall be taken that all the pipes and fittings are properly jointed so as to make the joints completely watertight.

18.50.4 Testing

On completion, the pipe line shall be tested to a hydraulic pressure of 6 kg/sqcm (6 metre) under working condition of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced.

18.51 Laying of GI pipes (Internal work)

All important provisions of IS 2065-1983 as applicable shall be complied with in consultation with EIC

18.51.1 GI pipes and fittings, when fixed above ground shall run on the surface of the walls or ceilings, unless specified to be concealed. Where unavoidable, pipes may be buried for short distance provided adequate protection is given against damage. Where directed by EIC, a mild steel tube sleeve shall be fixed where the pipe is passing through a wall or floor for reception of the pipe and to allow freedom of expansion and contraction and other movements. Pipes, which are embedded in walls, ceilings or floors shall be painted with bituminous paint of approved quality, The pipes should not come in contact with lime mortar or lime concrete as pipes are affected by lime.

18.51.2 All pipes and fittings shall be fixed truly vertical and horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern holder bat clamps of required shape and size so as to fit tightly on the pipes when tightened with screwed bolts. The pipes when fixed shall be 15mm clear of wall. The clamps shall be embedded in brick work in cement and sand mortar 1:3 and shall be spaced at regular intervals in straight lengths as under :-

Dia of pipe mm	Interval of clamps for	
	Horizontal run	Vertical run
	m	m
15	2	2.5
20,25 & 32	2.5	3
40 and 50	3	3.5
65 and 80	3.5	5

18.51.3 The clamps shall be fixed at shorter lengths near the fittings as directed by the Engineer-in-charge.

18.51.4 For GI pipes 15 to 25 mm diameters, the holes in the walls and floors shall be made by drilling with chisel or jumper and not by dismantling the brick work or concrete. However for bigger dimension pipes the holes shall be carefully made of the smallest possible size as directed. After fixing the pipes the holes shall be made good with cement and sand mortar 1:3 and properly finished to match the adjacent surfaces.

18.51.5 In case of concealed pipe work, chasing may be adopted or pipes fixed in the duct-or-recess etc. and shall be secured by clamps or iron hooks spaced at regular intervals as indicated provided there is sufficient space to work on the pipes with the usual tools,

18.52 Jointing of Unplasticised PVC pipes

18.52.1 Solvent Welded Joints

This technique is used with both spigot as well as spigot and socket type joints in which socket is made specially to form a close fit on the pipe end, and with injection moulded fitting. The pipes shall be cut perpendicular to the axis of the pipe length. Pipe ends shall be bevelled slightly with a beveling tool (reamer) at an angle of about 30^{o}. The total length of insertion of the fitting socket shall be marked on the pipe and checked how far the pipe end could be inserted into the fitting socket. Attempt shall be made to push the pipe to the marked distance, if not possible, it shall at least be pushed for 2/3 of this distance.

18.52.1.1 Dust, oil, water, grease, etc shall be wiped out with a dry cloth from the surface. Further the grease should be thoroughly removed with a suitable solvent, such as methylene chloride or as an alternative the outside surface of the pipe and the inside of the fitting may be roughened with emery paper.

18.52.1.2 Generous coating of solvent cement shall be evenly applied on the inside of the fittings alround the circumference for the full length of insertion and on the outside of the pipe end upto the marked line with non-synthetic brush of suitable dimension. The pipe shall be pushed into the fitting socket and held for 1 or 2 minutes as otherwise the pipe may come out of the fitting due to the slippery quality of cement and the tapering inside bore of the fitting. The surplus cement on the pipe surface shall be wiped out. If the solvent cement has dried up too much or the tapering of the socket is too steep, jointing will not be proper and pipe will come out of the fitting.

18.52.2 Flanged Joints

For jointing PVC pipes particularly of larger sizes, flanged joints are made by the compression of gasket on a ring seal set in the case of a flange. Flanges solvent welded to the PVC pipes shall be supplied by the manufacturer.

18.52.3 Rubber Ring Joints

Rubber ring joints can provide a water tight seal but do not resist pull. As such these may be used only as repair collar and for jointing pipes larger than 110 mm dia. Such joints may be provided on pipes which are buried in the ground and supported throughout on a bedding so that they are not subject to movement and longitudinal pull. The material of rubber ring shall conform to IS 5382-1985, where aggressive soils are met with synthetic rubbers perform better for jointing. The ring shall be housed in groove formed in plastic or metallic housing. The rubber is compressed and makes a seal between the pipe and the housing. The ring shape and the method of compressing the ring vary considerably in different types of joints. Most joints often require the application of lubricating paste which shall be procured from the manufacturer of PVC pipes, Rubber rings shall be supplied by the manufacturers.

The rubber ring joints may be made either :-

1. With spigot and socket, or
2. With separate collar pieces having two rubber rings, one at either end.

18.53 Jointing Polyethylene (PE) Pipes

18.53.1 Type of Joints

The commonly used joints are as follows :

(a) Insert Type Joints : They are commonly used for LDPE pipes wherein a serrated HDPE or metallic fitting is inserted into the pipe and tightened by clip

(b) Compression fittings : They are used for LDPE and HDPE joints. They are detachable joint and are made of metals or plastics

(c) Fusion Welding Joints : They are commonly used for LDPE pipes and is a permanent type of joint.

(d) Screwed Joints (Threaded Joint) : These are used for LDPE and HDPE pipes, with higher pressure ratings which have thicker walls.

(e) Flanged Joints : They are used for jointing LDPE and HDPE pipes, particularly of larger size for valves and vessels, and large size metal pipes, where strength in tension is required.

(f) Telescopic Joints

18.53.2 There are insert type of fittings of both plastic and metals available for use with polyethylene pipes. In corrosive locations plastic fittings are preferred because of their high resistance to corrosion. In less corrosive conditions gun metal fittings are used and in normal or slightly corrosive environment brass fittings are employed.

18.53.3 Insert Type Joints

The outer serrations of HDPE/metal insert type fittings lock into the pipe to prevent their coming out under sudden pressure surge. If the pipe bore is slightly undersized, a little heating by immersion in boiling water in case of LDPE pipes and oil bath in case of HDPE pipes would soften them to enable insertion of fitting. As a measure of safety worm drive clip shall be used in all cases. This type of jointing is used normally in small diameter pipes upto 110 dia.

18.53.4 Compression Fittings

The flanged pipe wall is compressed on a conical insert either by two male and female threaded metallic units or by backing loose flanges. The water seal is made by compression of ends of flared pipe between sloping surface of metallic nuts/flanges and conical inserts.

18.53.5 Fusion Welding

The pipe shall be cut square and the face of the pipe shall be slightly scraped prior to welding to remove oxidized layer. At the time of welding, beveling of the pipe is essential particularly in case of larger diameter pipes. Welding temperature should be 200^{o} C and surface of heating mirror should be at $210^{o}C \pm 5^{o}C$. The pipes to be welded should be held on either side of the heating mirror with only contact pressure of about 0.2 kg/cm^2. When the rim of the molten material is formed, the pipes are removed from heating mirror or mirror from pipe and immediately the joint is made by application of moderate pressure of approx 1 to 2 kg/cm^2 for 2 to 3 seconds. The initial heating time for achieving molten rim varies from 1 minute to 5 minutes depending upon the pipe wall thickness and size.

18.53.6 Screwed Joints (Threaded Joints) : LDPE and HDPE pipes of higher wall thickness may be threaded in the same manner as in the case of GI and other metallic pipes. Ordinary metal cutting dies of adjustable and guided variety may be used. As far as possible, a full thread should be cut in end operation. It is advisable to plug the end of the pipe during threading operation to avoid distortion due to flexibility. When threading the pipe, taper threads should be used and only the exact number of thread required for the joint should be cut so that when the joint is made the threaded pipe is totally enclosed in the fittings.

18.53.6.1 Galvanized iron fittings are suitable where there is no risk of corrosion. In corrosion conditions, rigid PVC fittings shall be used.

18.53.7 Flanged Joints

It consists of flanges either loose or welded to the pipe ends. It is recommended that suitable metallic backing plates be used to support the polyethylene flanges to enable them to be bolted together. Injection moulded polyethylene flanges with metal inserts of 6 to 9mm thickness may also be used. In most cases, sealing is improved by incorporating a natural or synthetic rubber gasket between polyethylene flanges.

18.53.8 Telescopic Joints

The socket may be an integral part of the pipe at one end or both the ends or a special coupler into which the free end of the pipes are pushed to achieve a watertight joint.

18.53.8.1 Telescopic joints are normally weak in longitudinal pull and shall be anchored where indicated. External anchorages shall be provided at each end of the pipe line, at valves and at a change of direction. The supports of the side connection should ensure that excessive lateral bending does not occur.

18.53.8.2 In small diameter pipes the coupler itself could be modified to have a split threaded grip type gasket of hard material in addition to 'O' ring type or rubber gasket (for water tightness) to prevent any slipping out of the free end of the pipe in longitudinal pull.

18.53.9 Installation

Provision shall be made for the effects of thermal movement. Between the anchors for suspended pipes, the supports should not grip or distort the pipe, but should allow the repeated longitudinal temperature movement to take place without abrasion. Line or point contact with the pipe shall be avoided. Heavy components such as metal valves shall be individually supported.

18.53.9.1 Plastic pipes shall not be installed near hot water pipes or near any other heat sources. The pipes shall be supported properly.

18.53.9.2 Valves and hydrant tees shall be supported in such a manner that the torque applied in operating a valve is not transmitted to the pipe line.

18.54 Testing of Mains After Laying

After laying and jointing, the main shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25mm inlet with a stop valve, allowed to stand full of water for a few days if time permits and then tested under pressure. The test pressure shall be 5kg/cm^2 or the maximum working pressure plus 50 percent. Whichever is greater. The pressure shall be applied by means of a manually operated test pump, or in the case of long mains or mains of large diameter, by a power-driven test pump, provided that the pump is not left unattended. In either case due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure gauges shall be accurate and shall preferably have been recalibrated before the test. The test pump having been stopped, the test pressure shall maintain itself without measurable loss for at least half an hour. The mains shall be tested in sections as the work of laying proceeds. The open end of the main may be temporarily closed for testing under moderate pressure by fitting a watertight expanding plug. The end of the main and the plug shall be secured by struts or otherwise to resist the end thrust of the water pressure in the mains.

18.54.1 If the section of the main tested terminates with a sluice valve, the wedge of the valve shall not be used to retain, the water; instead the valve shall be temporarily fitted with a blank flange or in the case of a socketed valve, with a plug, and the wedge placed in open position while testing.

18.55 Testing of Service Pipes and Fittings

When the service is complete, it shall be slowly and carefully charged with water, allowing all air to escape and avoiding all shock or water hammer. The service shall then be inspected under working conditions of pressure and flow. When all draw-off taps are closed, the service pipe shall be absolutely watertight. All piping, fittings and appliances shall be checked over for satisfactory functioning support and protection from damage, corrosion and frost. Because of the possibility of damage in transit, cisterns shall be re-tested for water tightness on arrival on the site, before fixing.

18.56 Back Filling

18.56.1 For the purpose of back filling, the depth of the trench shall be considered as divided into the following three Zones from the bottom of the trench to its top.

Zone 'A'	From the bottom of the trench to the level of the center line of the pipe
Zone 'B'	From the level of the center line of the pipe to a level 300mm above the top of the pipe and
Zone 'C'	From a level 300mm above the top of the pipe to the top of the trench.

18.56.2 Back Fill Material

All back fill material shall be free from cinders, ashes, slag, refuse, rubbish, vegetable or organic material, lumpy or frozen material, boulders, rocks or stone or other martial, which in the opinion of the Engineer-in-charge is unsuitable or deleterious. However, material containing stones upto 200mm at their greatest dimension may be used in Zone 'C' unless specified otherwise herein.

18.56.3 Back Fill sand

Sand used for back fill shall be natural sand complying with requirements in Para 18.56.2 graded from fine to coarse. The total weight of loam and clay in it shall not exceed 10 percent. All material shall pass through a sieve of aperture size 20mm and not more than 5 percent shall remain on IS sieve of aperture size 6.30 mm.

18.56.4 Back Fill Gravel

Gravel used for back fill shall be natural gravel complying with requirement in para 18.56.2 and having durable particles graded from fine to coarse in a reasonably uniform combination with no boulders or stones larger than 50 mm in size. It shall not contain excessive amount of loam and clay and not more than 15 percent shall remain on a sieve of aperture size 75 micron.

18.56.5 Back Fill Under Permanent Pavement

Where the excavation is made through permanent pavements curbs, paved footpaths or where such structures are under cut by the excavation, the entire backfill to the sub grade of the structures shall be made with sand in accordance with para 18.56.3 paved footpaths and pavement consisting of broken stone, gravel, slag or cinders shall not be considered as being of a permanent construction. Method of placing and consolidating the back fill material shall be as specified under section 3 (Earth work) .

18.56.6 Back Fill with Excavated Material : The excavated material may be used for back fill in the following case, provided it complied with para 18.56.2 :-

(a) In zone 'C', in cases where settlement is unimportant and when shown on the drawing or specified, the back fill shall be neatly rounded over the trench to a sufficient height to allow for settlement to the required level.

(b) In any Zone when the type of back fill material is not indicated or specified provided that such material consists of loam, clay, sand, fine gravel or other material which are suitable for back filling in the opinion of EIC.

18.56.7 Back Filling in Freezing Weather

Back filling shall not be done in freezing weather except with the permission of EIC and shall not be done with the frozen material. No filling shall be done where the material already in the trench is frozen.

18.56.8 Back filling in Zone 'A' shall be done by hand with sand or gravel or any other material approved by EIC, placed in layers of 150mm and compacted by tamping. The back filling material shall be deposited in the trench for its full width on each side of pipe fittings and appurtenances simultaneously.

18.56.9 Back Filling in Zone 'B' shall be done as prescribed or directed by EIC, special care taken to avoid injury or movement of pipe from alignment with approved material.

18.56.10 Back filling in Zone 'C' shall be done by hand or any other approved mechanical method. The type of back fill material shall be excavated material as approved and directed by EIC or as prescribed.

18.57 Fixing Sluice Valve

18.57.1 The valve shall be fully examined and cleared of all foreign matters before being fixed. The fixing shall be done by means of bolts, nuts and 3mm rubber insertions or chemically treated compressed fiber board 1.5 mm minimum thickness with the flanges of spigot and socketed tail pieces drilled to the same specification in the case of spigot and socket pipes and with flanges in case of flanged pipes. These shall be jointed to the pipe line by means of lead caulked joints.

18.57.2 Sluice valve shall be installed with spindle vertical on horizontal pipes and horizontal on vertical pipes. While fixing sluice valves in pipe lines below ground level a clear space about 200 mm shall be available between the tops of the sluice valve spindle and surface box.

18.57.3 Clearance between the top of the stuffing box and the underside of the gland shall be uniform on all sides. Gland shall not be tightened too hard. The pressure applied shall be just enough to stop leakage. Hemp packing, shall be adequately soaked in grease and shall not be allowed to remain dry. The valves shall be tightly closed when being installed. While installing flanged valves, each flange bolt shall be tightened a little at a time, taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after the other is highly undesirable.

18.57.4 After installation of the valve the valve and the pipe line shall be flushed with water to remove any foreign matter that may be present in them.

18.57.5 If any leak is detected at the valve seat, applying extra torque on the valve spindle to set right the valve shall not be permitted. The valves seats shall be examined and if necessary repaired by scrapping or replacing where necessary.

18.57.6 Care should be taken to ensure that the jointing material sets squarely between the flanges of the valves and pipe line or tails without obstructing the water way and that there are no kinks in the joining materials as might allow leakage in service.

18.58 Fixing Fire Hydrant

The flanged end of the hydrant shall be fixed to the flanged end of a tee in the water main by meant of nuts and bolts and 3 mm rubber insertion or chemically treated compressed fiber board 1.5 mm minimum thickness. This may also be fixed by means of flanged tail pieces which may be connected to the water main by cast iron specials.

18.59 Making Connection of GI Distribution with GI Main

18.59.1 Connection of GI Distribution/service pipes to CI/GI. Mains shall be done as per clause 9.6 of IS 2065-1983 code of practice of water supply in building as specified and directed.

18.59.2 Tapping CI Mains

The use of right angled non ferrous metal ferrules of 15 mm bore or less shall only be restricted to service connections from CI mains of 100 mm bore or more to isolated and odd connections. Otherwise special T-branches of appropriate size and type as directed have to be inserted into the line of the mains for distribution and service connections.

18.59.3 Tapping GI Mains

A pit of suitable dimensions shall be dug at the point where the connections is to be made with the main and earth removed upto 50 mm below the main. The flow of water in the water main shall also be disconnected by closing the sluice or wheel valves on the mains.

The GI mains shall first be cut. Water if any collected in the pit shall be bailed out and ends of the GI pipe threaded. The connection of distribution pipe shall then be made by fixing malleable GI Tee of the required size and fittings such as jam nut, GI socket connecting piece etc. The portion of the pipe in the pit shall be painted with bituminous paint and encased with sand 150 mm alround. The pit shall be filled with earth in level with the original ground surface, watered, rammed and the area dressed.

18.60 Water Storage Tanks

Hosting of tanks into position shall be carried out with proper tackle care being taken that no part of the tank or of the structure is damaged in the operation. The tanks, shall be installed in position truly level, unless otherwise directed. The joints or connection to pipes shall be made with boiler screw, union, tee etc. as directed. Supports for tanks shall be provided as indicated.

18.60A P.V.C.

water tank shall be "Rotational moulded polyethylene water storage tank" as per IS 12701-1996, hoisting and fixing in position, connecting up pipes etc. shall be executed as per manufacturer's instruction.

18.61 Lagging

The plastic composition shall be applied evenly in layers, each layer being allowed to thoroughly dry out before the next layer is applied. The final layer shall be trowelled smooth and even.

Hair felt lagging shall be done with 100 mm wide strips, wound on spirally in one or more thickness in one operation, to a thickness not less than 15 mm and securely bound with stout tarred twine.

Lagging shall not be carried over manholes or hand holes but neatly finished 25 mm clear of the covers.

SUB SECTION B-PLUMBING

18.62 Fixing Brass or Gun Metal Fittings

The fitting shall be carefully examined and cleared of all foreign matter before being fixed. The fittings shall be fitted in the pipe line in a workman like manner. The joints between fittings and pipe shall be made leak-proof. Defective fittings and joint shall be replaced or redone.

18.63 Fixing Water Meter and Stop Valve in GI Pipe Line

18.63.1 Cutting GI Pipe Line

The GI pipe shall be cut to the required length at the position where the meter and stop valve are required to be fixed. The ends of the pipe shall be treaded. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and few turns of spun yarn wrapped round the screwed end of the pipe.

18.63.2 Fixing Meter and Stop Valve

The Meter and Stop Valve shall be fixed in position by means of connecting pipes GI jam nut and socket etc. the stop valve shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed and the meter installed exactly horizontal or vertical in the flow line in the direction shown by the arrow cast on the body of the meter. The factory seal of the meter shall not be disturbed. Wherever the meter is fixed to newly fitted pipe line, the pipe line shall be completely washed before fitting the meter.

18.64 Pipe work in branch connections

All joints in pipe work and of pipe work to appliances shall be made in such a manner as to be air-tight and water-tight and to remain so during use. Care shall be taken to ensure that no jointing material projects inside the bore of the pipe.

18.65 Bends

Bends shall be of long radius where practicable. In the case of bends in the bottom most pipes they shall necessarily be of long radius and shall preferably be made 135^0 (1/8) bends.

18.66 Ample provision

Ample provision shall be made for access to all pipe work; embedding of joints in wall shall be avoided as far as possible.

18.67 Soil, Waste and Vent Pipes

18.67.1 Soil, Waste and Vent Pipes shall be of cast iron or asbestos cement pipes as indicated.

18.67.2 Jointing Cast Iron Pipes
Joints shall be lead or cement joints as indicated. The pipes and fittings shall be as specified under Sub-Section A-Water Supply.

18.67.2.1 In case of run lead joints the quantity of lead to be used for each joint shall be not less than 0.80 Kg for 50 mm dia pipes. 1 Kg for 75 mm dia pipes 1.30 Kg for 100 mm dia pipes.

18.67.3 Jointing AC Pipe
AC soil pipes shall be jointed as specified for asbestos cement rain water pipes in Section 11, Roof Covering.

18.67.4 Fixing of Cast Iron Pipes and AC Pipes
Cast iron and asbestos cement pipes shall be fixed to the walls etc, as specified for rain water pipes in Section 11 Roof Covering.

18.67.5 All soil and vent pipes shall be carried up above the roof to a height of 1 m or as indicated and shall be provided on the top with vent cowl. The top unsupported portion of such pipes shall be secured with stack clamps fixed to the parapet or other part of the structure.

18.67.6 The connection between the main pipe and branch shall be made by using branches and bends with access door for cleaning. Access doors to fittings shall be provided with 3 mm rubber insertion pickings and secured with set screws to make them air and water tight.

18.67.7 Testing
Soil, waste and vent pipes shall be tested as specified under clause 18.79.

18.67.7A PVC Soil, waste and Rainwater (SWR) Drainage Pipes.

18.67.7A.1 Laying and Jointing of Pipes.

18.67.7A.1.1 The pipes shall be cleaned from outside spigot end and inside of the sealing groove of the fitting. Lubricant supplied by the manufacturer shall be applied uniformly to the spigot end and sealing ring. Spigot end shall be passed into the socket containing sealing ring until fully home as per manufacturers instructions.

18.67.7A.1.2 The method of installation and fixing to wall shall be as per manufacturers instructions.

18.67.7A.1.3 All PVC (SWR) Pipes and fittings shall be tested with water to detect any leakage as per manufacturers instructions.

SUB-SECTION C-DRAINS AND SEWERS

18.68 Concrete Foundations, Beds, etc.

18.68.1 Concrete Foundations to the drain and sewer pipes and the hunching or encasing to the pipes shall be provided as indicated. No work shall be covered over or surrounded with concrete until it has been inspected and approved by the EIC after testing as specified.

18.68.2 Bedding

The thickness of concrete bed below the barrel of the pipe where indicated shall be 10 cm for pipes 100 mm and 150 mm dia and 15 cm for pipes 200 mm dia and over. Width of concrete bedding shall extend laterally 15 cm beyond either side of the pipe i.e. outer diameter of drain pipes (not of sockets/collars).

18.68.3 Where bedding only is provided, the concrete shall be brought up at least to the invert level of the pipe to form a cradle.

18.68.4 Haunching

Shall consist of concrete bed as described for bedding with full width of bed carried upto the level of horizontal dia of the pipe and splays from this level carried up on both sides of the pipe from the sides of the bed to meet the pipe barrel tangentially.

18.68.5 Surround or Encasing

Shall be similar to the haunching upto horizontal dia of the pipe and the top portion over this finished in semicircular form to give a uniform encasing for the top half of the pipe.

18.69 Laying of Pipes

18.69.1 The drains and sewers shall be laid accurately and true to line, level and gradient from manholes to manholes on solid ground or concrete bed as indicated. Each pipe shall be individually set for line and for level without any vertical undulation or horizontal displacement.

18.69.2 All junctions and changes in the direction and diameter shall be made inside the manholes by means of curved or tapered channels formed in cement concrete smooth finished and benches on both the sides.

18.69.3 The pipes shall be laid with the sockets upto the gradient and shall rest on solid and even foundations for the full length of the barrel. Socket holes shall be formed in the foundation sufficiently deep, to allow sufficient space for the pipe jointer to work right round the pipes and as short as is practicable to accommodate the socket in proper position and allow the joint to be made.

18.70 Jointing Glazed Stoneware pipes

Tarred gasket for hemp yarn socket in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be placed well home into the socket of the pipe previously laid. The pipe shall then be adjusted and fixed in the correct position and the gasket caulked lightly home so as not to fill more than ¼ of the total depth (or 13 mm in depth) of socket . The remainder of the socket shall be filled with a still mix of cement and sand mortar 1:1. When the socket is filled, a fillet shall be formed round the joint with a trowel, forming an angle of 45 with the barrel of pipe. Mortar mixed as required for immediate use and no mortar shall be beaten up and used after it has begun to set.

18.70.1 After the joint is made, any extraneous material shall be removed from the inside of the joint with a suitable scrapper or 'badger'. The newly made joint shall be protected until set from the sun, drying winds, rain or frost. Sacking or other suitable materials, which shall be kept damp may be used for the purpose. The joints shall be cured for at least seven days.

18.71 Jointing cast iron Pipes

Joints shall be lead or cement joints as indicated. The pipes and fittings shall be jointed as specified under Sub-Section A-Water Supply.

18.72 Jointing Stoneware with cast iron Pipes

Where any water closet pan or earthen ware trap is to be jointed with a cast iron pipe, the joint between the stoneware/earthenware spigot and cast iron socket shall be made with cement joint.

18.73 Jointing cast iron Pipes with Stoneware Pipes

The beaded spigot end of cast iron pipe or traps shall be inserted into the socket of stoneware drain and the joint made with cement joint.

18.74 Reinforced Concrete Pipes Drains

18.74.1 Lowering and laying of Pipes

The laying and jointing of pipes shall conform to IS 783-1985, pipes shall be jointed by collar joints.

The trench shall be checked for proper level, gradient and alignment before lowering the pipes.

18.74.2 Lowering

The pipes shall be lowered cautiously to prevent disturbance of the bed and side of the trench. The heavy pipes shall be lowered by means of proper legs chain pulley blocks as directed by Engineer-in-charge. Great care should be taken to prevent sand etc. from entering the pipes.

18.74.3 Laying

Laying of pipes shall proceed up-grade of slopes. The error of grade shall not be rectified by packing up earth underneath the pipes. If required, concrete shall be used for packing.

The ends of the pipes shall be kept closed to keep dirt, mud and foreign materials out. Adequate provision shall be made to prevent floating of pipe in the event of flooding of trenches.

The body of the pipe for its entire length shall rest on an even bed in the trench and places shall be excavated to receive the collar for the purpose of jointing.

18.74.4 Jointing of pipes

A few skeins of spun yarn soaked in neat cement wash shall be inserted in the groove at the end of the pipe and the two adjoining pipes put against each other. The collar shall then be slipped over the joint covering equally both the pipes. Spun yarn soaked in neat cement wash shall be passed round the pipes and inserted in the joint by means of caulking tools from both ends of the collar. More skeins of yarn shall be added and well rammed home. The objects of yarn is to center the two ends of the pipes within the collar and to prevent the cement mortar of the joint penetrating into the pipes should be fully served.

Cement mortar 1:2 (1 cement : 2 sand) shall be slightly moistened and must on no account be soft or sloppy and shall be carefully inserted by hand into the joint. The mortar shall then be punched and caulked into the joint and more cement mortar added until the space of the joint has been filled completely with tightly caulked mortar. The joint shall be finished off neatly outside the collar on both sides at an angles of 45^{o}

Any surplus mortar projecting inside the joints is to be removed and to guard against any projections, sack or gunny bags shall be drawn past each joint after completion.

18.74.5 Curing

The cement mortar joints shall be cured at least for seven days.

18.75 Covering pipes

No work shall be covered over or surrounded with concrete until it has been inspected and approved by the EIC after testing as specified.

18.76 Back filling

Back filling shall be carried out as specified under Sub-Section A-Water supply.

18.77 Connection to an Existing Sewer

Connection to an existing sewer shall, as far as possible, be done at the manholes. Where it is unavoidable to make connection in between two manholes, the work of breaking into the existing sewer and forming the connection shall be carried out as directed by the EIC. Breaking into the sewer shall be effected by the cautious enlargement of a small hole, every precaution shall be taken to prevent any material from entering the sewer. No connection shall be formed in such a way as to constitute a projection into the sewer or to cause any reduction in its effective size.

18.78 Manholes

Manholes shall be built at every change of alignment, gradient or diameter of drain, or where directed. Bends and junction in the drains shall be grouped together in manholes. The maximum distance between manholes shall be 45 m for pipes upto 300 mm dia and 75 m for pipes upto 500 mm dia and 90 m for pipes upto 900 mm dia.

Manholes of different type and sizes as indicated shall be constructed in the sewer line at such places and to such levels and dimensions as shown in the drawings or as directed by the Engineer-in-charge

18.78.1 Where the diameter of the drain is increased, the crown of the pipe shall be fixed at the same level and necessary slope given in the invert of the manhole chamber. In exceptional cases, where unavoidable the crown of the branch sewer may be fixed at lower level but in such cases the peak flow level of the two sewers shall be kept the same.

18.78.2 The branch sewers shall deliver sewage in the manhole in the direction of main flow and the junction must be made with care so that flow in the main is not impeded.

18.78.3 No drain from house fitting e.g. gully trap or soil pipe, to manhole shall normally exceed a length of 6 m unless it is unavoidable.

18.78.4 Excavation

The manhole shall be excavated true to dimension and levels shown on the plans or as directed by the EIC.

18.78.5 Bed Concrete

The manhole shall be built on a bed of cement concrete 1:3:6 type C2 or 1:2:4 type B2 where indicated. The thickness of the bed concrete shall be 20 cm for manholes upto 4.25 m depth and 30 cm for depth beyond 4.25 m unless otherwise indicated or directed by the EIC. In bad ground, special foundations as suitable shall be provided.

18.78.6 Brick Work

The Brick work shall be with sub class B bricks in cement and sand mortar 1:4. The external joints of the brick masonry shall be finished flush, and the joints of the pipes and the masonry shall be made perfectly leak proof. For arched type and circular manholes brick masonry in arches and arching over the pipes shall be in cement and sand mortar 1:3. In the case of manholes of circular type the excess shaft shall be corbelled inwardly on three sides at the top to reduce its size to the cover frame to be fitted. Specification for the type of masonry shall be as indicated.

18.78.7 Plastering and pointing

The walls of the manholes shall be plastered inside with 15 mm thick cement plaster 1:3 finished smooth. Where saturated soil is met with the external surface of the walls of the manholes shall also be plastered with 15 mm thick cement plaster 1: 3 finished smooth. The plaster shall further be water proofed where indicated with addition of approved integral water proofing compound in a quantity as indicated.

18.78.8 Benching

The channels and benching shall be done in cement concrete 1:2:4 type B1 rendered smooth with extra cement. The depths of channels and benching shall be as under:-

Size of Drain	Top of channel at the center above bed concrete	Depth of benching of side walls above bed concrete
mm	cm	cm
100	15	20
150	20	30
200	25	35
250	30	40
300	35	45
350	40	50
400	45	55
450	50	60

18.78.9 Steps

All manholes deeper than 0.8 m shall be provided with steps. These shall be embedded 20 cm deep with 20 x 20 x 10 cm blocks of cement concrete 1:3:6 type C1. The block with foot rest placed, in its center shall be cast in situ alongwith the masonry.

18.78.10 Manhole Covers and Frame

The frame of manhole shall be firmly embedded to correct alignment and levels in RCC slab or plain concrete as the case may be. Before completion of work manholes covers shall be sealed by means of thick grease.

18.79 Testing

18.79.1 Comprehensive tests of all fittings and appliances shall be made by simulating conditions of use. Over flows shall also be examined for obstructions. Leaking or sweating joints shall be remade till these are gas tight or water tight as required

18.79.2 Smoke Test

All soil pipes, waste pipes, vent pipe and all other pipes when above ground shall be tested gas tight by a smoke test conducted under a pressure of 25mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tar paper or similar material in the combustion chamber of a smoke machine. Chemical smokes are not satisfactory.

18.79.3 Water Test

Drains and swears shall be subjected to a test pressure of at least 1.5 m head of water at the highest point of the section under test. A tolerance of two liters per centimeter of diameter per kilometer may be allowed during a period of ten minutes. The test shall be carried out by suitably plugging the lower end of the drain and the ends of connection, if any, filling the system with water. A Knuckle bend shall be temporarily jointed in at the top end and a sufficient length of vertical pipe jointed to it so as to provide the required test head. Allowance shall be made for absorption of water by pipes and joints by adding water until absorption has ceased after which the proper test shall commence. Any leakage will be visible and the defective part of the work shall be cut and made good. A slight amount of sweating which is uniform may be overlooked but excessive sweating from a particular pipe or joint shall be watched for and taken as a defect to be made good.

18.79.4 Test for straightness and Obstruction

These test shall be carried out :

(a) by inserting at the high end of the sewer or drain a smooth ball of diameter 13 mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints the ball should roll down the invert of the pipe and emerge at the lower end, and

(b) by means of a mirror at one end of the line and lamp at the other. If the pipe line is straight, the full circle of light can be observed. If the pipeline is not straight, this will be apparent. The mirror will also indicate obstruction in the barrel.

18.79.5 Test Record

Complete record shall be kept for all tests carried out both during construction and after being put into service.

SUB-SECTION D-SANITARY INSTALLATION

18.80 General Requirements

Setting and bedding of sanitary appliances and fitting shall be done carefully to the required levels.

18.81 Support for Appliances

Brackets for building in shall be provided with lugs, length of lugs shall be related to the thickness of wall and the weights to be supported, brackets for screwing to wall shall be provided with ear holes for fixing screws which shall be screwed into suitable wall plugs. In the case of thin partition walls, they shall be bolted through the wall, especially where the appliances are heavy using back plates on the remote sides. It may sometimes be possible to fix appliances on both the sides of the partition by bolting either the appliances or their brackets back to back.

18.82 Chases and Ducts

All holes, chases and ducts required for pipe work shall be properly provided.

18.83 Delivery of Appliances

All appliances shall be carefully checked that they are in accordance with requirement and are free from defects and damage before fixing.

18.84 Siting of Appliances

Appliances shall be fixed in the position and at height as indicated by the Engineer-in-charge . The outlets of water closet pans and similar appliances shall be examined to see that outlet ends are abutting on the receiving pipes before jointing. Attention shall also be given to the possibility of movement and settlement from other causes which are liable to cause leakages of the pipe joints and also the noise transmission.

18.85 Protection of Appliances

Care shall be taken at all times, particularly after fixing, to protect glazed, plated and enameled surfaces of appliances and fittings from damage. All orifices shall be temporarily plugged during the progress of work to prevent obstructions. Appliances shall finally be cleaned of all marks of cement, lime, oil, paint etc.

18.86 Water Closet Squatting Pans Suite

18.86.1 Fixing of Pan

The pan shall be sunk into the floor and embedded in a cushion of average 15 cm cement concrete 1:5:10 or lime concrete 1:2 both preferably using brick ballast 40 mm nominal size. This concrete shall be left 115 mm below the top level of the pan so as to allow for flooring and its bed concrete. The pan shall be provided with a 100 mm trap 'P' or 'S' type with an approximately 50 mm seal and 50 mm dia vent horn, where required. The joint between the pan and the trap shall be made leak proof with cement and sand mortar 1:1.

18.86.2 Fixing of Flushing Cistern

The cistern shall be fixed on cast iron or rolled steel cantilever brackets which shall be firmly embedded in the wall in cement and sand mortar 1:4 or fixed by using wooden plug and screws as directed. The cistern shall be provided with 20 mm nominal bore GI overflow pipe 1:85 m long or of length as indicated with fitting. The flush pipe shall be securely connected to the cistern by means of coupling nut made of non-ferrous metal or of galvanized steel. The outlet of flush pipe from the cistern shall be connected to the pan by means of cement or putty joint. The flush shall be fixed to wall by using holder bat clamps. If connection between cistern and pan is made with GI pipe the bends and offsets shall be made cold.

18.86.3 Foot Rest

After laying the floor, a pair of foot rest of size not less than 250 x 125 mm of white glazed vitreous China shall be set in cement and sand mortar 1 : 3.

18.87 Wash Down Water Closet Pedestal Type Suite

18.87.1 The closet shall be fixed to the floor by means of 75mm long, 6.5 mm diameter counter sunk bolts embedded in concrete floor.

18.87.2 Fixing of Seat and Cover

The seat shall be fixed to the pan by means of two 8 mm diameter corrosion resistant hinge bolts with a minimum length of shank of 65 mm and threaded to within 15 mm of the head. Each bolt shall be provided with two suitably shaped washers of rubber or other similar material for adjusting to level of the seat while fixing it to the closet. In addition one 8 mm non-ferrous metal washer shall be provided with each bolt. One arm of the hinge in each bolt shall be fixed to the underside of the seat by three Nos. 20 mm long wood screws. The other arm of the hinge shall be fixed to the underside of the cover, flush with the surface by means of three Nos. 10 mm long wood screws.

18.87.3 Fixing of Flushing Cistern

Specification given under water closet squatting pan shall apply. In the case of high level flushing cistern, the connection between the flush pipe of cistern and the closet shall be made by using GI inlet connection; in the case of low level flushing cistern, it shall be connected to the closet by means of 40 mm diameter white porcelain enameled bend or GI inlet connection as indicated or directed.

18.88 Urinals

18.88.1 Fixing of Lipped Urinals

Lipped urinals shall be fixed in position by using wooden plugs and screws. Wooden plugs of suitable size shall be fixed in the wall in cement and sand mortar 1:3. The height of front edge of lipped urinal, from the standing level, shall be 65 cm unless otherwise directed. Each urinals shall be connected to 32 mm dia. waste pipe which shall discharge into a channel or a floor trap. The connection between the urinal and flush or waste pipe shall be made by means of putty or white lead mixed with chopped hemp.

18.88.2 Fixing of Flushing Cistern

Specification given under water closet squatting pan shall generally apply. The connection between the flush pipe and the cistern shall be made by using GI pipe inlet. The main and distribution flush pipe shall be fixed to the wall by means of standard pattern holder bat clamps.

18.88.3 The capacity of flushing cistern and size of flush pipe for urinals in a range shall be as under:-

No of urinals in range	Capacity of flushing cistern Litres	Size of flush pipe (galvanized iron) Main mm	Size of flush pipe (galvanized iron) Distribution mm
One	5	-	15
Two	10	20	15
Three	10	25	15
Four	12.5	25	15

18.89 Wash Basins and Sinks

The basin or sink shall be supported on a pair of cast iron brackets set in cement mortar 1:3 for lighter appliances or embedded in cement concrete 1:2:4 type B1, blocks 100 x 75 x 150 mm in size. The wall plaster on the rear shall be cut to rest over the top edge of the basin where directed. After fixing the basin, the plaster shall be made good and surface finished as directed.

18.89.1 The chromium plated trap and union shall be connected to 32 mm dia waste pipe in case of wash basins and 50 mm waste pipe in case of sinks, which shall be suitably bent towards the wall. Waste pipe shall discharge directly on to a floor or nahani trap or gully trap or into an open channel leading to floor trap, or shall be connected to a waste pipe stack through a floor trap. CP brass union shall not be provided when a surface channel, drain or floor trap is placed directly under the wash basin and the waste discharges into it vertically. The height of front edge of wash basin or sink from the floor level shall be 80 cm unless otherwise indicated.

18.90 Stainless Steel Sink and Drainage Board

It shall be manufactured from Salem Stainless Steel Sheets grade A1 S1 305. Thickness of Sheet shall be 1 mm. Size of sink shall be as indicated. The surface of the sink shall be plastic coated to make it safe and scratch free installation.

18.91 Fixing of Mirror

The Mirror shall be mounted on 4 mm thick asbestos cement building board or 4 mm thick, 3 ply, plywood with commercial face veneers and shall be fixed in position by means of 4 No Chromium plated brass screws and cup washers and wooden plugs embedded in walls. Alternatively CP brass clamps with CP brass screws may be used for fixing. Unless otherwise directed, the longer side shall be fixed horizontally.

18.92 Glass Shelf, Hand Rail and Toilet Paper Holder

These shall be fixed to wall in the position as directed by the EIC, with CP brass screws and rawl plugs.

18.93 Testing

18.93.1 Installation shall be tested on completion, care being taken that all work which is to be encased or concealed is tested before it is finally enclosed.

18.93.2 Pipes systems shall be tested for gas tightness and for hydraulic performance.

18.93.3 BLANK

18.93.4 Water Test

The water test may be applied before the appliances are connected and may be carried out in sections so as to limit the static head to 4.5 m. it is necessary to seal all opening affected by the test and provide support to the plug used as stoppers.

18.93.5 Smoke Test

Faults shall be located by pumping smoke into the system with a smoke machine. Care shall be taken to ensure that the system is filled with smoke before sealing with plugs.

18.93.6 Hydraulic Performance

Discharge tests shall be made on all the appliances, singly and collectively. Obstruction in any of the pipe lines shall be traced and the whole system examined for proper hydraulic performance, including the retention of an adequate water seal in each trap.

18.94 Ductile iron Pipes and Fittings

18.94.1 Centrifugally Cast (spun) Ductile Iron Pressure Pipes

Shall conform to IS-8329-2000 Centrifugally cast (spun) Ductile Iron Pressure pipes for water, gas and sewage. Spigot and socket pipes shall be of class K-7 or K-9 and flanged pipes shall be class K-7 or K-9 as indicated.

The pipes shall withstand the hydrostatic test pressure after installation, without showing leakage, sweating or defects of any kind as laid down in IS.

Note : IS covers flanged pipes only up to 1000 mm diameter

18.94.2 Ductile iron Fittings for Pressure Pipe

Shall conform to IS 9523-2000, Specifications of DI fittings for Pressure pipes for water, gas and sewage. The fittings shall withstand hydrostatic test pressures without showing any leakage, sweating or defects of any kind as laid down in IS.

18.95 Laying and jointing of Ductile iron Pipes

The pipes shall be laid, jointed and tested all as per IS –12288-1987: Code of practice for use and laying of DI pipes.

18.95.1 Laying of Pipes

18.95.1.1 Laying Underground

Pipes should be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 250 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes, either a well designed set of shear legs or mobile crane should be used. When lifting gear is used, the positioning of the slings to ensure a proper balance, should be checked when the pipe is just clear of the ground. If sheathed pipes are being laid, suitable wide slings or scissor dogs should be used.

All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. When laying is not in progress, temporary end closure should be securely fitted to the open end of the pipeline. This may make the pipe buoyant in the event of the trench becoming flooded, in which case the pipes should be held down either by partial re-filling of the trench or by temporary strutting. All persons should vacate any section of trench into which the pipe is being lowered.

18.95.1.1.1 On gradients of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is backfilled over the barrel of the pipe. The backfill should be well compacted.

18.95.1.2 Laying Above Ground

The ground should be dressed to match the curvature of the pipe shell for an arch length subtending an angle of 120° at the centre of the pipe. Alternatively, the pipeline should be laid either on saddle, roller or rocker supports as specified. The pipes may be allowed to rest on ground if the soil is non-aggressive.

18.95.1.3 Supporting Pipes above Ground

The following recommendations assume that no additional bending moments above those due to the self weight of the pipe and its contents are present.

18.95.1.3.1 With spigot and Socket Pipes

It is recommended that above ground installations of spigot and socket pipes be provided with one support per pipe, the support being positioned behind the socket of each pipe.

This result in a normal distance between support of 4m as shown in Fig 2A.

Pipes should be fixed to the supports with mild steel straps so that axial movement due to expansion or contraction resulting from temperature fluctuation, is taken up at individual joints in the pipeline. In addition, joints should be assembled with the spigot end withdrawn 5 to 10 mm from the bottom of the socket to accommodate these thermal movements.

Pipes supported in this way are capable of free deflection and axial movement at the joints which accommodate small movement of the pipe support.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, etc.

Where a pipeline crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse. The concerned authorities may be consulted to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variation, etc, which affect the design and laying of pipeline. Early consultation with river authorities will assist in evaluating the effect of river characteristics (for example, nature of bed, scour levels, maximum velocities, high flood levels, seasonal variations, etc.), on design and construction.

If necessary, unsupported spans between 4 and 6 m may be obtained by positioning the pipe supports relative to the pipe joints as shown in Fig 2B.

18.95.1.3.2 With flanged Pipes

The recommended maximum supported span above normal ground is 8m. The support shall be located at the centre of every second pipe as shown in Fig 3A

The recommended maximum supported span at water course is 8m. The relative position of pipe joints and pipe should be as shown in Fig 3B

The supports of all flanged pipe work spans should be stable and unyielding due to movements in the pipe line.

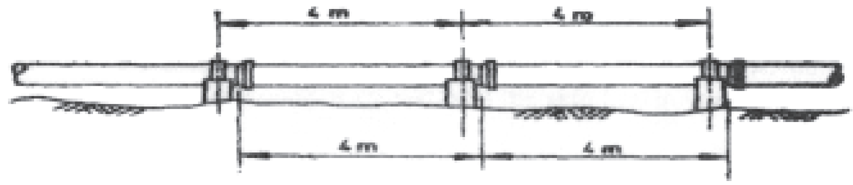
The straps should prevent any lateral movement or lifting of the pipeline but not restrict expansions and constructions caused by temperature fluctuations.

18.95.1.4 Cutting of pipes

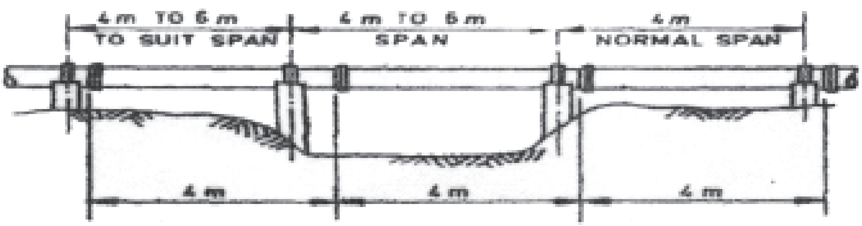
The cutting of pipe for inserting valves, fittings, etc, shall be done in a neat and workman like manner without damage to the pipe or lining so as to leave a smooth end at right angle to the axis of the pipe.

18.95.1.4.1 By Hacksaw

Hand or power operated hacksaw should be used with blades having teeth at a pitch of 1 mm.

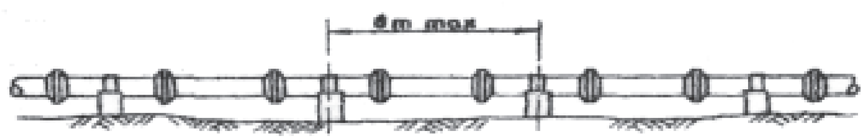


2A. PIPES OVER NORMAL GROUND

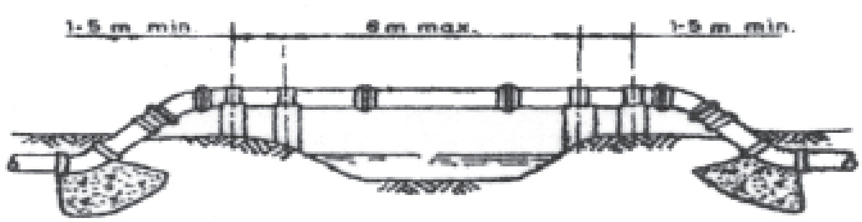


2B. PIPES CROSSIN OVER WATER COURSE

Fig.2 SPIGOT AND SOCKET LAYING ABOVE GROUND



3A. PIPES ABOVE NORMAL GROUND



3B. PIPES CROSSIN WATER COURSE

Fig.3 FLANGED PIPE LAYING ABOVE GROUND

18.95.1.4.2 By manually operated Wheel Cutter

The type of cutting wheel used for cast iron pipes is not suitable for ductile iron pipe. Special wheels, as used for cutting steel, pipes shall be used and cut ends are trimmed with a file.

18.95.1.4.3 By Pipe cutting Machine

Machine with cutter heads or abrasive wheels shall be used. Cutter head should have a front rake angle 7° as used for steel pipes.

18.95.1.5 End preparation of Cut Pipes for Jointing

The burr left after cutting should be trimmed off by light grinding or by filling.

18.95.1.6 Wrapping

When ductile iron pipes are to be laid in aggressive soils, the pipes should be wrapped externally with protective coating, such as bitumen or coaltar sheathing protective layer or by loose polythene sleeving, or in certain circumstances, concrete before laying. At joints, bends and valve, precautions should be taken to provide sufficient overlap of the wrapping sleeve so that no pipeline is exposed to the aggressive soil.

18.95.1.7 Pipeline Markers

Distinctive markers should be erected at all roads, railways, river and canal crossings, and elsewhere as required to identify the pipeline and to indicate its position. Markers should be placed at field boundaries. Preferably in such a way that they are not obscured by vegetation. At all valve installations, plates should be provided to give the same information as on the makers. Markers should not be treated with any substance likely to be harmful to livestock.

18.95.1.8 Pipeline Anchorage

All pipeline having unanchored flexible joints require anchorage at changes of direction and at dead ends to resists the static thrusts developed by internal pressure. Dynamic thrusts caused by flowing water act in the same direction as static thrusts. This thrust is of sufficient magnitude at high velocities to warrant safety consideration.

Anchorages to resist the thrust should be designed taking into account the maximum pressure the main is to carry in service or on test, and the safe bearing pressure of the surrounding soil.

Where possible, concrete anchor blocks should be of such a shape as to allow sufficient space for the remaking of the joints. Figure 4 shows typical anchorages using concrete anchor blocks.

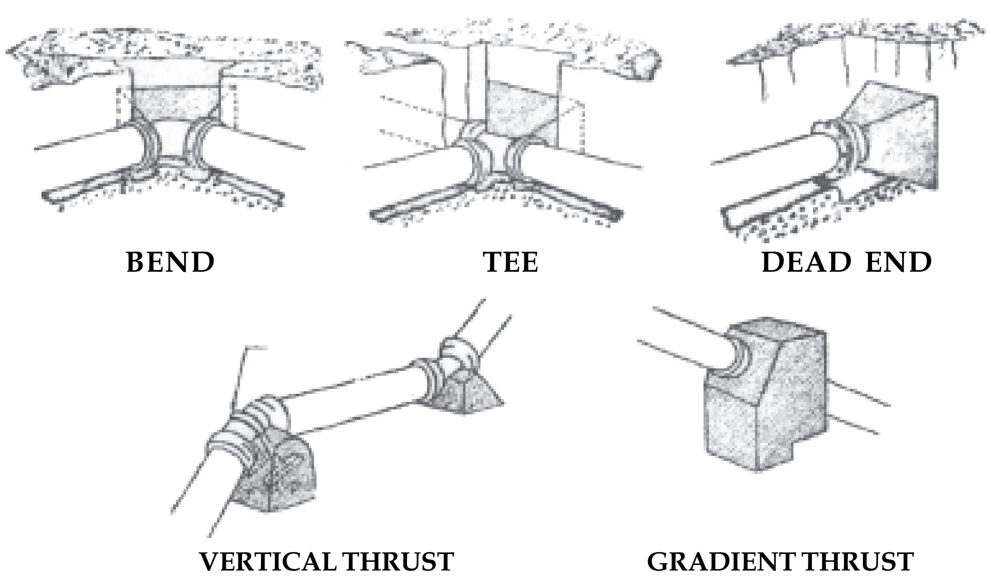


FIG. 4 TYPICAL THRUST BLOCKS

Pipeline should be securely anchored at dead ends, tees, bends, tapers and valves to resist thrust arising from internal pressure. Anchors and thrust blocks should be designed in accordance with IS 5330-1984. Steeply inclined pipelines should be secured by transverse anchors spaced as shown below:-

Spacing of transverse anchors for steeply inclined pipelines

Gradient	Spacing m
1 in 2 and steeper	5.5
Below 1 in 2 to 1 in 4	11.0
Below 1 in 4 to 1 in 5	16.5
Below 1 in 5 to 1 in 6	22.0
Flatter than 1 in 6	Not usually required

Typical anchor blocks to resist horizontal thrust, vertical thrust and gradient thrust for buried mains are shown in fig-4

18.95.2 Joints And Jointing

18.95.2.1 Two main types of joints are used with ductile iron pipes and fittings.

(a) Spigot and Socket flexible joints :-
  (i) Push in joints and
  (ii) Mechanical joints;
(B) Rigid Flanged joint

18.95.2.2 Flexible Joint

The spigot and socket flexible joint should be designed to permit angular deflection in direction and axial movement to compensate for ground movement and thermal expansion and contraction. They incorporate gasket of electrometric materials and the joints may be of the simple push-on-type or the type where the seal is effected by the compression of a rubber gasket between a seating on the inside of the socket and the external surface of spigot. Joints of the latter type are referred to as mechanical joints. Both push in (Fig 5A) and mechanical joints are flexible joints. Flexible joints require to be externally anchored at all changes in direction such as at bends, etc and at blank end to resist the thrust created by internal pressure and to prevent the withdrawal of spigots.

18.95.2.3 Flanged joint

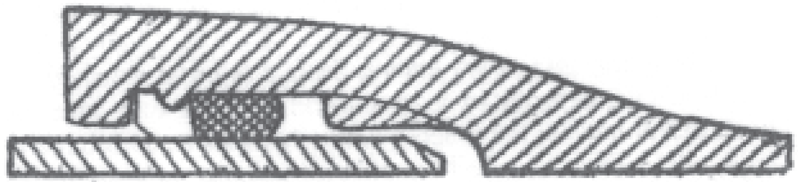
Flanged joints are made on pipes having a machined flange at each end of the pipe. The seal is usually effected by means of flat rubber gasket compressed between two flanges by means of bolts which also serve to connect the pipe rigidly (see Fig. 5B). Gaskets of the other materials, both metallic and non-metallic, are used for special applications.

18.95.2.4 Jointing Procedure

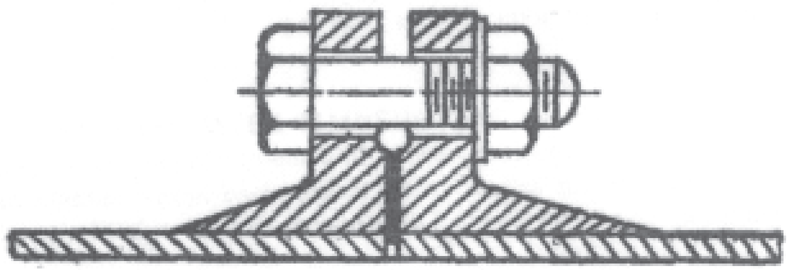
Procedure for joining will vary according to the type of joint being used. Basic requirements for all types are :

(a) Cleanliness of all parts.
(b) Correct location of components
(c) Centralization of spigot within socket and
(d) Strict compliance with manufacturer's jointing instructions.

The inside of sockets and the outside of spigot should be cleaned and wire brushed for a distance of 150 to 225 mm. Glands and gaskets should be wiped clean and inspected for damage. When lifting gear is used to place the pipe in the trench, it should also be used to assist in centralizing the spigot in the socket.



5A. FLEXIBLE JOINT (PUSH IN TYPE)



5B. FLANGED JOINT

FIG. 5 TYPICAL TYPES OF JOINTS

Where the pipeline is likely to be subjected to movement due to subsidence or temperature variations, the use of flexible joints is recommended. A gap should be left between the end of the spigot and the back of the socket to accommodate such movement.

18.95.3 Transportation, Handling and Inspection

18.95.3.1 General

Ductile iron pipes are less susceptible to cracking or breaking on impact but the precautions set out should be taken to prevent damage to the protective coating and brushing or damage of the joining surfaces.

18.95.3.2 Transportation

Pipes should be loaded in such a way that they are secured and that no movement should take place on the vehicle during transit.

The pipes should be loaded on vehicles in pyramid or straight sided formation. Incase of pyramid loading, the pipes in the bottom layer should be restrained by the use of broad wooden wedge secured to the vehicle being loaded. The pyramid is to be formed by resting pipes between the pairs of pieces in the preceding layer with the sockets in layers reversed. Straight sided loading may be used with supports along the sides of the vehicles. The use of straight sided loading is advantageous for utilizing full capacity of the vehicle.

18.95.3.3 Off loading

Cranes should be preferred for off-loading. However for pipes upto 400 mm nominal bore, skid timbers and ropes may be used.

When using mechanical handling equipment it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipe should be lifted smoothly without any jerking motion and pipe movement should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or giant surrounding objects.

Where the crane operator does not have a clear view, he should be guided by the personnel supervising the operation. When cranes are used, the whole sequence of operation should be carried out smoothly and without snatch. Properly designed hooks and adequate stead ropes are essential. The hooks should be of suitable shape to ensure positive engagement when entered into the ends of the pipes and then should be pass over any protective packing fitted around the pipes end.

The use of slings passed around bundles of pipes is not recommended because bundles become unstable as the sling is drawn tight or released. However, when it is necessary to use the central slinging method for lifting single pipe, a board webbing sling is recommended which minimizes the risk of the pipe slipping. Chain slings may slip and are dangerous.

18.95.3.4 Stacking

Pipes being taken to a stock ground for storage and held pending further distribution should be arranged into stacks. The first layer of pipes should be laid on a firm foundation consisting of solid timbers set level on the ground. Subsequent layers should be placed according to the method of stacking adopted, care should be taken so that the pipes do not rest on their sockets. The height of any stack should not exceed 2m

18.95.3.4.1 Square Stacking

In square stacking method, second and subsequent layers are set at right angles to the previous layer with spigots and sockets alternating in each layer and sockets project beyond spigot end. The pipes rest directly upon those beneath it and care is needed in placing to prevent damage.

18.95.3.4.2 Parallel Stacking With Timbers

All the pipes are parallel with the sockets of successive layers reversed end-to-end with sockets projecting beyond spigot end. Timber battens, placed about 600mm from each end at right angles to the pipes, are used to separate the successive layers. Wedges at both ends of each batten prevent pipe movement.

18.95.3.4.3 Nested Stacking (Pyramid Stacking)

Nested stacking consists of placing each pipe between the two pipes underneath it, with the sockets being all at one end of each layer and being reversed in successive layers. The bottom layer should be firmly anchored to prevent the stack collapse.

18.95.3.4.4 Special Precautions For Bitumen-sheathed Pipes

Bitumen-sheathed pipes should be handled with care to avoid any damage to the sheathing. They should not be stacked but laid in a single layer supported on timbers placed under the uncoated portions of the spigots and sockets. Sheathed pipes should be lifted by means of properly designed hooks, fittings into the spigot or socket, or by specially designed slings which will not damage the sheathing, Wire rope, chains or hemp slings should not be used.

18.95.3.4.5 Stringing

Stringing consists of placing pipes on the ground in line ready for laying. Care should be taken to prevent damage during this operation.

18.95.4 Hydraulic Testing

18.95.4.1 After a new pipeline is laid and jointed, testing shall be done for :

(a) Mechanical soundness and leak tightness of pipe and fittings
(b) Leak tightness of joints and
(c) Soundness of any construction work, in particular that of the anchorages.

18.95.4.2 Hydrostatic Testing

The completed pipeline may be tested either in one length or in section; the length of sections depending upon:

(a) availability of suitable water
(b) number of joints to be inspected, and
(c) difference in elevation between one part of the pipeline and another

Where the joints are left uncovered until after testing, sufficient material should be backfilled over the centre of each pipe to prevent movement under the test pressure.

It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1.5 km or more are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances.

Each section should be properly sealed-off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it . All permanent anchors should be in position and, if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

18.95.4.3 The test pressure to be applied should be not less than any of the following:-

(a) The maximum sustained operating pressure.
(b) The maximum static pressure plus 5 N/mm^2, and
(c) The sum of the maximum sustained operating pressure (or the maximum static pressure) and the maximum calculated surge pressure.

After filling, the pipeline should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions.

The length of this period of time depends on many factors such as slight movement of the pipeline under pressure whether air is trapped in the pipeline or whether the pipeline has a concrete lining which absorbs water.

The pipeline is then pressurized upto the full test pressure and the section under test completely closed off. The test should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point.

18.95.4.4 In case of extreme temperature conditions, there may be a tendency of hydraulic pressure building up inside the pipeline because of expansion of water during the high day time. This should normally not be of any major concern as the joints and the pipes are manufacurted to resist a much high pressure. Hoover, sufficient care should be taken to prevent floating bulging of the pipeline because of building up of such high pressure during the temperature rise.

18.95.4.4.1 If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section under test should be sub-divided and each part tested separately.

Methods employed for finding leaks include:

(a) Visual inspection of each joint if not covered by the backfill.
(b) Use of a bar probe to detect signs of water in the vicinity of joints, if backfilled.
(c) Aural inspection using a stethoscope or listening stick in contact with the pipeline;
(d) Use of electronic listening device which detects and amplifies the sound or vibrations due to escaping of water, actual contact between the probe and the pipes is not essential.
(e) Injection of dye into the test water particularly suitable in water logged ground and
(f) Introduction of nitrous oxide in solution into the test water and using an infra-red gas concentration indicator to detect the presence of any nitrous oxide that has escaped through the leak.

18.95.4.5 After all sections have been joined together on completion of section testing, a test on the complete pipeline should be carried out. This test should be carried out at a pressure not less than the maximum sustained operating pressure or the maximum static pressure of the pipeline and, during the test, inspection made of all work which has not been subject to section tests. During the test, the pressure at the lowest point in the pipeline should not exceed the maximum given in Table 1.

Table 1 : Maximum Field Hydrostatic Test Pressure for Ductile Iron Pipelines with Flexible Joint

NOMINAL BORE mm	MAXIMUM FIELD HYDROSTATIC TEST PRESSURE N/mm^2
Upto 300	4.5
350 to 600	3.0
700 to 1200	2.1

Note 1 : The above pressure are 0.5 N/mm^2 higher than the pressure ratings for ductile iron pipes and fittings with flexible joints. It is not considered necessary to field test ductile iron pipelines to 1 ½ time the design operating pressure as is often the practice with grey iron pipelines.

Note 2: The field test pressures is applied to ductile iron pipelines only when the pipeline and its fittings are properly anchored.

18.95.4.6 It is important to ensure that proper arrangements are made for the disposal of water from the pipeline after completion of hydrostatic testing and that all consents which may be required from authorities have been obtained. In some cases, for example, heavily chlorinated water, some treatment may be necessary before final disposal.

18.95.5 Flushing And Disinfection of Mains Before Commissioning

18.95.5.1 The mains intended for potable water supplies should be disinfected before commissioning them for use.

18.95.5.1.1 Distribution System Chlorination of New Mains

Special care should be taken to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contained soil in the trench, contamination from workmen and or their equipment and, unavoidable foreign material present in the trench during construction.

18.95.5.1.2 Education of crew members for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installations of mains. All sewers, water mains and other underground conduits should be located prior to construction and relocated, if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, water tight plugs should be installed in all pipe openings. Gunny sacks and rags are not adequate. Provision should be made to pump any other water that might have collected in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction, each should be inspected and, if necessary, cleaned before installation.

After pressure testing the main, it should be flushed with water of sufficient velocity to remove all dirt and other foreign materials. When this process has been completed, disinfection (using liquid chlorine, sodium or calcium hypochlorite is processed by one of the recommended methods)

18.95.5.2 Continuous Feed

In this method, water from the distribution system or other approved sources and the chlorine from selected sources are fed at constant rate into the new main at a concentration of at least 20 to 50 mg/litre. A properly adjusted hypochlorinator solution injected into the main with hypochlorite, or liquid chlorine injected into the main through a solution feed chlorinator and booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level main is filled. All valves, hydrants, etc, along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hour period, not less than 10mg/litre chlorine residual should remain in the main.

18.95.5.3 Slug Method

In this method, a continuous flow of water is fed with a constant dose of chlorine with rates proportioned to give a chlorine concentration of at least 300mg/l. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that will contact all interior surfaces of the main for a period of at least three hours. As the slug passes tees, etc, valves should be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical.

18.95.5.4 Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated and the results again tested before placing the main in service.

18.96 Flexible Quick coupling GI pipes and Fittings

18.96.1 Flexible Quick coupling GI pipes

Shall conform to IS-11722 - Flexible Quick coupling GI pipes. These pipes shall be of class B made from tested cold rolled steel strips (0 grade IS 513) with ERW process. These pipes shall be hot dip galvanized in accordance with IS-4736. The pipes shall withstand hydrostatic test pressure after installation, without showing leakage, sweating or defects of any kind as laid down in IS.

Note : IS covers pipes from 25 mm to 300 mm

18.96.2 Fittings for Flexible Quick coupling pipes

These shall conform to IS-11722A, pressure activated coupling system. The technical specification of these fittings shall be as laid down in IS.

18.96.3 Laying and jointing of Flexible Quick Coupling GI Pipes – The pipes shall be laid, jointed and tested all as per IS –11722-1987: Code of practice for use and laying of flexible quick coupling GI pipes.

18.97 Gel coated glass fibre reinforced polyester resin bath tub

Bath tub shall conform to IS 6411-1985. The fibre glass used in the manufacture of bath tubs shall be non alkaline conforming to 'E' type or 'A' type grade. The proportion of glass fibre shall not be less than 25 percent of the glass fibre reinforced polyster layer including gel-coated layer unsaturated polyster resin used in the manufacture of the bath tubs shall be resistant to hot water and weathering. When filler and colouring materials are used, their quality and proportion should be compatible to the polyster and the materials shall not have any harmful effect on the quality and performance of bath tubs. The bath tub shall possess a uniform gel-coat on working surface. The resin used in the gel-coat shall be isophthalic grade of polyster or epoxy resin or any equally suitable chemical resistant grade of resin. The gel-coat shall not be less than 0.25 mm thickness nor more than 1.00 mm thickness.

Bath tub shall be one piece unit with an opening for waste outlet with floor sloping towards the outlet. An overflow shall normally be provided on the side near the waste outlet. An apron (side panel) may be provided integrally or separately with bath tab. The waste opening shall be suitable for the proper installation of waste fittings which are ordinarily used for the purpose. The bath tub shall be provided with a supporting structure integral to the unit in between the space between the bottom of the bath tub and the floor of the building on which the bath tub rests, unless otherwise specified. The materials of the supporting structure shall be atleast equal to the material of the bath tub in resistance to deterioration with age and shall meet the requirement of fungus and vermin.

In forming the roll, the outer edges shall be flanged or rolled back underneath sufficiently to prevent exposure of sharp edges. The vertical height of the flanged or rolled edges shall be not more than 30mm. At the tap end of the roll, there shall be a level area within a radius of at least 25mm from the centre of each tap hole. For the safety of users, bath tubs shall be as flat-bottomed as practicable. The fall along the bottom head end to the outlet shall be adequate for complete emptying. The waste hole shall be formed as to be suitable for receiving a 40mm waste fitting. Arrangement to attach an earth continuity conductor shall be provided at the tap end. The bath tub shall be inspected for the defects as described hereinafter.

18.97.1 Method of Inspection for defects of Bath Tubs

The surface of the bath tubs shall be visually inspected for blemishes from a distance of 600 mm after being inked. The light source shall be partially diffused daylight supplemented if necessary, with diffused artificial light to provide illumination comparable to that usually available within short distance of the outside window facing north, but not in direct sunlight. The illumination shall have an intensity of 1,000 to 2,000 lux.

18.97.1.1 Ink test

To do the visual examination of the surface of the bath tub ink is applied to the area to be inspected as follows**:-**

(a) Wash the entire area to be inspected with a water soluble ink.
(b) Rinse the surface with fresh water and dry. Ink will remain entrapped in cracks, pits etc.

All reference to visible defects shall refer to defects apparent to the eye upon close inspection, after the surface has been ink tested.

18.97.2 Defects whose presence cannot be permitted

Part	Non-permissible Defects
Upper rim, inner wall, bottom, apron, other readily visible faces	Small pores, wrinkle, craze, bubbles, defective impregnation superficial defects, injuries, aggregate defects.
Obscure faces	Defective impregnation, superficial defects.

18.97.3 Permissible defects

Defects/Parts	Upper Rim	Inner Wall	Apron	Bottom	Other Readily Visible Parts
Traces of mending	2	2	2	2	Not conspicuous
Impurities	2	3	2	3	
Pinholes	2	3	2	3	
Colour blot	Should not be conspicuous				
Unevenness	Should not be conspicuous				
Deformity	The horizontal section of the upper rim shall drain off water readily. The bend of the section in contact with wall shall be less than 5 mm. Deformities of the other sections of the bath tub shall not be conspicuous				

18.98 Enameled Steel Bath Tub

18.98.1 The bath tub shall conform to IS –3489-1985. The tub shall be of pattern 1 or pattern 2 as specified in IS and shall comply with the dimensions as specified in table below and as indicated and do not fix the details of the design. The bath tub shall be made from mild steel sheet conforming to IS 513-1973 and having a minimum thickness 1.6mm free from lamination and surface cracks. The bath tub shall be constructed of the fewest practicable number of sections compatible with the manufacturing practice which shall be such as to ensure a suitable finished surface for the reception of the enamel coating. Any welded surface shall be adequately cleaned off inside and outside the bath tub. The necessary surface shall be free from undulations, drawing lines and other defects deletirious to the progress of satisfactory enamel coating.

18.98.2 The interiors of the bath tub shall be adequately and evenly coated with vitreous enamel as measured on a flat surface by a layer thickness measuring instruments (electromagnetic). The enameling shall conform to IS 772. Thickness of the enamel shall not be less than 0.2 mm and not more than 0.5mm. External surfaces of the bath tub shall be given one ground or primer enamel coating. Gloss colour and opacity shall be uniform and visually satisfactory.

18.98.3 The finish of bath tub shall not show the following

(a) **Crazing**(Not to be confused with mechanical scratching, which will exhibit an irregular edge under a magnifying glass);

(b) Dimples, Rundown, sagging unless not readily attracting attention when viewed from normal eye level under natural light;

(c) Blisters : Not more than two in number on the interior surface shall be permitted provided they cannot be broken by pressure of a finger nail;

(d) Pinholes - Pinholes not more than two in number for coloured bath tubs and not more than four for white enameled bath tubs shall be permissible. There shall be no grouping of pinholes and they shall not penetrate to the metal; and

(e) Specks : Specks shall be less than one millimeter in size and maximum five in number and there shall no grouping. Specks less than 0.25mm in size shall not be treated as defect unless in sufficient number to form discolouration.

18.98.4 Warpage of edges set against wall or floor and edges of roll rims shall not exceed 5mm per m. Warpage of all other edges shall not exceed 7.5mm per m.

18.98.5 In-forming the roll, the outer edges shall be flanged or rolled back underneath sufficiently to prevent exposure of sharp edges. The vertical height of the flanged or rolled edges shall be not more than 30 mm. At the top end of the roll there shall be a level area within a radius of at least 25 mm from the center of each top hole.

18.98.6 For the safety of users, bath tubs shall be as flat bottomed as practicable. The fall along the bottom head end to out let shall be adequate for complete emptying. The waste hole shall be so formed as to be suitable for receiving a 40mm waste fitting. The bath tubs shall be provided at the top end with effective means of attaching an earth continuity conductor. With each bath tub, two spacing washers of suitable thickness to take up the difference between the thickness of the metal of the bath tub and the depth of the seating on pillar taps shall be supplied. In addition two fiber or lead washers for each tap shall be supplied for fitting above and below the tap roll to prevent the enamel from crazing when the taps are tightened in position.

18.98.7 The maximum permissible variation from the dimensions specified shall be + 4% in all cases except overall width and over all length where the variation shall not exceed + 1% .

18.98.8 Supports made of cast iron, mild steel or any other suitable material as specified shall be provided. The support shall be non adjustable type, as indicated without panels. This shall includes two sizes **:-**

(i) For bath tubs to which a trap with 35 mm minimum seal is to be fitted.

(ii) For bath tubs to which a trap with 70 mm minimum seal is to be fitted

18.98.9 The surface of bath tubs shall be visually inspected for blemishes from a distance of 600mm after being inked. The light source shall be partially defused day light supplemented, if necessary with defused artificial light to provide illumination. Comparable to that usually available within short distance of the outside window facing north but not in direct sunlight. The illumination shall have an intensity of 1000 to 2000 lux. Blemishes other than those given in table below shall not be allowable**.**

18.98.10 Ink Test

To do the visual examination of the surface of the bath tub ink is applied to the area to be inspected as follows**:-**

(a) Wash the entire area to be inspected with a water soluble ink.

(b) Rinse the surface with fresh water and dry. Ink will remain entrapped in cracks, pits etc.

18.98.10.1 All reference to visible defects shall refer to defects apparent to the eye upon close inspection, after the surface has been ink tested.

18.98.11 Defects Whose presence cannot Be Permitted

Part	Non-permissible Defects
Upper rim, inner wall, bottom, apron, other readily visible faces	Small pores, wrinkle, craze, bubbles, defective, impregnation superficial defects, injuries, aggregate defects.
Obscure faces	Defects impregnation, superficial defects.

18.98.12 Permissible defects

Defects/Parts	Upper Rim	Inner Wall	Apron	Bottom	Other Readily Visible Parts
Trace of mending	2	2	2	2	No conspicuous
Impurities	2	3	2	3	-do-
Pinholes	2	3	2	3	-do-
Colour blot	Should not be conspicuous				
Unevenness	Should not be conspicuous				
Deformity	The horizontal section of the upper rim shall drain off water readily. The bend of the section in contact with wall shall be less than 5 mm. Deformities of the other sections of the bath tub shall not be conspicuous.				

TABLE OF BATH TUBS

(all dimensions in millimeters)

PARTICULARS	Dimensions of bath tubs			
	Pattern 1			Pattern 2
	Size 1	Size 2	Size 3	
Length overall	1525	1700	1850	1700
Width overall	700	700	700	730
Depth inside (at waste hole),	440	440	440	440
Roll (at sides), (See Note)	60-80	60-80	60-80	60-80
Roll (at head end),	60-80	60-80	60-80	60-80
Roll (at tap end),	75-100	75-100	75-100	75-100
Distance of tap holes, center to center	180	180	180	180
Height overall,				
With 35 mm Min seal trap	580	580	580	570
With 70 mm Min seal trap	620	620	620	610
Waste hole – horizontal distance from out side edge of roll at tap end to center of waste hole	250 Min	250 Min	250 Min	250 Min
Overflow center-vertical distance below top edge,	90-105	90-105	90-105	90-105

Note – In case of bath tubs pressed from one sheet the dimension may be increased to 100 mm maximum, whilst the slope of the sides and ends will be steeper than shown in IS.

18.98.13 Bath tub shall have a circular waste hole into which the interior of the tub shall drain.

18.98.14 All internal angles shall be designed so as to facilitate cleaning.

18.98.15 In forming the roll, the outer edge shall be rolled back underneath sufficiently to prevent exposure of sharp edges. The vertical height of the rolled edges shall not be more than 30 mm.

18.98.16 The waste opening shall be suitable for the proper installation of waste fittings which are normally used for this purpose.

18.98.17 At the top end of the roll, there shall be a level area within a radius of at least 25 mm from the center of each tap hole.

18.98.18 The appliance shall be placed on a flat surface so as to ascertain the amount of deviation from the horizontal plane at the edges. If a feeler gauge of thickness equal to the total allowable warpage does not slide under the appliance without forcing, the appliance shall be considered to be within the warpage limitations. If the appliances rocks on two opposite high corners, the horizontal plane shall be determined by placing one feeler gauge of the total warpage allowed under one low corner holding the appliances firmly on this if a second filler gauge of the same thickness does not slide under the appliance at any other point, the appliance shall be considered as not warped out of the horizontal plane and that it falls within the warpage limitation.

18.99 PVC Flushing Cistern White / Colour

18.99.1 Flushing Cistern

18.99.1.1 PVC Flushing Cistern for water closets and urinals shall be built and conforming to IS 7231-1994(Specifications of PVC high level and low level flushing cistern for water closets and urinals) . It shall be solid moulded with valveless syphonic fitting. Manually operated with one PVC ball valve. Horizontally plugged type and with inbuilt polyethylene of float. Flushing pipe of required length for cistern including coupling and bend shall be as per manufacturer. The PVC flushing cistern shall be high level or low level of capacity 3, 5, 6 &10 litres single flush / dual flush type as indicated. The parts of single/dual flush system in a cistern shall be as per IS. The cistern shall be manufactured from high density polyethylene (HDPE) IS 7328-1992 or polystyrene high impact IS 2267-1972 or polypropylene or Acrylonitrile-butadiene-styrene (ABS) or Glass fibre reinforced plastic (GRP) as indicated. The chain shall be hot- dip galvanized steel wire or inter locked nonferrous metal as indicated. The coupling nut and lock nut shall be of non-ferrous metal or Hot-dip galvanized steel / malleable iron or injection-moulded (HDPE)/ polyacetal. The thickness of the body including cover at any point shall not be less than 2mm for GRP and not less than 3mm for other material.

18.99.1.2 The cistern shall have a removable cover which shall fit closely on it and shall be secured against displacement. The operating mechanism shall be built in/screwed with body properly. The outlet fitting of each cistern shall be securely connected to the cistern. The nominal diameter of cistern outlet shall not be less than 38mm. The length of outlet of the cistern shall be 37 + 2mm.

18.99.1.3 The siphonic action of the flushing cistern shall be capable of being rapidly brought into action by the operating lever, but shall not self siphon or leak. When tested the discharge rate for capacity of 10 litres and 5 letres shall be 10 + 0.5 litre in 6 seconds and 5+ 0.5 litre in 3 seconds respectively. The cistern shall be so designed that there is not appreciable variation in the force of flush during the discharge of the required quantity of water. The cistern shall have a discharge capacity 5 and 10 litre as specified.

18.99.1.4 Inlet and overflow holes

The cistern shall be provided with inlet and overflow holes, situated one at each end which shall be capable of accommodating an overflow pipe of not less than 20mm nominal bore and 15mm size ball valve. The holes shall be cleanly moulded or drilled and the adjacent surface shall be smooth.

18.99.2 Operating Mechanism lever

Operating Mechanism/lever shall not project beyond the side of the cistern for a distance greater than 350 mm measured from the center of the cistern to the end of the lever arm. The lever arm shall be provided with a suitable hole near the end through which a split ring or S-hook can be inserted . A string (chain) shall be attached to the ring or hook. When S-hook is employed, it shall be effectively closed after assembly to prevent accidental disconnection**.**

18.99.2.1 In the case of low-level cistern where the mechanism is handle operated, the handle whether situated on the front or at the end of the cistern shall be within the projection limit as given above. Particular attention shall be given to the ease of operation of the handle.

18.99.3 String (Chain)

18.99.3.1 The string (chain) shall be of such a strength as to sustain a dead load of 500 N without any apparent or permanent deformation.

18.99.3.2 The String (Chain) shall terminate in a suitable handle or pull made of molding in any heat-resisting and non-absorbent plastic or any other equally suitable material. The finish shall be smooth and all burrs which are liable to cause injury to the hand when gripped shall be removed.

18.99.4 The flaot/Ball valve shall be of screwed type 15mm in diametre and shall conform to IS-1703-2000 or IS-12234-1988 or SI-13049-1991 as indicated. The float shall be made of polyethylene as specified in IS- 9762-1994(The design shall permit the cistern to fill in rapidly and close effectively when the level of water reaches the working water level. The handle shall be a chromium plated**.**

18.99.5 Finish

18.99.5.1 The surface of the cistern including cover shall be free from blisters and delamination and reasonably free from flow lines, streaking or colour variation. The cistern and cover shall be opaque to light.

18.99.6 The flush pipe shall be of (a) Steel tube seamless or welded light or Medium grade, galvanized hot-dip(inside and out side) electroplating or vitreous enameling as indicated (b) Polyethylene pipes or high density . (c) Un plasticised PVC pipes . (d) Copper alloy tubeIS-407-1981/ IS-2501-1985 (e) Lead pipe IS-404(Part-I)-1977.The flush pipe shall be of suitable length with bends etc as required for fixing it with front or back inlet of WC pan The flush pipe (except plastic flush pipe) shall have an internal diameter 32 +1mm, for high level and 38+1mm for low level cistern. The steel flush pipe shall not be less than 1mm thick whereas lead flush pipe shall have minimum thickness of 3.5mm. For high density polyethylene and un-plastisized PVC pipes, the outside diameter of the pipes shall be 40 mm. When PVC plumbing pipes are used the input side diameter of the pipe shall be 50 mm for low level and 40mm for high level . The flush pipe (except plastic flush pipes) shall be 30 cm long and 38 + 1mm diameter.

18.99.7 Over flow Pipe

18.99.7.1 GI over flow pipes shall be of not less than 20mm nominal bore and shall incorporate a non corrodible mosquito proof device screwed in a manner which will permit it to be readily cleaned or renewed when necessary. No provision shall be made whereby the overflow from the cistern shall discharge directly into the water closet or soil pipe without being detected .The invert of the overflow pipe in case of high level and low level cisterns and the top edge of the over flow pipe in case of coupled cistern shall be 19mm (minimum) above the working water level. In case of overflow due to any reason, water should drain out through the overflow pipe and not through the siphon pipe.

18.99.8 Fixing of flushing cistern

18.99.8.1 PVC flushing cistern shall be connected to the closet by means of flush pipe as directed and as per manufacturer instruction. A high level flushing cistern shall be operated at a minimum height of 125cm between the top of the pan and the underside of the cistern. A low level flushing cistern shall be intended to operate with a maximum height of 30 cm between top of the pan and under side of the cistern. The flushing cistern shall have two holes in the back side for screwing in to the wall. The flushing cistern shall be fixed to wall with two Nos steel screws and rawl plug of adequate size as per manufacturers. A coupled cistern shall be operated sitting on flat surface provided at the back portion of wash down water closets. A dual flush cistern shall enable the user to cause a short flush of partial discharge when only urine needs to be flushed away instead of the customary full flush. The parts of single/dual flush system in a cistern shall be as per IS.

18.99.9 Flush pipe connection to cistern

18.99.9.1 The flush pipe shall be securely connected to the cistern outlet and made airtight by means of a coupling nut. The nuts made of injection-moulded HDPE/Polyacetal may be used only if the end pipe is also made of plastic. The nominal internal diameter of the cistern outlet shall be not less than 32 mm and 38 mm for high-level and low-level cisterns respectively. The screw threads for connection to the flush pipe shall not be less than size 1½ of IS-2643 (Part 3) : 1975. In the case of polyethylene and unplasticized PVC flush pipe, the upper end of the flush pipe shall be provided with suitable means of ensuring and maintaining a watertight and airtight joint to the flushing cistern. When ordered for use with a flush pipe, the outlet connection may be supplied with coupling nut made of copper based alloy or other non-corrodible material and a plain tail piece having a minimum length of 60 mm. The center of the outlet hole shall be generally central to the length of the cistern. The length of the outlet shall be 37 + 2mm. In the case of interchangeable siphon is provided the outlet length shall be 20 + 2mm.

Note – The length of the cistern outlet shall be the dimension from the bottom surface of the cistern to the end of the outlet after the cistern with siphon/stand pipe has been duly fitted with all washers, lock-nuts etc.

18.99.10 Operational and Performance Requirements

18.99.10.1 Flushing Arrangement

The cistern under working conditions and with the float valve in closed position shall operate on a single operation of the operating mechanism/lever without calling for a sudden jerk in pulling. If a valve is used instead of siphon for flushing purposes, the valve shall be completely leak proof.

18.99.10.2 Working Water Level

18.99.10.2.1 The working water level shall be a minimum of 6.5 cm below the effective top edge of the cistern and shall be legibly and permanently marked on the inside of the cistern. Effective top edge shall be taken as edges of the body without considering bead**.**

18.99.10.3 Freedom from Self Siphonage

18.99.10.3.1 The Siphonic system shall be capable of being rapidly brought into action when the water is at the working water level, but shall not self siphon or leak into the flush pipe when the water is up to 1 cm above the invert of the overflow pipe

18.99.10.4 Reduced Water Level

18.99.10.4.1 The discharge shall operate satisfactorily when the cistern is filled to a level upto 1 cm below the working water level.

18.99.10.5 Discharge Capacity

When tested in accordance with the producer as per IS cistern of 5 litres and 10 litter capacities when required to give a full flush, shall respectively discharge 5 litres and 10 litres with variation of ± 0.5 litres. Dual-flush cistern of 10 litres capacity shall discharge alternatively a short of 5 ± 0.5 litres. Dual flush cistern of 6/3 litres capacities shall be discharge 6± 0.5litres and alternatively a haft flush of 3± 0.5 litres .

18.99.10.6 Discharge Rate

When tested in accordance with procedure described in IS, the discharge rate shall be 10± 0.5 litres within 6 second and 5± 0.5 litres within 3 seconds for cistern of capacities 10 litres and 5 litres and 6± 0.5 litres within 6 seconds and 3± 0.5 litres within 3 second for cistern of capacity 6/3 litres respectively. The cistern shall be so designed that there is no appreciable variation in the force of the flush during the discharge of the required quantity of water. For coupled cistern, this test shall not be applicable.

18.100 Stainless Steel Sink with or without draining Board

18.100.1 The sink shall conform to IS 13983-1994. It shall be manufactured from Austenitic stainless steel of grade designation X04Cr19Ni9 (Numerical symbol 304) or X07Cr18Ni9 (Numerical symbol 302) conforming to IS 5522-1992. Nominal thickness of stainless steel sheet used in the construction of sink shall be not less than 1.0mm. The sink shall be one of the following type :-

(i) Type A-1 or A-2 : Single Bowl without drainer.
(ii) Type B-1 or B-2 : Double Bowl without drainer.
(iii) Type C : Single Bowl single drainer right or left hand.
(iv) Type D : Single Bowl double drainer.
(v) Type E-1, E-2 or E3 : Double Bowl single drainer. Right or left hand.
(vi) Type F : Double Bowl double drainer.

Note : Hand of sink refers to position of drainers when viewed from the front**.**

18.100.2 The minimum internal dimensions, when measured on the bowl center lines across the top of the bowl, shall be 380mm x340mm for rectangular bowls and 360mm for round bowl. The depth of the sink bowl shall be 150mm minimum, when measured from the top edge of the bowel to the base of the sink. Depth of the smaller bowl for type E2 and E3 may be reduced upto 100mm.

18.100.3 The distance between the edge of the sink bowl and the end of the sink shall be 15 mm minimum for sit-on type sink and 30mm minimum for inset type sink. Depth of the collar provided for inset sinks shall be 10 + 2 mm.

18.100.4 For sinks designed for use with a 600 mm wide worktop, the distance between the edge of the sink bowl and the front of the sink shall be 50mm minimum and in the case of sink designed for use with 500 mm wide worktop, the distance shall be 45 mm minimum.

18.100.5 Both single and double bowl sink shall be set minimum of 10 mm from gridline.

18.100.6 Construction and Workmansip

18.100.6.1 Sink shall be constructed of the lowest practical numbers of section compatible with the manufacturing practice to ensure a smooth surface. The surface shall be free from any sharp edges. Sink bowl shall have rounded corners to facilitate cleaning. All welded surfaces shall be adequately cleaned off inside and outside the sink.

18.100.6.2 The edges of any holes in the sink shall not show evidence of undulation, chips, creaks or any other defect which would impair its appearance or performance.

18.100.6.3 When examined by an unaided eye of an experienced observer, from a distance of 600 + 100 mm from exposed surface, the sink shall be free from visible defects.

18.100.6.4 The visual examination shall be carried out with uniform illumination at the surface of the sink of 300 lux and with the sink positioned so that it is between the light source and the observer.

18.100.6.5 Waste Outlet Sink Bowl shall be designed/constructed with a fall to the waste outlet. The waste outlet fitting shall be recessed type.

18.100.7 Tap Holes

18.100.7.1 Sink shall be provided, in one of the following:-

(a) Without tap holes;
(b) With two tap holes of 30 + 2 mm diameter with a distance of 180 + 2 mm between center, or 300 + 2 mm between center for round bowled sinks only, for nominal size ½ outlet pillar or high level combination taps.
(c) With single tap holes of 35 + 2 mm diameter for high outlet mixer tap.

18.100.7.2 The center of tap holes shall be more than 60 mm from the nearest back edge of the bowl and not less than 50mm to the front face of the upstand.

18.100.8 Overflows

Sinks shall be provided in either of the following conditions:

(a) without an overflow hole;

(b) With an overflow hole having a horizontal dimension not greater than 64 mm, and a vertical height not less than 15 mm giving an area of not less than 640 sqmm and located completely below the spillover level of the sink.

18.100.9 Finish

Sinks may be supplied with a bright or dull finish as per IS as indicated.

18.100.9.1 Sink with draining board shall be ready made one unit. The chain rubber plug arrangement shall be chromium plated brass. Waste fittings screwed with fly nut and washers suitable for 50mm bore pipe shall be of brass chromium plated. The waste pipe from sink to trap, 50mm board GI pipe light grade shall be provided. The CI brackets for supporting sink shall be conforming to IS 775

18.100.10 Fixing

The sink and draining board shall be supported on CI cantilever brackets embedded in cement concrete 1 : 2 :4 block of size 100 mm x 75mm x 150mm. Brackets shall be fixed in position before the dado work is done. The CP brass or PVC union shall be connected to 40 mm nominal bore GI or PVC waste pipe which shall be suitably bent towards the wall and shall be discharged into a floor trap. The height of front edge of sink from the floor level shall be 80 cm. The bracket shall be painted with two coats of paint over a primer coat.

18.101.Ferrules

18.101.1 The ferrules for connection with mains shall generally conform to IS – 10942-2000. It shall be of non-ferrous materials with a CI bell mouth cover and shall be of nominal bore as specified. The ferrule shall be fitted with a screw and plug or valve capable of completely shutting off the water supply to the communication pipe, if and when required.

18.101.2 Fixing of Ferrules

For fixing of ferrules the empty mains shall be drilled and tapped at 45 degree to the vertical and the ferrule screwed in. The ferrule must be so fitted that no portion of the shank shall be left projecting within the main into which it is fitted.

18.102 Gun Metal Gate Valve

18.102.1 These shall be of gun metal fitted with wheel head (iron or gun metal), screwed/ flanged both ends for iron pipe opening full way and of the size as specified. These shall conform to IS 778. The weight of Gun Metal Gate valve shall be as under:-

Size in mm	Flanged ends Kg	Screwed ends Kg
15mm	1.021	0.567
20mm	1.503	0.680
25mm	2.495	1.077
32mm	3.232	1.559
40mm	4.082	2.268
50mm	6.691	3.232
65mm	10.149	6.804
80mm	13.381	8.845

18.102.2 Fixing Gun Metal Gate Valve

18.102.2.1 The Gun Metal Gate Valve shall be carefully examined and cleared of all foreign matter before being fixed. The Gun Metal Gate Valve shall be fitted in the pipe lines in a workman like manner. The joints between Gun Metal Gate Valve and pipe shall be made leak-proof when tested to a pressure of 17.5 Kg/sq cm.

18.103 Plastic bib taps and stop valves

They shall be screwed down type and shall conform to IS 9763-2000. Specification for plastic bib taps, pillar taps, angle valve and stop valve for hot and cold water services. Spindle / glands, crutches (handles) should be of plastic. The handle be crutch or butterfly type as directed. The control devices for taps shall be identified by the colour preferably blue for cold water and red for hot water. The thickness in any portion of the body and bonnet shall not be less than 2.5 mm for all sizes.

18.103.1 Marking

Each tap or valve shall be permanently marked with the manufacturers name or brand name, nominal size, batch No /date of manufacture and an arrow for direction of flow for stop valves. This shall also be marked with BIS standard mark.

18.104 Combination tap wall mounting and pillar mounting assembly

It shall be of cast copper alloy screwed down type and shall conform to IS 8931-1993. Specification for cast copper alloy fancy single, combination tap assembly and stop valves for water services. It shall be of approved pattern and shall be nickel chromium plated complying with condition 2 of IS 1068-1993. However body of the concealed stop valve and side stop valve of the pillar mounting tap assembly may be polished bright or may have an unpolished surface as cast finish. Material used for different component/parts of taps and valve shall be in accordance with table I of IS 8931-1993.

Each combination tap assembly shall be legibly marked with the following information.

(a) Manufacturer's name or trade mark.
(b) The hot water shall be on left and cold water on right side with letter 'H' or 'C' marked on tap.
(c) It may also be marked with standard mark.

18.105 Concealed stop cock

These shall be screwed down type and shall conform to IS 8931-1993. The spindles, glands, crutches, washer plates etc. shall be of brass. The knob shall be crutch or butterfly type. Knob shall be nickel chromium plated complying with condition 2 of IS 1068-1993. However body of the valve shall be unpolished surface as cast finish**.** The normal size shall be designated by the nominal bore of pipe.

18.106 Shower Rose

18.106.1 Shower rose over head

The shower rose shall be of chromium plated brass of specified diameter. It shall have uniform perforation. The inlet size shall be 15mm or 20mm as required. The body of the shower rose shall be sound and free from laps, blow holes and pittings. External and internal surface shall be clean, smooth and free from sand burning, plugging, stopping or patching of casting shall not be permissible. The body and swivel joint shall be machined true to shape so that when assembled the parts are axial parallel and cylindrical with surfaces, smoothly finished and are correct in adjustment. The thickness of plating shall not be less than that for the grade specified in the relevant IS Specifications. The plating shall be capable of taking high polish and shall not easily tarnish or scale.

18.106.2 Telephonic Shower

With 1 mt flexible hose and wall hook, the telephonic shower shall be of chromium plated brass of specified diameter. It shall have uniform perforation. The wall hook shall also be of chromium plated and fixed to wall with steel screws of suitable size. The flexible hose pipe shall be chromium plated outside and inner side LDPE pipe of 8mm internal dia, Both ends shall be fitted with male and female sockets so as to house the shower. Pipe shall be clean, smooth and free from patching of moulding. The holes shall be suitably placed so as to give uniform shower and to satisfy the performance test and each shower assembly shall be clearly and permanently marked with the manufacturers name and trade mark if any.

18.106.3 Shower and shower fittings for marine use shall be all as per IS 6251-1971

18.107 Jet Spray

with 1Mtr and 1.5 Mtr flexible LDPE pipe conforming to IS 3076-1985 fabricated and jointed with jet of 100mm long on one side and socket joint of 15mm dia. on other end. A steel plate of 22guage with adjustable hole and a groove to adjust the nozzle of jet, shall be chromium plated brass. Each plate shall be clearly permanently marked with manufacturers name and trade mark if any. Nozzle of jet shall also be chromium plated.

18.108 Workmanship

18.108.1 The work shall be carried out generally complying with the relevant bye-laws and rules wherever in force.

18.108.2 All water supply/sanitary and plumbing installations work shall be carried out through licensed /skilled plumbers. All fitting shall be fixed as to be completely airtight or watertight as specified.

18.109 Fixing plastic taps and valves

The fitting shall be carefully examined and cleared of all foreign matter before being fixed. The fitting shall be fitted in the pipe in workmanlike manner. The joints between fitting and pipes shall be made leak proof. The defective fitting and joints shall be replaced or re-done.

18.110 Testing

Comprehensive tests of all fittings and appliances shall be made by simulating conditions of use. The type of test shall consist of resistance to residual chlorine in water/thermal shock/ drip proofness test/hydraulic pressure test and mechanical strength test as mentioned in IS and shall be carried out all as per IS. Construction workmanship and finishes shall be all as per IS 9763-2000.

18.111 Fixing of combination tap assembly and concealed stop cock

It should be examined for any foreign matter before being fixed. The joints between fittings and pipe shall be made leak proof. The size of the combination tap shall be 15 mm. The sizes of wall mounting combination tap assembly, pillar mounting assembly (central hole) and pillar taps assembly shall be all as per table 6,7,8 of IS 8931-1993.

18.112 Testing

Comprehensive tests of all fittings and appliances shall be made by simulating conditions of use. The type of test like material test, performance test shall be carried out all as per IS.

18.113 Fixing of JET Sprayer

It shall be jointed with the angular stop cock or with the plug of 15mm dia. The joint shall be made leak proof. The chromium plated triangular plate shall be fixed with the same nut and bolts as that of seat cover and nozzle shall be fixed in the groove specially meant for it.

18.114 Polypropylene Random Copolymer (PP-R) Pipes and Fitting

18.114.1 Piping materials

The piping system shall consist of Polypropylene Random Copolymer Type 3 pipes and fittings confirming to DIN 8078.

For any internal works, the Polypropylene pipes and fittings shall be embedded in the wall chase or run on the floor/ceiling unless otherwise specified. No unsighted exposed runs shall be permitted. Outside the building the piping shall be installed at least 1.0 meter below the finished grade level.

18.114.2 Fusion Welded Polypropylene Pipes and Fittings

18.114.2.1 The pipe shall be three Layered Polypropylene Random Copolymer whereby the different layers of the pipes shall consist of: -

(a) The inner-most layer of the pipe to be anti-bacterial to prevent bacteria growth inside the pipe surface.
(b) The middle layer to be of plain PP-R which is neither in contact with water and nor under direct effect of the atmospheric conditions.
(c) The outer-most layer to be of U.V. stabilized PP-R to prevent the pipe surface from sunlight under exposed atmospheric conditions.

18.114.2.2 The pipes shall be conforming to the requirements of DIN 8078 (PPR pipes General Quality requirements and testing) and DIN 8077 (PPR Pipe dimensions). The pipes should have smooth inner surface with non-contracting diameters. The pipes shall be cleanly finished, free from cracks and other defects. The pipes shall be clean and well cut along ends after taking into consideration the desired length, using the Pipe scissors.

18.114.2.3 The fittings shall be as follows

a) Plain fittings from sizes 16 mm to 160 mm.
b) Chrome Plated Brass Threaded fittings from sizes 16 mm to 75 mm.
c) Valves from sizes 20 mm to 63 mm.

18.114.2.4 The valves sizes availability in Polypropylene Random Copolymer are as follows : -

i)	Gate Valve	-	20MM & 63MM
ii)	Ball Valve	-	20MM, 25MM, 32MM, 40MM, 50MM & 63MM
iii)	Concealed stop Cock	-	20MM & 25MM
iv)	Chrome Coated Valve	-	20MM & 25MM

18.114.2.5 However, other Brass/Bronze valves can be connected to PP-R pipes using CP Brass threaded fittings of desired size without extra cost to Govt.

18.114.3 Laying and Joining of Polypropylene Random Pipes and Fittings

18.114.3.1 The Polypropylene Random pipes and fittings shall run in wall chase or ceiling or as specified. The installation of Polypropylene Random Copolymer pipes is similar to that of the metal pipes with the only difference in the jointing procedure. The jointing of the Fusion welded PP-R pipes and fittings shall be done by means of a Welding Machine

18.114.3.2 The pipe to the desired length shall be cut by using the pipe scissors. The proper heating piece shall be taken and mounted on the welding machine. The welding device when switched on - control lamp and switch lamp will lit. When ready, control lamp gets off, which means that welding temperature of 260 Degrees 10 Degrees Celsius has been reached. The pipe end and the fitting to be welded shall be heated on the welding machine. Before heating the fittings and the pipe, the dirty welding tools, pipe and fitting shall be cleaned with a cloth. When heated up (with heating time as per the table shown below), the pipe and the fittings shall be removed from the welding machine and the two pieces connected together by applying a little pressure without twisting. The joint shall be allowed to cool down for a few seconds.

Guidelines for welding PP-R Pipes and fittings (DVS guidelines 2207, Part 11)

Outer diameter of pipe (MM)	Heating Time (Seconds)	Cooling Period (Minutes)
16	5	2
20	5	2
25	7	2
32	8	4
40	12	4
50	18	4
63	24	6
75	30	8
90	30	8
110	45	10
160	60	12

18.114.3.3 The same procedure shall be adopted for exposed as well as concealed fittings. The crossovers may be used wherever the overlapping of the PP-R pipes is required. The fixing shall be done by means of Wall Support Clamps keeping the pipes about 1.5 cm clear of the wall where to be laid on the surface. Where it is specified to conceal the pipes, chasing maybe adopted. For pipes fixed in the shafts, ducts etc. there shall be sufficient space to work or the pipes with the usual tools. Where directed pipe sleeves shall be fixed at a place the pipe is passing, through a wall or floor for reception of the pipe and allow freedom for expansion and contraction and other movements. Fixed supports prevent any movement of the pipe by fixing it at some points. Fittings are used in creating the fixed point. Fixed support shall not be installed at bending parts and the direction changes shall be done in the pipe itself. In between the fixed supports some arrangements shall be done to compensate any potential elongation or shrinkage in the pipe length.

18.114.3.4 Piping Installation Support

(a) Piping shall be properly supported by means of wall support clamps as specified and as required, keeping in view the proper designing for expansion and contraction. Risers shall be supported at each floor with Clamps.

(b) When necessary Polypropylene Random pipes may be bend by heating, but the pipes shall not be put on flame. Heating should be done by hot air blowing device. To bend the pipes, they shall be heated upto 140 degree Celsius. Advised minimum radius for bending are shown in the under table : -

PIPE DIAMETER (d)	BEND RADIUS, MINIMUM (R=8xd)
20	160
25	200
32	256
40	320
50	400
63	500
75	600
90	720
110	880
160	1280

(c) All pipe work shall be carried out in a proper workman like manner, causing minimum disturbance to their existing services, building roads and structure. The entry piping work shall be organized in coordination and consultation with other agencies work, so that all works can be carried out in one stretch.

(d) All pipes shall be accurately cut to the required lengths and then cleaned with a clean cloth before fusion welding. Open ends of the pipes where the C.P. Brass threaded fittings are welded for C.P. connections at the later stage shall be closed by means of Plugs to avoid the entrance of foreign matter.

(e) Automatic air valves shall be provided at all high points in the piping system for venting. Automatic air valves shall also be provided on hot water risers. Discharge form the air valves shall be piped to the nearest drain or sump. All pipes shall be pitched towards the drain points.

18.114.4 Installation of Water Meter and Valves

18.114.4.1 PP-R lines shall be cut to the required lengths at the position where the Meter and Valves are required to be fixed. Suitable C.P. Brass threaded fittings shall be attached to the pipes. The Meter and Valves shall be fixed in a position by means of connecting pipes, jam nut and socket etc. The stop cock shall be fixed near the inlet of the Water Meter. The paper disc inserted in the ripples of the Meter shall be removed and the Meter shall be installed exactly horizontally or vertically in the flow line in the direction shown by the arrow cast on the body of the Meter. Care shall be taken not to disturb the factory seal of the Meter. Wherever the Meter shall be fixed to a newly fitted pipeline, the pipeline shall have to be completely washed before fitting the meter.

18.114.5 Testing

18.114.5.1 The Contractor shall inform in advance of any test so that the Engineer in Charge can witness the tests. All water supply system shall be tested to Hydrostatic pressure test of at least one and a half (1.5)times the maximum working pressure but not less than 10 kgs/sqcm for a period of not less than 8 hours.

18.114.5.2 The pressure test is performed in 3 steps being preliminary test, main test and final test. For the preliminary test a pressure which is 1.5 times higher than the possible working pressure is applied and this is repeated two times in 30 minutes with intervals of 10 minutes. After a test period of 30 minutes, the test pressure must not be dropped more than 0.6bar and no leak must occur. Main test follows the preliminary test. Test time is two hours, in doing so the test pressure taken from the preliminary test must not have fallen more than 0.2 bar.
After completion of these tests, the final test comes which has to be done under a test pressure of 10 bar and 5 bar in the interval of 15 minutes. Between the respective test courses pressure has to be removed.

18.114.5.3 All leaks and defects in joints revealed during the testing shall be rectified and got approved at site by retest. Piping required subsequent to the above pressure test shall be retested in the same manner. A record of pressure test has to prepared and signed by the EIC and Contractor with statement of place and date.

18.114.5.4 Control Schedule

Start of the test: ________________ End ____________ Test period
Contractor's Engineer : ______________________________________
Engineer-in-Charge : ____
Place :____

18.114.5.5 System may be tested in sections and such sections shall be entirely retested on completion to the overhead tanks or pumping system or mains. In case of improper circulation, the contractor shall rectify the defective connections. He shall bear all expenses for carrying out the above rectifications including the tearing up and refinishing of floors and walls as required.

18.114.5.6 After commissioning of the water supply system, contractor shall test each valve by closing and opening it a number of times to observe if it is working efficiently. Valves which are not working efficiently, shall be replaced by new ones, at contractor's expenditure.

18.114.6 Disinfection of Piping System and Storage Tanks

18.114.6.1 Before commissioning the water supply system, the contractor shall arrange to disinfect the entire system. The water storage tanks and pipes shall first be filled with water and thoroughly flushed out. The storage tanks shall then be filled with water again and disinfecting chemicals (chlorine) added gradually at the time of tanks being filled to ensure thorough mixing. Sufficient chemical shall be used to give water a dose of 50 ppm of water.

18.114.6.2 For any other chemical used, the proportions shall be specified by the manufacturer, When the storage tank is full, the supply shall be stopped and all the taps on the distributing pipes are opened successively. Each tap shall be closed when the water discharged begins to smell of chlorine. The storage tank and pipe shall then remain charged at least for three hours. Finally the tank and pipes shall be thoroughly flushed out before any water issued for domestic purpose.

18.114.7 Sterilization of Main

After the pipe work has been tested and approved, but before it is coupled, it shall be sterilized with a solution of chloride of lime.

18.114.8 Valves

18.114.8.1 The valves shall be Polypropylene Random Copolymer Valves. The valves comprise of Gate Valve and Ball Valve in available sizes. The outer casing of the Gate Valve shall be Polypropylene Random Copolymer, while the inner parts shall be all Brass. For Ball Valves the outer casing of valve shall be Polypropylene Random Copolymer, while the inside parts shall all brass parts and the inside ball shall Stainless Steel ball.

18.114.8.2 The Valves sizes availability in Polypropylene Random Copolymer is as follows : -

i) Gate Valve	-	20MM, 25MM, 32MM, 40MM, 50MM, 63 MM
ii) Ball Valve	-	20MM, 25MM, 32MM, 40MM, 50MM, 63 MM

18.114.8.3 However, the other Brass/Bronze Valves as specified can be connected to Polypropylene pipes using C.P. threaded fittings of desired sizes without any extra cost to Govt.

SECTION 19
ELECTRICAL WORK

19.1 Indian Standards

The following Indian Standards apply to this section:

I.S. No.	*Subject*
280-2006	Specification for mild steel wire for general engineering purposes (Fourth revision).
335-1993	New insulating oil for transformers and switchgear (Third revision).
371-1979	Ceiling Roses (Second revision).
398-(Part 1) 1976	Aluminium conductors for overhead transmission purposes. Part: 1 Aluminium stranded conductors (Third revision).
398-(Part 2) 1976	Aluminium conductors for overhead transmission purposes. Part: 2 Aluminium conductors, galvanised steel reinforced (Third revision).
613-2000	Specifications for Copper rods for electrical purposes (Third revision).
692-1994	Paper insulated lead sheathed cable for electricity supply (Third revision).
694-1990	PVC insulated cables for working voltages upto and including 1100 volts (Third revision).
731-1971	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 volts (Second revision)
732-1989	Code of Practice for electrical wiring installations. (Third revision)
876-1992	Specification Wood pole for over-head power and telecommunication line (Third revision).
1180 Part 1 - 1989	Outdoor three phase distribution transformers upto and including 100 KVA, 11KV : Part 1 Non sealed type.
1180 Part 2 - 1989	Outdoor type three phase distribution transformers upto and including 100 KVA, 11KV : Part 2 sealed type.
1255-1983	Code of Practice for installation and maintenance of paper insulated power cables.(upto and including 33 KV) (Second revision).
1258-2005	Bayonet lamp holders (Fourth revision).
1293-2005	Specification for plugs and sockets out let of rated voltage upto and including 250 Volts and rates current upto and including 16 Amperes (Third revision).
1445-1977	Porcelain insulators for overhead power lines with nominal voltage upto and including, 1000 volts (Second revision).
1554-(Part 1) 1988	Specification for PVC insulated (heavy duty) electric cables. Part: 1 For working voltages upto and including 1100 volts (Third revision).
1554-(Part 2) 1988	Specification for PVC insulated (heavy duty) electric cables. Part: 2 For working voltages from 3.3 KV upto and including 11 K.V. (Second revision).
1569-1976	Capacitors for use in tubular fluorescent, high pressure mercury and low pressure., sodium vapour discharge lamp circuit (First revision).

I.S. No.	*Subject*
1596-1977	Polyethylene insulated cables for working voltages upto and including 1100 volts (Second revision).
1646-1997	Code of practice for fire safety of buildings (general) Electrical installations (Second revision).
1678-1998	Specification for Pre-stressed concrete poles for overhead power, traction and telecommunication lines (Second revision).
1777-1978	Industrial luminaire with metal reflectors (First revision).
1866-2000	Code of Practice for maintenance and supervision of mineral insulating oil in service equipment (Third revision).
1913- (Part 1) - 1978	General and safety requirements for luminaries Part I, Tubular fluorescent lamps (Second revision).
1944-(Part 1 & 2)-1970	Code of practice for lighting of public thoroughfares (First revision).
2026-(Part 1) - 1977	Power transformers Part 1 (First revision).
2086-1993	Carriers and bases used in rewireable type electric fuses upto 650 volts (Third revision).
2121-(Part 1 & 2) 1981	Conductor and earth wire accessories for overhead power lines, Part 1 & 2 (First revision).
2141-2000	Hot dip Galvanised stay strand (Fourth revision).
2215-1983	Starters for fluorescent lamps (Third revision).
2268-1994	Electric call bells and buzzers for indoor use (Third revision).
2309-1989	Code of practice for protection of buildings and allied structures against lighting (Second revision).
2315-1978	Specification for Thimbles for wire ropes (First revision).
2412-1975	Link clips for electrical wiring (First revision).
2418-(Part 1 to 4) 1977	Specification for Tubular fluorescent lamps for general lighting service.
	Part 1-Requirements and tests. (First revision)
	Part 2-Standard lamp data sheets. (First revision)
	Part 3-Dimensions of G-5 and G-13 Bi-pin caps. (First revision)
	Part 4-Go and no go gauges and G-5 and G-13 Bi-pin caps. (First revision)
2486-(Part 1) 1993	Metal fittings insulatiors for overhead power lines with nominal voltage greater than 1000 V General requirements and tests (Second revision).
2486-(Part 2)-1989	Insulator fittings for overhead power-lines with nominal voltage greater than 1000 V : Part 2 Dimensional requirements (Second revision).
2544-1973	Porcelain post insulators for systems with nominal voltages greater than 1000 volts (First revision).
2551-1982	Danger notice plates (First revision).
2667-1988	Fittings for rigid steel conduits for electrical wiring (First revision).

I.S. No.	*Subject*
2675-1983	Enclosed distribution fuseboards and cutouts for voltages not exceeding 1000volts (Second revision).
2713-(Part I to 3)-1980	Tubular steel poles for overhead power-lines (Second revision)
3034-1993	Code of Practice for fire safety of industrial buildings-Electrical generating and distribution stations. (Second revision)
3043-1987	Code of practice for earthings (First revision).
3070-(Part I)-1985	Specification for Surge arresters for Alternating Current systems, Part I-Non-linear resister type Surge arresters (Second revision).
3070-(Part 2)-1989	Lightning arresters for Alternating Current systems, Part 2 Expulsion type lightning arresters.
3070-(Part 3)-1993	Lighting arresters for AC system: Part 3 Metal Oxise arresters without gap.
3188-1980	Characteristics of string insulators (First revision).
3287-1965	Industrial lighting fittings with plastic reflectors.
3323-1980	Bi-pin lamp holders for tubular fluorescent lamps (First revision).
3324-1982	Holders for starters for tubular fluorescent lamps (First revision).
3419-1988	Fittings for rigid non-metallic conduits (Second revision).
3427-1997	AC Metal enclosed switchgear and control gear for rated voltages above 1 KV and upto and including 52 KV (First revision).
3480-1966	Flexible steel conduits for electrical wiring.
3553-1966	Watertight electric lighting fittings.
3639-1966	Specification for Fittings and accessories for power transformers.
3837-1976	Accessories for rigid steel conduits for electrical wiring (First revision).
3854-1966	Switches for domestic and similar purposes.
4004-1985	Application guide for non-linear resister-type surge arrestors for Alternating Current systems (First revision).
4160-2005	Specification for Interlocking switch socket outlet (First revision).
4615-1968	Switch socket outlets (non-interlocking type).
4648-1968	Guide for electrical layout in residential buildings.
4710-1968	Switches and switch isolators above 1000 Volts but not exceeding 11000 Volts.
5039-1983	Specification for distribution pillars for voltages not exceeding 1000 Volts DC (First revision)
5216-1969 (Part 1)- 1982	Recommendation safety procedures and practices in electrical works Part 1: General (First revision).
5216-(Part II)- 1982	Recommendation safety procedures and practices in electrical works Part II: life saving techniques (First revision).
5300-1969	Porcelain guy strain insulators.

I.S. No.	*Subject*
5578-1984	Guide for marking of insulated conductors (First revision).
5613-(Part I Sec.1)-1985	Code of Practice for design installation and maintenance of overhead power lines. Lines upto and including 11 KV Section I: Design. (First revision).
5613-(Part I Sec 2)-1985	Code of Practice for design installation and maintenance of over head power lines. Section 2: Installation and maintenance. (First revision)
5820-1970	Precast concrete cable covers.
7098 (Part 1)-1988	Crosslinked Polyethylene (XLPE) insulated PVC Sheathed Cables: Part 1 For working voltage upto and including 1100 Volts. (Second revision)
7098 (Part 2)-1985	Crosslinked Polyethylene (XLPE) insulated PVC Sheathed Cables. For working voltage from 3.3 KV upto and including 33 KV (First revision).
8061-1976	Code of practice for design installation and maintenance of service lines upto and including 650 V
9385 (Part 2 & 3)- 1980	High voltage; Part 2 expulsion fuses and similar fuses; Part 3 Application guide
9537 (Part 2)-1981	Condition for electrial installation Part 2: Rigid steel conduit
9537 (Part 3)-1983	Condition for electrical installations Part 3 : Plain rigid conduit of insulating material.
9900 (Part 1 to 4) 1981	High Pressure mercury vapour lamps - Part 1 to Part 4
9920 (Part III)-1982	AC switches for voltages above 1000 volts. Part III Design and construction.
9921 (Part 1)-1981	Alternating current disconnectors (isolators) and earthing switches for voltage above 1000 Volts. Part 1: General and Definitions.
9921 (Part 2)-1982	Alternating current disconnectors (isolators) and earthing switches for voltage above 1000 Volts. Part 2: Ratings.
9921 (Part 5)-1985	Alternating current disconnectors (isolators) and earthing switches for voltage above 1000 Volts. Part 5: Information to be given with tender enquiries & orders.
9968 Part 1-1988	Specification for Elastomer insulated cables: Part 1 For working voltages upto and including 1100 Volts.
9968 Part 2 -2002	Specification for Elastomer insulated cables: Part 2 For working voltage from 3.3 KV upto and including 33 KV.
9974 (Part 1 & 2) 1981	High pressure sodium vapour lamps
10028 (Part I)-1985	Code of Practice for selection, installation and maintenance of transformers : Part 1: Selection
10028 (Part 2)-1981	Code of Practice for selection, installation and maintenance of transformers : Part 2: Installation
10028 (Part 3)-1981	Code of Practice for selection, installation and maintenance of transformers : Part 3: Maintenance.
10118 (Part I)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears : Part 1: General

I.S. No.	Subject
10118 (Part II)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears (superseding IS 3072-75 & 3106-66): Part 2 Selection
10118 (Part III)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears (superseding IS 3072-75 & 3106-66): Part 3 Installation
10118 (Part IV)-1982	Code of Practice for selection, installation and maintenance of switch gears and control gears (superseding IS 3072-75 & 3106-66): Part 4 Maintenance
11353-1985	Guide for uniform system of marking and identification of conductor and apparatus terminals.
13703 Part 1 & Part 2	Low voltage fuses for voltage not exceeding 1000 V AC or 1500 V DC
13703 (Part 1 to 4) 1993	Specification for Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V PC
13947 - Part 1 1993	Specification for low voltage switchgear and control gear Part 1: General rules.
13947 - Part 3 1993:	Specification for low voltage switch gears and control gear- Part 3 switches, Disconnectors, switch disconnectors and fuge combination unit.
14772-2000	General requirements for enclosures for accessories for house hold and similar fixed electrical insutations.

19.2 General Requirements

19.2.1 Materials

All materials, fittings, appliances etc. used in electrical installations shall comply with the requirements of relevant Indian Standard specifications and shall be well finished. Materials for which Indian Standard specifications have not been indicated, shall conform in quality to the samples maintained by the GE or as approved by him.

19.2.2 Conformity with Indian Electricity Act, Rules etc

All electrical work shall be carried out in conformity with the requirements of the Indian Electricity Act 2003 & Indian Electricity Rules 1956 framed thereunder and Fire insurance act as applicable and also the relevant regulations of Electric Supply authorities concerned as amended from time to time. Extracts from the Indian Electricity Rules 1956 are given in Appendix 'A'.

19.2.3 Execution of Work

Unless otherwise exempted under the rule of the Indian Electricity rules the work of electrical installation shall be carried out under the supervision of a person holding a certificate of competency issued by the recognised authority.

The workmen shall also hold certificate of competency. Good workmanship is an essential requirement for compliance with these specifications.

19.2.4 The work shall be executed in such sections and in a manner as directed by the Engineer-in-Charge to suit the building operations or the convenience of users/occupants.

19.2.5 Testing-Generally

All electrical work shall be systematically tested by the Contractor in the presence of EIC to ensure compliance with the specifications laid down. Test results shall be recorded and signed by the Contractor and the EIC. If the test results are not acceptable, all repairs and replacements and extra work of removal and relaying or refixing shall be carried out by the Contractor at his expense and installation retested, until test results indicate compliance with the prescribed requirements.

The Contractor shall supply the necessary apparatus, labour and instruments or equipment required for testing.

19.2.6 Record of Installations

On completion of the work the Contractor shall submit to the Engineer-in-Charge complete wiring diagram for each of the installations in the case of internal electrical works, schematic diagram of equipment and connections for sub-stations and switch gear works and the route layout plans in case of external overhead line or underground cable work. Five sets of plans shall be submitted and it shall be ensured that the plans indicate complete site data of the installations.

All circuits shall be clearly indicated and numbered in the wiring diagram and all points shall be given the same number as the circuit to which they are electrically connected.

19.2.7 Safety Procedures and Practices

In all major electrical installations; such as substations industrial establishments, transmission and distribution lines and cable networks; safety procedures instructions for working on low, medium and high voltage mains and apparatus and safety practices listed in IS 5216-1982 (first revision) Guide for safety procedures and practices in electrical works shall be followed to the extent applicable. The Contractor shall provide workmen with safety devices and appliances.

19.2.8 Fire Safety

All electrical equipment shall satisfy the requirements laid down in IS 1646-1997 Code of Practice for fire safety of buildings (general) electrical installations and IS 3034-1993 Code of practice for fire safety of industrial buildings, electrical generating and distributing stations, to the extent applicable.

MATERIALS
SUB-SECTION A-EXTERNAL ELECTRICAL WORKS

19.3 Tubular Steel Poles Swaged

19.3.1 Tubular steel poles shall be swaged type & shall conform to IS 2713 (Parts 1 to 3) 1980 specification for Tubular poles for overhead power lines (Second Revision). The tubes for making poles shall be out of steel conforming to grade YSt 240 (with minimum tensile strength of 410 Mpa) except that Manual metal arc welding process may also be used to manufacture tubes and Cold bend test need not be conducted.

19.3.2 Swaged poles shall be made of seamless or welded tubes of suitable lengths swaged and joined together. No circumstantial joints shall be permitted in the individual tube length of the poles. If welded tubes are used, they shall have longitudinal weld seam only, and the longitudinal welds shall be staggered at each swaged joints. Pole shall be well finished, clean and free from harmful surface defects. Ends of the poles shall be cut square. The poles shall be straight, smooth and cylindrical.

19.3.3 The dimensions of poles shall be as under:-

Designation	Over all length	Planting depth	Length of section	Outside dia & thickness of section mm	Apply weight of Pole
	m	m	m	mm	kg
1	2	3	4	5	6
410SP-22	8.50	1.50	5.00	165.1x4.50	141
			1.75	139.7x4.50	
			1.75	114.3x3.65	
410SP-31	9.00	1.50	5.00	165.1x4.50	147
			2.00	139.7x4.50	
			2.00	114.3x3.65	
410SP-37	9.50	1.80	5.00	165.1x4.50	153
			2.25	139.7x4.50	
			2.25	114.3x3.65	
410SP-44	10.00	1.80	5.20	165.1x4.85	168
			2.40	139.7x4.50	
			2.40	114.3x3.65	
410SP-55	11.00	1.80	5.60	193.7x4.85	227
			2.70	165.1x4.50	
			2.70	139.7x4.50	
410-SP-64	12.00	2.00	5.80	219.1x4.85	292
			3.10	193.7x4.85	
			3.10	165.1x4.50	

19.3.4 A through hole of 14 mm diameter shall be provided in each pole at a height of 300 mm above the planting depth for earthing arrangements.

19.3.5 Finials and base plate shall be of cast iron and conform to the details given in fig. 3 and 4 of the Standard (I.S. 2713 Part 1 to 3-1980).

19.3.6 Protection Against Corrosion

The poles shall be coated with two coasts of black bituminous paint throughout internally, and externally up to the planting depth. The remaining, portion of the exterior shall be painted with one coat of red oxide primer.

19.4 BLANK

19.5 Prestressed Cement Concrete Poles

These shall comply with the requirements of IS 1678-1998 Specifications for Prestressed concrete poles for overhead power, traction and telecommunication line and it shall carry an earth bond in accordance with Rule 90 of IE rules and comply with the following requirements.

Class of Poles	Maximum Overall Length m	Minimum Ultimate Trans verse Load kg
9	11.0	450
10	9.0	300
11	7.5	200

19.6 Insulators and Insulator Fillings

19.6.1 Pin and Shackle lnsulator

Shall comply with IS 1445-1977, Specification for porcelain insulators for overhead power lines with a nominal voltage upto and including 1000 volts and IS 731-1971, Specification for porcelain insulators for overhead power lines with a nominal voltage greater than 1000V. The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed.

19.6.1.1 The pin insulator shall be in one piece and shall have a top groove and shall be threaded to take galvanised mild steel pin.

19.6.1.2 The shackle insulator shall be in one piece and shall have a groove on the side and a hole for a cotter pin and two galvanised bolts and nuts with or without a pair of straps as indicated.

19.6.2 Disc Insulators

Porcelain of disc insulators shall comply with IS 731-1971, Specification for porcelain insulators for overhead power lines with nominal voltage greater than 1000 volts. Dimensions of disc insulators shall be as per IS 3188-1980 Dimensions for disc insulators.These shall be in one piece, sound, free from defects, thoroughly vitrified and smoothly glazed.

19.6.3 The design of the insulators shall be such that stress due to expansion and contraction in any part of the insulator shall not lead to its deterioration.

19.6.4 Insulator Fittings

Insulator fittings shall comply with requirements of IS 2486. Insulted fittings for overhead power lines with nominal voltage greater than 1000 volts (Part 1)1993, General requirements and tests and (Part 2)-1989, Dimensional, requirements.

19.7 Stay Wires

The stay wires shall be of grade 4 quality with minimum tensile strength of 700/N/sqm and conform to IS 2141-2000 Specification for galvanised stay strand and of size as indicated.

19.7.1 Wires shall be so stranded together that when an evenly distributed pull is applied at the end of completed strand, each wire will take an equal share of the pull. The stay wire shall be circular and shall be free from scale, irregularities imperfections flaws, splits and other defects; the zinc coating shall be smooth, even and bright.

19.7.2 The construction and minimum breaking load of stay strand, grade 4, shall be as per 1S:2141-1979.

19.8 Stay Assemblies

Thc slay assemblies shall comprise of stay clamp, stay wire, stay insulator, stay grips, thimble stay bow, stay-rod and stay-plate.

19.8.1 Stay clamp shall be made of mild steel flats and shall be galvanised.

19.8.2 Stay insulators or egg type insulators shall conform to IS 5300-1969 Specification for porcelain guy strain insulators.

19.8.3 Stay grips shall conform to the specifications for stay wires.

19.8.4 Thimbles shall comply with IS 2315-1978 Specifications for thimbles for wire ropes.

19.8.5 Staybows shall be of mild steel, galvanised of 14 mm dia and 40 cm length.

19.8.6 Stay-rods shall be of mild steel, galvanised, having a tensile strength not less than 420 N/ sq.mm. Stay-rods shall be either of 16 mm or 20 mm dia as indicated and 1.8 metre long.

19.8.7 Stay-plates shall be of mild steel galvanised, having 6 mm thickness and either of 23x23 cm or 30x30 cm as specified.

19.9. Steel Cross Arms

Steel cross arms shall be of angle or channel sections as indicated. They shall be in one piece, sound, free from defects. Steel cross arms shall be given a coat of primer and 2 coats of painting as indicated or as directed. The length of the cross arms shall be suitable indicated to accommodate the number of insulators on them giving sufficient spacing between the insulators. A minimum distance of 8 cms for low and medium voltage lines and 10 cm for higher voltage lines shall be left from the centre of the extreme insulator pin hole to the end of the cross arm. The cross arm shall be complete with pole clamp made of MS Flat of size not less than 50 mmx6 mm with necessary nuts, bolts and washer The pin holes on the cross arm shall be on required basis. Length of cross arm for carrying guard wire shall be such that the guard wire shall always run not less than 30 cms beyond the outermost bare conductor of the configuration.

19.9.1 D Iron Clamps

Where conductors are to be spaced vertically these shall be supported on shackle insulators which are fixed to the pole by means of 'D' shaped clamps made of MS flat of size not less than 50 mmx6 mm having of specified dimensions.

The D-iron clamp shall be complete with pole clamp with necessary bolt, nuts and washers and insulator bolt holes.

19.9.2 GI Strap

Where D-iron clamps are not specified a pair of strap plates of galvanised Iron of size 40 mmx3 mm and length 23 cms shall be used with shackle insulator.

19.10 Conductors

Conductors for overhead power tramsmission shall conform to IS 398-1976 Specification for aluminium conductors for overhead transmission purposes, Part I, Aluminium stranded conductors or Part 2, 1976 Aluminium conductors galvanised steel reinforced as indicated.

19.10.1 Aluminium stranded conductor (ASC) shall be made up of seven or more aluminium wires twisted together in concentric layers. When the conductor consists of more than one layer, successive layers are twisted in opposite directions. Stranding and size of the conductor shall be as indicated. Natural grease shall be applied between the layers of wire.

19.10.2 Aluminium conductors galvanised sleel reinforced (ACSR) shall be made of seven or more aluminium and galvanised steel wires built up in concentric layers. The centre wire or wires are of galvanised steel and outer layer or layers of aluminium. Stranding and size of conductor shall be as indicated. Natural grease shall be applied between the layers of the wire.

19.11 Bearer Wires

Bearer wires shall be plain galvanised steel wire or galvanised stay strand as indicated. In case of stay strand the number of wires and diameter of each wire shall be as indicated. Plain galvanised steel wire shall conform to IS 280-2006 Specification for mild steel wire for general engineering purposes. Stay strand shall be of quality Grade-3/1100 N/sq.mm and shall conform to IS 2141-2000 Specification for hot dip galvanised stay strands. The wires shall be round, free from splits, surface flaws, rough, jagged and imperfect edges and all other harmful defects. The zinc coating shall be smooth even and bright.

19.11.1 Guard Wire

Guard wire shall be G.I having minimum breaking strength of 635 Kg in accordance with Rule 88 of IE Rules. Every guard wire or cross-connected system of guard wires shall be of sufficient current carrying capacity to ensure rendering the line dead without risk of fusing or guard line.

19.11.2 Earth Wire

The continuous earth wire shall not be less than 8 SWG GI.

19.12 Non-Linear Resister Type Lightning Arresters

Non-linear resister lightning arresters shall comply with IS 3070 (Part I)-1985 Specification for lightning Arresters to alternating current systems Part I Non-linear resister type lightning arrester. These lightning arresters consist of single or multiple spark gaps in series with one or more non-linear resister.

NOTE : This type of lighting arresters, are designed for repeated operation to limit voltage surges on alternating current power circuits and to interrupt power follow current and are suitable for operation when install outdoors and exposed to direct sun with ambient temperature within the range of (-)10^0 C to 50 ^{0}C

19.13 Expulsion Type Lightning Arresters

Expulsion type lightning arresters shall comply with IS :3070 (Part 2)-1989, Specification for lightning arrester for alternating current systems Part II Expulsion type lightning arresters.

NOTE : The expulsion type lightning arresters are used for surge protection and insulation coordination of distribution and transmission systems having low short circuit currents and are suitable for operation under the following normal service conditions of ambient air temperature :

(a) Maximum ambient air temperature 45 °C
(b) Maximum daily average ambient air temperature 36^0 C and
(c) Maximum yearly average ambient air temperature 30^0 C.

19.13.1 Expulsion Type lightning arresters shall be of the following class as indicated :-

(a) Thirty kilo-amperes discharge capacity distribution class
(b) Sixty five kilo-amperes discharge capacity distribution class and
(c) Sixty five kilo-amperes transmission class.

19.13.2 33 KV/11 KV Lightening Arresters

19 13.2.1 The lightening arresters shall be single pole zinc oxide (gap less) surge type suitable for use in effectively earthed system with nominal voltage of 36 KV, or 12 KV.The lighting arresters shall comply with IS : 3070 (Part-3) 1993 or latest edition.

19.13 2.2 The lightening arresters shall be of pedestal mounting or station structure mounting or cross-arms mounting type as specified in schedule and it shall be suitable for out door installations. All the clamps, bolts, nuts and washers, etc required for mounting arresters on the structures, cross arms etc shall be supplied alongwith the arresters and shall be galvanised.

19.13.2.3 The top metal cap and the base of the lightening arrester shall be galvanised. The top metal cap shall be provided with terminal arrangement suitable for both horizontal and vertical take off. The base of lightening arresters shall be provided with terminals distinctly marked for connection to earth. The lightening arrester shall be installed on steel structure through base insulators as per the recommendations of the manufacturers.

19.13.2.4 The lightening arrester shall be hermetically sealed to avoid ingress of moisture. A suitable pressure relieving devices shall be provided to avoid damage to the external insulator in case of severe discharge.

19.13.2.5 The lightening arrester shall be subject to all tests (Type and Routine test) as laid down in the ISS at manufacturers premises. The Contractor shall produce test certificate from the manufacturers as per IEC/ISS before installation of the same.

19.13.2.6 The lightening arrester shall conform to the para meters given below:-

Ser No	*Particulars*	*Specification/ parameters for working Voltage of*	
		33 KV	*11 KV*
1.	Type of arrester	30KV,metal oxide (Gap less type), heavy duty, single pole self supporting station class.	9 KV metal oxide (Gap less type), heavy duty, single pole, self supporting station class
2.	Applicable standard	IEC : 99.4	IEC99.4
3.	Rated system voltage	36 KV	12KV
4.	Rated system frequency	50 Hz	50 Hz
5.	System Neutral earthing	Effectively earthed	Effectively earthed
6.	Installation	Outdoor	Outdoor
7.	Rated arrester voltage	30 KV (rms)	9KV
8.	Maximum continuous operating voltage (MCOV)	Not less than 24 KV (rms)	Not less than 7.65 KV (rms)
9.	Nominal discharge current	10 KA (peak)	10 KA(peak)
10.	Power frequency reference voltage	Not less than MCOV	Not less than MCOV
11.	Max Residual voltage for discharge current of 10 KA and 8/20 micro-sec-current wave	100 KVp	40 KVp
12.	Long duration discharge class	Class-II (As per IEC)	Class-II(As per IEC)
13	Pressure relief class/ current	Class-A/40 KA	Class-A/40KA
14	Insulation level	70/170KV	28/75KV
15	Switching residual discharge voltage(KV crest) 30/60 micro-sec-current wave at 500 Amps	70KV	29.9KV
16.	Peak value high current impulse of 4/10 micro sec wave shape	100 KA(Peak)	100 KA(peak)
17.	Minimum creepage distance	25mm/KV of highest system voltage	25mm/KV of highest system voltage

19.13.2.7 The lightening arrester shall be able to withstand wind load of 195 Kg/Sqm and seismic acceleration of 0.39 g.

19.14 Transformers

19.14.1 Three phase outdoor distribution transformers shall conform to IS 1180-Part 1-1989 and 1180-Part 2-1989 Specification for outdoor type three phases distribution transformers upto and including 100 KVA-11 KV. These transformers are oil immersed naturally cooled type. Preferred KVA ratings are 16,25,40,63 and 100 KVA and their no load voltage ratios are 3300/433 V, 6600/433V and 11000/433 V.

19.14.1.1 The oil of the transformer shall comply with the requirements of IS 335-1993 Specification for new insulating oil for transformers and switchgear.

19.14.1.2 Fittings

The transformer shall be provided with the following:

(a) Two earthing terminals for body earthing and two additional for neutral brought out on a bushing.
(b) Oil level gauge indicating oil level minimum and maximum.
(c) Lifting lugs.
(d) Rating and terminal marking plates.
(e) Plain breathing device which would not permit ingress of rain water and insects.
(f) Drain-cum-sampling valve (3/4" nominal size thread) preferably steel with plug,
(g) Thermometer pocket (for transformers of rating above 25 KVA).
(h) Oil filling hole (1-1/4" Nominal size thread) with cover (for transformers without conservator).

19.14.1.3 The following fittings shall be provided as extra, if indicated. -

(a) Dehydrating breather in lieu of plain breathing device.
(b) Filter valve (1-1/4" nominal size thread).
(c) Thermometer pocket (For transformers of rating 25 KVA and below).
(d) Draining-cum-sampling plug on transformers without conservators.
(e) Filling hole with cover on transformers without conservators.

19.14.2 Indoor type naturally cooled oil immersed transformers shall conform to IS 2026 (Part I) 1977, Specification for power transformers. Preferred KVA ratings are 6.3, 10, 25, 40, 63, 100, 160, 250, 400, 630 & 1000 KVA.

19.14.2.1 This type of transformer shall be provided with the following fittings :

(a) Rating plate and terminal marking plate.
(b) Two earthing terminals for body earthing and two additional for neutral brought out on a bushing.
(c) Lifting lugs.
(d) Drain valve with plug or cover plate on 25 KVA and above.
(e) Dehydrating breather on 25 KVA and above for rated voltage 11 KV and below; and for all ratings above 11 KV.
(f) Oil level indicator with minimum and maximum Marking.

(g) Cooling Radiator.
(h) Thermometer pocket.
(i) Conservator on 50 KVA and above for rated voltage 11 KV and below; and for all ratings above 11 KV.
(j) Oil filling hole with cover.
(k) Air release device on all transformers fitted with conservators.
(l) Jacking lugs on transformers above 1600 KVA.
(m) Filter valve on transformers above 1600 KVA.

19.14.2.2 The following fittings shall be provided as extra if indicated :

(a) Filter valves ___________________ 1600 KVA and below
(b) Rollers _______________________ Details of rollers to be indicated
(c) Thermometer 100mm dial/stem type with metal guard having maximum temperature indication with resetting device for transformer having capacity 250 KVA and above.
(d) Additional thermometer pocket
(e) Winding temperature indicator
(f) Explosion vent for transformer having capacity more than 400 KVA.
(g) Gas and oil actuated relay
(h) Skids
(i) Inspection cover ______________ 1600 KVA and above.
(j) Facility to connect BUCHHOLTZ relay for transformer having capacity more than 800 KVA

19.14.3 Fittings and Accessories of Transformers shall conform to IS 3639-1996, Specification for fitting and accessories for power transformers.

19.14.4 BLANK

19.14.5 Transformer 33KV/11KV

19.14.5.1 Power transformers shall comply with the requirement of IS: 2026 (Part-I) 1977 (General), IS: 2026 (Part 2)-1977 (Temperature Rise), IS: 2026(Part 3) 1981 (Insulation level and dielectric tests) and IS: 2026 (Part 4) (Terminal marking tapping and connections) as modified herein. The transformers shall be suitable for supplying mixed power and lighting loads. Primary winding (HV Side) shall be suitable for Delta connection whereas secondary winding (LV Side) shall be suitable for Star with neutral.

19.14.5.2 The transformers shall have continuous maximum ratings at specified normal pressure rated frequency and temperature. These shall be capable of carrying sustained overload as specified in IS : 2026 (Part I, 3, 4) and shall be suitable for vector group DYN-11.

19.14.5.3 The transformer shall be provided with 'ONLOAD' Tap changer (OLTC) with automatic voltage regulation (AVR) in suitable steps/positions on HV side to take care of variation in voltage on HV side to give output of 11 KV on LV side. The OLTC system with AVR shall be so designed to facilitate automatic voltage regulation as well as remote controlled arrangement for changing the Tap position on Load from the Control panel to be installed inside the substations.

19.14.5.4 The No load and Full load losses shall not exceed the values recommended by Central Board of Irrigation and Power (CBIP) and impedance shall be 7.15% plus tolerance as per IS.

19.14.5.5 Transformer tank shall be sufficiently strong to allow transportation, of each transformer complete with tank and with oil by rail, road, jacked or lifted with out causing deformation and leakage of oil. The tank shall be made of mild steel plates of suitable thickness and shall be provided with external cooling tubes. Care shall be taken to ensure that the joints between the tubes and body of the tank are oil tight. The transformer shall be provided with four solid cast steel bi-directional reversible, detachable rollers to facilitate transporting the transformer to and from its point of installation. The transformer shall be provided with approved arrangement of lugs suitable for lifting the transformer with necessary fittings and complete with first fill of oil. The transformer tank cover shall be so designed as to prevent the collection of moisture on any part. The tank cover shall also be fitted with thermometer pocket.

19.14.5.6 The transformer shall be fitted with conservator vessel with oil filling cap, cap drain valve with plug and magnetic oil gauge with alarm contacts.

19.14.5.7 The dehydrating breather shall be fitted to each concentrate vessel and shall be complete with first fill of dehydrating agent.

19.14.5.8 Transformer shall be provided with one number of pressure relief valve connected directly to main tank top and designed for certain and rapid release of any excessive pressure in the tank due to internal fault that may be generated in the transformer or in the cooling equipment. The pressure relief valve shall be reset to normal after release of the pressure. To prevent any dirt or insect entry inside pipe, the free end shall be fitted with a wire mesh.

19.14.5.9 The transformer oil shall conform to IS 335 of 1993. The thermometer fitted on the transformer shall be 150mm vapour pressure type, having range of 0-120C with reading pointer. It shall be fitted with maximum temperature indicator with resetting device and alarm contacts. One thermometer each shall be provided to indicate the temperature of oil and windings.

19.14.5.10 All the valves are of standard type and makes. Means shall be provided to lock the valves. Every valve shall be provided with an indicator to show clearly purpose of the valve and directions of rotation to 'OPEN' or "CLOSE".

19.14.5.11 Earthing terminals shall be provided on the tank cover and the tank for earthing purposes. Terminals on the tank cover and tank shall be suitable for connections to the earthing strip of Gl of 50mmx6mm section. Separate Neutral bushing shall be provided for earthing.

19.14.5.12 The NO-LOAD voltage ratio corresponding to the principal tapping shall be 33/11 KV (33000/11000 Volts).

19.14.5.13 Transformers shall be provided with HV outdoor bushing insulators on 33 KV side and on 11 KV side. Bimetallic type connectors for vertical take of suitable for ACSR / Aluminium conductors shall be provided on 33 KV bushing.

19.14.5.14 The electrical characteristics of bushing insulators shall be in accordance with IS: 2099-1986 as amended from time to time. All tests (type and routine) shall be carried out in accordance with the above-mentioned IS at manufacturers workshop and certificate furnished to GE.

19.14.5.15 The dimensions of bushing on 11 KV side shall conform to IS: 3347 (Part 3)-1973 and those of 33 KV side shall conform to 1S:3347 (Part 4) 1973 or the latest versions thereof.

19.14.5.16 All the transformers shall be deemed to have undergone satisfactory tests as specified in IS: 2026 (Part 1, 2, 3 and 4). The tests certificate shall be furnished to GE for these tests.

19.14.5.17 All electrical installations shall comply with the requirements of Indian Electrical Act and Rules. The following rules of Indian Electricity Rules 1956 are particularly applicable: - 35, 45, 50, 51, 59, 61, 62, 63, 64, 65, 67, 68, 69 and 114.

19.14.6 On-load Tap Changers For 33/11 KV Transformer

19.14.6.1 ON-LOAD tap changers shall comply with IS : 8468-1977 or the latest version thereof. For oil as cooling medium, the on-load tap changers shall be suitable for operation over a temperature range of 5^0 C to 100^0 C when the ambient temperature is 50^0 C.

19.14.6.2 The motor drive mechanism shall be suitable for operation in any ambient temperature between 5^0 C to 50^0 C. The motor drive mechanism shall be suitable for working voltage as per manufacturer standard practice.

19.14.6.3 The ON-Load tap changer (OLTC) chamber shall be position in such way as to ensure that oil in OLTC chamber does not get mixed up with oil in the main tank. Contacts of OLTC shall be easily accessible for repair/replacement.

19.14.6.4 Suitable oil surge relay shall be provided on OLTC chamber. The relay shall have only an oil surge float and shall not have an alarm float. An oil level gauge shall be provided in the OLTC chamber.

19.14.6.5 The tap chamber and its motor drive mechanism shall have separate nameplates fitted in clearly visible positions. The name plate shall be marked in accordance with IS : 8468-1977 or latest version thereof.

19.14.6.6 Suitable indicating device shall be provided to show the positions of the tap. The indicator shall be located in such a position that it shall be easily visible through window even when the motor drive cubicle is closed.

19.14.6.7 Following controls are to be provided in the OLTC: -

(a) The motor drive mechanism shall incorporate mechanical and electrical limiting device to prevent over running of the drive mechanism.
(b) Necessary provision shall be made to check against more than one tap changing operation being performed at a time.
(c) Suitable devices (thermal or other suitable devices) shall be provided to protect the motor and control circuits. All relays, switches, fuse etc shall be mounted in driving gear housing and shall be clearly marked for purpose of identifications.
(d) All relays and operating devices shall operate correctly at any voltage between the limit specified in the relevant Indian Standards. The devices for which an auxiliary DC supply is required shall be suitable for 30 volts DC.
(e) Cubicle lighting with necessary control switch shall be provided in the driving gear housing. Heater to prevent condensation of moisture shall also be incorporated.

19.14.6.8 Tests as specified in IS 8468-1977 or latest edition Type and Routine tests shall be carried out as per manufacturers instruction. The contractor shall provide test certificate from the manufacturers as per IS: 8468-1977 or latest edition before installation of the equipment.

19.15 Isolators

The oil and air break AC isolators for rated voltage above 1000 volts for indoor and outdoor installation shall conform to IS 9921-1985 Specification for alternating current isolators (disconnectors) and earthing switches.

19.16 Expulsion Fuses

Shall comply with IS 9385 (Part 2)-1980, Specification for high voltage expulsion fuses and similar fuses.

19.17 Line Connectors

Line taps, aerial fuses, link fuses, safety devices, guards and anti-climbing devices for HT lines shall be of approved make and shall be provided as directed.

19.18 Danger Notice Plates

The plate shall be made from mild steel sheeting at least 1.6 mm thick and vitreous enamelled white, with letters, figures and the conventional skull and bones in signal red colour on front side. The rear side of the plate shall also be enamelled. The size of danger plate shall be 200x150 mm for medium voltage installation land 250/200 mm for high and extra high voltage insulations. The danger notice plate shall comply with IS 2551-1982 Specification for danger notice plates.

19.19 Power Cables

Power cables suitable for LT and HT supply shall conform to the following Indian Standards as indicated. The characteristics of the cables viz. the size of the conductors, single core, twin-core, three core or multi-core, whether armoured or unarmoured, type of insulation and sheathing and the rated voltage of the cables shall be as indicated :

(a) IS 692-1994, Specification for paper insulted lead-sheathed cables for electric supply.
(b) IS 1554-(Part 1)-1988, Specification for PVC insulated (heavy duty) electric cables, Part 1 for working voltage upto and including 1100 volts.
(c) IS 1554-(Part 2)-1988, Specification for PVC insulated (heavy duty) electric cables. Part 2, for working voltages from 3.3 KV upto and including 11 KV.
(d) IS 7098 (Part 1)-1977 and Part 2-1985 (XLPE) insulated PVC sheathed cables.

19.19.1 HT Cables

19.19.1.1 All HT cables shall be of three core aluminium conductors, XLPE insulated, armoured and conforming to 1S-7098 (Part-2)/1985. These cables shall be suitable for Earthed system.

19.19.1.2 The aluminium conductor used in HT Cables shall be stranded, compacted and round to achieve minimum electrical stresses.

19.19.1.3 The aluminium conductor shall have a semi-conducting layer of XLPE of suitable thickness wrapped in such a way that it covers the conductor entirely.

19.19.1.4 The main insulation shall be of cross linked polyethylene (XLPE) in natural colour and shall be free of air voids and foreign materials.

19.19.1.5 The main insulation shall be covered with another layer of semi conducting layer followed by copper Tape to provide suitable earthing around the each core to keep the electrical stresses radial.

19.19.1.6 Each core shall have a numbered/coloured polyester tape applied over the copper tape for identification of all the three cores.

19.19.1.7 Inner sheath over the laid up cores shall be of thermoplastic extruded type and armouring over the inner sheath shall be of galvanised steel wire or strips of adequate size to give mechanical protection and PVC FRLS (Flame Retardant Low Smoke) outer sheath over the armour shall also be of adequate thickness all as specified in the IS.

19.19.1.8 The XLPE cables shall be suitable to with stand maximum conductor temperature of 90^0 C and 250^0 C during operation and short circuit respectively and these cables shall be manufactured by triple extrusion using single (Common) cross head extrusion technique and dry cure inert gas cured cross linking process.

19.19.2 LT Cables

19.19.2.1 All LT cables shall be of 2/3/3 ½ or 4 core aluminium conductors, XLPE insulated heavy duty and suitable for 1100 volts grade and conforming to IS-7098 (Part-1 - 1988).

19.19.2.2 The aluminium conductors used shall be stranded, compacted and circular/shaped and the main insulation shall be of cross linked polyethylene (XLPE) with inner sheathing PVC extruded and each core of the cable shall have colour identification all as specified in IS.

19.19.2.3 Armour over the inner sheath shall be either of strip or wire type and outer sheath shall be of Extruded PVC conforming to ISS.

19.19.2.4 The cables shall be suitable to withstand maximum conductor temperature of 90^0 C and 250^0 C during operation and short circuit respectively.

19.20 Precast Concrete Cable Covers

Precast concrete cable covers shall comply with IS:5820-1970, Specification for precast concrete cable covers and shall be of class and type as indicated. The concrete used in the manufacture of cable covers shall be of a grade not lower than M-20.

Class	Type No.	Description of cable over	Minimum average breaking load for unreinforced covers kg	Size L.	Size W.	Size T.	Condition where normally used
1	2	3	4	5			6
EHV	1	Reinforce precast concrete with peak	450	450	230	50	For underground power cables of voltage rating 22 KV and 33 KV
	2	Ditto	750	600	230	50	
HVP	1	Un-reinforced pre-cast concrete with peak	300	300	180	40	For power cables of voltage rating above 11 KV excluding 22 KV and above
	2	Ditto	350	450	180	40	For power cables upto and including 11 KV
HV	1	Un reinforced pre-cast concrete flat	300	300	180	40	
	2	Ditto	350	450	180	40	
LV	1	Un-reinforced pre-cast concrete flat	200	250	150	40	
	2	Ditto	200	300	180	40	
	3	Ditto	200	450	180	40	

19.21 Distribution Pillars

Distribution pillars shall be as per IS:5039-1983, Specification for Distribution pillars for voltages not exceeding 1000 volts. These shall be double pole and neutral link, triple pole or triple pole and neutral link type 4, 6, 8 and 10 ways.

19.21.1 For single phase and three phase system rated voltages of 240 volts and 415 volts are preferred. Outgoing or incoming current of distribution pillars shall be 160, 200, 250, 400 and 630 amperes as indicated. Unless otherwise specified the sum of the rated current of the incoming circuits shall be fixed at the 2/3 of the sum of the current ratings of outgoing circuits, rounded upto the nearest higher value of the preferred current.

19.21.2 Construction

It shall be fabricated out of MS sheet, thickness 3.15 mm suitable for outdoor type.

19.21.3 Canopy

The top of pillar shall be fitted with a sloping canopy so that rain water shall not accumulate on the top.

19.21.4 Distribution pillars shall have a set of double hinged doors at the front. Similar doors shall be provided at the back if indicated. The hinges shall be such that the doors can be swung open by not less than 150'. The hinged design shall permit the doors being completely removed when necessary.

19.21.5 Locking

The doors shall be provided with a suitable locking arrangement.

19.21.6 Apron

It shall be provided with aprons. They shall be easily removable. Thickness of sheet shall be 3.15 mm.

19.21.7 Corrosion Protection

It shall be suitably protected against corrosion.

19.21.8 Rating of Bus Bar

Unless otherwise specified, the rating of the phase bus bars shall take into account the diversity factor given below. The current carrying capacity of the neutral bus bar for DPN and TPN pillars shall be half that of the phase bus bar. In the case of bus bars having a center feeding point it is permissible to have a phase bus bar rating which is 50 percent of the normal rating.

19.21.9 Rated Diversity Factor

The rated diversity factor of the distribution pillar having several incoming and outgoing circuits is the ratio of the maximum sum at any time, of the assumed currents of all the circuits involved, to the sum of the rated currents of all the circuits of the distribution pillars.

Conventional values of Diversity Factor	
Number of fuse ways	Diversity Factor
2 and 3	0.9
3 and 5 .	0.8
6 and 9 inclusive	0.7
10 and above	0.6

19.22 Cable Termination And Joint Kits

19.22.1 Cable Termination and Joint Boxes

Cable boxes for straight through and termination joint shall be in the form of "Kits" with jointing instructions and literature/test certificate. The kit shall also carry the name of manufacture, date of manufacture and expire date on the kit also size type and or cable for which suitable.

19.22.2 Cable Termination Accessories

All the cable termination accessories such as cable sockets, compression joint sleeves, conducting jellys, cable glands reducing bushes and check nuts etc. shall be best quality available or as indicated.

19.23 Low Voltage Switching Stations and Distribution Panels

Reference is drawn to the requirement stipulated in IS : 10118 (Part 3)-1982 Code of Practice for selection, installation and maintenance of switchgears and control gears.

19.23A. Synthetic Insulating Mat/Sheet For 11 KV & 33 KV Electrical Systems

19.23A.1 The mat shall be made from synthetic insulating material, free from any insertions leading to deterioration of insulating properties. The upper surface of insulating mat shall have small aberration (Rough Surface) without edges to avoid slippery effects. The lower surface shall be plain.

19.23A.2 The material shall be free from blisters, pinholes, cracks, embedded foreign matter and other defects when visually examined. The mat shall be fire retardant & self extinguishing and the fire shall extinguish within 5 seconds after removal of flames. The mat shall be of Blue colour and pasted on the floor after necessary preparation of surface including water proofing of floor and sealing of all joints as per manufacturer's recommendations.

19.23A.3 The length of the mat/sheet shall be in multiple of 5 Mts. (Min) and width shall be preferably not less than 900 mm plus / minus 20 mm . The thickness of mat shall be of 2.5 mm plus/minus 10% and shall be permanently pasted in the rear & front of the system upto 3 meters subject to the availability of the space in the substations.

19.23A.4 The tensile strength and the Elongation at break of the rubber shall be as follows :-

(a) Min Tensile strength	: 15 N/mm2
(b) Elongation at Break :	
(i) For use under temp more than 4 degree C	: 250%
(ii) For use under all temp condition including Subzero temp	: 300%

19.23A.5 The Tensile strength and Elongation at break of the test samples when subjected to ageing for 7 days at 70 +1C shall not exceed the following limit of the corresponding values obtained before aging:-

Characteristic	% change from original value
(a) Tensile strength	+ 10% - 25%
(b) Elongation at Break	+ 10% - 25%

Effects of Acid, Alkaline, Diesel and transformer oil to Tensile strength and Elongation shall be within plus/minus 20% of actual value.

19.23A.6 Electrical Properties
The mat shall have minimum insulation resistance with water (i.e. wet condition) of 10,000 Mega ohms when measured with 5,000 volts Megger. Similarly Leakage Current shall be below 10 MA when tested at rated system voltage. The mat shall have minimum Dielectric strength of 30 KV.

19.23A.7 The contractor shall submit the following test certificates from CPRI:-

(a) Type Test report for Break test report for Breakdown test, Leakage current test etc. as per IS - 8437.
(b) Flame extinguishing & Flame retardant test and effect of acid.

19.23B High Mast Lighting System

19.23B.1 High mast lighting system shall be designed, supplied, installed, tested and commissioned to give average illumination level of 25 lux for non essential supply and 7 lux for essential supply . The quantity of High masts and luminaries etc shall be as per requirement and technical data for High mast and components.

19.23B.2 The permissible head load shall have direct relation to the projected area of the luminaries mounted on the top. The tower shall be designed to carry head load of 1.2 sq mtr of projected area in the condition of maximum wind exposure existing at the station as listed in IS : 875 **Part 3** 1987,

19.23B.3 The easy portability of the complete equipment shall be ensured by mounting these extendible tower sections on a trolley fitted with pneumatic tyres with leaf springs, which also eliminates the shocks Lantern Carriage shall be suitable to mount 4 Nos. Luminaries symmetrically or in one side depending on the lighting requirement. The lantern carriage shall have arrangement to rotate 360 degree manually.

19.23B.4 The mobile lighting mast system shall be rugged in design telescopic tubular structure consisting of Two/Three sections. These sections shall be extendible to any height upto 9 meters. The telescopic and tilting action of the tower shall be controlled by winch separately for tilting, raising and lowering of tower sections. The motorised winches will be operated by remote control provided with distribution board. The winch used in the system shall be fully self-sustaining without the use of brake or ratchet and pawl to ensure elimination of chances of accidents during the tilting, raising and lowering of the telescopic towers.

19.23B.5 Two separate sets of Galvanised steel wire ropes for tilting and telescopic operation shall be provided. These wire ropes shall be 10mm dia minimum and of 7 x 37 (or 7 x 19) construction and shall be extremely flexible for bending over small pulley radius. The pulleys shall be constructed from carbon steel with bronze bush.

19.23B.6 The individual tower sections shall be designed with the help of extensive structural calculations for optimum sizes of the tower frame, mobile chassis and outriggers. These shall withstand extreme wind gust speed prevailing in the area of installation for duration as specified in IS : 875 to support the head load area specified.

19.23B.7 No hydraulic shall be provided in the equipment to make it more simple and robust and all operations of raising and lowering, folding and tilting of tower sections shall be affected with the help of motor operated winch and rope system to ensure minimum maintenance and leakage of oil etc under the deteriorating site conditions.

19.23B.8 Provision and supply of spirit levels shall be included to ensure vertical and horizontal leveling of the chassis outriggers and structure with respect to each other to avoid unrelated development of fatigue stresses due to eccentric centre or gravity.

19.23B.9 A universal mounting arrangement shall be provided for mounting of diesel generating set and control panel to make the equipment's self sufficient in its energy requirement.

SUB SECTION B-INTERNAL ELECTRICAL WORK

19.24 Cables, Cords and Earthing Leads

Cables and cords shall be from fresh stocks and shall be of approved make. Earthing lead shall of solid copper conductor of size 1.5 sqmm.

19.24.1 The minimum sizes of Multistranded conductor cables shall be as under :-

(a) Lighting and fan circuit cables 1.5 sq.mm nominal area.
(b) Power circuit cables 4 sq.mm nominal area.
(c) Submain cables 4 sq.mm area.
(d) Earthing lead 4 sq.mm area.

19.24.2 The capacity of the current shall be as under :

(a) The light and fans may be wired on a common circuit. Such circuit shall not have more than a total point of light, fan and light socket outlet or a load of 800 watts, whichever is less.

(b) The power circuit shall be designed with a maximum two outlets per circuit.

(c) Wherever the load to be fed is more than 1 KW, it shall be controlled by an isolator switch or miniature circuit breaker.

19.25 Cable for internal wiring for light, power and submains

Shall be with multi stranded copper conductors and shall be of the following types as indicated:

(a) Wiring on TW battens

(i) PVC single core sheathed, cables or flat twin core sheathed cables 1100 volts grade Conforming, to IS :694-1990, Spectification for PVC insulated sheathed or unsheathed cables for working; voltages upto 1100 volts, with aluminium conductors.

(ii) Single core cable, polyethylene insulated and PVC sheathed conforming to IS :1596-1977, specification for polyethylene insulated cables for working voltage upto and including 1100 volts.

(b) Wiring in conduit, surface or concealed PVC Curing Caping double tock type

(i) Single core PVC insulated unsheathed cable upto 1100 volts grade conforming to IS : 694-1990

(ii) For the purpose of colour coding in conduit wiring in particular the samples for make and colour of insulation of wires shall be got approved before the wires/cables are procured and drawn into conduit. Red/yellow/blue wires for phases, black wire for neutral and green wire for earth shall be used wiring in conduit without coding will not be acceptable. Wire/cables shall be 1100 volts grade single core conforming to IS :1596-1977 or IS: 694-1990.

19.26 Weather Proof Cables

Weather proof cables for house service connection shall be single core or twin flat with aluminium conductor conforming to IS 9968 (Part 1)-1988 or IS :694-1990 as indicated.

19.27 Flexible Cords, Twisted, with Copper Conductors

Flexible cords for pendent light points twin core, each with tinned annealed stranded copper conductor elastomer insulated and textile braided and twisted together, size nominal cross sectional area 0.5 sq.mm shall be as per IS :9968 (Part 1)-1988.

19.28 Wooden Battens Blocks and Boards

19.28.1 Wooden battens shall be of well seasoned timber complying with specifications for timber for joinery work vide Section 8. Wooden battens, unless otherwise indicated, shall be of teak-wood. Battens shall be wrought on all exposed surfaces and coated twice all over with shellac varnish before erection and another coat after erection to the exposed surfaces. The shellac varnish used for this purpose shall comply with IS 347-1975, Specification for varnish, shellac for general purposes. The finished thickness of batten shall be not less than 10 mm and width of the batten shall such as to suit the total width of cables to the laid thereon.

19.28.2 Wooden boards shall be of seasoned teak wood, unless otherwise indicated, and shall be of substantial design; and exposed edges shall be rounded or chamfered as directed. They shall be dovetail jointed. The thickness of face and back of boards shall be not less than 6 mm and sides not less than 20 mm. The size of the boards shall be suitable for the accessories to be mounted thereon so that accessories are neatly and conveniently mounted.

The holes for screws shall be drilled and prepared for countersinking of screws. The board shall be finished with 2 coats of shellac varnish.

19.28.3 Round Blocks

Round blocks shall be of teak wood, unless otherwise indicated, double or single as indicated, and varnished. Minimum size of blocks shall be 40 to 50 mm thick and 80 to 100 mm in diameter, or of any size, as indicated.

19.29 Conduit and Conduit Fittings

All conduit and conduit fittings and accessories shall be of rigid steel conduit or rigid non metallic PVC conduit as indicated and shall comply with the following Indian Standards. Rigid Steel conduits shall be solid drawn or seamed by welding and with stove enamelled black or galvanised finish as indicated.

(a) IS 3837-1976 Specification for accessories for rigid steel conduit for electrical wiring.
(b) IS 2667-1988 Specification for fittings for rigid steel conduits for electrical wiring. The conduit fittings shall be made of steel, cast iron or malleable cast iron. Malleable iron casting shall be well annealed.
(c) IS 3480-1966 Specification for flexible steel conduit for electrical wiring.
(d) IS :4649-1968 Specification for adaptors for flexible steel conduits.
(e) IS :3419-1988 Specification for fittings for rigid non metallic conduits. Conduit fittings shall be of unplasticiscd PVC.
(f) IS 9537-1981 Part 2-Rigid steel conduit.
(g) IS 9537-1983 Part 3-Plain rigid conduit of insulating material.

19.30 Wooden plugs (Gutties) and Rawl plugs

All wooden plugs shall be seasoned hardwood not less than 5 cms long 2.5 cm square on inner face and 2 cms square on the outer exposed face. These shall be fixed securely as the work proceeds in the structure subsequently as indicated, cemented and finished flush with the surface. Rawl plugs or epoxy resin Phill plugs or metallic split hammered type plugs manufactured by number of proprietary firms may be used as alternative when so indicted and fixed as per manufacturer's instructions.

19.31 Screws and Fastenings

All screws shall be of alloy aluminium or cadmium plated iron unless otherwise indicated.
Link Clips:- Joints link clips shall be of aluminium conforming to IS 2412-1975, Specification for link clips for electrical wiring.

19.32 Ceiling Rose

Ceiling rose shall be surface type and shall comply with IS :371-1979, Specification for ceiling roses having two or three terminal plates and of outside diameter not less than 63.5. mm. Ceiling roses shall be provided, with means for gripping flexible cord which shall not damage the insulation and/or sheath of the cord and shall be such that the load on the cord is not transmitted to the terminals.

19.33 Shades

Metal shades shall be well finished in vitreous enamel, blue or green or white outside and while inside. Glass shades shall be heat resistant frosted/opaque type and shall be true in shape, free from flaws, specks or bubbles and shall be uniform in thickness, free from sharp edges and uniform in colour.

19.34 Bulk Head Fittings

These shall be robust in construction, made from cast iron, pressed steel or cast aluminium and fitted with Porcelain lamp holder, vitreous enamelled reflectors and hinged water tight front with key and wire or pressed metal guards.

19.35 Fluorescent Tube Lamps, Fittings and Accessories

Shall comply with the following Indian Standards ;

- i. IS-1569-1976 Capacitors for use in tubular fluorescent, high pressure mercury and low pressure Sodium vapour discharge lamp circuits.
- ii. IS-1777-1978 Industrial luminaire with metal reflectors.
- iii. IS-2215-1983 Starters for fluorescent lamps.
- iv. IS-2418-(Part 1 to 4)-1977 Tubular fluorescent lamps for general lighting service,
- v. IS-3323-1980 Bi-pin lamp holders for tubular fluorescent lamps.
- vi. IS-3324-1982 Holders for starters for tubular fluorescent lamps.
- vii. IS-3287-1965 Industrial lighting fittings with plastic reflectors.

19.35.1 Compact Fluorescent lamp, fitting and Accessories

These fittings shall be of standard make and shall be complete with lamp, lamp holder, fitting with reflector, choke, capacitor of appropriate size and quantity complete with eletrical connections.

19.36 Mercury Vapour Lamp with Fittings

These fittings shall be of standard type of approved make and shall be complete with mercury vapour lamp, lampholder, fitting with reflector, choke and starter of appropriate size and quantity, complete with electric connections.

19.36.1 Sodium vapour lamp with fittings

These fitting shall be of standard make and shall be complete with lamp, lamp holder fitting with reflector, chock, capacitor of appropriate size and quantity complete with electrical connection.

19.36.2 Metal Hallied lamp and fittings

These fittings shall be of standard make and shall be complete with lamp, lampholder, fitting with reflector, choke, capacitor of appropriate size and quantity complete with electical connection.

19.37 Tumbler Switches

These shall be of single pole; one way or two way, quick make and break type with phosphor bronze contacts, 5 or 15 amps, 250 volts; with or without porcelain base, surface or flush type as indicated and conforming to IS 3854-1966 Specification for switches for domestic and similar purposes.

19.38 Sunk Type Boxes

Boxes for housing electrical accessories and recessed into a wall or ceiling shall be of sheet steel or cast iron as indicated and shall conform to IS 14772-2000. General requirement for enclosures for accessories for house hold and similar fixed electrical installations. The boxes shall also be suitable for surface mounting. C.I. boxes shall be galvanised or painted black with two coats of black bituminous paints or any other paint as indicated and steel sheet boxes painted with one coat red oxide primer and two coats finishing as indicated in case of surface mounting. Terminal boxes shall be covered with Bakelite sheet 3mm thick. Boxes shall be earthed.

19.39 Water Tight Switches

The switch conforming to IS 3854-1966 shall be mounted in a galvanised cast or malleable iron conduit box provided with lever and on/off handle. The box shall be provided with fixing lugs. The cover shall be provided with rubber washer and stuffing box gland. On/off positions shall be clearly marked on the cover.

19.40 Socket outlets

Socket outlets, surface or flush type, 5 or 15 amp, 250 volts shall be three pin shuttered/non shuttered or interlocking type as indicated and shall comply with the following Indian Standards

i. IS 1293-2005 Specification for 3 pin plugs and socket outlets,
ii. IS 4615-1968 Switch socket outlets (non interlocking type).
iii. IS 4160-2005 Specification for interlocking switch socket outlets.

19.41 Lamp Holders

Lamp holder shall be metal cased type or insulated type as indicated and shall comply with IS 1258-2005 Specification for bayonet lamp holders. Lamp holders shall be suitable for fixing in pendent or to bracket or angular as ordered.

19.42 Street Light Fittings

Shall be of cast aluminium housing and shall comply with the requirements of IS 2149-1970, Specification for luminaries for street lighting.

19.43 Watertight Lighting Fittings

Shall comply with the requirements of IS 3553-1966, Specification for watertight electric lighting fittings.

19.44 Distribution Fuse Boards and Cutouts

Distribution fuse boards and cutouts shall be metal clad/iron clad complying with IS 2675-1983 Specification for enclosed distribution fuse boards and cutouts for voltage not exceeding 1000 V. These are rated for 240 and 415 voltages for single phase and three phase AC systems. Current rating of fuse wire shall be 6, 16, 25, 32, 63 or 100 amps as indicated. The distribution fuse boards shall be single pole (SP) or cutout, single Pole and neutral (SPN), double pole (DP), triple pole (TP) and triple pole and neutral (TPN) as indicated. The distribution fuse boards shall be marked with rated voltage, total number of outgoing fuse ways and number of poles and rated current of outgoing fuse ways.

19.45 Switch Fuses (Main Switch)

For use in distribution circuits and motor circuits shall be metal clad enclosed pattern and shall comply with IS 13947: Part 3/2607 and 4047, Specification for air break switches, air break disconnectors, air-break switch disconnectors and fues-combination units for voltages not exceeding 1000 V, AC or 1200 V, DC,; Part I General requirements and Part II specific requirements for the direct switching of individual motors. The fuses used in the switch shall conform to IS 2086-1993. Specification for carriers and bases used in rewireable type electric fuses upto 650 V. The current rating of fuse carrier and fuse bases shall be 6, 16, 32, 63, 100 and 200 amp and rated voltage of 240 and 415 V as indicated. Iron clad switches shall be marked with rated voltage and current.

19.46 Miniature Circuit Breaker

Miniature Air Circuit Breakers shall conform to (IS -8828 -1996) Specification for miniature air circuit breakers for AC circuits for Voltages not exceeding 1000 volts.

Note:- These are used in place of mains switches distribution boards of single pole, double pole and triple pole having the standard rating of 5, 10, 15, 20, 30, 40, 50 and 60 amp and 250/440 volts.

19.46.1 MCB Distribution Boards

19.46.1.1 Distribution boards shall be factory made and conforming to IS : 8623 suitable for universal mounting copper busbar, Neutral bar, Earth bar, Standard DIN bar Rail and cable ties for cable management. Top and bottom shall have removable gland plates with knock outs.

19.46.1.2 SPN Distribution boards shall be suitable for provision for DP/SPN MCBs/isolators as incomer and SP outgoings all as specified and shall be flush mounting type. The degree of protection shall be IP -42 protection with acrylic door .

19.46.1.3 TPN Distribution boards shall be suitable for FP/TPN MCBs/Isolator as in comer and TPN/SP outgoings all as specified and shall comply with IP-42 protection with metal door.

19.46.2 MCBs - All MCBs shall be conforming to IS-8828 of 1996 and shall be ISI marked. These shall be suitable for ‘C curve and 10 KA Breaking capacity and shall be provided with box terminal on top and bottom both suitable for adopting cable size upto 35 Sqmm. The enclosure of MCBs shall be of’Moulded Self Extinguishing thermo set plastic and these shall be suitable for snap fixing on standard Din Rail.

19.46.3 MCBs Isolators - All MCB type isolators shall conform to IS : 13947- Part3, 1993 and shall be suitable for impulse voltage of 6 KV and short time with stand capacity of 1000 amps for 0.3 seconds.

19.46.4 Plug and Socket DBs - Plug and socket Distribution Boards including SP/DP MCBs for protection of appliances like window type/Split type Air conditioners and Geysers shall only be provided. All these plug and socket DBs shall be of Universal mounting type.

19.47 BLANK

19.48 Change Over Switches

19.48.1 All the changeover switches shall be suitable for 415 volts, 3 phase, 50 Hz AC supply and shall be FOUR POLE ON LOAD type, manually operated and conforming to IS : 13947 (Part-3) - 1993. It shall have high thermal and dynamic strength to with stand rated short circuit current level of 80 KA rms.

19.48.2 The changeover switches shall be of compact design with body made from fiberglass reinforced polyester. It shall have very high mechanical strength, self extinguishing and high dielectric strength properties. All current carrying parts shall be silver plated and suitable for tropical conditions (relative humidity 95%, 45 degree Celsius).

19.48.3 The switches shall incorporate quick make and quick break feature independent of the operating speed enabling the switch to closed and open circuits under the most severe conditions i.e. highly inductive load. The contacts making and opening shall be within polyester reinforced glass body.

19.48.4 Operating handle of switches shall be in front position. It shall be strong and ergonomic and pad lockable in 'OFF' as well as in I and II position and shall also have door inter lock feature in 'ON' position.

19.48.5 Switch shall have three stable position (I, O & II) and possible changeover from one to the other while functioning as given under:-
Position 'O' - Circuit I and II open (Neutral position)
Position 'I' - Circuit I close and Circuit II open (Transformer supply ON and generator supply OFF)
Position 'II' - Circuit I open and circuit II close. (Generator supply On and Transformer Supply OFF).

19.48.A TY Socket

TV Socket compatible with reception of antena satellite and cable net work signals 9.5mm dia connector TV female for coaxial cable and PVC conduit in external wall of the building shall be provided in these hoxes

19.48.B Telephone Connection

Socket with connecealed conduit and telephone cable upto the external wall of buildings. PVC insulated PVC sheathed unarmaured annealed tinned copper conductor with tape and thread as per ITD.

G/WIR -06/02,0.50mm dial one pair telephone cable shall be provided

19.48.C Meter Boxes/Switch Boxes

MS sheet type meter boxes/switch boxes shall be used. No wodden component shall be provided in these boxes.

19.48.D Exhaust Fan

225mm sweep fresh air fan with limit in wiremesh/louvers shall be provided as indicated.

19.48.E Geysers

Geysers shall be of standard make ISI marked vertical type and installed with following:

(i) Plug and socket with 16amp MCB SPN
(ii) Vent pipe
(iii) Furible plug
(iv) Pressure reducing value in case of multistoreyed buildings
(v) Safty Value
(vi) Proper earth connector

19.49 General

Lighting of public thorough fares-shall be carried out as described in IS 1944 (Parts I & II)-1970 Code of practice for lighting of public thorough fares. Electrical wiring installations where system voltage exceeds 650 volts shall be carried out as described in IS 732 (Parts I & 3)-1989. Code of practice for electrical wiring installations (system voltage exceeding 650 volts).

WORKMANSHIP

SUB SECTION A-EXTERNAL ELECTRIFICATION

Overhead Power Lines

19.50 Poles

Steel tubular poles, wood poles or prestressed concrete poles, as indicated, shall be used for overhead power lines upto 11 KV. '

19.51 Foundation

A hole 1.2x0.6 m. unless otherwise indicated, shall be made in the direction of line. The depth of the pit shall be in accordance with the length of the pole to be planted in the ground as given in respective Indian Standards, normally 1/6 of the length of pole shall be buried under ground.

19.51.1 Poles shall be so positioned in the foundations that the bigger section modulus of the pole is always transverse to the length of the line.

19.51.2 Steel Tubular and Prestressed Concrete Poles:- A pad of cement concrete shall be provided at the bottom of the pit before the pole is erected. The pole shall then be encased in cement concrete, the foundation being continued upto 20 cm above ground level and tapered to form a collar. The mix and size of concrete foundation shall be as indicated. The excavated earth shall be refilled around concrete foundations and consolidated.

19.51.3 Wood Poles

Wood poles shall not be concreted or provided with a concrete collar at the ground level. The portion of wood poles below ground shall be painted with bitumen. After a wood pole is erected the pit shall be partially filled with brick bats or large gravel pieces and rammed well with a crowbar. Thereafter, earth filling shall be done and consolidated.

19.51.4. After the first rainy season, foundations of the poles shall be inspected and the pits back filled with earth consolidated wherever the filling has sunk.

19.52. Erection of Poles

Heavier poles are generally erected by the derrick pole method while lighter poles are normally erected by the dead-man's method. Details of these methods are described in IS 5613 (Part I/Section 2-1985). If required, cross arms and insulators may be attached to poles before they are erected.

19.53 Pole Fittings and Cross Arms

19.53.1 Lines upto 650 Volts:-

The phase and neutral conductor in horizontal configuration shall be run on the pin or shackle insulators as indicated. These insulators shall be attached to the cross arms with the help of pins. The earth wire may be run on cast iron reel mounted directly on the cross arms. For vertical configuration the insulators shall be fixed on the pole by the use of D-type or other suitable clamps. The earth wire may be run directly on a D-clamp. Details of method of fixing are described in I.S. 5613 (Part I) Section 2-1985.

19.53.2 Lines beyond 650 V and upto 11 KV

These lines normally shall be arranged in Delta formation by placing one of the conductors on the top of the pole and fixing it with an insulator mounted on a bracket type clamp and by placing the bottom conductor on a suitable cross arm. In situations where birds are found in large numbers such as refuse dumping grounds, 'V or 'U' type cross arms made of sections shall be used. Bird guards may also be provided in such locations, if necessary.

19.53.3 Cross Arms

Cross arms shall be as prescribed and as directed by E-I-C made to shape, holes drilled (not punched hot or cold) out of structural grade steel sections channels or angles of medium grade. Cross arms shall be fixed to poles by means of suitable 'D' type clamps in case of tubular steel poles and clamps made to shape in case of P.C.C. poles, made from M.S. Flats of not less than 50x6 mm. However from safety point of view it is advisable to provide stay insulator.

19.54 Insulators

The type, size and volatage rating of the insulator shall be as indicated.

Pin type insulators are recommended for use on straight runs and upto a maximum of 10 deviation. Disc insulatorn are used at pole positions having more than 10 degree angle or for dead ending of 11 KV lines. For lines having a bend of 10 to 30 degree either double cross arms or disc insulators shall be used.

19.54.1 When insulators are assembled on the cross arms, the porcelain shall be inspected for breakages, chipped spots, cracks scratches and bare unglazed areas. The fitting shall also be inpected for cracks, damaged galvanised coating. etc.

19.55 Stays and Staying Arrangement

Overhead lines supports at angles and terminal postitions shall be well stayed with stay wire, rod, etc. The angle between the pole and the wire should be about 45^0 and in no case should be less than 30^0. If the site conditions are such that an angle or more than 30^0 between the pole and the wire cannot be obtained special stays such as foot stays, flying stays of struts shall be used as indicated.

19.55.1 Nominal dimension of the components parts of the stay set shall be as follows:

Rod		Size of stay strand	Size of stay grip	Size of stay plate
Dia	Length			
16mm	1.8m	7/3.15mm	7/2.50mm	230x230x6mm
20mm	1.8m	7/4.00mm	7/3.15mm	300x300x6mm

19.55.2 The stay rod shall be embedded in cement concrete 1:3:6 type C2 to a depth not less than 1.67 metres and by not less than 0.28 cu.m of concrete, in such a way that the top of the concrete block so formed is well below the ground level to prevent uprooting of the stay rod. A length of 45 cm of the rod shall project above the ground level. The stay wire shall be fixed to the stay rod at the bottom and to the stay clamp to the pole, by means of well spiced joints with a poreclain guy insulator and a trun buck to inserted in the middle and near the top respectively. The stay clamps shall be located near about the centre of gravity of the pull of the over head conductors. Stay rod and thimble shall be in correct alignment with stay wire. Double stays shall be provided at all dead ends and at any other palce if directed by the Engineer-in-Charge.

19.55.3 In the Case of stays fixed to metal poles which are earthed by continuous earthwire it shall not be necessary to fix the stay insulator, but the stay wire shall be so clamped to the pole that there is a perfect metal to metal contact with the pole. In addition it shall be also connected and bonded properly to the continous earth wire. The stay rod where indicated shall be provided with GI pipe which shall not be less than 50 mm dia and 1.5 metre long so as to be 0.6 meter below ground level and 0.9 meter above it. The legth of stay rod, shall be accordingly modified.

19.55.4 A strut shall consist of a pole of the same section unless otherwise indicated. It shall be chamfered at the top so as to rest on the pole squarely and shall be secured by means of a through bolt, nut, and washer. It shall be buried in the ground to a depth not less than 1.2 m. At the ground level, the strut shall be at a distance not less than 1.8 metre from the pole. A typical arrangement of stay fixing is illustrated in electrical Plate No. 1.

19.56 Type of conductor

Phase and neutral conductors shall be alminium stranded conductors (ASC) or steel reinforced aluminium conductors. (ACSR) as indicafed. Galvanised steel conductor shall be used as earthing conductor. All conductors, unless otherwise indicated, shall have a breaking strength of not less than 350 Kg.

19.57 Spacing of Conductors

To have proper insulation clearance and to avoid conductors clashing due to wind conductors in an overhead lines shall be adequately spaced.

19.57.1 The minimum horizontal spacing of conductors on four wire cross arm shall be 45 cm between the inner conductors and 106 cm between outer conductors and for the two wire cross arms the minimum horizontal spacing shall be 45 cm. For cross arms carrying more than four wires the pacing shall be as directed by Enginner-in-Charge. Minimum vertical spacing of conductors shall be 30 cm.

19.58. Sag and Tension

Sag and tension in an overhead line shall be calculated in accordance with the procedure given in IS 5613 (Part I/Sec. 1)-1985.

19.59 Recommended Span Lengths

The spacing between the poles shall be selected keeping in view Rules 77 and 85 of Indian Electricity Rules. The recommended span lengths for lines upto 11 KV are-45, 60, 75, 90, 105 & 120 m, depending on size of conductors and height of poles indicated.

19.59.1 Clearances

Clearances shall be in accordance with Rules 77, 79, 80 and 83 of the Indian Electricity Rules 1956.

19.60 Installation of Conductors

The conductors shall run out along the route of line. As the conductor is payed out, it is passed through gloved hands and examined for defects and damages by feel. When a defect is found, paying out is discontinued and the faulty section is either cut or repaired. After paying off, the conductor shall be placed on poles. The conductor shall be pulled tight to remove excess slack and to bring the sag to the required value. Sagging shall be done in sections from one tension point in the line to the other. However, if no tension point comes automatically in the line for a distance of 3 km. one such point shall be made either by using a disc insulator or by dead ending the line whichever is applicable.

19.61 Attachment of Conductors with Insulators

The insulators shall be bound with aluminium binding wire or tap for aluminium and steel reinforced aluminium conductors and GI binding wire for GI conductors. The size of binding wire shall be not less than 2 sq mm.

19.62 Conductors of Different Voltages on Same Support

Where conductors forming part of systems at different voltages are erected on the same support, the clearance between the bottom most conductor of the system placed at the top and the top most conductor of the other system shall be not less than 1.2 m.

19.63 Tee Off

The tee off from a line should be done only on a pole and not in between any span. Suitable parallel groove clamps or crimped sleeves joints shall be used for tappings from main lines of heavier cross section to tee off lines of lighter cross section.

19.64 Road Crossing

The maximum interval between poles when the line has to cross a road shall be in accordance with requirements laid in the Indian Electricity rules.

19.65 Crossing of Power Lines and Telecommunication Lines

For the safety of telecommunication lines at locations where the overhead power line may be crossing over the same, the recommendations laid down in the Code of Practice of the power and telecommunication co-ordination committee shall be followed. Rule 87 of the Indian Electricity Rules shall also be referred.

19.66 Earthing of steel and concrete poles

All metal supports of overhead lines and metallic fittings attached thereto shall be permanently and efficiently earthed. A continuous earth wire shall be provided and securely fastened to each pole and connected with earth at 3 points in every kilometer, the spacing between the points being as equidistant as possible; unless each pole and metallic fittings attached thereto are indicated to be earthed.

19.66.1 The cross-sectional area of earth conductor (Continuous earthwire) shall not be less than 25 sq.mm if of galvanised iron or steel.

19.67 Lightening Arrestor

These shall be non-linear resistance expulsion type as indicated. The non-linear resistance type shall be as per IS-3070 (Part I) - 1985 and expulsion type as per IS-3070 (Part 2) - 1989. Horn gaps non-linear resistor type shall be used in voltage system upto 33 KV beyond which BURKE gap arrestors shall be used. Similarly lightning arresters of Thyrite or Pellet expulsion type shall be used in the system voltage upto 33 KV beyond which Ferrante surge absorbers shall be used. These devices shall be connected ahead of fuse, if any.

Independent earth electrode shall be provided for lightning arrestors.

As per IE rule 92, the earthing lead for any lightning arrestor shall not pass through any iron steel pipe but shall be taken as directly as possible from lightning arrester to a separate earth electrode subject to avoidance of bends wherever practical.

19.68 Overhead Service Lines

19.68.1 No service connection shall be taken off an overhead line except at a point of support.

19.68.2 Bare Conductor

This type of service connection shall be restricted to bare minimum and be avoided as far as possible.

19.68.3 PVC insulated armoured heavy duty cable of 1100 volts grade conforming to I.S. 1554 (Part l)-1988 as indicated depending upon the load requirement shall be used for all service connections to all permanent buildings through ducts/pipes or laid in trenches as indicated.

19.68.4 Insulated conductors

Service connections with weather proof or PVC insulated and sheathed cables as indicated on G.I. bearer wire minimum 3.15 mm dia, one end fixed to the pole and the other end fastened to 40 mm dia G.I. double bend pipe Medium service bracket 3.0 m in length shall be restricted to isolated single storey or temporary buildings with load less than one kw.

19.68.5 The phase conductors of the service line shall be connected to the distributing main through aerial fuses.

19.68.6 Earthing

In case of bare conductor service line, a separate earth wire shall be run along with the phase and neutral conductors, and shall be connected to the earth of overhead distributing system. At the building end, a separate earth wire is connected and terminated at the earth terminal at the service position.

19.69 Gang Operated Air Break Switches (Swing out expulsion fuse isolators)

Gang operated air break switches (swing out expulsion fuse isolators) shall be of 3.3 KV, 6.6 KV, 11 KV and 33 KV, rated upto 400 amps as indicated. They shall be three pole type, 3 insulators per phase, triple pole rocking, out-door type, gang operated, suitable for both horizontal and vertical mounting with the following components :

(a) Channel bases for mounting post insulators.
(b) Operating mechanism complete with 5/6 m long operating pipe phase coupling shaft, operating handle with padlock arrangements but without padlocks.
(c) Easy replacement type MS arcing horns with make first and break after features.
(d) Multi-built type contacts will be provided to grip incoming and outgoing ACSR conductors.
(e) None-ferrous parts shall be electroplated and ferrous parts hot dip galvanised.

These shall be installed as directed by the Engineer-in-Charge.

19.70 Service Fuses

Service fuses shall conform to IS-2086-1993 and HRC cartridge fuse links upto 650 V shall conform to IS 13703 (Part 1 to 4) 1993 and shall be suitable size for entry to ends of lines jointed to them. They shall be fixed at the pole end of the service line except when otherwise directed. MCB's of appropriate size in sheet metal enclosures can also be provided alternatively.

19.71 Painting of Poles, Cross Arms etc.

External surface of metal and wooden poles shall be painted with two coats of tar or bitumen composition in the portion buried in ground and upto concrete collar where collars are to be provided before erection. Steel tubular poles shall in addition be coated with bitumen composition on the inner surface throughout. After erection the external surface of metal poles above ground or collar level and all pole fittings shall be painted with two coafs of aluminum paint

19.72 Cutting of Trees

Construction of overhead lines will include cutting of trees or clearing other obstructions that may occur in the way of overhead lines but this shall be done with the approval of the Engineer-in-Charge.

19.72.1 Anti- Climbing Device

This shall be provided to prevent unauthorised climbing of HT line supports as per IE Rules 91. For this purpose, unless otherwise specified, barbed wire conforming to IS-278-1969 having 4 points barbs spaced 75 mm apart shall be wrapped vertically with a pitching of 75 mm around the limb of the support and tide firmly commencing from a height of 3.5 m and upto a height of 5 or 6 meters as directed by the Engineer-in-Charge.

19.72.2 Numbering of Supports

All supports shall be numbered as directed by the Engineer-in-Charge.

19.72.3 Testing

Before charging the lines a Megger test shall be carried out. For LV & MV 500 V and for HV 2500/5000 V Megger shall be used.

Underground Cables.

19.73 Type of cables

The type and size of cables, their voltage ratings and core construction shall be as indicated.

19.74 Trenching

The bottom of the trench shall be carefully levelled and made free of stones but if gradients and charges in depth are unavoidable they shall be gradual.

19.74.1 Depth of Trench

Depths from the upper surface of the street pavement or ground to the cable axis shall be not less than the following :-

Upto l.l KV Working pressure	45 cm plus radius of complete cable.
3.3 KV to 11 KV Working pressure	75 cm plus radius of complete cable.
22 KV to 33 KV Working pressure	1 metre plus radius of complete cable.

19.75 Method of Laying

Before laying the cable, the trench shall be provided with a layer of sand of 8 cm depth for the purpose of cushioning. After the cable has been uncoiled and laid into the trenches over the rollers, the cable shall be lifted slightly over the rollers beginning from one end by helpers standing about 10 metres apart and drawn straight. The cables shall then be taken off the rollers by additional helpers lifting the cable and then laid straight into the route. When the cable has been properly straightened, it shall be covered with sand to a depth of 15 cm. This is then gently punned down to a depth of 10 cm above the top of the upper-most cable, thus providing a good bedding for the protective cable covers or warning covers which are placed centrally over the cable. The punning shall be done by hand; mechanical punners shall not be used.

19.75.1 Laying Of HT/LT Cables

19.75.1.1 The work of underground cables shall be carried out as specified in IS-1255-1983.

19.75.1.1 The cables under road crossing railway tracks etc (existing or proposed) shall be enclosed in GI pipes. Size of the pipe shall be such that the suitable space around the cable is available. The pipe shall be provided through out the width of roads, drains and extended for 1200mm either side of the road. GI pipes shall be of light grade conforming to IS : 1239 - Part 1 2004 specifications. The two ends of pipes shall be sealed with wooded plug/pegs and bitumen compound after drawing the cable through pipe.

19.76 Spacing Between Cables

When more than one multicore cable or trefoil group of single core cables is laid in the same trench a horizontal inter axial spacing 25 to 40 cm shall be provided to reduce the effect of mutual heating and to ensure that a fault occurring in one cable, will not damage the adjacent cable. When more than one tier of cable is necessary, riddled soil shall be filled in the trench, and rammed down to form a solid bed to a height of 25 to 40 cm above that of the first tier. The mesh of the screen through which the soil is riddled shall not exceed 12.5 mm IS sieve. The width of the trenching shall in no case be less than 45 cm so as to facilitate working on the cables. Laying of cables in tier formation shall be avoided as far as possible as loading of cables is very much reduced.

19.77 Cables Laid in Tier Formations

When more than one tier of cables is necessary the trench shall first to be provided with a layer of sand to a depth of 8 cm for the purpose of cushioning. After laying one tier of cables sand shall be filled in the trench and punned down to form a bed to a minimum height of 25 cm above that of the first tier. This shall be continued keeping the top most tier at a minimum depth of 60 cm below ground level.

19.78 Road Crossing

When crossing roadways, it is preferable to cross on the skew to reduce the angle of the bend as the cable enters and leaves the road crossing. The cable shall pass through a RCC/CI/ Steel pipe.

19.79 Railway Crossing

When the cables are laid under railway tracks, the cables shall be laid in reinforced concrete or cast iron or steel pipes as indicated at such depths as may be specified by railway authorities but not less than 1 metre below the surface of formation level. In case of single core cables, the pipes shall be large enough to contain all the three phases of the power circuit. Long lengths of pipes shall be laid with a gradient to facilitate drainage.

19.80 Pulling Out the Cable

On no account the cable shall be allowed to twist or kink as it is likely to spring the armour and fracture the paper insulation and outer serving of the cable. When pulling cable around the bends, rollers should be placed sideways so as to keep the cable on a safe radius. Cable drums should be rolled in the direction of arrow.

19.80.1 Care shall be taken during laying to avoid sharp bending and twisting. Cable shall be unwound from the drum by lifting the drum on the center shaft supported both ends with suitable Jacks/stands. Under no circumstances the cable winding shall be lifted off a coil or drum lying flat at the flanges to avoid serious twist and damages. Further the minimum bending radius of 15 x Diameter of the cable shall be ensured.

19.80.2 The cable shall be snaked to provide a 4 meters length of cable for further joints at all straight joints (both side of the joint i.e. 4 meters on each side) of cable laid in trenches and a 3 mtrs lengths at terminal cable boxes.

19.81 Minimum Bending Radius

Cables shall always be bent (or straightened) slowly; they should never be bent to a small radius. The minimum safe bending radius for impregnated paper insulated cable may be taken as given below, but wherever possible large radius shall be used.

Voltage	Minimum Bending radius		
	Single Core cables	Multicore Cables	
		Unarmoured	Armoured
Upto 11 KV	20 D	15 D	12 D
Upto 22 KV	25 D	20 D	15D
Upto 33 KV	30 D	25 D	20 D

Note :- 'D' is the overall diameter of the cable. At joints and terminations, the individual cores of multiple cable should never be bent so that the radius of the bend is less than 15 times the diameter over the insulation.

19.82 Laying of Cables Inside Buildings

19.82.1 Cable laid in Ducts or Floors

Cable ducts shall be of such dimensions that the cables laid in it do not touch one another. If necessary, cable may be fixed with clamps on the walls of the duct. The duct shall be covered with removable slabs or chequered plates.

19.82.2 Cable Laid along the Surface of the Wall

Cables shall be fixed by means of suitable MS clamp or bracket or on cable racks, as directed. If necessary, the cable may also be laid in a chase cut in the wall and fixed with clamps. The chase may be covered with removable MS sheet.

19.83 Joint Holes

These shall be of sufficient dimensions as to allow jointers to work with as much freedom of movement and comfort as possible. For this purpose, the depth of the hole should be at least 30 cm below the cables proposed to be jointed. The side of the holes should be draped with small tarpaulin sheets to prevent loose earth from falling in the joint during the course of making. The two lengths of cables meeting at a joint are laid with an overlap of about 1 metre. This enables the jointer to adjust the position of the joint slightly to allow for any obstruction that may encountered.

When two or more cables are laid together the joints shall be arranged to be staggered by two or three metres so as to isolate the joints from each other and reduce the possibility of one joints failure affecting the other joints.

A tent shall be used in all circumstances where jointing work is being carried out in the open to prevent dust be blown on to the exposed joint and jointing materials, specially to the compound and tapes.

19.84 Preliminary to Making a Joint or Cutting Cable

If the cable seals are found broken or the sheath covering punctured, the cable ends shall not be jointed until after examination and testing by the EIC. Before jointing a paper insulated cable, the paper insulation shall be tested for presence of moisture in hot compound or in a paraffin wax at a temperature between 120^0 and 140^0 C. Before jointing is commenced, the insulation resistance of both sections of the cable to be jointed shall be checked with the megger The cables shall be tested and phased out to prevent cross jointing. Generally it will be found that numbers or colours represent the phases but this shall not be taken for granted.

19.85 Cable Jointing

Cable as far as possible shall be laid in complete lengths, uncut lengths from one termination to the other. Before start of cable laying, cable schedule shall be prepared and approved by EIC to minimise/avoid straight through required in the entire network shall be worked out and approved by the EIC. All cable jointing in terminal or through joint boxes shall be carried out by experienced/trained and qualified cable jointers.

19.85.1 Cable Joints

Jointing work shall be carried out only by a licensed/experienced cable jointer. Sufficient surplus cable approximate 3 meter shall be left on each end of the cable and on each side of underground joints at the time of original installation. A caution board indicating "CAUTION CABLE JOINTING WORK IN PROGRESS" shall be displayed to public and traffic where necessary.

19.85.2 Cable Terminations and Straight Through Joint Kits for 3 Core HT XLPE Cables

19.85.2.1 The cable termination kits and straight through joint kits shall be suitable for HT. XLPE cables shall be of Cold shrinkable or push type on with sound and proven technology. These terminations shall be environmental friendly and flame retardant

19.85.2.2 Each kit shall contain all necessary components accessories, including cable glands wherever required cable lugs (climping type) jointing materials and consumables to make a complete termination in such a way that no live parts of the terminal and connecting lugs are exposed.

19.85.2.3 The basic raw material used in construction of Joints and termination shall be Electrical grade EPDM (Ethylene Propylene Diene Monomer Rubber component) with high dielectric strength. The termination shall control the voltage distribution of electrical field effectively and shall minimize the surface stress by uniformly redistributing the electrical field over the entire surface of the insulator. Insulators shall be made of silicon rubber with long service life.

19.85.2.4 The straight through joint kits shall be suitable for underground buried installation with uncontrolled back fill and chances of flooding by water and suitably designed to be protected against rodent and termite attack. Further the joint kit shall be in capsulated in cast resin compound to provide excellent mechanical & moisture protection in sub soil conditions. While making termination, earthing connection & outer protection arrangement shall also be ensured.

19.85.2.5 The test certificates from the manufacturer for termination kits and straight through joints kits shall mention results of the following tests :-

(i) AC Voltage withstand test (as per IEC-68)
(ii) Partial discharge test
(iii) Impulse withstand test (as per IEC-68)
(iv) Load cycling test (as per VDE-2078)
(v) Thermal short circuit test.
(vi) DC Voltage withstand test.
(vii) Humidity test (as per IEC-166)
(viii) Dynamic short circuit test (as per VDE-2078)
(ix) Salt Fog (outdoor termination only) test.
(x) Impact test (for joints only)

19.85.3 Cable End Termination and Straight Through Joint for 1100V Grade XLPE Cables

Cable end termination Indoor/outdoor type and straight through joints for LT cables shall be based on cast resin system. The casting resin shall be polyurethane based having compatibility with the cable components. The termination kit shall be designed for easy installation and have a crutch sealing arrangement for environmental protection on the core trifurcation.

The joints shall be suitable to withstand mechanical impact, heat shock tests, load cycle test and water, penetration test (under pressure) without damage to the outer sheath.

19.86 Cable Terminations

All cables shall be terminated at the end in such a manner as to prevent ingress of moisture into cable. The type and method of termination of cable shall depend on the voltage of cable and type of termination whether indoor or outdoor. All types of cable and termination joints shall be indicated as prescribed by the cable manufacturers. However the following types of joints and termination systems are common and popular.

(i) Tapex system
(ii) Heat shrinkable sleeve type
(iii) Push on or slip on type technique

19.86.1 Cable Ends

All PVC cables upto 1100 volts gde shall be terminated into the equipment by means of compression type cable glands having screwed nipples and check nuts. The cable conductors shall be provided with crimped type solderless cable sockets or connectors to suit the termination arrangement of the equipment. The crimping shall be done by hand/hydraulically operated crimping tool after applying conducting jelly. The insulation of the cable shall be removed just immediately before the crimping is done.

19.87 Cable Boxes

19.87.1 Straight Through and Tee Boxes

Boxes shall be of best quality cast iron, compound filled type. LT boxes shall be without lead sleeves, and HT boxes shall be with lead sleeves in an outer cast iron protection boxes. These shall be supplied with armour clamps, copper strip bond for the lead sheath of the cable, terminal copper ferrule for jointing conductors, insulating tapes, sealing compound, lead bonding strip for armour, solder and flux etc.

19.87.2 LT Outdoor, Inverted Type, Dividing Boxes

These shall be of cast iron outdoor, inverted, pole mounting type, dividing boxes, arranged to suit XPLE cables entering at the bottom through a brass wiping gland and armour clamp.

19.87.3 HT Outdoor, Inverted Type, Dividing Boxes

These shall be of well grained cast iron, outdoor inverted, pole mounting type, end dividing boxes to suit 3 core PVC, XLPE cables entering at the bottom through a brass wiping gland and armour clamps and shall be provided with copper rods and lugs at extremities of the porcelain insulators for taking off bare, copper or aluminium connections to the overhead lines. The joints should be completed with all internal fittings, insulating tapes, tropical sealing compound, steel pole clamps fabricated from 50x6 mm flat iron, plumbing materials, insulating tape, solder, flux etc.

19.87.4 LT Indoor, End Dividing Boxes

These boxes shall be of well grained, smooth finished cast iron indoor, wall/switch board mounting type, end dividing boxes to suit PVC,LXLPE cable entering at the bottom through brass wiping glands. A hard wood bush is provided which shall be drilled at site to suit outgoing VIR tails. These boxes are vertically split pattern with accurately machined faces to prevent compound leakage. These shall be complete with armour clamp, where required, weak back split pattern conductor ferrules, internal fittings, tropical grade compound for sealing, plumbing material, solder, flux and VIR tails, etc.

19.87.5 HT Indoor, End Dividing Boxes

These boxes shall be of well grained cast iron indoor, sturdy wall/switch board mounting type end dividing boxes to suit HT, PVC LXLPE aluminium conductor 3 core cables entering at the bottom through brass wiping glands. The box shall be provided with requisite voltage terminal insulator to suit outgoing tails. These boxes shall be vertically split pattern with accurately machined faces to prevent compound leakage. These shall be complete with armour clamps, weak back split conductor ferrule, internal fittings, tropical HT sealing compound, plumbing materials, solder, flux, HT tapes, VIR tails etc.

19.88 Protection of Cables

Where indicated, the final protection shall be provided by laying precast concrete cable convers of the type and size as indicated.

19.88.1 The un-reinforced pre cast cover and bricks are provided for protection of cable for covering the cables. The un-reinforced pre cast cover shall be laid flat (width of protection being equal to length of brick). After the layer of un-reinforced pre cast cover is laid the remaining trenches will be filled with excavated earth .

19.88.2 Cable path indicators shall be provided at distance of every 100 meters and at cable joints and turning of all cables except for street light cables and 2 core cables size and voltage written on it. The CI path indicator shall be fixed on MS angle iron. The cable path indicators shall be erected at the time of refilling the trenches and the cable path indicator shall be painted as under. -

(i) For HT 11 KV cables - "BROWN"
(ii) For LT cables - "BLUE"

19.89 Bonding Single Core Cables in Trefoil Formations

The method of bonding the metal sheaths of single core cables in close trefoil formation shall preferably consist of sheet lead 3 mm in thickness and approximately 10 cm wide, wrapped round the trefoil cable assembly in such manner as to make close contact therewith. The edges of the lead strip shall be bell mouthed so as to improve the wiped connection which shall be made at each side. Free ends of lead shall be left so that connection can be made thereto by means of tinned copper strip between the lead ends and two outer copper backing strips. Three 8 or 10 mm galvanised steel or phosphor bronze bolts shall be used for the connection of the copper strip to the lead bond.

When buried direct in the ground, the complete bond shall be enclosed in creosoted wood box which shall be filled in solid with bituminous compound.

19.90 Earthing and bonding

Earthing of cables, metal pipes or conduits in which the cables have been installed shall be efficiently bonded and earthed. At specified points on the route, where the presence of stray currents is suspected the joints, the metal sheat and armour, if any, of the cables shall be bonded to the earthing system, and connected to one or more earth electrode The cross-scctional area of every bond shall be not less than 65 sq.mm and in any case shall be such that the resistance of each bond connection shall not exceed the combined resistance of an equal length of metal sheath and armour any, of the cable.

19.91 Clearance from Communication Cable

When power cables are laid in the proximity of communication cables, the minimum horizontal and vertical separately between the power and communication cables shall normally be 60 cm but in any case not less than 40 cm for single core cables and 30 cm for multicore cables. Where there is no sufficient space to allow such minimum separation, either the communication cable or the power cable or preferably both should be laid solid over the distance affected unless the communication cable is specially designed so as to be suitable for laying close to the power cable in the same trend. The power and communication cables should as far as possible cross at right angles to each other.

19.92 Laying of Service Cables

19.92.1 Lead-in-Tube

Where the service cable is to be laid, the entry to the building through the wall shall be through a lead-in-tube fixed the wall. The lead-in-tube shall be of size as to permit easy drawal of cables. Unless otherwise directed, lead-in shall be GI pipes of diameter as directed, embedded and firmly grouted in the wall. The point of entry shall be properly scaled to prevent the ingress of water and entry of vermin etc.

19.92.2 Supporting the Cable

Suitable supports (clips, clamps, etc.) shall be provided at regular intervals between one and two metres depending upon the size and weight of the cable. The supports shall be fixed either to the walls or to the ceiling, as required

19.92.3 In multistoryed buildings readily accessible vertical ducts or chases shall be provided for the accommodation of service cables or rising bus-bars, as indicated. In general vertical ducts or chases should not be less than 450 mm and 150 mm deep but in large buildings where a number of rising service cables or rising bus-bars are to be installed the duct or the chase may be as much wide as necessary. Fire.barriers shall be provided to comply with the fire fighting requirements as indicated.

19.92.4 Only non-draining type of cables shall be used for service upto the upper floors. Adequate precautions shall be to prevent the entry of water or dust into the duct.

19.92.5 Method of Termination

XLPE sheathed cables shall be connected terminated in a terminal box in accordance with the details given in IS: 1255-1983. In case of PVC cables, a gland made of brass, mild steel or aluminium, of suitable size, may be for termination of the service cables.

19.92.6 The cores of the service cable shall be connected to suitable size of cutouts/switch installed inside the enclosure.

19.93 Testing of Cables

Testing During Laying

All new cables shall be megger tested before jointing. After jointing is completed all low voltage (LV) cables shall be megger tested and high voltage (HV) cables pressure tested before commissioning. The cables shall be tested for :

(a) Continuity,
(b) Absence of cross-phasing,
(c) Insulation resistance to earth, and
(d) Insulation resistance between conductors.

19.93.1 Testing after Laying and Jointing

Immediately after the initial laying and jointing work is completed, a high voltage test shall be applied to HV cables to ensure that they have not been damaged during or after the laying operations and that there is no flaw in the jointing.

The following tests shall also be carried out on all cables :-

(a) Insulation resistance test-sectional and overall,
(b) Continuity test-sectional and overall,
(c) Full load test,
(d) Earth test.

Insulation resistance test shall be carried out between conductors, and conductors and earth by Megger. High voltage test shall be carried out by applying test voltages between conductors and each conductor to sheath as given in Appendix F to IS:1255-1983.

19.94 Test Voltages for HT Cables After Laying and Jointing

(Appendix F to IS: 1255-1983).

Test Voltage are to be applied for 15 minutes

Rated Voltage	Belted Cables				Single core cables between any conductor and sheath	
	Between conductors		Between any conductor and sheath			
	AC	DC	AC	DC	AC	DC
	V	V	V	V	V	V
	(A) Cables for earthed system					
1.1KV	2,000	3,000	2,000	3,000	2,000	3,000
3.3 KV	6,000	9,000	3,500	5,000	3,500	5,000
6.6 KV	12,000	18,000	7,000	10,500	7,000	10,500
11 KV	20,000	30,000	11,500	17,500	12,000	18,000
22 KV	40,000	60,000	23,000	35,000	25,000	37,500
	(B) Cables for Unearthed system					
3.3 KV	6,000	9,000	6,000	9,000	6,000	9,000
6.6 KV	12,000	18,000	12,000	18,000	12,000	18,000
11 KV	20,000	30,000	20,000	30,000	20,000	30,000

19.95 Cable Records

The following essential data shall be furnished by the Contractor as cable record of all the buried cable installations :

(a) Size and type of cable and manufacturer's cable drum number;
(b) Location of the cables in relation to the buildings, kerb line, etc., with depth;
(c) Cross-sections showing where cables are laid in pipes or ducts, giving their sizes, types and depths together with an indication of any spare ways available;
(d) Positions and types of all joints;
(e) Location of other cables which run alongside or across the cable route;
(f) Position and depths of all pipes, ducts etc., which are met as obstructions to the cable route; and
(g) Accurate lengths from joint to joint.

19.96 Record of Service Lines

On completion of the work, the following particulars or the service lines shall be furnished by the Contractor :

(a) Reference No. of the building where the service line is installed,
(b) Size and type of service line,
(c) Location of the run and termination of the service line in relation to the streets, kerb line and building etc.,

(d) Position of all joints,
(e) Accurate lengths of service cable from joint to joint or from the distributing mains to service termination points, and
(f) Date of laying and jointing the service line.

Typical examples of these records in the form of sketches are given in Fig 6, 7 and 8 of IS:8061 -1976.

19.97 Installation of Transformers

19.97.1 Inspection on Arrival

The transformer shall be examined for any sign of damage in transit. Particular attention is being paid to the following

(a) Tank sides or cooling tubes dented
(b) Protruding fittings damaged
(c) Oil sight glass broken
(d) Bushings cracked or broken
(c) Bolts loose due to vibration in transit and
(f) Oil leakage (if filled with oil) particularly along the welds or reduction in the pressure of the gas (if filled with gas).

19.97.2 Installation

The transformer shall be installed as per the set of record plans to be supplied by the manufacturer and as described IS-10028(Pt. 2)-1981.

19.97.3 Lifting

Transformers shall be lifted by the lugs or shackles provided for the purpose, simultaneous use should be made of a such lugs or shackles in order to avoid any imbalance in lifting. Where it is necessary to use jacks for lifting, the projections provided for the purpose of jacking shall be used. Jacks shall never be placed under valves or cooling tube. In certain circumstances jacks may be placed under stiffening curbs on the tank base.

19.97.4 Indoor Transformer

Indoor transformers not expected to be installed immediately shall be stored under cover and shall be filled with oil to reduce the extent of possible condensation of moisture and the breathing pipe shall be plugged. Transformers which are required to be kept in storage for long periods shall preferably be drained of oil and the tanks filled with nitrogen under slight pressure. When it becomes necessary to store a partially or completely disassembled transformer the core and coils shall be immersed in dry oil and stored in a dry room having as uniform a temperature as possible. The indoor transformer shall be installed well away from the wall to provide proper ventilation. There shall not be chance of water dripping either on the transformer or any where in the transformer room itself. Chemical fume particularly acid fumes should not be allowed in the transformer room. The air inlets and air outlets shall be of adequate sizes and so placed as to ensure proper air circulation for the efficient cooling of the transformers. The inlets should preferably be as near the floor as possible and the outlets as high as the building allows to enable the heated air to escape readily and be replaced by cooled air. The transformer should be so installed that severe vibrations are not transmitted to its body.

19.97.5 Outdoor Transformer

Only transformers designed for outdoor use shall be installed outdoor. In case of locations where the atmosphere is polluted, it is desirable that the transformer shall be located in suitable covered shelter to minimize adverse effects of polluted atmosphere.

19.97.6 Foundation

The transformer shall be installed on a level concrete plinth, of size to accommodate the transformer in such a way that no person may step on the plinth, if necessary bearing plates of sufficient size and strength shall be provided. When transformer is fitted with rollers. Suitable rails or tracks shall be provided and when the transformer is in the final position, the wheels shall be locked to prevent accidental movement of the transformer.

19.97.7 Pole Mounting

For installing pole-mounted transformers, junction poles, subsidiary poles and street lighting poles shall not be used as transformer poles. Where unavoidable, special care shall be taken to maintain proper climbing space and to avoid crowding of wires. Double cross arms shall be provided for each transformer installation. The climbing space shall be carefully maintained so that it should not be necessary for a lineman to come close to the transformer tank in climbing up or down a pole. A suitable anti-climbing device shall be provided.

19.97.8 Testing

All routine and other tests prescribed by IS 2026 shall be carried out at the Manufactures works before the despatch the transformer. Copies of the test certificates shall be furnished to the department. In addition to the prescribed routine tests, temperature rise test shall be invariable done on one transformer of each design. A copy of impulse test shall be furnished in accordance with IS for purpose of record. Copies of the certificate for pressure test, test for bushings type be test for short circuit shall be supplied to the departments. In addition to tests at manufacturers premises, all relevant pre-commissioning checks and tests conforming to IS code of practice No. 1886 shall be done before energisation. The following tests shall be particularly done before cable jointing or connecting up the bus-bar trunking:-

(a) Insulation test between HV to earth and HV to MV with 5000 volts Megger.
(b) Insulation test on oil.
(c) Insulation tests between MV to earth wire 500 V Megger.
(d) Earth Resistance Tests.

All tests results shall be recorded.

19.97.9 Earthing

All connections to earth and earthing of neutral shall be carried out in accordance with IS 3043-1966.

19.98 Installation of Switch gear

Switchgear when despatched by the manufacturer in dismantled condition shall be carefully inspected on arrival at site to ascertain whether they are damaged in transit or any items are missing; particular attention shall be paid to bushings, meters and relays as these items are liable to damage. The packing cases of the switchgears shall not be unpacked in damp place or outside.

19.98.1 Storage

Before installation the switchgear shall be stored in a cool, clean, dry, airy place, free from dust and corrosive gases. All the items of switchgear shall be carefully handled to avoid damage or breakage; many parts are made of insulating materials which are likely to suffer early, if not handled carefully. Slinging shall be carried out only at the points provided for it.

19.98.2 Installation

Installation shall be done as per the drawings of erection given by the manufactures and as described in IS 10118-(Part 3)-1982. code of practice for installation of switchgear.

Levelling and Grouting:- In assembling the units of switchgear, care shall be taken to ensure that the equipment is installed correctly and levelled properly before the holding down bolts are grouted in, thereby ensuring correct operation of isolation mechanisms and joining together the bus-bars of the various units.

19.98.3 Connections

It shall be ensured that connections between units are properly made and are tight. When two or more switchgears are to be connected together to form a switch board, they shall be aligned and bus-bars shall be connected in such a way as to provide adequate clearance between phases; and phase and neutral. When making connections to terminals of switchgear, care shall be taken to avoid undue strain on insulators.

19.98.4 Earthing

The switchgear shall be solidly and efficiently earthed at two points as described in I.S. 3043-1987.

19.98.5 Testing and Commissioning

The equipment, when erected, shall be thoroughly cleaned and checked to ensure that:

(a) all nuts and bolts are light;
(b) all components containing oil, other liquid or compound are filled to the correct level;
(c) all moving parts, where required are lubricated;
(d) breaker operates mechanically;
(c) all wiring is in accordance with diagram;
(f) earth connections are connected to main earth bar; and
(g) no tools or loose materials are left in and around the switchgear.

The HT switchgear shall be applied voltage for insulation resistance test as under :-

Nominal circuit voltage	Test Voltage
upto lKV	1000 V
above 1 KV	2500 V

In case of small wiring and ancillary equipment test voltages shall be not more than 500 volts DC.

19.99 H.T. 11 Kv Switch Gear (HT Vaccum Circuit Breaker)

19.99.1 Vaccum circuit breaker shall comply with IS : 13947 Part 1 to Part 5 (Circuit Breaker),IS; 3156 (Voltage transformers),IS : 2705 (Current transformers)

19.99.2 BLANK

19.99.3 The HT switchgear panels shall be vertical/Horizontal isolation, horizontal drawout, extensible pattern, and fixed portion shall incorporate air insulated busbars and their supports, connections, automatic shutter current transformers, fixed main and secondary contacts, breaker lifting device, ground bus, etc. The moving portion shall incorporate the vacuum circuit breakers (VCBs) mounted on withdraw-able truck.

19.99.4 Each unit shall have an instrument panel in the front on which the instruments, relays, selector switch fuses, etc shall be mounted.

19.99.5 The side frames shall be built from substantial metal sections and the housing of the panels shall be built from MS sheet of thickness 12 gauge, forming a rigid and strong construction. The circuit Breaker shall have a hinged door lockable handle to give flush front appearance. The bottom of the panel shall have an arrangement to allow for cable entry and wiring

19.99.6 The bus bars and electrical connections between several parts of apparatus forming an equipment, shall be either of copper or aluminium. The insulated bus bars, connections and their insulated supports shall be standard construction and mechanically strong to withstand all the stresses which may be imposed upon the inordinary working due to fixing, vibrations, fluctuations in temperature, short circuit or other causes. The bus bar spouts shall be made of cast epoxy resin compound. The bus bars shall be so arranged that these can be extended in length without difficulty. The aluminium bus bars shall be of electrical grade aluminium complying with the requirements of latest BIS. The copper bus bars shall be electrolytic copper.

19.99.7 The complete switchgear equipment, bus bars and connection shall be capable of carrying fault current for period of not less than 3 seconds and shall also be capable of carrying continuously the specified rated current without damage or overheating of the contacts points or any other parts.

19.99.8 Means shall be provided to allow easy access to the contacts for inspection and repair. Circuit breakers shall be constructed of approved non-hygroscopic and noninflammable material throughout. Auxiliary arcing contacts shall be provided to protect the main contacts from burning during the operation of Circuit Breaker. Suitable means shall be provided to enable adjustments, and maintenance of the fixed and moving contacts and tripping mechanism.

19.99.9 The various parts of vacuum circuit breaker shall be of substantial construction, carefully fitted so as to ensure free action. The design shall be such as to reduce mechanical shock to the minimum, during opening and closing or withdrawing and to prevent inadvertent operation due to vibration or other causes.

19.99.10 Provision shall be made for temporarily complete circuit connection to the circuit breaker when it is isolated, in order to permit the circuit to be operated for testing purposes. One such set of the cable connection with suitable plug/sockets at the ends shall be provided for each type of circuit breaker.

19.99.11 The vacuum circuit breaker (VCB) bushings shall be fabricated out of epoxy resy compound.

19.99.12 All mechanical interlocks shall be designed to prevent maloperation and to ensure safety. Arrangements shall also be provided for locking the VCBs panels by means of padlocks.

19.99.13 Current Transformers (CTs)

19.99.13.1 Current transformers shall comply with the IS : 2705 (Part 1, 2 and 3 as applicable) and shall be enclosed in air insulated chambers. The primary of current transformers, shall be of bar type. These shall be of specified ratio and shall be capable of providing the necessary energy to operate the co-related protective devices and instruments.

19.99.13.2 The method of securing the current transformers in position shall be such that undue pressure is not exerted on the windings. They shall not have saturated ratio or produce harmonic voltage in the secondary windings which will affect the accuracy of the relay with primary current upto 20 times the rated full load current. These shall have extended current ratings upto 200 percent of the rated primary current

19.99.13.3 The load of current error and phase displacement prescribed for 120 percent after rated primary current in table I of IS : 2705 (Part 2) - 1992 or latest edition and they shall have short circuit level as specified for the associated switchgears.

19.99.14 Relays

19.99.14.1 Over current and earth fault relays shall be of 3 phase, induction type with two poles for overload and one pole for earth fault protection and shall have inverse time and definite minimum time and limit characteristic with separately adjustable time and current ratings. The definite minimum time shall be adjustable from 0 to 3 seconds and the current settings range shall be adjusted as per requirement.

19.99.14.2 Relays shall be of flush pattern type, capable of breaking or making contacts at the maximum current which may occur in the circuit being controlled and they shall not be affected by vibration or by external magnetic fields. The relays shall conform to IS : 3072 (Part I). All relays shall be contained in dust and vermin proof cases duly earthed and shall be mounted in suitable place on panel.

19.99.14.3 The instruments shall be capable of carrying their full load current continuously without undue heating and shall conform to IS : 1248-1968 (first revision) or latest edition. They shall have clearly divided and indelible scale and the pointer shall be of clean out line. Scale of ammeter on H.T panel shall have red (caution) marking on the dial corresponding to the full load capacity of the panel specified and shall be provided with non-reflecting type glass fronts. They shall be capable of withstanding fault current through primary of their corresponding instrument transformer and suitable means shall be provided for zero adjustment without dismantling the instruments..

19.99.14.4 KWH meters shall be suitable for measuring accurately KWH on balancing or unbalancing there phase circuit. KWH meters shall conform to relevant IS.

19.99.14A Potential Transformers (PTs)

19.99.14A.1 The voltage transformers shall be of 3 phases and shall have 110 volts secondary. They shall be drawout type and shall be capable of being isolated when the associated busbars or equipments are alive. They shall be complete with current limit fuses (HRC fuses suitably rated) on both primary and secondary sides. Fuses shall be mounted integral with the transformers.

19.99.14A.2 The voltage transformers connected to the metering and protection circuits shall be designed in accordance with IS : 3166 (Part I, II and III) and shall be capable of carrying continuously, without injurious heating at 30% VA burden over and above the VA burden of meters, relays and indication lamps, etc

19.99.14A.3 All potential circuits to instruments shall be protected by a fuse on each phase of the circuit, placed as close as possible to the instrument transformer terminals.

19.99.14A.4 The automatic tripping device shall be suitable for operating on normal DC voltage of 30 volts. DC battery shall be of lead acid, storage type . The circuit breaker shall be capable of operating satisfactorily when voltage at the terminals of the shunt trip coil is of any value from 70% to 110% or rated voltage of the auxiliary supply and when not carrying current shall be capable of operating satisfactorily when the voltage at the terminals of the shunt tripping is not more than 50% of the rated voltage of auxiliary supply.

19.99.15 Other Details/Equipments For HT Panels

19 99.15.1 Indication lamps to show ‘OFF’ and ‘ON’ position of the circuit breaker shall be connected to 30V supply. These lamps shall be of low consumption type and with removable coloured caps, red for ‘ON’ and green for ‘OFF’

19.99.15.2 Cable boxes for the switch gears shall be of standard design and shall be suitable for end terminations jointing.

19.99.15.3 The switch boards shall be complete with necessary internal connections and wiring. Each panel shall be fitted with a chromium plated brass name plate engraved with current rating of the panels and indicating whether it is transformer control panel or otherwise etc as applicable. This will be in addition to the one to be fixed on the VCB as per IS 13947.

19.99.15.4 Vacuum circuit breaker shall have independent spring charging type closing mechanism. The spring shall be charged through motor of suitable capacity. The motor shall be suitable for operating on 230 Volts, single phase, 50 cycles, AC supply system. The operating mechanism shall have all necessary apparatus of operation and supervision. In the event of failure of motor or motor supply, means shall be provided to charge the spring manually with an external handle. Manual closing of the breaker shall also be possible for maintenance purposes through detachable handle. The handle shall be supplied with the HT switchgear.

19.99.15.5 All current carrying parts in the breaker shall be silver plated and suitable arcing contacts shall be provided to protect the main contacts. Arc shutters be provided for each pole and these shall be suitable for being lifted out for inspection of main and arcing contacts.

19.99.15.6 Automatically operated safety shutters shall be provided to screen the live cable and bus bars connections when breaker is withdrawn from the cubical.

19.99.15.7 A safety catch shall be provided to ensure that movement of the breaker as it is withdrawn, is checked before it is completely out of the cubicle thus preventing its accidental fall due to its weight. Withdrawal from or insertion into the housing shall be only possible when the breaker rests in the withdrawn position on the truck platform.

19.99.15.8 Raising or lowering the breaker shall be possible only when :-

(i) The circuit breaker is switched off.

(ii) The interlock lever is in 'free' position

19.99.15.9 To close the breaker it shall be necessary to lock the breaker in position by shifting the interlock lever to 'Locked' position. This shall be possible only when the breaker is held in -

(i) The 'withdrawn' position.

(ii) The 'Isolated/Earthed' position.

(iii) The plugged in'position'.

19.99.15.10 Additional mechanical (cartel) interlocks, electrical interlocks, etc as per ISS/BIS shall also be provided.

19.99.16 Switch Tripping Battery With Charging Equipment

19..99.16.1 The battery shall be comprising of 15 cells each of 2 volts having 200 Ampers hours The cells/batteries shall be manufactured with pag tubular positive plates and pasted type negative plates and shall be assembled in hard rubber containers. These batteries/cells shall conform to 1S-1651.

19.99.16.2 Spray arresters shall be provided to prevent loss of acid by spraying during charge. The battery shall be completed with support insulators connection between cells, interrow and/ or intertier connectors, cable socket for end and tapping connections, quantity of concentrated or diluted acid for first filling and 10% spare acid in glass ware of 5 litres capacity.

19.99.16.3 The charger shall be suitable for operation from single phase, 50 cycles, 200/250 volts, AC supply system. The output of the charger shall be 1.5 Amps on quick charge and 10/50 MA on trickle charge. The battery charging equipment shall be manually operated.

19.100 LT Switch Gear Panel

19.100.1 LT Switch gear panel shall be Indoor type totally enclosed dust and vermin proof, free standing, fully compartmentalized in design suitable for 415 volts, 3 phase, 50 Hz, 4 wire AC system conforming to IS : 375 all as specified herein after. Degree of protection shall not be less than 1P-51 as per IS : 2147 and it shall be suitable to withstand a Fault level of 50 KA (rms) for one second.

19.100.2 Busbars shall be either of copper or aluminium of rated capacity . Cross section of Busbars for each phase and neutral shall be same. All the Busbars shall be air insulated and will be codified in Red, Yellow, Blue and Black colours as per the standard practices using heat shrinkable sleeves. Copper busbars shall be made of high conductivity 99.9% pure copper of ETP grade. Aluminium busbars shall be made of 63401 WP grade aluminium alloy. All the busbars shall have full round edges and shall be suitably braced with non-hygroscopic SMC supports of 660 volts grade.

19.100.3 LT Switch gear shall be made up of requisite vertical section, which when coupled together shall form continuous dead front switchboard. It shall be readily extensible on both sides by addition of vertical sections after removal of end covers. It shall be constructed only of materials capable of with standing the mechanical, electrical and thermal stresses as well as the effect of humidity, which are likely to be encountered in the normal service of the panel.

19.100.4 Each vertical section shall consists of: -

(a) A front framed structure of rolled folded steel channel section of minimum 3mm thickness rigidly bolted/welded together. The structure shall comprise of the components contributing to the major weight of the equipments such air circuit breakers, main busbars, vertical risers and other front mounted accessories.

(b) The structure shall be mounted on rigid Base Frame of MS channel of minimum thickness 5mm and height 75 mm. The design shall ensure that the weight of the mounted components is adequately supported without loss or deformation in transit.

(c) A rear cable chamber housing the cable and connections and power/control cable terminations shall be provided. The design shall ensure generous availability of space for ease of installation & maintenance of cabling & adequate safety in working in any vertical section with out coming in accidental contact with the live parts in the other.

(d) The top most doors in each vertical section shall house ventilating louvers where necessary. All louvers shall be covered with perforated sheet having holes of diameter less than 1 mm to prevent the entry of vermin.

(e) Front and rear door shall be fitted with Neoprene gaskets with fasteners designed to ensure proper compression of the gasket. Where covers are provided in place of doors, generous overlap shall be provided between sheet surface with closely spaced fasteners to preclude the entry of dust.

19.100.5 The height of the panel shall always be less than 2000mm. The depth of panel shall be adequate to cater,for proper cabling space and shall not be less than 1000mm for ACB Panel.

19.100.6 Doors and covers shall be of minimum 2mm thick sheet steel. Sheet shrouds & partitions shall be of minimum 1.6mm thickness. All sheet steelwork forming the exterior as well as interior of the switchboard shall be smoothly finished, leveled and free from flaws. The corners shall be properly rounded without any Burrs.

19.100.7 The switch gears in the panel shall be such arranged so as to facilitate their maintenance and ease of inspection at the same time a adequate degree of safety.Minimum clearance of 25mm and 19mm respectively shall be maintained between phases/phase to neutral/phase to earth and between neutral to earth. When for some reason, these clearances are not available, suitable insulation shall be provided.

All insulating materials used in the construction shall be non-hygroscopic type duly treated to withstand the effects of high humidity, high temperature tropical ambient service conditions.

19.100.8 Functional units such as circuit breakers, switch fuse unit, MCCBs etc shall be arranged in multitiers except for ACB which shall not be more that two in a single tier.

19.100.9 All doors bearing instruments shall be earthed with the body of the panel. Provision shall be made for permanently earthing the frames and other parts of the switchgear by two independent connections. Earthing busbars (2 Nos) shall be of aluminium of minimum size 50x6mm.

19.100.10 Large clearances & creepage distances shall be provided on the busbar system to prevent the possibility of fault. High tensile bolts and spring washers shall be provided at all busbar joints. The cross section of busbars and risers for various sections shall be adequate from temperature rise tests point of view also.

19.100.11 All sheet metal work incl. frames etc shall be with anti corrosive coating and finally epoxy polyester powder coating of flint grey shade (RAL-7032) all as specified in relevant ISS.

19.100.12 The switchgear panel shall be tested for the following and test results for the same from manufacturer shall be submitted to GE-

(a) Electrical and Mechanical operation test.
(b) Insulation test at 2.5 KV for one minute.
(c) Heat run test at rated current.
(d) Megger test by 1000V megger.

19.100.13 Air Circuit Breakers (ACBs)

19.100.13.1 Air circuit breakers shall be suitable for operational voltage of 415 V AC, 50 Hz, 3 phase 4 wire system for a rated current at ambient temperature of 50 C and conforming to IS : 13947 (Part 3, 1993) and IEC : 60947 (Part I & 2).

19.100.13.2 Breakers shall be electrically operated (AC motor & control) draw out type with cradle with 4 positions in draw out to facilitate maintenance. It shall be suitable for modular construction with Ultimate Breaking Capacity (Icu) of 50 KA (rms), Making capacity of 105 KA (Peak) and short time with stand capacity of 50 KA (Peak) for 1.0 second. The breakers shall with stand Mechanical and Electrical endurance cycles of 2500 and 500 respectively.

19.100.13.3 The operating mechanism shall be of Robust design with a minimum number of linkages to ensure maximum reliability and shall be of aesthetically elegant design incorporating the following features:-

(a) Unique 'Rating Error Prevention Device' to ensure matching of breakers rating with corresponding cradle.

(b) Flag indication for Service/Test/Isolated positions.
(c) Common panel cut out for all ratings of draw out breakers to ensure greater flexibility.
(d) Easy racking on telescopic rails.
(e) Racking handle with housing facility.
(f) Safety of operating personnel during operation and maintenance with following inter locking arrangements: -
    (i) Door interlock.
    (ii) Locking in isolated position.
    (iii) Racking interlock
    (iv) Shutter assembly to prevent access to live terminals when breaker is in draw out position.
(g) Micro switches for. -
    (i) Position indication
    (ii) Fault indication
    (iii) Operation through voltmetric/Electronic releases
(h) Lockable trip push button for inter locking
(j) In built mechanical anti pumping
(k) Mechanical operation counter suitable to display total number of breaker

19.100.13.4 Protection Devices - Breaker shall be provided with CT operated 'Solid State Analog Releases' to ensure comprehensive protection against over load, short circuit and ground fault (Earth Fault). The relay shall be self powered type requiring no external power and shall trip the ACBs through Flux Shift Device providing the protections as described below:-

(a) Overload Protection: - The release shall provide inverse time-current characteristics against over load and shall be adjustable from a range of 50% to 100 % of the nominal current. It shall also be suitable for three different trip time of 2.5 second, 13 second and 25 second at six times the rated current.

(b) Short Circuit Protection - The release shall provide a wide range of protection against short circuit conditions: -
    (i) Current continuously adjustable for 2 to 10 times the nominal current,
    (ii) Time delay continuously adjustable from instantaneous to 400 m sec.

(c) Ground Fault (earth Fault) Protection - The release shall provide time-delayed protection against ground fault. The device shall have current and 'Time Delay' adjustable continuously from a range of 0.2 to 0.5 times the nominal current and 100m sec to 400 m sec respectively.

19.100.13.5 Under-Voltage release

Breaker shall also be provided with "Under-Voltage release' to trip the system on low system voltage. It shall be of Type MVR with a built in time delay of 3+ 1 Sec to prevent undesirable tripping of breaker in case of voltage dips due to transient faults. It shall be suitable for 415 V, 50 Hz with range of operation as under -
(a) Pick up : 80% of standard voltage
(b) Drop off: From 35% to 65% of standard voltage

19.100.14 Moulded Case Circuit Breakers (MCCBs)

19.100.14.1 Moulded case circuit breakers (MCCBs) shall be suitable for operational voltage of 415V AC, 50 Hz, 3 phase, 4 wire system for a rated current and ultimate breaking capacity and it shall conform to IS : 13947 (Part 3, 1993) and IEC-60947 (Part 2).

19.100.14.2 MCCBs shall be of compact and elegant design suitable for reversible load and line terminations without affecting its performance. MCCBs shall be suitable for fixing flush on the panels and shall be provided with handle operating mechanism including Rotary Handle vari-depth type.

19.100.14.3 The insulating case and cover of MCCBs shall be made of high resistant and flame retardant thermosetting insulating materials. The switching mechanism shall be quick make, quick break and trip free. The position of the operating knob/handle shall clearly indicate ON, OFF and TRIP position.

19.100.14.4 Each pole shall be provided with a pair of contacts, which shall open at a high speed over a large distance under short circuit faults. The special designed arc chutes of insulating materials shall be provided to contain the arc by providing effective arc quenching device.

19.100.14.5 The tripping mechanism shall be hydraulic type or Electronic release or thermal magnetic release for protection for over load and short circuit as per the details given below. -

Capacity Of MCCBs	*Ultimate breaking Capacity*	*Overload release*	*Short circuit release*
Upto 125 Amps	16 KA	Adjustable Thermal release (0.7 to 1.0 In)	Fixed magnetic type suitable for 10.0 In.
160 or 250 Amps	36 KA	-do-but range from 0.64 to 1.0	Adjustable magnetic release (3.5 to 10.0 In)
400 and 630 Amps	36 KA	Electronic release with over load Zone of adjustment 0.4 to 1.0 In	Electronic release with Short circuit Zone of adjustment 1.5 to 10.0 Ir. (Adjusted current) with time.

19.100.14.6 Under voltage trip, mechanical interlocks etc shall be provided as per standard practice and ISS. Under voltage trip shall be designed to operate when the control voltage drops below a tripping threshold i.e. 20% to 70% of rated voltage and shall be suitable for operation on 230V/415V AC.

19.100.14.7 The terminals shall be suitable for both copper and aluminium terminations

19.100A. Automatic Voltage Stabilizers Servo Controlled Type

19.100A.1 Voltage stabilizers shall be oil cooled, servo type conforming to IS. 9815 (Part-II) and suitable for 3 phase AC system to give a guaranteed out put voltage of 415 V +- 1%without spikes at 50HZ. Speed of correction of voltage shall be high enough to give jerkless out put voltage and in any case it shall not be less than 50 volts per second per phase without under/overshooting. Voltage stabilizers shall be with solid state sensor unit (IC Based) Relay free smooth and silent operation with servomotor and copper wound transformers in CRGO laminations.

19.100A.2 Voltage stabilizers shall be suitable for unbalance type load with provision of switch to select any or all three phases for monitoring. It shall have efficiency not less than 98% and shall be fee from distortion in wave forms. Response time of voltage stabilizer shall not exceed 10milli seconds and Power Factor at full load shall not exceed 0.95.

19.100A.3 Protections : Voltage stabilizer shall have protection against loss of any of the phases, phase reversal and overload with indicating and alarm system. It shall also have high and low voltage cut off facilities besides by pass facility in case of emergency.

19.100A.4 The specification of its main components shall conform to the following standards: -

19.100A.4.1 Step-syn Motor : shall be of low speed (60 RPM, 50 Hz), high torque 240 volts AC single phase and shall have instant start-stop reverse characteristics and shall take very low current. It shall not have communtator or brushes on the rotor and shall be noiseless in operation with suitable ball bearings.

19.100A.4.2 Dimmerstat: It shall be continuously variable voltage auto-transformer type, wound on high grade CRGO, toroidal core.

19.100A.4.3 Transformer: The secondary winding shall be in series with the line voltage. The primary winding shall be fed by the output of Dimmerstat.

19.100A.4.4 Control & Monitor System : All necessary monitors and user controls shall be provided on the front panel.

19.100A.5 Testing

19.100A.5.1 On full and final installation of the voltage stabilizer, it shall be put on water load testing or testing with strip heaters. Testing shall be carried out by the Garrison Engineer/ Engineer-in-Charge for continuous running of 24 hours on full load including testing with 10% over load for one hour in between. The contractor shall make all necessary arrangement for testing including water/strip heaters load.

19.100A.5.2 During the testing of 24 hours on load, following aspects shall also be considered to ascertain the satisfactory performance of the voltage stabilizer: -

(a) Noise level and temperature rise of oil.
(b) Rate of voltage correction, sensitivity and response time.
(c) Functioning of metering monitoring controls alarm and indicating.

SUB SECTION B-INTERNAL ELECTRICAL WORK

19.101 Siting of Electrical Equipment

The siting of cable and conduit runs, controls, distribution boards fittings and accessories, etc., shall be as laid down in IS 4648-1968. Guide for electrical layout in residential buildings or as directed by the EIC. The location of fittings etc., shall be marked in advance on walls, etc, and approved by the EIC.

19.102 Systems of Wiring

19.102.1 Wiring shall be carried out in any of the following systems as indicated: -

(a) Elastomer insulated and Elastomer sheathed or PVC insulted and PVC sheathed or Polyethylene insulated and PVC sheathed wiring system on Wood battens.

(b) Conduit wiring system recessed or surface type.

All conductors as far as possible shall run near walls and ceiling so as to be easily accessible and capable of being thoroughly inspected. 'Power' wiring shall be kept separate and distinct from 'Light' wiring. In all types of wiring due consideration shall be given for neatness, good appearance and safety. Diagonal runs will not be permitted.

19.102.2 The balancing of circuits in three wire or polyphase installation shall be arranged beforehand. Circuits on different phase of a polyphase system shall be kept apart at a minimum distance of 2 m unless they are enclosed in earthed metal casing suitably marked to indicate the risk of dangerous shock due to the voltage between the conductors contained in them. In large or important rooms, light and socket outlet points shall be distributed over more than one circuit on different phases where possible.

19.102.3 Medium pressure wiring shall be carried out as specified in IS-732-1989 Code of practice for electrical wiring installations (system voltage not exceeding 650 volts).

19.102.4 Pressure and Frequency of Supply

All current consuming devices shall be suitable for the pressure and frequency of the supply to which these are to be connected.

19.103 Control at Point of Entry of Supply

19.103.1 There shall be a linked main switchgear with fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of a linked switchgear. No fuse should be inserted in the earthed neutral. The neutral shall also be distinctly marked. In this connection Rule 32(2) of the Indian Electricity Rules 1956 shall be referred.

19.103.2 The main switchgear shall be situated as near as practicable to the termination of service line and shall be easily accessible without the use of any external aid.

19.103.3 On the main switchgear where the conductors include an earthed conductor of a two wire system or an earthed neutral conductor of a multi-wire system or a conductor which is to be connected thereto, an indication of a permanent nature shall be provided to identify the earthed neutral conductor. In this connection Rule 32 of Indian Electricity Rules 1956 shall be referred.

19.103.4 Termination of all wiring in to MCBs/ MCCBs/DBs shall be through copper/lugs/ thimbles of adequate capacity.

19.104 Main Switchgears, Switch Board and their Location

19.104.1 All main switchgears shall be of metal clad and shall be fixed at close proximity to the point of entry of supply.

19.104.2 Open type switch boards shall be placed only in dry situation and shall not be placed in the vicinity of storage batteries or exposed to chemical fumes.

19.104.3 Main switch boards shall be installed in rooms or cupboards having provision for locking arrangement.

19.104.4 Switch boards shall not be erected above gas, stoves or sinks or within 2.5 m of any washing unit i.e. the washing rooms to laundries or in the bathrooms, lavatories, toilets or kitchens.

19.104.5 Switch boards, where indicated, shall have weather proof outlet casing and shall be provided with glands or bushings or adopters to receive screwed conduit according to the manner in which, cables are run. PVC double flanged bushes shall be fitted in the holes of the switches for entry and exit of wires.

19.104.6 A switch board shall be installed so that its bottom is not within 1.25 m above the floor unless the front of the switch board is completely enclosed by a door.

19.104.7 Switch boards shall be recessed in the wall, if so specified. The front shall be fitted with hinged panel as indicated, with locking arrangement; the outer surface of door being flush with the walls unless otherwise indicated. Ample room shall be provided at the back for connections and at the front between the switchgear mountings and the door.

19.104.8 Equipments which are on the front of a switch board shall be so arranged that inadvertent personal contact with live parts is unlikely during the manipulation of switchgears, changing of fuses or like operations.

19.104.9 No holes other than the holes by means of which the switch board panel is fixed shall be drilled closer than 13 mm from any edge of the panel.

19.104.10 Various live parts, unless they are effectively screened by substantial barriers of non-hygroscopic, non-inflammable, insulating material shall be so spaced that an arc cannot be maintained between such parts and earth.

19.104.11 The arrangement of the switchgears shall be such that they shall be readily accessible and their connections to all instruments and apparatus shall also be traceable.

19.104.12 In every case in which switches and fuses are fitted on the same pole, these fuses shall be so arranged that the fuses are not alive when their respective switches are in the 'off' position.

19.104.13 No fuses, other than those in instrument circuit, shall be fixed on the back of or behind a switch board panel or frame.

19.104.14 All the metal switchgears and switch boards shall be painted prior to erection with one coat of anti-rust primer. After erection they shall be painted with two coats of approved enamel or aluminium paint as directed on all sides where accessible.

19.104.15 All switch boards connected to medium voltage and above shall be provided with "Danger Notice Plate'.

19.105 Types of Switch Boards

19.105.1 Hinged Type Metal Boards

These boards shall be suitable for mounting metal clad switchgear consisting of not more than one switchgear and ICDB 4 way, or 6 way, 16A per way. Metal boards shall consist of a box made of metal sheet not less than 2 mm thick and shall be provided with a hinged cover to enable the board to be swung open for the examination of the wiring at the back. The joints shall be substantially welded.

19.105.1.1 Where indicated metal boards may be made of angle iron or channel frame work of minimum size 35x35x6 mm or 35x25x6 mm respectively. The frame work is suitably mounted on front with a 2 mm thick mild steel sheet and on back with 1.5 mm mild steel sheet. In case of wood batten system of wiring the top and bottom members may be replaced by 25 mm hard wood battens. The front sheet shall be provided with suitable hinges to enable the board to be swung open for examination of wiring. The joints shall be neatly welded.

19.105.1.2 The boards shall be fixed to the wall by means of rag bolts and shall be provided with a locking arrangement and earthing stud. All wires passing through the metal boards shall be bushed.

19.105.2 Fixed Type Metal Boards

These boards shall be provided for large switch boards requiring large number of switchgears and/or higher capacity metal clad switchgear. These shall consist of an angle iron or channel frame fixed on the wall or on the floor and supported on the wall at the top. There shall be a clear distance of 1 m in front of the switch board. A working distance of 1 metre behind the switch board is preferable. If there are any attachment or bare connections at the back of the switch board Rule 51(1) of Indian Electricity Rules shall apply. The connections between the switchgear mounting and the outgoing cable upto the wall shall be enclosed in heavy gauge conduit pipe.

19.106 Marking of Apparatus

19.106.1 When a board is connected to voltage higher than 250 volts all the terminals or leads of the apparatus mounted on it shall be marked in the following colours to indicate the different poles or phases to which the apparatus or its different terminals may have been connected.

AC	DC
Three Phases-Red, Blue and Yellow Neutral-Black	Three Wire System-2 Outer Wires-Red and Blue Neutral-Black

19.106.2 Where four wire there phase wiring is done the neutral shall preferably be in one colour and the other three wires in other colours. For the purpose of colour coding in conduits wiring particulars of the sample for make and colour of insulation of wires shall be got approved before the wires/cables are procured and drawn into conduit Red/yellow/blue wires for phases, black wire for neutral and green wire for earth shall be used for wiring in conduit without coding will not be acceptable. Wire/cables shall be 1100 volts grade single core conforming to IS 1596-1977 or IS 694-1990.

19.106.3 Where a board has more than switchgear each such switchgear shall be marked to indicate which section of the installation it controls. The main switchgear shall be marked as such. Where there is more than one main switch board in the building each such switch board shall be marked to indicate which section of the installation and building it controls.

19.106.4 All markings required under this rule shall be clear and permanent.

19.106.5 All distribution boards shall be marked 'Lighting' or 'Power' as the case may be and also marked with the pressure and number of phases of the supply. Each shall be provided with circuit list giving details of each circuit which it controls, the current rating of the circuit and size of the fuse element.

19.107 Main and Branch Distribution Boards and their Location

19.107.1 Unless otherwise specified, main and distribution fuse boards shall be of the metal clad type.

19.107.2 Main distribution boards shall be controlled by a linked switch fuse or circuit breaker. Each outgoing circuit shall be provided with a fuse on the phase or live conductor.

19.107.3 Branch distribution boards shall be controlled by a linked switch fuse or a circuit breaker. Each outgoing circuit shall be provided with a fuse on the phase or live conductor. The earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purposes.

19.107.4 The distribution fuse boards shall be located as near as possible to the centre of the load they are intended to control.

19.107.5 The distribution fuse boards shall be fixed on suitable stanchion or wall and shall be accessible for replacement of fuses.

19.107.6 These shall be or metal clad type but if exposed to weather or damp situations they shall be of the weather proof type and if installed where exposed to explosive dust vapour or gas they shall be flameproof type.

19.107.7 Where two or more distribution fuse boards are connected at different phases these distribution boards shall be:

(a) Fixed not less than 2 metre apart or

(b) Arranged so that two cannot be opened at a time, such as they are interlocked and metal case is marked 'Danger 415 volts'.

19.108 Wiring of Distribution Boards

19.108.1 In wiring a branch distribution board the total load of the consuming devices shall be divided as far as possible evenly between the number of ways of the board,leaving the spare circuit for future extension.

19.108.2 All connections between pieces of apparatus or between apparatus and terminals on a board shall be neatly arranged in a definite sequence following the arrangement of the apparatus mounted thereon and avoiding unnecessary crossing.

19.108.3 Cables shall be connected to terminals only by soldered or crimped lugs unless the terminals are of such a form that they can be securely clamped without cutting away of cable strands.

19.108.4 All bare conductors shall be rigidly fixed in such a manner that a clearance of at least 25 mm is maintained between conductors of opposite polarity or phase and between the conductors and any material other than insulating material.

19.108.5 In a hinged board the incoming and outgoing cables shall be neatly bunched and shall be fixed in such a way that the door shall be capable of swinging through an angle of not less than 90 degrees.

19.108.6 Where indicated a pilot lamp shall be fixed and connected through an independent single pole switch and fuse to the bus bars of the board.

19.109 Joints and Looping Back

Unless otherwise indicated, looping back system of wiring shall be done without any junction or connector boxes on the line. Where joint box system is indicated all joints in conductors shall be made by means of approved mechanical connectors in suitable and approved joint boxes.

19.109.1 In any system of wiring, no bare or twist joints shall be made at intermediate points in the through run of cables; unless the length of a final sub-circuit, sub-main or main is more than the length of the standard coil as given by the manufacturer of the cable. If any jointing become unavoidable such joint shall be made through proper cut-outs, or through proper junction boxes open to easy inspection but in looping back systems no such junction boxes shall be allowed.

19.110 Connection to Ancillary Buildings

Electrical connections to ancillary building like out houses, garages etc., adjacent to main buildings at a distance not greater than 3 metre and when no roadway intervenes shall be taken in an earthed galvanised steel pipe of suitable size in the exposed portion at a height of not less than 2.5 metre or by underground cables as indicated. This applied to both runs of mains or sub-mains or final sub-circuit wirings between the buildings. When the distance between the buildings exceeds 3 metre or a roadway intervenes, normally separate mains or sub-mains shall be run from the main building to ancillary buildings and the portion of the same exposed to weather shall be carried in weather-proof cable on galvanised steel bearer wire at a height not less than 4 metre above the ground as directed.

19.111 Passing Through Walls and Floors

19.111.1 Where conductors pass through walls and floors, the following methods shall be employed. Care shall be taken to see that wires pass freely through protective pipe or box and that the wires pass through in a straight line without any twist or cross in wires on either ends of such holes :

(a) The conductor shall be carried either in a rigid steel conduit or a rigid non-metallic conduit or in a porcelain tube of such a size which permits easy drawing in. The ends of conduit or tube shall be neatly and securely bushed.

(b) Insulated conductors while passing through floors shall be protected from mechanical injury by means of rigid steel conduit to a height not less than1.5 metre above the floors and flush with the ceiling below.

This steel conduit shall be earthed and securely bushed.

19.111.2 Where a wall tube passes outside a building so as to exposed to weather the outer end shall be bell-mouthed and turned downwards and properly bushed on the open end or shall be sealed to prevent entry of water.

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19.113 Fittings

19.113.1 Where conductors are required to be drawn through tube or channel leading to the fittings, the tube or channel must be free from sharp angles or projecting edge and of such size as will enable them to be wired with the conductors used for the final circuit without removing the braiding or tapping. As far as possible all tubes or channels should be of sufficient size to permit of looping back.

19.113.2 Enclosed type fittings shall be provided with a removable glass receptacle and of such size or construction as to prevent undue heating of the lamp, or if the position of fittings be such that the glass receptacle is liable to mechanical damage, the glass shall be protected by a suitable wire guard.

19.113.3 The leads of pre-wired fixture shall be terminated on ceiling rose or connector.

19.113.4 Outdoor Fittings

External and road lamps shall have weather proof fittings or as indicated so as to effectively prevent the admission of moisture. An insulating distance piece of moisture proof material shall be inserted between the lamp holder nipple and the fitting. Flexible cord conductors and cord grip lamp holders shall not be used where exposed to weather.

19.113.5 Bulk Head Fittings

Bulk head fittings shall be of cast iron or cast aluminium body as indicated suitably painted white inside and grey outside or any .other colour complete with heat resistant glass cover, B.C. holder and wire guard suitable for 100 watts incandescent lamp. Where specified, gasket for glass cover and B.C. holder of shock proof material shall be provided.

19.114 Accessories

19.114.1 Switches

All switches shall be placed in the live conductor of the circuit and no single pole switch or fuse shall be inserted in the earth or earthed neutral conductor of the circuit. Single pole switches (other than for multiple control) carrying not more than 15A may be of the tumbler type or flush type as indicated and the switch shall be 'ON' when the handle or knob is 'DOWN'.

19.114.2 Lamp Holders

Lamp holders for use on brackets and the like shall have not less than 13 mm nipple and all those for use with flexible pendant shall be provided with cord grips. All lamp holders shall be provided with shade carriers. Where centre contact. Edison Screw lamp holders are used, the outer or screw contact shall be connected to the middle wire or the neutral or to the earthed conductor of the circuit.

19.114.3 Lamps

All incandescent/CFL lamps, unless otherwise required, shall be hung at height 2.5 metre above the floor level. They shall be provided with caps of the following patterns :

(a) Upto and including 300 watts	(i) Standard Bayonet (B)
	(ii) Edison Screw (ES)
(b) Above 300 watts	Goliath Screw (GS)

19.114.4 Celling Rose

A ceiling rose shall not be used on a circuit, if the voltage exceeds 250 Volts. Normally, only one flexible cord shall be attached to a ceiling rose.

19.114.5 Socket Outlets

Every socket outlet shall be controlled by a switch. The switch controlling the socket outlet shall be on the 'Live' side of the line.

19.114.5.1 5 A and 15 A Socket outlets or multisocket outlets shall be controlled by a switch, which preferably be located immediately adjacent thereto or combined therewith. The switch controlling the socket outlet shall be on the live side of the line. Socket outlets shall normally be fixed at any convenient place above 230 mm from the floor level. However if desired by EIC the 5A socket outlet shall be placed at the normal switch level. 15A socket outlet in the kitchen shall be fixed at convenient place 230 mm above working plate form.

19.115 Attachment of Fittings and Accessories

19.115.1 In domestic accommodation, where indicated, terminal points for power plugs, switches etc. of internal surface type wiring shall terminate in recessed cast iron boxes as for concealed wiring fitted flush with the wall surface.

19.115.2 In case of conduit wiring, all accessories like switches, socket outlets, call bell pushes and regulators shall be fixed in flush pattern inside metal boxes. Accessories like ceiling roses, brackets, battens, stiff pendants, etc. shall be fixed on metal outlet boxes.

19.115.3 Aluminium alloy or cadmium plated iron screws shall be used to fix the accessories to their boxes or as indicated.

19.115.4 Fan Regulators and Clamps

19.115.4.1 All ceiling fans shall be wired to ceiling roses or to special connector boxes and suspended from hook or shackles with insulators between hooks and suspension rods. There shall be no joint in the suspension rod.

19.115.4.2 For wooden joists and beams, the suspension shall consist of MS flat of size not less than 40x6 mm secured on the sides of the joists or beams by means of two coach screws of size not less than 50 mm for each flat. Where there is space above the beam, a through bolt of size not less than 15 mm dia shall be placed above the beam from which the flats are suspended. In the latter case the flats shall be secured from movements by means of another bolt and nut at the bottom of the beam. A hook consisting of MS rod of size not less than 15 mm dia, shall be inserted between the MS flat through oval holes on their sides. Alternatively the flats may be bent inwards to hold tightly between them by means of a bolt and nut, a hook of 'S' form.

In the case of I beam, flats shall be shaped suitably to catch the flanges and shall be held together by means of a long bolt and nut. As regards RCC roofs, a 10 cm dia CI box with a bent hook shall be provided.

19.115.4.3 Canopies on to top of suspension rod shall effectively hide the suspension.

19.115.4.4 The lead in wire shall be of nominal cross sectional area not less than 1.5 sq mm with aluminium conductor and shall be protected from abrasion.

19.115.4.5 Unless otherwise indicated, all ceiling fans shall be hung 2.75 metre, above the floor.

19.115.4.6 Exhaust fans shall be erected at the places indicated by the Engineer-in-Charge. For fixing an exhaust fan a circular hole shall be provided in the wall to suit the size of the frame which shall be fixed by means of rag bolts embedded in the wall. The hole shall be neatly plastered to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken that the blades rotate in the proper direction.

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19.118 Bends on Wiring

The wiring shall not in any circumstances be bent so as to form an abrupt right angle but must be rounded of corners to a radius not less than six times the overall diameter of the cable.

19.119 Protection of Wiring from Mechanical Damage

In cases there are chances of any damage to the wiring, such wiring shall be covered with a sheet metal covering (not less than 1.63 mm) the base of which being flush with the plaster or brick-work as the case may the wiring shall be drawn through a metal conduit pipe by complying with all the requirements of conduit wiring as directed. Such protective covering shall in all cases be fitted on all down drops within 1.5 metre from the floor level upto the switch board whichever is less.

19.120 Passing through Floors

All cables taken through floors shall be enclosed in an insulated heavy gauge steel conduit extending 1.5 metre above the floor or upto the switch board whichever is less and flush with the ceiling below or by means of any other approved type of metallic covering. The ends of all conduits or pipes shall be neatly bushed with porcelain, wood or other a materials. The conduit pipes, wherever accessible shall be securely earthed.

19.121 Passing through Walls

The conductor shall be carried in steel conduit or porcelain tube of such a size that it permits easy drawing in. of conduit shall be neatly bushed with porcelain, wood or other approved material in such a case there shall be conduit for every twin core cable or two runs of single core cable and the conduits shall be neatly arranged so cables enter them straight without bending.

19.122 Stripping of Outer Covering

While cutting and stripping of the outer covering of the cable care shall be taken that the sharp edge of the instrument does not touch the inner insulation of the conductors. The protective outer covering of the cables stripped off near connecting terminal and this protective covering shall be maintained upto the close prox connecting terminals as far as practicable. Care shall be taken to avoid hammering on link clips with any metal instrument after the cables are laid. Where junction boxes are provided, they shall be made moisture-proof with a plastic compound.

19.123 Identification of cables/wires and painting of surface wiring if so required to match the surrounding finish walls/ceilings etc.

(a) Where colour coding is not followed and only one single colour cables/wires used in wiring the cables/wires shall be in identified by taping coloured PVC tapes in the terminal boards/switch board the cables/wires terminal ends for easy identification for the wires/cables. Red/yellow/blue colour for phases and black for neutral shall be used.

(b) If so required the wiring after installation shall be painted with enamelled paint and neatly finished match the surrounding finish on the walls etc. as directed.

Surface Metallic and Non-Metallic Conduit Wiring System

19.124 Bunching of Cables

Cables carrying direct current may, if desired, be bunched whatever their polarity, but cables carrying alternating current, if installed in metal conduit shall always be bunched so that the outgoing and return cables drawn into the same conduit.

19.125 Conduit and Conduit fittings

The number of cables allowed in the steel and non-metallic PVC rigid conduits shall be as given in the following tables :-

(A) Maximum permissible number of 1100 Volts grade single core aluminium cables that may be drawn into rigid steel conduits

Size of Cable		Size of Conduit (mm)									
Nominal cross sectional area sq.mm	Number and diameter in mm of wires	19/20		25		32		40		50	
		S	B	S	B	S	B	S	B	S	B
1.5	1/1.40	7	5	12	10	20	14				
2.5	1/1.80	6	5	10	8	18	12				
4	1/2.24	4	3	7	6	12	10				
6	1/2.80	3	2	6	5	10	8				
10	1/3.55	2	-	5	4	8	7				
16	7/1.70	-	-	2	-	4	3	7	6		
25	7/2.24					3	2	5	4	8	6
35	7/2.50					2		4	3	7	5
50	7/3.00							2		5	4

Note 1: The table shows the maximum capacity of conduits for the simultaneous drawing in of cables. The columns headed 'S' apply to runs of conduit which have distance not exceeding 4.25 metre between drawn-in boxes and which do not deflect from the straight by an angle of more than 15^0. The column head 'B' apply to runs of conduit which deflect from the straight by an angle of more than 15^0

Note 2: In Case an inspection type drawn-in box has been provided and if the cable is first drawn through one straight conduit through the drawn-in box and then through the second straight conduit such system may be considered as that of straight conduit even if the conduit deflect through the straight by more than 15^0

(B) Maximum permissible number of 1100 Volts grade single core aluminium cables that may be drawn into Rigid Non-metallic conduits

Size of Cable		Size of Conduit mm				
Nominal cross sectional area sq.mm	Number and diameter in mm of wires	19/20	25	32	40	50
1.5	1/1.40	6	10	14		
2.5	1/1.80	5	10	14		
4	1/2.24	3	6	10	14	
6	1/2.80	2	5	8	11	
10	1/3.55		4	7	9	
16	7/1.70		2	4	5	12
25	7/2.24			2	2	6
35	7/2.50				2	5
50	7/3.50				2	3

19.126 Conduit Joints

Conduit pipes shall be joined by means of screwed couplers and screwed accessaries only. Where there are long runs of straight conduit, inspection type couplers shall be provided at suitable intervals or running threads with couplers and jamnuts shall be provided. In the latter case the bare threaded portion shall be treated with anti-corrosive preservative. Threads on conduit pipes, in all cases, shall be between 13 mm to 19 mm long, sufficient to accommodate pipes to full threaded portion of couplers or accessories. Cut ends of conduit pipes shall have neither sharp edges nor any burrs as otherwise these may damage the insulation of conductors while drawing them through such pipes.

19.126.1 Protection Against Dampness

The layout of conduits should be such that any condensation or sweating inside conduit is drained out. Suitable precaution shall be taken to prevent entry of insects inside the conduit.

19.127 Protection of Conduit Against Rust

All steel conduit screwed connections shall be metal to metal and exposed screwed threads in parts, where the galvanising or enamelling has been damaged, shall be thoroughly cleaned and painted with two coats of anti-corrosive paint; such painting shall be done as the work proceeds.

19.128 Fixing of Conduit

Conduit pipes shall be fixed by heavy gauge saddles and spacing plates secured to suitable wood plugs or other approved plugs with screws in an approved manner, at an interval of not more than one metre. In case of the couplers or bends or similar fittings saddles shall be fixed at a distance of 300 mm from the centre of such fittings. The saddle shall comply with the requirements of IS :3837-1976.

19.128.1 Where conduit pipes are to be laid along the trusses, steel joists etc. the same shall be secured by means of ordinary clips or girder clips as required. Where it is not permitted to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or girder clips shall not be less than as given in the following table:-

SI. No.	Size of conduit	Width of ordinary clip	Thickness of ordinary clip
	mm	mm	mm
1	20	20	0.90
2	25	20	0.90
3	32 and above	25	1.25

19.129 Bends on Conduit

All necessary bends in the system including diversion shall be done by bending conduit pipes or by inserting suitable solid or inspection type normal bends, elbows or similar fillings or by fixing cast iron inspection boxes as approved by EIC. Conduit fittings shall be avoided as far as possible on conduit system exposed to weather and where considered necessary solid type fittings shall be used. Radius of bends in conduit pipes shall not be less than 75 mm.

19.130 Outlets

The switch or regulator box shall be made of metal on all sides, except on the front. In the case of cast boxes wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes, the wall thickness shall be not less than 1.22 mm for boxes upto a size of 200x300 mm; and above this size 1.63 mm thick mild steel boxes shall be used. Except where otherwise stated 3 mm thick phenolic laminated sheets shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern. All fittings shall be fitted in flush pattern.

Only a portion of the outlet box shall be sunk in the wall: the outer portion being projected out for suitable entry of conduit pipes into the box.

The outlet box shall be mounted flush with wall. The metal box shall be efficiently earthed with conduit.

19.131 Erection and earthing of Conduit

The conduit of each circuit or section shall be fixed before conductors are drawn in. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth conforming to the requirements specified for earthing. Gas or water pipe shall not be used as earth medium. If conduit pipes are liable to mechanical damage, they shall be adequately protected. In a conduit system, conduit pipe shall be continuous when passing through walls or floors.

19.132 Recessed Conduit Wiring System

19.132.1 General

Recessed conduit wiring system shall comply with all the requirements of surface conduit wiring system except with regard to fixing of conduits and in addition the requirements specified in the following clauses shall also be complied with.

19.132.2 Making of Chases

Chases in the wall shall be neatly made and of ample dimensions to permit the conduit to be fixed in the desired manner. In the case of buildings under construction, conduits shall be buried in the wall before plastering and shall be finished neatly after erection of conduit. In case of exposed brick/ rubble masonry work special care shall be taken to fix the conduit and accessories in position along with the building work.

19.132.3 Fixing of Conduit In Chase

Conduit pipe shall be fixed by means of staples or by means of saddles not more than 600 mm apart. Fixing of standard bends or elbows shall be avoided as far as practicable and all curves shall be maintained by bending the conduit pipe itself with a long radius which will permit easy drawing in of conductors. All threaded joints of conduit pipes shall be treated with approved preservative compound to secure protection against rust.

19.132.4 Fixing of MS/Cast Iron Conduit Boxes In Walls

Conduits boxes of mild steel or cast iron shall be fixed in the walls with cement and sand mortar 1:2. No screwing of conduit boxes shall be required when fixed in recessed conduit wiring system.

19.132.5 Inspection Boxes

Inspection boxes shall be provided to permit periodical inspection and to facilitate replacement of wires, if necessary. These shall be mounted flush with the wall. Suitable ventilating holes shall be provided in the inspection box covers.

19.132.6 To facilitate drawing of wires in the conduit, galvanised iron fish wire of 3.25 mm diameter shall be provided alongwith laying of recessed conduit. ,

19.133 Bus Bar Chambers

Bus bar chamber shall be fabricated with mild steel angle frame work and covered alround with steel sheet of thickness not less than 1.5 mm in a box form. It shall be provided with detachable covers on all sides fitted with dust excluding gasket secured with sufficient numbers of cadmium plated iron screws to ensure that the covers are dust tight. Bus-bar chambers for bus-bar of more than 900 mm length shall have horizontal and vertical stiffeners welded to the main frame. Alternatively the bus-bar chamber shall be made of steel sheet of thickness not less than 3 mm in a box form with detachable covers on all sides and dust excluding gasket. The joints shall be continuous welded. The detachable covers shall be secured to the box with sufficient number of cadmium plated iron screws to ensure dust tightness. This type of bus-bar chamber shall be restricted for bus-bar upto 900 mm length. Bus-bar chambers of size upto 900 mm can be extended from the ends having detachable end covers. The bus-bar chamber shall be painted with a coat of primer of red oxide paint and finished with two coats of synthetic enamel paint, as indicated.

19.134 Bus-Bar

Bus-bar shall be made of wrought copper or aluminium alloy conforming to relevant Indian standards and shall be of sufficient cross section so that current density of 130 A/cm^2 is not exceeded at nominal current rating. For bus-bar of capacities upto 200A the cross section of neutral bus-bar shall be the same as that of the phase bus-bar and for higher capacities the neutral bus-bar shall be not less than half the cross section of that of phase bus-bar. When bus-bars are used as vertical risers in a multi-storeyed building a fireproof barrier inside the bus-bar chamber shall be provided at each floor crossing.

19.135 Bus-Bar Supports and Attachments

19.135.1 Supports

Bus-Bar shall be firmly fixed on supports constructed from a suitable insulated material such as phenolic laminated sheet as approved by the EIC or as indicated. Alternatively bus -bars shall be supported on insulators of suitable lengths conforming to relevant Indian Standards. The supports shall be sufficiently robust to effectively withstand electro-mechanical stresses produced in the event of short circuit.

19.135.2 Connections to Bus-Bars

Connections to bus-bars of ratings more than 200A shall preferably be made with clamping arrangement with bolts and nuts; and for bus-bars of smaller rating use of holes drilled into the bus-bars may be made.

Bolts and nuts used for connections to bus-bars shall be of aluminium alloy, tinned forged brass or galvanised iron. Suitable precaution shall be taken against heating due to bimetallic contact. Further for tapping off connections from bus-bars. Elastomer Insulated or PVC insulated wire may be used for current capacities upto 100A and for higher current capacities solid conductors/strips suitably connected with PVC sleeve/tape shall be used.

19.135.3 Clearances

The minimum clearances to be maintained for open and enclosed indoor air insulated bus-bars, electrically non-exposed and working at system voltages upto 600 volts shall be as follows :

Phase Connection	Minimum Clearance
(a) Phase toEarth	26 mm
(b) Phase to Phase	32 mm

19.136 Marking of Bus Bar and Main Connections

19.136.1 For marking bus-bars and main connections the following colours or letters (or symbols) or both as given in IS :375-1963 shall be used :-

Bus-Bar and Main Connections	Colour	Letter (or Symbol)
(1)	(2)	(3)
For AC Phase Connection :		
Three-Phase	Red, Yellow & Blue	RYB
Two-Phase	Red & Blue	RB
Single-Phase	Red	R
Neutral Connection	Black	N
Connection to earth	Green	E
Phases Variable (such as in connections to reversible motors)	Grey	Grey or GY

19.136.2 Phase Sequence and Polarity

(a) Bus Bars and main connections, when marked shall be marked as under:-

System	Phase Sequence	
	As Indicated by colours or letters	As Indicated by Vectorially
(1)	(2)	(3)
Three-Phase	Red, Yellow, Blue	R Y B
Two-Phase	Red, Blue	R B

19.137 Earthing

Earthing shall be carried out as described in IS 3043-1987, Code of practice for earthing.

19.137.1 Pipe Earth Electrode

Galvanised steel pipe electrode shall be of medium grade 40 mm dia and 2.5 metre in length. Pipe electrodes shall be cut tapered at the bottom and provided with 12 mm holes (staggered) at 75 mm Centre to centre upto 2 metre of length from bottom. The electrode shall be buried in the ground vertically with its top not less than 1.25 metre below ground level. Typical illustration of pipe earth electrode is given in Electrical Plate No. 4.

19.137.2 Plate Earth electrode

Plate electrode where made of galvanised iron or steel shall be 600x600x6.3 mm or 600x600x3.15 mm if of copper as indicated.

19.137.2.1 The electrode shall be buried in ground with the faces vertical and its top most edge not less than 1.5 metre below ground level as shown in plate No. 5. The use of plate, electrode is recommended where current carrying capacity is the prime consideration, for example; the earthing of equipment in Generting Station and power distributing substations. Where necessary, plate electrode shall have a galvanised iron water pipe of 50 mm internal dia bore buried directly vertical and adjacent to the electrode.

One end of such pipe shall be 5 to 10 cms above the ground level and the other end shall be near the centre of the plate electrode but in no case it shall be extended more than the bottom edge of the plate electrode.

19.137.3 Strip or Conductor Electrode

Such rocky strata where excavating earthing pits is difficult without blasting and blasting is prohibited or for minimising the earth resistance of a lightning protective network in rocky area.

19.137.3.1 Strip electrodes shall not be less than 25x4 mm in case of galvanised iron or steel and 25x1.6 mm in case of copper. If round conductor are used as electrodes, the cross sectional area of such conductor shall not be less than 3.0 sq.mm in case of copper and 6.00 sq.mm in case of galvanised iron or steel wire.

19.137.3.2 The length of buried strip or round conductor shall not be less than 15 metres. This length of the electrode shall be increased if necessary on the basis of soil resistivity so that the required earth resistance is obtained.

19.137.3.3 The electrode shall be buried in trench not less than 500 mm deep. If conditions necessitate use of more than one strip or conductor electrode, they shall be laid as widely distributed as possible, preferably in a single straight or circular trench or in a number of trenches radiating from one point.

19.138 Method of Installing Watering Arrangement

In the case of plate earth electrodes a watering pipe of 20 mm dia and of galvanised iron, shall be provided up to the electrode. A funnel with wire mesh pipe shall be provided on the top of this pipe. In the case of pipe electrode a 40x20 mm reducer shall be used for fixing the watering pipe to the electrode. The funnel attachment shall be housed in concrete enclosure as shown in Plate No. 4.

19.138.1 A cast iron mild steel frame with cover having locking arrangement shall be suitably embedded in the masonry enclosure, finished flush with Ground level.

19.139 Location for Earth Electrode

19.139.1 Normally an earth electrode shall not be situated less than 1.5 metre from any building. Care shall be taken that the excavations for earth electrode may not affect the column footings or foundation of the building; in cases where excavation affect the foundations, the distance of electrode from the building shall be increased.

19.139.2 The location of the earth electrode shall be such where the soil has reasonable, chance of remaining moist. Entrances, pavements and roadways shall be avoided for locating the earth electrode.

19.140 Artificial Treatment of Soil

In case there is no option of site and earth electrode resistance is high, the earth electrode resistance shall be reduced by artificial chemical treatment of the soil. For this purpose the most commonly used substances are sodium chloride (common salt), calcium chloride, sodium carbonate, copper sulphate, salt and soft coke and salt and charcoal in suitable proportions, Unless otherwise indicated, the electrode shall be surrounded by charcoal/coke and salt.

19.141 Main Earthing Lead

The main lead shall be either stranded or solid bars or flat rectangular strips and may be bare provided due care is taken to avoid corrosion and mechanical damage to it and shall not be more than 15 metres in length for minimum resistance. The length may be increased with proportional increase in cross section in case of copper or galvanised iron or steel wire so as to ensure minimum resistance. Preferably the main earthing lead shall be galvanised iron or steel in case of galvanised pipe electrode, galvanised iron wire or galvanised strip in case of earth electrode of galvanised plate or strip or rod and copper wire or strip in case of copper plate or strip or rod earth electrode. For all electrical installations except substations and generating stations the size of earthing lead shall not be less than half of the largest conductor carrying current to be protected. The size of earthing lead shall not be greater than 100 sq mm for copper conductors and 150 sq mm for galvanised iron conductors. The minimum size of earthing lead in any earthing shall not be less than 3.00 sq.mm cross section in case of copper and 6 sq.mm in case of galvanised iron wire. For equipment earthing in Substation ard generating station or lightning protection system it shall not be less than 20x3 mm copper strip or 25x4 mm galvanised iron strip. However the actual size will depend on the maximum fault current which earthing will require to carry safely. Protection against mechanical damage/pilferage shall remain the concern.

19.142 Size of Earth Continuity Conductor

The minimum cross sectional area of an earth continuity conductor not contained within a cable or flexible cord shall be 1.5 sq mm for copper and 2.5 sq.mm for aluminium. As regards the size of the galvanised iron, it may be equal to the size of the current carrying conductors with which they are used.

19.142.1 For flexible cables the size of the earth-continuity conductors should be equal to the size of the current-carrying conductors.

19.143 Method of Connecting Earthing Lead to Earth Electrode

In the case of plate earth electrode the earthing lead shall be securely bolted to the plate with two bolts, nuts, check nuts and washers. In the case of pipe earth electrode, it shall be connected by means of a through bolts, nuts and washers and cables socket as indicated. All materials used for connecting the earth lead with electrode shall be galvanised iron in case of galvanised iron pipe and galvanised iron plate earth electrodes, and of tinned brass in case of copper plate electrodes. The earthing lead shall be securely connected at the other end to the main board. Loop earthing shall be provided for all mountings of main board and other metal clad switches and distribution fuse boards with not less than 2.5 sq.mm for copper or 4 sq.mm aluminium wire.

19.144 Protection of Earthing Lead

The earthing lead from electrode onwards shall be suitably protected from mechanical injury by a 15 mm dia medium quality galvanised iron pipe in case of wire and by 40 mm dia pipe in case of strip. Portion of this protection pipe within ground shall be buried atleast 300 mm deep (to be increased to 600 mm in case, of road crossing and pavement). The portion within the building shall be recessed in walls and floors to adequate depth.

19.145 Protection Against Earth Leakage

All metal work, shall be isolated in such a way that they cannot come in contact with any live part or earthed metal work.

19.146 Testing

On completion of installation and also after carrying out additions/alterations to an existing installation, the following tests shall be carried out.

19.146.1 Insulation Resistance

19.146.1.1 The insulation resistance shall be measured by applying between earth and the whole system of conductors or any section thereof with all fuses in place and all switches closed, and except in earthed concentric wiring, all lamps in position or both poles of the installation otherwise electrically connected together, a direct current pressure or voltage of not less than twice the working pressure or voltage provided it does not exceed 500 volts for medium voltage circuits. Where the supply is derived from the three wire (AC or DC) or poly phase AC system, the neutral pole of which is connected to earth either direct or through added resistance, the working pressure or voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.

19.146.1.2 The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or to the neutral or to the other pole of phase conductor of the supply with all lamps in position and switches in off position.

19.146.1.3 The insulation resisance in megohms measured as above shall be not less than 50 megohms divided by the number of outlets in the circuit

19.146.1.4 Where insulation is being tested, a lower value than that given by the relevant formula, subject to a minimum of 1 mega ohm should be acceptable.

19.146.1.5 A preliminary and similar test may be made before lamps etc. are installed, and in this event the insulation resistance to earth should be not less than 100 megohms divided by the number of outlets or 25 megohms divided by the number of outlets when PVC insulated cables are used for wiring.

19.146.1.6 The term outlet includes every point along with every switch except that a switch combined with a socket outlet appliance or lighting fitting is regarded as one outlet.

19.146.1.7 Control rheostats, heating and power appliances and electric signs may, if required, be disconnected form the circuit during the test, but in that case the insulation resistance between the case or framework and all live parts of each rheostat appliance and electric sign shall be not less than half a megohm.

19.146.2 Polarity Test of Switch

19.146.2.1 In a two wire installation a test shall be made to verify that all switches in every circuit have been fitted in the same conductor throughout and such conductor shall be labelled or markcd for connection to the phase conductor or to the non-earthed conductor of the supply.

19.146.2.2 In a three wire or a four wire installation a test shall be made to verify that every non-linked, single pole switch is fitted in a conductor which is labelled or marked for connection to one of the outer or phase conductor of the supply.

19.146.2.3 The installation shall be connected to the supply for testing. The terminals of the switches shall be tested by a test lamp, one lead of which is connected to the earth. Glowing of test lamp to its full brilliance, when the switch is in 'on' position irrespective of appliance in position or not, shall indicate that the switch is connected to the right polarity.

19.146.3 Testing of Earth Continuity Path

The earth continuity conductor including metal conduits and metallic envelopes of cables in all cases shall be tested for electric continuity and the electrical resistance of the same alongwith the earthing lead but excluding any added resistance or earth leakage circuit breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

19.147 Protection of Buildings against Lightning

19.147.1 General

Installation of lightning arrestor system for protection of buildings and allied structures shall be carried out as described in IS 2309-1989, Code of practice for protection of buildings and allied structures against lightning.

19.147.2 Materials

19.147.2.1 Copper

Solid or stranded copper wire or flat copper strips shall be of grade ordinarily required for commercial electrical work, generally designated as being of 98 percent conductivity when annealed.

19.147.2.2 Galvanized Steel

Steel shall be thoroughly protected against corrosion by a zinc coating.

19.147.2.3 Aluminium

Aluminium wire and strips shall be at least 99 percent pure, of sufficient mechanical strength and effectively protected against corrosion. Aluminium shall not be used under ground in direct contact with walls.

19.147.2.4 All air terminations shall be of galvanized iron and all down conductors shall be of galvanized iron or aluminium except where copper is indicated for air terminations and down conductors.

19.147.2.5 Shapes and sizes

The recommended shape and minimum sizes of conductors for use above ground and below ground are given as under :-

A-For use above Ground

SI. No.	Material and Shape	Minimum Size
1.	Round copper wire	6 mm diameter
2.	Stranded copper wire	50 sq.mm (or 7/3.0 mm diameter)
3.	Copper Strip	20x3 mm
4.	Round galvanized iron wire	8 mm diameter
5.	Galvanised iron strip	20x3 mm
6.	Round Aluminium wire	9 mm diameter
7.	Aluminium strip	25x3.15 mm

B-For use below Ground

SI. No.	Material and Shape	Minimum Size
1.	Round copper wire or copper clad steel wire	8 mm diameter
2.	Copper Strip	32x6 mm
3.	Round galvanized iron wire	10 mm diameter
4.	Galvanized iron strip	32x6 mm

19.147.3 Air Terminations

For the purpose of lightning, protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminations or vertical finials is, therefore, not regarded as essential. However, vertical air termination shall be provided where indicated. A vertical air termination shall have one point and shall project at least 300 mm above the object salient point or network on which it is fixed.

19.147.3.1 Horizontal air terminations shall be interconnected as indicated; such that no part of the roof is more than 9 metre away from the nearest horizontal conductor except that an additional 300 mm may be allowed for each 300 mm by which the part to be protected is below the nearest protective conductor. For a flat roof horizontal air terminations along the outer perimeter of the roof is used. For a roof of larger area a network or parallel horizontal conductors shall be installed as indicated,

19.147.3.2 Horizontal air terminations shall be coursed as indicated, along contours such as ridges, parapets and edges of flat roof and where necessary over flat surfaces in such a way as to join each air termination to the rest and should themselves, form a closed network.

19.147.3.3 All metallic finials, chimneys, ducts, vent pipes, railings, gutters, metallic flagstaff, etc., on or above the main surface of the roof of the structure shall be bonded to form part of the air termination network. If portions of a structure vary considerably in height, any necessary air termination or air termination network of the lower portions shall be addition to their own conductors, be bonded to the down conductors of the taller portions.

19.147.3.4 All air terminals shall be effectively secured against overturning either by attachment to the object to be protected or by means of substantial braces and fixing which shall be permanently and rigidly attached to the building. The method and nature of the fixing shall be as directed.

19.147.4 Down Conductors

Down conductors shall be distributed around the outside walls of the structure as indicated. They shall preferably be run along the corners and other projections, due considerations being given to the location of air terminations and earth terminations. Lift shafts shall not be used for fixing down conductors.

19.147.4.1 Down conductors shall follow the most direct path possible between the air termination and the earth tcrmination avoiding sharp bends upturns and kinks. Joints shall as far as possible be avoided in down conductors. Metal pipe shall not be used as protection for the conductors.

19.147.4.2 Metal pipes from the roof to the ground may be connected to the down conductors but cannot replace them. Such connections shall have disconnecting joints.

19.147.5 Joints and Bonds

The lightning protective system shall have as few joints in it as possible. Wherever joints in the down conductor above ground level are necessary they shall be mechanically and electrically effective. In down conductors below ground level there shall be no joints. The joints may be clamped, screwed, bolted, riveted, sweated, braced or welded. The bonding of the external metal forming part of a structure of drain water pipe shall have a cross sectional area not less than that employed for the main conductors. In no case gas pipe, shall be bonded to the earth termination system.

19.147.6 Testing Points

Each down conductor shall be provided with a testing point in a position convenient for testing but inaccessible for interference. No connection, other than one direct to an earth electrode shall be made below a testing point. Testing points shall be of phosphor bronze, gunmetal, copper or any other suitable material.

19.147.7 Earth Terminations

Each down conductor shall have an independent earth termination.

19.147.8 Earth Electrodes

Earth electrodes shall be constructed as specified under Earthing.

19.147.9 Fasteners

Conductors shall be securely attached to the building or other object to be projectod by fasteners which shall be substantial in construction, not subject to breakage and shall be galvanized steel or other suitable materials with suitable precaution to avoid corrosion. The lightning conductors shall be secured at not more than 1.20 metre apart for horizontal run and 1 metre for vertical run.

APPENDIX A

EXTRACT FROM INDIAN ELECTRICITY RULES, 1956

Identification of Earth and Earthed Neutral Conductors and Position of Switches and Cutouts therein

Where the conductors include an earthed conductor of a two wire system or an earthed neutral conductor of a multi wire system or a conductor which is to be connected thereto, the following conditions shall be complied with :-

1. An indication of a permanent nature shall be provided by the owner of the earthed or earthed neutral conductor or the conductor which is to be connected thereto, to enable such conductor to be distinguished from any live conductor. Such indication shall be provided :-
   (a) Where the earthed or earthed neutral conductor is the property of the supplier, at or near the point of commencement of Supply;
   (b) Where a conductor forming part of a consumer's system is to be connected to the supplier's earthed or earthed neutral conductor, at the point where such connection is to be made; and
   (c) In all other cases at a point corresponding to the point of commencement of supply or at such other point as may be approved by an inspector and authorised under sub-rule (2) or rule 4A.
2. No cutout link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and live conductors shall be inserted or remain inserted in any earthed or earthed neutral conductor of a two wire system or in any earthed or earthed neutral conductor of multiwire system or in any conductor connected thereto with the following exceptions :-
   (a) A link for testing purposes or
   (b) A switch for use in controlling a generator or transformer.

Earthed Terminal on the consumer's Premises

(1) The supplier shall provide and maintain on the consumer's premises for the consumers' use a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under Rule No. 58 :
Provided that in the case of medium, high or extra high voltage installation, the consumer shall, in addition to the aforementioned earthing arrangement, provide his own earthing system with an independent electrode :
Provided further that the supplier may not provide any earthed terminal in the case of installations already connected to his system on or before the date to be specified by the State Government in this behalf if he is satisfied that the consumer's earthing arrangement is efficient.

(2) The consumer shall take all reasonable precautions to prevent mechanical damage to the earthed terminal and its lead belonging to the supplier.

(3) The supplier may recover from the consumer the cost of installation of such earthed terminal on the basis laid down in sub-rule (2) of the Rule No. 82.

Supply and Use of Energy

(a) A suitable linked switch or a circuit breaker of required capacity to carry and break the current is placed as near as possible to, but after the point of commencement of supply as defined under Rule 58, so as to be readily accessible and capable of being easily operated to completely isolate the supply to the installation, such equipment being in addition to any equipment installed for controlling individual circuits or apparatus :

Provided that where the point of commencement of supply and the consumer's apparatus are near each other, one linked switch or circuit breaker near the point of commencement of supply shall be considered sufficient for the purpose of this rule:

(b) A suitable linked switch of a circuit breaker of requisite capacity to carry and break the full load current is inserted on the secondary side of a transformer, in the case of high or extra high voltage installation :

Provided, however, that the linked switch on the primary side of the transformer may be of such capacity as to carry the full load current and to break only the magnetizing current of the transformer :

Provided further that the provision of this clause shall not apply to transformers installed in sub stations up to and including 100 KVA belonging to the supplier;

(c) Except in the case of composite control gear designed as a unit-every distinct circuit is protected against excess energy by means of a suitable cut-out or a circuit breaker of adequate breaking capacity suitably located and so constructed as to prevent danger from over-heating arcing or scattering of hot metal when it comes into operation and to permit of ready renewal of the fusible metal of the cut-out without danger;

(d) The supply of energy to eachmotor or other apparatus meant for operating one particular machine, is controlled by a suitable linked-switch or a circuit breaker or an emergency tripping device with manual reset of requisite capacity placed in such a position as to be adjacent to the motor or a group of motors or other apparatus readily accessible to and easily operated by the person in charge and so connected in circuit that by its means all supply of energy can be cut off from the motor or apparatus, and from any regulating switch, resistance or other device associated therewith;

(e) All insulating material is chosen with special regard to the circumstances of its proposed use, the mechanical strength being sufficient for its purpose, and so far as is practicable, is of such a charactcror or so protected as to maintain adequately its insulating properties under all working conditions in respect of temperature and moisture: and

(f) Adequate precautions are taken to ensure that no live parts are so exposed as to cause danger.

(2) Every consumer shall use all reasonable means to ensure that, where energy is supplied by supplier,no person other than the supplier shall interfere with the service lines and apparatus placed by the supplier on the premises of the consumer.

51. Provisions applicable to medium, high or extra high voltage installations

The following provisions shall be observed, where energy at medium, high or extra high voltage is supplied, converted / transformed or used :-

(1) (c) Every main switchboard shall comply with the following provisions, namely :-

(i) A clear space of not less than 0.914 meter in width shall be provided in front of the switch board;

(ii) If there are any attachments of bare connections at the back of the switchboard, the space (if any), behind the switchboard shall be either less than 0.229 metre, or more than 0.762 metre in width, measured from the furthest outstanding part of any attachment or conductor;

(iii) If the space behind the switchboard exceeds 0.762 metre in width, there shall be passage-way from either end of the switchboard clear to a height of 1.829 metre.

58. Point of commencement of supply

The point of commencement of supply of energy to a consumer shall be deemed to be the point at the outgoing terminals of the cut-outs inserted by the supplier in each conductor of every service line other than an earthed or earthed neutral conductor of the earthed external conductor of a concentric cable at the consumer's premises.

61. Connection with earth

1. The following provisions shall apply to the connection with earth of systems at low voltage in cases where the voltage normally exceeds 125 volts and of systems at medium voltage:-
   (a) The neutral conductor of a three phase four-wire system, and the middle conductor of a two phase three-wire system shall be earthed by not less than two separate and distinct connections with earth both at the generating station and at the sub-station. It may also be earthed at one more points along the distribution system or service-line in addition to any connection with earth which may be at the consumer's premises.

(2) The frame of every generator, stationary motor, and so far as practicable, portable motor, and the metalic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or controlling energy and all medium voltage energy consuming apparatus shall be earthed by the owner by two separate and distinct connections with earth.

(3) All metal casings or metallic coverings containing or protecting any electric supply line or apparatus shall be connected with earth and shall be so joined and connected across all junction boxes and other openings as to make good mechanical and electrical connection throughout their whole length;

Provided that where the supply is at low voltage, this sub-rule shall not apply to isolated wall tubes or to brackets, , electroliers, switches, ceiling fans or other fittings (other than portable hand lamps and portable and transportable , apparatus) unless provided with earth terminal :

Provided further that the supply is at low voltage and where the installations are either new or renovated all plug sockets shall be of the three-pin type, and the third pin shall be permanently and efficiently earthed.

This sub-rule shall come into force immediately in the case of new installations and in the case of existing installations and provisions of this sub-rule shall be complied with before the expiry of a period of two years from the commencement of those rules.

OVERHEAD LINES

74. Material and Strength

(1) All conductors of overhead lines other than those specified in sub-rule (1) of rule 86 shall have a breaking strength of not less than 350 Kg.

(2) Where the voltage is low and the span is less than 15 metres and is on the owner's or consumer's premises, a conductor having an actual breaking strength of not less than 150 Kg may be used.

75. Joints

Joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation. The ultimate strength of the joint shall not be less than 95 percent of that of the conductor, and the electrical conductivity not less than that of the conductor.

76. Maximum stresses:- Factors of safety

(1) (a) The owner of every overhead line shall ensure that it has the following minimum factors of safety :-

(i) for metal supports	1.5
(ii) for mechanically processed concrete supports	2.0
(iii) for hand moulded concrete supports	2.5
(iv) for wood supports	3.0

The minimum factors of safety shall be based on such load as would cause failure of the support to perform its function (assuming that the foundation and other components of the structure are intact).

The aforesaid load shall be (i) equivalent to the yield point stress or the modulus of rupture, as the case may be, for supports subject to bending and vertical loads, (ii) the crippling load for supports used as struts.

The said owner shall so ensure that the strength of the supports in the direction of the line is no less than one-fourth of the strength required in the direction transverse to the line :

Provided that in the case of latticed steel or other compound structures, factors of safety shall not be less than 1.5 under such broken wire conditions as may be specified by the State Government in this behalf.

(b) The minimum factor of safety for stay wires, guard-wires or bearer-wires shall be 2.5 based on the ultimate tensile strength of the wire.

(c) The minimum factor of safety for conductors shall be 2 based on their ultimate tensile strength. In addition, the conductor tension at 32' C, without external load, shall not exceed the following percentage of the ultimate tensile strength of the conductor :-

Initial unloaded tension	35 percent
Final unloaded tension	25 percent

Provided that in the case of conductors having a cross-section of a generally triangular shape, such as conductors composed of three wires, the final unloaded tension at 32" C shall not exceed 30% of the ultimate tensile strength of such conductor.

(2) For the purpose of calculating the factors of safety prescribed in Sub-rule (1).

(a) The maximum wind pressure shall be such as the State Government may specify in each case;

(b) For cylindrical bodies the effective area shall be taken as two thirds of the projected area exposed to wind pressure;

(c) For latticed steel or other compound structures the wind pressure on the lee-side members shall be taken as one half of the wind pressure on the windward side members and the factors of safety shall be calculated on the crippling load of struts and upon the elastic limit of tension members;

(d) The maximum and minimum temperatures shall be such as the State Government may specify in each case.

(3) Notwithstanding anything contained in Sub-rules (1) and (2), in localities where overhead lines are liable to accumulations of ice or snow the State Government may by order in writing, specify the loading conditions for the purpose of calculating the factor of Safety.

77. Clearance above ground of the lowest conductor:-

(1) No conductor of an overhead line, including service lines, erected across a street shall at any part thereof be at a height less than :-

(a) For low and medium lines	5.8 metres
(b) For high voltage lines	6.1 metres

(2) No conductor of an overhead line, including service lines, erecled along any street shall at any part thereof be at a height less than :-

(a) For low and medium voltage lines	5.5. metres
(b) For high voltage lines	5.8. metres

(3) No conductor of an overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than:-

(a) For low, medium and high voltage lines up to and including 11,000 volts if bare	4.6 metres
(b) For low, medium and high voltage lines up to and including 11,000 volts, if insulated	4.0 metres
(c) For high voltage lines above, 11000, volts	5.2 metres

(4) For extra high voltage lines the clearance above ground shall not be less than 5.2 metres plus 0.3 metre, for every 33,000 volts or part thereof by which the voltage of the lines exceeds 33,000 volts :

Provided that the minimum clearance along or across any street shall not be less than 6.1 metres.

79. Clearance from Buildings of low and medium voltage lines and service lines

(1) Where a low or medium voltage, overhead line passes above or adjacent to or terminates on any building the following minimum clearances from any accessible point, on the basis of maximum sga, shall be observed :-

(a) for any flat roof, open balcony, verandah, roof and lean-to roof :-

(i) When the line passes above the building, a vertical clearance of 2.5 metres from the highest point and

(ii) When the line passes adjacent to the building, a horizontal clearance of 1.2 metre from the nearest point, and

(b) for pitched roof :-

(i) when the line passes above the building a vertical clearance of 2.5 metre immediately under the lines, and

(ii) when the line passes adjacent to the building a horizontal clearance of 1.2 metre.

(2) Any conductor so situated as to have a clearance less than that specified in sub-rule (1) shall be adequately insulated and shall be attached by means of metal clips at suitable intervals to a bare earthed bearer wire having a breaking strength of not less than 350 Kg.

(3) The horizontal clearance shall be measured when the line is at a maximum deflection from the vertical due to wind pressure.

80. Clearances from buildings of high and extra high voltage lines

(1) Where a high or extra high voltage overhead line passes above or adjacent to any building or part of a building it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line, of not less than :-

(a) for high voltage lines up to and including 33000, volts	3.7 metres
(b) for extra high voltage lines	3.7 metres plus 0.3 metre for every additional 33,000 volts or part thereof.

(2) The horizontal clearance between the nearest conductor and any part of such building shall on the basis of maximum deflection due to wind pressure, be not less than :-

(a) for high voltage lines up to and including 11,000 volts	1.2 metres
(b) for high voltage lines above 11,000 volts and up to and including 33,000 volts	2.0 metres
(c) for extra high voltage lines	2.0 metres plus 0.3 metre for every additional 33,000 volts or part thereof.

81. Conductors at different voltages on same supports

Where conductors forming parts of systems at different voltages are erected on the same supports the owner shall make adequate provision to guard against danger to lines man and other from the lower voltage being charged above is normal working voltage by leakage from or contact with the higher voltage system : and the method of construction and the clearances between the conductors of the two systems shall be a subject to the prior approval of the Inspector.

82. Erection of or alteration to buildings, structures, flood banks and elevation of roads

(1) If at any time subsequent to the erection of an overhead line (whether covered with insulating material or bear), any person proposes to erect a new building or structure or flood bank or to raise any road level or to, carry out any other type of work whether permanent or temporary, or to make in or upon any building or structure or flood bank or road, any permanent or temporary addition or alteration, he and the contractor whom he employs to carry out the erection, addition or alteration, shall, if such work, building, structure, flood bank road or additions and alterations, thereto would, during or after the construction result in contravention of any of the provisions of rule 77, 79 or 80 give notice in writing of his intention to the supplier, and to the Inspector and shall furnish therewith a scale drawing showing the proposed buildings, flood bank, road, any addition or alteration and scaffolding required during the construction.

(2) (a) On receipt of the notice referred to in sub rule (1) or otherwise, the supplier shall examine whether the line under reference was lawfully laid and whether the person was liable to pay the cost of alteration and if so, send a notice without undue delay, to such person together with an estimate of the cost of die expenditure likely to be incurred to so alter the overhead line and require him to deposit, within 30 days of the receipt of the notice with the supplier, the amount of the estimated cost.

(b) If the person referred to in sub-rule (1) disputes the supplier's estimated cost of alteration of the overhead line or even the responsibility to pay such cost, the dispute may be referred to the Inspector by either of the parties whereupon the same shall be decided by the Inspector.

(3) No work upon such building structure flood bank, road and addition or alteration thereto shall be commenced of continued until the Inspector has certified that the provisions of rule 77, 79 or 80 are not likely to be contravened either during or after the aforesaid construction :

Provided that, an Inspector may, if he is satisfied that the overhead line has been so guarded as to secure the protection of person and property from injury, or risk of injury, permit the work to be executed prior to the alteration of the overhead line, or in the case of temporary addition or alteration, without alteration of the overhead line.

83 Clearances General

For the purpose of computing the vertical clearance of an overhead line, the maximum sag of any conductor shall be calculated on the basis of the maximum sag in still air and the maximum temperature as specified by the State Government under rule 76 (2) (d).

Similarly for the purpose of computing any horizontal clearance of an overhead line, the maximum deflection of any conductor shall be calculated on the basis of the wind pressure specified by the State Government under rule 76 (2) (a) or may be taken as 35° whichever is greater.

84 Routes

Proximity to aerodromes Overhead lines shall not be erected in the vicinity of aerodromes until the aerodrome authorities have approved in writing the route of the proposal lines.

85 Maximum Intervals between supports

All conductors shall be attached to supports at intervals not exceeding the safe limits based on the ultimate tensile strength of the conductor and the factor of safety prescribed in rule 76 :

Provided that in the case of overhead lines carrying low or medium voltage conductors, when erected in, over, along or across any street, the interval shall not, without the consent in writing of the Inspector, exceed 65 metres.

86 Conditions to apply where telecommunication lines and power lines are carried on same supports

(1) Every overhead telecommunication line erected on supports carrying a power line shall consist of conductors each having a breaking strength of not less than 270 Kg.

(2) Every telephone used on a telecommunication line crected supports carrying a power line shall be suitably guarded against lightning and shall be protected by cutouts.

(3) Where a telecommunication line is erected on supports carrying a high or extra high voltage power line arrangements shall be made to safeguard any person using the telephone against injury resulting from contact leakage or induction between such power and telecommunication lines.

87 Lines crossing or approaching each other

(1) Where an overhead line crosses or is in proximity io any telecommunication line, either the owner of the overhead line or the telecommunication line, whoever lays his line later, shall arrange to provide for protective devices or guarding arrangements, in a manner laid down in the Code of Practice or the guide lines prepared by the Power and Telecommunication Coordination Committee and subject to the provisions of the following sub rules :-

(2) When it is intended to erect a telecommunication line or an overhead line which will cross or be in proximity to an overhead line or telecommunication line, as the case may be, the person proposing to erect such line shall give one month's notice of his intention so to do along with the relevant details or protection and drawings to the owner of the existing line.

(3) Where an overhead line crosses or is in proximity to another overhead line, guarding arrangements shall be provided so as to guard against the possibility of their coming into contact with each other

(4) A person erecting or proposing to erect a line which may cross or be in proximity with an existing line, may normally provide guarding arrangements on his own line or require the owner of the other overhead line to provide guarding arrangement as referred to in sub-rule (3).

(5) In all cases referred to in the preceding sub-rules, the expenses of providing the guarding arrangements or protective devices shall be borne by the person whose line was last erected.

(6) Where two lines cross, the crossing shall be made as nearly at right angles as the nature of the case admits and as near the support of the line as practicable, and the support of the lower line shall not be crected below the upper line.

(7) The guarding arrangement shall ordinarily be carried out by the owner of the supports on which it is made and he shall be responsible for its efficient maintenance.

(8) All work required to be done by or under this rule shall be carried out to the satisfaction of the Inspector.

88 Guarding

(1) Where guarding is required under these rules the provisions of sub-rule (2) to (4) shall apply.

(2) Every guard wire shall be connected with earth at each point at which its electrical continuity is broken.

(3) Every guard wire shall have an actual breaking strength of not less than 635 Kg and if made of iron or steel, shall be galvanised.

(4) Every guard wire or cross-connected system of guard wires shall have sufficient current carrying capacity to ensure the rendering dead, without risk of fusing of the guard wire or wires till the contact of any live wire has been removed.

89. Service lines from overhead lines

No service line or lapping shall be taken off an overhead line except at a point of support.

90. Earthing

(1) All metal supports and all reinforced and prestressed cement concrete supports of overhead lines and metallic fittings attached thereto, shall be permanently and efficiently earthed. For this purpose a continuous earth wire shall be provided and securely fastened to each pole and connected with earth ordinarily at three points in every km the spacing between the points being as nearly equidistant as possible.

Alternatively, each support and the metallic fittings attached thereto shall be efficiently earthed.

(2) Each stay wire shall be similarly earthed unless an insulator has been placed in it at a height not less than 3 metre from the ground.

(3) Mix of concrete shown all round the pit in Electrical Plate No. 4 shall be P.C.C. (1:4:8).

(4) The distance between top of 15 mm G.I. Pipe and top of cover in Electrical Plate No. 4 shall be 300 mm.

However in case of road crossing, this distance shall be kept as 600 mm.

91. Safety and Protective devices

(1) Every overhead line (not being suspended from a dead bearer wire and not being covered with insulating martial and not being a trolley wire) erected over any part of a street or other public place or in any factory or mine or any consumer's premises shall be protected with a device approved by the Inspector for rendering the line electrically harmless in case it breaks.

(2) An Inspector may by notice in writing require the owner of any such overhead line wherever it may be erected to protect it in the manner specified in sub-rule (1).

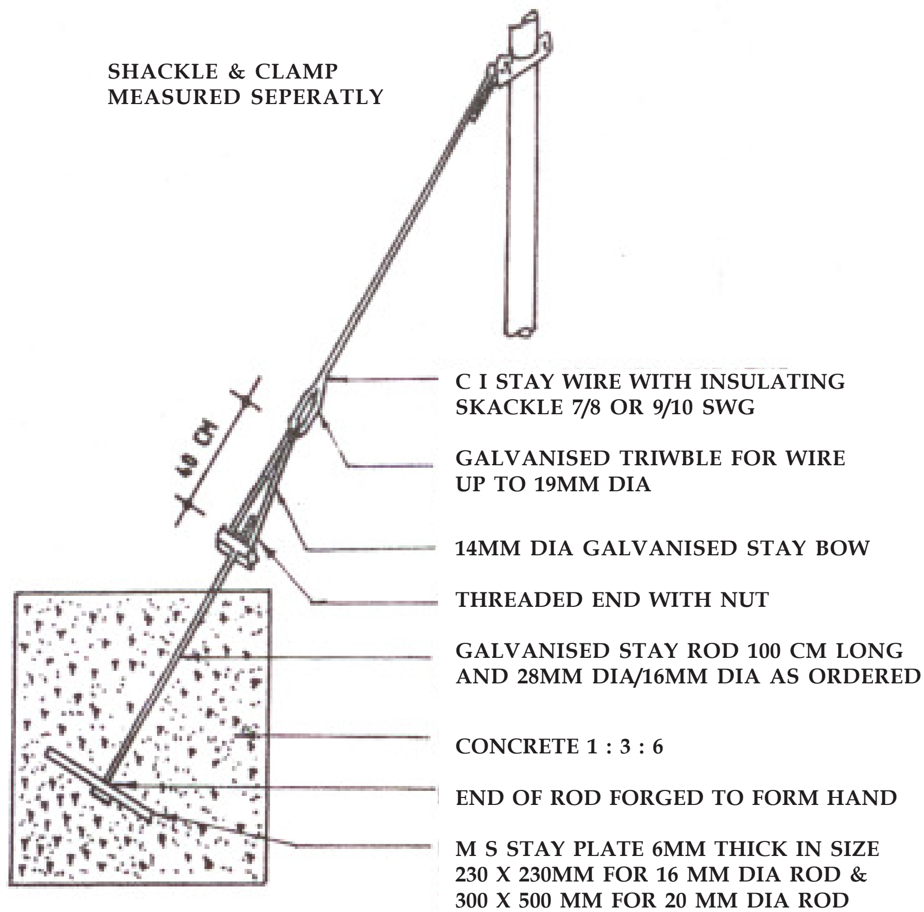
(3) The owner of every high and extra high voltage overhead line shall make adequate arrangements to the satisfaction of the Inspector to prevent unauthorised persons from ascending any of the support, of such overhead lines without the aid of a ladder or special appliances.

92. Protection against lightning

(1) The owner of every overhead line which is so exposed as to be liable to injury from lighting shall adopt efficient means for diverting to earth any electrical surges due to lightning.

The earthing lead for any lightning arrester shall not pass through any iron or steel pipe but shall be taken as directly as possible from the lightning arrester to a separate earth electrode subject to the avoidance of bends, wherever practicable.

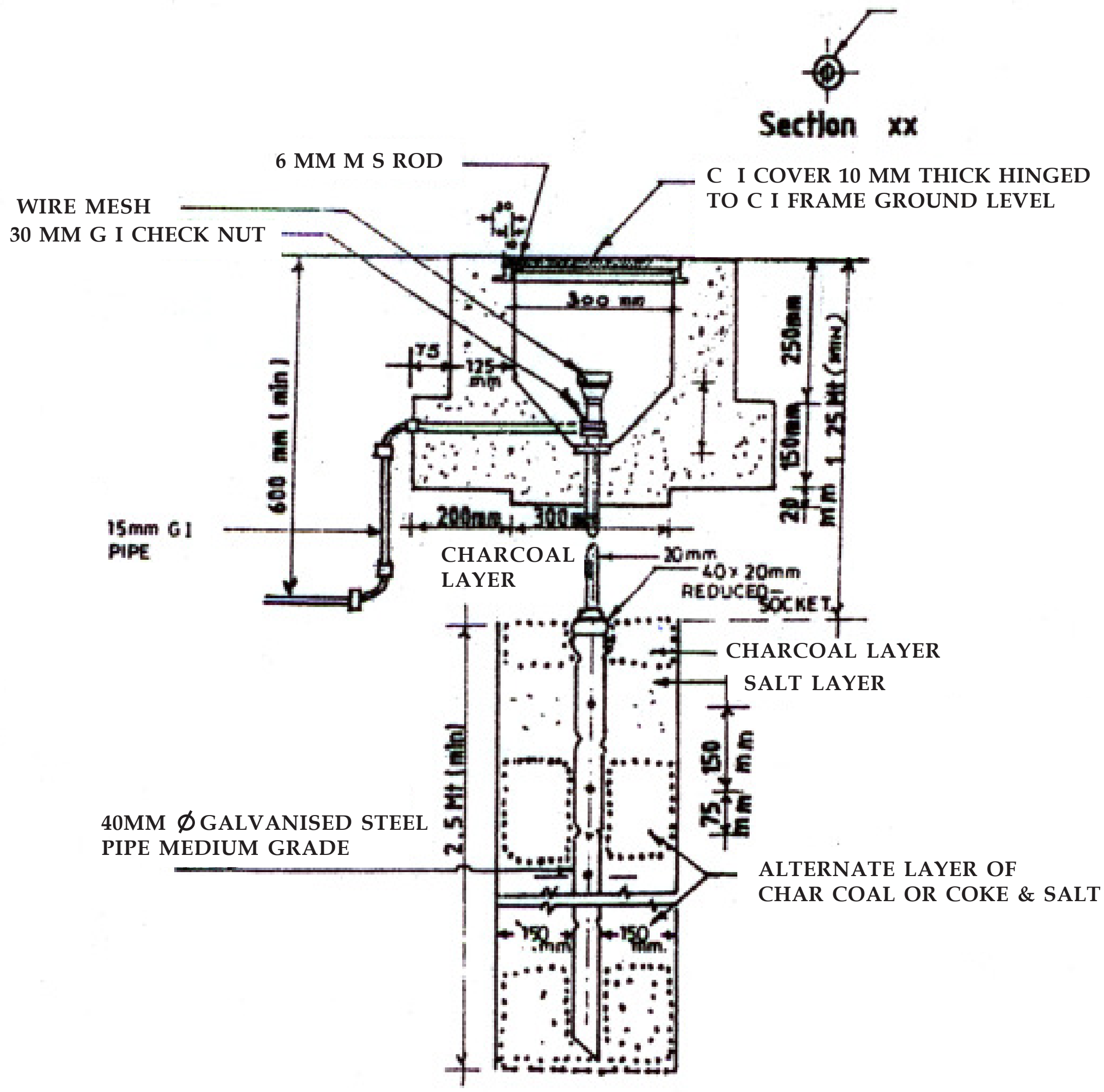
Note:- *In case of any variation between the Indian Electricity rules, as reproduced above, and Indian Electricity Rules 1956 as amended, Indian Electricity Rules shall take precedence.*



(NOT TO SCALE)

STAY ASSEMBLY

ELECTRICAL PLATE NO. 1



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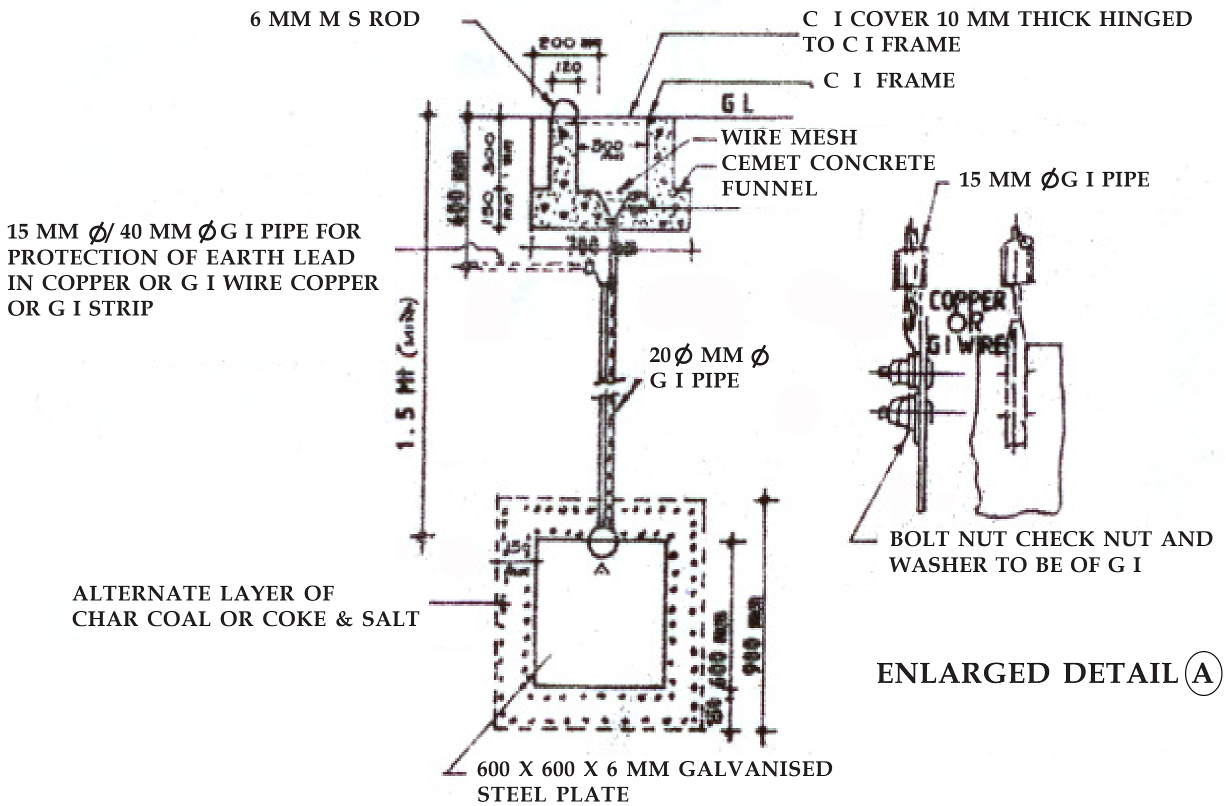
PIPE EARTHING

ELECTRICAL PLATE NO. 2



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PIPE EARTHING

ELECTRICAL PLATE NO. 3

SECTION 20-A
ROAD WORK

20.A.1 Indian Standards

The following IS and IRC apply to this section.

I S No.	*Subject*
73-2006	Specification of Paving Bitumen (Second Revision)
164-1981	Ready mixed paint for road marking, (First Revision)
217-1988	Specification for cut back bitumen (Second Revision)
269-1989	Specification for 33 grade ordinary Portland cement (Fourth Revision)
334-2002	Glossary of terms relating to bitumen and tar (Third Revision)
454-1994	Specification for cut back bitumen (Second Revision)
455-1989	Specification for Port land slag cement (Fourth revision)
458-2003	Specification for precast concrete pipes with and without reinforcement (Fourth Revision)
460 (Part-I) 1985	Test Sieves : Part I Wire cloth test sieves (Third Revision)
460 (Part-2) 1985	Test Sieves : Part II Perforated plate test sieves (Third Revision)
460 (Part-3) 1985	Test Sieves : Part III Methods of examination apertures of test sieves of (Third Revision)
702-1988	Specification for industrial bitumen (Second Revision)
712-1984	Specification for building limes (Third Revision)
1195-2002	Specification for bitumen mastic for flooring (Third Revision)
1203-1978	Method of testing tar and bituminous material, determination of penetration
1205-1978	Method of testing tar and bituminous material, determination of softening point
1208-1978	Method of testing tar and bituminous material, determination of ductility.
1212-1978	Method of testing tar and bituminous material, determination of loss on heating.
1216-1978	Method of testing tar and bituminous material, determination of solubility in carbon disulphide trichloroethylene.
1489 (Part I&2)1991	Specification for port land pozzolona cement (fly ash a calcined clay based) (Third revision).
2386 (Part-I) 1963	Methods of test for aggregate for concrete Part I particle size and shape.
2386 (Part-2) 1963	Methods of test for aggregate for concrete Part 2 Estimation of deleterious materials and organic impurities.
2386 (Part-3) 1963	Methods of test for aggregate for concrete Part 3 Specific gravity, density, voids, absorption and bulking.
2386 (Part-4) 1963	Methods of test for aggregate for concrete Part 4 Mechanical properties.
2720 (Part-5) 1985	Methods of test for soils, Part 5 determination of liquid and plastic limit, (Second Revision)

2720 (Part-7) 1980	Methods of test for soils, Part 7 determination of water content dry density relation using light compaction (Second Revision).
2720 (Part-28) 1974	Methods of test for soils, Part 28 determination of dry density of soils in place, by sand replacement methods (First Revision).
3117-2004	Specification for bitumen emulsion for roads (anionic type) (First Revision).
3812 (Part 1) 2003	Specification for fly ash for use as pozzalana and admixture (First Revision).
5317-2002	Specification for Bitumen mastic for bridge decking and roads (Second Revision).
5640-1970	Method of test for determining aggregate, impact value of soft coarse aggregates.
5779-1986	Specification for burnt clay soling bricks (First Revision).
6241 – 1971	Methods of test, for determination of stripping value of road aggregates.
8112-1989	Specification for high strength ordinary cement (First Revision).
IRC STANDARDS	
10-1961	Recommended practice for borrow pits for road, embankments constructed by manual operation.
19-1972	Standard specification and code of practice for water Bound Macadam.
29-1988	Specification for bituminous concrete for road pavements.
36-1970	Recommended practice for construction of earth embankments for road works.
60-1976	Tentative guidelines for the use of lime fly ash concrete as pavement base or sub-base.
88-1984	Recommended practice for lime fly ash stabilized soil base/ sub base in pavement construction
107-1992	Tentative specifications for bitumen mastic wearing courses.

20.A.2 Stone & Boulders for Soling (Sub-base)

Stones for soling (Sub bases) shall be free from laminations, foreign matter, and unsound weathered fragments & shall be granite, trap-basalt-limestone, sandstone-kankar, laterite or any other hard rock as indicated. Stones shall be broken to a size range 100mm to 50mm. Stones shall be obtained from approved quarries/ sources as indicated.

20.A.2.1 Where soling is of broken boulders or cobble stones, these shall be obtained from as large boulders as available. Cobble stone shall be less than 13 cm when measure across the proudest part in any direction.

20.A.3 Aggregates for Water Bound Macadam

20.A.3.1 Coarse Aggregates

1. **General requirements**
   Coarse aggregates shall be either crushed or broken stone, crushed slag , over burnt brick metal or naturally occurring aggregates such as kankar or laterite, as indicated.

The aggregates shall conform to the following physical requirements given below and shall be obtained from approved quarries/ sources as indicated.

Sl. No.	*Type of Construction*	*Test*	*Test method*	*Requirement*
1	Sub-base/ Base course	1. Los Angeles Abrasion Value or Aggregate Impact Value	IS-2386 (Part IV) IS-2386 (Part IV) or IS-5640	Max. 35% Max. 30%
		2. Combined flakiness & elongation index (Total)	IS-2386(Part I)	Max. 25%

Notes :- 1. Aggregate may satisfy the requirements of either the Los Angeles test or Aggregate Impact Value test.

2. Aggregate like brick metal, kankar and laterite, which get softened in presence of water, should invariably be tested for impact value under wet conditions in accordance with IS:5640-1970.
3. The requirements of Flakiness index and elongation index shall be enforced only in the case of crushed broken stone & crushed slag.

2. Crushed or broken stone

Crushed or broken stone shall be hard, durable and generally free from flat, elongated, soft and disintegrated particles. It shall also not have excess of dirt or other objectionable matter beyond 5% of weight of the aggregate.

3. Overburnt brick metal

Brick metal shall be made out of over burnt bricks or brick bats and shall be free from dust and other foreign matter. It shall be homogeneous in texture & roughly cubical in shape.

4. Kankar

Kankar shall be clean, tough, having a blue almost opalescent fracture, free from moorum and sand and shall not contain any clay in the cavities between nodules.

5. Laterite

Laterite shall be hard, compact, heavy and of dark colour. Light colored sandy laterites as also those containing a good bit of ocherous clay shall not be utilized.

5A. Crushed Slag

Crushed slag shall be made from air cooled blast furnace slag. It shall be of regular shape, reasonably uniform in quality and density. It shall generally be free from thin elongated & soft pieces, dirt or other objectionable matter. Crushed slag shall not weigh less than 1120 Kg/Cum and percentage of glossy material in it shall not be in excess of 20. Water absorption of slag shall not exceed 10% (IS-2386 Part-III).

6. Size and Grading Requirements

Coarse aggregates shall conform to one of the following grading as indicated

Grading No.	SIEVES		
	Size Range	*Sieve Designation*	*Percentage by weight passing the sieve*
1	90 mm to 45 mm	125 mm 90 mm 63 mm 45 mm 22.4 mm	100 90-100 25-65 0-15 0-05
2	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90-100 25-75 0-15 0-05
3	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 90-100 65-90 0-10 0-05

Notes :

1. The use of grading 1 shall be restricted to sub base courses only but it is not tenable for a compacted layer thickness of less than 90 mm.
2. For crushable type aggregates like brick metal, kankar and laterite, the above grading are not so relevant and need not be strictly enforced but the material should generally be within the size range indicated.

20.A.3.2 Screenings

1. Screening to fill voids in the coarse aggregates shall generally be of the same material as the coarse aggregate. However, predominantly non-plastic material such as kankar nodules, moorum or gravel (other than river-borne rounded aggregate) may also be used, where indicated, for this purpose provided that the liquid limit and plasticity index of such material is below 20 and 6 respectively and the fraction passing 75 micron sieve does not exceed 10 per cent.
2. Screening shall conform to the grading shown as under :-

Grading No.	*Size of screening*	*IS Sieve Designation*	*Percentage by weight passing the IS sieve*
A	13.2 mm	13.2 mm 11.2 mm 5.6 mm 180 micron	100 95-100 15-35 0-10
B	11.2 mm	11.2 mm 5.6 mm 180 micron	100 90-100 10-30

3. Screenings of type A shall be used in conjunction with coarse aggregates of grading 1 and of type B with coarse aggregates of grading 3. With coarse aggregates of grading 2, either Type A or Type B screenings may be used. For screenings like moorum and gravel, the gradings given are not binding
4. The use of screenings may be dispenses with in the case of crushable type coarse aggregates such as brick metal, kankar and laterite.

20.A.3.3 Binding Materials

Binding material to prevent raveling of water bound macadam shall consist of fine grained material possessing plasticity index value of 4 to 9 when the WBM is to be used as a wearing course and 4 to 6 when WBM is being adopted as sub base / base course with bituminous surfacing on top of it. The plasticity Index shall be determined in accordance with IS –2720 (Part 5). Binding material should pass 100% through 425 IS sieve. If lime stone formations are available nearby, lime stone dust or kankar nodules may be usefully employed for this purpose. Application of binding material may not be necessary where the screenings consist of crushable type material like moorum or gravel. The quantity of binding material used in each layer shall be as per directions of Engineer-in-Charge.

20.A.4 Aggregate for Bituminous Surface Dressing

Aggregates shall consist of crushed stone or crushed gravel, as specified and shall have clean, strong durable and fairly cubical fragments free from disintegrated pieces, salt, alkali, vegetable matter, dust and adherent coatings. The aggregate shall preferably be hygrophobic in nature and of low porosity.

20.A.4.1 The aggregate shall satisfy the following physical requirements for surface dressing. Asphaltic concrete shall be obtained from approved quarries/ sources as indicated.

Property	*Test method*	*Value, Max. percent*
Los Angeles Abrasion Value or Aggregate Impact Value	IS 2386 (Part 4) IS 2386 (Part 4)	35 30
2.Combined flakiness & elongation index (Total)	IS 2386 (Part 1)	25
Stripping Value	IS 6241 - 1971	25
Water absorption	IS 2386 (Part 3)	1

20.A.4.1.1 Stone chippings for surface dressing / painting

The stone chippings shall consist of fairly cubical fragment of clean, hard, tough and durable rock of uniform quality throughout. These shall be obtained by crushing stone, river gravel (shingle) or other approved materials. Rounded gravel shall be used only if specifically permitted by the Garrison Engineer. The chipping shall be free of elongated or flaky pieces, soft or disintegrated stone, salt, alkali, vegetable matter, dust and adherent coatings. They shall conform to the quality requirement of para 20.A.3.2 (2). However, the total quantity of such deleterious material including clay lumps, soft fragments & foreign material shall not exceed 5% of the weight of aggregate/chippings.

20.A.4.2 Size and Grading

Size and Grading of aggregates shall be as follows:

Type of construction	*Nominal Size*	*Sieve Designation*
First Coat	12 mm	Passing through 18mm IS sieve and retained on 9 mm IS sieve.
Second coat or Renewal coat	9 mm	Passing through 12mm IS sieve and retained on 6mm IS sieve.

20.A.5 Aggregates for Bitumen Carpet (Thickness 20 mm or more)

20.A.5.1 Coarse Aggregates.

Aggregates shall consist of angular fragments and shall be clean, hard, tough, durable and of uniform quality throughout. They shall be crushed rock or gravel and shall be free of soft and disintegrated material, vegetable or other deleterious matter. The aggregates shall preferably be hygrophobic in nature and of low porosity. The aggregates shall satisfy the physical and grading requirements as specified for aggregates for surface dressing and shall be obtained from approved quarries/ sources as indicated. However water absorption may be upto 2%.

Note : Uncrushed and rounded river gravel or shingle may also be used where indicated. With rounded aggregates it may be necessary to add sufficient quantity of coarse sand and appropriate quantity of hot bitumen to make the mixture suitable. The mix will have to be designed for binder content depending on in individual cases.

20.A.5.2 Sand

Fine aggregate or sand shall consist of natural sand or crusher run screenings or a mixture of both and shall be clean, hard, durable, uncoated, coarse dry particles and be free from injurious amounts of dust, soft or flaky particles or organic matter or other deleterious substances.

20.A.6 BLANK

20.A.7 Low Grade Aggregates

20.A.7.1 General

Low grade aggregates are those aggregate which lose strength generally by more than 15 percent upon wetting when measured in terms of their Aggregate Impact value. Low grade aggregate shall be laterite, kankar, moorum, natural sand, gravel or brick aggregates, as indicated.

20.A.7.2 Physical Requirements

Low grade aggregates for sub-base course or surfacing course for light traffic roads except for materials like moorum and sand, shall satisfy the following requirements in term of Wet-Aggregate Impact value:

Sub base	:	Max. 50%
Base Course	:	Max. 40%
Surfacing Course	:	Max. 30%

In the case of materials like moorum and sand whether used as sub-base or as surfacing course, the soaked CBR value shall be not less than 20.

20.A.7.3 Grading

Low grade aggregates shall be reasonably well graded so as to achieve a dense and well inter-locked mass. Recommended grading for aggregates of laterite, kankar, gravels and broken brick aggregate to be used in WBM construction are given under coarse aggregates for WBM. These grading shall be taken by way of guidance only as the aggregates are generally of crushable nature. Moorum, sand, fine gravel shall be well graded and as far as possible, be within the following grading limits:

IS Sieve Designation	*Percent passing by weight*
80 mm	100
40 mm	85-100
10 mm	45-100
4.75 mm	25-85
600 micron	8-45
75 micron	0-10

20.A.7.4 Laterite and Kankar

Laterite and Kankar shall be as specified for water bound macadam.

20.A.7.5 Gravel

Gravel shall be composed of large, coarse silicious grains, sharp and gritty to the touch and shall be free from dirt and other foreign matter. Laterite gravel may be used if the excess of clay is separated by screening.

20.A.7.6 Moorum

Moorum shall be clean, of good binding quality, and shall be obtained from approved pits or quarries of disintegrated rock which contain silicious material and natural mixtures of clay of calcareous origin.

20.A.7.7 Red Bajri

Red Bajri shall be dark red in colour, consisting of coarse grain free from mica dust and other foreign matter.

20.A.7.8 Sand

Sand shall be as specified under Aggregates for 2 cm thick carpet.

20.A.7.9 Shingle

Shingle shall be obtained from approved river or nullah beds and shall be clean and free from foreign matter. Shingle shall be well graded and shall contain a sufficient proportion of fine particles to help binding when consolidated.

20.A.8 Soling Bricks

Soling bricks shall comply with requirements of IS 5779-1986, Specification for burnt clay soling bricks. Bricks shall be of size 19 x 9 x 9 cm as in the Standard or 23 x 11.4 x 7.5 cm as indicated. The brick shall be free from cracks and other flaws and lime nodules. The bricks shall have as far as possible, plain rectangular faces and straight, right angle edges. The average compressive strength shall not be less than 50 Kg/Sqcm. Water absorption by weight after 24 hour immersion in cold water shall not be more than 20 percent. The rating for efflorescence shall not be more than "slight".

20.A.9 Stacking of Materials

20.A.9.1.1 Aggregates

Ground where stacks are proposed to be made shall be cleared, levelled or dressed to a uniform slope and all lumps, depressions etc shall be removed. The stacked material shall be free from vegetation and other foreign matter.

The aggregate shall be stacked in convenient units of 1.0 M top width, 2.2 M bottom width, 60 Cm height and of length in multiples of 3 M for new roads. Where berm width is limited or for repair works, it shall be stacked in units of 40 Cm top width, 1.4 M bottom width, 50 cm height and length in multiples of 3.0 M. Template of steel shall be used for making the stacks and shall always be kept at site for checking the measurements. The Engineer-in-Charge may permit stacking in different sizes and height ranging between 45 Cm to 75 Cm for new roads and 40 Cm to 60 Cm for repair work, in case the site conditions so demand. In a particular reach of road, the quantity of stacked material shall be comparable to the theoretical quantity required for particular item of road.

The stack shall be uniformly distributed along the road and shall be numbered serially. The number plate shall be planted on each stack, which shall remain in position until the stack is used in the work. A register showing daily consumption of stack shall be maintained at site of work. The collection of stone metal shall be for complete length of one Km (for each layer) or as directed by the Engineer-in-Charge.

20.A.9.2 Blank

20.A.9.3 Moorum/Stone Chippings

Ground where stacks are proposed to be made, shall be dressed to a uniform slope and all lumps, depressions etc., shall be removed. Sample of moorum shall be got approved from the Engineer-in-Charge, before the material in bulk is brought to site.

Moorum shall be stacked in convenient units of one cubic metre in between aggregate stacks in each length of 100 M as per requirement. The stacks shall be made with wooden boxes open at both ends and of 2x2x0.25 M dimensions. These shall always be kept at site for stacking and check measurements.

The stacks shall be uniformly distributed along the road. Supply of moorum shall be completed for the entire work or for a complete length of one Km or as directed by Engineer-in-charge.

20.A.10 Blank

20.A.11 Bitumen

20.A.11.1 Paving Bitumen

Paving bitumen shall conform to IS 73-2006, Specification for paving bitumen. Paving bitumen shall be of the following two categories

(a) Paving bitumen from Assam Petroleum.
(b) Paving bitumen from other sources.

Paving bitumen obtained from Assam Petrolium is classified into six grades and that from other sources into five grades according to their penetration. The Grade of paving bitumen shall suit the type of construction and climatic conditions and shall be approved by the GE.

20.A.11.2 Cut Back Bitumen

Cut-back bitumen, shall conform to IS 217-1988, for cut-back bitumen. Cut-back bitumen is classified into three types, namely, Rapid curing (RC), Medium curing (MC) and slow curing (SC). Each of these types is further classified into six grades on the basis of initial viscosity.

20.A.11.2.1 Cut-back bitumen, Digboi type shall conform to IS 454-1994, Specification for Digboi type cut-back bitumen. This is classified into three grades, namely, light grade, medium grade and heavy grade.

20.A.11.2.2 The type and grade of cut back bitumen shall suit the type of construction and climatic conditions and shall be approved by the GE.

20.A.11.3 Bitumen Emulsion

Bitumen emulsion shall conform to IS 3117 – 2004, Specification for bitumen emulsion for roads (Anionic type). Bitumen emulsion is classified into three types, namely, Rapid setting (RS), Medium setting (MS) and slow setting (SS) and their use is as under :

(i) Rapid Setting

Rapid setting emulsified bitumen is used for penetration and surface treatment.

(ii) Medium Setting

Medium setting emulsified bitumen is used for plant mixes with coarse aggregate substantially all of which is retained on 2.80 mm IS sieve with practically no material passing a 75 micron IS sieve.

(iii) Slow Setting

Slow setting emulsified bitumen is used for aggregate mixes in which a substantial quantity of aggregate passes 2.80 mm IS sieve and a portion may pass 75 micron IS sieve.

20.A.11.3.1 The type of bitumen emulsion shall suit the type of construction and climatic conditions and shall be approved by the GE.

20.A.11.4 When the binders are to be supplied by the contractor, he shall obtain these from approved manufactures or their authorised outlets and deliver to the site in maker’s sealed containers. Binder brought in damaged containers shall not be accepted. The binders shall be stacked in fenced enclosures as directed by the EIC on one side of the roadway.

20.A.11.4.1 Substantial requirement of binder shall be brought to the site of work sufficiently in advance of its use. All the drums brought at site shall be serially numbered and used in the same order. The empty containers shall not be removed from the site of work till the particular stretch of road is completed and permission of the EIC for their removal is obtained in writing.

Workmanship

20.A.12 Road Work Generally

All roads, etc, and appurtenant works shall be constructed to the widths, alignments, cambers, super elevations and gradients, etc., as specified or as directed. Where a road is required to the opened for traffic urgently, work shall be carried out in convenient sections as directed by EIC.

20.A.13 Protection of Property

The contractor shall undertake all reasonable precautions for the protection from injury or damages and preservation of any or all existing roadside poles, trees, drains, sewers or other sub-surface drains, pipes, conduits, cables and any other structures under or above the ground which may be affected by the construction operations. However, if any of these objects is damaged by reason of contractor’s negligence, it shall be replaced or restored to the original condition at his expense.

20.A.14 Arrangement of Traffic during Construction.

The contractor shall at all times carry out work on the roads in a manner creating least interference to the flow of traffic while consistent with the satisfactory execution of work. For all works involving improvement to the existing road, the contractor shall, as directed by EIC, provide and maintain during the execution of work a passage for traffic either along a part of the existing road under improvement or along a temporary diversion constructed close to the road. The contractor shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades, including signs, marking, flags, lights and flagmen as may be required by the EIC for the information and protection of traffic approaching and passing through the section of the road under construction/improvement.

20.A.15 Earth work in Road Constructions

20.A.15.1 Earth work connected with road construction fall broadly into three categories

(a) Earth work in cutting including borrow pits.
(b) Earth work in filling in embankments (without optimum moisture conditions).
(c) Earth work in filling in embankments (under optimum moisture conditions).

Note :- Materials for earth work/embankments i.e. approved earth, moorum, gravel etc shall be procured from out side MD land unless otherwise indicated.

20.A.15.2 Detailed specifications relating to earth work already described in Section-3 shall be followed. In addition to above there are certain special requirements of earth work for road construction especially in embankments and excavation from borrow pits. These shall broadly conform to:

(a) IRC : 36 Recommended practice for construction of earth embankments for road works.
(b) IRC : 10 Recommended practice for borrow pits for road embankments by manual operations.

20.A.15.2.1 Excavation from borrow pits shall confirm to provisions in para 3 of IRC : 10 and the road embankment shall generally conform to section, slopes and locations of borrow pits as specified & directed.

20.A.15.2.2 Embankment construction (without optimum moisture conditions)

In addition to specifications contained in para 3.22 of Section-3, following shall apply :

Material used in embankments shall be approved earth, moorum, gravel, a mixture of these or any other material as suitable and as approved by Engineer-in-Charge. Such material shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment.

20.A.15.2.2.1 The foundations of the embankment shall be ploughed to a depth of 15 to 25 Cm. All clods shall be broken into fine earth and the area roughly levelled. The surface shall then be well watered before the work is started.

Joining of old and new embankments shall be done by stepping in an over all slope of about 1 to 5. If the material delivered to the road bed is wet, it shall be dried by aeration and exposure to sun, till the moisture content is acceptable for compaction. It shall then be rolled with roller of minimum ½ tonne weight, not less than 5 times, till gets evenly & densely consolidated with wooden/steel rammers of 7 to 10 Kg weight having a base of 20 cm square or 20 cm diameter. The labour for ramming shall be atleast one rammer to six diggers. Every third layer and top most layer shall be well consolidated with power roller of minimum 10 Ton weight, rolled not less than 5 times, till the filling behaves as an elastic material and gets compressed elastically under the load of roller. The embankment shall be dressed neatly as per designed section and grade, after it has been completed & thoroughly consolidated. The top and slopes shall be protected from any damage and maintained till the work is completed and handed over.

20.A.15.3 Earth work for widening existing Road embankment

20.A.15.3.1 Where an existing embankment is to be widened and its slope is steeper than 4:1 continuous horizontal benches each atleast 0.3 M. wide, shall be cut in to the old slope for ensuring adequate bond with the fresh embankment material to be added. The material obtained from cutting to benches could be utilized in the widening of the embankment. However, when the existing slope against which the fresh material is to be placed is flatter than 4:1, the slope surface may only be ploughed or scarified instead of resorting to benching.

20.A.15.3.2 Where the width of the widened portion is insufficient to permit the use of standard rollers, compaction shall be carried out with the help of sheeps foot roller, mechanical tampers or other approved equipment. End dumping of materials from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other type of hauling equipment.

20.A.15.3.3 Where formation level of the road is lower than the ground level, cutting shall be done upto formation level. Side slopes except in rock cutting shall be evenly and truly dressed.

20.A.15A Embankment Construction (Under Optimum Moisture Conditions)

20.A.15A.1 Each layer of the earth shall be carefully moistened to give field moisture content of about +1% to – 2% of the optimum moisture content (OMC). The OMC shall be determined accordingly to IS-2720 (Part-VIII) Methods of tests for soils. Each layer shall then be compacted by rolling with 08 to 10 tonnes power road roller and a sheep foot roller if required. The required amount of water shall be added during consolidation to keep the moisture content of the soil at the optimum as per the test. Density to be achieved for each layer shall not be less than 95% of the density obtained in the laboratory by proctor method.

20.A.15A.2 Each compacted layer shall be tested in the field for density and accepted before the operations for next layer are begun. A systematic record of these tests shall be maintained.

20.A.15A.3 Density measurements and acceptance criteria

20.A.15A.3.1 One measurement of density shall be made for each 500 Sqm of compacted area or for a smaller area as decided by Engineer-in-Charge. The measurement shall consists of atleast 05 density determinations and the average of these determination shall be treated as the field density achieved. The determination of density shall be as per IS : 2720 (Part XXVIII).

20.A.15A.4 Control tests on borrow material.

20.A.15A.4.1 Soil suitable for consolidation under O.M.C. conditions shall preferably have following characteristics meeting I.S. requirements:

(a) Minimum percentage of clay.
(b) Liquid limit.
(c) Plasticity Index.
(d) Percentage of silt.
(e) Peat, muck / organic soil.

20.A 15A 4.2 Various test required to be conducted on borrow material with their frequency are indicated below:

(a) Gradation	:	At least one test for each kind of soil. Usual rate of testing 1 to 2 tests per 8000 Cum of soil.
(b) Plasticity	:	At least one test for each kind of soil. Usual rate of testing 1 to 2 tests per 8000 Cum of soil.
(c) Proctor tests	:	At the rate of 2 tests per 8000 Cum of soil.
(d) Deleterious Contents	:	As required.
(e) Moisture Content	:	One test for 250 Cum of soil.

20.A 15A.3 Sub-grade shall satisfy the surface tolerances as specified.

20.A 15A.4 Borrow Pits

Where earth for filling is to be obtained from approved borrow pits, their location, size and shape shall be as directed by EIC and shall not be opened without his written permission.

Pits shall not be dug continuously. Ridges of not less than 8 metres width shall be left at intervals not exceeding 300 metres. Small drains shall be cut through ridges to facilitate drainage. The depth of pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the toe of the final section of the bank, the maximum depth in any case being limited to 1.5 metres. Also no pit shall be dug within 5 metres of the toe of the final section of the road embankment.

20.A.15B Soil stabilization (with lime or cement)

20.A.15B.1. Lime

Lime for lime soil stabilization work shall be commercial dry lime slaked at site or preslaked lime delivered at site in suitable packing.

20.A.15B.2. Cement

Cement for cement soil stabilization shall comply with the requirements of IS : 269, 455, 1489 or IS-8112 as indicated.

20.A.15B.3. Water

The water to be used for stabilization work shall be clean & free from injurious substances. Potable water shall be preferred.

20.A.15B.4. Soil/Earth

Soil/earth or moorum for soil stabilization shall be approved earth to be procured from approved sources outside MD land.

20.A.15B.4A Grading limits of good earth for stabilization with cement/lime

IS Sieve Size	*Percentage by mass passing*	
	Sub-base	*Base*
	Finer than:	*Within the range:*
53.0mm	100	100
37.5mm	95	95-100
19.0mm	45	45-100
9.5mm	35	35-100
4.75mm	25	25-100
600 micron	8	8-65
300 micron	5	5-40
75micron	0	0-10

20.A.15B.5. Quantity of cement/lime in stabilized mix

The quantity of cement/lime to be added percent by weight of dry soil shall be as indicated. The mix design shall be done on the basis of 7 days unconfined compressive strength (UCS). The laboratory strength values shall be at least 1.5 times the minimum field UCs value as indicated.

20.A.15B.6. Construction Operation

20.A.15B.6.1. Weather Limitations

Stabilization shall not be done when the air temperature in the shade is less than 10^0C.

20.A.15B.6.2. Degree of Pulverisation

For stabilization, the soil before addition of cement as stabilizer, shall be pulverized mechanically using power road roller, and/or agricultural machineries such as disc, harrows rotavators etc. The degree of pulverization should be such that it passes the requirement given in Table given below:

Is Sieve Size Designation	Minimum percent by weight passing the IS Sieve
26.5mm	100
5.6mm	80

20.A.15B.6.2.1 Determination of Degree of Pulverisation

(a) A sample of pulverized soil approximately 1 Kg in weight should be taken as weight (W1).

(b) It should be spread on the sieve and shaken gently, care being taken to break the lumps of soils as little as possible. Weight of soil retained on the sieve should be recorded (W2). Lumps of finer soils in the retained material should be broken until all the individual particular finer than the aperture size of the sieve are separated.

(c) The soil should again be placed on the sieve and shaken until sieving is complete. The retained material should be weighed (W3).

(d) Weight of soil by per cent passing the sieve can than be calculated from the expression.

$$\frac{(W_1 - W_2) \times 100}{(W_1 - W_3)}$$

20.A.15B.6.3. Equipment for Construction

Stabilized soil sub-bases shall be constructed by mix-in-place method of construction or as otherwise approved by the Engineer-in-Charge. Manual Mixing shall not be permitted except for the places where the width of laying is not adequate for mechanical operations.

The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of pulverizing and mixing the soil and water to specified degree to the full thickness of the layer being processed, and of achieving the desired degree of mixing and uniformity of the stabilized material. If so desired by the Engineer-in-Charge, trial runs with the equipment shall be carried out to establish its suitability for work.

20.A.15B.6.4. Mix-in-place Method of Construction

Before deploying the equipment, the soil after it is made free of undesirable vegetation of other deleterious matter shall be spread uniformly on the prepared sub-grade in a quantity sufficient to achieve the desired compacted thickness of the stabilized layer. The moorum/ good earth layer to be stabilized with cement/lime shall be spread in layers of uniform thickness not exceeding 200 mm (loose thickness). The equipment used shall either be of single pass or multiple pass type. The mixers shall be equipped with an appropriate device for controlling the depth of processing and the mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

With single pass equipment the forward speed of the machine shall be so selected in relation to the rotor speed that the required degree of mixing , pulverization and depth of processing is obtained. In multiple pass processing, the prepared sub grade shall be pulverized to the required depth with successive passes of the equipment and the moisture content adjusted to be within prescribed limits. The blending or stabilizing material shall then be spread uniformly and mixing continued with successive passes until the required depth and uniformity of processing have been obtained.

The mixing equipment shall be so set that it cuts slightly into the edge of the adjoining lane processed previously so as to ensure that all the material forming a layer has been properly processed for the full width.

20.A.15B.6.5. Mixing of Cement/Lime

The proper amount of cement/lime by dry weight of moorum/good earth as indicated is spread on the surface of the moorum/good earth mixed manually. The bags of cement/lime are placed along the surface in rows of predetermined spacing. The bags are than opened and the cement/lime spread in uniform transverse rows by hand spreading is completed by the use of spike toothed harrow and dry mixing is done to ensure that the good earth and cement/lime blend into a homogeneous mixture by tools such as disc harrow, spring toothed barrow and rotellers. Careful control is necessary in a good earth & cement/lime mixing operation to ensure that the mixing is carried to a proper depth specified and also a uniform mix is obtained.

20.A.15B.6.6 Addition of Water

The stabilizer mix is sprinkled with water. The quantum of water is determined in the laboratory as the OMC (Optimum Moisture Content). The moisture content at compaction checked as per IS:2720 (Part-II) shall not be less than the optimum moisture content determined in accordance with IS:2720 ((Part-VIII) nor more than 2% above it.

If the mixture has less than the required moisture content, necessary amount of water shall be sprayed on it after it has been spread with sprinklers. If the soil is too wet, it shall be dried by aeration or exposure to the sun till the moisture content is within acceptable limits for compaction.

20.A.15B.6.7. Rolling And Compaction

Immediately after spreading, grading and leveling of the mixed material, each layer shall be compacted with power road roller of 8-10 tonnes and /or sheep footed roller/vibratory roller as approved by Engineer-in-Charge, preceded by a few passes of light roller, if necessary, immediately after the mix is laid and spread to grade. Successive layers shall not be placed until the lower layer has been thoroughly compacted to satisfy the density requirements, and all quality control tested as per requirement of the specifications.

Rolling shall commence at edges and progress towards the center, except at super elevated portions where it shall commence at the inner edge and progress towards outer edge. During rolling the surface shall be frequently checked for grade and cross fall (camber) and any irregularities corrected by loosening the material and removing/adding fresh material. Compaction shall continue until the density/achieved is at least 98 per cent of the maximum dry density for the material determined in accordance with IS:2720 (Part-VIII).

Care shall be taken to see that the compaction of cement stabilized material is compacted within two hours of its mixing or such shorter period as may be found necessary in dry weather.

During rolling it shall be ensured that roller does not bear directly on hardened or partially hardened treated material previously laid other than what may be necessary for achieving the specified compaction at the joint. The final surface shall be well closed, free from movement under compaction planes, ridges, cracks or loose material. All loose or segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

The filed density of compacted layer shall be measured by “Sand replacement Method” as specified in IS: 2720 (Part-XXVIII).

20.A.15B.6.8. Curing

The compacted course shall be suitably cured for a minimum period of 7 days. Subsequent pavement course shall be laid soon after to prevent the surface from drying out and becoming friable. No traffic of any kind shall ply over the completed sub-base unless permitted by the Engineer in Charge.

20.A.15.B.6.9 Surface Finish

The finished surface shall be true to level and conform to the lines, grades, camber and dimension as directed by the Engineer-in-Charge.

The finished surface shall be true to level, grade and camber, when a straight edge of 3 meters length is placed longitudinally or transversely. The maximum undulations should not be more than 15 mm longitudinally and 12mm in the transverse direction. The maximum number of undulation exceeding above in any 300 meters length shall not exceed 30. Undulations of size bigger than that specified above shall be made good after loosening the area and adding /removing mix materials and re-compacting to the required density under OMC conditions.

20.A.15B.6.9.1. Horizontal Alignment

Horizontal alignments shall be reckoned with respect to the center line of the runway/ taxiways/overruns/turning pads and aprons as shown on the drawings. The edges as constructed shall be correct within a tolerance of +25mm there form.

20.A.15B.6.9.2. Longitudinal Profile

The levels of the sub-grade and different pavement course as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile shown in the drawings or as directed by the Engineer-in-Charge beyond the tolerance mentioned below:

Sub-grade (Longitudinal Profile)	+24mm
(Cross Profile)	+15mm
Granular Sub-base (Longitudinal Profile)	+15mm
(Cross Profile)	+12mm

20.A.15B.6.9.3. Surface Regularity of Subgrade and Pavement Courses

The surface regularity of compacted sub-base in the longitudinal and transverse directions shall be within the tolerance indicated hereinafter.

The longitudinal profile shall be checked with a 3 meter long straight edge, at the middle of each 3 meter longitudinal strip along a line parallel to the centre line of that particular type of construction. The transverse profile shall be checked with a set of camber boards at intervals of 10 meters.

Permitted Tolerance of Surface Regularity For Subgrade And Sub-base

Sl. No.	Type of Construction	Longitudinal profile with 3 meter straight edge					Cross Profile
		Maximum permissible undulation	Maximum number of undulations permitted in any 300 meters length exceeding mm				Maximum permissible variation from specified profile under camber template (mm)
			10	12	10	6	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Earthen Sub-grade	24	30	-	-	-	15
2.	Granular Sub-base	15	-	30	-	-	12

20.A.15B.6.9.4 Rectification of Surgrade Irregularity

When the surface regularity falls outside the specified tolerance, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer-in-Charge.

20.A.15B.6.10. High Surface

Where surface is high, it shall be trimmed in such a way that the materials below is not disturbed due to this operation.

20.A.15B.6.11. Low Surface

For cement/lime treated material, when the time elapsed between detection of irregularity and the time of mixing of the material is less than 2 hours, the surface shall be scarified to a depth of 50mm, supplemented with freshly mixed materials as necessary and re-compacted to the relevant specification. When the time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material laid to Specification.

20.A.15B.6.12. Quality Control Test During Construction

The material supplied and the works carried out by the Contractor shall conform to the specifications.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer-in-Charge shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications.

Following quality control tests shall be carried out at frequencies noted against each:

A. Good Earth

Sl. No.	*Test*	*Test Method*	*Frequency*
(a)	Sieve Analysis (Gradation)	IS:2720 (Part-4)	1 test per 250 cum of good earth.
(b)	Sand Content	IS:2720 (Part-5)	2 tests per 3000 cum of good earth.
(c)	Plasticity Test	IS:2720 (Part-5)	2 tests per 3000 cum of good earth.
(d)	Density Test	IS:2720 (Part-7)	2 tests per 3000 cum of good earth (Each soil type).
(e)	Deleterious Content Test	IS:2720 (Part-27)	As and when required by Engineer-in-Charge.
(f)	Moisture Content	IS:2720 (Part-2)	1 test for every 250 cum of good earth.

B. Cement Stabilized Soil Sub-base

Sl. No.	*Test*	*Frequency (Minimum)*
1.	Quality of Cement	One test for each consignment subject to a minimum of one test per 5 tonnes.
2.	Cement Content	Regularly, through procedural checks.
3.	Degree of pulverization	Periodically as considered necessary by the Engineer-in-Charge.
4.	CBR (IS:2720 Part 17) on soaked/unsoaked samples	One test per 3000 cum. Mean of 3 samples shall constitute one test result.
5.	Moisture Content Prior to Compaction (IS:2720 Part-2)	One test per 250 Sqm.
6.	Field Density of Compacted Layer (IS:2720 Part 28)	One test per 500 Sqm.
7.	Surface Accuracy	Regularly.

20.A.16 Plying of Construction Traffic

Construction traffic shall not use the prepared surface of the embankment/cut formation without the prior permission of Engineer-in-charge. Any damage arising out of such use shall be made good by the contractor.

20.A.17 Pipe Culverts

Reinforced concrete pipes in culverts shall be non-pressure pipes, class NP 2 or class NP 3, as indicated, conforming to "IS – 458 2003, Specification for Concrete Pipes with or without Reinforcement" and shall be laid and jointed as specified for drain work in Section 18 – Water Supply, Plumbing, Drains and Sanitary Appliances.

20.A.18 Weather and Seasonal Limitations for Bituminous Work

Bituminous work shall not be executed during rainy or foggy weather or when the sub grade, sub base or base course is damp or wet or normally when the atmospheric temperature in shade is 16 degree C or below.

20.A.19 Alignment, Profile and surface Evenness

20.A.19.1 Horizontal Alignments

Horizontal alignment shall be controlled by marking the center line of the road by means of reference pillars on both sides of center line located at frequent intervals along the straights and at all changes of horizontal curvature. Edges of each pavement layer shall be delineated with respect to the center line before placement.

20.A.19.2 Control of layer Thickness

Average thickness of a layer shall not be less than the specified thickness, unless otherwise specified. In addition, the sport reduction in thickness shall not exceed 15 mm incase of sub-bases and base courses of water bound macadam and bituminous macadam and 6mm incase of surface wearing courses of bituminous carpet and cement concrete.

20.A.19.3 Surface Evenness

Surface evenness both for longitudinal and cross profile in Road-work shall not exceed the following limits, unless otherwise specified :-

Sl. No.	Type of construction	Longitudinal Profile with 3 metre straight edge						Cross Profile
		Maximum Permissible Undulation	Maximum No. of undulation permitted in any 300 mm length exc. (*)					Maximum permissible Variation from specified profile under chamber template
			18 mm	16 mm	12 mm	10 mm	6 mm	mm
1	2	3	4	5	6	7	8	9
1	Subgrade (cut formation earthen embankment)	24	30	-	-	-	-	15
2	Soling (Stone or brick)	20	-	30	-	-	-	12
3	Granular Sub-base (Stabilised soil)	15	-	-	30	-	-	12
4	Water Bound Macadam with oversize metal (40-90 mm size)	15	-	-	30	-	-	12
5	Water Bound Macadam with normal size metal (20-50mm and 40-63mm size) bituminous mac-adam base course.	12	-	-	-	30	-	8
6	Surface dressing (two coat) over WBM	12	-	-	-	20	-	8
7	Open Graded Premix carpet 20-25mm thick.	10	-	-	-	-	30	6

Notes:
1. For surface dressing on existing surfaces and in all other cases, the standard of surface evenness will be the same as for the surface receiving the surface dressing.
2. Surface evenness requirements in respect of both longitudinal and cross profiles shall be simultaneously satisfied.
3. (*) These are for machine laid surfaces, if laid manually due to unavoidable reasons, tolerance upto 50 percent above the values in this column may be permitted on the discretion of the Engineer-in-charge. However this relaxation does not apply to the values of maximum undulation for longitudinal profile mentioned in column 3 of the table.

20.A.19.4 Control of Transverse Profile

Each layer of road from the subgrade level upwards shall be checked for transverse profile. For obtaining correct transverse profile on the finished surface of layer, it is necessary that the spread material before compaction should conform to the desired profile as far as possible. Profile of the spread material shall therefore be continuously regulated with template or camber boards; normally a set of 3 templates should be used at an interval of 10 metres. Additional checks may be made when visual appearance suggests an excessive variation.

20.A.19.5 Control of Longitudinal Profile

The Procedure to be followed for measuring surface unevenness with a straight edge shall be as under (for further details refer Appendix V to Indian Road Congress Special Publication 11- 1977, Hand book of Quality Control for Construction of Roads and Runways).

1. The depressions under the straight edge are measured with a graduated wedge. The wedge should preferably be metallic but alternatively may be of seasoned hard wood. These should be graduated to read undulations upto 25mm with a least count of at least 3 mm.
2. For recording undulations in the longitudinal profile the straight-edge is placed longitudinally parallel to the center line of the road. Measurements along two parallel lines may normally be sufficient for a single-lane pavement and along three lines for the two-lane pavement. One additional line may be covered for each additional lane.
3. The straight-edge may be placed at the starting point, wedge inserted between it and the test surface where the gap is maximum and reading taken. The edge is then slided forwarded by about 1/2 length i.e., 1.5 M and the wedge reading is repeated. This process is continued. The straight edge need not always be moved forward but may be moved backward and forward to record the maximum undulation existing at a location. Locations with undulations in excess of the specified limits shall be marked on the surface.

20.A.19A Subgrade Preparation and Consolidation

20.A.19A.1 The surface of the formation for a width of sub base, which shall be 15 cm more on either side of base course, shall first be cut to a depth equal to the combined depth of sub base and surface courses below the proposed finished level (due allowance being made for consolidation). It shall then be cleared of all foreign substances. Any ruts or soft yielding patches that appear due to improper drainage conditions, traffic hauling or from any other cause, shall be corrected and the sub grade dressed off parallel to the finished profile.

20.A.19A.2 The sub grade shall be consolidated with a power road roller of 8 to 12 tonnes. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass (the roller shall pass a minimum of 5 runs on a sub grade). All undulations in the surface that develop due to rolling shall be made good with material or quarry spoils as the cases may be and the sub grade is re-rolled.

20.A.19A.3 The finished surface shall be uniform and conform to the lines, grades and typical cross section. When tested with template & straight edge, the variation shall be within the tolerance specified in para 20.A.19.3 (Surface Evenness).

20.A.20 Soling

20.A.20.1 Broken Stone Soling

The edges of soling shall be marked out by strings and stakes, carefully ranged. Broken stones/boulders shall be spread uniformly and evenly upon the prepared base, surface carefully trued up and all high and low spots corrected by removing or adding broken stones as may be required. The soling shall be consolidated by a road roller 8 to 10 tonnes weight in the same manner as described for water bound macadam except that screening and binding material shall not be applied. The finished surface shall be checked for lines, levels and regularity. The surface evenness of completed surface in longitudinal and transverse directions shall be within the tolerances specified.

20.A.20.2 Brick Soling

Soling of bricks shall be laid in one or two layers flat or on edge, as indicated. Bricks used shall be full size; brickbats shall not be used. Bricks shall be hand laid, with each brick as far as possible touching the other, parallel and at right angles to the center line of the road-unless directed to be laid to an oblique pattern. The gap between the adjacent bricks shall not exceed 10mm. After laying each layer of bricks, interstices shall be filled with sand, moorum, grit or any other mineral matter with plasticity index not exceeding 6, so as to fill the gaps completely. The soling shall be sprinkled with water and rolled with a light roller. Weight of light roller shall be selected according to the nature of sub soil and strength of bricks used. On rolling, breakage of the bricks shall not exceed 5 per cent. Particular care shall be taken to use only sufficient quantity of water so as not to soften the subgrade.

20.A.20.3 Where brick soling is laid in two layers, top layer shall break joints with the bottom layer and each layer rolled and interstices filled to their full depth.

20.A.21 Water Bound Macadam Sub-base and Base Course

20.A.21.1 Water bound macadam may be used as a base course under surfacing or as a sub-base. For use as sub-base water bound macadam (WBM) shall be constructed with oversized aggregates 90-40 mm size, grading 1. For use as base course, WBM shall be constructed with normal sized aggregates 63-40 mm size, grading 2, or 50-20 mm size, grading 3, where indicated.

20.A.21.2 Preparation of Foundation

1. The subgrade or sub-base to receive the water bound macadam course shall be prepared to the required grade and camber and cleaned of all dust, dirt and other extraneous matter. Any ruts or soft yielding places that have appeared due to improper drainage, service under traffic or any other reasons shall be corrected and rolled until firm.
2. Whether the water bound macadam is to be laid on an existing un-surfaced road, the surface shall be scarified and reshaped to the required grade and camber as necessary. Weak places shall be strengthened corrugations removed and depressions and potholes made good with suitable material before spreading the coarse aggregates for WBM.

3. Where the existing road surface is black topped, 50x50mm furrows shall be cut in the existing surface at one metre intervals at 45 degree to the center line of the carriage way before proceeding with the laying of coarse aggregates.
4. In all cases, the foundation shall be kept well-drained during the construction operations.
5. Before starting with WBM construction, necessary arrangements viz. a well tamped clay bund or fillers about 15 cm wide and to the height required shall be made for the lateral confinement of aggregates.

20.A.21.3 Spreading Coarse Aggregates

1. Coarse aggregates shall be spread uniformly and evenly upon the prepared base in required quantities from stockpiles along the side of the road. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed base be permitted. The aggregates shall be spread to proper profile by using templates placed across the road about 10 metre apart. Approved mechanical devices may be used to spread the aggregates uniformly so as to minimize the need for their manipulation by hand.
2. The WBM course shall normally be constructed in layers of not more than 75mm compacted thickness. In sub base course with aggregate of grading 1, the compacted thickness of layer may go upto 100mm. Each layer shall be tested by depth blocks. No segregation of large or fine particles shall be allowed. The coarse aggregates as spread shall be of uniform gradation with no pockets of fine material.
3. The coarse aggregates shall normally not be spread in lengths exceeding three day's average work ahead of the rolling and bonding of the preceding section.

20.A.21.4 Rolling

1. After the lying of coarse aggregates, these shall be compacted to full width by rolling with either three wheel power roller of 6 to 10 tonnes weight or an equivalent vibratory roller.
2. Rolling shall begin from edges with roller running forward and backward until the edges have been compacted. The roller shall then progress gradually from the edges towards the center parallel to the center-line of the road, uniformly lapping each preceding rear wheel track by one half-width. Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, where screenings are not to be applied, as in the case of crushable aggregates like brick metal, laterite and kankar, compaction shall be continued until the aggregates are thoroughly keyed with no creeping of stones ahead of the roller. Slight sprinkling of water may be done during rolling, if necessary.
3. On super elevated portions of the road, rolling shall commence from the lower edge and progress gradually towards the upper edge of the pavement.
4. Rolling shall not be done when the sub-grade is soft or yielding nor when it causes a wave-like motion in the base course or sub-grade. If irregularities that develop during rolling exceed the limits specified, the surface shall be loosened and aggregates added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired cross section and grade. The surface shall also be checked transversely by template for camber and any irregularities corrected in the manner described above. In no case shall the use of screenings to make up depressions be permitted.

20.A.21.5 Application of Screenings

After coarse aggregates have been rolled as per para 20.A.21.4(2) screenings to fill the interstices shall be applied gradually over the surface. Dry rolling shall be done when the screenings are being spread so that the jarring effect of roller causes them to settle into voids of coarse aggregates. The screenings shall not be dumped in piles but applied uniformly at a slow rate in three or more application as necessary, until no more screening can be forced into the voids. This shall be accompanied by rolling and brooming. Either mechanical brooms/hand brooms or both may be used. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface making the filling of voids, difficult or preventing the direct bearing of roller on the coarse aggregates. The spreading, rolling and brooming or screenings shall be taken up on sections which can be completed within one day's operation. Damp and wet screenings shall not be used in any circumstances.

20.A.21.6 Sprinkling and Grouting

After application of screenings, the surface shall be copiously sprinkled with water, swept and rolled. Hard brooms shall be used to sweep the wet screenings into the voids, and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued and additional screenings applied where necessary until the coarse aggregates are well bonded and firmly set for its entire depth and a grout of screenings and water forms ahead of the wheels of the roller. Care shall be taken that the sub-grade or sub base does not get damaged due to addition of excessive quantities of water during construction.

20.A.21.7 Application of Binding Material

After the application of screenings, sprinkling and grouting, binding material where it is required to be used, shall be applied at a uniform and slow rate in two or more successive thin layers. After each application of binding material, the surface shall be copiously sprinkled with water and the resulting slurry swept in with hand brooms/ mechanical brooms or both as to fill the voids properly. This shall be followed by rolling with a 6-10 tonne roller, during which water shall be applied to the wheels to wash down the binding material that may get stuck to them. The spreading of binding material, sprinkling of water, sweeping with brooms and rolling shall continue until the slurry of binding material and water forms a wave ahead of the wheels of moving roller, and wave of grit is formed ahead of the wheels of roller.

20.A.21.8 Setting and Drying

After final compaction of the course, the road shall be allowed to cure overnight. Hungry spots shall then be filled with screenings or binding material, lightly sprinkled with water, if necessary, and rolled. No traffic shall be allowed till the macadam sets. Bituminous surfacing shall be laid only after the WBM course is completely dry and before allowing any traffic on it.

20.A.21.9 Plying of Construction Traffic

In general, construction traffic may ply over completed portions of the WBM course provided vehicles move over its full width avoiding any rutting or uneven compaction. However, the Engineer-in-Charge shall have full authority to stop the passage of construction traffic when in his opinion this is leading to excessive damage.

20.A.21.10 Surface Evenness of WBM Course

The finished surface shall be checked for line, level and regularity. The surface evenness of completed WBM course in longitudinal and transverse directions shall be within the tolerances specified.

20.A.21.11 Rectification of Defective Construction

Where the surface irregularity of the WBM course exceeds the specified tolerances or where the course is otherwise defective due to subgrade soil mixing with the aggregate, the layer to its full thickness shall be scarified over the affected area, reshaped with added material, or removed and replaced with fresh material as applicable, and re-compacted. The area treated in the aforesaid manner shall not be less than 10 Sqm. In no case shall depressions be filled up with screenings or binding material.

20.A.21.12 Patching of Pot-holes along with removal of Ruts and Depressions

Pot holes, ruts and other depressions should be drained of water and cut to regular shape with vertical sides. All loose and disintegrated material shall be removed and exposed surfaces swept clean. The hole/depressions shall then be filled with salvaged coarse aggregates mixed with sufficient quantity of fresh aggregates and re-compacted as normal WBM so that the patched area merges with the adjoining surface. Where the area so treated in small, hand rammers may be used for compaction instead of rollers.

20.A.21.13 Quantities of Material for WBM

1. Approximate quantities of coarse aggregates and screenings required for 10 Sqm of 100 mm compacted thickness of WBM sub-base and 75mm compacted thickness of WBM base course of surfacing course are given in the following table :-

Type of Construction	Thickness of WBM	Coarse Aggregates		Screenings		
		Grading/ size/range	Loose quantity Cum	Grading/ classification & size	Loose quantity (cum)	Loose quantity for crushable type aggregate (cum)
Sub-base	100 mm	Grading 1, 90 to 45mm	1.21 to 1.43	Type A 13.2 mm	0.40 to 0.44	0.44 to 0.47
Base Course	75 mm	Grading 2, 63 to 45 mm	0.91 to 1.07	Type A 13.2 mm	0.18 to 0.21	0.33 to 0.35
-do-	75 mm	-do-	-do-	Type B 11.2 mm	0.30 to 0.33	0.33 to 0.35
-do-	75 mm	Grading 3, 53 to 22.4 mm	-do-	Type B 11.2 mm	0.27 to 0.30	0.33 to 0.35

2. The quantity of binding material where it is to be used will depend on the type of screenings and function of WBM. Generally, the quantity required for 75mm compacted thickness will be 0.06 –0.09 Cum per 10 Sqm for WBM. For 100mm thickness the quantity required will be 0.08 to 0.10 Cum per 10 sqm.

Note : The approximate quantities of coarse aggregates and screening given above are as given in IRC 19-1972 Standard Specification and code of practice for water bound macadam. For each work depending upon the type and grading of aggregates and screenings proposed to be used, their minimum quantities required shall be arrived at and approved by EIC in writing. Quantities of coarse aggregates and screenings actually incorporated in the work shall be adequate to provide the WBM of the specified thickness but in no case those shall be less than the minimum quantities approved by the EIC.

20.A.22 Granular Sub-base and Light Wearing Surfaces with Low Grade Aggregates

20.A.22.1 Preparation of Subgrade

Sub-grade shall be prepared in conformity with lines, grades and cross sections as indicated or directed by EIC. All vegetation and other extraneous matter shall be removed, subgrade lightly sprinkled with water and rolled with 6 to 10 tonne power roller.

20.A.22.2 Spreading and Compacting

The material, as indicated shall be spread on the prepared subgrade with the help of a drag spreader or other approved means. Moisture content of loose material shall be checked and suitably adjusted by sprinkling additional water so that at the time of compaction it is from one percent above to two percent below the optimum moisture content. After water has been added, the material shall be processed by mechanical or other approved means until the layer is uniformly wet.

20.A.22.3 Rolling

Immediately thereafter, rolling shall be done with 6 to 10 tonnes power roller. Rolling shall commence at the edges and progress towards the center longitudinally except that on super elevated portions, it shall progress from the lower to the upper edge parallel to the center line of the road. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling the grade and camber shall be checked and any high spots and depressions which become apparent corrected by removing or adding fresh material. Rolling shall be continued till the density achieved is 100 percent of the maximum dry density of the material or there is no movement under the roller. The surface of any layer of the material on completion of compaction shall be well closed, free from compaction planes ridges, cracks or loose materials. All loose segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

20.A.22.4 Surface Evenness

The finished surface shall be checked for lines, levels and regularity. The surface evenness of completed surface in longitudinal and transverse direction shall be within the tolerances specified.

20.A.22.5 Opening to Traffic

No traffic shall be allowed on the granular sub base and light wearing surface till it sets.

20.A.22.6 Granular sub-base and light wearing surface shall be laid to the thickness as indicated in layers not more than 150mm compacted thickness.

20.A.23 Priming with Bituminous Primers

20.A.23.1 Porosity Characteristics of Road Surfaces

Porosity characteristics of the surface to be primed are classified as under :-

(a) Surfaces of low Porosity

Pavements with tightly bonded surfaces, built with materials which are hard and dense when consolidated, such as well graded crushed rock gravels with clayey soil binders, sand and other granular materials when properly consolidated, present a surface of relatively low porosity.

(b) Surfaces of Medium Porosity

Pavements constructed with materials with a soil binder or low strength and medium porosity present relatively less tight surfaces.

(c) Surface of High Porosity

Surface built of materials which will not consolidate to a tight surface. It includes those which when finished, present a weak and open textured surface.

20.A.23.2 Viscosity Requirements

Different ranges of viscosity requirements for the primers to be used for the different types of surfaces to be primed shall be as follows :-

Type of Surface	Standard 'tar' viscosity of primers at 60 degree C.
Low Porosity	0 to 5
Medium Porosity	6 to 12
High Porosity	16 to 32

The bituminous primer shall be straight run or cut back bitumen.

20.A.23.3 Preparation of Road Surface

Surface to be primed shall be swept clean, free from dust, dirt or other deleterious matter by hard brushing , with wire brushing-bass brooms and finally by fanning the cleaned surface with gunny bags and for best results be dry. Large irregularities, pot holes-depressions, etc, shall be repaired prior to priming. Minor depressions and hole may be ignored until after the surface is primed, after which they should be patched with suitable premixed materials prior to the surface treatment.

20.A.23.4 Application of Bituminous Primer

Bituminous primer shall not be applied on a wet surface or during dust storm or when the weather is foggy or rainy. After the surface to be primed has been prepared, the bituminous primer shall be sprayed uniformly over the dry surface preferably using mechanical sprayers. The primer shall be applied at the rate indicated. Recommended rates of application are given in the following table :-

Grade of Primer	*Quantity per 10 Sqm in Kg.*
Primer for surfaces of low porosity	7.5 to 10
Primer for surfaces of medium porosity	10 to 12
Primer for surface of high porosity	12 to 14.5

Temperature of application of a primer need only be high enough to permit the primer to be sprayed effectively through the jets of the spray bar and to cover the road surface effectively. Generally it may very from 40 degree to 80 degree C for the range of viscosities of the primers specified. Any pools of excess primer left on any part of the surface should be swept out over the adjacent surface, and then a light spreading of sand shall be applied.

20.A.23.5 Curing

The primed surface shall be allowed to cure for not less than 24 hours or till it is cured. During this period, traffic shall be kept off of the primed surface.

20.A.24 Tack Coat

20.A.24.1 Binder

binder used for tack coat shall be paving bitumen or cut back bitumen as indicated. Binder shall be of suitable grade.

20.A.24.2 Preparation of Surface

The surface on which the tack coat is to be applied shall be thoroughly swept and scrapped clean of dust and any other extraneous material before the application of the binder.

20.A.24.3 Application of Binder

Binder shall be heated to the appropriate temperature and sprayed uniformly on the base at the rate specified. The tack coat shall be applied just ahead of the oncoming bituminous construction.

20.A.25 Single Coat Bituminous Surface Dressing

20.A.25.1 Binder

Binder for surface dressing shall be paving bitumen of suitable grade.

20.A.25.2 Preparation of base

The base on which surface dressing is to be laid shall be prepared, shaped and conditioned to a uniform grade and section as indicated. Any depressions or pot-holes shall be properly made up as directed and thoroughly compacted sufficiently in advance. The defective parts shall be clearly cut out and the patches of new material put in and not put on the existing surface. Where the existing surface shows signs of 'fatting-up', such portions shall be rectified as directed. The surface shall be dry and thoroughly cleaned immediately before applying the binder. The surface shall be swept clean, free of caked earth and other foreign matter, cleaned first with hard brushes, then with softer brushes and finally blowing off with sacks or gunny bags to remove the fine dust.

20.A.25.3 Whenever a primer coat is applied to the surface, binder for surface dressing shall not be applied until the primer coat has thoroughly cured.

20.A.25.4 Application of Binder

The edges of the surface to be treated shall be defined by rope lines stretched in position. Binder shall be sprayed uniformly over the prepared dry surface at the rate specified preferably using mechanical sprayers. The binder shall be applied at a temperature appropriate to the grade of binder used. Excessive deposits of binder on the road surface caused by stopping or starting the sprayer or by leakage or otherwise, shall be suitably corrected before the chipping are spread.

20.A.25.5 Application of Stone chippings

Immediately after the application of binder, stone chipping in the specified quantities and in a perfectly dry condition shall be spread uniformly by hand or preferably by means of a mechanical gritter so as to cover the surface completely. If necessary, the surface shall be broomed with a view to ensure uniform spreading.

20.A.25.6 Rolling

Immediately after the application of stone chippings the entire surface shall be rolled with 8 to 10 tonne power roller. The rolling shall commence at the edge and progress towards the center longitudinally except in the super-elevated portions, where it shall proceed from the inner to the outer edge. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While the rolling is in progress, additional aggregate shall be spread by hand in quantities as may be required to fill irregularities. Rolling shall be continued until the particles are firmly embedded in the binder and present a uniform closed surface. Excessive rolling, which results in the crushing of the aggregate particles, shall be avoided.

20.A.25.7 Finishing

The finished surface shall be uniform and confirm to the lines, grades and cross-sections indicated. The surface evenness of completed surface dressing in longitudinal and transverse directions shall be within the tolerances specified.

20.A.25.8 Quantities of Materials

The quantities of materials used for surface dressing shall be as under :-

Type of Construction	*Stone Chipping*		*Binder Kg.*
	Normal Size	*Quantity Cum.*	
Single coat surface dressing or first coat of two coat surface dressing.	12.5 mm	0.14 to 0.15	17 to 19.5
Second coat of two coat surface dressing or renewal coat	10 mm	0.09 to 0.11	10 to 12

20.A.26 Two Coat Bituminous Surface Dressing

20.A.26.1 Surface Preparation and Application of First Coat

Base shall be prepared and first coat of surface dressing applied as specified for single coat bituminous surface dressing.

20.A.26.2 Second Coat

The second coat of surface dressing shall be applied either immediately after the laying of first coat or soon after depending on the conditions at site and the type of binder used.

20.A.26.2.1 Application of Binder

Prior to the application of second coat of binder, the surface shall be cleared as already described and loose material and foreign matter removed. After getting the surface irregularities corrected and the surface trued to camber and gradient, a second application of binder heated to the temperature appropriate to the grade of binder used shall be uniformly sprayed at the rate specified.

20.A.26.2.2 Application of Stone Chippings

Immediately after application of the binder, stone chipping of 10mm size in the quantities specified and in a perfectly dry condition shall be spread uniformly so as to cover the surface completely. While rolling, the surface shall be broomed with a view to ensure uniform spreading of aggregate.

20.A.26.2.3 Rolling

Soon after the chippings are spread uniformly, rolling with a 8 to 10 tonne power roller shall be done in the same manner as described for first coat.

20.A.26.3 Finishing

The finishing surface shall be uniform and conform to the lines, grades and cross sections specified. The surface evenness for two coat surface dressing in longitudinal and transverse direction shall be within the tolerance specified.

20.A.26.4 Opening of Traffic

Provisions specified under single coat surface dressing shall apply.

20.A.26.5 Quantities of Material

The quantities of materials shall be as specified in 20.A.25.8.

20.A.27 Bituminous Carpet (20 mm Thick or More)

20.A.27.1 Preparation of Base

Before the carpet is applied to the existing base, the surface shall be cleaned by removing dirt, caked earth and other foreign matter with wire brushes, sweeping with broom and finally dusting with sacks. Where the existing base is potholed or rutted, these irregularities shall be corrected with premixed chippings or coated macadam, as indicated or ordered depending upon the depth of the pothole, laid after applying a tack coat or binder and well rammed thereafter.

20.A.27.2 Tack Coat

The binder shall be heated, wherever required, to the temperature appropriate to the grade of binder used and applied uniformly to the base at the rate specified by means of a sprayer. The binder shall be evenly brushed, if need be. The tack coat should be applied just ahead of the spreading of the premix.

20.A.27.3 Preparation of Premix

Hot mix plant of suitable capacity or Mechanical mixers of approved type shall be employed for mixing as indicated. For small quantities for work, improvised hand mixing drums may also be used as approved by the EIC. The binder shall be heated to the temperature appropriate to the grade of bitumen used. Where paving bitumen is used, the aggregate shall be suitably heated before these are placed in the mixer. After about 15 seconds of dry mixing the heated binder shall be distributed over the aggregates at the rate specified. The mixing of the binder with chippings shall be continued until the chippings are thoroughly coated with the binder.

20.A.27.4 Spreading of Premix

Immediately after the application of the tack coat, the premix shall be spread evenly with mechanical paver or rakes or distributed evenly by means of a drag spreader as indicated to the desired thickness and to the correct camber. The surface shall then be checked for camber by means of camber board and all inequalities corrected. For premix carpet of thickness 25 mm or more, Mechanical Pavers shall only be used unless otherwise indicated.

20.A.27.5 Rolling

As soon as sufficient length has been spread with the premix, the surface shall be rolled with 8 to 10 tonnes smooth wheeled power rollers or pneumatic tyre rollers. Rolling shall commence at the edge and progress towards the center longitudinally, except in the case of super-elevated curves, where rolling shall progress from the inside towards the outside of the curve. When the roller has passed once over the whole area any high spots or depressions which become apparent, shall be corrected by removing or adding premixed chippings. When this has been done, the surface shall be rolled to compaction and all roller marks eliminated. Excessive rolling shall be avoided as this serves no useful purpose and may spoil the carpet. In each pass of the roller and preceding track shall be overlapped uniformly by atleast 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to wheel and being picked up. Fuel and lubricating oils shall not be used for this purpose. Longitudinal and transverse edges of the carpet laid and compacted earlier shall be cut to their full depth so as to expose fresh surface, which shall be painted with a thin surface coat of binder before new mix is placed against it.

20.A.27.6 Seal Coat

A premixed sand seal coat or liquid seal coat, as indicated, shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

20.A.27.7 Finished Surface

The finished surface shall be uniform and conform to the lines, grade and cross-sections specified. The surface evenness of the compacted carpet in the longitudinal and transverse directions shall be within the tolerances specified.

20.A.27.8 Opening to Traffic

Traffic may be allowed on the road after providing the seal coat.

20.A.27.9 Quantities of Materials

Quantities of materials required for 10 Sqm of road surface shall be as under :-

Sl. No.	*Treatment*	*Stone Chippings Cum*	*Binder Kg*
1	**Tack Coat :**		
	(a) On water bound macadam surface	–	7.5 to 10
	(b) On existing black top surface	–	5 to 7.5
2	**Carpet :**		
	(a) 12.5 mm size chippings	0.18	9.5
	(b) 10 mm size chippings	0.09	5.1
	Total	0.27	14.6

20.A.27A Premix Carpet With Bitumen Emulsion

20.A.27A.1 This type of work is not ordinarily recommended but may be done in case of urgent repairs under damp conditions.

20.A.27A.2 Binder shall be as specified and shall conform to RS grade IS:8837. Quantity of stone chippings shall be as per para 20.A.25.8.

20.A.27A.3 Preparation of surface and binder application shall be as specified for premix carpet with hot bitumen except that the rate of application of bitumen for tack coat shall be 0.75 Kg per Sqm on water bound macadam surface and 0.5 Kg per Sqm on black topped surface.

20.A.27A.4 Preparation, spreading, consolidating mix, surface finishing shall be same as that of premix carpet using hot bitumen except that bitumen emulsion shall not be heated but it shall be poured to wet the aggregate at atmospheric temperature at correct rate before spreading on the road surface. The rolling shall commence 24 hours after spreading the mixture. The surface shall be protected by a suitable device such as barricading & posting of watchman for closing the traffic.

20.A.28 Seal Coat

20.A.28.1 Seal coat for sealing the voids in a bituminous surface shall be of the following types as indicated

(a) ***Premixed sand seal coat***
It is recommended in low rainfall areas i.e. those having rainfall under 150 cm per year.

(b) Liquid Seal Coat
It is recommended for high rainfall areas i.e. those having rainfall over 150 cm per year.

20.A.28.2 Binder

Binder shall be paving bitumen of suitable penetration grade or a cut back bitumen of suitable viscosity, as indicated.

20.A.28.3 Stone Chippings for Liquid Seal Coat

Stone chippings shall be of 6.3 mm size defined as 100 percent passing through 10mm size IS Sieve and retained on 2.36mm size IS sieve. The chippings shall satisfy the quality requirements specified for coarse aggregate for bituminous carpets, except that the upper limit for flakiness index shall be 30.

20.A.28.4 Sand for Premixed Sand Seal Coat

Sand or fine grit shall pass 1.7 mm size IS Sieve and be retained on 180 micron size IS Sieve.

20.A.28.5 Premixed Sand Seal Coat

The binder shall be heated to the temperature appropriate to the grade of bitumen being used. Also dry sand shall be suitably heated to the required temperature before it is placed in a mechanical mixer. Mixing of binder with sand to the specified proportions shall be continued till the sand is thoroughly coated with the binder. As soon as sufficient length has been covered with premixed material, the surface shall be rolled with 8 to 10 tonne power roller. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained.

20.A.28.6 Liquid Seal Coat

The binder shall be heated to the temperature appropriate to the grade of bitumen being used and applied to the cleaned surface, blinded with chippings and rolled. The construction operation shall be as described under surface dressing.

20.A.28.7 Opening to Traffic

In the case of sand seal coat traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. In the case of liquid seal coat provisions as for Surface Dressing shall apply.

20.A.28.8 Quantities of Materials

The quantities of materials required per 10 Sqm of road surface shall be as under

Type	*Stone Chippings Cum*	*Sand Cum*	*Binder Kg*
Premixed sand seal coat	-	0.06	6.8
Liquid seal coat	0.09	-	9.8

20.A.29 Bituminous Sheet with Hot Bitumen

20.A.29.1 This type of treatment is normally done for garden paths, driveways, foot paths, play ground & roads. The treatment is also useful in providing a thin wearing course over existing cement concrete roads. This can also be used over worn out cement concrete pavements, the concrete surface is roughened before laying the binder coat. It is also useful as a corrosion resistant flooring in sheds & godowns for storing salt, fertilizers etc. This treatment consists of a mixture of coarse sand and stone chippings with bituminous binder, spread and consolidated to a specified thickness on prepared surface after the application of a tack coat.

The consolidated thickness shall be 2.5 cm or 4 cm as specified. The work shall be carried out only when the atmospheric temperature in shade is 16 degree C or above. No bituminous material shall normally be applied when the road surface or material is damp or when the weather is foggy or rainy or during dust storms.

20.A.29.2 Quantities of materials

The quantities of materials shall be as specified below:

Consolidated thickness of bituminous sheet	Bitumen			Stone chippings Cum/100 Sqm	Course sand Cum/100 Sqm
	Kg/Sqm of surface area (for tack coat)	Kg/Cum of grit	Kg/Cum of Sand		
2.5 Cm	0.75	56	128	1.65 *	1.65
4 Cm	0.75	56	128	2.6 *	2.6

* 60% 12.5 mm nominal size and
40% 10 mm nominal size.

20.A.29.3 Preparation of mix, laying & consolidation shall be generally as that of premix carpet with hot bitumen except that the mixing shall be done in two stages. Stone aggregate of correct standard size and in proportion shall be fed into mixer to which 2/3rd of the total specified quantity of bitumen heated to the appropriate temperatures shall be added when the stone metal is well coated, the sand in the specified proportion and then the balance 1/3rd quantity of bitumen shall be fed into the mixer. Mixing shall be continued until a homogenous mix is produced and all particles are uniformly coated with bitumen.

20.A.29.4 Any high spots or depressions which become apparent shall be corrected. Rolling shall continue until the maximum consolidation is achieved to the satisfaction of Engineer-in-charge.

20.A.30 Bitumen Mastic Wearing Course

20.A.30.1 Bitumen mastic is an intimate homogenous mixture of mineral fillers and well graded fine & coarse aggregate with a hand grade bitumen, cooked and laid hot, troweled and floated by means of wooden float. The mixture settles to a coherent void less and impermeable solid mass under normal temperature conditions. Bitumen mastic is used on a wearing course in different situation of heavy duty road pavements. However, uses of this materials is not recommended in places where abundant fuel oil dripping is expected on the surfaces like bus depots, fuel filling & service station etc.

20.A.30.2 Materials

20.A.30.2.1 The bitumen shall be straight run bitumen conforming to IS 73 or Industrial bitumen as per IS-702 of suitable consistency satisfying the requirement of physical properties as under :-

Physical Properties of Bitumen

Sl. No.	*Characteristics*	*Requirement*	*Method of test*
1	Penetration at 25 degree C in 1/10 mm	20 to 40	IS : 1203
2	Softening point (R&B)	50 to 90 degree C	IS : 1205
3	Ductility at 27 degree C (minimum in cms)	3	IS : 1208
4	Loss on heating percent (maximum)	1	IS : 1212
5	Solubility in CS 2 percent (minimum)	99	IS : 1216

20.A.30.2.2 Physical requirement of coarse aggregates for bitumen mastic

Sl. No.	Test	Allowable (max in percent)	Test method
1	Los Angeles Abrasian value or Aggregate impact value.	30 40	IS : 2386 (Pt IV) -do-
2	Flakiness Index	35	IS : 2386 (Pt – I)
3	Stripping value.	25	IS : 6241
4	Soundness (i) Loss with sodium sulphate 5 cycles (ii) Loss with magnesium sulphate 5 cycles.	 12 18	 IS : 2386 (Pt-V)- -do
5	Water absorption	2	IS : 2386 (Pt – III)

20.A.30.2.3 Grading and Percentage of Coarse Aggregates for Wearing Course and Foot Path

Sl. No.	Type of work	Grading of Coarse aggregate		Thickness of finished coarse aggregate (mm)	% of coarse aggregate
		IS Sieve	% passing IS Sieve		
1	Wearing coarse for road pavements & bridge decks	19 mm 13.2 mm 2.36 mm	100 88.96 0 - 5	(a) 25 – 40 or (b) 41 – 50	(a) 30 - 40 or (b) 40 - 50
2	Foot path	6.7 mm 600 micron	100 0.15	20 - 25	15 - 30

20.A.30.2.4 Fine aggregate shall consist of crushed hard rock or natural sand or a mixture of both. The grading of fine aggregates inclusive of filler material passing 75 micron shall be as given below :

Grading of Fine Aggregates including Filler

Passing I.S. Sieve	Retained on I.S. Sieve	% by weight
2.36 mm	600 micron	0 - 25
600 micron	212 micron	5 - 25
212 micron	75 micron	10 - 20
75 micron	-	30 - 50

Filler : The filler shall be limestone powder passing 75 micron and shall have a calcium carbonate content of not less than 80% when determined in accordance with IS – 1195.

20.A.30.3 Manufacture of Bitumen Mastic

This involves different stages. Initially the filler alone shall be heated to a temperature of 170 degree C to 200 degree C in a mechanically agitated mastic cooker and half the required quantity of bitumen heated at 170 degree C to 180 degree C added. They shall be mixed & cooked for one hour. After that the fine aggregates and the balance bitumen at 170 degree C to 180 degree C shall be added to that mixture in the cooker and heated upto 170 degree C to 200 degree C and further mixed for another one hour. In the final stage, the coarse aggregates shall be added and heating of mix shall continue for another one hour. Thus a total period of minimum three hours will be needed to prepare the mastic. During mixing & cooking, care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 200 degree C.

20.A.30.4 Laying the Bitumen Mastic

20.A.30.4.1 Preparation of Base

The base on which bitumen mastic is to be laid shall be prepared, shaped and conditioned to the specified levels, grades and camber as directed. If the existing surface is too irregular and wavy, it shall be made good by providing a corrective course by adopting bituminous concrete mix as per IRC : 29. The surface shall be thoroughly swept clean and made free of dust. To receive and contain the mastic, angle irons of sizes 25 or 50 mm shall be placed at required spacing.

20.A.30.5 Transportation & laying

Arrangement for transportation shall be made in a towed mixer transporter with adequate provision for heating and stirring so as to keep the aggregates and filler suspended in the mix till the time of laying. The bitumen mastic shall be discharged in to containers sprinkled with lime stone dust or provided with lime wash. The bitumen mastic shall be deposited directly on the prepared base immediately in front of the spreader where it is spread uniformly to the required thickness. The mix shall be laid in one metre width. Temperature of mix at the time of laying shall be 170 degree C. In case blowing takes place while laying the bitumen mastic, the bubbles shall be punctured while the mastic is hot and the surface made good. Since mastic asphalt is an expansive material, extreme care shall be taken while fixing the angle irons and their levels checked with instrument at suitable intervals.

20.A.30.6 Surface Finish

The bitumen mastic surfacing has got a very fine texture which on initial laying provides very little resistance to skidding. Therefore, bitumen mastic after spreading and while still hot condition shall be spread over with bitumen pre-coated fine grained hard stone chips / aggregates of approved quality of 9.5 mm to 13.2mm size, depending upon the thickness of mastic, using bitumen at the rate of 1 to 3 percent of S-65 or S-90 grade and aggregate at the rate of 0.005 Cum (1/200 Cum per 10 Sqmm) and at the spacing of 10 cm C/C in both directions and pressed into the surface when the temperature of bitumen mastic is between 80 degree C to 100 degree C. Such pre-coated aggregates when laid should protrude 3mm to 4mm over the mastic surface. Flakiness index of stone aggregate used for anti skid measures shall be less than 25 percent.

20.A.31 Bajari Paths

20.A.31.1 Preparation of Subgrade

The formation for a width equal to that of the bajri path shall first be cut to a depth, below the proposed finished level, equal to the thickness of the course of brick aggregate (due allowance being made for consolidation) and dressed off in level to the finished profile.

20.A.31.2 Laying and Packing Brick Aggregate

Shall be spread uniformly and evenly in required quantities with a twisting motion to avoid segregation and laid to 7.5 cm depth unless otherwise specified. Consolidation shall be done by rolling with three tones or light power roller instead of by heavy roller as directed by the Engineer-in-Charge. Rolling with blinding material shall be done with light power roller.

20.A.32 Painting Road/Runways Marking

20.A.32.1 Material

Special road marking paint of brand and manufacturer shall be used. The paint shall conform to IS-164. Ready mixed paint as received from the manufacturer shall be used without adding any admixture. During work, if the consistency of the paint gets thick, thinning shall be done by use of thinner of the specified brand of paint, recommended by the manufacturer.

20.A.32.2 Preparation of surface and application

Surface shall be thoroughly cleaned and dusted. All the dirt, scales, oil etc shall be thoroughly removed before painting is started. The painting shall be applied evenly and smoothly by means of crossing and laying off. Each coat shall be allowed to dry out thoroughly before the next coat is applied. No left over paint shall be put back into the stock tins. No hair marks from the brush or clogging of paint puddles shall be left on the work. Trial patches of paint shall be laid at intervals to check if drying is satisfactory.

20.A.33 Kerb and Channel Stones

20.A.33.1 Laying

Trenches shall first be made along the edge of the wearing course of the road to receive the kerb and the channel stones. The bed of the trenches shall be compacted manually with steel rammers to a firm and even surface and then stones shall be set in cement mortar of specified proportion. The kerb stones with top 20 cm wide shall be laid with their length running parallel to the road edge, true in line and gradient at a distance of 30 cm from the road edge to allow for the channel and shall project about 12.5 cm above the latter. The channel stones with top 30 cm wide shall be laid in position in camber with finished road surface and with sufficient slope towards the road gully chamber. The joint of kerb and channel stones shall be staggered and shall be not more than 10 mm. Wherever specified all joints shall be filled with cement mortar 1:6 and pointed with cement mortar 1:2.

20.A.33.2 Finishing

Berms and road edges shall be restored and all surplus earth including rubbish etc; disposed off as directed by Engineer-in-Charge.

20.A.34. Repairs

20.A.34.1 Scarifying and Renewing Water Bound Macadam

The surfaces shall be scarified by means of pick-axes or other means approved by the EIC. After removing the black top surface, if existing the aggregate base shall be loosened to a depth of 50 mm or as indicated. The resulting material, shall be removed from the road bed and screened to salvage coarse aggregate for use in the renewal work. High spots on the exposed surface shall be corrected and any hollows that remains after picking, shall be filled with new aggregate, 50mm nominal size and well consolidated, so that the surface broadly conforms to the specified grade and camber. The salvaged coarse aggregate mixed with the requisite quantities of fresh aggregate shall be spread on the prepared bed and compacted as water bound macadam to the thickness as indicated.

30.A.34.2 Patching of Pot Holes

The pot holes (or ruts) shall be drained of water and cut to a rectangular form with vertical sides. All loose and disintegrated materials shall be removed. The pot holes shall then be filled either with coarse aggregates and screenings as for water bound macadam and compacted with heavy hand rammers/approved mechanical tampers or premixed material as for premixed thin carpet and compacted with heavy hand rammers or approved mechanical temper/roller after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both, as indicated. In case of deep pot holes, where indicated, a tack coat at the rate of 10 Kg per Sqm shall be applied, pre-coated aggregate as described for bituminous macadam filled-in, thoroughly compacted and finally finished with a seal coat. The surface shall be finished slightly proud by at least 6mm to allow for subsequent settlement under traffic.

20.A.35 Cutting WBM Roads & Making Good

20.A.35.1 Cutting

All road crossings shall be cut in half the width at a time and repaired, unless otherwise permitted by the Engineer-in-Charge. Cutting shall be straight and uniform in width. Soling stone and aggregate obtained from cutting macadam shall be stacked separately, clear of the road surface. Aggregate shall be screened stones of small size below 20mm and with round edges discarded and disposed.

20.A.35.2 Making Good

After the trenches have been filled in with excavated earth in layers of 15 cm thickness, watered, well consolidated with heavy iron rammers and brought to sub grade level, soling stones obtained from cutting shall be laid as per existing soling and consolidated with heavy iron rammers. Where the earth consolidation is well done, no settlement need occur subsequently, for this excess watering should be avoided.

20.A.35.2.1 New aggregate 50mm nominal size, as required shall be added to old aggregate and spread over to a depth of 7.5 cm as specified in 20.A.21.3. This shall then be consolidated with hand roller or heavy iron rammers, as directed, first with light sprinkling then with sufficient application of water till the aggregate has become adequately consolidated and does not get displaced. All undulations shall be loosened by hand picking, surplus aggregate removed from high spots and depressions filled with surplus and new aggregate and the surface compacted again. When thoroughly consolidated, kankar moorum and red bajri, freshly collected shall be spread over it in 12mm layer and consolidated with hand roller or heavy iron rammers with sufficient application of water till a uniform surface is obtained.

20.A.35.2.2 The finished surface shall be in camber with and left a little higher than the adjoining road surface to allow for any settlement on drying.

20.A.36 Cutting Bituminous Roads & Making Good

20.1.36.1 Cutting, making good shall be as specified in 20.A.35 except the top bituminous surface shall be finished as per the existing surface or as directed by the Engineer-in-Charge. This shall include cutting and restoration of WBM portion as well as, bitumen portion.

20.A.37 Cutting Bajri Paths & Making Good

20.A.37.1 Cutting

Cutting shall be straight and uniform in width. Aggregate obtained from cutting shall be screened, aggregate of smaller size discarded and disposed off and rest stacked clear off path way.

20.A.37.2 Making good

After the trenches has been filled in with excavated earth, consolidated and brought to sub-grade level, aggregates obtained from the cutting and mixed with new aggregates 50mm nominal size as required shall be spread to a depth of 7.5 cm. This shall be consolidated with blinding materials and finished.

SECTION 20-B
RUNWAY PAVEMENT & HARD STANDING
FLEXIBLE & RIGID PAVEMENT

20.B.1 Indian Standards

The following I.S. shall apply:

I.S. No.	*Subject*
73-2006	Specification for Paving Bitumen (Second revision).
217-1988	Specification for cut back bitumen (Second revision).
269-1989	Specification for ordinary and low heat port land cement (Fourth revision).
383-1970	Specification for coarse and fine aggregate from natural source for concrete (Second revision).
454-1994	Specification for Digboi type cut back bitumen (Second revision).
456-2000	Code of practice for plain and reinforced concrete (Third revision).
516-1959	Method of test for strength of concrete.
1199 - 1959	Method of sampling and analysis of concrete.
1203 - 1978	Determination of Penetration.
1205 - 1978	Determination of Softening Point.
1206 - Part 1 1978	Determination of Viscosity : Industrial viscosity.
1206 - Part 2 1978	Determination of Viscosity: Absolute viscosity.
1206 - Part 3 1978	Determination of Viscosity: Kinematic viscosity.
1834 -1984	Specification for hot applied sealing compound for joints in the concrete (First revision).
1838 - (Part 1) 1983	Specification for preformed filler for expansion joints in concrete, non-extending and resilient type (Bitumen impregnated fibre) (First revision).
2386-(Part 1) 1963	Method of test for aggregate Part I : Particle size and shape.
2386 - (Part 2) 1963	Method of Test for aggregates for concrete Part 2 : Estimation of deleterious materials and organic impurities.
2386 - (Part 3) 1963	Method of Test for aggregates for concrete Part 3 : Specific gravity, density, voids, absorption and bulking.
2386-(Part 4) 1963	Method of test for aggregates Part IV : Mechanical properties.
2506 - 1985	General requirement for Concrete Vibrates, Screed Board Type (First revision).
2720 - Part 8: 1983	Method of Test for soils Part 8 : Determination of Water Content - Dry Density Relation using heavy compaction (Second revision)
6241 - 1971	Method for Test for Determination of Stripping Value of Road Aggregate.
6925 - 1973	Method of Test for Determination of Water Soluble Chlorides in Concrete Admixtures.
8112 -1989	Specification for 43 Grade ordiniary portland cement.

9103 - 1999	Concrete Admixtures - Specification (First revision).
9381 - 1979	Method of Testing Tar and Bituminous materials : Determination of FRAASS breaking point of Bitumen.
9382 - 1979	Method of Testing Tar and Bituminous materials : Determination of effect of heat and air by thin film oven test residue.
15462 - 2004	Polymer and Rubber Modified Bitumen

20.B.2 Materials

20.B.2.1 Binder

It shall be paving bitumen of suitable penetration such as 10/40, 60/70, 80/100 as per I.S. 73-1992 as indicated.

20.B.2.2 Cement

The cement used shall be indicated as any of the following:

(a) Ordinary and low-heat Portland cement conforming to I.S. 269-1989, Specification for ordinary and low heat cement.

(b) High strength cement conforming to I.S. 8112-1989 Specification for 43 Grade Ordinary Portland cement.

20.B.2.2.1 Storage and precaution in storage

Provision as applicable vide clause 4.3.1., specified here in before shall also apply to this section.

20.B.2.3. Modified Binder

Modified binders comprise a base binder, to which is added either natural rubber, crumb rubber or a polymer such as Styrene-Butadiene Styrene (SBS), Ethylene-Vinyl-Acetate (EVA) or low Density Polyethylene (LDPE). The purpose is to achieve a performance binder with improved properties, particularly at extremes of temperature. The selection and specifications of bitumen will be in accordance with IRC: SP: 53-2002 and IS 15462: 2004.

The modifier, in the required quantity shall be blended at the refinery /factory only. Site blending will not be permitted even for small quantities.

20.B.2.3.1. Base Binder

The base binder into which the modifier is incorporated shall conform to IS: 73. The choice of grade shall be such that it is compatible with the modifier.

20.B.2.3.2. Modifier

The modifier shall be a natural rubber, crumb rubber or any other polymer, which is compatible with the base binder. The modifier, in the required quantity shall be blended at the refinery /factory only. Site blending will not be permitted even for small quantities.

20.B.2.3.3. During use, the requirements for softening point, penetration and elastic recovery shall be tested regularly on weekly basis and conform to the requirements given in Tables below:

REQUIREMENTS OF POLYMER MODIFIED BINDERS (ELASTOMERIC THERMOPLASTICS AND RUBBER LATEX)

Designation	*Grade and Requirements*			*Method of test*
	PMB 120	*PMB 70*	*PMB 40*	
Penetration at 25° C, 0.1 mm, 100 g 5 sec.	90 to 150	50 to 89	30 to 49	IS : 1203 - 1978
Penetration at 4°, (0.1 mm, 200g, 60 sec, Minimum*	35	22	18	IS:1205-1978
Softening Point, (R&B), °C, Minimum	38	48	59	IS:1205-1978
Fraass Breaking Point, °C, Maximum*	-24	-16	-12	IS:9381-1979
Ductility at 27°C, cm, Minimum	75	50	50	IS:1208-1978
Flash Point, COC, °C, Minimum	220	220	220	IS:1209-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	70 (50)**	60 (40)**	50 (30)**	ASTM D5976-1996
Separation Difference in Softening Point, R&B, °C, Maximum	4	4	4	ASTM D5976-1996
Viscosity at 150°C, Poise	1-3	2-6	4-8	IS:1206-1978

Test on Thin Film Over Test Residue, TFOT (IS:9382-1979)

Designation	*Grade and Requirements*			*Method of test*
	PMB 120	*PMB 70*	*PMB 40*	
Penetration at 4°C, 0.1 mm, 200g, 60 sec, Minimum*	18	15	12	IS:1203-1978
Loss in Weight, % Maximum	1.0	1.0	1.0	IS:9382-1979
Increase in Softening Point, °C, Maximum	7	6	5	IS:1205-1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS:1203-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C,%, Minimum	60 (35)**	40 (30)**	35 (25)**	ASTM D5976-1996

* Relevant to snow bound cold climate areas.
** Natural Rubber Modified Bitumen.

REQUIREMENTS OF POLYMER MODIFIED BINDERS (PLASTOMERIC THERMOPLASTICS)

Designation	*Grade and Requirements*			*Method of test*
	PMB 120	*PMB 70*	*PMB 40*	
Penetration at 25° C, 0.1 mm, 100 g 5 sec.	90 to 150	50 to 89	30 to 49	IS: 1203-1978
Penetration at 4°, 0.1 mm, 200g, 60 sec, Minimum*	35	22	18	IS: 1205-1978
Softening Point, (R&B), °C, Minimum	38	48	59	IS.1205-1978
Fraass Breaking Point, ^{0}C, Maximum*	-20	-15	-10	IS.9381-1978
Ductility at 27°C, cm, Minimum	50	40	30	IS: 1208-1978
Flash Point, COC, °C, Minimum	220	220	220	IS: 1209-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	60	50	40	ASTM D5976-1996
Separation Difference in Softening Point, R&B, °C, Maximum	3	3	3	ASTM D5976-1996
Viscosity at 150°C, Poise	1-2	2-4	4-8	IS: 1206-1978

Test on Thin Film Over Test Residue, TFOT(IS:9382-1979)

Designation	*Grade and Requirements*			*Method of test*
	PMB 120	*PMB 70*	*PMB 40*	
Penetration at 4°C, 0.1 mm, 200g, 60 sec, Minimum*	18	15	12	IS:1203-1978
Loss in Weight, % Maximum	1.0	1.0	1.0	IS:9382-1979
Increase in Softening Point, °C, Maximum	7	6	5	IS: 1205-1978
Reduction in Penetration at 25°C, %, Maximum	35	35	35	IS: 1203-1978
Elastic Recovery of Half Thread in Ductilometer at 15 °C,%, Minimum	45	35	30	ASTM D5976-1996

REQUIREMENTS OF POLYMER MODIFIED BINDERS (TREATED WITH MODIFIED CRUMB RUBBER)

Designation	*Grade and Requirements*			*Method of test*
	PMB 120	*PMB 70*	*PMB 40*	
Penetration at 25° C, 0.1 mm, 100 g 5 sec.	50 - 70	50 - 60	40 - 60	IS : 1203-1978
Softening Point, (R&B), °C, Minimum	50	55	60	IS:1205-1978
Elastic Recovery of Half Thread in Ductilometer at 15°C, %, Minimum	40	35	30	ASTM D5976-1996

Test on Thin Film Over Test Residue, TFOT (IS:9382-1979)

Designation	Grade and Requirements			Method of test
	PMB 120	PMB 70	PMB 40	
Reduction in Penetration at 25°C,%, Maximum	60	60	60	IS: 1203-1978
Increase in Softening Point, °C, Maximum	5	5	5	IS: 1205-1978
Elastic Recovery of Half Tread in Ductilometer at 15 °C, %, Minimum	25	20	15	ASTM D5976-1996

CRMB - Crumb Rubber Modified Bitumen

20.B.2.3.4. Usage

Pre-blended modified binders which are to be stored without circulation or agitation facility shall be tested for storage stability prior to use. The selection and specifications of bitumen will be in accordance with IRC: SP: 53-2002 and IS 15462: 2004. The mean of the differences in softening point, top to bottom, of not less than three pairs of samples shall not exceed 5°C.

Other pre-blended modified binders shall be stored with appropriate circulation or agitation facility, according to the manufacturer's instructions.

The modifier, in the required quantity shall be blended at the refinery/factory only. Site blending shall not be permitted even for small quantities.

20.B.2.4. SAMI (Stress Absorbing Membrane Interlayer)

A SAM is a bitumen membrane which is laid over a cracked road surface together with a covering of aggregate chips. SAMI can be laid as a single coat or double coat as indicated. Aggregate chips shall be of quality suitable for Bituminous Macadam except that water absorption shall be restricted to 1 % & polished stone value requirement will not apply. Where indicated, aggregate shall be precoated.

20. B.2.5 Aggregate for Bituminous Works/Wet Mixed Macadam

20 B.2.5.1 Coarse Aggregate: Coarse Aggregates shall consist of crushed rock, crushed gravel or other hard materials. They shall be clean, hard, and durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. The specifications for binder and granular course shall be as per MORTH specifications, Forth Revision (reprinted Apr 2005) or as per subsequent revisions from time to time.

Note :-

(i) Before sample of material for aggregates is approved, these shall be tested for stripping. Where aggregates have poor affinity for bitumen, these shall be treated with approved anti-stripping agents.

(ii) Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces.

(iii) The aggregates shall satisfy the physical requirements & grading requirements as indicated hereinafter & shall be procured in bulk only after obtaining sample approval from the GE.

20.B.2.5.2 Physical requirements

The coarse aggregate shall satisfy the following physical requirements:-

Test	Percentage Max				
	Wet Mixed Macadam	Bituminous Macadam	Dense Graded Bituminous Macadam	Semi Dense Asphaltic Concrete	Dense Asphaltic Concrete
Flakiness Index	15	15	15	15	10
Impact Value	30	30	27	27	30
Los Angeles Abrasion Value	40	40	35	35	40
Stripping Test	-	25	25	25	25
Water Absorption Test	-	1%	1%	1%	1%
Soundness Test Sodium Sulphate Magnesium Sulphate	- -	- 12% 18%	- 12% 18%	- 12% 18%	- 12% 18%

*Aggregate impact value may be up to 35% if bituminous macadam is used as base course.

20.B.2.5.3 Fine Aggregate

The fine aggregate shall consist of crushed or naturally occurring material and be fraction passing 2.36 mm sieve and retained on 75-micron sieve consisting of crushed screening, natural sand or mixture of both. It shall be clean, hard, durable uncoated and dry, free from injurious, soft or flaky pieces and organic or deleterious substance.

20.B.2.5.4 The combined grading of coarse/fine aggregate shall conform to following:-

(a) Wet Mixed Macadam

IS Sieve designation		*Percent by weight passing IS sieve*
1		2
53.00	mm	100
45.00	mm	95 - 100
26.50	mm	-
22.40	mm	60 - 80
11.20	mm	40 - 60
4.75	mm	25 - 40
2.36	mm	15 - 30
600	micron	8 - 22
75	micron	0 - 8

Note :-

(i) Material finer than 425 micron shall have plasticity Index (PI) not exceeding 6.

(b) Bituminous Macadam

Mix designation *Nominal aggregate size* *Layer thickness* *IS sieve (mm)*	*Grading 1* *40 mm* *80 - 100 mm* *Cumulative % by weight of total aggregate passing*	*Grading 2* *19mm* *50 - 75 mm*
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90-100
13.2	35-61	56-88
4.75	13-22	16-36
2.36	4-19	4-19
0.3	2-10	2-10
0.075	0-8	0-8
Bitumen content, % by weight of total mixture	3.1 - 3.4	3.3 - 3.5

Note: Appropriate bitumen contents for conditions in cooler areas of India may be up to 0.5% higher as per mix design.

(c) Dense Bituminous Macadam

Grading	*I*	*2*
Nominal aggregate size	*40 mm*	*25 mm*
Layer Thickness	*80-100 mm*	*50-75 mm*
IS Sieve (mm)	*Cumulative % weight of total aggregate passing*	
45	100	
37.5	95-100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	28-42
1.18	-	-
0.6	-	-
0.3	7-21	7-21
0.15	-	-
0.075	2-8	2-8
Bitumen content % by mass of total mix	Min 4.0	Min 4.5

(d) Semi Dense Asphaltic Concrete

The combined grading of aggregates i.e. coarse aggregate, fine aggregate & filler shall conform to the following table. The filler shall be an inert material whole of which passes 710 micron sieve, at least 90% passing 180 micron sieve & not less than 70 percent 90 micron sieve. Unless otherwise indicated, filler shall be cement (OPC-43 Gde).

GRADATION OF AGGREGATES IN THE FINAL MIX

IS sieve	Percent passing by weight
22.4 mm	100
13.2 mm	79-100
11.2 mm	68-90
5.6 mm	33-55
2.8 mm	22-38
710 Micron	6-22
355 Micron	4-14
180 Micron	2-9
90 Micron	0-5

(e) Dense asphaltic Concrete

The combined grading of aggregates i.e. coarse aggregate, fine aggregate & filler shall conform to the following table. The filler shall be inherit material whole of which passes 600 micron sieve, at least 90 percent passing 150 micro sieve and not less than 70 percent passing 75 micron sieve unless otherwise indicated, filler shall be cement (OPC-43 Gde).

Sl. No	*IS sieve No*	*Percent by weight passing the sieve 50 mm thick*
1	*2*	*3*
1.	22.4 mm	100
2.	13.2 mm	85-100
3.	11.2 mm	75-90
4.	5.60 mm	58-70
5.	2.36 mm	45-55
6.	600 micron	23-35
7.	300 micron	16-24
8.	150 micron	10-16
9.	75 micron	6-9

20.B.2.6. Aggregates for Dry lean Concrete & Quality Concrete Work

20.B.2.6.1. Coarse Aggregate

Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 25 mm unless otherwise indicated. No aggregate which has water absorption more than 2 per cent shall be used in the concrete mix. The aggregates shall be tested for soundness in accordance with IS : 2386 (Part - 5). After 5 cycles of testing the loss shall not be more than 12 per cent if sodium sulphate solution is used or 18 per cent of magnesium sulphate solution is used. Coarse aggregates Loss Angles Abrasion Value shall not exceed 30% when tested in conformity with IS-2386 (Part -4).

Dumping and stacking of aggregates shall be done in an approved manner. In case GE considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching as directed by the Engineer.

20.B.2.6.2. Fine aggregate

The fine aggregate shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS : 383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregate shall not contain deleterious substances more than the following:-

Clay lumps	:	4.0 percent
Coal and Lignite	:	1.0 percent
Material passing IS sieve No 75 micron	:	4.0 percent

20. B.2.6.3. Samples of the aggregates proposed to be used in the work shall be approved by the GE prior to bulk delivery of the same at site of work. Field testes (as applicable) shall be carried out by Engineer-in-Charge at laid down frequency to ensure that the material brought at site are in conformity with the samples approved by the GE.

20.B.2.6.4. Grading of Aggregates

20.B.2.6.4.1 Dry Lean Concrete (DLC)

The grading of coarse & fine aggregate for dry lean concrete (DLC) shall be as per approved mix design with limits as under:-

Sieve designation	%passing the sieve by weight
26.50 mm	100
19 mm	80-100
9.50 mm	55-75
4.75 mm	35-60
600 micron	10-35
75 micron	0-8

20.B.2.6.4.2. Quality concrete (Pavement/Hard Standing)

Coarse aggregates & fine aggregates shall be mixed in suitable proportions as per approved mix design. Mix sieve analysis test of the mixed aggregates shall be carried out at least once a day at random.

20.B.2.7. Water

Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS : 456.

20.B.2.8. Admixtures (For use in quality concrete)

Admixtures conforming to IS : 6925 and IS:9103 shall be permitted for use to improve workability of the concrete or extension of setting time, on satisfactory evidence that they will not have any adverse effect on the properties of concrete with respect to strength, volume change, durability.

20.B.2.9. Fillers for Expansion Joints

Preformed fillers for expansion joints shall comply with the requirements of ARE 1838-1961. Specification for preformed fillers for expansion joints in concrete. Non-extruding and resilient type (Bitumen impregnated fibre). Fibre used may be of soft-board, fibre board or other suitable fibres (natural or artificial) of cellular nature and the preformed strips of fibrous material shall be securely bonded together and uniformly impregnated with bitumen.

Preformed strips if expansion joint fillers shall not be deformed by twisting, bending or other handling when exposed to atmospheric conditions. Holds to accommodate dowel bars shall be accurately bored or punched.

Tolerances of + 1.5 mm in thickness and + 3 mm in depth shall be permitted.

20.B.2.10. Sealing Compounds for Joints in Concrete Pavements

Cold applied Polysulphide / Polyurethane joint sealant of approved make will be used. The specifications shall conform to BS-5212, BS 4254 and EN-141875-2003 (for hydrolysis/water resistance test). In addition, the Movement Accommodation Factor (MAF) of the sealant should be minimum ± 30 %. The sealant shall be cold applied polysulphide or polyurethane type approved make with minimum performance guarantee of ten years.

20.B.2.11. Mix design criteria for Bituminous Macadam/Asphaltic Concrete/Semi Dense Asphaltic Concrete

Pavement:- The design requirement shall be as under:-

Sl. No.	*Properties*	*Bituminous Macadam*	*Dense Bituminous Macadam/Semi Dense Asphaltic Concrete*	*Asphaltic Concrete*	*Method of test*
(a)	Marshall stability (75 blows) at 60°C minimum	545	1050	1200	ASTMD: 1559 - 1979
(b)	Marshall flow at 60 °C, mm	2.0 - 4.0	2.0 - 4.0	2.5 - 4.0	-do-
(c)	Marshall quotation, Kg/mm		250 - 500	250 - 500	Stability + Flow
(d)	Voids in compacted Mix, %	10 - 15	3.0 - 5.0	3.0 - 5.0	
(e)	Requirement of retained stability after 24 hours in water at 6 °C % minimum	-	90	90	ASTMD: 1075 - 1979
(f)	Coating with aggregate % (minimum)	-	-	95	AASHTD 182
(g)	Type of binder	Grade 35 - 90	As per mix design	As per mix design	
(h)	Binder content percent by weight of total mix	3.5 to 4.5	4.5 to 5.5	5 to 6.5	

Note :-

(i) The quantity of binder content has been indicated tentatively and shall be as per actual mix design.

(ii) Compression test to measure the loss of Marshall Stability due to effect of water on the mix shall be conducted for Semi Dense Asphaltic Concrete & Dense Asphatlic Concrete. If the Index Retained Stability is less than 75, the mix shall be rejected or the aggregates shall be processed by approved method to increase the index to minimum of 75. The immersion test shall be carried out on Marshall test specimens of design job mix after storing in 1 % sodium chloride solution v/v distilled water for 24 hours at 60° C and then tested for Marshall Stability Values. The percentage loss or retention of stability values after immersion in water with reference to the values obtained before immersion is expressed in terms of percentage of the original values.

20.B.3 Bituminous Macadam

20.B.3.1 Preparation of the surface

The surface shall be dry and cleaned of all dust and foreign matter with wire brushes. Any depressions or pot holes shall be properly made up and thoroughly compacted.

20.B.3.2 Application of Tack Coat

The binder shall be heated to its appropriate temperature and applied uniformly over the prepared surface with the help of either self propelled or towed pressure sprayer with self heating arrangement and spraying nozzles, a system capable of spraying bitumen at specified rates and temperatures so as to provide a uniform & even spread of bitumen. The tack coat shall be applied just immediately before spreading the mix. The rate of tack coat shall depend upon the surface and should be as per MORTH specifications, Forth Revision (reprinted Apr 2005) and subsequent revisions from time to time. The temperatures of application of binder shall be between 165°C to 180 °C.

20.B.3.3. Preparation of Mix

20.B.3.3.1. Weather and Seasonal Limitations

Bitumen macadam shall not be laid during rainy weather or when the surface is damp or wet or when the temperature is less than 16°C under shade.

20.B.3.3.2. Plant

Hot mix plant of not less than 100 ton/hour output (or as indicated) and capable of producing a proper and uniform quality mix shall be used for preparation of the mix. The plant will have separate load cells to accurately weigh and feed different type of aggregates and a separate load cell for weighing bitumen. The plant will be of batch type. The plant shall have coordinated set of essential units such as a dryer for heating the aggregates, device for batching, feeding by weight the required control unit for ensuring that the correct quantity of heated binder is fed into the mechanical mixer for thorough mixing of the binder and aggregates. For small quantity continuous drum mixing plant may be used with approval of GE. The plant shall have coordinated set of essential units capable of producing uniform mix as per the Job Mix formula such as:

(a) Cold aggregate feed system for providing blended aggregates in correct proportions. At least 4 bin system shall be deployed.
(b) The rotating drum shall be fitted with suitable burners capable of heating the aggregates to the required temperature without any visible un burnt fuel or carbon residue on the aggregate.
(c) The dryer part shall be fitted with thermometric instruments so as to indicate/automatically record the temperature of heated aggregates before mixing with the binder.
(d) The three bin aggregates feed system shall have variable speed belt conveyors, (Load cells or other suitable devices) for regulating the accurate proportioning of aggregates into an even flow automatically from a central control cabin.
(e) Bitumen control unit of the system shall be capable of measuring/metering and spraying required quantity of bitumen at specified temperature with synchronization of bitumen and aggregates feed.
(f) Filler system suitable to receive bagged or bulk supply of filler material and its incorporation in the mix in correct quantity, which could be controlled from central control unit.
(g) Dust control unit shall be part of the plant.
(h) Suitable auxiliary bitumen boiler of adequate capacity with self-heating arrangement and temperature control device.

20.B.3.4. Temperature

20.B.3.4.1. The temperature of the binder at the time of mixing shall be in the range of 150° C-177° C and shall be so maintained without overheating of the binder. The temperatures of the aggregates shall be in the range of 155° C-163° C. At no time, however, shall the difference in temperature between the aggregates and the binder shall exceed 14° C. It shall be ensured that bitumen or aggregates are not over heated.

20.B.3.4.2. The hot combined aggregates and bitumen shall be measured separately and as accurately as practicable, to the proportions in which they are to be mixed. Mixing shall be done thoroughly at least for 30 seconds or more after the addition of the binder, as required so that a homogenous mixture is obtained in which all the particles are uniformly coated.

20.B.3.5. Transporting Mixed Materials

20.B.3.5.1. The mixed materials shall be transported from mixing plant to the site in clean vehicles. Every precaution shall be taken to avoid segregation and to ensure that they do not become contaminated with dust or foreign matter. In order to maintain satisfactory temperature of materials in transit, particularly in cold weather, and to prevent undue loss of heat, adequate precautions shall be taken to ensure that the materials are properly protected/covered during transportation. Hauling over freshly laid material will not be permitted.

20.B.3.5.2. The temperature of the mix in every transporting vehicle shall be checked immediately prior to discharge into the spreader. If the temperature of any batch is below the laying temperature specified the mix shall be rejected and shall be removed from site immediately

20.B.3.6. Laying

20.B.3.6.1. The mix transported from the hot mix plant to the site shall be laid by means of a self-propelled mechanical paver finisher with electronic sensor and hydraulic controls with suitable screed capable of laying, spreading, tamping and finishing the mix true to the specified width and profile without causing segregation, dragging, bringing, irregularities or other surface defects. The paver shall be capable of being operated at a speed consistent with the character of the mix and the thickness of the course being laid, so as to produce a surface having a uniform density and surface texture. Where not operated on side forms the paver-finisher shall employ equalizing runners, evener arms or other devices to adjust the profiles and confine the edges of the courses to true lines. The temperature of the mix at the time of laying shall be in the range of 120°C to 160°C. The sequence of laying shall be decided by the Engineer-in-Charge preferably starting from edge towards the centre line of the pavement.

20.B.3.6.2. Only in confined spaces and areas when the paver finisher can not operate, hand spreading may be permitted by the Engineer-in-Charge. Sub-base areas will meet the specified compaction standards and layer thickness. Generally hand spreading is prohibited unless specifically authorized by the Engineer-in-Charge.

20.B.3.7. Joints in Bituminous Macadam

20.B.3.7.1. General

All joints shall present the same texture, density and smoothness as other sections of the layer. Special care shall be given to joints of sections laid at different time, to ensure a proper bond and a smooth surface between the old and new sections.

20.B.3.7.2. Longitudinal Joints

Longitudinal joints and edges shall be constructed true to the delineating line parallel to the centre line of pavement. The longitudinal joints shall be truly vertical in straight lines which are continuous for the full length of the pavement, or in smooth curves around bends. Joints in successive asphaltic concrete layers above shall be staggered by 500mm from those underlying layers. The exposed vertical edges of the longitudinal lane joints shall be carefully cut back and trimmed to a dense vertical face in the compacted lane, or for a minimum of one and a half times the layer thickness, whichever is greater. All debris/loose material arising from this operation shall be removed from the pavement and the underlying surface cleaned. The exposed joints face shall then be cleaned and painted with hot bitumen immediately before the laying of the adjacent lane.

20.B.3.7.3. Transverse Joints

(i) They shall be formed at right angles to the longitudinal joints, and be truly vertical. Transverse joints shall be staggered from each other and in the layers above atleast 500mm. The end of day's operations the roller shall pass over the unprotected end of the freshly laid mix.

(ii) The exposed vertical edges of the transverse joints shall be cut back and trimmed to firm material or for a distance of not less than 1-1/2 times the thickness of layer or up to meeting a dense material of full thickness, whichever is greater. All debris/loose material arising from this operation shall be removed from the pavement and the underlying surface cleaned. The exposed joints shall then be cleaned and painted with hot bitumen immediately before resumption of the laying operation.

20. B.3.7.4 The longitudinal and transverse joint shall be overlapped by a minimum 50 cm in each additional successive layers to ensure that no weak joint is formed either longitudinally or transversely along the pavement crest thickness.

20.B.3.8. Rolling

20.B.3.8.1. After spreading of the mix, consolidation shall be done by an approved power driven roller or rollers weighing not less than 8 to 10 tones each, and vibratory road roller of adequate capacity. Rolling shall start as soon as possible after the material has been spread. Rolling shall start longitudinally at the sides and proceed towards the centre of the pavement, overlapping on each successive strip by at least one half the width of the rear wheel. End stop channel boards may have to be used if the middle portion of the runway is taken first. Alternate trips of the roller shall be of slightly different lengths.

20.B.3.8.2. The speed of the roller shall not exceeded 5 KM per hour and shall at all points be slow enough to avoid displacement of the mixture and, displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall at once be corrected by the use of rakes and addition of fresh mixture where required.

20.B.3.8.3. When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh material. Rolling shall then proceed continuously with at least 10 passes of the roller till no further compaction is possible. To prevent adhesion of the mixture to the wheels of the roller, the wheel shall be kept damp with water, but excess of water shall not be permitted. In no case shall fuel lubricating oil be used for this purpose. Rolling operations shall be completed in every respect before the temperature of the mix falls below 80°C.

20.B.3.9. Pavement Edges

20.B.3.9.1. Pavement shall be laid to correct width and alignment. To achieve straight and vertical edges, the contractor shall cut back the edges to correct width and alignment by removing extra mix spread. Nothing extra shall be paid on this account.

20.B.3.10. Quality Control

20.B.3.10.1. The following quality control tests shall be carried out at frequencies specified against each: -

Sl. No.	*Test*	*Test Method*	*Frequency*
1.	Flakiness Index and Elongation Index	IS:2386 (Part-1)	Before approval of the quarry and at every subsequent change in the source of supply and one test for every 50 Cum of aggregate.
2	Impact Value	IS:2386 (Part-4)	-do-
3	Los Angeles Abrasion Value	IS:2386 (Part 4)	-do-
4	Stripping Value	IS:6241	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates
5	Water-absorption of aggregates	IS:2386 (Part-3)	-do-
6	Grading of aggregate	IS:2386 (Part-1)	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer.
7	Temperature of aggregate at mixing	-	At regular close intervals
8	Temperature of binder at mixing	-	-do-
9	Temperature of mix at laying	-	-do-
10.	Temperature of mix at rolling	-	-do-
11.	Soundness (Magnesium and Sodium Sulphate)		Initially, one determination by each method for each source supply, then as warranted by change in the quality of the aggregates.
12	Marshal Stability, flow, air voids and density		At regular close intervals to ensure uniform strength of the pavement

20.B.3.10.2. Minimum one test (3 moulds/tests) shall be conducted for every 100 m Ton of mix for Marshal Stability and Flow Value. Field density of Bituminous layer shall be checked for every 100 sq. meters. The field density shall not vary + 2% of the laboratory density.

20.B.3.11. Bitumen Content & Bituminous Grading

The bitumen content of the mix shall be tested periodically and as directed by the GE using centrifugal extraction method or such method approved by the GE. The test shall generally be carried out in accordance with established practices and as directed by the GE. Whenever, there is a deviation in the resultant bitumen content from approved job-mix-formula values, it shall be reported to the GE immediately and necessary correction made at the Job-mix plant as directed. The permissible tolerance of bituminous content & gradation shall be as under:-

(a)	Aggregate passing 4.75 mm	± 7%
(b)	Aggregate passing 4.75 mm sieve and retained on 2.36 mm sieve	± 5%
(c)	Aggregate passing 75 micron sieve	± 2%
(d)	Bitumen	± 0.5%

20.B.3.11.1. Field Density Determination By Sand Replacement Method

The metallic tray of the field density unit is kept on a level spot of the surface and a hole, 10cm in dia is cut to the entire thickness of the layer.

All materials removed from the, hole are carefully collected and weighed. A known weight of dry standard sand, passing 710 micron IS sieve and retained on 335 micron I.S. sieve is taken in sand pouring cylinder. The cylinder is kept directly over the hole and the shutter of the cylinder is released without any jerk and closed when the hole is filled with the sand. The quantity of the residual sand in the cylinder is weighed and the quantity of filling the cone of the cylinder is determined.

The in-situ density of the layer is calculated as follows: -

$$\text{Density} = \frac{A}{\dfrac{W-(W1+W2)}{d}} \text{ gm. per c.c.}$$

Where,

A	=	Weight of the materials removed from the hole.
W	=	Initial weight of sand taken in the cylinder.
W1	=	Weight of the sand filling the cone of the cylinder.
W2	=	Weight of the sand remaining in the cylinder.
d	=	Bulk density, gm per cc of sand.

20.B.3.12. Acceptance Criteria of Field Density

(i) The optimum density for the Bitumen Macadam on consolidation shall be taken as the density achieved in Marshall mould after compaction in laboratory with 75 blows on each end of the spectrum. The field density determined as per Clause 20.B.3.11.1 in no case shall be less than 98 % of this optimum lab density.

(ii) When the field density works out to be less than 98 % of optimum density achieved in Marshall mould in the laboratory, the surface shall be further consolidated till the required field density is achieved. If this is not found possible, the work represented by the sample shall be dismantled and redone by the contractor at his own cost.

20.B.3.13. Control on laid thickness & rectification

The surface accuracy shall be checked immediately after rolling. The surface when tested with 3 metre straight edge placed anywhere in any direction, there shall be no gap greater than 6 mm between the bottom of edge & surface any where.

Surface irregularities falling outside shall be rectified by removing to full depth the affected areas which shall not be less than 10 Sqm and relaying with fresh materials. In no case shall depressions be filled up with screenings of binding material.

20.B.4 Semi-Dense Asphaltic Concrete/Dense Asphaltic Concrete

20.B.4.1 Preparation of under lying course

The underlying course shall be prepared, shaped and conditioned to a uniform grade and section as specified. Any depression or pot hole shall be properly made up and thoroughly compacted. The surface shall be scrapped clean and free from dust and foreign material before applying tack coat.

20.B.4.2 Application of tack coat

The preparation and method of application shall be same as per clause 20.B.3.2 herein-before.

20.B.4.3 Job mix formula

The blending of various type and size of aggregate shall be done on the basis of the requirement as indicated vide clause No. 20. B.2.5.4 here-in-before. The exact binder content shall be worked out and adjustment in the rates shall be made on the basis of designed job formula, and indicated binder content. Type of binder shall also be as indicated and shall be procured from approved sources as indicated.

20.B.4.4 Preparation of mix

Hot mix plant of not less than 100 ton/hour output (or as indicated) and capable of producing a proper and uniform quality mix shall be used for preparation of the mix. The plant will have separate load cells to accurately weigh and feed different type of aggregates and a separate load cell for bitumen. The plant will be of batch type. The plant shall have coordinated set of essential units such as a dryer for heating the aggregates, device for batching, feeding by weight the required control unit for ensuring that the correct quantity of heated binder is fed into the mechanical mixer for thorough mixing of the binder and aggregates. For small quantity, continuous drum mixing plant may be used with approval of GE. The plant shall have coordinated set of essential units capable of producing uniform mix as per the Job Mix formula such as:

(a) Cold aggregate feed system for providing blended aggregates in correct proportions. At least 4 bin system shall be deployed.
(b) The rotating drum shall be fitted with suitable burners capable of heating the aggregates to the required temperature without any visible un burnt fuel or carbon residue on the aggregate.
(c) The dryer part shall be fitted with thermometric instruments so as to indicate/automatically record the temperature of heated aggregates before mixing with the binder.
(d) The three bin aggregates feed system shall have variable speed belt conveyors, (Load cells or other suitable devices) for regulating the accurate proportioning of aggregates into an even flow automatically from a central control cabin.
(e) Bitumen control unit of the system shall be capable of measuring/metering and spraying required quantity of bitumen at specified temperature with synchronization of bitumen and aggregates feed.
(f) Filler system suitable to receive bagged or bulk supply of filler material and its incorporation in the mix in correct quantity, which could be controlled from central control unit.
(g) Dust control unit shall be part of the plant.
(h) Suitable auxiliary bitumen boiler of adequate capacity with self-heating arrangement and temperature control device.

The temperature of binder at the time of mixing shall be in the range of 150° - 177°C and of aggregates in the range of 155-163 °C. Provided also that at no time, the difference in temperature between the aggregates & the binder shall exceed 14 °C. The temperature of mix shall not exceed 160 °C.

20.B.4.5. Transportation of Mix

The mix shall be transported from the mix plant to the point of use in suitable tipper vehicles, specified here-in-after. The vehicles employed for transport shall be clean and be covered using suitable covers in transit to ensure that temperature of mix does not fall below 120° C at the time of laying. The temperature of the mix in every transporting vehicle shall be checked immediately prior to discharge into the spreader. If the temperature of any batch is below the laying temperature the mix shall be rejected and shall be removed from the site immediately.

20.B.4.6. Spreading of Mix

20.B.4.6.1 The mix shall be transported from the hot mix plant by tipper trucks to the site and spreading shall be done by means of self propelled mechanical paver. The paver shall also have electronic sensing device for automatic leveling and profile control within the specified tolerance and internal heating arrangement for the screed. The longitudinal joints and edges shall be constructed true to line marking parallel to the centre line of runway. Longitudinal joints should be offset at least by 150mm from those in binder course, if any and transverse joints or construction joints shall be placed in the vertical plane after cutting back to the original thickness of previously laid mix. The vertical cut face shall be painted with hot bitumen [60/70 grade] prior to the laying fresh mix.

20.B.4.7. Rolling and Compaction

20.B.4.7.1. The mix after spreading shall be thoroughly and uniformly compacted by rolling by a set of rollers at a speed not more than 5 Km per hour, immediately following the paver. The initial or break down rolling shall be with 8-12 tone three wheel steel roller and the surface finished by final rolling with the 8-10 tone tandem roller. Before finishing with the tandem roller, break down rolling shall preferably be followed by an intermediate smooth wheel pneumatic roller of 15 to 30 tone having a tire pressure of 7 kg/sq.cm. The joints and edges shall be rolled with breakdown rolling, intermediate rolling and finish rolling can be accomplished by using a vibratory roller of 8-10 tone static weight. During finish rolling the vibratory system shall be switched off.

20.B.4.7.2. The wheels of roller shall be kept moist to prevent the mix from adhering to them. In no case shall fuel/lubricating oil be used for this purpose nor excessive water poured on the wheels. Rolling shall commence longitudinally from edge and progress towards the center except on super-elevated portions where it shall progress from the lower to upper edge, parallel to the centerline of the pavement. The roller should proceed on the fresh material with rear fixed wheel leading so as to minimize the pushing of the mix and each pass of the roller shall overlap the preceding one by half the width of the rear wheel. Rolling shall be continued till the desired density of not less than 98 percent of the lab design density is achieved and all roller marks are eliminated. The mix shall be spread such that required thickness is achieved after rolling. The maximum consolidated thickness after rolling shall not be more 50 mm in one layer.

20.B.4.8. BLANK

20.B.4.9. Quality Controls

20.B.4.9.1. Adequate quality control at every stage of work is essential and the contractor shall establish field laboratory which shall be suitable staffed headed by Material Engineer with sufficient experience in conducting day to day quality control test as enumerated. The field lab shall be equipped with testing equipments/apparatus as indicated. The laboratory in charge shall work under the direction of GE and Engineer-in-Charge and tests shall be conducted as per their approval. Sufficient number of machines and equipment shall be installed by the contractor so that all control tests could be performed at site. This shall be in addition to any other tests which will be required by the GE and Engineer-in-Charge through approved Laboratory/Test House. Expense on all tests/procurement of machines or equipments etc shall be borne by the contractor.

20.B.4.9.2 The lab equipments will be calibrated before the commencement of each overlay works and records maintained. Any payment to the contractor shall only be paid after it is ensured by GE that, these equipments are calibrated before the commencement of works.

Sl No.	*Test*	*Test Method*	*Frequency*
1.	Sieve Analysis	IS-2386 (Part-1)	Before approval of quary and at every subsequent change of source of supply and one test for every 50 Cum aggregate
2.	Flakiness Index	IS-2386 (Part-1)	-do-
3.	Aggregate Crushing Value	IS-2386 (Part-4)	-do-
4.	Aggregate Impact Value	IS-2386 (Part-4)	-do-
5.	Soundness (Magnesium and Sodium Sulphate)	IS-2386	Initially, one determination by each method for each source of supply, then as warranted by change in the quality of aggregate/quary.
6.	Stripping Value	IS-6241	Initially one set of three representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates/ quary.
7.	Water Absorption of aggregate.	IS-2386 (Part-4)	-do-
8.	Sieve Analysis for filler	IS-2386 (Part-3)	For each consignment of cement used as filler one test for every 5 cum of filler.
9.	Mix Grading	IS-2386 (Part-1)	One set of test on individual constituents and mixed aggregate from dryer for each 100 T of mix subject to a minimum of two sets per plant per day.
10.	Control of temperature of the binder in boiler, aggregates in drier & mix at the time of paving & rolling.		Regularly check. The difference of temperature between aggregates and binder not to exceed 14^{o} C. The aggregates shall not be heated to more than 163^{o} C. The temp of the mix shall not exceed 160^{o} C and shall not be less than 120^{o} C at the time of laying. Rolling operation shall be completed before mix temp falls below 100^{o} C.

Sl No.	*Test*	*Test Method*	*Frequency*
11.	(a) Stability of Mix (b) Flow Value (c) Void Content (d) Bitumen Content (e) Sieve Analysis of aggregates after extraction of bitumen	Marshall (ASTM O-1559)	Min one sample for every 100 T of mix discharged at the plant chute shall be collected and 3 Marshall samples prepared to determine these values. At least 2 sets shall be tested per plant per day.
12.	Thickness and Density of compacted layer of asphaltic concrete.		One test per 500m^2. The bulk density achieved shall not be less than 98% of lab density.
13.	Test for clay, silt & Impurities in aggregates.	IS 383 IS-2386 (Part-3)	One test for 300 cum.

Note for SI No. 12

Test for field density shall be sampled in such a way that tests are done at every 200 metres interval along the longitudinal joints of two lanes apart from middle lane. The mean density value shall be same as that obtained for central portion of two lanes.

20.B.4.9.3. The permissible variation of various ingredient shall be as per following table :-

Sieve Size	Dense A/C	Semi-Dense A/C
4.75 mm sieve	• •	• •
2.36 mm sieve	+ 5%	+ 5%
Passing 2.36 mm sieve and retained on 75 micron	+ 3%	+ 3%
Size of mineral finer than 75 micron	±1%	+ 1%
Binder content	0.3%	+ .3%
Field density	Not less than 98% lab density	

20.B.4.10. Controls on laid thickness

After the mix is compacted, the thickness shall be checked by noting the depth of penetration of hot scale. Except cross the crown off camber or change with the finished surface of the wearing course is to such regularity that when tested with 3 metre straight edge placed any where in any direction there shall not be a gap greater than 3mm between the bottom of edge and surface any where. Any depression or protrusion shall be rectified as specified vide clause 20.B.3.13 here-in-before.

20.B.4.11. Plants/Machines to be Used for Semi Dense Asphaltic Concrete/Asphaltic Concrete & Bituminous Concrete

20.B.4.11.1 Hot Mix Plant

Hot mix plant of not less than 100 ton/hour output (or as indicated) and capable of producing a proper and uniform quality mix shall be used for preparation of the mix. The plant will have separate load cells to accurately weigh and feed different type of aggregates and a separate load cell for bitumen. The plant will be of batch type. The plant shall have coordinated set of essential units such as a dryer for heating the aggregates, device for batching, feeding by weight the required control unit for ensuring that the correct quantity of heated binder is fed into the mechanical mixer for thorough mixing of the binder and aggregates. For small quantity, continuous drum mixing may be used with approval of GE. The plant shall have coordinated set of essential units capable of producing uniform mix as per the Job Mix formula such as:

(a) Cold aggregate feed system for providing blended aggregates in correct proportions. At least 4 bin system shall be deployed.
(b) The rotating drum shall be fitted with suitable burners capable of heating the aggregates to the required temperature without any visible un burnt fuel or carbon residue on the aggregate.
(c) The dryer part shall be fitted with thermometric instruments so as to indicate/automatically record the temperature of heated aggregates before mixing with the binder.
(d) The three bin aggregates feed system shall have variable speed belt conveyors, (Load cells or other suitable devices) for regulating the accurate proportioning of aggregates into an even flow automatically from a central control cabin.
(e) Bitumen control unit of the system shall be capable of measuring/metering and spraying required quantity of bitumen at specified temperature with synchronization of bitumen and aggregates feed.
(f) Filler system suitable to receive bagged or bulk supply of filler material and its incorporation in the mix in correct quantity, which could be controlled from central control unit.
(g) Dust control unit shall be part of the plant.
(h) Suitable auxiliary bitumen boiler of adequate capacity with self-heating arrangement and temperature control device.

20.B.4.11.2. Paver Finisher

Paver finisher shall have the following essential features:

(a) Loading hoppers and suitable distributing mechanism.
(b) Hydrostatic drive/control for all drives.
(c) Hydraulically extendible screed for appropriate width requirement.
(d) The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or spoiling the surface. It shall have adjustable amplitude and infinitely variable frequency. The screed plate should have pre-heating arrangements.
(e) Necessary control mechanism so as to ensure that the finished surface is free from surface blemishes.
(f) Electronic sensing device for automatic leveling and profile control.
(g) Internal heating arrangement for screed.

20.B.4.11.3. Spray for Prime and Tack Coat

A tipper mounted with storage browser for bitumen with heating arrangement and having nozzles fixed at the end with suitable pumping arrangement to spray the heated bitumen shall be used for the purpose. The system should have a built in arrangement to control the speed of the vehicle to give exact/desired quantity of bitumen to be sprayed.

20.B.4.11.4. Tippers

Tippers deployed for transportation of asphaltic concrete should be minimum six cum capacity and be directly able to discharge into the paver hopper and shall have suitable hydraulic control for operating the system.

Rolling or Compaction Equipment

20.B.4.11.5. Tandem Vibratory Roller

Tandem vibratory roller shall be of make Bomag, vibromax 752 B or equivalent. The machine shall have both modes of compaction i.e. static mode as well as vibratory mode. It is desirable to use the static mode for the initial rolling and then resort to vibratory rolling and final finishing to be done by static rolling. The machine shall have auto water spraying system.

20.B.4.11.6. Pneumatic Tired Roller

Final rolling shall be carried out by pneumatic tired roller of make Bamag, Vibromax 752 B or equivalent. The roller shall have pneumatic tyres placed in such a way that area traversed is suitably covered by the combination of front/ rear wheels. The empty weight may be to the tune of 10 tone and it shall be possible to increase load to about 21 tone with ballast or other materials for compaction purposes. The machine shall have auto water spraying system.

20.B.5. Wet Mix Macadam (WMM)

20.B.5.1. Weather And Seasonal Limitations

The work of laying of wet mix macadam shall not be done during rain.

20.B.5.2. Preparation of Base

The surface of the sub grade to receive the WMM course shall be prepared to the specified lines, grades, camber, slopes and cross-falls and made free of dust and other extraneous matter. Any ruts or soft yielding places shall be corrected in an approved manner using the specified materials & compacting it in place to the requirements of relevant specifications and as per direction of the Engineer-in-Charge to achieve firm surface, if necessary sprinkling water shall be used..

20.B.5.3 Provision of Lateral Confinement of Aggregates

Before starting with wet-mix macadam construction, if so directed by the Engineer-in-Charge, necessary arrangements should be made for the lateral confinement of wet mix. This shall be done by laying material adjoining shoulders along with that of wet-mix layer. The sequence of operation shall be such that the construction of the shoulder is done in layers each matching the thickness of the adjoining pavement layer. Only after a layer of pavement and corresponding layers at shoulder have been laid and compacted, the construction of the next layer of pavement and shoulder shall be taken up.

20.B.5.4. Mixing

Aggregates as per required grading for wet-mix macadam shall be mixed with the requisite quantity of water in a batch mixing plant of suitable capacity having provision of controlled addition of water and forced/positive mixing arrangements as approved by the GE. Optimum moisture for mixing shall be determined in accordance with IS: 2720 (Part-8), after replacing the aggregate fraction, retained on 19 mm sieve with material of 4.75 mm to 19mm size. However, the OMC (Optimum Moisture Content) and required number of passes to achieve the desired density may be determined at site during proof rolling using the roller selected for compaction. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary by more than + 1 percent.

20.B.5.5 Spreading of Mix

20.B.5.5.1. Immediately after mixing, the mix material shall be transported to site and spread uniformly and evenly upon the prepared sub-base/base in required quantities. Hauling of the mix over a freshly completed stretch is not permitted. The mix shall be spread with the help of mechanical paver. In no case should mix be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted. The aggregates mix should be spread to proper profile by using paver having hydraulic control suitable for initial adjustment and maintaining the same to achieve the specified slope and grade.

20.B.5.5.2. The surface of the layer as spread shall be carefully checked with templates and all high or low spots remedied by removing or adding wet mix aggregate as may be required. The layer thickness may be checked by depth blocks during construction. No segregation of coarse and fine particles shall be allowed. The aggregates mix, as spread should be of uniform gradation with no pockets of fine materials.

20.B.5.6. Compaction

20.B.5.6.1. After the mix has been laid to the required thickness, grade and cross-fall (camber), the layer should be uniformly compacted to the full width by rolling with a three-wheeled power roller of 8 to 10 tones capacity and with a vibratory roller of the approved type and capacity. The speed of roller shall not exceed 5 Km/hour. The rolling shall commence from the lower edges with the roller running forward and backward until the edges have been firmly compacted. The roller should then progress gradually towards the center parallel to the center line of the pavement, uniformly over-lapping each preceding rear wheel track by at least one third width of the wheel, until the entire surface has been rolled up to the centre line.

20.B.5.6.2. Rolling should not be carried out when the sub grade is soft or yielding or when it causes a wave-like motion in the sub - base/base course or sub-grade. If irregularities develop during rolling which exceed 12mm when tested with a 3 metre straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and cross fall. In no case should the use of unmixed material be permitted to make up the depressions.

20.B.5.6.3. Rolling should be continued till the density achieved is at-least 98 percent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-VIII). After completing, the finished surface shall present a well-closed appearance, free from movement under compaction equipment or any compaction marks, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted to the satisfaction of the Engineer-in-Charge.

20.B.5.6.4. Longitudinal joints and edges shall be constructed true to the delineating line parallel to centre line of pavement. All longitudinal and transverse joint shall be cut vertical to the full thickness of the previously laid mix before laying the fresh mix.

20.B.5.7. Setting And Drying

After final compaction of wet-mixed macadam course, the pavement shall be allowed to dry for 24 hours before overlaying with any bituminous layer.

20.B.5.8. Opening To Traffic

No vehicular traffic except construction vehicles shall be allowed on the finished wet-mix macadam surface till the subsequent bituminous course is laid. In exceptional cases, construction traffic may be allowed with approval of the Engineer-in-Charge for short durations once the course is completely dry provided vehicles move over the full width avoiding any rutting or uneven compaction. The contractor will take all precautionary measures to prevent any damage to the finished surface till next layer is laid over it.

20.B.5.9. Surface Finish And Quality Control Of Work

20.B.5.9.1. The surface level of a wet mix layer laid as base course shall have a tolerance of not more than +10mm from the designed longitudinal and cross profile. For checking compliance with this, surface levels shall be taken on grid of points placed 6.25 metre longitudinally and 3.5m transversely. For any 10 constructive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the above tolerances, thus one measurement being not in excess of 5mm above the permitted tolerance.

20.B.5.9.2. The longitudinal profile shall also be checked by a 3 metre straight - edge at the middle of each traffic lane along a line parallel to the centre line of pavement. The maximum allowable difference between the pavement surface and underside of a 3 metre straight edge shall be 8mm.

20.B.5.9.3. Quality Control

The frequency of the quality control tests shall be as under -

SI. No.	*Test*	*Frequency (minimum)*
(i)	Grading	One test per 100 Cum.
(ii)	Atterberg Limits of portion of aggregates passing 425 micron sieve.	One test per 100 Cum.
(iii)	Moisture Content prior to compaction	One test per 250 Cum.
(iv)	Density of compacted layer	One test per 500 Sqm.
(v)	Aggregate Impact Value or Los Angeles Abrasion value.	One test per 200 Cum.
(vi)	Flakiness and Elongation Index	One test per 200 Cum.

20.B.5.9.3.1. The materials supplied and the works carried out by the contractor shall conform to the relevant technical specifications and as approved by the Engineer-in-Charge.

20.B.5.9.3.2. For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described above. The testing frequencies set forth are the desirable minimum and the Engineer-in-Charge shall have the full authority to carry out tests at frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications.

20.B.5.9.3.3. Test procedures for the various quality control tests are indicated in the respective section of theses specifications or for certain tests within this section. Where no specific testing procedure is mentioned, the tests shall be carried out as per IRC: 109.

20.B.5.9.4. Rectification of Surface Irregularity

Where the surface irregularity of the layer as laid down exceeds the permissible tolerances or where the course is otherwise defective due to sub-grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added premix material or removed and replaced with fresh premix material as applicable and re-compacted in accordance with the specifications mentioned above. The area treated in the aforesaid manner shall not be less than 5m long and 2m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

20.B.6. Dry Lean Concrete (DLC)

20.B.6.1. Proportioning of Materials for the Mix

20.B.6.1.1. The aggregate gradation shall be as per MORTH specifications, Forth Revision (reprinted Apr 2005) or as per subsequent revisions from time to time. The proportioning of the materials of the mix should be as per Clause 601.3. of MORTH specifications, Forth Revision (reprinted Apr 2005) or as per subsequent revisions from time to time.

20.B.6.2. Moisture content

The right amount of water for the lean concrete in main work shall be decided so as to ensure full compaction under rolling and shall be assessed at the time of rolling the trial length. Too much water will cause the lean concrete to heaving up before the wheels and picked up on the wheels of the roller and too little will lead to inadequate compaction, a low in-situ strength and an open-textured surface.

The optimum water content shall be determined and demonstrated by rolling during trial length construction and the optimum moisture content and degree of compaction shall be got approved from the Engineer-in-Charge. While laying in the main work, the lean concrete shall have a moisture content between the optimum and optimum + 2 percent, keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

20.B.6.3. Cement content

The minimum cement content in the lean concrete shall not be less than 150 Kg/cu.m of concrete. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as per actual mix design.

20.B.6.4. Concrete Strength

Unless otherwise indicated, the average compressive strength of each consecutive group of 5 cubes made in accordance with IS : 516 shall not be less than 10 Mpa at 7 days unless otherwise indicated. In addition, the minimum compressive strength of any individual cube shall not be less than 7.5 Mpa at 7 days. The design mix complying with the above Clauses shall be got approved from the Engineer-in-Charge and demonstrated in the trial length construction.

20.B.6.5. Sub Grade

The sub grade shall conform to the grades and cross sections shown on the drawings and shall be uniformly compacted to the design strength in accordance with these specifications. The lean concrete sub base shall not be laid on a sub grade softened by rain after its final preparation; surface trenches and soft spots, if any, must be properly back-filled and compacted to avoid any weak or soft spot. As far as possible, the construction traffic shall be avoided on the prepared sub grade. A day before placing of the sub base, the sub grade surface shall be given a fine spray of water and rolled with one or two passes of a smooth wheeled roller after a lapse of 2-3 hours in order to stabilize loose surface. If Engineer-in-Charge feels it necessary, another fine spray of water may be applied just before placing sub base.

20.B.6.6. Batching and mixing

The batch mixing plant of minimum 30 cu m/ hr capacity shall be used for production. It should be capable of proportioning the materials by weight, each type of material being weighed separately. Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells. The cement from the bulk stock shall be weighed separately from the aggregates. The capacity of batching and mixing plant shall be at least 25 per cent higher than the proposed capacity for the laying arrangements. The batching and mixing shall be carried out in a forced action central batching and mixing plant having necessary automatic controls to ensure accurate proportioning and mixing. Polyester triangular synthetic fibres of approved mix as secondary reinforcement mixed in concrete shall be 12mm long with circum circle diameter of 30-35 microns designed for melting point of 240-260 degree Celsius and having specific gravity of 1.34 -1.40 polyester triangular synthetic fibres of approved mix where specified in Sch-'A' item shall be uniformly mixed at the rate of 0.25% (or at the rate as per manufacturer's instructions) by weight of cement

20.B.6.7. Transporting

Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering the tippers/ dumpers with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner.

20.B.6.8. Placing

20.B.6.8.1. Lean concrete shall be laid/placed by a mechanical paver. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the sub base.

20.B.6.8.2. The laying of the two-lane road sub base may be done either in full width or lane by lane. Preferably the lean concrete shall be placed and compacted across the full width of the road, by constructing it in one go or in two lanes running forward simultaneously. Transverse and longitudinal construction joints shall be staggered by 500-1000mm and 200-400mm respectively from the corresponding joints in the overlaying concrete slabs.

20.B.6.9. Compaction

20.B.6.9.1. The compaction shall be carried out immediately after the material is laid and leveled. In order to ensure thorough compaction, which is essential, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is closed. The minimum dry density obtained shall be 97 per cent of that achieved during the trial length construction vide Clause 4.7.8. The densities achieved at the edges i.e. 0.5m from the edge shall not be less than 95 per cent of that achieved during the trial constructions vide Clause 601.7 as per MORTH specifications, Forth Revision (reprinted Apr 2005) or as per subsequent revisions from time to time.

20. B.6.9.2. The spreading, compacting and finishing of the lean concrete shall be carried out as rapidly as possible and the operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the concrete temperature is above 25 and below 30 degree Celsius and 120 minutes if less than 25 degree Celsius. This period may be reviewed by the Engineer in the light of the results of the trial run but in no case shall it exceed 2 hours. Work shall not proceed when the temperature of the concrete exceeds 30 degree Celsius. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35°C. After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day's work near the location where work was terminated the previous day.

20.B.6.9.3. Double drum smooth-wheeled vibratory rollers of minimum 80 to 100 KN static weight is considered suitable for rolling dry lean concrete. In case any other roller is proposed, the same shall be got approved from GE, after demonstrating its performance. The number of passes required to obtain maximum compaction depends on the thickness of the lean concrete, the compatibility of the mix, and the weight and type of the roller etc. and the same as well as the total requirements of rollers for the job shall be determined during trial run by measuring the in-situ density and the scale of the work to be undertaken.

20.B.6.9.4.

(i) In addition to the number of passes required for compaction there shall be a preliminary pass without vibration to bed the lean concrete down and again a final pass without vibration to remove roller marks and to smoothen the surface.

(ii) Special care and attention shall be exercised during compaction near joints, kerbs, channels, side forms and around gullies and manholes. In case adequate compaction is not achieved by the roller at these points, use of plate vibrator shall be made, if so directed by the Engineer-in-Charge.

20.B.6.9.5. The final lean concrete surface on completion of compaction and immediately before overlaying, shall be well closed, free from movement under roller and free from ridges, low spots, cracks, loose material, pot holes, ruts or other defects. The final surface shall be inspected immediately on completion and all loose, segregated or defective areas shall be corrected by using fresh lean concrete material laid and compacted as per Specification. For repairing honeycombed surface, concrete with aggregates of size 10mm and below shall be spread and compacted. It is necessary to check level of the rolled surface for compliance. Any level/thickness deficiency should be corrected after applying concrete with aggregate, of size 10mm and below after roughening the surface. Similarly the surface regularity also should be checked with 3m straight edge. The deficiency should be made up with concrete with aggregates of size 10mm and below.

20.B.6.9.6. Segregation of concrete in the dumpers shall be controlled by premixing each fraction of the aggregates before loading in the bin of the batching plant, by moving the dumper back and forth while discharging the mix on it and other means. Even paving operation shall be such that the mix does not segregate.

20.B.6.9.7. Joints

Contraction and longitudinal joints shall be provided as per the direction of GE. At longitudinal or transverse construction joints, unless vertical forms are used, the edge of compacted material shall be cut back to a vertical face where the correct thickness of the properly compacted material has been obtained.

20.B.6.10. Curing

As soon as the lean concrete surface is compacted, curing shall commence. One of the following two methods shall be adopted:

20.B.6.10.1 The initial curing shall be done by spraying with liquid curing compound. The curing compound shall be white pigmented or transparent type with water retention index of 90 per cent when tested in accordance with BS 7542. Curing compound shall be sprayed immediately after rolling is complete. As soon as the curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days.

20.B.6.10.2. Curing shall be done by covering the surface by gunny bags/ hessian, which shall be kept continuously moist for 7 days by sprinkling water.

20.B.6.11. Trial Mixes

20.B.6.11.1. The contractor shall make trial mixes of dry lean concrete with moisture contents like 5.0, 5.5, 6.0, 6.5 and 7.0 per cent using cement content specified and the specified aggregate grading but without violating the requirement of aggregate cement ratio specified in 20.B.6.1.1. Optimum moisture and density shall be established by preparing cubes with varying moisture contents. Compaction of the mix shall be done in three layers with vibratory hammer fitted with a square or rectangular foot having an area of between 7500 to 14000 Sqmm. The vibrating hammer shall be electric or pneumatic type. The compaction shall be uniformly applied for 60 + 5 seconds with a down ward force between 300 N and 400 N on each of three layers. After establishing the optimum moisture, a set of six cubes shall be cast at that moisture for the determination of compressive strength on the 3rd and the seventh day. Trial mixes shall be repeated if the strength is not satisfactory either by increasing cement content or using higher grade of cement. After the mix design is approved, the Contractor shall construct a trial section in accordance with Clause 20.B.6.12 here-in-after.

20.B.6.11.2. If during the construction of the trial length, the optimum moisture content determined as above is found to be unsatisfactory, the Contractor may make suitable changes in the moisture content to achieve a satisfactory mix. The cube specimens prepared with the changed moisture content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be determined on a day-to-day basis so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in raveling of surface.

20.B.6.12. Trial Length

20.B.6.12.1. The trial length shall be constructed at least 14 days in advance of the proposed date of commencement of work. At least 30 days prior to the construction of the trial length, the Contractor shall submit for the Engineer's approval a "Method Statement" giving detailed description of the purposed materials, plant, equipment, mix proportion, and procedure for batching, mixing, laying, compaction and other construction procedures. The Engineer-in-Charge shall also approve the location and length of trial construction, which shall be a minimum of 60m length and for full width of the pavement. The trial length shall contain the construction of at least one transverse construction joint involving hardened concrete and freshly laid sub-base. The construction of trial length will be repeated till the Contractor proves his ability to satisfactorily constructed the sub base.

20.B.6.12.2. In order to determine and demonstrate the optimum moisture content which results in the maximum dry density of the mix compacted by the rolling equipment and the minimum cement content that is necessary to achieve the strength stipulated in the Contract. Trial mixes shall be prepared as per Clause 20.B.6.11 here-in-before.

20.B.6.12.3. After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method with 20 cm dia density cone. Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length; average of these densities shall be determined. These main density holes shall not be made in the strip 50cm from the edges. The average density obtained from the three samples collected shall be the reference density and shall be considered 100 per cent. The field density of regular work will be compared with this reference density in accordance with Clause 20.B.6.9.1. A few cores may be cut as per the instructions of the Engineer-in-Charge to check segregation or any deficiency.

20.B.6.12.4. The hardened concrete shall be cut over 3m width and reversed to inspect the bottom surface for any segregation taking place. The trial length shall be constructed after making necessary changes in the gradation of the mix to eliminate segregation of the mix. The lower surfaces shall not have honeycombing and the aggregates shall not be held loosely at the edges.

20.B.6.12.5. The trial length shall be outside the main works. The main work shall not start until the trial length has been approved by the Garrison Engineer. After approval has been given, the materials mix proportions, moisture content, mixing, laying, compaction plant and construction procedures shall not be changed without the approval of the Engineer-in-Charge.

20.B.6.13. Tolerances for Surface Regularity, Level, Thickness, Density and Strength

The tolerances for surface regularity, level, thickness, density and strength shall conform to the requirements given in relevant IS /MOSRT & H or as per subsequent revisions from time to time.

20.B.6.14. Traffic

No heavy commercial vehicles like trucks and buses shall be permitted on the lean concrete sub base after its construction. Light vehicles if unavoidable may, however, be allowed after 7 days of its construction with prior approval of the Engineer-in-Charge.

20.B.7 Rigid Pavement / PQC pavement

20.B.7.1 Mix proportion/and strength

Mix will be designed as per the design and the flexural strength shall not be less than specified value at 28 day in the field. The strength which is known as mean flexural strength shall depend upon quality control. The following relationship shall be used in calculating mean flexural strength.

$$S = \frac{\overline{S}}{1 - t.V/100}$$

Where

S = average strength at 28 days for which the mix is to be designed (kg/sq.cm. or N/mm^2 or MPa) as specified.

$\overline{S}$ = minimum (flexural) strength in the field at 28 days (kg/sq.cm. or N/mm^2 or MPa) as specified.

t = factor (dimensionless) depending on specified tolerance level as per table II

V = co-efficient of variation (percent) specified as per table I (dimensionless percentage)

TABLE I
VALUE OF COEFFICIENT OF VARIATION (PERCENT) "V" FOR DIFFERENT RANGES OF STRENGTH

Degree of quality control	Minimum specified flexural Strength (Kg/cm^2)					
	Less than 40		Greater than 40		40	
	Tolerance Level	Coefficient of variation "V"	Tolerance Level	Coefficient of variation "V"	Tolerance Level	Coefficient of variation "V"
Very Good	1 in 15	10	1 in 15	7	1 in 20	7
Good	1 in 10	15	1 in 15	10	1 in 15	10
Fair	1 in 10	20	1 in 10	15	-	-

Note : (1) **Very Good Quality Control :** Control with weight batching, use of graded aggregates, moisture determination of aggregates, etc. Rigid and constant supervision by the Quantity Control Team.

(2) **Good Quality Control :** Control with weight batching, use of graded aggregates, moisture determination of aggregates, etc. Constant supervision by Quality Control Team.

(3) **Fair Quality Control :** Control with volume batching for aggregates. Occasional checking of aggregates moisture. Occasional supervision by Quality Control Team.

TABLE II
VALUES OF TOLERANCE FACTOR (t)

Tolerance level No. of samples	1 in 10	1 in 15	1 in 20	1 in 40	1 in 100
10	1.37	1.65	1.81	2.23	2.76
20	1.32	1.58	1.72	2.09	2.53
30	1.31	1.54	1.70	2.04	2.46
Infinite	1.28	1.50	1.64	1.96	2.33

20.B.7.2 Water Cement Ratio

The actual and designed quantity of water shall be used in the mix. The cement content shall be kept within a range of 350 Kg/cum to 425 Kg/cum only. The water cement ratio should invariably be kept between 0.39 to 0.42.

20.B.7.3 Trial Mix

Trial mix shall be made and beam tested for flexural strength as per requirement of IS 516-1959. Nine sets of beams shall be tested, three for 7 days and three for 28 days. If the difference between the highest and lowest value at 28 days in any trial mix is more than 15% of strength of these beams, the test shall be discarded and further trial mix made. Crushing Strength of concrete shall be approved for the flexural strength.

20.B.7.4 Preparation of base

Before fixing the form work for laying concrete, the base shall be checked for proper compaction, density and levels.

20.B.7.5 Trial Bays

Before commencement of work and where as paver is not used, a trial bay of 3.5m x 3.5m and of same thickness as that of designed pavement shall be laid at an approved place. After laying the concrete, cores shall be taken out when concrete is 7 days old, to determine the degree of compaction achieved, should any of the cores show honey combing, the trial bay shall be re-laid. The method of compaction and spreading and also desired surface finish shall be approved.

20.B.7.6 Form Work

20.B.7.6.1 Steel Formwork

All side forms shall be of mild steel except for curves having radius less than 45 meters. The steel forms shall be of M.S. channel section and depth equal to thickness of pavement.

A section shall have length of 3 metres except on curves of less than 45m radius, where shorter section or wooden formwork may be used. In case of transverse joints, a full length of the bulk head shall act as formwork. When set to grade and staked in place, no deviation of the top surface from the specified level shall be allowed. Use of bent, twisted or worn-out form shall not be permitted. The method of connection between the two length of forms shall be such that the joint formed is free from play or movement. Atleast three stakes for bracing pins or stakes shall be provided for each 3.00m of form and the bracing and support must be ample to prevent the springing of the forms under the pressure of the concrete or weight or thrust of machinery operation on the forms.

20.B.7.6.2 Wooden forms

Wooden forms shall normally be used only for curves having radii of less than 45m. Wooden forms shall be wrought on one side, these shall have minimum base width of 100 mm and depth equal to edge thickness of concrete. These forms, when specially permitted to be used on straights, shall have minimum length of 3.0m. Forms shall be held by stakes set at intervals not exceeding 2m, two stakes to be placed at each joint. The forms shall be firmly nailed or secured to the side stakes, and securely braced at pint where necessary so that no movement will result from the pressure of the concrete or the impact of the tamper and during finishing work. Wooden forms shall be capped along the inside upper edge with 50mm angle iron, well recessed and kept flush with the face of wooden forms.

20.B.7.6.3 Setting of Forms

The forms shall be jointed neatly. After the forms are placed and set the base of the forms shall be thoroughly tamped in an approved manner. All forms shall be cleaned and oiled each time before they are used. Forms shall be set, for at least one day's work ahead of concreting and shall remain in position for at least 12 hours after laying of concrete or longer as directed by the EIC. When forms have to be fixed on existing concrete bases they shall be secured at the side by M.S. stakes of 20 dia properly anchored into the base. Holes of suitable size for stakes shall be drilled at least 75 mm deep into the base and after the stakes are inserted they shall be properly wedged so that the stakes shall not get loosened during compaction of concrete.

The trueness of form shall be checked by means of a 3m straight edge and any deviation greater than 1.5mm shall be rectified. No deviation from the straight edge shall be permitted at the joints.

20.B.7.7 Batching and Mixing

20.B.7.7.1 All the ingredients of concrete shall be batched by weight. Weigh batching shall be done with fully computerized weigh batching plant of minimum 30 cum / hour capacity (or as indicated). Where combined batching and mixing plants are not available, weigh batchers of adequate capacity shall be used for weighing of aggregates and cement. Power driven mechanical concrete mixers of adequate capacity in conjunction with weigh batches shall be used.

A small quantity of water will be added before loading of aggregates and cement. The remaining water shall be added during the mixing operation. The mixing shall be done for at least two minutes and until a uniform colour and consistency are achieved.

Quantity of concrete mixed in any one batch shall not exceed the rated capacity of the mixer. The drum of the mixer shall be completely emptied before ingredients for the next mix are charged into it. Concrete mixed as above shall not be modified by addition of water or other wise in order to facilitate handling or for any other purpose.

20.B.7.8 Placing and Compaction of Concrete

20.B.7.8.1 Concrete shall be transported without delay and incorporated in the works within 20 minutes from the time of discharge. The concrete shall be deposited and spread to such a depth that when compacted and finished, it shall conform to the grade and cross section specified in the plan to ensure the minimum slab thickness shown on the drawing to be obtained at all points.

In order to obtain adequate compaction, the concrete shall be spread so as to stand proud of the finished level and produce a surcharge. With screed and internal vibrator, slabs of thickness not exceeding 20cm shall be laid in one layer. Where medium duty pavers are used, this limit shall be raised to 25 cm. Concrete for slabs of greater thickness shall be laid in two equal layers. The second layer shall be laid over the unfinished but compacted first layer within half an hour (within setting time of the cement used) of the laying of the first layer.

Concrete shall be deposited in such a manner as to require as little handling as possible. Spreading, compacting and finishing (except final completed belt finishing) operations shall be within a period not exceeding one hour from the time the mixing starts. In case of dry and hot weather, this time will not exceed 35 minutes. Concrete shall be placed around man-holes or other structures after these have been brought to the correct alignment.

20.B.7.8.2 Compaction of concrete

Compaction shall be carried out by electrically operated needle and screed vibrators as stipulated hereafter. Needle vibrators shall be used all over the area for obtaining initial compaction of concrete. These shall be of diameter not less than 4.5 cm. If the vibrators are pneumatic, the pressure must not be below 4 Kg/cm^2. If electrically operated they shall have a minimum frequency of 3500 impulses per minute. Minimum number of petrol driven vibrators as specified by the EIC with minimum frequency of 3500 per minute shall be provided at each work head as a stand by arrangement. The screed and internal vibrator shall conform to IS. 2506-1985 respectively.

Vibrating screed consisting of a steel section or timber section weighing not less than 15 Kgs per metre with a tamping edge of not less than 7 cm. width and having a vibrator mounted thereon shall follow needle vibrators to obtain full compaction. The face of the wooden tamping edge of the screed shall be lined with an M.S. plate to be rigidly fixed by means of counter sunk screws. Where screed vibrators are used for compaction, at the discretion of the EIC for compaction of edges and joints, vibrators may be supplemented by hand tamping and Roding for securing satisfactory results. Under no circumstances, honey combing of concrete at joints or elsewhere shall be permitted.

When using vibrating screed for compaction it shall not be dragged over the concrete. During the initial passes, it shall be lifted to the adjacent forward position in short steps. Subsequently, it shall be slowly slided over the surface with its axis slightly tilted away from the direction of sliding and the operation repeated until a close, dense surface is obtained.

Concreting shall be carried out in one operation between the expansion joints and construction joints without any break at the dummy joints.

Concrete shall be deposited on the base as near the forms as possible without touching them. It shall then be shoveled against the sides, maintaining equal pressure and deposited approx. 50 mm higher than the depth of forms, care being taken that it is worked well around the forms. The concrete shall not be dumped from the bucket directly upon or against the forms.

Workmen shall not be allowed to walk on freshly laid concrete. All operations shall be carried out from suitable wooden bridges spanning the lane.

20.B.7.9. Use of Pavers

The contractor shall use slip from/fixed form paver as indicated for depositing, consolidation & finishing of concrete pavement. The paver(s) shall be of adequate capacity and suitable width of work bridge so as to complete concrete pavement within stipulated/agreed period of completion.

20.B.7.10. Joints in Concrete Pavement (using sealing compound)

20.B.7.10.1. General

Joints shall be of the types and dimensions as indicated and shall be located as indicated.

20.B.7.10.2 Dummy Joints

The dummy joints shall be 8 mm wide and shall extend vertically from the surface of the slab to a depth equal to 1/3 to 1/4 of the thickness of the slab. The joint may be formed by depressing into the soft but compacted concrete a high tensile mild steel. 'Tee' or flat bar of depth not less than the required depth of the joint plus 25 mm. The bar used for forming the groove shall be coated with soft seal or other suitable lubricant and have built in handles rigidly fixed to facilitate its removal without spalling or crumbling the edges. When the steel bar is removed, joints shall be nearly reformed immediately with proper tools and with mortar/fine material from the slab itself. No additional cement mortar shall be used. Alternatively the slot may be formed by sawing the concrete with a joint cutting machine (diamond cutter) of approved design within 6 hours of placing under moderate climatic conditions and when the concrete has sufficiently hardened. Under extreme cold conditions, this period may be suitably increased based on experience. In all cases, except where cutting is done with saw, the joint edges shall be bull nosed. Care shall be taken that the edges of the joints are not damaged. The edge shall not stand proud of the concrete slabs.

20.B.7.10.3 Construction Joints

The construction joints shall be 10 mm wide and straight and vertical though the full thickness of the slab. The vertical edge of the concrete on the side of the joint shall be treated with a coat of lime wash or bituminous paint before the adjacent bay is concreted. A groove 2.5 cm deep and 1 cm wide shall be formed at the top surface of the joint to receive the sealing compound. The groove shall be formed in the same manner as that for a dummy joint. The edges of the groove shall be bull-nosed and not stand proud of the concrete surface.

20.B.7.10.4 Expansion Joints

The expansion joints shall be straight and shall extend through the full thickness of the slab and shall be of the shape and dimensions shown on the drawings. The slab edges adjacent to the joint shall be formed truly vertical. The joints shall be filled with a 2 cm thick filler board. Cold applied joint sealant (polysulphide or polyurethane) of approved make with minimum ten years of performance guarantee will be used as joint sealant. The guarantee should be taken in writing from the contractor before the approval of joint sealants. The technical specifications of the cold applied joint sealants (irrespective of whether polysulphide or polyurethane) should meet the requirements mentioned in BS-5212, BS 4254 and EN-141875-2003 (for hydrolysis/water resistance test). In addition, the Movement Accommodation Factor (MAF) of the sealant should be minimum ± 30 %.

The groove to receive the sealing compound may be formed by cutting the extra filler board to the required depth.

20.B.7.10.5 Sealing of Joints

20.B.7.10.5.1 All joints shall be sealed as soon as practicable after 28 days of placing of the slabs. The joints shall be finished flush with the finished concrete surface if the sealing of joints is done in summer and 3 mm below the finished concrete surface, if the sealing of joints is done in winter. After the sealing compound has hardened, the excess sealing compound, if any, adhering to the slab outside the joints shall be removed by scraping or otherwise and the surface left clean. The pavement shall be opened to traffic only after the completion of joint sealing over the entire pavement.

20.B.7.10.5.2 Cleaning of Joints

All foreign materials in the joints shall be removed with pneumatic blower. The joints shall, thereafter, be cleaned with a coir brush. Fine particles clinging to the concrete faces shall be removed with the help of an air compressor only to avoid damage to the edges. The joints shall be cleaned and surface dried before the application of primer.

20.B.7.10.5.3 Application of Primer

The cleaned joint shall be primed with a 20-25 mm side painter's brush, while painting, light pressure shall be applied so that the primer penetrates into the pores of concrete. The primer shall be applied twice on one side (i.e. by forward and reverse movement of brush) The primer shall be applied in the thinnest possible complete film and then left for some till the primer feels "tacky" soon after the primer is applied, the joint is covered with 10-15 cm wide paper strips so that no dust is deposited on the primer.

20.B.7.10.5.4 Sealant joints

Only cold applied Polysulphide or Polyurethane joint sealant of approved make will be used in rigid pavements. The criteria for selection of the joint sealant will depend on the minimum performance guarantee of ten years offered by the firm. This performance-based selection would accrue better cost effective results rather than using a joint sealant without any guarantee. The technical specifications of the cold applied joint sealants (irrespective of whether polysulphide or polyurethane) should meet all the requirements mentioned in BS-5212, BS 4254 and EN-141875-2003(for hydrolysis/water resistance test).ln addition, the movement accommodation factor (MAF) of the sealant should be minimum ± 30 %.

While the joints shall be sealed flush with the adjacent pavement surface in summer, in winter they shall be filled to a depth of 3-4 mm below the surface. This procedure will reduce the possibility of ingress of grit and other foreign matter into the sealing compound as well as dislodging of the hardened sealing compound under traffic.

20.B.7.11. Joints in pavement concrete, (using polysulphide/ polyurethane material)

20.B.7.11.1 General

Joint shall be of the types and dimensions specified and be located in all as directed by Garrison Engineer. The edges of the groove/joints shall be bull nosed & not stand proud of the concrete surface.

20.B.7.11.2 Dummy Joints

20.B.7.11.2.1 The size of joints shall be as indicated/specified.

20.B.7.11.2.2. The joint shall be formed using mechanical equipment (diamond cutter) within 6 hour of placing of concrete under moderate climatic conditions and when the concrete has sufficiently hardened. Cutting or sawing by a sawing mounted at movable frame and driven mechanically will also be permitted as a method for making the joint. Care shall be taken that the edge of the joints are not damaged.

20.B.7.11.2.3 In case of sudden rain or storm, the work can be concluded at the dummy joint but the latter will then be formed into a construction joint.

20.B.7.11.3 Construction Joints

20.B.7.11.3.1 Construction joints shall also be provided at places where concreting is stopped due to unforeseen circumstances. The size of joints shall be as specified and as shown on drawings.

20.B.7.11.3.2 Construction joints shall be straight and vertical through the full thickness of the slab. The vertical edge of the concrete of the side of the joint shall be treated with a coat of lime wash or bituminous paint before the adjacent bay is concreted. A groove of dimension as specified in contract shall be formed. The groove shall be formed in the same manner as that for a dummy joint.

20.B.7.11.4 Expansion Joints

20. B.7.11.4.1 The expansion joints shall consist of a joint filler board as detailed in the drawing. The depth of the non extruding filler pad (joint filler board) shall be cut by 25mm from top to prepare the joint.

20.B.7.11.4.2 Joints shall be straight and shall extend through the full thickness of the slab and shall be of the shape and dimensions shown on the drawings. The slab edge adjacent to the joint shall be formed truly vertical. The joints shall be filled with approved joint filler as per clause 20.B.7.10.4.

20.B.7.11.4.3 Before the provision of expansion joint, the face of the already laid concrete slab shall be painted with the approved primer at the rate of 2.6 liters per 10 square metres. The expansion pad shall be properly cut to shape. Bond breaker tape shall be applied on the top face of the pad before inserting the closed cell backup rod. It shall then be placed in position abutting the painted face of the already laid concrete slab. The adjacent slab shall then be concreted. The faces of the pad against which the new concrete slab is to be laid shall also be painted with the approved primer before laying the concrete. While concreting a neat groove as per drawing shall be formed on top of the pad taking care that the edges are absolutely straight and that the groove so made does not get filled with any material like concrete, mortar and other rubbish.

20.B.7.11.4.4 The groove to receive the sealant may be formed by cutting the excess filler board material to the required depth.

20.B.7.11.4.5 Expansion joints shall be provided both longitudinally and transverse direction at spacing as shown on drawing or as directed by Engineer-in-Charge.

20.B.7.11.5 Procedure Of Joint Filling With Polysulphide / Polyurethane Selant

20.B.7.11.5.1 The technical specifications of the cold applied joint sealants (irrespective of whether polysulphide or polyurethane) should meet all the requirements mentioned in BS-5212, BS 4254 and EN-141875-2003 (for hydrolysis/water resistance test). In addition, the Movement Accommodation Factor (MAF) of the sealant should be minimum ± 30 %. The criteria for selection of the joint sealant of approved make will be a minimum performance guarantee of ten years offered by the firm. This performance-based selection would accrue better cost effective results rather than using a joint sealant without any guarantee. Contractor shall not procure the materials required for joint filling unless the samples are approved by the GE and a ten years of guarantee is given in writing by the contractor. The primer and sealant shall got tested by GE from a reputed testing laboratory who has the NABL accreditations like Indian Rubber Manufacturer's Research Association's Laboratory /CRRI/IIT/NIT/SEMT Wing, CME Pune before approval. The test certificate shall be obtained for every 5 MT of material incorporated in the work.

20.B.7.11.5.2 Joint Preparation

Before commencing joint sealing operations, the following shall be ensured: -

(a) The groove extends fully across the bay between consecutive longitudinal joints in the case of transverse joints and is continuous in the case of longitudinal joints.

(b) No concrete and foreign matter shall be left in the groove.

(c) In case of expansion joint, the filled materials is exposed to the full length of the joint and expansion joint filler is tightly packed.

(d) Joint surface must be dry, free from dust, coaling, bituminous mastics, concrete curing agencies, mould release agents, oil, grease and loose particles.

(e) All joints shall be thoroughly cleaned out by compressed air and sanding with emery paper or other approved means and shall be approved by Engineer-in- Charge before they are sealed.

(f) The cleaned and prepared joints shall be primed on the sides of the joints up to the depth where sealing component is to be provided and filled with approved sealant.

(g) Wipe out oil and grease by solvent soaked cloth (such as Xylene, Toluene or Acetone or Gardoclean).

(h) Before sealing, insert a bond breaker tape and bond breaker(closed cell polyethylene frame rod) caulked tightly into the base of the sealing groove to prevent the sealant from adhering to the base of slot. Width of bond breaker (backup rod) shall be 20 to 25% more than the joint so that there is no seepage of sealant through joints edges.

20.B.7.11.5.3 Fixing/Masking Tape

Fix masking tape to prevent edges of joints becoming dirty due to spillage of sealant at the time of pouring.

20.B.7.11.5.4 Application Of Primer

(i) Suitable primer shall be first applied to the vertical faces of the concrete joint before pouring cold applied sealant confirming to specifications given at clause 20.B.7.11.5.1, in order to improve the adhesive qualities of the product. Primer as specified by manufactures shall be applied to the joint vertical surfaces and allowed to dry for 30 minutes to 2 hours depending on the climatic condition. The surfaces shall be primed twice @ 0.075 litre (minimum) primer per square metre.

(ii) If the primer film has become completely tack free, the surface must be re-primed before applying the sealant.

(iii) If the primed areas are left unsealed overnight the primer film must be removed by grit blasting or grinding and the joints interfaces shall be re-primed.

20.B.7.11.5.5 Mixing

Mixing and application of sealant will be through mechanical means to avoid any human error. The mixed product shall be used immediately as per manufacturer's instructions within its pot life i.e. within 30 minute. The mixed sealant should be kept for a few minutes to allow air to escape before commencement of jointing filling.

20. B.7.11.5.6 Application or Pouring of Sealant

Mixed sealant shall be applied by mechanical means (machine application) based on the manufacturer's instructions and shall be executed by his approved and trained applicator. Application temperature of sealant should be in between 5 to 45 degree Celsius (or as per manufacturer's instructions). It should be filled to a level 2 to 3mm below the top of the pavement leaving a recess to protect the sealant from damage. To prevent accidental spillage of sealant on the top surface and to give a neat finish masking tape should be applied on front edges of joint in such a manner that the material will not be spilled on the exposed surface of the concrete. Any excess filler on the surface of the pavement shall be removed immediately and the pavement surface cleaned. All necessary precautions as per the manufacturer's recommendations shall be taken. The sealant should be immediately tooled either with stainless steel or wooden spatula of the size of the joint to give a smooth finish before it begins to set. Masking tape shall be removed immediately after the sealant has been tooled. The sealant should be allowed to cure as per manufacturer's instructions during which period no traffic should be allowed on the pavement.

The test certificate shall be obtained for every 5 MT of material incorporated in the work.

20.B.7.11.5.7 Some Miscellaneous Aspects

(i) The sealant are sensitive to temperature while in storage as well as during mixing. Temperatures for all phase of handling of the sealing compounds viz mixing, placing and curing conditions must be in accordance with manufacturer's recommendations.

(ii) All safety precautions during handing and application of these sealants as prescribed by the manufacturers shall also be strictly adhered to.

20.B.7.11.5.8 Precautions

(a) Some people are sensitive to resins, hardeners, vapour etc. Therefore it is advisable to use hand gloves/goggles and suitable protective clothing.

(b) Avoid application below 10°C temperature.

(c) Avoid application on damp or Moist surfaces.

(d) Do not expose primer to naked flames or other sources of ignition.

(e) Materials to be kept in no smoking area.

(f) Containers should be tightly sealed when not in use.

(g) In the event of fire, extinguish with carbon dioxide or foam.

(h) Should accident skin contact occurs, remove immediately with a resin removing cream, followed by soap and water. Do not use solvent.

(j) In case of contact with eyes, rinse immediately with plenty of clean water and seek medical advise.

(k) Use only in well ventilated areas.
(I) All consumables (masking tape, empty cartridges etc) should be removed and disposed off safely.

20.B.7.11.5.9 Separation Membrane

A separation membrane shall be used between the concrete slab and the sub base. Separation membrane shall be polythene sheeting 250 microns thick laid flat without creases. Before placing the separation membrane, the surface shall be swept clean of all the extraneous materials using air compressor and screen sand layer shall be laid over cleaned surface. Wherever overlap of plastic sheets is necessary, the same shall be at least 300mm and any damaged sheeting shall be replaced at the Contractor's expense. The separation membrane may be nailed to the lower layer with concrete nails.

20.B.7.12 Finishing of Concrete

20.B.7.12.1 Straight Edging

Immediately after the compaction of concrete and the construction of joints but before the concrete has hardened and while the concrete is still in plastic state, the pavement surface shall be inspected for irregularities with a profile checking template and any needed correction made by adding or removing concrete by means of long handled floats and scraping straight edge followed by further compaction and finishing. The long handled floats may be used to smoothen and fill in open textured areas in the pavement surface but the final finishing is to be made with scraping straight edges.

The scraping straight edges are to be 3 metres long with flexible long enough to reach the other side of slab when operated from one side of the pavement. They are to be placed parallel to the forms at the side of the pavements and worked backwards and forward uniformly across the width of the slab. After this operation has been completed and the surface shall be brought to the required finish, the straight edges shall be moved forward by not more than half their length and this process repeated.

The straight edge testing and re-floating shall continue until entire surfaces:-
(a) are free from observable departure from the straight edge ;
(b) conforms to the required levels and cross section ; and
(c) when the concrete has hardened, it shall conform to the specified surface levels.

The foregoing work shall be carried out while the concrete is still plastic and workable and in such time sequence as to ensure the removal of water of laitance from the surface.

After the concrete has sufficiently hardened to about 12 hours and not later than 24 hours, the surface shall be tested again for high spots shall be marked and those exceeding 3 mm shall be ground down immediately. Care shall be taken to ensure that the grinding does not in any way damage the concrete surface.

The final surface finish is to be such that when tested with 3 metres long straight edge placed any where within the same or adjoining slab in any direction on the surface there is no gap greater than 3 mm between the bottom of the straight edge of the surface of the pavement.

20.B.7.12.2 Belting

Just before the concrete becomes non-plastic the surface shall be belted with a two-ply canvas belt not less than 20 cm wide and atleast 1 metre longer than the width of the slab. Hand belt shall have suitable handles to permit controlled uniform manipulation. The belt shall be operated with short strokes transverse to entire line of pavement and with a rapid advance parallel to the centre line.

20.B.7.12.3 Brooming

After belting and as soon as surplus water, if any, has arisen to the surface the pavement shall be given a broom finish with an approved steel or fibre broom not less than 45 cm wide. The broom shall be pulled gently transversely and in straight strokes over the surface of pavement from edge to edge. Adjacent strokes shall be slightly over-lapped. Brooming shall be perpendicular to the centre line of the pavement and so, executed that the corrugations thus produced will be uniform in character and width, and not more than 1.5 mm deep. No pressure will be applied to be broom and scoring shall be done under the weight of broom head without tearing the surface.

Brooming shall be completed before the concrete reaches such a state that the surface is likely to be torn or unduly roughened by the operation. The broomed surface shall be free from porous or rough spots, irregularities, depressions, and pot-holes such as may be caused by accidental disturbing of particles of coarse aggregate embedded near the surface.

20.B.7.12.4 Edging

Immediately after belting/brooming has been completed, the edges of the slab shall be carefully finished with an edging tool of 6 mm radius and the pavement edges shall be left smooth and true to line.

20.B.7.12.5 Honey combing

As soon as the side forms are removed minor honey combed areas shall be filled with mortar composed of one part of cement to two parts of fine aggregate. Major honey-combed areas or segregated concrete or other defective work or areas damaged by the removal of the forms or concrete damaged by rain or any other reasons shall be removed an replaced. The total area of honey-combed surface more than 2.5 sq.cm. each shall not exceed 4% of the area of the slab side. Honey-combing exceeding 300 cm^2 in area at any one location shall be considered as major honey-combing.

Every slab shall bear an impression not exceeding 3 mm in depth comprising the number allotted to the slab and the date on which it was laid. The impression shall be formed when the concrete is green so as to leave permanent mark of setting.

20.B.7.13 Curing and Protection of Concrete

20.B.7.13.1 Initial Curing

Immediately after completion of the finishing operations, the surface of the pavement shall be entirely covered with wetted burlap, cotton or jute mats. The mats used shall be of such length (or width) that as laid they will extend at least 450 mm beyond the edges of the slab. The mats shall be so placed that the entire surface and edges of the slab are completely covered. This covering shall be placed as soon as in the judgment of the Engineer-in-Charge, the concrete has set sufficiently to prevent damage to the surface. Prior to being placed with the wettest side down, the mats shall be so placed and weighed down as to cause them to remain in intimate contact with the surface covered, and the covering shall be maintained fully wetted and in position for 24 hours, after the concrete has been placed, or until the concrete is sufficiently hard to be walked on without getting damaged. Water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove a mat for any reason, the concrete slab shall not be exposed for a period more than half an hour.

Worn burlap or burlap with holes shall not be permitted. Burlap reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes. If burlap is obtained in strips, the strips shall be laid to overlap atleast 150 mm.

Burlap shall be placed from suitable bridges. Waling on freshly laid concrete to facilitate placing burlap shall not be permitted.

Alternately, Membrane curing/polythene film is advocated for curing especially in arid regions and curing done as specified.

20.B.7.13.2 Final curing

Upon removal of the burlap the slab shall be thoroughly wetted and cured as follows :

Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high immediately covered with a blanket of sandy soil free from stones to prevent the drying up and cracking of clay. The rest of slab shall then be covered with sufficient sandy soil so as to produce a blanket of earth not less than 37 mm depth after wetting. The earth covering shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 21 days and thoroughly wetted down during the mornings of subsequent days up to 29 days and shall thereafter remain in place until the concrete has attained the required strength when the covering shall be removed and the pavement cleaned and swept. If the earth covering becomes displaced during the curing period, it shall be replaced to the original depth and re-saturated.

Concrete shall not be subjected to any load or weight of any plant until atleast 14 days after laying. Concentrated loads or sharp objects like iron wheels of concrete mixer and any vehicular traffic including construction traffic will not be allowed on the concrete surface for 28 days.

20.B.7.14. Testing of pavement concrete

20. B.7.14.1 Testing of pavement concrete shall be in accordance with relevant IS Specifications.

20.B.7.14.2 7-day strength

The concrete mix should be prepared for the flexural strength given in the design and will be accepted on 28 days strength. However the 7 days strength gives an early indication of the strength likely to be achieved. 7-days strength shall be determined at least 8 to 10 days prior to laying of concrete. At least 3 beams should be casted and tested for flexural strength as per IS : 516 of 1959. The strength achieved should be 75% of the 28 days strength. If it is less, then the concrete mix should be re-designed and re-tested. After the laying of concrete starts, determination of 7-day strength is not necessary.

20.B.7.14.3 28 -days Strength

At least 3 beams for every slab (100 ft x 12.5 ft x 1 ft) will be casted and tested for flexural strength as per IS : 516 of 1959. The concrete mix should be prepared for the flexural strength given in the design. After at least 30 samples have been cast for slab laid in similar conditions their results should be tabulated and LCL determined as follows:

$$LCL = X - tv$$

where

LCL = Lower Control Limit (minimum flexural strength)
X = Mean flexural strength from the samples tested,
t = Tolerance level factor,
v = Standard deviation of the samples tested.

LCL so determined should not be less than specified value. Along with the beams, cubes will also be cast and tested for compression as IS : 516 of 1959. The compressive strength will be tabulated along with the corresponding flexural strength to establish correlation between flexural and compressive strength.

20.B.7.14.4 Workability

Compacting factor tests and slump tests should be carried out as per IS : 1199 of 1959. In case concrete is being machine-laid, then only compacting factor tests should be carried out other wise either of the two can be carried out at the discretion of the EIC. Compacting factor/ slump tests shall be carried out for every 10 cu.m of concrete mixed. The concrete shall not be laid unless the appropriate test has been carried out and authority given for start of laying. Any batch of concrete giving a compacting factor or slump which does not comply with the laid down value (+0.02 in case of compacting factor only) shall be rejected and removed from the site.

20.B.7.14.5 Acceptance of concrete

Concrete shall only be accepted if it satisfies the following main conditions:

(i) LCL of every lot (atleast 30 samples) is not less than specified value,

(ii) Co-efficient of variation is not greater than 10%.

(iii) Tolerance Level Factor is 1.5.

(iv) There is no honey-combing in the concrete.

20.B.7.14.6 Critical Examination of Test Data

In case LCL of a lot is less, then the following procedure shall be adopted before core tests are undertaken :

(i) Omit the slab having lowest average strength and revaluate the remaining test date of the samples.

(ii) If the revaluated data conforms to the above acceptance criteria, accept the lot less the slab omitted.

(iii) In case of unsatisfactory result, repeat the process by omitting the next lowest till all weak slabs are segregated for further testing by core cutting and the part lot gets specified value.

20.B.7.14.7 Core Tests

In case the concrete fails in flexure test i.e. the LCL is less than specified for a particular lot, then concrete shall not be rejected unless it also fails in core test. In core test, atleast two cores of the same will be cut per slab. The crushing strength of this core is then determined. The crushing strength should not be less than 0.8 times the corresponding crushing strength of 15 cm cubes. The crushing strength determination will be as per IS : 516 of 1959. In case the L/D ratio of the core is between 1 and 2, then the crushing strength of the cube will be reduced. The correction will be carried out as per the formula given below

$$F = 0.11n + 0.78$$

Where F = Correction factor

$n = \frac{L}{D}$ ratio ('L' and 'D' are height and Diameter respectively of core

In case the concrete fails the flexure (LCL) test, but is found satisfactory in core test, it shall be accepted as the core test takes the precedence over the flexure test, However, in case the concrete fails both flexure as well as core test, then it shall be rejected and replaced.

20.B.7.14.8 All holes from which cores have been cut, will be filled with the same concrete from which the original slab was laid i.e., concrete of the same design mix.

20.B.7.15 Quality Control

20.B.7.15.1 The following quality control tests shall be carried out at frequencies specified against each during progress of work: -

SI No.	*Test*	*Test Method*	*Frequency*
1.	**Coarse Aggregates**		
	(a) Flakiness Index	IS:2386 (Part-1)	one test for every 100 Cum of aggregates.
	(b) Impact Value	IS: 2386 (Part-4)	-do-
	(c) Los Angeles Abrasion Value	IS: 2386 (Part 4)	-do-
	(d) Deleterious materials	IS: 2386 (Part-2)	Before approval of the quary and at every subsequent change in the source of supply.
	(e) Moisture content	IS: 2386 (Part-3)	Minimum of two test per day for correcting the water demand of the mix.
	(f) Soundness	IS: 2386 (Part-5)	Before approving the aggregates and every month subsequently.
	(g) Alkali aggregate reactivity	IS: 2386 (Part-7)	-do-
2.	**Fine Aggregates**		
	(a) Silt content	IS: 2386 (Part-1)	One test per 250 Cum.
	(b) Gradation of sand.	IS: 2386 (Part-1)	-do-
	(c) Deleterious materials	IS: 2386 (Part-2)	Before approval of the quary and at every subsequent change in the source of supply.
	(d) Moisture content	IS: 2386 (Part-3)	Regularly for correcting the water demand of the mix on daily basis.
3	**Cement** Physical and chemical tests	IS: 269 IS:455 IS:1489 IS: 8112 IS:12269	Once for each source of supply and occasionally when called for in case of long/improper storage. Besides the contractor also will submit daily test data on cement released by the manufacturer.
4	**Water** Chemical tests	IS: 456	At approval of source of supply, subsequently at interval of three months.
5.	**Mixed Aggregates** Grading	IS: 2386 (Part-1)	1 test per 150 Cum.

SI No.	Test	Test Method	Frequency
6	**Concrete**		
	(a) **Slump test** (Workability of fresh concrete)	IS: 1199	One test per each dumper load at both batching plant site and paving site initially when works starts. Subsequently sampling may be done from alternate dumper.
	(b) **Flexural strength of concrete**	IS: 516	One test consisting of nine works test beam for every 150 cum of concrete. Three of the beams shall be tested at 7 day and three at 28 days for flexural strength. The remaining three beams shall be kept as reserve exclusive for government use for subsequent testing (if so desired by Government) and preserved for one year from completion of work under the contract. The contractor can not claim testing of these beams for any purpose, as a matter of right.
	(c) Core strength on hardened concrete.	IS: 516	In case of doubt or in case of lab test not found satisfactory.
	(d) Thickness determination		From the level data of concrete pavement surface and sub base at grid points of 5/6.25m x 3.5m
	(e) Thickness measurement for trial length		3 cores per trial length.
	(f) Verification of level of string line in the case of slip form paving and steel forms in the case of fixed form paving		String line or steel form shall be checked for level at an interval of 5.0m or 6.25m. The level of tolerance allowed shall be + 2mm. These shall be got approved 1-2 hours before the commencement of the concreting activity.

20.B.7.15.2 Quality control test for levels alignments and texture shall be carried out as under:-

(i) Level tolerance	+ 5mm
(ii) Width of pavement and position of paving edges	+ 10mm
(iii) Pavement thickness	- 5mm to +25mm
(iv) Alignment of joints, widths, depth of dowel grooves	To be checked @ one joint per 400m length or a day's work whichever is more.
(v) Surface regularly both transversely and longitudinally	Once a day or one day's work, without disturbing the curing operation.
(vi) Texture depth: -	

Sl. No	Time of Test	Number of measurements	Required Texture depth	
			Special Value	Tolerance
(a)	Between 24 hours and 7 days after the construction of the slab until the slab is first used by vehicles.	An average of 5 measurements	1.00mm	+ 0.25mm
(b)	Not later than 6 weeks before the pavement is opened to traffic.	An average of 5 measurements	1.00mm	+ 0.25mm -0.35mm

20.B.16 Reinforcement Glass Grid

20.B.16.1. Technical Specifications

20.B.16.1.1 The reinforcement glass grid in use should be in conformity to ASTM 6637, ASTM D 276 and ASTM D 5261-92 specifications. These are summarized below:-

TABLE-1
TECHNICAL SPECIFICATION (100 KN /M X 100 KN/M)

(a)	Tensile Strength	
	(i) Longitudinal Direction	100 kN/m
	(ii) Transverse Direction	100 kN/m
(b)	Elongation at Break	Less than 5 %
(c)	Weight	370 g /sq m
(d)	Grid Size	12.5mm x 12.5 mm
(e)	Melting Point	218°C(min)
(f)	Material	Glass fibre strands, covered with a polymer modified coating, self adhesive at one side with sufficient bond to allow normal construction traffic and paving machinery operations.

TABLE-2
TECHNICAL SPECIFICATION (50 KN /M X 50 KN/ML)

(a)	Tensile Strength (i) Longitudinal Direction (ii) Transverse Direction	 50 kN/m 50 kN/m
(b)	Elongation at Break	Less than 5 %
(c)	Young's Modulus	69000 MPa (min)
(d)	Weight	185g/sqm
(e)	Grid Size	25mm x 25 mm
(f)	Adhesion	Self adhesive
(g)	Melting Point	218 °C (min)
(h)	Material	Glass fibre strands, covered with a polymer modified coating, self adhesive at one side with sufficient bond to allow normal construction traffic and paving machinery operations.

20.B.16.2 Placing

20.B.16.2.1 The surface shall be dry and free of dirt, swept or vacuum cleaned preferably by a mechanical device as well as free of oil, vegetation and other debris. The surface of the glass grid mesh shall be rolled with a pneumatic tyred roller, one or two passes to activate the adhesive. It should be ensured that the self adhesion of the glass grid to the existing surface shall be minimum 5Kg of direct pull (on one sq mtr areas) to ensure a ripple free surface. Transverse joints must be lapped in the direction of the paver by as minimum of 100mm. Longitudinal joints must be overlapped by 25 to 50mm. All glass grid mesh placed in a day shall be covered with bituminous concrete the same day.

20.B.16.3 No glass grid should be applied below new rigid overlays i.e. rigid over rigid or rigid over flexible.

20.B.16.3 Selection

20B.16.3.1 The supplying firm should have good credible past record and should have Supplied identicalSeal materials of International standards for the purpose of runway over lays and new runway works in India. Random samples should be got tested for quality from an IIT / National Test House and kept in record.

20.B.16.3.2 The width of roll should not be more than 1.5 mtr to ensure a wrinkle free surface which would avoid inducing of Shear stresses at the interface leading to premature failure of the Asphalt Layer.

SECTION 21
DEMOLITION AND DISMANTLING

(a) *For dismantling of wall and floor tiling, see section 14-Plastering and Pointing.*
(b) *For dismantling of sanitary fittings and water supply work, etc., see Section 18-Water Supply Plumbing, Drains and Sanitary Appliances.*
(c) *For dismantling of electrical work, see Section 19-Electrical Work.*

21.1 Dismantling

The term "dismantling" implies carefully taking up or down and removing the building materials without damaging them. The articles dismantled shall be lowered to the ground and not thrown. Dismantling work shall cover complete removal of the existing structure or part of a work including all relevant items as indicated or as directed, clearing the site, sorting out useful materials and stacking them as directed; and disposing of the unserviceable materials within a lead of 100m.

21.2 Demolition

The term "demolition" implies breaking up the components of the structure building and then taking the components up or down. This shall consists of demolishing whole or part of work including all relevant items as indicated or as directed, clearing the site, sorting out useful materials and stacking them as directed and disposing of the unserviceable materials and rubbish as directed within a lead of 100m. The removal of overlying or adjacent materials, if required for demolition of the structure shall be separately indicated.

21.2.1 Unless otherwise specified, the building/structure shall be dismantled/demolished upto 450 mm below ground level.

21.3 Serviceable and Unserviceable Materials

21.3.1 Inventory

Before dismantling/demolition operations are undertaken by the contractor, inventory of all materials, fittings and fixtures (except hidden materials) which are considered useful shall be made and signed by the EIC and the Contractor.

21.3.2 Serviceable materials

Any material which in the opinion of the EIC could be reused or otherwise useful will be considered as serviceable.

21.3.3 Unserviceable materials

Any material declared by the EIC as not serviceable shall be considered as unserviceable.

21.3.4 A register shall be opened at the work site to show day-to-day account of the turn out of salvaged materials. The register shall also indicate whether dismantled materials are properly stacked or wasted.

21.3.5 The contractor shall be responsible for the safe custody of serviceable materials until handed over to the MES representative or incorporated in the work and a written receipt for the same obtained.

21.4 Planning

21.4.1 A definite plan of procedure for the dismantling/demolition work, depending upon the manner in which the loads of the various structural parts are supported, shall be prepared by the Contractor keeping in view the safety requirements and approved by the Engineer-in-charge and this shall be followed in actual execution of the dismantling/demolition work.

21.4.2 The demolition shall generally proceed systematically storey by storey, in the descending order. All work in the upper floor shall be completed and approved by the EIC, prior to disturbance to any supporting member on the lower floor. Demolition of the structure in sections may be permitted in exceptional cases if proper precautions are ensured to prevent injuries to persons and damage to the property.

2 1.4.3 Stairs with railings, passage ways and ladders shall be left in place as long as possible and maintained in a safe condition.

21.4.4 It shall be ensured that the dismantling/demolition operations do not, at any stage, endanger the safety of the adjoining buildings. Dust and other nuisance effect of the dismantling/ demolishing work on the use of the adjacent buildings shall be kept to the minimum.

21.5 Precautions Prior to Dismantling and Demolition

21.5.1 All water, electricity, gas and other service lines shall be disconnected from the buildings/ structures to be dismantled/demolished as directed. Any temporary service connections required for the demolition work shall be separately taken.

21.5.2 Measures necessary to prevent accidental collapse by way of bracing, propping, shoring, under-pinning, etc., shall be provided as approved by EIC for the safety of the structure and also of the adjoining building or structures.

21.5.3 Necessary safety appliances shall be issued to the workers prior to starting of work.

21.5.4 Suitable safety precautions for fire shall be taken.

21.5.5 In the case of structures which are to be removed for re-erection, all members shall be properly marked, with painting The pins, nuts, plates, structural steel members, timer, etc., shall be similarly marked for identification of their position in the entire assembly. All machined surfaces, pin-holes, pins etc., shall be coated with grease. Portion required to be retained shall be clearly marked before dismantling or demolition.

21.5.6 Prominent danger signs shall be posted all around the building/structures. During night, warning lights shall be placed on or above all barricades leading to the building/danger zone.

21.6 Precautions during Dismantling and Demolition

21.6.1 Prior to the commencement of the work all materials of fragile nature like glass, ceiling boards, wall lining, electric, sanitary and water supply fittings, etc., shall be removed.

21.6.2 All materials which are likely to be damaged by dropping from a height during demolition of masonry walls, roof etc., shall be carefully dismantled first.

21.6.3 Where fixing has been done by nails, screws, rivets, etc., dismantling shall be done by taking out the fixing with proper tools and not by tearing or ripping off.

21.6.4 Any damage caused to the structure being dismantled/demolished in part and/of adjacent structures due to carelessness and negligence of contractor shall be made good by him at his own expenses.

21.7 Dismantling and Removal

21.7.1 Where existing building is to be extended or otherwise incorporated in the new work, only such parts of the existing structure shall be removed as are necessary to provide a proper connection to the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging the part of the structure to be retained.

21.7.2 If sewers or drains are removed or disturbed, arrangements shall be made for immediate disposal of the foul matter. If sewers or drains have to be temporarily removed, arrangements shall be made for the temporary passage of the flow.

21.7.3 As far as possible no materials shall be dropped. They shall be lowered by containers ropes and tackles or chutes properly designed.

21.7.4 Serviceable materials shall be stacked in such a manner to avoid deterioration. Different categories of materials shall be stacked separately as directed by EIC.

21.7.5 Unless otherwise provided, excavated materials shall be used in back filling the excavation made in removing the structures, in levelling the ground or otherwise disposed off as directed by EIC.

21.7.6 Unserviceable materials shall be disposed off as directed by EIC. Debris shall be removed at the earliest to ensure safe and adequate working space.

21.8 Catch Platforms

In demolition of exterior walls of multi-storey structures, catch platforms of sufficient strength to prevent injuries to workers below, shall be provided.

21.9 Grading of area

When a building has been demolished and no building operations have been projected, the area dismantled shall be filled upto the adjoining ground level, cut and graded as indicated.

SECTION 22
HEATING VENTILATION AND AIR CONDITIONING

22.1 Indian Standards: The following IS shall apply :-

I.S. No.	*Subject*
277 - 2003	Specification for Galvanized Sheet ducts (Sixth revision)
325 - 1996	Specification for 3 phase induction motors
655 -1963	Specification for Metal Air ducts (Second revision)
659 -1964	Safety code for Air Conditioning (Revised)
660 -1963	Safety code for Mechanical Refrigeration (Revised)
661 - 2000	Code of practice for thermal insulation of cold storage (Third revision)
732 - 1989	Code of practice for electrical wiring and fittings for buildings (Third revision)
778 - 1984	Specification for Gun Metal Gate, Globe and Check valves for general purposes (Fourth revision)
900 - 1992	Code of practice for installation and maintenance of induction motors (Second revision)
996 - 1979	Specification for single phase AC and universal motors (Second revision)
1239 Part 1 & 2 - 2004	Mild Steel tubes, tubular and other wrought steel tubes fittings
1391 (Pt l &II) - 1992	Unitary and Split Air Conditioners (Second revision)
1520 - 1961	Horizontal centrifugal pumps for cold, clear and fresh water (Second revision)
1545 -1994	Solid drawn copper and copper alloy tubes for Condensers, Heat Exchangers (Third revision)
2062 - 2006	Hot Rolled Low, Medium and High tensite structural steel (Sixth revision)
2312 - 1967	Propeller type AC Ventilation fans (First revision)
2370 -1963	Specification for Walk in type sectional cold rooms
2372 - 2004	Specification for Timber for cooling towers
2952 Part 1 -1964	Method for measurement of fluid flow by means of orifice plates and nozzles Part 1: Incompressible fluids
3103 - 1975	Code of practice for industrial ventilation (First revision)
3129 - 1985	Specification for Low density particle Board (First revision)
3144 - 1992	Mineral wool thermal insulation - methods of tests (Second revision)
3315 - 1994	Specification for Desert coolers (Second revision)
3346 - 1980	Method for determination of thermal conductivity of insulation material (First revision)
3588 - 1987	Specification for Electrical axial flow fans (First revision)
3589 - 2001	Specification for Electrically welded steel pipes for water, gas and sewage (Third revision)
3615 - 1967	Glossary of terms used in Refrigeration and Air Conditioning

3624 - 1987	Specification for pressure and vacuum gauges (Second revision)
3792 - 1978	Guide for heat insulation of non industrial buildings (First revision)
4578 - 1997	Specification for Lubricating oil for refrigeration machinery (Second revision)
4831 - 1968	Recommendation on units and symbols in refrigeration
4894 - 1987	Centrifugal fans (First revision)
5111 - 1993	Testing of refrigerant compressor (First revision)
5216 - I & II - 1982	Code for Safety Procedures and Practice in Electrical Work (First revision)
6272 - 1987	Industrial cooling fans (man coolers) (First revision)
7403 - 1974	Code of practice for selection of worm and helical gear boxes
7613 - 1975	Method of testing for panel type air filters for air conditioning purposes
7896 - 2001	Data for outside design conditions for AC in summer months (First revision)
8148 - 2003	Specification for Packaged Air Conditioners (First revision)
8183 - 1993	Bonded Mineral wool (First revision)
8362 - 1977	Copper and copper alloy rolled plates for condensers
9466 - 1980	Viscosity classification of industrial lubricants
9742 - 1993	Sprayed mineral wool insulation (First revision)
9842 - 1994	Specification for Preformed fibrous insulation (First revision)
10470 - 1983	Specification for Air cooled Heat Exchangers
10594 -1983	Thermostatic Expansion valves
10609 - 1983	Refrigerants - numbers - designation
10617 - 1983 Pt 1,2, and 3	Specification for Hermetic Compressors
11246 - 1992	Specification for Glass fibre reinforced polyester resin (GRP) squating Pans
11327 - 1985	Requirements for Refrigerant Condensing unit
11329 - 1985	Finned type heat exchangers for room air conditioners
11330 - 1985	Specification for Oil separators
11338 - 1985	Specification for Thermostats for use in refrigeration and air conditioning
11561-1986	Code of practice for testing of cooling towers
12436 - 1988	Preformed rigid polyurethane foams for thermal insulation
12615 - 2004	Specification for Induction motors - Energy Efficient motors
13204 - 1991	Rigid phenolic foams for thermal insulation
13947 Part 1 to 4 -1993	Specification for low voltage switchgear and control gear
14164 - 1994	Industrial application and finishing of thermal insulation material at temperature above 80 deg C and upto 700 deg C Code of Practice

22.2 WINDOW, SPLIT AND PACKAGE TYPE AIR CONDITIONER

22.2.1 Window Type Air conditioner

The unitary type air conditioner shall conform to IS 1391 Part (I&II) 1992, suitable for operation on 230 volts +10% single phase AC supply. The unit shall be capable of cooling, dehumidifying, air circulation, ventilation and filtering in the sizes of nominal cooling capacities provided with environment friendly refrigerant. The cabinet shall be made out of GI sheet powder coated anticorrosive pretreatment comprising of degreasing, phosphating and passivation. The unit shall be fitted with energy efficient rotary or reciprocating compressor. The air conditioners shall be provided with Bureau of Energy Efficiency (BE Star rating) ratings.

22.2.2 Split Type Airconditioner

The machinery shall have similar specifications as above for condenser and compressor outdoor unit. The indoor unit i.e. Fan coil unit shall be fitted with bacteriological filters, remote operation sensors and suitable drainage arrangement for dehumidified water in fan coil unit. The connection piping between outdoor and indoor unit shall conform to relevant IS. The wiring between indoor and outdoor unit shall be with copper stranded conductor of adequate size.

22.2.3 Cassette Type Air Conditioner

The cassette unit shall comprise of outdoor unit containing condenser, compressor housed in a weather proof powder coated cabinet and ceiling mounted indoor unit fan coil unit and drainage system for dehumidified water. The connection piping between outdoor and indoor unit shall conform to relevant IS. The wiring between indoor and outdoor unit shall be with copper stranded conductor. The drain pipe from indoor unit shall be of adequate size to ensure flow of water away from indoor unit.

22.2.4 Package Type Air Conditioner

22.2.4.1 The package unit shall be either air cooled or water cooled. The packaged type AC Plants shall conform to IS 8148 -2003. The plant shall have a single or multi refrigeration circuit as per design of reputed manufacturers.

22.2.4.2 Cabinet

The unit shall be constructed with adequate strength and rigidity to withstand handling, transportation and usages. The unit shall be free from undue noise during operation. The cabinet shall have a frame work of MS angle, of formed MS Sheet sections in order to provide structural rigidity. Properly formed close fittings and easily removable minimum 1.25 mm sheet metal panel shall be provided all around the frame work to make a closed and streamlined cabinet. Inside and outside surface shall be finished with polyester epoxy powder coating. The fan and coil section of unit shall be insulated with minimum 25 mm thick resin bonded fiber glass lining on the internal surface covered with minimum 0.50 mm thick aluminum sheet. An insulated cable tray with drain connection shall be provided below fan coil section so as to avoid dripping over the equipment installed in lower portion of the cabinet. A conditioned air outlet from the cabinet shall be provided with suitable flanges for flexible canvass duct connection for conditioned space. A return grill of streamlined design shall be provided in the elevation in front of filter section.

22.2.4.3 Compressor

22.2.4.3.1 The compressor shall be reciprocating/ scroll hermetic or semi hermetic type suitable for R-22 / R134 a refrigerant. It shall be fitted with suction and discharge stop valves to facilitate servicing, safety controls, filters, release valves, control valves and standard accessories for efficient operation. The compressor shall be mounted on anti vibration/vibration resilient material to ensure minimum noise and vibration during operation. Each compressor shall be microprocessor controlled with alarm for operation and protection against high refrigerant pressure, anti cycle timer, indicating lamp, low frequency, single phasing. the compressor shall be designed for 4.4^{o}C suction temperature and 43.3^{o}C discharge temperature.

22.2.4.3.2 The compressor motor shall be squirrel cage induction motor capable of continuous operation at 415 +10%, 50 Hz, 3 phase AC supply. The motor shall be suction cooled in case of semi hermetic type units. The starter shall be provided on packaged units itself.

22.2.4.4 Condensers

Condenser shall be horizontal shell and tube construction with MS Shell and integrally finned copper tubes. Thickness of tube shall be minimum 1 mm before finning. The end covers shall be removable type and suitable provision shall be made in the unit cabinet, enabling easy cleaning of tubes. The compressor shall serve liquid receiver for the refrigerant circuit and shall be complete with following: -

(a) Inlet and outlet refrigerant connections
(b) Inlet and outlet water connections
(c) Relief/Purge valve and connections
(d) Drain valve, air vent, test cock connection, facility with valves for descaling of tubes.

22.2.4.5 Cooling Coil, Fan Drive

22.2.4.5.1 Cooling coil shall be three or four row deep as per manufacturers standards, made of copper tubes of minimum 0.5 mm thick and aluminium fins of minimum 0.15 mm thickness mechanically bonded to coil. The fins shall be 4 to 5 per cm of tubes. Coil shall be fitted with equalizing copper distributor to ensure that each coil circuit receives equal amount of refrigerant. The coil shall be designed for face velocity not more than 155 metre per minute. The coil shall be thoroughly evacuated, dried and pressure tested to 300 psi (21 Kg/sq cm). The copper tubes for refrigerant shall include thermostatic expansion valve and suction gas strainer. The insulation of suction line shall be as per manufacturers standards.

22.2.4.5.2 The fan shall be statically and dynamically balanced single /double inlet centrifugal type, designed for quite operation. The fan wheel shall be constructed of aluminium or galvanized steel. Self oiling bearings easily accessible for maintenance with thrust collar shall be provided. The bearing shall be life lubricated sealed type mounted on vibration absorbing resilient supports. The fan shall be belt driven through adjustable pulley permitting air quantity to be varied by adjusting fan speed. Suitable fan belt tension adjusting arrangement shall be provided. The fan motor shall be mounted within cabinet. This shall be of TEFC enclosures, squirrel cage induction motor of suitable HP for the relevant class of duty. The same shall be located with proper alignment with fan pulley for the belt drive. DOL starter upto 5 HP motor with Single Phase Preventer shall be provided. The cleanable aluminium wire mesh/synthetic filter at least 25 mm thick shall be provided swung fit to prevent air bypass. The face velocity across filters shall not exceed 100 metre per minute.

22.2.4.6 Interlocking

The compressor motor shall be interlocked with air flow switch in the evaporator fan discharge, differential pressure switch in the condenser water line, condenser water pump and cooling tower fan motor.

22.2.4.7 Aircooled Package Units

The air cooled package units shall be supplied in two portions - outdoor portion made of the condenser and condenser fan and indoor unit made of evaporator, and evaporator fan. The compressor shall be provided along with condenser or the evaporator depending upon manufacture practice or as per site requirement as approved by GE. All the other items such as condenser, cooling coil etc. shall be similar to described in package unit – water cooled type.

22.3 Central Air Conditioning Plant

22.3.1 System components : The central AC Plant shall comprise of following components:

(a) Refrigeration unit comprising of compressor, condenser, expansion valve evaporator or chiller and interconnecting refrigerant piping.
(b) Hot water generator.
(c) Cooling Tower.
(d) Condenser water pumps.
(e) Chilled water pumps.
(f) Hot water pumps.
(g) Chilled water piping.
(h) Hot water piping.
(j) Condenser water piping.
(k) Air handling units (AHU) comprising of supply air blower, cooling coil and heating coil, humidifiers and filters.
(l) Air distribution system comprising of duct, grills, diffusers and plenums.
(m) Electrical power supply system.
(n) Controls and control wiring.

Depending upon application and design requirement, the combination of above components shall be adopted.

22.3.2 System Design and Plant Selection

22.3.2.1 The system design shall be done after detailed heat load calculation considering the outside and inside design conditions, ventilation requirement and internal load. The plant selection shall be made on calculated peak load, load diversity, partial load requirements and standby capacity.

22.3.2.2 The type, capacity and quantities of the various components of the system shall be worked out and specified.

22.3.2.3 The various components of the system shall be so selected as to match each other under operating conditions of full load as well as anticipated partial load.

22.3.2.4 The overall dimensions of various equipments in the system shall be suitable for installation in available space. The permissible loading of building structure, seismic considerations for various equipment foundations, acceptable noise levels, and aesthetic shall also be considered.

22.3.2.5 Areas with different requirement of fresh air, degree of filtration and/or different working hours shall be provided with different AHUs.

22.3.2.6 Storage area of the combustible articles such as explosives shall be served with independent AHUs complying with fire safety statutory requirements for various components of AHUs.

22.3.2.7 In the case of round the clock Air Conditioning where secondary chiller pumps are provided to save energy, secondary chiller pumps shall be provided with variable speed drive to regulate water flow to meet water requirement.

22.3.2.8 For 24 hour operation, fresh air AHUs variable speed drive shall be provided to regulate the flow of dehumidified air as per load requirement.

22.3.2.9 In case where the cooling is done with fan coil units placed in conditioned space and chilled water is circulated through them it shall be supplemented through 100% fresh air AHU by the network of ducting, grills and diffusers to the conditioned space for better ventilation conditions in terms of ventilation and humidity control.

22.3.2.10 For area like operation theatre, animal house and where specifically required functionally, AHUs with 100% fresh air shall be used. The return air in such cases shall be exhausted to atmosphere by suitable exhaust air system. It shall consist of ceiling suspended/ floor mounted single skin blower section and filter unit.

22.3.3 Reciprocating Compressors

22.3.3.1 Reciprocating compressor shall be multi cylinder open type, semi-sealed (semi hermetic), or totally (hermetically) sealed type as indicated. It shall be using refrigerant R-22/R-134a only. The suction chamber of the compressor shall be of generous proportions and shall have changes of direction of flow to ensure separation of entrained oil and liquid refrigerant from the gas before it enters suction manifold.

22.3.3.2 Drive: The compressor shall be direct driven.

22.3.3.3 Crankcase heaters

22.3.3.3.1 The compressors shall be equipped with electrical crankcase heaters. These heaters shall be fitted in steel pockets to avoid the oil coming in direct contact with the heating element. The heater elements shall remain energized only during the off cycle of the compressor and shall be de-energized when the compressor is operating to prevent the mixing of oil and refrigerant and their accumulation in the crankcase when the compressor is off.

22.3.3.3.2 An indicating light and a push button shall be provided for testing the continuity of the heater element.

22.3.3.4 Lubrication System

22.3.3.4.1 The lubrication system shall be force feed type with a reversible positive displacement type oil pump to provide pressure lubrication to bearings and other wearing surfaces

22.3.3 4.2 The crankcase shall be fitted with the following:-

(a) A pump suction strainer.
(b) An oil level bull's eye to check the oil level.
(c) An oil drain with a magnetic drain plug.
(d) Connection for oil pressure gauge with control valve.

22.3.3.5 Isolating valves and accessories

22.3.3.5.1 Suction and discharge isolating valves shall be provided for each compressor.

22.3.3.5.2 The compressor shall be complete with all accessories such as pipe flanges, suction strainers, etc.

22.3.3.6 Safety Controls: Safety controls shall be provided having essential equipment safety controls with alarm and microprocessor based monitoring system controls.

22.3.3.7 Capacity controls: Each compressor shall be equipped for capacity control by cylinder unloading. Unloading shall be achieved by lifting of suction valves or through bypass valves in the discharge chamber. The capacity control mechanism shall be so arranged that the compressor starts unloaded and shall be loaded in stages upto 100% loading of the compressor.

22.3.3.8 Interlocking: The compressor motor shall be interlocked with the following:-

(i) Differential pressure switch in the chilled water line(s) in case of chilled water system, and air flow switch in the evaporator fan discharge in the case of direct expansion system.

(ii) Differential pressure switch in the condenser water line(s) in case of water cooled condenser and air flow switch in the condenser fan discharge in the case of air cooled condenser.

(iii) Anti-freeze thermostat in case of chiller.

(iv) Condenser water pump in case of water cooled condenser and fan in case of air cooled condenser.

(v) Chilled water pump in case of chilled water system and evaporator fan in case of direct expansion system.

The interlocks shall be provided with indicating lamps or flags in the control panel in the refrigeration plant room.

22.3.3.9 Drive Motor

(i) The electrical motor driving the compressor shall be squirrel cage induction motor class 'F' insulation, fan cooled for open type unit and totally enclosed (refrigerant cooled) for hermetic/semi-hermetic-unit. The motor shall be suitable for operation on 415 +10% volts, 3 phase, 50 Hz alternating current supply unless otherwise specified. The motor synchronous speed shall not exceed 1500 r.p.m.

(ii) For open type compressor, the continuous B.H.P. rating of the motor shall be at least 110% of the maximum power requirement of compressor and drive under specified design conditions.

22.3.3.10 IKW/TR (input Kilo Watt/TR) shall not exceed 1.

22.3.4 Screw Compressors

22.3.4.1 The screw compressor shall have a rotary mono/twin screw, and may be of open/ semi sealed/totally sealed (thermetic) type as indicated using R22/R134a refrigerant.

22.3.4.2 The mono/twin rotary screw shall be manufactured from forged steel. The profile of screws shall permit safe operation upto a speed of 5000 RPM for 50 Hz operation. The compressor shall unload from fully loaded to the minimum capacity by means of hydraulically actuated slide valve positioned over the screw rotor/pilot operated solenoid valve.

22.3.4.3 The compressor housing shall be of high grade cast iron, machined with precision, to provide a very close tolerance between the rotor(s) and the housing.

22.3 4.4 The rotor(s) shall be mounted on antifriction bearings designed to reduce friction and power input. There shall be multiple cylindrical bearings to handle the radial and axial loads. There shall be built in oil reservoir to ensure full supply of lubricants to all bearings and a check valve to prevent backspin during shut down. There shall be oil pump or other means of differential pressure inside the compressor for forced lubrication of all parts during start up, running and during shut down. An oil pump header shall be provided in the casing.

22.3.4.5 The open type compressor shall also have a suitable shaft seal, to prevent leakage of refrigerant. The units shall be complete with automatic capacity control mechanism, to permit modulation between 20% to 100% of capacity range.

22.3.4.6 Interlocking. It shall be as per details given in para 22.3.3.8.

22.3.4.7 The driving motor shall be double squirrel cage type or suitable hermetic/semi hermetic/ open type, as indicated, protected against damage by means of built in protection devices.

22.3.4.8 Compressor motor

(i) These shall be as per details given under para 22.3.3.9, its synchronous speed, however, shall be 3000 RPM.

(ii) Continuous BHP rating shall not be less than the maximum power requirement of the compressor and drive under specified design condition.

22.3.4.9 IKW/TR (input Kilo Watt/TR) shall not exceed 0.71.

22.3.5 Centrifugal Compressors

22.3.5.1 Compressors shall be single stage centrifugal semi hermetic/open type as indicated. The rotor assembly shall consist of a heat treated alloy steel drive shaft and impeller shaft with a light weight, high strength, precision cast aluminium fully shrouded impeller. The rotor assembly shall be dynamically balanced. The impeller shall be designed for balanced thrust and tested for smooth vibration free operation.

22.3.5.2 The compressor motor assembly shall consist of single stage compressor driven by a motor through a step up gear housed in a open/semi hermetically sealed frame. The motor shall be air/liquid refrigerant cooled, as indicated with insulation particularly suited to this duty. The drive motor for the compressor shall be of 3000 rpm. The motor shall be drip proof, SPDP squirrel cage induction type motor suitable for AC 3 phase, 415 V, 50 Hz supply. Each machine will be provided with individual electronic soft start to ensure safe operation of the chiller. The motor starting current shall be limited to maximum permissible as per IES. The motor shall include inherent motor protective devices in all three phases which anticipate heat build up from motor overload, loss of cooling, single phasing or stalling and tripping the motor at lower temperatures as the rate of temperature rise increases. All motors shall be with high initial torque and low starting current.

22.3.5.3 All starters shall have their own ammeters with CTs & selector switches. The starters shall be provided with overload relays and single phase preventers with indication of thermostatic cut-off and lP cut-off on main panel and short circuit failure. The motors shall be provided with class 'B' insulation.

22.3.5.4 Bearings shall be insert type journal and thrust bearings, fabricated of aluminium alloy and shall be precision bored and axially grooved. Lubrication system shall consist of oil pump, oil cooler, oil filter, and all interconnecting oil piping and passages.

22.3.5.5 Lubricating oil shall be force-fed to all bearings and filtered by a 15 micron replaceable cartridge oil filter equipped with service valves. An automatic oil return system shall return oil that may have migrated into the refrigerant. The oil shall be cooled by a refrigerant cooled oil cooler. All oil piping shall be factory installed and tested. A thermostatically controlled heater shall be supplied in the oil, reservoir to keep the oil warm when the compressor is not operating.

22.3.5.6 The shaft seal for the open drive compressor shall consist of a spring loaded, precision carbon ring, high temperature elastomer 'O' ring static seal and stress relieved precision lapped collars. It shall provide an efficient seal under both vacuum and pressure conditions. The seal shall be flooded at all times and shall be pressure regulated during compressor operations.

22.3.5.7 The compressor shall be driven by single helical gears with crowned teeth in such a way that more than one tooth is in contact at all times to provide even distribution of the compressor load and quiet operation. Gears shall be integrally assembled in the compressor rotor support and shall be film lubricated. Each gear shall be individually mounted in its own journal and thrust bearings to isolate it from impeller and motor forces.

22.3.5.8 Interlocks switches shall be as follows:-

(a) Flow switches in chiller lines to prevent compressor starting without water flow.
(b) Flow switches in condensing lines to prevent compressor starting without water flow.
(c) Condensers and chilled water pumps shall be interlocked with refrigerant units to prevent compressor operation without pumps running.
(d) Crankcase heaters to be switched on when compressor stops.
(e) Flow switches for each chiller and condenser.

22.3.5.9 Centrifugal compressors shall be fully automatic shut down and start-up type. An automatic and self contained purge recovery unit shall also be provided for the removal of air and water vapour from the condenser.

22.3.5.10 Manual control for starting and stopping individual compressors shall be provided. Automatic capacity control for each unit shall be provided as specified hereinafter. Capacity control may preferably be by means of inlet guide vanes.

22.3.6 Condenser

Horizontal shell and tube type water cooled condenser of welded construction and sound design shall be supplied with each compressor. The condenser shall have removable end covers for periodical cleaning of tubes. Necessary gas and liquid test valves and safety valve shall be provided. At inlet and outlet of water circuit temperature and pressure gauges of dial type shall be provided. All condensers shall have integrally finned/ Thermo Excel heat transfer copper tubing.

22.3.6.1 Water Cooled Condensers

22.3.6.1.1 Where a package condensing or water chilling unit is required, the condenser capacity shall match the compressor capacity specified. The condenser shall be selected for 4.2 degree C temperature rise of water through the condenser unless otherwise specified.

22.3.6.1.2 The condenser shall be designed for a fouling factor of 0.0002 hr sqm degree C difference/K Cal unless other specified.

22.3.6.1.3 Unless otherwise specified, the condenser shall be designed for a entering water temperature of 32.2 degree C.

22.3.6.1.4 Material and Construction

22.3.6.1.4.1 The condenser shall be horizontal, shell and tube type, designed, constructed and tested for the refrigerant specified in the tender specifications.

22.3.6.1.4.2 The shell of the condenser shall be made of MS of thickness not less than 8 mm, with electric fusion welded seams. The shell capacity shall be such as to hold 1.25 times the refrigerant charge in the machine of which the condenser is a part, under pumped down conditions. The end plates of condenser shall be made of MS of thickness not less than 25 mm. The condenser shall be designed for a working pressure on the refrigerant side suitable for the refrigerant offered, and on the water side for 10 kg/sq.cm.gauge.

22.3.6.1.4.3 The tubes shall be of seamless hard drawn copper and finned, unless otherwise specified. The minimum wall thickness shall be 1.0 mm with root thickness of 0.63 mm below the fins. Intermediate tube supports of steel shall be provided at not more 1250 mm intervals to prevent sagging and vibration ol the tubes. The condensers shall have water boxes designed for multi pass flow. The tubes may be provided with special tabulating arrangement to improve heat transfer where such an arrangement is a standard design of the manufacturer.

22.3.6.1.4.4 The condensers shall be provided with removable heads on either side made of cast iron or steel with neatly machined surface for effective jointing with the shell for easy accessibility for cleaning/replacement of the tubes. Suitable baffles shall be incorporated to achieve the required number of passes. It shall be possible to descale the tubes without disconnecting the water line connections, wherever marine water boxes have been specified.

22.3.6.1.4.5 The condenser shall be provided with baffle arrangement for preventing direct impingement of hot gas over the tubes and to enable even distribution of the gas over the tube bundles.

22.3.6.1.4.6 The condenser shall include necessary provision for sub-cooling of the refrigerant where the refrigerating machine is selected with such sub-cooling requirement. The arrangement shall be such that the cold water entering the condenser first cools the liquid refrigerant in the sub-cooler.

22.3.6.1.4.7 The condenser shall be sand blasted from both inside and outside.

22.3.6.1.5 Connections and Accessories

The condenser shall be provided with the following connections and accessories and conforming to section "Refrigerant Piping" where applicable:-

(a) Hot gas inlet and liquid outlet connections. The liquid line connections shall be provided with isolating valves.
(b) Water inlet and outlet connections.
(c) Pressure relief device.
(d) Drain connection with valve for water side.
(e) Differential flow switch/pressure switch/flow sensor in the water line(s).

22.3.6.1.6 Pressure Testing

(a) The condenser shall be tested at the works to 1.5 times the maximum working pressure for the refrigerant or 15 kg/sq.cm. (Pneumatic) for refrigerant R-134a and 21 kg/sq.cm. for refrigerant R-22 whichever is higher.
(b) The water side of the condenser shall also be tested to a hydraulic pressure of 10 kg/sq.cm. in the works.
(c) Pressure test certificates shall be produced in respect of each condenser.

22.3.6.2 Air Cooled Condensers

22.3.6.2.1 Material and Construction

22.3.6.2.1.1 The condenser coil shall be fabricated of seamless hard drawn copper tubes and aluminium fins of 0.18 mm minimum thickness, fins spacing ranging from 3 to 5 fins per cm. The minimum wall thickness of tubes shall be 10 mm.

22.3.6.2.1.2 The coil shall normally be 2/3/4 rows deep unless otherwise specified.

22.3.6.2.1.3 The condenser shall be designed so as to hold 1.25 times the refrigerant charge in the system during the idle periods.

22.3.6.2.1.4 Suitable number and capacity of propeller type fans shall be provided. For moving the air through the entire condenser coils. For more uniform flow over the condenser coil, the condenser shall be designed on the draw through principle. The air velocity over the condenser coil shall be maintained upto 200 mpm maximum.

22.3.6.2.2 Connections and Accessories :

The following connections and accessories shall be provided on the condenser and conforming to section 'Refrigeration Piping' where applicable:-

(a) Hot gas inlet and liquid outlet connections. The liquid outlet connections shall be provided with isolating valves.
(b) Pressure relief device.

22.3.6.2.3 Pressure Testing

The pressure testing shall be done at 31 kg/sq.cm. on refrigerant.

22.3.7 Chiller

22.3.7.1 Chiller shall be of following types :-

(a) For reciprocating type units the chiller shall be Direct Expansion (DX) type.
(b) For centrifugal type units the chiller shall be of Flooded type.
(c) For screw type units the chiller shall be of Direct Expansion (DX) type or Flooded type.

22.3.7.2 Shell and Tube Type Water Chillers

22.3.7.2.1 In a package water chilling machine, the chiller shall match the compressor capacity specified in the tender specifications. The chiller shall be selected for 4.4 degree Centigrade temperature drop of water through the chiller for reciprocating compressor and 5.5 degree Centigrade for centrifugal and screw type compressors.

22.3.7.2.2 The fouling factor shall be 0.0001 hr.sq.mtr degree Centigrade temperature difference/ K. Cal unless otherwise specified.

22.3.7.2.3 Material and Construction.

22.3.7.2.3.1 The water chiller shall be horizontal, shell and tube type, designed, constructed and tested for the refrigerant specified.

22.3.7.2.3.2 The chiller shall be designed for a working pressure on the refrigerant side suitable for the refrigerant offered, and on the water side for 10 kg/sq cm gauge.

22.3.7.2.3.3 The end plates of the chiller shall be made of not less than 25 mm thick MS plate.

22.3.7.2.3.4 The shell of chiller shall be made of MS sheet of thickness not less than 8 mm with electrical fusion welded seams. The tubes shall be of seamless hard drawn copper with a minimum tube thickness of 0.71 mm for plain tubes and 0.63 mm at the roots of tube. The tubes shall be plain for DX type chiller and shall be either plain or internally finned for flooded type chillers as per manufacturer design. The tubes shall be rolled in grooves in the tube sheet and flared at end. The intermediate tube supports of steel or polypropylene shall be provided at spacing not less than 1250 mm for flooded type chillers and 500 mm for DX type chiller to prevent sagging / vibration of tubes. The flooded chiller shall have water boxes designed for multipass flow. The DX type chillers shall be provided with adequate number of properly spaced baffles so that water passes through the tube bundles many times. The chiller shall be smooth finished with one coat of Zinc chromate primer before insulation is applied. It shall be sand blasted from inside before insertion of tubes and outside. Chiller shall be complete with following accessories:-

(a) Refrigerant inlet and outlet connections.
(b) Thermostatic expansion valves and adjustable superheat control and external equalizer part.
(c) Line solenoid valve or pilot solenoid valves as required.
(d) Water inlet and outlet connections.
(e) Drain connection with stop valve for water connection.
(f) Vent connection with valve.
(g) Flow switch in water line.

22.3.7.3 Flooded Chillers

22.3.7.3.1 Chillers shall be shell and tube, multi pass flooded type and designed for the duty required. Tubes shall have integrally finned face surface rolled into tube supporting sheets or fixed by silver soldering or brazing or Thermo excel tubes. In either case, tubes shall be removable without affecting the strength and durability of the support sheet or causing any leakage in the adjacent tubes. Tubes shall be adequately supported to prevent tube vibration/Water boxes shall be designated for 7 kg/sq.cm. The design shall be adequate to eliminate liquid carry over and to sustain standard design pressure both on refrigerant and water sides. The temperature of chilled water at outlet shall not exceed 44 °F. Four pumping sets each capable of taking 100% compressor load independently will be provided for chilled water circulating system. The type of equipment and temperature of circulating water at inlet to and outlet from the chiller shall be clearly indicated. The piping for chilled water system shall be of adequate size and efficiently insulated to reduce friction drop and heat leakage. The method of routing the chilled water piping shall be clearly indicated. The chillers shall have removable end covers for periodical cleaning of tubes. The tubes shall be of copper not less than 22 gauge. At inlet and outlet of chilled water circuit, dial type temperature gauges shall be provided. Chillers shall be complete with the following accessories :-

(a) Eliminators and distributors.

(b) Liquid refrigerant sight glass, filter drier and evaporator pressure gauge.

(c) Refrigerant charging connection with valve.

(d) Relief device (valve/disc), purge and drain valves and necessary vents.

(e) Necessary shut off valves.

(f) Water inlet and outlet connections as required with dial type temperature and pressure gauges.

(g) Freeze up thermostat Fitted into proper water passage.

(h) Low refrigerant pressure cutout.

(i) Chiller insulation.

(j) Any other standard accessories necessary with the equipment supplied.

22.3.8 Microprocessor Controller

22.3.8.1 Chiller mounted control panel shall be of same make as chiller package manufacturer. Control panel with each package shall be microprocessor based soft start panel to provide peer to peer communication between all the chillers. It shall be provided with a friendly key board with 2 x 40 character LCD display and also LED display for all the important safeties and controls of the panel. The safety and operating controls shall cater for automatic parallel and independent operation and system protection, automatic capacity control device including temperature controller, load limiting device and leaving chilled water temperature control. Safety and operating cutouts shall include gauges, thermometers and indicating lamps. Automatic refrigerant cooled oil cooler and purge unit shall be in-built in the refrigerant system. Relays, time relays , fuses and inter connecting wiring along with low chilled water safety switch and chilled water thermostat shall also be provided. Microprocessor panel shall ensure that minimum no. of units are running to cater to the 'load and other units are switched off automatically.

22.3.8.2 The control centre shall include safety devices to protect the machine from malfunctions. These controls shall shut down the machine and signal the operator with their respective red neon lights. Each control shall have a manual reset circuit. Auxiliary SPDT contacts shall be provided to energize an alarm. Alarm circuit and alarms shall be included. The protective controls shall include solid state motor over current cutout and solid state low evaporator temperature control.

22.3.8.3 It shall provide all the indications for operation of the chiller unit through a alpha numeric graphic display.

22.3.8.4 The controls shall provide to view and change digital programmable set points, cause of shut down and type of restart required – All safety and cycling shutdowns shall be enunciated through alpha numeric / graphic display and consist of day, time. Cycling shut downs shall include low chilled water leaving temperature, chiller/condenser water flow interruption, low frequency, power fault, internal time clock, and anti recycling. The safety shutdowns shall include low oil pressure, high compressor discharge temperature, low evaporator pressure, motor controller fault, and sensor mal function.

22.3.8.5 The default display screen shall indicate minimum parameters viz date and time, return and leaving chilled water temperature, return and leaving condenser water temperature, differential oil pressure, percent motor rated current, evaporator and condenser refrigerant saturation temperatures, chiller operating hours, number of compressor starts, oil sump temperature for other than reciprocating compressors, status message.

22.3.8.6 The security access shall be provided to prevent unauthorized change of set points, to allow local or remote control of chiller, and to allow manual operation of the prerotation vanes and oil pumps. It shall be provided with ports compatible to output all system operation information, shutdowns/cycling messages and record of last hour cycling or safety shutdowns, to a remote printer. The control centre shall be programmable to provide data logs to the printer at set time intervals.

22.3.8.7 The microprocessor controller shall include the interlocking of compressor motor, with chilled water and condenser water flows, guide vane position, in case of centrifugal units and lubricating oil pressure. On initiation of start the micro processor control system shall chock all pre start safeties to verify that all pre start safeties are within permissible limits. In case any of the parameters are beyond limit, an indication of fault shall be displayed and the start be aborted.

22.3.9 Cooling Tower

22.3.9.1 The cooling tower shall be of mechanical draft. The cooling tower shall be in wooden construction with wood or PVC fills and RCC basin, FRP construction with PVC fills and FRP Basin or in masonary construction as indicated. Structural components of the tower, including the cold water basin, structural columns, hot water basin and fan cylinder shall be fabricated of fibreglass reinforced polyester. Mechanical equipment supports and all other stool components shall be HDG steel. Grillage shall be of sufficient strength to support the tower on piers located near the corners of the tower.

22.3.9.2 Motor

Motor(s) shall be of suitable capacity, SPDP, 1.00 service factor, and specially insulated to withstand tower duty. Speed and electric characteristics shall be 1500 RPM, single winding, 3 phase, 50 Hertz, 415 Volts.

22.3.9.3 Mechanical Equipment

Fans shall be adjustable-pitch, propeller type. Fans shall be driven through a right angle, industrial duty, oil lubricated, geared speed reducer, equipped with oil level sight glass. The motor shall be located outside the moist airstream. A full floating drive shaft consisting of stainless steel tube and neoprene flexelements shall couple the electric motor to the geared speed reducer. The mechanical equipment shall be structurally supported independent of the casing. HDG steel wire mesh guard to prevent entry of airborne objects into the fan itself shall be provided.

22.3.9.4 Fill, Louvers and Drift Eliminators

Fill shall be film type, with louvers and drift eliminators formed as part of each fill sheet. Fill shall be suspended from HDG steel structural tubing supported from the tower structure, and shall be elevated above the floor of the cold water basin to facilitate cleaning. Air inlet faces of the tower shall be free of water splash-out. Guaranteed drift losses shall not exceed 0.005% of the design GPM.

22.3.9.5 Hot Water Distribution System

An open basin above each fill bank shall receive hot water piped to each cell of the tower. Water shall enter the basin through a removable wave suppresser splash box, and the basin shall provide adequate freeboard against overflow and splash out. Equally sized and symmetrically spaced, removable and replaceable polypropylene nozzles installed in the floor of the basin shall provide full coverage of the fill by gravity flow. Fibreglass reinforced polyester hot water basin covers shall be provided.

22.3.9.6 Water Basin & Accessories

The cold water basin shall include flanged suction connection, overflow, and drain. A float-operated, mechanical make-up valve shall be provided. HDG steel screens shall be provided to prevent entry of airborne debris into the cold water basin outboard of the fill.

22.3.10 Air Handling Units

22.3.10.1 The Air Handling Units shall be of blow through/draw-through type having various sections such as filter section, coil section suitable for chilled water cooling coil and hot water heating coil, humidifier section and fan sections with centrifugal fan.

22.3.10.2 Capacity

The air flow and coil capacities (Air Conditioning Load) shall be specified based on air-conditioned space.

22.3.10.3 Casing

22.3.10.3.1 The units shall be of sectionalized construction consisting of fan section, coil section, filter section and an insulated drain pan. The housing/casing shall be of double skin construction. The frame work shall be of extruded aluminium hollow sections filled with preformed insulation and duly powder coated. All the frames shall be assembled with mechanical joints to make a sturdy and strong frame work for various sections with sufficient access panels for proper lubrication and maintenance. Base frame shall be constructed of fabricated steel channel of adequate size.

22.3.10.3.2 Double skin panels (each not exceeding 750 mm wide) shall be made of 16 gauge powder coated CRC sheet on the outside and 22 gauge galvanised sheet inside with 25 mm thick resin bonded fibreglass/rockwool thermal slab insulation sandwiched in between to prevent condensation. The panels shall be bolted from inside on to the framework with soft rubber gasket in between to make the joints airtight.

22.3.10.3.3 Frame work for each section shall be bolted together with soft rubber gasket in between to make the joints air tight. Suitable doors with chrome plated hinges and latches shall be provided for access to various panels for maintenance. The entire housing shall be mounted on steel channel frame work. Removable panels in fan and coil section shall provide access to all internal parts as also ease in dismantling the unit as required. All unit panels shall be constructed of GI/CRCA sheet. Drain pan shall be constructed of twin 16 gauge GI/CRCA sheet steel duly insulated and with necessary slope to facilitate for fast removal of condensate. Drain pan shall extend under coil and fan sections and shall also extend below control and isolation valves with drain connections on both sides. Necessary support shall be provided to slide the coil in the drain pan. Outlet shall be provided on both the sides of drain pan.

22.3.10.4 Motor and Drive

22.3.10.4.1 Fan motors shall be 415+10% volts, 50 cycles, 3 phase, squirrel cage, TEFC/SPDP (SPDP motors to be provided for capacity 15 HP and above and TEFC for capacities below 15 HP). Motor shall be especially designed for quite operation and motor speed shall not exceed 1140 RPM. Drive to fan shall be provided through belt drive arrangement. Belts shall be of oil-resistant type.

22.3.10.5 Fan

22.3.10.5.1 The fan shall be forward curved, double inlet, double width type. The wheel and housing shall be fabricated from heavy gauge galvanized steel. The fan impeller shall be mounted on a solid shaft supported to housing with angle iron frame and pillow block heavy duly ball bearings. The fan shall be selected for a speed not exceeding 1000 RPM. The impeller and fan shaft shall be statically and dynamically balanced. The fan outlet velocity shall not be more than 1800 FPM. The fan housing with motor shall be mounted on a steel base mounted outside the air handling housing on anti vibration springs mounts or cushy foot mounts. The fan outlet shall be connected with casing with the help of fire retardant canvass.

22.3.10.6 Cooling/Heating Coils

22.3.10.6.1 Chilled/hot water coils shall have 12.5 mm to 15 mm dia, copper tubes minimum 24 gauge thick with aluminium fins firmly bonded to copper tubes assembled in a zinc coated steel frame. Face and surface areas shall be such as to ensure rated capacity from each unit and such that the air velocity across each coil shall not exceed 150 metres per minute. The coil shall be pitched in the unit casing for proper drainage. The coil shall be factory tested at 21 kg. per sq.m. air pressure under water. Tube shall be hydraulically/mechanically expanded for minimum thermal contact resistance with fins. Fins spacing shall be 11 to 13 fins per inch.

22.3.10.7 Filters

22.3.10.7.1 Each unit shall be provided with a factory assembled filter section containing washable synthetic type air filters having anodized aluminium frame. The media shall be supported with HDP mesh on one side and aluminium mesh on other side. Filters face velocity shall not exceed 100 metre per minute. Filters shall fit so as to prevent by-pass. Holding frames shall be provided for installing a number of filter cells in banks. These cells shall be held within the frames by quick acting spring clips that snap over the cell handles. Cleaning efficiency of these prefilters shall be 95% down to 5 microns. Maximum pressure drop for clean filter shall be 4 mm WG and 12 mm WG when dirty. Cleaning efficiency for fine filters shall be 98% down to 5 microns and pressure drop when fine filter is clean shall not exceed 6 mm WG and maximum pressure drop when dirty shall not exceed 12 mm WG.

22.3.10.7.2 The housing shall be made from 11 gauge aluminium. All joints and welds shall be sealed airtight and shall be ground free of all burrs and sharp edges.

22.3.10.7.3 The filter locking mechanism shall be a spring loaded, toggle type mechanism with a bolt and thrust assembly which shall thrust the filter evenly against the sealing flange of the housing when it is installed.

22.3.10.7.4 The housing shall have two clamping maintenance nuts in each tier to operate the spring loaded mechanism which engages and disengages the filters on the internal sealing frame.

22.3.10.7.5 Pivot on the doors center line shall be provided to enable the door to make level contact on the gasket when closed and clamped. Stainless steel wing nuts shall be used to seal the door in place. The door shall have a 13 mm (1/2") thick closed cell neoprene gasket around the inside perimeter of the door. Vibration isolators shall be provided with all air handling units. Vibration isolators shall be Cushy foot Mounting type.

22.3.10.8 Fresh Air Intakes

22.3.10.8.1 Galvanized sheet steel fresh air louvers with bird screen, filters and damper shall be provided in the clear openings in masonry walls of the air handling unit rooms with at least one external wall. Louvers, filters, damper, and fresh air duct shall be provided for various air handling units. Fresh air dampers shall be of the interlocking opposed blade louver type. Blades shall be made of not loss than 16 gauge galvanized sheet steel, edges covered with felt to provide air-tight closure, and shall be rattle-free. Dampers shall be equipped with brass bushes and ball bearings. Filters shall be similar to those earlier specified for air handling units.

22.3.10.9 Each air handling unit shall be complete with following accessories :-

- **(a)** Two Nos. Insulated isolation valves, balancing valve, Y- strainer, descaling valve, unions and insulated condensate drain piping up to sump or floor drain in air handling unit room,as described here in after provisions for "Piping"
- **(b)** Manual air vents at high points in the cooling coil and drain plug in the bottom of the coil.
- **(c)** Temperature and pressure gauges (with cocks) within gauge ports in chilled and hot water supply and return lines.

22.3.10.10 Painting

Shop coats of paint that have become marred during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with enamel paint to match the finish over the adjoining shop painted surfaces.

22.3.10.11 Noise Control

Air handling units shall be selected for the lowest operating noise level of the equipment. Fan performance rating, power consumption, and sound power data with operating points clearly indicated shall be provided.

22.3.11 Fan Coil Unit

22.3.11.1 The fan coil units shall be vertical type for floor mounting or horizontal type for ceiling suspension, or bare units for completely recessed installation. Floor-mounted vertical units shall have vertical top discharge supply air plenum fitted with adjustable discharge grills supplying horizontally and horizontal units mounted within ceiling space shall have horizontal discharge. All units shall be complete with chilled/hot water coil, one or more centrifugal fans and motor, aluminium cleanable filters, three-way diverting valve for individual unit or group of units, double-walled insulated condensate drain pan with 25 mm thick resin bonded fibreglass/ rockwool insulation sandwiched between top and bottom sheets of drain pan, and 18 gauge galvanised steel casing panels insulated on discharge side of the fan. Horizontal units shall have U-slots in top panels for ease or installation and thermal barrier slots in unit discharge to reduce sweating. Horizontal fan coil units shall be provided with auxiliary secondary condensate drain pans, where shown on drawings.

22.3.11.2 Cabinet

Cabinets shall be constructed of 16 gauge die-formed cold-rolled sheet steel, bonderized and coated with bake enamel finish. Corners shall be rounded without break lines. The cabinets shall be of sufficient size to enclose all piping and controls. Access panels shall have positive locking fasteners for easy removal. Cabinets shall be provided with all floor-mounted vertical units and ceiling-suspended horizontal units, but not with recessed bare units nor with horizontal units mounted within ceiling space.

22.3.11.3 Interior Chassis

The interior chassis shall be constructed of not less than 16 gauge galvanized steel sheet and coated with a rust inhibiting paint. All cold panel surfaces shall be covered with not less than 25 mm thick resin bonded fibreglass/rockwool insulation. All fan coil units shall be securely mounted from the building structure and shall be set dead level in both directions.

22.3.11.4 Drain Pan

The drain pan shall be fabricated out of deep drawn stainless steel insulated with 25 mm thick heavy density fibreglass insulation, covered with FRP moulded jacket. The insulation shall be sandwiched between top and bottom panel to effectively prevent condensation. The pans shall be of sufficient size to catch all drippage of condensation from any part of the unit; in all cases pans shrill be large enough to cover cooling coil supply and return water headers and bends, and control valves. An extension condensate pan similar to primary drain pan shall be provided on those units where coil connections are to be made on both ends of the coil.

22.3.11.5 Cooling Coil

All cooling coils shall be standard three-row staggered seamless copper tube with aluminium plate fins mechanically bonded to copper tubes. Tubes shall be minimum 15 mm Outer dia and wall thickness shall be minimum 0.5 mm. All bends and joints shall be enclosed within insulated end sections of the base unit for protection against sweating. Each coil shall be provided with an air vent and drain plug. All coils shall be factory tested at 30 kg. per sq.cm. (450 psig) air pressure while submerged in water. Fin spacing shall be 12 or 13 fins per inch. Tubes shall be hydraulically expanded for minimum thermal contact resistance with fins.

22.3.11.6 Fans

Fans shall be centrifugal, forward-curve, direct-driven by a shaded-pole motor equipped with built-in overload protection. Units shall be complete with remote wall-mounted high, medium, low speed and off control switches.

22.3.11.7 Motor

Motor shall be 220+10 % volts, 50 cycles, single phase, six-pole, shaded pole type, speed not exceeding 1500 RPM at maximum airflow. Motors shall have three speed windings and shall be factory-wired to a junction box. Manufacturer shall supply a three-speed fan switch for wall mounting, where required.

22.3.11.8 Isolators

Ceiling-suspended horizontal units and units mounted within the ceiling space shall be hung through vibration isolation suspensions.

22.3.11.9 Accessories

All fan coil units shall be supplied with the following accessories:-

(a) Wall mounted thermostat for individual unit or group of units, containing three-speed and off control for fan speed, temperature control for summer/winter air conditioning.

(b) Three way motorized valve in water lines for individual unit.

(c) Outside-air wall box, as required.

(d) Adjustable discharge air grille, as required

(e) Automatic air vent.

22.3.11.10 BLANK

22.3.11.11 BLANK

22.3.12 Pumping Sets

Pump sets shall be of centrifugal type and suitable for the duty to be performed. Each pump shall have its own strainer, either 'Y' type or pot type strainers. With pot type strainer, 2 Nos isolating valves per strainer shall be provided. The valve on suction side of the pump may be used as one of the isolating valves. Motors for pumps shall be squirrel cage induction type, SPDP, and rated for continuous duty and suitable to-run on 415 volts, AC 3 phase. The pump shaft shall be of heat treated steel. The impeller, guide ring, stuffing box rings and shall be of bronze. The casing shall be of high quality cast iron.

22.3.13 Refrigerant and Oil Charge

Sufficient first charge of the proper refrigerant and lubricating oil for the compressor units and other accessories shall be provided.

22.3.14 Piping

22.3.14.1 All piping laid shall be as follows:-

Pipe Size	Material	Joints & Fittings	Sealing	Material
Upto 40mm	MS tube Heavy class IS 1439 - 1964	(i)Screwed/welded fittings (ii)Unions (iii)Slip-on flanges	(i) Non-hardening (ii) Lubricant	3 mm 3ply Rubber insertion
50 mm to 150 mm	MS tube Heavy Class IS 1439 - 1964	(i) Welded fittings (ii) Slip-on flanges (iii)Screwed flanges (for Gl pipes)	(i) Non-hardening (ii) Lubricant	3 mm, 3 ply Rubber insertion
200 mm to 300 mm	ERW welded pipes IS 3589 - 2001	(i) Welded (ii) Slip-on flanges	(i) Non-hardening (ii) Lubricant	3 mm, 3 ply Rubber insertion
350 mm and over	ERW welded pipes IS 3589 - 2001	(i) Welded (ii) Slip-on flanges	(i) Non-hardening (ii) Lubricant	6 mm, 3 ply Rubber insertion

Pipe size	Thickness of wall
350 mm to 400 mm dia	6 mm
450 mm to 900 mm dia	8 mm
1000 mm to 1400 mm dia	10 mm

22.3.14.2 All piping shall be black steel unless otherwise stated. Pipes shall be given one primary coat of red-oxide paint before being installed. Pipes shall be sloping towards drain points.

22.3.14.3 Fittings shall be new. Fittings used on welded piping shall be of malleable casting of pressure ratings suitable for the piping system. Fittings used on welded piping shall be of the weldable type. Supply of flanges shall include bolts, washers gaskets, etc. as required.

22.3.14.4 Tee-off connection shall be through reducing tees, wherever possible. Otherwise ferrules welded to the main pipe shall be used. Drilling and tapping of the walls of the main pipe shall not be resorted to.

22.3.14.5 All equipment and valve connections shall be through flanges (welded or screwed) for galvanized steel.

22.3.14.6 Sufficient number of flanges and unions shall be provided.

22.3.14.7 Gate valves/wafer type butterfly valves shall be provided as required:-

Size	Construction	Ends	Type
14 mm to 40 mm, 50 mm and over	Gun Metal Body - cast iron Seat - The resilient lining molded black nitride rubber Disc - SG Iron to TS: 1865 SG 400/14 Nylon coated	Screwed	Gate Butterfly valve

22.3.14.8 Valves shall have non-rising spindles unless otherwise specified and shall be suitable for 21 kg /sq cm test pressure. Tail pieces shall be used where required.

22.3.14.9 Butterfly valves shall conform to BS:5155, MSS SP 67 & APT 609 and designed to fit without gaskets between mating flanges. The valves shall be suitable for flow in either direction and seal in both directions. The valve shall be of integral moulded design.

22.3.14.10 Check valves shall be provided as required or and conform to the following specifications:

Size	Construction	Ends
14 mm to 65 mm	Gun metal	Screwed Female
75 mm and over	Gun Metal/CI	Flanged

22.3.14.11 Swing check valves shall normally be used in all water services. Lift type valves shall be used in horizontal runs. Air release and clean nut plugs shall be provided and valves shall be suitable for 21 kg/sq cm test pressure.

22.3.14.12 Balancing Valves

22.3.14.12.1 The balancing valves shall be flange type with built-in pressure drop and flow measuring facility. The body and bonnet of balancing valve shall be constructed in high quality cast iron (Cl-220) BS : 1152, Grad 220 ASTM - A48 CT-35. The disc shall be of corrosion resistant stainless steel of ASTM A296 GR. C A 15 with EPDM Sealing Spindle shall be provided with special double seal by EPDM back flow and graphite asbestos glared packing. Spindle shall be non-rising type of corrosion resistant stainless steel ASTM - A267 - 1967; Grade 410. The valve shall have two body plugs and one set of pressure test locks with built-in needle valves to measure pressure drop across the valve. The valve shall be suitable for maximum operating pressure of 16 Bar (230 Psi)

22.3.14.13 Strainers shall be preferably of the approved 'Y' type with Cl or fabticated steel bodies designed to the test pressures specified for the gate valves. Strainers shall have removable bronze/brass screen with 3 mm perforations and a permanent magnet. Strainers shall be provided with flanges or threaded sockets as required. They shall be designed so as to enable blowing out accumulated dirt and facilitate removal and replacement of screen without disconnection of the main pipe. All strainers shall be provided with equal size isolating gate valves so that the strainer may be cleaned without draining the system. Strainers shall be provided on the suction side of each pump; and inlet side of heat exchanger equipment wherever shown in the drawings.

22.3.14.14 Pipe Insulation

22.3.14.14.1 No insulation shall be applied on pipes until the pipes are satisfactorily tested.

22.3.14.14.2 All chilled water piping etc. shall be insulated in the manner specified here under.

22.3.14.14.3 Rigid sections of fibreglass wool (uniform density of 80 Kg/m^3 min) and with a 'K' value of not more than 0.034 Kcal per hr-sqm-degree C/Meter at 10 degree C mean temperature shall be used for chilled water pipes/chiller/expansion tank.

22.3.14.14.4 Bonding of insulation material shall be with a cold setting compound. Adhesive used for setting the insulation shall be non-flammable, vapour proof adhesive.

22.3.14.14.5 Chilled water pipes shall be insulated with rigid preformed sections of fibreglass or equivalent approved insulation of the following thickness :-

Pipe Dia (mm)	Thickness (mm)
15 - 200	65
over 200	75

22.3.15 Ducting

22.3.15.1 Duct Material

All ducts shall be fabricated from aluminium or from galvanized steel sheet of thickness as laid down in IS.655-1963 (Revised)

22.3.15.2 Duct Fabrication

22.3.15.2.1 All galvanized ducts shall be fabricated from lock form grade galvanized sheet steel zinc coated having zinc coating as specified. If not specified it shall be 275gm/m^2 total on both sides conforming with IS : 277-2003. Ducts shall be installed in a workman like manner, conforming to IS : 655 - 1963 (Revised)

22.3.15.3 Dampers

22.3.15.3.1 All dampers shall be with louver dampers of robust construction and tightly fitted. The design, method or handling, and control shall be suitable for the location and service required.

22.3.15.3.2 Dampers shall be provided with suitable links, levers and quadrants as required for their proper operation; control or setting devices shall be made robust, easy to operate and accessible through suitable access doors in the ducts. Every dampers shall have an indicating device clearly showing the damper position at all times.

22.3.15.3.3 Dampers shall be placed in ducts and at every branch of supply air duct connections, whether or not indicated on the drawings, for the proper volume control and balancing of the system.

22.3.15.4 Fresh Air Damper

22.3.15.4.1 Fresh air Damper shall be fabricated out of galvanized steel. The frame shall be fabricated out of 2.4 mm thick GS framed in channel shaped for adequate strength. The damper shall be multiblade opposite action. Each blade shall be 4" wide and fabricated out of 16 gauge galvanized steel framed for extra strength. The bearing shall be of nylon and hardware shall be of brass. Damper shaft have extension for actuator mounting.

22.3.15.5 Fire Dampers

22.3.15.5.1 Supply air ducts in plant room shall be provided with approved fire damper of at least 1½ hours fire rating.

22.3.15.5.2 Fire damper blades shall be single piece folded type high strength galvanized steel construction. In normal position these blades shall remain parallel to air stream providing maximum air passage and preventing passing air currents from creating noise or chatter. The blades shall be held in position through a motor. Access doors shall be provided at all damper locations and wherever indicated on the drawings. All access doors to be fabricated of the same material as the duct work and shall have a minimum of two hinges. Hinges shall be zinc plated, pins shall be of brass.

22.3.15.5.3 In case of fire, the signal from smoke detector, mounted in housing having air sampling arrangement by means of air sampling tubes and filters, shall close the fire damper as well as the air handling unit.

22.3.15.5.4 Fire damper sleeves and access doors shall be provided within the ducts. A self closing or sliding inspection door shall be provided in each duct section with fire damper.

22.3.15.6 Supply Air Registers

22.3.15.6.1 Supply air registers shall be of approved make and of aluminium construction with individually adjustable bars. Supply air registers shall be double deflection type, with removable key-operated volume control dampers. The outer frame shall be made out of extruded-aluminium section.

22.3.15.6.2 All registers shall be selected in consultation with the GE. Different spaces shall require horizontal or vertical face bars, and different width of margin frames.

22.3.15.6.3 All registers shall have a soft, continuous rubber gasket between the periphery of the register and the surface on which it has to be mounted. The effective area or the registers shall not be less than 80 percent total area.

22.3.15.6.4 Registers shall be adjustable pattern as such grill bar shall be pivotable to provide pattern with 0 to 100 degree horizontal arc and upto 30 degree deflection up or down. Bars shall hold deflection settings under all conditions of velocity and pressure.

22.3.15.6.5 Bars longer that 45 cm shall be reinforced by set back vertical member.

22.3.15.6.6 Registers shall be given a rust inhibiting prime coat and factory applied powder coat finish of approved color.

22.3.15.7 Supply Air Diffusers

22.3.15.7.1 Diffusers shall be of approved make and of aluminium construction, square in shape with flush fixed pattern or adjustable flow pattern. Diffusers for different spaces shall be selected in consultation with the consultant. All supply air diffusers shall be equipped with removable key operated volume control dampers. Anti - smudge ring shall be provided with all the diffusers.

22.3.15.8 Outside Air Louver

22.3.15.8.1 Outside air louvers shall be of approved make and of aluminium construction. Louvers shall be 100 mm thick, trainable, fixed type and shall have 55% free area. Blades shall be of one piece extrusion with gutters designed to catch and direct water to jamb and mullion drains. Jamb and mullion drains shall open on front face in order to direct water away from inside of the louver. All fasteners shall be of aluminium and louvers shall have enamel finish. All outside air louvers shall have framed 15 mesh removable mill finish aluminium bird screen.

22.3.15.9 Duct Insulation & Duct Lining

22.3.15.9.1 Insulation material shall be resin bonded fibreglass wool (density of 24 Kg/m^3). The Thermal conductivity of the insulation material shall not exceed 0.034 Kcal per hr-sq metre degree C/metre or 0.27 Btu/hr-sq. ft-degree f/inch at 32 degree C (90 degree F) mean temperature. Thickness of the insulation shall be 50 mm for exposed ducts and 40 mm for indoor ducts.

22.3.16 Hepa Filter Assembly

22.3.16.1 The housing shall be made from 11 gauge type 304 stainless steel. All joints and welds shall be sealed airtight and shall be ground free of all burrs and sharp edges.

22.3.16.2 The filter locking mechanism shall be a spring loaded, toggle type mechanism with thrust assembly which shall thrust the filter evenly against the sealing flange of the housing when it is installed.

22.3.16.3 The housing shall have two clamping maintenance nuts in each tier to operate the spring loaded mechanism which engages and disengages the filters on the internal sealing frame.

22.3.16.4 The housing access doors shall have double-pin hinges which shall pivot on the doors centerline to enable the door to make level contact on the gasket when closed and clamped. Stainless steel wing nuts shall be used to seal the door in place. The door shall have a 13m/$\frac{1}{2}$" thick closed cell neoprene gasket around the inside perimeter of the door.

22.3.16.5 The housing shall be designed such that all flanges shall be 45 mm wide.

22.3.16.6 The HEPA filters shall be industrial grade. The HEPA filter medium shall be all glass with a wet strength, water repellent, binder in accordance with MIL-F-51079 and preceded by a 30% efficiency plated medial filter.

22.3.16.7 Each filter shall be tested for resistance to airflow and penetration in accordance with MIL-F-51068. The critical pressure drop shall not exceed 0.249 Kpa (1" w.g) and the penetration shall not exceed 0.03%. The HEPA filters shall comply with the requirements for type A filters as per IES RP-CC-001-83-T. Each filter and filter carton shall bear identical labels indicating the filter model number, compliance with IES-RP-CC-001-83T, the serial number and the resistance and penetration readings taken for the filter on the manufacturer's penetrometers.

22.3.16.8 A magnetic gauge with quick disconnect fittings shall be furnished by the unit vendor and mounted on the exterior of the unit. The gauge range shall be 0-76 mm (0-3") water column. Capillary tubing and hardware used for the magnetic gauges shall be stainless steel.

22.3.16.9 Special Considerations

The filter body housing shall be 304 SSI, left hand configuration and have two gasketed access openings.

22.3.17 Automatic Controls and Instruments

22.3.17.1 Automatic Controls

22.3.17.2 Necessary automatic controls shall be provided to maintain the required conditions of temperature and humidity inside the air conditioned spaces. The individual safety control and various automatic controls shall be installed within the machines. However, the following automatic controls where indicated if not already installed on the machines shall be installed without any extra cost :-

(a) Three way Diverting Valves for air handling units shall be provided in chilled and hot water line at each air handling unit. Each valve shall be actuated by a space thermostat. Constant space conditions shall be maintained by allowing all of the chilled/hot water to either pass through the coil or to bypass the coil and mix-with the chilled/hot water return. The valve shall revert to fully bypass position when fan is shut off. Valve shall have brass seat, self adjusting Teflon cone packing and constant total flow through fullplug travel. These shall be installed in chilled/hot water line to act as three way diverting valves. Valve shall have facility to replace motor actuator without removing valve body.

(b) Motor shall be two position, no spring return reversible action, snap acting 60 sec/160 degree stroke, 150 TB/inch nominal torque, 300 TB breakaway torque, power consumption 15 watts. Motor shall be suitable for 24 volts supply and shall have a cover mounted 217/24 volts transformer factory-installed.

(c) Thermostats shall be electronic type with 3 point output for modulating 2 position reversible motor of 3 way valve of AHU with sensing element located in the return air stream. All thermostats shall be supplied with the standard mounting boxes. Electronic thermostat for operation and temperature control-of Fan Coil Unit shall be suitable for actuating the motorized diverting valve of FCU as well as on-off control of FCU along with the three speed control for fan motor. The range of thermostat shall be 15°C to 35°C with a differential of 1°C.

(d) Humidistat shall be provided with air handling unit where indicated for areas which require constant indoor humidity. One humidistat shall activate the reheat coils in case the space humidity rises beyond the preset limit, another humidistat shall energize the humidifier when the humidity falls below the present limit. These humidistats shall also de-energize these devices when the desired humidity is reached.

Humidistats shall be snap acting with humidifier/dehumidifier control from 17-80 percent relative humidity; with differential of 5 percent. Humidistat shall have nylon element with three bobbins, and removable knob to prevent tampering of set point. Humidistats shall also be provided with reheat applications.

22.3.17.3 Calibration and Testing

All automatic controls and instruments shall be factory calibrated and provided with necessary instructions for site calibration and testing. Various items of the same type shall be completely interchangeable and their accuracy shall be guaranteed. All automatic controls and instruments shall be tested at site for accuracy and reliability before commissioning the installation.

22.3.18 Electrical Installation

22.3.18.1 Work shall be carried out in accordance with the relevant clause of 'External Electrification' Specifications, local rules, Indian Electricity Act, 1910 as amended upto date and rules issued thereunder, regulations of the Local Fire Insurance Association and Indian Standard code of practice No IS:732-1989 (revised) including Indian Electricity Rules, 1956.

22.3.19 Workmanship

22.3.19.1 Installation of Equipment

22.3.19.1.1 All working plants and accessories such as compressors pumps, fans etc. shall be installed in accordance with the latest engineering practice on adequately designed vibration proof cement concrete foundations.

22.3.19.1.2 The installation work shall be carried out as per detailed dimensioned drawings and specifications of the foundations provided by manufacturer and seismic requirement.

22.3.19.1.3 All electrical equipment and wiring shall be electrically earthed in accordance with the latest Indian Electricity Rules.

22.3.19.1.4 Unless otherwise specified all civil works connected and incidental to air conditioning work including making foundation for equipments, making holes in walls/ floors/ceilings and making good the same after installation of chilled/hot/ condenser water piping, ducting and cabling work shall be done.

22.3.19.1.5 All equipment and steel and iron works shall be neatly installed and painted with three coats of painting, primer, under coat and finishing coat with approved quality of paint.

22.3.19.2 Installation Of Air Handling Units

22.3.19.2.1 Connections

22.3.19.2.2 The piping installations adjacent to units shall allow unit servicing and maintenance.

22.3.19.2.3 Connection piping to air-handling units shall be with flexible connections.

22.3.19.2.4 The condensate drain pans shall be connected by using 65 mm (2-1/2-inch) minimum, insulated Gl pipe and extend to nearest floor drain. There shall be deep trap at connection to drain pan and clean outs at changes in direction shall be installed.

22.3.19.2.5 Adjusting, Cleaning and Protecting

22.3.19.2..6 Water coil flow shall be adjusted, with control valves to full coil flow, to indicate lps (gpm).

22.3.19.2.7 Damper linkages for proper damper operation shall be adjusted.

22.3.19.2.8 Unit cabinet interiors shall be cleaned to remove foreign material and construction dirt and dust vacuum clean fan wheel fan cabinet, and coils entering air face.

22.3.19.2.9 Commissioning

22.3.19.2.10 The following operations and checks shall be performed before start-up :-

(a) Disconnect fan drive from motor and verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

(b) Lubricate bearings, pulleys, belts, and other moving parts with factory recommended lubricants.

(c) Set outside-air and return air mixing dampers to minimum outsideair setting.

(d) Comb coil fins for parallel orientation.

(e) Install clean filters.

(f) Verify manual and automatic volume control, and fire dampers in connected ductwork system are in the full-open position.

Disable automatic temperature control operators.

22.3.19.2A Testing of AHUS

Cooling/heating capacity of various air handling units and FCUs shall be computed from the measurements of air flow and dry and wet bulb temperatures of air entering and leaving the coil. Flow measurements shall be by an anemometer and temperature measurements by accurately calibrated digital thermometers. Power consumption shall be computed from measurements of incoming voltage and input current where as, noise level at various locations within the conditioned spaces shall be measured by a sound pressure level meter.

22.3.19.3 Piping Installation

22.3.19.3.1 Piping shall be properly supported on or suspended from stands, clamps, hangers etc., as specified and as required.

22.3.19.3.2 Pipe supports shall be of steel, adjustable for height and primer coated with rust preventive paint and finish coated black. Where pipe and clamp are of dissimilar material, a gasket shall be provided in between. Spacing of pipe supports shall not exceed the following :-

Pipe Size (mm)	Spacing (m)
3 to 12	1.19
19 to 25	1.83
32 to 150	2.44
150 and above	3.05

22.3.19.3.3 Vertical risers shall be parallel to walls and column lines and shall be straight and plumb. Risers passing from floor to floor shall be supported at each floor by clamps or collars attached to pipe and with a 12 mm thick ribbed rubber pad or any other approved resilient material. Where pipes pass through the terrace floor, suitable curbing shall be provided to prevent water leakage. Risers shall also have a suitable concrete pipe support at the lowest point. Pipes laid in masonry trenches shall include proper steel supports. Pipe hangers shall be fixed on walls and ceilings by means of metallic rawl plugs/dash fasteners/expansion bolts.

22.3.19.3.4 Pipe sleeves of 50 mm or larger diameter shall be provided wherever pipes pass through wall and the annular space filled with fiber glass and finished with retaining rings and covered with fire proof silicon.

22.3.19.3.5 Insulated piping shall be supported in such a manner as not to put undue pressure on the insulation. 1.80 mm metal sheet shall be provided between insulation and the clamp saddle or roller extending at least 150 mm on both sides of the clamp, saddle or roller.

22.3.19.3.6 Piping work shall be carried out with minimum disturbance to the other works being done at the site.

22.3.19.3.7 Piping layout shall take due care for expansion and contraction in pipes.

22.3.19.3.8 All pipes using screwed fittings shall be accurately cut to the required sizes and threaded and burrs removed before laying. Open ends of the piping shall be locked as the pipe is installed to avoid entrance of foreign matter. Wherever reducers are to be made in horizontal runs, eccentric reducers shall be used if the piping is to drain freely; in other locations, concentric reducers shall be used.

22.3.19.3.9 The pipe welding shall be done by making a proper "V" at the joints by chamfering the end by means of grinder. For pipes of 200 mm dia and above, the welding of joints shall be done by inserting a MS flat/round ring inside the joints. Flanges shall also be chamfered before welding to pipes.

22.3.19.3.10 Air valves shall be provided at all high points in the piping system for venting. Valves shall be of the double float type, with GM/CI body, vulcanite balls, rubber seating, etc. Air valves shall be of the sizes specified and shall be associated with an equal size, gate valve with rising spindle. Discharge from the air valves shall be piped through an equal sized GS pipe to the nearesl drain or floor waste or as shown.

Mains	Air Valves
Upto 100 mm dia	25 mm dia
100 mm to 300 mm dia	32 mm dia
Over 300 mm dia	50 mm dia

22.3.19.3.11 All buried pipes shall be insulated as specified and then wrapped with two layers of fiberglass felt, each layer laid in bitumen.

22.3.19.3.12 Drain shall be provided at all low points in the piping system and shall be of the following sizes:

Mains	Drains
Upto 300 mm dia	25 mm dia
Over 300 mm dia	38 mm dia

22.3.19.3.13 Drains shall be provided with gate valves of equal size with rising spindle. Drains shall be piped through equal size GI pipe to the nearest drain or floor waste or as shown on the drawings. Piping shall be pitched towards drain points.

22.3.19.4 Pressure Gauges

22.3.19.4.1 Pressure gauge shall not be less than 100 mm dia dial type and of appropriate range and be complete with shut off gauge cocks etc. duly calibrated before installation.

22.3.19.4.2 Pressure gauges shall have micro meter type zero adjuster.

22.3.19.4.3 Scale of gauge shall be white with black letters (printed).

22.3.19.4.4 Pressure gauges shall be as per IS-3624 - 1987.

22.3.19.4.5 Scale shall be so selected that normal process pressure is approximately 75% of full scale reading.

22.3.19.4.6 Pressure gauges shall be provided at the following location and as indicated on the drawings :-

(a) Supply and return of condensers.

(b) Suction and discharge of pumps.

(c) Inlet and outlet of heat exchangers (cooling coils & heating coils).

22.3.19.5 Temperature Gauges

22.3.19.5.1 Temperature gauges shall be 100 mm dia dial type of appropriate range duly calibrated before installation.

22.3.19.5.2 Temperature gauges shall have 100 mm dia. dial with diecast minimum, stove enamel black finish case, aluminium screwed ring and shatter proof glass.

22.3.19.5.3 Accuracy shall be +1.0% of full scale or better.

22.3.19.5.4 Minimum over range protection shall be 25 % of full scale range.

22.3.19.5.5 Dial type temperature gauges shall be provided at supply and return of chillers, condensers, cooling coils. Hot water generator and coils and as indicated on the drawings.

22.3.19.6 Vibration Elimination

22.3.19.6.1 Piping installation shall be carried out with vibration elimination fittings wherever required.

22.3.19.7 Expansion Tank

22.3.19.7.1 Expansion tank of the required size shall be provided. The bottom of the tank shall be at least 0.61 M above the highest point of the system. MS tanks may be provided unless other wise stated. The tanks shall bo insulated as described in the section 'insulation' and shall be complete with float valves, gauge glass, drain, overflow and make-up connections complete with gate valves and vent piping wherever required. MS sheet shall be minimum 5 mm thick.

22.3.19.8 Testing

22.3.19.8.1 All piping shall be tested to hydrostatic test pressure of at least one and a half times the maximum operating pressure, but not less than 21 kg/sq. cm for a period of not less than 24 hours. All leaks and defects in joints revealed during the testing shall be rectified.

22.3.19.8.1.1 Piping repaired subsequent to the above pressure test shall be retested in the same manner.

22.3.19.8.2 Systems may be tested in sections and such sections shall be securely capped.

22.3.19.8.3 All testing shall be witnessed by the GE or his authorized representative.

22.3.19.8.4 Proper noiseless circulation of fluid shall be achieved through all coils and other heat exchange equipment in the system concerned.

22.3.19.8.5 No insulation shall be applied to piping until the completion of the pressure testing to the satisfaction of the GE.

22.3.19.8.6 All materials, tools, equipment, instruments services and labour required to perform the test, shall be provided by the contractor.

22.3.19.9 Painting

22.3.19.9.1 After the piping has been installed, tested and run for at least ten days of eight hours each, the piping shall be given two finish coats as follows:

Services	Flow	Colour
Condenser water	Supply and return	As approved by the GE
Chilled water	Supply and return	-do-

22.3.19.9.2 The direction of flow of fluid in the pipes shall be visibly marked in white arrows or as directed by the GE.

22.3.19.10 Air Distribution

22.3.19.10.1 All ducts leading to and returning from, including recirculation for zero bacteria. HEPA filtration area shall be of aluminium construction from the AHU onwards.

22.3.19.10.2 Ducts shall be straight and smooth on the inside with neatly finished joints. All joints shall be made air tight by applying sealant during the assembly of the duct work. Sealing of the seams shall be accomplished by using sealant.

22.3.19.10.3 Transverse joints shall be made using sponge rubber sulphur-free rubber gasketing (3 mm thick and 20 mm wide).

22.3.19.10.4 All exposed ducts within conditioned spaces shall have only slip joints and no flanged joints. The internal ends of slip joints shall be made in the direction of air flow. Changes in dimensions and shape of ducts shall be gradual. Curved elbow, unless otherwise approved, shall have a center line radius equal to one and half times the width of the duct. Air turns shall be installed in all abrupt elbows and shall consist of curved metal blades or vanes, arranged to permit the air to make the turns without appreciable turbulence.

22.3.19.10.5 All ducts shall be rigid and shall be adequately supported and braced where required with standing seams, tees or angles of ample size to keep the ducts true to shape and to prevent buckling, vibration or breathing.

22.3.19.10.6 All sheet metal connections, partitions and plenums required to confine the flow of air to and throughout the filters and fans, shall be constructed out of 18 gauge galvanized steel sheet, thoroughly stiffened with 210 mm x 210 mm x 3 mm angle iron braces and fitted with all necessary doors as required to give access to all parts of the apparatus. Doors shall not be less than 410 cm x 410 cm in size.

22.3.19.10.7 Volume control dampers shall be installed as required.

22.3.19.10.8 Duct Installation

22.3.19.10.8.1 All ducts shall be installed generally as per the drawings prepared.

22.3.19.10.8.2 Where it becomes necessary to avoid beams or other structural work, plumbing or other pipes, and/or conduits, the ducts shall be transformed, divided or curved to one side.

22.3.19.10.8.3 All duct work shall be independently supported from building elements. All horizontal ducts shall be rigidly and securely supported, in an approved manner, within hangers formed of MS rods and angle iron under ducts not greater than 2 metre centres. All vertical duct work shall be supported by structural members at each floor.

22.3.19.10.8.4 Ducting on top of the ceiling shall be supported from the slab above, or from beams. In no case shall a duct be supported from the ceiling hangers or be permitted to rest on a hung ceiling

22.3.19.10.8.5 All ducts shall be totally free from vibration under all conditions of operations. Whenever duct work is connected to fans, that may cause vibrations in the duct, ducts shall be provided with two flexible connections located close to the unit in mutually prependicular directions. Flexible connection shall be constructed on fire resistant flexible double canvas sleeves at least 10 cm long, secured properly and bolted at both ends. Sleeves shall be made smooth and connecting duct work rigidly held by independent supports on both ends. Flexible connections shall be suitable for pressure at the point of installation.

22.3.19.10.8.6 The two mating flanges of the ducts being joined with each other shall be made air tight by providing 3 mm thick 20 mm wide Sulfur free sponge rubber gasket on mating flanges.

22.3.19.10.9 Testing and Balancing

22.3.19.10.9.1 After completion of the installation of the complete air distribution system, all ducts shall be tested for air leaks.

22.3.19.10.9.2 Before painting the interiors, air distribution system shall be allowed to run continuously for 48 hours for driving away any dust or foreign material lodged within ducts during installation.

22.3.19.10.9.3 The entire air distribution system shall be balanced using approved anemometer. Air quantities at the fan discharge and at various outlets shall be identical to, or less than 5 percent in excess of, those specified and quoted. Leakage in each air distribution system shall be within 3 percent so that supply air volume at each fan shall be identical to or not greater than 3 percent in excess of the total air quantity measured at all supply outlets served by the fan. Branch duct adjustments shall be made by volume or splitter dampers. Dampers shall be permanently marked after air balance is complete so that these can be restored to their correct position if disturbed at any time. Complete air balance report shall be submitted to the GE for scrutiny and approval, after which six copies of the approved report thereafter shall be provided by contractor.

22.3.19.10.9.4 The duct access holes used for balancing are to be sealed with metal or plastic snap-in plugs. Complete air balance report shall be submitted to the GE for scrutiny and approval, and six copies of the approved report thereafter shall be provided with completion documents by contractor.

22.3.19.11 Pipe Insulation

22.3.19.11.1 Insulation on chilled water pipes shall be applied as described here in after.

22.3.19.11.2 Pipes shall be thoroughly cleaned with wire brush and rendered free from dirt, dust, grease and all foreign matter. Surface shall be painted with two coats of bituminous paint.

22.3.19.11.3 Two coats of rubber based adhesive CPRX compound manufactured by Ms Shalimar Tar products/equivalent shall be applied on the cleaned pipe surface.

22.3.19.11.4 Fibre glass rigid sections shall be fixed tightly to the surface. All joints shall be sealed properly. Fixing and sealing compound shall be CPRX.

22.3.19.11.5 Cover with Aluminium Foil /Kraft Paper laminate with a minimum overlap of 50 mm shall be provided. Each lap joint shall be sealed with self adhesive Aluminium Foil tape 50 mm wide.

22.3.19.11.6 Vapour retarder mastic (1st layer) MAS 130 or equivalent for outdoor and Mastic MAS 136 or equivalent for indoor application shall be applied @ 1 kg/m^2 by trowel or brush application.

22.3.19.11.7 Above layer is still tacky, re-inforcing matrix of open weave glass fabric 10 x 10 mesh shall be provided.

22.3.19.11.8 Apply finish coat of MAS 130 or equivalent mastic for outdoor and Mastic MAS 136 or equivalent for indoor duty @ 1.5 kg/m^2 all over finishing the surface cleanly leaving no thin spots and ensuring continuation of vapour barrier at the interface of pipe/equipment metal shell edges in insulation. Care shall be taken around nozzle and manholes and at any spots where there are gaps in the foil layer.

22.3.19.11.9 Two coats of synthetic enamel paint shall be applied as specified after surface preparation.

22.3.19.11.10 Condensate piping shall also be insulated in the manner specified above.

22.3.19.11.11 Hot water pipes shall be insulated as below:-

(a) Clean the surface to be free of loose mill scale, rust, old paint and all foreign matter using wire brush and mop.

(b) Apply recommended paint suitable for continuous exposure upto 110°C using recommended primer.

(c) Apply bonded rock wool pipe section 50 mm thick and hold in place using bands of aluminium 15 mm wide and 0.111 mm thick at every 500 mm spacing. Fill voids at joints with insulation or loose rock wool to ensure that there are no gaps.

(d) Finally cover the insulation with fabricated aluminium cladding duly grooved, lapped by at least 50 mm and sealed against ingress of water using MAS-94 or equivalent sealant.

22.3.19.11.12 All valves, fittings, strainers, etc., shall be insulated to the same thickness as specified for the main run of piping and applied generally in the manners specified above, valves bonnets, yokes and spindles shall be insulated in such a manner as not to cause damage to insulation when the valve is used or serviced.

22.3.19.11.13 Pumps shall be insulated to the same thickness as the pipe to which they are connected and applied generally in the manner specified above. Care shall be taken to apply the insulation in a manner as to allow the dismantling of pumps without damaging the insulation.

22.3.19.11.14 Expansion tanks shall be insulated to the same thickness as for the pipes to which they are connected. The mode of the insulation shall generally be as above.

22.3.19.11.15 All pipes laid underground shall be provided with a layer of synthetic tar felt over the insulation described earlier.

22.3.19.12 Duct Insulation

22.3.19.12.1 Duct insulation shall be applied as follows:-

(a) Clean the surface to be insulated to make it free of millscale, dirt, dust, grease and such foreign matter. Paint the surface with two coats of Bituminous paint - taking special care over non galvanised parts that may be buried within the insulation.

(b) Apply rubber based adhesive CPRX compound manufactured by Shalimar Tar products/ Equivalent at 1.12 to 1.8 sq.mtr per kg.

(c) Fiber glass rigid sections shall be fixed tightly to the surface. All joints to be sealed properly. Fixing and sealing compound shall be CPRX.

(d) Cover with Aluminium Foil Kraft Paper laminate with a minimum overlap of 50 mm. Seal each lap joint with self adhesive Aluminium Foil tape 50 mm wide.

(e) In all cases where the duct width is over 600 mm, insulation support hangers. either of metallic or PVC/HDPE fabrication adhered to bottom of duct surface shall be provided to prevent sagging. Support spacing shall not be over 500 mm in each direction for 25 mm thickness of insulation and 350 mm for 50 mm thickness of insulation.

(f) Apply vapour retarder mastic (1st layer) MAS 130 or Equivalent @ 1 kg/m^2 by trowel or brush application at all points of penetration of support brackets, hangers etc. to maintain complete protection against vapour ingress through these vulnerable points. Self adhesive Aluminium Foil tape may be used for this purpose where the penetration point is in a flat insulation area.

(g) No metal cladding is needed for indoor applications. In case of ducting exposed to weather, a final aluminium cladding of 0.121 mm thickness fabricated with grooves at edges, cross ribbed and overlapped at joints to 50 mm (min). All joints in cladding shall be disposed to shed water and sealed with MAS-94 or equivalent metal sealant.

(h) All cladding joints shall be secured with minimum usage of 'pop' rivets. While drilling holes for the purpose, specially shortened drill bits shall be employed and care taken to prevent puncturing of the inner vapour barrier layer. Main securement shall be with aluminium straps 25 mm wide, 0.91 mm thick and at a spacing of 425 mm (max). Sheet angles 50 x 50 x 125 long shall be placed at corners to prevent local buckling.

22.3.19.13 Duct Lining

Material for acoustic lining shall be resin bonded fibre glass or other approved equivalent. The thermal conductivity shall not exceed 0.034 Kcal per hr sqm. degree C/meter at 30 degree C mean temperature difference and density shall not be less than 32 kg./cum. Acoustical linning of duct wherever specified shall be applied as follows :-

(a) Fix wooden frame work in hollock (Assam Teak) 25 mm wide x depth equal to thickness of insulation at 600 mm centre, screwed to the sheet metal by means of brass metal screws.

(b) Supply and fix fibreglass Crown 200 or other approved equivalent material in the Wooden frame work with joints well butted together.

(c) Cover insulation with RP tissue.

(d) Finally cover the insulation with 213 SWG perforated aluminium sheet having at least 20% perforation with joints overlapped and screwed to the wooden frame by means of brass metal screws, to produce an even surface.

22.3.19.14 Balancing, Testing and Commissioning

22.3.19.14.1 Balancing of all air systems and all tests shall be carried out by the contractor in accordance with the specifications, the relevant Indian Standard Specifications and recommendations of the American Society of Heating, Refrigerating and Air Conditioning Engineers (USA). Test results for summer,winter and monsoon shall be tabulated in approved manner and four copies shall be submitted to the Accepting Officer for his scrutiny. Four copies of the certified manufacturers performance curves for each piece of equipment shall be submitted along with the test results. The contractor shall also provide to the GE four copies of record of all safety and automatic control settings for the entire installation.

22.3.19.14.2 The contractor shall pay for and arrange, without any extra cost to the Govt, all necessary balancing and testing equipment, instructions, materials, accessories, fuel and the requisite labour. Electricity and water supply shall be made available by the department free of cost. Any defect in materials and/or in workmanship detected in the course of testing shall be rectified by the contractor entirely at his own cost, to the satisfaction of the GE. The installation shall be tested again after removal of defects and shall be commissioned only after approval by the Accepting Officer. All tests shall be carried out in the presence of the representative of accepting officer.

22.3.19.15 Laying of Cables

22.3.19.15.1 Cables on overhead supports

Cable on overhead support shall be properly secured and supported at required intervals as directed by Engineer-in-Charge on mild steel slotted angles.

22.3.19.15.2 Clamps at regular intervals as directed by the GE shall be provided. No inflammable material shall be used for clamping or supporting cables.

22.3.19.15.3 At all entrances/exists through walls, the cable shall pass through asbestos cement pipes. The contractor shall submit complete layout of cables and location of AC pipes before commencement of work and obtain the approval of GE. The ends of pipe shall be sealed after the cable is laid with a suitable non-combustible material by the Contractor. LT panels shall have glands for cable entry and exit and bushes for wire entry and exit.

22.3.19.16 Drawings

Shop drawing for control panel and wiring of equipment showing the route of conduit/ cables shall be got approved from the Accepting Officer before starting the fabrication of panel and starting the work. On completion, two sets of completion "As installed" drawings incorporating all details like conduit routes, number of wires in conduit, location of panels, switches, junction/pull boxes and cable route etc. shall be furnished by the contractor.

22.3.20 Testing

22.3.20.1 Intial Test : Phase I Test

22.3.20.1.1 The installation shall be taken over after the plants have been commissioned and the GE is satisfied on the points given below which constitute Phase I Test. All facilities to conduct Phase I test shall be provided by the contractor:-

(a) That the plants, equipments and accessories provided are as per specifications.

(b) That all plants, equipments and accessories are mechanically sound and other related items of air condit ioning work are of adequate structural strength and the installations are in conformity with the specifications embodied in the contract.

(c) That all ducts, pipes, fittings etc. are of specified type, quality, design and workmanship and are neatly laid, fixed and painted to match the surrounding work.

22.3.20.2 Phase II Tests

22.3.20.2.1 The "Phase II Tests" shall be carried out by the contractor in the presence of an officer nominated by the Accepting Officer after phase I tests. The authorized representative of the users shall also be associated during this Phase II Test. Each test shall last continuously for 3 days. The plant shall be able to achieve design temperature and relative humidity with in tolerance limits as specified during 72 hours testing for each of the three seasonal tests, except readings taken in the first two hours of start. The contractor shall afford all facilities and make all necessary arrangements for these tests. The phase II tests shall be carried out as soon as the stipulated load and weather conditions are available but within one year after Phase I Test. It shall be the responsibility of contractor to get the phase II tests conducted within this period. In case of failure to get the tests conducted within time contractor will not be absolved of his responsibility to get the tests conducted subsequently and shall become liable to such liabilities and penalties as per stipulation in the contract in this regard. In case the required load is not available, arrangement will be made by the contractor at his own cost to provide artificial load. These tests comprise of the following :

22.3.20.2.2 Hot weather test shall be conducted in Apr/May and performance is to be recorded.

22.3.20.2.3 Monsoon test shall be conducted in Jul/Aug and performance is to be recorded.

22.3.20.2.4 Winter test shall be conducted in Dec/Jan and performance is to be recorded.

22.3.21 Charts and Layout Diagrams

22.3.21.1 After completion of work the contractor shall provide at the plant room the following drawing glass frame :-

(a) Schematic diagram of the A/C plant.

(b) Brief Description of the A/C plant.

(c) Wiring Diagram.

(d) Refrigerant Schematic diagram.

(e) Condenser water piping etc.

(f) Shock treatment chart

(g) Operating instructions.

(h) One additional set of the above drawings shall be provided for record.

22.3.22 Fire Safety

22.3.22.1 All air conditioning installation comprising of all the components including AHUs, Ducts, piping etc. shall satisfy the requirements laid down in relevant IS.

SECTION 23
LIFTS : PASSENGER, GOODS AND SERVICE LIFTS

23.1 General
These specifications pertaining to lift works cover the details of equipment to be supplied, installation, testing and commissioning of lifts.

23.1.1 The lifts (passenger, goods and service lifts) shall comply with these specifications,statutory Code of practices, BIS specifications and IE Rules. The lifts shall comply with all regulations on safety aspects. The installation of lifts shall also conform to local lifts Act and rules and local municipal bye Laws.

23.1.2 The number of lifts, its speed, capacity and type of lifts for different usage shall be as per recommendations of IS:14665(part-I) 2000.

23.2 List of Code of Practices and BIS specifications
The design, installation, testing and commissioning of lift work shall comply with the following as applicable :-

IS:14665 (Part-1) - 2000	: Electric Traction Lifts (Part-1 Guidelines for dimensions of passenger, goods, service and hospital lifts)
IS:14665(Part-2/Sec 1&2) - 2000	: Electric Traction Lifts (Part-2 Code of practice for installation, operation and maintenance. Sec 1-Passenger and Goods Lifts, Sec 2-Service Lift)
IS: 14665 (Part-3/Sec 1&2) - 2000	: Electric Traction Lifts (Part-3 Safety Rules, Sec 1-Passenger and Goods Lifts, Sec 2-Service Lifts)
IS: 14665 (Part-4/Sec 1to9) - 2001	: Electric Traction Lift(Part 4 components)
IS:14665 (Part-5) - 1999	: Electric Traction Lift (Part-5 Inspection Manual)

23.3 Details of lift well for installation of lifts

23.3.1 The lift well shall be as per clause 5 of IS: 14665.

23.3.2 There shall be no other opening in the lift well except for the landing openings. All landing openings in lift well enclosures shall be protected by doors/collapsible doors which shall extend to the full height and width of the landing opening.

23.3.3 Light points shall be provided in the lift well at a spacing not exceeding 10m. All the light points shall have control from the machine room. A socket outlet may also be provided at a suitable place for use by maintenance staff above the ground floor landing.

23.3.4 Lift Pit: The lift pit shall be provided proper water proofing treatment so that the same remains dry. If the lift pit depth is more than 1.6m, a ladder to the height of 0.75m above the lift pit floor shall be provided to reach the lift pit. The lift pit shall have provision for a separate access. In case of two lifts in the well, one access to the lift pit shall be adequate.

23.3.5 Machine Room: The load carrying capacity of the floor shall be obtained from the lift manufacturers. Suitable lifting beams below the machine room shall be provided for lifting any heavy object as per requirement of the lift manufacturer. Provision for pulley for lifting of heavy items/lift machinery is required which will facilitate inspection and repair. The machine room shall be properly ventilated.

23.4 Partition in lift well

Where two or more lifts are installed in a common lift well, provision shall be made by dividing beam and rigid metal screen to separate each lift from an adjacent lift or its counterweight.

23.5 Guide Rails

The guide rails shall be as per IS: 14665. Rigid steel guides shall be used for guiding lift car and counterweight throughout its travel. The strength of the guides, its attachments and the joints shall be sufficient to withstand the forces imposed due to the operation of the safety gear and deflection due to uneven loading of the lift car. Only machined guide rails shall be provided for passengers and hospital lifts. The guide tracks shall be supported at suitable intervals and shall be embedded into the walls. Wood or fibre blocks or plugs shall not be used for securing guide brackets.

23.6 Guide shoes

Two numbers of guide shoes at the top and two numbers at the bottom shall be provided on the lift car and counter weight. Guide shoes shall be provided with adjustable mountings and shall be rigidly secured in accurate alignment at the top and bottom on each side of the car sling and counterweight frame construction. When oil buffers attached to the bottom of the counterweight are used then additional guide shoes shall be provided on each side of the buffer frame.

23.6.1 For passenger lifts and bed-cum-passenger lifts, sliding guide shoes shall be provided for speeds upto 1.5 mps (metre per second. Sliding guide shoes for cars shall be flexible. Solid guide shoes can be used for counterweights for speeds up to 1.0 mps. When speed exceeds 1.5 mps, roller guide shoes shall be provided for car and the counterweight.

23.7 Buffers

Buffers shall be provided at the bottom limit of travel for cars and counterweights. Energy dissipation type buffers shall be used wherever the rated speed of the lift excceeds 1mps but energy accumulation type buffers shall be preferred if the rated speed of the lift does not exceed 1 mps.

23.8 Counterweight

The counterweights shall be of metal and it shall be in the form of multiple sections. It shall be contained and secured within a steel frame and shall be equal to the weight of the complete car plus approx 50% of the rated load. At least, four guide shoes, capable of being easily renewed or having renewable linings shall be provided on the counterweight.

23.9 Suspension ropes

Cars and counterweights shall be suspended from round strand steel wire ropes of best quality having a tensile strength not less than 12.5 tonnes/cm2. The size and number shall be in accordance with standard Code of practice/BIS specifications. Lubrications between the strands shall be achieved by providing impregnated hemp core. The nominal diameter of the ropes shall be at least 8 mm.

23.9.1 Compensation ropes

For travels over 40 m and/or rated speed of the lift exceeds 2.5mps, the provn of compensation ropes with tensioning pulleys shall be considered. For speeds of 2.5 mps or below, quiet operating chains or similar devices shall be used as the means of compensation. For speeds above 3.5 mps, an anti-rebound arrangement of idler tension pulley shall be provided to prevent the counterweight jumping with the application of the car safety gear.

23.10 Car Construction

The lift car construction shall be in conformity with Code of Practices, BIS specifications and IE Rules.

23.10.1 Car Frame: The lift car body shall be carried in a steel car frame sufficiently rigid to withstand the operation of the safety-gear without permanent deformation of the car frame. The deflection of the members carrying the platform shall not exceed 1/1000 of their span under static conditions with the rated load evenly distributed over the platform.

23.10.2 Car Enclosures: The whole of the internal face of the car shall be of 1.5mm thick stainless steel sheet lined. A suitable plywood backing shall be used to reinforce the car wall panels. A stainless steel handrail shall be provided on three sides of the lift car, extended to within 150 mm of all corners and a stainless steel skirting panel approximately 100 mm deep shall be provided. Stainless steel false ceiling with concealed fluorescent light fitting and ventilating fan complete with metal ceiling diffuser shall be provided. The car ventilation fan shall be switched off within a period which shall be adjustable from 5 to 15 minutes after the last registered call is answered. The lift car excluding linings, shall be constructed of non-combustible materials. The lift car shall have adequate illumination. The illumination level shall not be less than 150 lux on the lift floor level.

23.10.3 Emergency Lighting: The lift car shall also be provided with emergency lighting operated by a rechargeable battery supply. The lighting shall be automatically switched on in the event of failure of normal power supply to the lift.

23.10.4 Car Platform: The lift car platform shall be designed on the basis of rated load evenly distributed. The dimensions shall conform to IS: 14665 unless otherwise specified. The flooring shall be smooth and non-skid type. The PVC/rubber flooring of minimum 3mm thickness shall be preferred for passenger and bed-cum-passenger lifts. The flooring for goods lift shall be strong enough to take the rated load without any deformation or damage.

23.10.5 Car Roof: The car roof shall be solid type and capable of supporting a weight of atleast two persons (approx 140 kg) without causing permanent deformation. Ceiling lights shall be of recessed type and be protected by stainless steel metal bars. A recessed ceiling fan complete with heavy duty metal diffuser and capable of providing 20 air changes per hour in the car shall be provided.

23.10.6 Car Doors: The doors for passenger lifts shall be of metal and the internal face of the car door shall be suitably lined as the same in the lift car. The doors shall be in two panels and centre opening with automatic power opening and closing unless otherwise specified. The car shall be equipped with an electronic door sensor which can detect an obstruction at the car entrances and control the closing of the doors. The car door shall be provided with an electrical switch which will prevent the lift car from being started or kept in motion unless all car doors are closed.

23.10.7 Door re-opening device: Door re-opening device shall be fitted to the leading edge of both car door panels, which shall automatically initiate re-opening of the door in the event of a passenger being struck (or about to be struck) by the door in crossing the entrance during the closing movement. It shall be so designed and installed that for centre opening doors the obstruction of either leading edge when closing will cause it to function.

23.10.8 "Door-Open" alarm for manually operated doors: For manually operated doors and power assisted doors, a 'door open' alarm shall be provided in the car to draw attention to a car or landing door which has been left open for an adjustable period up to 10 minutes.

23.11 Landing doors

The car entrance shall be provided with a car door which shall extend to the full height and width of the car opening. The opening for the landing doors shall not be wider than that of the lift car. The top track of the door shall not obstruct the car entrance. All landing openings in lift well enclosures shall be protected by doors/collapsible doors which shall extend to the full height and width of the landing opening.

23.11.1 Vision Panels

The landing doors shall be provided with transparent vision panel of minimum thickness 6mm, made of an approved material or glass of a tempered or laminated type.

23.11.2 Landing door locking device

Every landing door shall be provided with an effective locking device so that it shall not normally be possible to open the door from the landing side unless the lift car door is in that particular landing zone. It shall not be possible under normal operation to start the lift car or keep it in motion unless all landing doors are in the closed position and locked.

23.12 Terminal stopping and limit switches

The lift shall be provided with normal terminal stopping switches and limit switches. They shall be positively operated by the movement of the car. These switches shall either be mounted on the car frame or in the lift well.

23.12.1 The limit switches shall either open directly by mechanical separation of the circuits feeding the motor and brake, and provisions shall be made so that the motor cannot feed the brake solenoid, or open, by an electrical safety device, the circuit directly supplying the coils of the two contactors, the contacts of which are in series in the circuits supplying the motor and brake.

23.13 Safety Gear

The lift (except service lift) shall be provided with safety gears capable of operating only in the downward direction and capable of stopping a fully laden car, at the tripping speed of the over-speed governor, even if the suspension devices break, by gripping the guides and holding the car there.

23.14 Over-speed governor

The car safety shall be operated by speed governor located overhead and driven by governor rope suitably connected to the car and mounted on its own pulley. Over-speed governor shall operate the safety gear at a speed at least equal to 115% of the rated speed. For rated speeds upto 1 mps maximum governor tripping speed shall be either 140% of the rated speed or 0.88mps, whichever is higher. For rated speed exceeding l mps, maximum governor speed shall be 115% of the rated speed plus 0.25mps. The means for adjusting the over-speed governor shall be sealed after setting the tripping speed.

23.14.1 Governor Ropes

The governor ropes shall not be less than 6 mm in diameter and shall be of flexible wire rope. The rope shall be tensioned by a tensioning pulley and the pulley (or its tensioning weight) shall be guided. The breakage or slackening of the governor rope shall cause the motor to stop by means of an electrical safety device. The device shall be of bi-stable type requiring manual reset.

23.15 Overload device and full load device

The lift shall be provided with an overload device which shall operate when the load in the car is 10% or more in excess of the rated load of the lift. The overload device, when in operation, shall :-

(i) prevent any movement of the car,
(ii) prevent the closing of any power operated door whether fitted to the car or to the landing at which the car is resting, and
(iii) give audible and visible signals inside the car.

The lift shall resume normal operation automatically on removal of the excessive load. The overload device shall be inoperative while the lift car is in motion.

23.15 Full load device

The lift (other than a service lift) shall be provided with a full load device having an adjustable setting range from 80% to 100% of the rated load and when operated, it shall by-pass all landing calls. When the load in the car is reduced, the car shall stop for landing calls as normal.

23.16 Emergency alarm device

An emergency alarm push button together with a buzzer (or an alarm bell) shall be provided in the lift car and connected to the machine room and the main entrance lift lobby and backed up by an emergency supply. The pattern of lift alarms shall be distinguishable from that of fire alarms.

23.16.1 An intercom system connecting the lift car and the machine room /guard room (if manned) shall be provided.

23.17 Emergency exit

The lift car shall be provided with an emergency exit in the roof of minimum size 500 mm x 350 mm or 400 mm in diameter. Panels for emergency exits shall : -
(i) be clear of any apparatus mounted above the roof of the lift car
(ii) be capable of being opened, re-closed and re-locked without a key
(iii) be provided with an electric safety device which will prevent operation of the lift when the panel is not locked, operate the buzzers (or alarm bells) and also switch off the car ventilation fan.

23.18 Control and indication in car

The lift car shall have a control faceplate made of stainless steel with thickness of not less than 2.5mm and comprising :-
(i) Call buttons with acceptance signals to correspond with the landing served
(ii) An alarm push button with protection from being operated accidentally
(iii) "door open" and "door close" push buttons
(iv) Audible and visible signals in connection with the overload device
(v) Light switch, alarm reset switch, fan switch and cleaner's "Stop-switch" keeping the car door open in the form of key switches or housed in a recessed metal box with hinged or sliding lid which will be key-locked.
(vi) Two-way intercom speaker (optional).
(vii) The control faceplate shall be fixed onto the car panel by stainless steel screws.

24.18.1 For lifts equipped with attendant control, the control faceplate shall also incorporate a non-stop button for the purpose of bypassing landing calls, but the calls shall remain registered until answered. This button shall be inoperative unless the lift is operated by an attendant.

24.18.2 The car direction and position indicator shall be of digital type display with LEDs actuated by solid state circuitry unless otherwise specified. The position indicator shall have a minimum height of 50 mm and easy to read even from distance and properly illuminated.

23.19 Lift machinery for electric lift

23.19.1 Lift motor

The induction motor shall be designed to operate for an unlimited period according to the expected duty of the lift. The motor may be supplied and controlled by static elements when A.C. variable speed system is specified.

23.19.2 Motor generator set

The motor generator set shall comprise a motor and a generator built as a complete unit directly coupled. The motor and the generator shall be suitably rated to deal with the load and speed specified. Controls shall be provided so that the set shall start up on the registration of a landing call or car call and shall continue to run for a period which shall be adjustable from 5 to 15 minutes, after the last registered call is answered.

23.19.3 Bearing and gear case

Bearings shall be of the ball bearing type or sleeve ring type with oil ring bearings. Gear cases shall be provided with thrust bearings suitable for the application.

23.19.4 Emergency operation by manual device

For geared lift machines, the hoisting machine shall be provided with a smooth wheel which may be fitted to the shaft to move the lift car up or down by manual operation. The direction of movement of the car shall be clearly indicated on the machine.

23.19.5 Emergency operation by electrical switch

For machines where the manual effort to raise the car together with its rated load exceeds 400N, an electrical switch for emergency operation shall be installed in the machine room. Directional push buttons protected against accidental operation shall be provided in the machine room such that when the emergency electrical switch is operated, the car can be moved up or down by applying constant pressure on the buttons. The car speed under the emergency operation shall not exceed 0.63 m/s. The emergency electrical switch and its push buttons shall be so placed that the machine can readily be observed during operation.

23.19.6 Electro-mechanical brake

Every lift machine shall be provided with a brake which is capable of stopping the machine when the car is travelling at its rated speed and with the rated load plus 25%. It shall also be fitted with a manual emergency operating device capable of having the brake released by hand while a constant manual pressure is required to keep the brake open.

23.20 BLANK

23.2.1 Goods Lift

23.21.1 Details of the goods lift car

The side and rear wall panels shall each be provided with three-equally-spaced full length lateral protective wooden battens of 200 mm wide by 25 mm thick. The surface of the wooden battens shall be covered with 1.0 mm thick metallic sheet as required. The top battens shall be fixed at a height of 1100 mm above finished car floor level. The car roof shall be able to support the weight of two persons without causing permanent deformation. Ceiling lights shall be of recessed type and be protected by stainless steel metal bars. A recessed ceiling fan complete with heavy duty metal diffuser shall be provided. The car floor shall be constructed of metallic sheet of suitable thickness with 2 mm high multi-grip non-slip pattern. The floor construction shall be in the form of a metal drain pan (optional). In case of metallic floor being drain type, the rear and side edges shall be folded up by 100 mm from the floor to form the drain pan. All joints and the corners of the pan shall be welded to prevent water leakage. The goods lift cars may also be constructed as mentioned above except the floor drain system.

23.21.2 Goods lift car door

The car doors shall be robust, manually operated, horizontally sliding and made of stainless steel / MS sheet. Power operated, automatic, horizontally sliding doors shall be multi-panel of stainless steel construction, similar to those for passenger lifts, but strong enough for goods lift use.

23.22 Service Lift

Neither the internal depth nor the internal width of the car shall exceed 1.00 m. The overall internal height of the car shall not exceed 1.20 m. The rated load shall not exceed 250 kg.

23.22.1 Lift car and method of drive

Service lift cars shall be of rigid construction and totally enclosed except for service openings and made of wood or metal and reinforced at the point of suspension. The car shall not be made of inflammable materials. Two pairs of renewable guide shoes shall be fitted. Unless otherwise specified, removable shelves shall be fitted inside the car and be so retained that they shall not be displaced by the movement of the car. The car shall be constructed with openings on opposite sides and shall be provided with some form of protection to prevent the goods from projecting outside the car. The method of drive for the lift shall be by traction i.e. sheaves and ropes or by positive drive using drum and ropes without counterweights.

23.22.2 Guide

The car and counterweight shall each be guided by rigid guides. Guides and their fixings shall be capable to withstand the application of the safety-gear (if provided) when stopping a fully loaded car or counterweight.

23.22.3 Buffer

Buffers shall be provided under all cars and counterweights. A lift with positive drive shall be provided with additional buffers on the car top to function at the upper limit of travel. The buffers used shall be one of the following types viz spring, rubber or resilient plastic.

23.22.4 Counterweight

Counterweights shall be of metal. A metal frame shall be provided to prevent their displacement. In the case of drum drive, there shall be no counterweight.

23.22.5 Suspension

Cars and counterweights shall be suspended by means of round strand steel wire ropes. The factor of safety of suspension ropes shall not be less than 10. The minimum number of ropes shall be two and they shall be independent. The diameter of sheaves or pulleys shall not be less than 30 times the rope diameter.

23.22.6 Safety Gear

Safety gear tripped by an over-speed governor shall be provided for the car where the rated capacity is 250 kg, accessible spaces exist beneath the lift well or gross car roof area equals to or greater than 0.37 m^2. Where there is an accessible space beneath the well, the counterweight shall be equipped with safety gear.

23.22.7 Load plate and warning notice

A load plate giving the contract load of the lift in kg shall be fixed in a prominent position at each landing entrance. A warning notice in English, Hindi and local language shall be prominently fixed at each landing entrance.

23.22.8 Car and landing door

All landing openings in the lift well shall be protected by doors. Every car or landing door shall be provided with an electric safety device which shall prevent the lift from being operated when any car or landing door is open. It shall not be possible during normal operation to open a landing door unless the car is in the unlocking zone. The landing doors shall be provided with the facility of being unlocked from outside with the aid of a special purpose key provided for use only by a competent lift worker.

23.22.9 Terminal stopping switches

Service lifts shall be provided with terminal stopping switches to stop the car automatically at or near the terminal service levels.

SECTION 24
ELECTRIC OPERATED CRANES
E.O.T. CRANES

24.1 Indian Standards : The following IS shall apply

I.S. No.	*Subject*
807 - 2006	Design, Erection and testing (Structural Portion) of Cranes and Hoists - Code of Practice (Second revision)
3177 - 1999	Code of Practice for Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Work Cranes (Second revision)
4137 - 1985	Code of practice for heavy duty electric overhead travelling cranes including special service machines for use in steel work (First revision)
8686-1 - 1989	Cranes - Design Principles for Loads and Load Combination
8686-5 - 1992	Cranes-Design Principles for Loads and Load Combinations: Part 5: Overhead Travelling and Portal Bridge Cranes
9373 - 1989	Cranes and Related Equipment - Accuracy Requirements for Measuring Parameters During Testing
13367 Part 1 - 1992	Safe use of cranes - Code of practice: Part 1 General
13473 Part 1 - 1992	Cranes - Vocabulary: Part 1 General
13558 Part 1 - 1992	Cranes - Controls - Layout and characteristics: Part 1 General principles
13834 Part 1 - 1994	Cranes - Classification Part 1 General
13834 Part 5 - 1993	Cranes - Classification: Part 5 Overhead travelling and portal bridge cranes
13870 Part 1 - 1993	Cranes and lifting appliances - Selection of wire ropes: Part 1 General
14471 - 1997	Cranes and lifting appliances - Technical characteristics and acceptance documents
14472 Part 5 - 1997	Cranes - Information to be provided: Part 5 Overhead travelling cranes and portal bridge cranes
14473 Part 1 - 1997	Cranes - Inspections: Part 1 General

24.2 General Requirement

24.2.1 Scope of work shall include design, assembly, testing, packing, delivery, installation and commissioning & testing of EOT cranes.

24.2.2 All components, equipments and accessories shall be conforming to latest Indian Standards as applicable. The installation shall comply with the applicable Codes of Practice (wherever such Codes of Practice issued by the Competent Authority) regulation and Indian Electricity Rules and other safety regulations.

24.2.3 The layout of various components and accessories shall match with the actual site dimentions where equipments, shall be installed.

24.2.4 The entire installation work shall be in work man like manner and in accordance with the Modern Engineering Practice adopted for such works.

24.3 Essential Requirements

24.3.1 The crane installation shall comprise of bridge structure with platform and hand railing, track wheels for longitudinal and cross travels, travelling mechanism for longitudinal and cross travels, hoisting mechanism, limit switchgear for hoisting travelling motions, motors, electrical control gear, alarm, electrical wiring, down shop leads along with brackets and insulators, earth wire on crane portion, Brake mechanism separately for longitudinal travel, cross traverse and hoisting, Trolley, Service Platform and Pendent.

24.3.2 The crane shall be capable of:-

(a) Hoisting i.e. lifting and, lowering of all loads upto the maximum specified working load at different specified speed.
(b) Travelling and traversing at specified speeds under both loaded and unloaded conditions.
(c) Working in hot, humid and dusty atmosphere of industrial buildings
(d) Hoisting travelling and traversing simultaneously.

24.3.3 Crane controls shall be conveniently located and shall provide control suitable for variable speeds and all direction & hoist. The various controls shall be suitably interlocked to prevent accidental movement of the crane.

24.3.4 The crane shall be rigid, robust and of sturdy construction.

24.3.5 The crane shall be designed, manufactured, erected and tested generally in accordance with the following specifications:

(a) IS: 3177- 1999- Indian Standard Code of Practice for EOT cranes
(b) IS: 807 - 1976 - Indian Standard Code of Practice for design, manufacture, erection and testing (structural portion) of crane.

24.3.6 The design of the crane structure as well as of all the component parts of Crane mechanism shall conform to class duty. The class of duty is based on design parameters/stipulated in IS : 807.

24.3.7 The stipulations in these technical specifications shall be complementary to those set in the Indian Standard Specifications 3177 and 807 mentioned above. If any of the stipulations mentioned in the specifications is at variance with those of ISS; the technical specifications herein shall prevail.

24.4. Material

24.4.1 The material for welded construction such as that of bridge, girder and end carriages trolley frames, rope drums, gear boxes etc. shall be in accordance with IS-2062-1965 and IS-226 : 1975 or other relevant IS standards.

24.4.2 The crane shall be supplied complete in all respects and the supply shall include but not limited to the following along with necessary fittings, fixtures and ancillaries.

(a) Bridge structure with platform and hand railing
(b) Track wheels for longitudinal and Cross Travels
(c) Traveling mechanism for longitudinal and Cross Travels
(d) Hoisting mechanism
(e) Limit switchgear for hoisting traveling motions
(f) Motors
(g) Electrical control gear
(h) Alarm
(i) Electrical wiring
(j) Down shop leads along with brackets and insulators
(k) Earth wire on crane portion
(l) Brake mechanism separately for longitudinal travel, cross traverse and hoisting
(m) Trolley
(n) Service Platform
(o) Pendent

24.4.3 The complete details regarding type, materials construction, specifications and special features, shall be furnished if any for main items

24.4.4. The designing, manufacturing and erection of the crane shall be done as per the conditions under which the crane is to be used together with other particulars.

24.4.5. Bridge Girders

24.4.5.1 The main girders having cross traverse rail on top shall be of welded plates and shall be cambered to an amount equal to the deflection caused by dead load plus one and half times the live load and the trolley. The limiting deflection is 1/1000 of span with safe working load on trolley stationed at the mid span and including deflection due to the dead load. The amount of camber to be provided shall be clearly given in the girder detail drawing and shall confirm to IS standards.

24.4.5.2 In the main bridge girders, in addition to the required full length diaphragms, short diaphragms shall be inserted wherever required to transmit the trolley wheel load to the web plates and to limit the maximum stress in the trolley rail with in permissible limits. All diaphragms must bear against the top flange.

24.4.5.3 Full allowance shall be provided for shock and inertia forces corresponding to the duty and the class of crane offered. Allowance shall also be made for twisting movement caused by starting and stopping of L.T. motor. The calculation made for such allowance shall be furnished. The main girder shall extend over the whole width of the end carriage and the extension shall have sufficient section to take the maximum reaction and moment. The girders shall be rigidly attached to end carriages by suitable end plates, capable of resisting the torsional moment at the end of the girder. Squaring mark shall be provided on each girder to facilitate erection end squaring of the bridge. A centerline shall be marked and a hook welded on the platform side bridge girder for taking the plum bob for deflection test. Connection in general shall be as per clause 26 of IS 800. Black bolts shall not be used in the main structure of the crane. Bolts used in shear shall be fitted in to reamed holes. The bridge girder shall be connected to end carriage by large gusset plates. Turned fitted bolts in reamed holes shall be used in case of bolted connections. All butt welds in structural members subject to tensile strength shall be radio graphically tested and test certificates to be furnished. The box girders shall be so constructed to eliminate accumulated water or oil inside them.

24.4.6 End Carriage

24.4.6.1 The end carriage shall be designed to carry the rated load when lifted at one end of the crane bridge. Wheel assemblies shall be of rotating axle type and shall be designed to permit easy changing of crane wheels. End carriage shall be of ample strength to resist all stresses likely to be imposed upon them under service conditions, including collision with other cranes or stops. The length of the end carriage including the buffer shall be such that no other part of the crane is damaged in the collision.

24.4.7 Trolley Frame

24.4.7.1 The trolley frame shall be machined in one setting to prevent misalignment. The welding shall be done on trolley frame after machining. Trolley frame shall be produced in one piece unless there are transport limitations. In the case of splicing of the frame, the design shall be such that one unit of the trolley does not come over the other part. Connection between the two parts of the trolley shall be done by machine bolts or rivets. Drum bearings and supports for upper sheaves shall be so located as to equalize the load on the trolley wheels as nearly as possible.

24.4.7.2 The trolley frame shall be built up of rolled sections and plates to form a rigid structure capable of withstanding all stresses that may develop during the working of the crane and shall be arranged to afford maximum accessibility to mechanical and electrical parts placed on it. It shall be designed such that at the highest position of hook, there shall be a clear distance of 700 mm between the lowest point of trolley obstruction and the highest point of bottom block. Deviation shall be made only with specific approval of GE. The top of the trolley frame shall be plated all over except for openings required for the ropes and flexible cables for bottom block etc., to pass. The openings in the trolley frame shall be so as to keep the ropes and cables approximately 125 mm away from any part of the trolley frame or equipment to prevent damage to any parts of bottom block. The mechanical and electrical equipment shall be placed above the trolley top plate as far as practicable. For any parts placed below the trolley top plate, access for maintenance, repair and replacement shall be provided. Suitable handrails shall be provided on the required number of sides. The trolley shall be fitted with substantial safety stop to prevent the trolley from falling more than 25 mm in the event of breakage of a track wheel or the boggle axle. This safety stops shall not interfere with removal of wheels. The trolley shall be provided with lifting pads for jacking up the trolley in case of wheel removal. The jacking pads shall be at a height of about 300 mm from the level and shall not interfere with the removal of wheels.

24.4.8 Gantry Rails

The gantry rail shall be provided in each bay. These rails shall be aligned and clamped. However, before erection necessary final alignment and clamping of gantry rails shall be carried out to ensure the smooth running of the cranes.

24.4.9 Operator's Pendent/ Panel

The operator's pendent shall be hanging on the crane and shall be able to operate the crane from floor. The height of pendent from floor shall not be more than 1.5 meters. All the control switches shall be of push button type preferably. Separate switches shall be provided for different speeds and directions. Pendents shall have independent movement along with Cross Travel.

The entire weight of the pendent control shall be taken by steel link chain hung from the crane so that no weight is transferred to electrical cables.

24.4.10 Rope Drums

24.4.11. Rope drums shall be designed to withstand the compressive stresses caused by the wound on rope and the bending stress due to beam action of the drum. The drum shall be fabricated from mild steel. The steel shall be IS: 2062-1966 quality. The rope drum shall be stress relieved after fabrication. "T" joint shall be radio graphically tested. The rope drum shall be designed to take the entire length of the rope in single layer and single fall. The drum shall be flanged at both ends. Rope ends shall not be bent for clamping purpose. The length of the drum shall be such that it shall have minimum two full turns of rope at the lowest position of the hook and atleast the spare groove for each lead of rope with the hook at the highest position. Each rope shall be clamped with minimum two clamping wedges with atleast three numbers of bolts on each clamping arrangement.

24.4.11.1 All gears shall be completely enclosed splash lubricated type and in case of vertical gear boxes, if the reduction exceeds two stages the gear shall be forced pump lubricated. All gear boxes shall be oil tight and sealed with the heat resistant and leak proof hard rubber gasket. All gear shafts shall be supported in bearings mounted in gear boxes. The gearboxes shall be fabricated and shall be made of minimum 8 mm thick plate or suitably designed casting of sufficient strength. All fabricated gearboxes shall be strees relieved. Covers shall be split horizontally at each shaft centerline and parallel so that top half can be removed for inspection and repair. Vertical gearboxes shall have inverted split. The gearboxes shall be provided with breather vents, oil level indicator, dipsticks and easily accessible drain plugs. The radial clearance between the gearbox inner surface and outside diameter of the gears, shall not be less than 20 mm The facial clearance between the inner surface of the gearbox and the face of gear and pinion shall be at least 10 mm. All gearboxes shall be mounted on machined surfaces and shall have machined feet, shims shall not be used, and these shall be provided with lugs or other means of lifting. Gearboxes shall be specially designed for Crane duty.

24.4.12 Gearing

The gears in power operated motions shall be of suitable wear resistant alloy steel and shall conform to relevant Indian Standard. All gears shall be fully hardened and ground on lapped in sets. Surface hardening is not permitted. The hardness of the pinions and gears shall be in the range of 300-350 BHN and 250-300 BHN respectively. The difference in hardness of pinion and gears shall not be less than 20 BHN. Worm Wheels and bevel gears shall not be used. First and high speed reduction shall be through helical gears. Straight gear and helical gearing shall be used on all motions. Teeth shall be cut in metric module system. The gears shall have positive addendum modification to improve contact and the sliding conditions and increase the bending strength of pinion and the surface. Traverse wheels shall be directly driven from the respective gear boxes.

24.4.13 Drives

All motors shall be of crane duty having approximate half an hour higher rating. The wheels of each end carriage shall be driven by independent motors mounted near each end carriage. Motors shall however be electrically synchronized. A separate cross traverse motor shall be used for Cross Travel drive through suitable gearbox. L type Plummet blocks with rotating axles shall be used for long travel and cross traverse wheels. Creep motion for the hoist shall only be provided so as to achieve 10% of the speed of the hoist. Ball and roller antifriction bearings shall be of reputed make. For long and cross travel wheels spherical roller bearings shall be used. Raised life of ball and roller bearings shall not be less than total life in working hours given in IS specification for particular class of duty. Bearing housings shall be split on the shaft centreline to permit easy removal of the shaft. Bottom surface of each bearings pedestal shall be machined. The barrel coupling shall be used for simplification of maintenance and the gearbox and the drum shall be treated as separate items. The trolley wheels shall be double flanged. The axle bearings shall be spherical roller type. The bearing housing shall be designed for easy removal of wheels and bearing for maintenance. The trolley shall be provided with lifting pads for jacking of the trolley in case of wheel removal. Jacking pad shall not interfere with the removal of wheels. Rails wheels shall be double flanged with straight tread. Solid wheels shall be forged steel. Wheel rim shall be heat treated to have a hardness of BHN 250-300 on the rolling surface and flanges to a depth not less than 10 mm with a smooth pass to the non-hardness zone.

24.4.14 Brakes

24.4.14.1 Hoisting, cross traverse and long travel motions shall be provided with fall safe electro hydraulics thrust or operated brakes of commercially proved model. The thrust or brake shall have counter weight for return motion. The braking torque for each brake shall not be less than 125% of full load torque. Double shoe brake shall be used for each drive; brakes shall be mounted on the input pinion shaft of all the gearboxes. The brake shoe shall be of hinged type. The brake levers shall be forged and hinge pin shall be provided with steel bushes at the bearings points and hinge pin shall be lubricated.

24.4.14.2 Brake drum shall be of forged steel and shall be completely machined. Brake drum diameter shall be selected from preferred number series. Width of brake drum shall be about 10 mm more than the width of the brake shoe on each side. Hardness of brake drum shall be nearly 300 BHN. In an emergency, it shall be possible to lower to the ground the full load on the crane safely by means of hand operation of the brake.

24.4.15 Rope Sheaves

All sheaves shall be cast or forged steel. They shall be of identical width except for equalizer sheave. The equalizer sheave shall be mounted above the trolley floor and shall be easily accessible and removable from the trolley floor level. Equalizer sheave shall be arranged to turn and swivel in order to maintain rope alignment in all circumstances. Sheave grooves shall be smooth finished for getting increased rope life.

24.4.16 Lifting Hook

The hook shall confirm to relevant latest Indian Standard specifications. Hook shall be mounted on the grease lubricated antifriction thrust bearings. Proof of load test as per Indian Standard specification from Government recognized lab shall be submited. The nut height shall not less than one thread diameter. The hole in the nut and shank which locks the nut in place shall be located so that a clear height of at least three forth of one thread diameter exist between the bottom of the hole and the bottom of the nut. No welding shall be allowed on hooks.

24.4.17 Wire Ropes - Hoisting rope shall be of 6x36 construction of Best Plough steel having min. Tensile strength of 180 kg/sqmm. Rope shall be tested in a Govt. approved test house and Test Certificate shall be produced.

24.4.18 Buffers - Suitable buffers shall be fitted on the four corners of the crane and also at the four ends of the bridge girders. All buffers shall have sufficient energy absorbing capacity to stop bridge or Trolly in either direction when travelling at the speed of atleast 40% full load rated speed. Bridge buffers shall have a contact surface of not less than 125mm in diameter.

24.4.19 Electrical Works

24.4.19.1 Bridge Conductors

Flexible PVC insulated and PVC Sheathed, multi strand Copper cables shall be used. Flexible Trailing cable system shall be mounted on retracting supporting system. The Flexible trailing cable system shall have ample length and shall be supported by means of properly designed movable clamps. Each clamp shall be fitted with 4 nos single flanged rollers and run freely on a guide beam allowing relative movement of bridge and trolley without undue stress or wear on the suspended cable. The trolley rollers shall be fitted on anti friction bearing ; bush bearing are not to be used. The bridge conductors shall not be mounted between the girders and shall be accessible for service. Only flexible trailing cables shall be used as bridge conductors. The current carrying shunts on all the collectors shall be designed so that there is no danger of contact with adjacent collectors.

24.4.19.2 Collector Shoes

24.4.19.2.1 Carbon brush spring type current collectors shall be supplied. The crane supplier shall connect the cable on to the DSL Trolley.

24.4.19.2.2 The collectors shall have adequate current carrying capacity. Collectors shall be designed for ease of maintenance and mounted so that they are readily accessible.

24.4.19.3 Motors

24.4.19.3.1 All crane motors shall be of specified make and shall be totally enclosed fan cooled slip ring type/sq. cage and designed for 150 starts per hour. The motors shall be suitable for heavy-duty reversible crane service having duty rating not less than 40%. The type of enclosure shall be IP55 for terminal box. The motors shall be suitable for 45^{o}C ambient temperature and 415 V ± 10%, 50 Hz ± 3%, 3 Phase, 4-wire AC supply. The wiring shall be copper wire specially insulated and impregnated to withstand moist tropical climate.All motors shall be provided with insulation of class B for staters and class F for rotors.

24.4.19.3.2 The maximum permissible winding temperature measured by resistance method shall not exceed 115^{o}C . The pull out torque of the motors at the rated voltage and frequency range shall be as per IS : 3177 - 1999. The terminal box shall be provided on top or front of the motor for easy accessibility. The terminals shall be large enough to accommodate cables if necessary. The cable size shall be decided after considering de rating due to grouping and ambient temperature.

24.4.19.4 Crane Controller

For crane with cabin operation, the master controllers, connected through contactors, time delay relays and rotor resistance shall be provided for all the motions. Push button type of switches / controllers shall be used for all the motions. Each controller shall be provided with OFF position interlocks. Each controller shall bear the indication of the controlled motion and direction of movement. On all motions the circuit shall be so designed that brakes come into operation immediately in the event of tripping of main circuit breaker. All controllers shall be so disposed that the contact and terminal arrangements are readily accessible for inspection and for maintenance purpose. Each controller shall be fitted with auxiliary contacts to provide interlock between the controllers and circuit breaker and cannot be closed unless the controller is in OFF position. The controllers on OFF position shall open all supply lines of the respective motors. The rating of contactors shall be at least 50% higher than the respective motors full load current at the specified duty cycle. The directional contactors of all the motions shall be suitably interlocked. Resistors shall adequately be protected to prevent accidental contacts. The resistors shall be air-cooled, robust, heavy duty, corrosion resistance. The resistance boxes shall be placed in racks that permit independent removal of any selected box and spacing recommended by resistor manufacture shall be maintained. The racks shall be robust in construction to withstand vibration due to crane operation. Electrical clearance in air between resistors and earthed metal shall be approximately 100 mm. The temperature of resistors element shall not exceed 175^0 C. at specified duty. The cable entry to the resistors banks shall be from underside and terminal arrangement shall be such that cable cores do not get lose due to vibration. The intermediate jumpers in resistance boxes shall be of copper conductors. The value chosen shall ensure smooth and uniform acceleration and allow for plugging and dynamic braking without over heating.

24.4.19.5 Circuit Protective Switch Gear

24.4.19.5.1 One triple pole manually operated moulded case circuit breaker (MCCB) shall be provided serving as main incoming protective device fitted with 80 volts short circuit and overload releases and rated to carry at least combined full load current of the two motions of the crane having largest power. Instantaneous adjustable electro magnetic type over current releases on each pole shall be provided to trip the circuit breakers. The setting of these over current releases shall be such that the circuit trips instantaneously.

24.4.19.5.2 The circuit breaker shall have adequate rupturing capacity to withstand and clear fault current of order of 30 KA. The circuit breaker shall be located inside the drivers cabin or nearby in such a way that adequate clearance is provided as per IE rules. The trip circuit of the circuit breaker shall be designed such that it shall prevent the circuit breaker from being closed when the main contactor of any of the motion has failed to open, although the corresponding controller has been brought to OFF position. Other protective features as detailed under limit switches and emergency stop push buttons shall be incorporated in the trip circuit of the CB to fulfill required functions. To indicate whether power & control sources are ON and whether any emergency switch has been operated, indication lamps shall be provided on the pendent. Against overloads, adjustable inverse time lag release shall be provided for each motor. These release shall be mounted in respective control panels and shall be set to trip the circuit of the motion controlled when current exceeds 200% of the normal values for more than 10 seconds. The control circuit of individual motion shall have OFF position interlock with respective master controllers. Each motor feeder shall be protected with HRC Fuses, Magnetic over load relays and single phasing preventor. Isolators for both power circuit and control circuit shall be provided for each of the motor panel.

24.4.19.6 Auxilliary Switch Gear

24.4.19.6.1 A main metal clad Triple Pole isolating Switch shall be provided on the Long Travel Bridge walkway as close as possible to the main current collectors. This shall isolate all the circuit except the crane lighting circuits. This switch shall be without any fuse and off load isolating type.

24.4.19.6.2 Each of the above mentioned main isolating switches shall be rated to carry at least combined full load current of the 2 motions of the crane having the largest HP, and shall be provided with means of locking the switch operating handle in off position. The switch cover shall be interlocked with the operating handle. The live contacts inside the switch shall be shielded to prevent accidental contacts.

24.4.19.7 Limit Switches

24.4.19.7.1 All hoist motions shall be provided with Limit Switches to prevent the crane hook from over hoisting and over lowering. Two limit switches shall be provided for proper backup protection. The first limit switch to act in the event of over hoisting and over lowering shall be of Rotary type with self resetting feature and incorporated in the control circuit of the respective drive motor and the second limit switch shall be of gravity operated hand resetting type switch connected in the trip circuit of the main incoming breaker. The limit switch incorporated in the motor control circuit shall be made to act first but incase the limit switch fails to operate, the second limit switch connected to the main incoming circuit breakers controlled circuit shall operate and trip the power.

24.4.19.7.2 Limit switches for Cross Travel and Long Travel shall be supplied and installed with proper access to attend the repair work on the switches. Anti collision Limit Switches are to be provided to avoid collision of cranes working in the same bay. Safety switches of sustained contact type shall be provided at the 4 corners so that under any emergency conditions, by operating any one of the switches, the incoming circuit breaker is tripped thus cutting power to all the motions. Further a mushroom head type OFF pushbutton shall be provided in the operator's Panel pendant operated cranes, so that the main incoming breaker can be tripped under any emergency condition by pressing the operating head. A pilot lamp incorporated in the control circuit shall glow when any of these switches are operated.

24.4.19.8 Control Panel

24.4.19.8.1 All power and auxiliary contactors, individual overload relays,. time relay block shall have enough clearance to avoid tracking. A minimum of 20% spare terminal shall be provided in the terminal strips.

24.4.19.8.2 All equipments inside the panel shall have permanent identification labels in accordance with circuit diagrams as also the power and control terminal. Terminal blocks shall be robust and of such construction so as to preclude possibility of cable connection getting loose due to vibration of the crane. Sheet steel used for fabrication of panel shall have minimum thickness of 2 mm. Panels shall be mounted such that bottom of panel is at least 150 mm above the floor. The electrical clearance in air between all live parts of different polarity and voltage and between live parts and earth shall not be less than 75 mm. Contactor panels shall be well braced to the crane structure and each panel shall be provided with adequate no of lifting lugs.

24.4.19.9 Lighting

24.4.19.9.1 Lighting shall be provided in the areas where control panels, resistors and transformer's shall be installed. Bulkhead fitting with dust proof covers shall be used for above areas. Four nos of under slung light of 400 W with HPMV lamps shall be provided. Industrial toggle switches shall be used for lighting distribution. 4 socket outlets for hand lamps shall be provided each at Long Travel side Bridge and in the areas, where control panel, resistors and transformers shall be installed. Hand lamps shall operate at 24V AC. supply. Industrial metal clad plug and socket shall be provided.

24.4.19.10 Cabling

24 .4.19.10.1 All wiring for power, control, lighting etc. shall be carried out with 1.1 KV grade PVC armoured cable except trailing flexible cable on which armouring shall not be provided. Power cables shall be minimum of 2.5 sqmm copper or 6 sqmm aluminium. Cables shall be of standed construction. Control cable shall be minimum 1.5 sqmm copper.

24.4.19.11 Earthing

Earthing to the crane shall be effected through track rails and crane structure. As such, all the electrical equipments mounted on the crane shall be connected to the crane structure by means of earth links. The crane structure in turn shall be made electrically continuous by providing jumpers over riveted or bolted joints. Equipments fed by flexible cables shall be earthed by means of spare core provided in the flexible cable.

24.5 Workmanship

24.5.1 The design of crane shall be such that it shall have easy maintainability.

24.5.2 Standardization shall be carried to the maximum extent in designing and manufacturing the various sub-assemblies constituting the various crane mechanisms. Units shall be designed such that they are dismantled quickly without disturbing the installation of the neighboring units with which they are connected.

24.5.3 Units and assemblies other than the welded integral parts shall be replaceable and interchangeable with the other identical units with ease. In design, care shall be taken so that inventory is kept low and down time becomes minimum.

24.5.4 All components for cranes of identical capacity and duty shall be interchangeable unless otherwise required.

24.5.5 Safe access for maintenance and removal of all mechanical, electrical and structural components shall be assured. All parts required replacement, inspection shall be easily accessible without the need of dismantling other equipment or structure.

24.5.6 All electrical cables shall be so laid that they are not liable to damage and they can be easily inspected and maintained.

24.5.7 A platform shall be provided along side the bridge girder at one side 0.70 M clear width from the face of any equipment placed on the platform and made skid proof with chequered plate of 6 mm thickness fenced with double tired guard rails.

Full length of Service platform on the other side of the bridge girder with a clear width of 500 mm shall also be provided. Chequered plates shall be adequately supported and fastened to the supports.

24.5.8 Fasteners for pedestal blocks, gear boxes etc, shall be easily removable from the top of platform.

24.5.9 A Tool box containing all necessary tools like torque wrenches, portable hydraulic jacks, hand grease gun, set of spanners, screw drivers etc., required for maintenance of the crane shall be supplied with each crane where catered in unit rate .

24.6 Safety Requirements

24.6.1 The crane shall comply with relevant safety requirements under factory Act and Indian Electricity Rules and other statutory regulations as applicable.

24.6.2 The design of the crane shall be made keeping in mind the safety of the operating personnel plant and public safety.

24.6.3 The crane shall have suitable limit switches for long travel and cross travels and for the main hoists to prevent over travel of the various moving parts of the crane.

24.6.4 The crane shall have suitable stoppers to prevant over travel of the crane mechanism in longitudinal and traverse directions.

24.6.5 Suitable guards/enclosures shall be provided to prevant inadvertent human contact with Down Shop Leads or other exposed electrical conductors/cables.

24.6.6 Suitable isolation switches and stop buttons shall be provided to isolate the electric supply for maintenance or in the event of an emergency.

24.6.7 All wheel, couplings gears etc. shall be provided with cover. All heavy covers shall be provided with inspection windows.

24.6.8 Safety hand railing of tubular construction shall be provided on bridge foot walks, end carriages, stair case landing in trolley and any other places where access has been provided, Railing shall not be less than 1000 mm high with an intermediate member at a spacing of 300 mm.

24.6.9 Guards shall be provided in the crane to prevent the hoist rope coming in contact with the down shop leads.

Suitable cover shall be provided with rigid guards to retain the ropes in the grooves. All cables shall be clamped individually. All trailing cables shall be clamped by PVC or non-metallic clamps.

24.6.10 Grouped lubrication systems for all bearing one each for the end carriage and one for trolley platform shall be provided. The internal diameter of the greased pipe shall be 6 mm. The grease nipples battery shall be located in a convenient place to facilitate regular greasing with standard equipments.

24.6.11 All gears and bearing enclosed inside gearboxes shall be splash lubricated. Bottom locks and pedestal bearings shall have independent greasing points. All lubrication pipe work shall be secured and protected from damage and shall be accessible throughout. A lubricating chart shall be provided indicating all lubricating points, the type of lubricants required and recommended frequency of lubrication.

24.6.12 All parts of the crane shall be thoroughly cleaned, all dirt scales and rust or foreign matter removed and painted with one coat of best quality zinc chromate primer and exposed machine parts shall be cleaned with rust preventer at premises of manufacturer/contractor. All parts accessible after assembly shall be painted.

24.6.13 Two coats of paint shall be given at site after the erection as indicated below, as per shade 368 of IS-5/1961.

(a) Structural and all metal parts - Traffic yellow enamel paint.
(b) All electrical motors - Battle ship enamel grey paint.
(c) Snatch block - Signal red enamel paint.

24.7 Inspection Process-Inspection at Purchaser's Premises

24.7.1 The crane shall be inspected and tested during different stages of its manufacture, starting from raw materials to the completion of the crane, by authorized representative of the Accepting Officer at the contractor's works site.

24.7.2 For final inspection purpose, the crane to the extent possible shall be assembled with all electrical and mechanical components. The wiring shall be carried out under the above conditions, and dimensional accuracy shall be inspected and recorded.

24.7.3 An authorised representative of the Accepting Officer shall be detailed to inspect the equipment before dispatch at contractors workshop. The inspecting officers as detailed shall issue a certificate accepting the equipment and this certificate shall not bind the Govt. to finally accept the equipment, shall it on further tests after erection at site be found not to comply with the specified requirements.

24.7.4 The cranes shall be tested at contractor's premises for full load, overload and deflection tests. The speed tests also shall be carried out except long Travel motion.

24.7.5 Dimensional Tolerance

The crane designed, manufactured and erected shall be within the following tolerances limits:-

(a) Span over long travel wheels	-	± 6 mm
(b) Diagonal on wheels	-	± 5 mm
(c) Long travel wheel alignment	-	± 1 mm
(d) Tilt of wheels (Horizontal and vertical)	-	± 1 mm/1000 mm
(e) Trolley wheel gauge	-	± 3 mm
(f) Trolley track gauge	-	± 3 mm

(g) Difference in height between rails (H) for different trolley track gauges (S) shall be within the following :-

S mm	H mm
Upto 2000	4
2500 to 4500	6
above 4500	8

(h) Speeds at full notch with the rated load, voltage and frequency shall be as follows

(i) Traveling traversing	±10% of specified speed
(ii) Hoisting	± 10% of specified speed
(iii) Lowering	± 10% of specified speed

(i) **Deflection test -** The deflection of the bridge girder shall not exceed 1/1000 span with the fully load trolley stationed at mid span (SWL) at rest.

(j) **Capacity test -** All the motions of the cranes shall be tested with the 25% overload in which case the rated speeds need not be attained. But the crane shall prove it self-capable of dealing with the overload without difficulty.

(k) **Brake test -** All brakes shall be capable of braking the respective movements effectively at various speeds and conditions.

(l) The long travel and cross travel brakes shall be capable of arresting the motions with in a distance equal to 5% to 8% of the speed in m/mm and the retardation due to brake shall be minimum such that there shall be no skidding of wheels. The calculations and the table followed to arrive at the values of retardation shall be furnished in the offer by tenderer.

SECTION 25
SEWERAGE TREATMENT PLANT

25 Sewage Treatment Plant

IS No.	*Subject*
4111 - Part 1 -1986	Code of Practice for Ancillary Structures in Sewerage System: Manholes (First Revision)
4111 - Part 2 - 1985	Code of Practice for Ancillary Structures in Sewerage System: Flushing tanks (First Revision)
4111 - Part 3 - 1985	Code of Practice for Ancillary Structures in Sewerage System: Inverted Siphon (First Revision)
4111 - Part 4 - 1968	Code of Practice for Ancillary Structures in Sewerage System: Pumping Stations and Pumping Mains(Rising Mains)
4111 - Part 5 - 1993	Code of Practice for Ancillary Structures in Sewerage System: Tidal Outfalls
4127 - 1983	Code of Practice for Laying of Glazed Stoneware Pipes (First Revision)
5329 - 1983	Code of Practice for Sanitary Pipe work above ground for building (First Revision)
6924 - 1973	Code of Practice for Construction of Refuse Chutes in multistoried buildings
7208 - 1992	Code of Practice for Flocculator Devices Guidelines (First Revision)
7740 - 1985	Code of Practice for Construction and Maintenance of Road Gullies (First Revision)

25.1 General

25.1.1 Treatment process used shall depend upon method of disposal, degree of treatment, waste water influent quality and availability of the land etc.

25.1.2 The CPHEEO Manual of wastewater treatment and relevant IS Codes shall be taken as the main reference/guideline for design and execution of the treatment facility for any type of domestic wastewater.

25.1.3 The overall objectives of the biological treatment of domestic wastewater shall be to:-

(a) Transform dissolved and particulate biodegradable constituents into acceptable end products

(b) Capture and incorporate suspend and settleable colloidal solids into a biological flock or biofilm.

(c) Transform or remove nutrients, such as nitrogen and phosphorus.

25.1.4 One of the following methods shall be adopted for WASTE WATER treatment which ever is economical for a particular station as indicated:-

(a) AEROBIC PROCESS

(i) Activated sludge process (ASP) including extended airation system

(ii) Fluidised Media Reactor (FMR)

(iii) Moving Bed Biological Reactor (MBBR)
(iv) Trickling filters
(v) Rotating Biological Contactors (Also Called Biodisks) RBCs
(vi) Facultative aerated lagoons and extended aeration process
(vii) Wet Lands
(viii) Soil Biotechnology
(ix) Oxidation ponds
(x) Oxidation ditches
(xi) Sequential Batch Reactor (SBR)

(b) ANAEROBIC UNITS

(i) Anaerobic ponds
(ii) Up flow Anaerobic Sludge Bed reactor (UASB) followed by lagoons etc.

25.2 Design Parameters

25.2.1 The characteristics of raw domestic wastewater, peak flow factor and desired limits for treated wastewater shall be determined for design of Sewage Treatment Plant (STP).

25.2.2. In absence of exact ground data following parameters shall be assumed for design of STP.

Raw Wastewater Characteristics

Ph	:	6-9
TSS	:	350-450 mg/litre
BOD	:	200-275 mg/litre
COD	:	550-600 mg/litre
Coli form	:	16^6-10^7 counts/100ml

However, exact values shall be obtained by examination of raw wastewater sample at the earliest opportunity

25.2.3 Ratio of Peak flow and average flow shall be 2.5 for higher populations. However, for population between 5000 and 25000 it shall be 3 and for less than 5000 it shall be 3.5.

25.2.4 Peak flow period shall be taken as 2 hrs in morning.

25.2.5 Invert levels of sewer at first sump & soil analysis data shall be as provided in the tender documents and accordingly bidder shall design proper system, without any assumptions.

25.2.6 If treated wastewater disposed off in natural stream, guidelines of CPCB (mainly BOD <30 mg/lit) shall be followed. Other specifications shall be as under: -

Wastewater Characteristics for Disposal

Ph	:	6-9
TSS	:	< 50 mg/litre
BOD	:	< 30 mg/litre
COD	:	< 250 mg/litre
Res. Cl	:	< 0.5 mg/litre
E-Coli	:	< 10^3 counts/100 ml

25.2.7 As a matter of policy wastewater shall be recycled for non-potable uses after proper treatment unless there are reasons for not doing so. For this purpose wastewater shall be treated up to tertiary level.

25.2.8 Tertiary treatment shall have three stages i.e. filtration by dual media sand filter, adsorption by activated carbon columns and finally super chlorination.

25.2.9 Following specifications shall be adhered for treated effluent before non-potable reuse.

Wastewater Characteristics For Reuse

Ph	:	6.5-8.5
TSS	:	< 10 mg/litre
BOD	:	< 10 mg/litre
COD	:	< 150 mg/litre
Res. Cl	:	< 0.5 mg/litre

25.3 Aerobic Process

25.3.1 General

25.3.1.1 Complete wastewater treatment facility shall be furnished and installed to provide primary and secondary treatment of the daily wastewater flow. Principal items of equipment shall include equilization tank, P.S.T., aeration and clarification chambers, air distribution system, air diffusion system, sludge return system, surface skimming system, mechanical equipment and equipment housing, electrical controls, galvanized metal grating with master-keyed locking device for all tank openings, and all necessary internal piping and mechanical equipment etc.

25.3.1.2 Treatment of the daily wastewater flow shall be accomplished by the Extended Aeration process. Biological treatment shall be accomplished in the aeration chamber of the facility. Air shall be introduced to produce a mixing and rolling action in the tank. The spiral rolling action created by the introduction of air shall ensure thorough mixing of the incoming organic material with the activated sludge present in the chamber. In addition, the spiral flow pattern shall prevent short circuiting of the flow and ensure adequate retention of all organic materials.

25.3.1.3 Gravity settling of the mixed liquor suspended solids shall be accomplished in the clarification chamber. Mixed liquor shall be transferred from the aeration chamber into the clarification chamber by hydraulic displacement.

25.3.1.4 The effective holding capacity of the clarifier shall be calculated after excluding the lower two-thirds, by height, of each hopper and shall be of sufficient volume to provide in excess of four hour retention of the daily flow

25.3.1.5 The extended Aeration wastewater treatment facility shall provide an anticipated eighty-five to ninety-five percent removal of BOD and suspended solids.

25.3.1.6 Net sludge volume increases shall be nominal and shall range from zero to one percent depending on influent characteristics.

25.3.1.7 Capability of a plant shall be certified by an independent approved Engineering Institute The manufacturer shall make certified data available to the regulatory agency, customer, consultant and contractor as required.

25.3.1.8 The wastewater treatment facility structure shall be reinforced to withstand normal pressures from external soil and internal hydrostatic loads.

25.3.1.9 RCC construction shall meet the requirement of concrete, steel, earth work specifications.

25.3.2 Operating Conditions

25.3.2.1 The wastewater treatment facility shall be capable of treating specified MLD per day of sanitary sewage.

25.3.2.2 This facility shall be designed and built to serve a population equivalent with a total loading and treatment capability of five day BOD per day.

25.3.3 Aeration

25.3.3.1 The aeration chamber shall have a capacity to provide twenty-four hour retention of the daily wastewater flow. The chamber shall be of sufficient size .

25.3.3.2 Concrete fillets shall be installed in the bottom of the chamber parallel to the treatment flow to ensure uniform tank roll and prevent deposition of solids.

25.3.3.3 Overall design of the chamber shall be such that effective mixing shall be maintained to provide optimum treatment. Each casting used to construct the chamber shall be a monolithic unit with all four walls incorporated into each tank section.

25.3.4 Air Distribution System

25.3.4.1 Galvanized steel pipe and galvanized malleable iron pipe fittings shall be used throughout the air distribution system. Individual galvanized pipe unions, dresser couplings and flexible couplings with stainless steel clamps shall be provided as necessary in the air distribution system.

25.3.4.2 Individual air control valves shall be installed in the air distribution piping as required to allow adjustment of each separate element within the system. Primary air distribution shall be accomplished through a galvanized air header. Individual drop pipes to each diffuser assembly shall be connected to the air header with a galvanized quick release coupling or union.

25.3.4.3 Each drop pipe shall be equipped with an air adjustment valve upstream of the quick release coupling allowing individual air adjustment and distribution balance.

25.3.5 Air Diffusion System

25.3.5.1 Diffusers shall be installed parallel to the treatment flow in each aeration chamber. Diffusers shall be designed to ensure uniform mixing within the aeration chamber.

25.3.5.2 Fine air bubble distribution effected by the diffusers shall be adequate to provide all oxygen necessary for the aerobic digestion process while maintaining an acceptable dissolved oxygen level in the final plant effluent. Arrangement of diffusers shall be consistent throughout the aeration chamber and shall provide at least one air diffusion orifice for each five inches of aeration chamber length.

25.3.6 Clarification

25.3.6.1 A final clarification chamber shall be provided for gravity settling of the mixed liquor suspended solids. Effective holding capacity of the clarifier shall be calculated after excluding the lower two-thirds, by height, of each hopper. Each casting used to construct the chamber shall be a monolithic unit with all four walls incorporated into each tank section. Individual tank sections shall be joined with a horizontal tongue and groove joint.

25.3.6.2 To ensure the watertight integrity of the finished structure, each joint shall be sealed with a self-adhering compression gasket. The gasket shall be of a resilient, synthetic, self- sealing material. Non-compression joints with grouted sealing compounds shall not be used. The clarification chamber shall consist essentially of four independent zones operating conjunctively to provide satisfactory solids separation.

25.3.6.3 An inlet baffle zone shall be provided at the flow inlet to the clarification chamber. All transfer turbulence shall be dissipated in this zone to preserve quiescence downstream of the baffle. The area contained behind the baffle shall provide sufficient capacity to allow surfacing of all buoyant material entering the clarifier. The baffle shall extend a minimum of 15 cm above the liquid surface to entrap all floating material and shall extend a minimum of two inches below the transfer port invert to eliminate the passage of buoyant material or surface turbulence.

25.3.6.4 Flow shall be directed out of the inlet baffle zone into the hopper zone. All transfer shall be accomplished below the bottom of the inlet baffle into the upper one-third area of the hopper zone. In this zone sludge shall settle by gravity to the bottom of the hopper. Each hopper shall have sloping sidewalls directing all sludge to the bottom near the airlift pump inlet.

25.3.6.5 The settled sludge shall be returned to the inlet end of the aeration chamber by continuous airlift pumping.

25.3.6.6 Clarified liquids shall be contained in the settling zone above the hopper area for additional gravity settling. Liquids in the settling zone shall be hydraulically displaced to the outlet zone. The outlet zone shall consist of an adjustable side plate effluent weir trough and outlet baffle.

25.3.6.7 The baffle shall span the entire length of the outlet zone and shall totally separate the surface liquids of the settling and outlet zones. Centered in the outlet zone parallel to the outlet baffle shall be an aluminum effluent weir trough with two adjustable v-notch side plates.

25.3.6.8 The trough shall be capable of being adjusted from end-to-end to provide adequate fall to the plant outlet. The side plates shall be capable of being leveled from side-to-side and end-to-end to provide a uniform flow line elevation.

25.3.7 Airlift Sludge Return System

25.3.7.1 A galvanized airlift sludge return pump shall be provided for each hopper in the clarification chamber.

25.3.7.2 Air shall be supplied to the airlift through a secondary air distribution system connected to the main air header of the treatment plant.

25.3.7.3 Individual air manifold piping shall be installed for each airlift and shall be equipped with a valve for fine adjustment or shut-off

25.3.8 Air Compressor

25.3.8.1 The air required for the treatment process and airlift operation shall be provided by air compressor , blowers or equal. The blowers shall be of the rotary positive displacement type and shall provide adequate free air at the rated operating pressure.

25.3.8.2 Each blower unit shall be provided with an inlet air filter/silencer, flexible discharge coupling, and shall be connected to the air header assembly by a main air supply manifold complete with a discharge pressure relief valve. When a standby blower unit is provided, discharge check valves shall be included for each blower unit. Blower connection to the drive motor shall utilize an industrial power transmission drive system.

25.3.9 Motors

25.3.9.1 Electric motor shall be used to drive each blower. When operating at the rated horsepower the motor shall reach a maximum speed that exceeds ninety-seven percent of the referenced synchronous speed.

25.3.9.2 Motors for the facility shall be designed and rated for continuous duty applications and shall not exceed name plate ratings when operating. Motors shall be mounted on an adjustable slide base for base of motor alignment and belt tension adjustment.

25.3.9.3 Mechanical equipment shall be mounted in a non-corrosive weatherproof enclosure. Each enclosure shall be constructed of heavy fiberglass for maximum protection and durability. The enclosure shall consist of a reinforced base and a steel reinforced hood section.

25.3.9.4 The base shall be sufficiently reinforced to withstand all normal motor-blower operating stresses. The hood section shall protect all internal components against environmental forces and protect personnel against injury.

25.3.9.5 The hood section shall be attached to the base with a non-ferrous continuous hinge. The enclosure assembly shall include a hood section handle, retainer cord, and latch complete with a pin tumbler type padlock that is a part of the master-keyed system used for tank openings, control cabinets, equipment housings and related equipment.

25.3.10 Electrical Controls

25.3.10.1 Electrical controls shall be installed within the weatherproof cabinet which houses the motor and blower unit. The cabinet shall be equipped with a master-keyed locking device to restrict access to the controls to authorized personnel.

25.3.10.2 The motor control center shall be factory-wired to the motor with a resilient power cable and tested under actual operating conditions prior to shipment to the job site.

25.3.11 Time Clock

25.3.11.1 The motor control center shall include a twenty-four hour time clock, adjustable in fifteen minute increments, to permit cyclical automatic operation of the treatment facility.

25.3.11.2 A three position "Hand-Off-Auto" toggle selector switch shall be installed for each blower unit supplied to allow the unit to operate continuously when in the "Hand" position or cyclically according to the cycle established on the time clock when in the "Auto" position.

25.3.12 Galvanized Metal Grating

25.3.12.1 Tank openings shall be protected with galvanized metal grating padlocked in position. Individual lock bar assemblies shall be provided for each tank opening. Pin tumbler type padlocks shall be used to secure each grating section and the locks shall be part of the master-keyed system used for tank openings, control cabinets, equipment housings and related equipment.

25.3.12.2 Gratings shall be of sufficient strength to have a deflection which does not exceed 5mm under a distributed load of 500 kg per meter square. No more than two individual grating sections shall be used to cover individual tank openings. Slot type loose or unsecured grating shall not be used.

25.3.12.3 The galvanized safety grating shall also be used as a leaf screen to prevent entry of leaves and discarded debris into the tankage.

25.3.13 Bar Screen:

25.3.13.1 Raw sewage from the source shall be received into bar screen chamber by gravity. Screen provided will remove all floating and big size matter. Normally these shall be made of steel.

25.3.14 Oil And Grease Trap

25.3.14.1 A small civil construction tank with a baffle wall and slotted oil pipe skimmer shall be provided. Specifications for concrete, steel and other trade shall be followed from respective Sections.

25.3.15 Equalization Tank

25.3.15.1 Equalization tank to collect the excess flow during peak hours and feed sewage in lean hours shall be provided . A typical equalization tank shall have a capacity of 8 - 12 hours of average flow rate. Provision of air grid shall be made for thoroughly mixing the sewage to make it of homogenous quality and to keep the suspended matter in suspension and to avoid septic conditions

25.3.16 Transfer of Sewage

25.3.16.1 The distance of transfer shall not exceed beyond 5 meter. The layout shall be as per approval of GE. The pump shall not run dry and it shall be ensured that sufficient sewage is available in the equalization tank.

25.3.17 Treated Water Collection Tank

25.3.17.1 The treated water collection tank shall be of civil construction in case required. The treated water shall be collected either from the chlorination chamber or from activated carbon filter as the case shall be.

25.3.18 Corrosion Protection

25.3.18.1 After completion of welding, all steel surfaces of the treatment plant equipment shall be blasted to white metal. All surfaces shall be primed with one coat of strontium chromate primer thinned ten percent with epoxy thinner, for a dry thickness of one and one-half mm.

25.3.18.2 After a minimum of eight hours drying time, two coats of catalyzed paint shall be applied, one coat in a horizontal spray pattern and one coat in a vertical spray pattern. This shall produce a four to six mm total dry thickness on the interior surfaces and six to nine mm total dry thickness on the exterior surfaces.

25.3.19 Manufacturer/Patented Technology

25.3.19.1 The equipment specified shall be the product of a manufacturer having a minimum of five years experience in the construction of prefabricated equipment.

25.3.19.2 Specification given above are of general nature. Nothing in these paras shall prevent Accepting Officer to accept, a patented technology approved by E-in-C's Branch, as per the design of the manufacturer subject to overall requirement of the input, output water parameters, land availability, economy in operation/maint costs and adherence to the environmental conditions stipulated in local pollution control norms etc.

25.3.20 Warranty

25.3.20.1 The manufacturer shall warrant the equipment being supplied against defects in workmanship and materials for a period of one year under normal use and service.

SECTION 26
SOLAR WATER HEATER

26.1. Indian Standards : The following IS shall apply

IS Code.	*Subject*
11907 - 1986	Recommendations for calculation of solar radiation on buildings
12762 - Part 2 - 1993	Photovoltaic devices Part 2 Requirement for reference solar cells
12834 - 1989	Solar photovoltaic energy system: Terminology
12933 - Part I - 2003	Solar Flat Plate Collector - Specification - Part 1 : Requirements (Second revision)
12933 - Part 2 - 2003	Solar Flat Plate Collector - Specification - Part 2 : Components (Second revision)
12933 - Part 3 - 2003	Solar Flat Plate Collector- Specification - Part 3 Measuring Instruments (First revision)
12933 - Part 5 - 2003	Solar Flat Plate Collector - Specification - Part 5 . Test Methods (Second revision)
12976 - 1990	Code of practice for solar water heating systems
13129 - Part I - 1991	Solar heating - Domestic water heating system: Part 1 Performance rating procedure using indoor test methods
13129 - Part 2 - 1991	Solar heating - Domestic water heating systems: Part 2 Procedure for system performance characterization and yearly performance predication
13129 - Part 3 - 1991	Solar heating - Domestic water heating systems: Part 3 Procedure for system component characterization and predication for yearly performance using component performance data
13129 - Part 4 - 1991	Solar heating - Domestic water heating system: Part 4 Determination of durability and reliability

26.2 General Requirement

26.2.1 Scope of work shall include supply, installation, testing and commissioning of solar water heater.

26.2.2 All components, equipments and accessories shall be conforming to latest Indian Standards as applicable. The installation shall comply with the applicable codes of practice (wherever such codes of practice issued by the competent authority), regulations and Indian Electricity Rules and other safety regulations.

26.2.3 The layout of various components, equipments and accessories shall match with the actual site dimensions where equipments shall be installed.

26.2.4. The entire installation work shall be in workman like manner and in accordance with the modern Engineering practices adopted for such works.

26.2.5 The position shall not be shaded by any obstacles (trees, buildings etc.) all around the year.

26.2.6 The installation shall be done according to the electric and plumbing regulations applicable.

26.2.7 In regions subject to heavy snowfalls, it shall be ensured that too much snow does not accumulate behind the storage tank, and the supports of the standard equipment are good enough to withstand the weight of the expected snow. The same attention shall be paid, for regions with heavy winds and storms. In these cases, the storage tank shall be placed in a stable way on the roof and shall be tightened with the additional metal straps. It shall be absolutely necessary to use the typhoon set.

26.2.8 The tubes of the solar water heater as well as the cold/hot water piping shall be very well insulated.

26.3 Solar Flat Plate Collectors

26.3.1 The collectors shall be manufactured as per IS: 12933 - 1992.

26.3.2 Collector Box Frame

26.3.2.1 Collector box frame shall be made up of extruded aluminum channel section of size not less than 100mm x 25 mm with thickness of 1.6+0.2 mm for sides, 0.71+ 0.07 mm thick aluminum sheet for bottom and aluminum angle section of 25 mm x 25 mm 1.2 mm for retaining the glass. All aluminum material shall be anodized in natural colour. The overall size of each BOX shall be size 'B' as described in IS 12933- 1992.

26.3.2.2 Surface shall be smooth and free from any defects. Sharp edges and corners shall be rounded off.

26.3.3 Cover Plate

26.3.3.1 Glass used for cover plates shall be minimum 4mm thick toughened glass. The glass shall be sealed with RTV silicon sealant/silicon glazing seal.

26.3.3.2 It shall have minimum of 85% transmissibility. The glass shall be free from bubbles/ rough surface and shall withstand thermal stock /impact test as per relevant IS. Aperture area shall not be less than 1.95m (size 'B' as per 1S-12933).

26.3.4 Sheet for Absorber

26.3.4.1 Absorber sheet shall be of copper having serrated fins to have increased surface area. The min thickness of the sheet shall be 0.19 mm.The absorber shall have min solar absorptive value of 0.92 and maximum Emissivity of 0.20.

26.3.4.2 Thickness of rise pipe shall not be less than 0.6 mm.Copper header dia shall not be less than 25mm.Thickness of header pipe shall be min 0.80 mm.Spacing shall be min 63mm.Bonding

(Header to riser) shall be continuous. Brazing and Riser to sheet bonding shall be continuous full length brazing at high temp.and shall be soldered with melting point 250 ^{0}C or above.

26.3.4.3 Pressure testing shall be done at 5 Kg/cm^2 min or twice the design pressure whichever is higher.There shall be no pressure drop within a period of 30 minutes. Nuts and bolts shall be of Stainless Steel

26.3.5 Collector Box Insulation

26.3.5.1 Collector box shall be insulated with Rock Wool having density 48 Kg/m^2. Thickness of insulation shall be min 50mm at the backside and 25 mm at the sides. Back and sides insulation shall be covered with aluminum foil of thickness not less than 0.05mm. A certificate regarding K value and Temperature test shall be provided by the manufacturer.

26.3.6 Gaskets and Grommets

26.3.6.1 Gasket shall be EDPM rubber channel and grommets shall be of EPDM. The material shall withstand thermal shock test at 125°C and shall not show any crack or brittleness. The panels shall be water tight and no water vapour shall be allowed in the collector

26.3.7 Assembly and Workmanship

26.3.7.1 The collector shall be assembled in such a way that weight of the absorber is distributed uniformly on the side walls of the collector Box.

26.3.7.2 The entire assembly shall be free from surface defects. All sharp edges and corners shall be rounded off. The exposed surfaces shall be properly made corrosion free.

26.3.7.3 The air gap between the cover plate bottom and absorber surface shall be within 20 to 40mm.

26.3.7.4 The insulation shall be provided in such a way that no slippage occurs from anywhere. This shall be done by providing additional insulation under the header.

26.3.7.5 The cover plate shall be fixed with the collector box through ethylene propylene diene monomer (EPDM) rubber channels in order to protect the cover plate from damage. Provision shall also be made for the expansion of glass.

26.3.7.6 The solar collector shall be assembled so that replaceable components are accessible for repair or replacement at site in accordance with the manufacturer's instructions.

26.3.8 Marking

26.3.8.1 Each flat plate collector shall be affixed with a name plate with the following information.

(a) Manufacturers name, initials and recognized trade name if any.
(b) The serial number.
(c) The country of manufacture.
(d) Maximum working pressure in kilo- Pascal.

26.3.8.2 Solar flat plate collectors shall be constructed strictly as per norms of Ministry of Non-conventional Energy Sources (MNES), Govt. of India and BIS specifications. Proper test certificates from the test house approved by Ministry of non-conventional Energy Sources certifying compliance of all parameters of MNES and BIS specification shall be produced by the contractor.

26.4. Collector Support Structure

26.4.1 The support structure for the collectors shall be of MS angle of size not less than 40x40x6 mm. The structure shall be provided with suitable flat iron sections to fix collectors on structure and to prevent from uprooting, during heavy winds. All structure, clamps, fittings etc, shall have galvanizing of 15 micron thickness, the structure shall be designed to withstand the wind pressure/ velocity on the seashore. The structure shall be anchored on the top of the roof without damaging any part of the roof.

26.5. Hot Water Storage Tank

26.5.1 Construction

Tank shall be of the full capacity as per the system. Tank shall have thermal stratification to prevent mixing of cold and hot water. The tank shall be made of 3.15mm thick stainless sheet SS-304.

26.5.2 Insulation

Hot water tank shall be insulated with 100 mm thick Rock Wool of density 48 Kg/m3. The insulation shall be fixed on outside the tank using chicken wire mesh and vapour barrier. On the top of the insulation, aluminium cladding with 26 SWG aluminium sheet shall be provided with weather proof joints to prevent any seepage of water/ water vapour.

26.5.3 Tank Support Structure

Tank support structure shall be made out of MS support structure. The structure shall be designed to carry the load of the tank, insulation and water with a adequate safety factor keeping in view the wind velocity. Adequate anchoring and other arrangement shall be made as safety precautions in addition to grouting. Support structure shall be galvanized with 15 micron thickness.

26.6. Water Circulating Pumps

26.6.1 Centrifugal type hot water circulating pumps of adequate capacity shall be used for each system. Pumping sets shall be suitable for circulating of hot water upto 100°C. The pumps shall operate at 1450 rpm and shall be suitable for operation on 415V, 3phse, 50-HZ, AC Supply. Pumping set shall be complete with common base frame, nuts and bolts, mechanical seal and Teflon glands etc.

26.7. Piping System

26.7.1 The layout of hot water pipes shall be as per site condition. Outlet pipes from the hot water storage tank shall be laid on the roof top upto the edge of roof only. Remaining insulated hot water pipe shall be laid by other agency. However, the connections with all fittings and fixtures shall be covered in the scope of this work. All pipes and fitting shall be medium grade Gl Pipe. The insulation of pipes shall be carried out as per specification mentioned for hot water tank but with 50mm thick Rock Wool. All valves and control including NRVS shall be made up of Brass. CI/GI valves shall not be used.

26.8. Instrumentation

26.8.1 Temperature indicator: Temperature indicator shall be dial type giving indication of temperature between 0-100°C with body of brass and non-corrosive metal parts. Temperature indicators shall be fitted at the following locations for each system.

(a) Cold water inlet
(b) Hot water outlet
(c) Hot water tank

26.8.2 Water Flow Meter

Water flow meter of the size of the inlet pipe made of brass body and non-corrosive metal parts shall be installed at the cold water inlet for each system.

26.8.3 Pressure gauges

Pressure gauge (dial type) indicating pressure from 0-7 kg/cm^2 shall be installed. One No. Pressure gauge shall be installed at the delivery of pump set and the other one on the top of hot water tank for each system.

26.9. Controls And Control Panels

26.9.1 Each system shall be provided with electric control panel completely enclosed floor mounted type made out of 18 gauge CRCA sheet and angle iron frame floor mounted duly epoxy coated consisting of the following:

(a) Aluminium bus bar 3 phase 4 wire of suitable capacity.

(b) Main incoming control i.e., MCCB of suitable capacity.

(c) Outgoing MCCB of suitable capacity for pump sets alongwith starters.

(d) Indicating lamp.

(e) Ammeter.

(f) Voltmeter.

(g) Time Totalizer.

(h) Differential Temp Controller with temp differential from 3-10°C.

(i) Sensors, PTs, CTs, etc.

(j) SWG GI wire of adequate length up to nearest existing earthing lead.

26.10. Testing

26.10.1 After the installation of system is completed the installation shall be put to 72 hour continuous testing for checking all design parameters. All arrangements for testing shall be done by the contractor. If the installation fail to achieve the design parameters, the contractor shall rectify the defects/replace the defective parts/installation and carry out retest till satisfactory results are achieved without any extra cost to the department.

26.11. Instruction Manual

26.11.1 The contractor shall provide Instructional Manual of the manufacturer of Solar Plate collectors containing the following information:-

(a) Installation instructions including mounting details, handling recommendations and safety precautions.
(b) Maintenance instructions, for example, cleaning of cover plate, painting, other maintenance schedules.
(c) Recommended output capacities of collectors at temperature range from 60^{0}C for 20°C inlet water temperature.

SECTION 27
FIRE HYDRANT, SPRINKLER, FIRE DETECTION & ALARM SYSTEM

27.1 Indian Standards: The following IS apply to this Section:-

IS Code	*Subject*
5 - 2004	Colours for ready mixed paints and enamels (Fifth revision)
325 - 1996	Three phase Induction Motors (Fifth revision)
444 - 1987	General purposes rubber water hose (Fourth revision)
636 - 1988	Non-percolating flexible fire fighting delivery hose (Third revision)
884 - 1985	Specification for first-aid hose reel for fire fighting (First revision)
901 - 1988	Specification for couplings, double male and double female, instantaneous pattern for fire fighting (Third revision)
902 - 1992	Specification for suction hose coupling for fire fighting purposes (Third revision)
903 - 1993	Specification for fire hose delivery couplings, branch pipe, nozzles and nozzle spanner (Fourth revision)
907 - 1984	Specification for Suction Strainer cylindrical type for fire fighting purposes (Second revision)
908 - 1975	Specification for Fire Hydrant, Stand Post Type (Second revision)
909 - 1992	Specification for underground fire hydrant, sluice valve type (Third revision)
1239 (Part 1) -2004	Specification for steel tubes, tubular and other wrought steel fittings Part 1: steel tubes (Sixth revision)
1239 (Part 2) -1992	MS tubes, tubular and other wrought steel fittings, Part 2 MS tubular and other wrought steel pipe fitting (Fourth revision)
2175 - 1988	Specification for heat sensitive fire detectors for use in automatic fire alarm system (Second revision)
2189 - 1999	Code of Practice for Selection, Installation and Maintenance of Automatic Fire Detection and Alarm System (Third revision)
2379 - 1990	Colour code for indentification of pipe lines (First revision).
3844 - 1989	Code of practice for installation and maintenance of internal fire hydrants and hose reels on premises (First revision)
4038 - 1986	Specification for Foot Valves for water works purposes (Second revision)
4928 - 1986	Specification for delivery valve for centrifugal fire pump outlets (First revision)
5290 - 1983	Specification for Landing Valves (Third revision)
5312 (Part I) - 1984	Specification for Swing check type reflex valves (Non return) for water works purposes: Part I single door pattern.

5312 (Part 2) -1986	Specification for Non-Return Valves for water works purposes: Part 2 multidoor pattern
5714 - 1981	Specification for Hydrant Stand-Pipe for Fire Fighting (First revision)
7673 - 2004	Fire Fighting Equipment - Glossary of Terms
8757 - 1999	Glossary of terms Associated with Fire Safety
9972 - 2002	Specification for Automatic Sprinkler Heads for Fire Protection Service (First revision)
10221 - 1982	Code of Practice for Wrapping and Coating of underground MS pipe lines
11101 - 1984	Specification for Extended Branch Pipe for Fire Brigade Use
11360 - 1985	Specification for smoke detectors for use in automatic electrical fire alarm system
12349 - 1988	Fire protection-safety signs
12407 - 1988	Graphic symbols for fire protection plans
12469 - 1988	Specification for Pumps for Fire Fighting System
14846 - 2000	Sluice Valve for water works purposes (50 to 1200 mm size)
14933 - 2001	High Pressure Fire Fighting Hose - Specification
15051 - 2001	High Pressure Fire Hose Delivery Couplings - Specification
15105 - 2002	Code of Practice for Design and Installation of Fixed Automatic Sprinkler Fire Extinguishing Systems
15301 - 2003	Code of Practice for Installation and Maintenance of Fire Fighting Pumps

A. FIRE HYDRANT & SPRINKLER SYSTEM

27.2 General Requirements

27.2.1 The scope shall cover the design, engineering, manufacture, shop testing, assembly, painting, forwarding delivery, unloading and storage at site, local transportation, erection, testing, commissioning, performance demonstration at site and handing over the Hydrant/ Wet Riser System etc.

27.2.2 Approval of the installations shall be obtained from the Directorate of Fire Services (DFS), CEIG and relevant fire regulation authorities before commissioning. Contractor shall be responsible for preparation of documents / applications / drawing(s) and follow up action from DFS / Local authorities.

27.2.3 The MES Operators shall be trained during the testing and commissioning period for efficient operation and maintenance of the systems.

27.2.4 The contractor shall prepare detailed working drawing showing the routing of the Hydrant piping showing the location of the risers for approval before starting the work. All drawings are to be prepared for Piping, Pump room layout, Sprinkler System etc.

27.3 Yard Hydrant/ Wet Riser System

27.3.1 The Yard Hydrant/ Wet Riser System shall consist of the following

(a) Electrically Driven Main Pump set.
(b) Diesel Engine Driven Main Pump set.
(c) Electrically Driven Jockey Pump set
(d) Water tank
(e) The Hydrant valves
(f) Fire brigade Inlet provided near the entrance
(g) The entire system capable to be either put in Auto / Manual mode.

27.3.2 Fire Pumpset

27.3.2.1 The pump shall be of horizontal end suction, centrifugal pump.

27.3.2.2 Pump shall preferably be designed to have the best efficiency at the specified duty point. The pump shall be suitable for continuous operation at any point within the "Range of Operation" i.e., 0% to 150% of rated capacity.

27.3.2.3 Pump shall preferably have a continuously rising head capacity characteristics from the specified duty point towards shut-off point, the maximum being at shut-off to enable parallel operation

27.3.2.4 Pump motor assembly shall be dynamically balanced and designed with critical speed substantially above the operating speed.

27.3.2.5 The pump shall be driven by drive unit directly coupled. A heavy duty coupling along with coupling guard shall be provided between the pump and drive unit.

27.3.2.6 Pump shall be capable of furnishing not less than 150% of rated capacity at a head of not less that 65% of the rated head.

27.3.2.7 The shut-off head shall not exceed 120% of rated head

27.3.2.8 The drive unit power rating shall be the maximum of the following requirements.

(i) 15% margin over the pump shaft input power at the rated duty point.
(ii) 5% margin over the pump shaft input power required to drive the pump at 150% of its rated discharge

27.3.2.9 The pump set shall be of securely mounted on a robust base frame and shall be free from vibration at all variations of load.

27.3.2.10 The pumps shall also be linked to recirculation pipe line required for minimum flow through the pump during its operation without any discharge through headers.

27.3.2.11 Pump shall be provided with a name plate indicating delivery head, capacity and RPM.

27.3.2.12 The material of construction of pump shall be as under :

(i)	Casing	:	Cast Iron, IS: 210, Gr.20.
(ii)	Impeller	:	Bronze IS:318, Gr.L T B 1
(iii)	Wearing Rings	:	Bronze.
(iv)	Shaft Sleeve	:	S/S Type AISI 10.
(v)	Stuffing Box	:	Cast Iron. IS:210, Gr.20.
(vi)	Gland	:	Cast Iron. IS:210, Gr.20.
(vii)	Gland packing	:	Teflon asbestos with mechanical seal
(viii)	Shat	:	Stainless Steel AISI 40.
(ix)	Base Frame	:	Fabricated M.S.

27.3.3 Jockey Pumpset

27.3.3.1 The pump shall be horizontal end suction, centrifugal pump.

27.3.3.2 The pump shall be directly coupled to the motor and proper coupling guard shall also be used.

27.3.3.3 The pump base frame shall be fabricated out of M.S. Channel section and shall be very rigid

27.3.3.4 The base frame shall accommodate both the pump and the motor.

27.3.3.5 The pump shall be suitable for automatic operation.

27.3.3.6 Jockey pump shall have non-overloading type power characteristics.

27.3.3.7 Jockey pump drive motor shall be suitable for frequent start / stop operations as required by the system.

27.3.3.8 Pump shall be provided with a name plate indicating delivery head, capacity and RPM.

27.3.4 Motors

27.3.4.1 The motors for the Main and Jockey Pumps shall be of general purpose, constant speed, and sized for the maximum output at an ambient temperature of 40° C.

27.3.4.2 The motor for the Main Pump shall be of TEFC. (Totally enclosed fan cooled)

27.3.4.3 The motor for the Jockey pump shall be of TEFC (Totally enclosed Fan Cooled).

27.3.4.4 The motor shall be wound for Class 'B' Insulation. The windings shall be vacuum impregnated with heat and moisture resisting varnish and preferably glass fibre insulated to withstand tropical conditions.

27.3.4.5 The motor shall be rated for continuous duty. These shall also be suitable for long period of inactivity.

27.3.4.6 The operating speed for the Main Pump and Jockey Pump Motor shall be 2900 RPM.

27.3.4.7 The motors shall be suitable for electric supply / D.G. set of 440 V, 3 Phase, 50 Hz. and shall run continuously at rated input over the entire range of voltage and frequency variations as under:

(i) Voltage	:	10%
(ii) Frequency	:	5%
(iii) Combined Voltage Frequency	:	10% (Absolute sum)

27.3.4.8 Motors shall be designed for direct on line starting at full voltage. The starting current shall not exceed 6 times full load current.

27.3.4.9 Motors shall be effectively grounded and shall be provided with two separate and distract grounding pads, each complete with tapped hole galvanised bolt and washer for connection to station ground conductors.

27.3.5 Control Panel for the Main Pumpsets and Jockey Pumpset

27.3.5.1 The starting switch gear for the main pumpsets shall be of Star Delta type and for the Jockey shall be suitable for direct on line starting.

27.3.5.2 The control circuit for the main pumpsets shall be designed for automatic operation i.e., whenever the pressure reduces in the system, the main pump shall automatically start. The stopping of the Main pump is 'Manual'.

27.3.5.3 The control circuit for the Jockey pumpset shall be designed that whenever pressure reduces the pump shall start automatically and when pressure reaches rated system pressure then it should automatically switch OFF.

27.3.5.4 Auto / Manual switch shall be provided for both the Main & Jockey pump set so that the pump sets can be started / stopped manually also. Provisions shall be made for receiving power supply from both EB/Gen set.

27.3.5.5 The panel shall be provided with the Voltmeter and Ammeter with indicating 'R' ‘Y’ 'B' Lamps.

27.3.5.6 The control panel shall be of welded construction, fabricated from sheet metal having 2.03 mm (14 SWG) thickness and shall be dust and vermin proof.

27.3.5.7 The panel shall be completely factory wired absolutely ready in all respect for installation at site and termination of external cables for which undrilled bottom gland plate shall be provided. The internal wirings of the panel shall be carried out with 650 V grade stranded copper wire of size rated for the current in the corresponding circuit. The minimum size of the wire shall not be less than 1.5 sq.mm. stranded copper. The wiring termination shall be done using ferrules having indelible marking at the termination to reduce the possibility of short circuit between various wires.

27.3.5.8 Neoprene or equivalent rubber gaskets shall be provided at all openings.

27.3.5.9 All the components used in the panel shall be of reputed makes.

27.3.5.10 Name plate shall be provided at the panel.

27.3.5.11 Isolating switch fuse units shall be provided in the panel for incoming A C power supply / D.G. set supply

27.3.5.12 Two numbers diametrically opposite earthing connection shall be provided for the panel. The earthing of the panel shall be done as per the rules and regulations.

27.3.6 Diesel Engine

27.3.6.1 The engine shall be of the compression ignition mechanical direct injection type, capable of starting without the use of wicks, cartridges, heater plugs or either at an engine room temperature 7 ^{0}C and shall accept full load within 15 seconds from the receipt of the signal to start.

27.3.6.2 The engine shall be naturally aspirated, supercharged or turbo charged and either air or water cooled. In the case of charge air cooling by means of a belt-driven fan or of a belt driven auxiliary water pump there shall be multiple belts such that should half the belts break, the remaining belts would be capable of driving the fan group.

27.3.6.3 The engine shall be provided with an adjustable governor to control the engine speed within 10% of its rated speed under any condition of load upto the full load rating. The governor shall be set to maintain rated pump speed at maximum pump load.

27.3.6.4 Engines, after correction for altitude and ambient temperature shall have bare engine horse power rating equivalent to the higher of the following two values.

- 20% in excess of the maximum brake horsepower require to drive the pump at its duty point.
- The brake horse-power required to drive the pump at 150% of its rated discharge.

The coupling between the engine and the pump shall allow each unit to be removed without disturbing the other.

27.3.6.5 Starting Mechanism

27.3.6.5.1 Provision shall be made for two separate methods of engine starting viz ,

(a) Automatic starting by means of a battery powered electric starter motor incorporating the axial displacement type of pinion, having automatic repeat start facilities initiated by a fall in pressure in the water supply pipe to the sprinkler and/or hydrant installation. The battery capacity shall be adequate for ten consecutive starts without recharging with a cold engine under full compression.

(b) Manual starting by :

(i) Crank handle, if engine size permits.

OR

(ii) Electric starter motor.

27.3.6.6 Battery

27.3.6.6.1 Battery, Battery charger and DC DB shall be housed in a metal enclosed, free standing compartmentalized, sheet steel panel.

27.3 6.6.2 The Batteries shall be housed in the bottom compartment with the Battery Charger in the middle and the DC DB housed in the top compartment.

27.3.6.6.3 The panel shall be fabricated out of adequate thickness mild steel of not less than 2.0mm thickness.

27.3.6.6.4 All retaining catches, screws and bolts shall be cadmium plated.

27.3.6.6.5 The Battery shall be maintenance free, sealed, Lead Acid type

27.3.6.6.6 The Cell containers shall be heat resistant, shock absorbing and shall be of hard rubber or polypropylene.

27.3.6.6.7 The complete batteries shall include the cells, intercell connectors, terminal lugs, etc.,

27.3.6.6.8 The batteries shall have an adequate capacity to supply power to steady state loads for eight (8) hours. At the end of the three (3) hours, the voltage shall not have fallen under 95% of the rated voltage.

27.3.6.6.9 The discharge capacity shall be so determined that at the end of the discharge period of the eight (8) hours the voltage is not less than that nominal discharge voltage. The battery capacity shall be adequate for 10 consecutive starts without re-charging.

27.3.6.6.10 All connections except inter-cell connections, shall be made with copper rod supported on insulators of approved type. The copper rod, as well as the cable connections, shall be protected from corrosion by painting with two coats of anti sulphuric enamel or other approved means.

27.3.6.6.11 Intercell connections shall be of low resistance and shall be in a clean condition when bolted and shall be protected by petroleum jelly, alternatively, intercell connections may be soldered.

27.3.6.7 Battery Charging

27.3.6.7.1 The means of charging the batteries shall be by a 2 rate trickle charger with manual selection on boost charge and the batteries shall be charged in position. Where separate batteries are provided for automatic and manual starting, the charging equipment shall be capable of trickle charging both the batteries simultaneously. The charging equipment shall charge the batteries.

27.3.6.8 Fuel System

27.3.6.8.1 The diesel engine will run on Light Diesel Oil.

27.3.6.8.2 Engine shall be provided with a fuel oil tank fitted with a level indicator and having adequate capacity to hold sufficient fuel oil for minimum two (2) hours on full load run. The fuel oil tank shall preferably be mounted on the engine. The level indicator shall be of float type and not PVC tube type.

27.3.6.8.3 The fuel oil tank shall be constructed of welded steel as per relevant IS Code. The tank shall be above the inlet of fuel injection pump of the diesel engine to ensure adequate pressure at suction of injection pump.

27.3.6.8.4 The fuel oil tank shall be provided with a sludge and sediment trap, so that the same is not carried to the injection pump. Adequately sized inspection and cleaning hole shall be provided to facilitate maintenance.

27.3.6.8.5 Pipe line carrying fuel oil shall be independent for each engine and gradually sloped from the tank to the injection pump. Any valve in this line shall be placed adjacent to the tank and kept locked in open position. A filter shall be incorporated in the fuel oil system and shall be mounted in an accessible position for cleaning.

27.3.6.8.6 Pipe joints shall be welded and shall not be soldered. No plastic pipes shall be used.

27.3.6.8.7 The design of complete fuel oil system shall be free of air pocket in any part of the pipe work, fuel pump, sprayers/injectors, filter system, etc., Use of screwed plugs shall be permitted where air relief is essential.

27.3.6.9 Air Filteration

The air Intake shall be fitted with a filter of adequate size to prevent foreign matter entering the engine.

27.3.6.10 Exhaust System

The exhaust shall be fitted with a suitable silencer to keep the total back pressure within the engine maker's recommendation The exhaust system shall also be free from any condensate flowing into the engine.

27.3.6.11 Engine Shut-down Mechanism

This shall be of manual operation to bring the engine to starting position after use.

27.3.6.12 Accessories

27.3.6.12.1 The engine shall be mounted on a frame of fabricated steel construction. Adequate access shall be provided to the big end and main bearings, camshaft and governor drives water jacket, etc.,

27.3.6.12.2 Indicator cocks shall be mounted directly on the cylinder head and located in such a manner as to permit preparation of the indicator cards without removing the valve operating gear covers.

27.3.6.13 Tools

27.3.6.13.1 A standard tools kit shall be provided with the engine.

27.3.6.14 Spare Parts

27.3.6.14.1 The following spare parts shall be supplied with the engine :-

(a) Two sets of fuel filters, elements and seals.
(b) Two sets of lubricating oil filters elements and seals.
(c) Two sets of belts (where used).
(d) One complete set of engine joints, gaskets and hoses,
(e) Two injector nozzles. .
(f) One complete set of piston rings for each cylinder.
(g) One Inlet valve and one exhaust valve,
(h) Scraper rings.

27.3.6.14.2 Yard Hydrant/Wet Riser system (Pumps)
(Spares are for each type of pumps)

(i) Impeller	-	1 Set.
(ii) Shaft	-	1 No.
(iii) Shaft sleeve	-	2 Nos.
(iv) Glands	-	2 Nos.
(v) Latern Rings	-	2 Sets
(vi) Bearings	-	2 Sets

27.3.6.15 Auto Start Control Panel for Diesel Engine

27.3.6.15.1 The Auto-start control panel shall have the following :
(i) Auto/Manual selector switch for pumpset.
(ii) Manual start/stop push button
(iii) Indicating lamps showing power on and run/stop.
(iv) Voltmeter/Ammeter in battery charging circuit.

27.3.6.15.2 The control panel shall be welded construction, fabricated from sheet metals having 2.03 mm (14 SWG) thickness and shall be dust and vermin proof.

27.3.6.15.3 The maximum and minimum height of the operating equipment on the panel shall be 1800mm and 750mm respectively from the floor level. If the control panel height is small then it should be mounted on a separate support, so that the operating height of the equipment comes within the above limit. The proper supporting arrangement shall be provided for the control panel.

27.3.6.15.4 The panel shall be completely factory wired absolutely ready in all respect for installation at site and termination of external cables for which undrilled bottom gland plate shall be provided. The internal wirings of the panel shall be carried out with 650 V grade stranded copper wire of size rated for the current in the corresponding circuit. The minimum size of the wire shall not be less than 1.5 Sq.mm stranded copper. Wiring shall be of switchboard type, single core, stranded, annealed copper wire with PVC Insulation. All the wirings to be hooked up with external cables shall be terminated in suitable terminal blocks complete with washers, terminal screws etc. .10% spare terminals shall be provided on the terminal blocks. The wiring termination shall be done using ferrules having indelible markings. Insulated sleeves shall be provided at the terminations to reduce the possibility of short circuit between various wires.

27.3.6.15.5 Neoprene or equivalent rubber gaskets shall be provided at all openings.

27.3.6.15.6 All necessary relays, contactors, indicators, alarm push buttons, shall be housed in the panel.

27.3.6.15.7 The Auto Start panel shall have both trickle & Boost charger to charge the batteries.

27.3.6.15.8 The panel should be designed and compatible with the make of the diesel engine offered.

27.3.6.15.9 All the components used in the panel shall be of reputed makes.

27.3.6.15.10 Name plate of approved design shall be furnished for panel and for each instrument or device mounted on the panel.

27.3.6.15.11 The panel shall have provision of cable entry from bottom/top. Arrangement shall be provided to make entry dust-tight and vermin proof.

27.3.6.15.12 The panel shall have provisions for fixing the multi-core cable glands. The cable gland support plate 4 mm thick shall be mounted not less than 200mm above floor level (for bottom entry).

27.3.6.15.13 Two numbers diametrically opposite earthing connection shall be provided for the panel. The earthing of the panel shall be done as per the rules and regulations.

27.3.7 MS Pipes and Fittings :

The use of M.S. Pipes in the execution shall be as follows :

27.3.7.1 Buried and Overground Pipes :

Mild Steel ERW Pipes as per IS:1239 (Part-I) medium grade (for pipes of sizes 150 mm NB and below) or IS:3589 (for pipes of sizes 200 mm. and above) with IS mark in both the cases.

27.3.7.1.1 Minimum thickness of steel pipes shall be as per IS: 3589.

27.3.7.1.2 All fittings to be used in connection with steel pipelines upto a size of 80 mm. shall be as per IS: 1239, Part - 2, 'Mild Steel tubulars and other wrought steel pipe fittings. Heavy grade Fitting with sizes above 80 mm to 150 mm. shall be fabricated from heavy grade pipes conforming to IS:1239 (Part-1) having thickness not less than those of IS: 1239 (Part-2) heavy grade pipes. Fitting with sizes above 150 mm shall be fabricated from pipes conforming to IS:3589 or steel plates having thickness not less than those specified in the IS:3589. All fittings shall be of forged steel for Sprinkler System.

27.3.7.1.3 Welded construction shall be adopted for steel pipelines unless specified otherwise

27.3.7.1.4 Hangers and supports shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipelines movement as necessary. All guides, anchors, braces, dampers, expansion joint and structural steel to be attached to the building / structure / trenches etc., shall be provided where required.

27.3.7.1.5 All piping system shall be capable of withstanding the maximum pressure arising from any condition of testing (as stipulated) and operation, including water hammer effects.

27.3.7.2 Coating and Wrapping

Steel pipelines to be laid underground buried in the soil shall have protection against corrosion by means of coating & wrapping as per IS: 10221.

27.3.7.2.1 The above coating and wrapping shall be carried out in systematic manner so that uniform thickness of coating is obtained as per IS specification

27.3.7.2.2 Pipeline thus coated and wrapped shall be tested for Holiday detection by means of high voltage Holiday Detector (10,000 Volts). Any defects observed during such test shall be suitably rectified.

27.3.7.2.3 Buried pipelines shall be laid in general with top of pipe 1 (one) metre below the ground level. Where soil conditions are not satisfactory, masonry or equivalent supports shall be provided at regular intervals.

27.3.8 Priming Tank and Accessories

27.3.8.1 The Priming Tank shall be of M.S. Tank.

27.3.8.2 The capacity of tank shall be atleast three times than that of the suction pipe from pump to the foot valve. However, the minimum capacity of the tank shall not be less than 1000 Litres.

27.3.8.4 The priming tank shall be connected to the delivery side of the pump by a steel pipe having a minimum internal diameter of 100 mm with a stop valve and a non return valve therein of the same size.

27.3.8.5 The priming tank shall be provided with a dependable independent filling arrangement and a level indicator.

27.3.8.6 Priming tank shall also be provided with overflow arrangement, drain pipe, venting, man-hole cover, and water inlet connection

27.3.9 Valves

27.3.9.1 Only Butterfly Valves shall be used.

27.3 9.2 Non-return Valves

27.3.9.2.1 Only Wafer Type slim non return valves shall be used

27.3.9.3 Foot-valves

27.3.9.3.1 Foot Valves shall be as per IS:4038-1986. It shall be cast Iron body with leather flap sealing clamped on cast iron disc plates.

27.3.9.3.2 Foot Valve shall be with a strainer which will have cored holes / slots with straining equivalent to two and half times the area of the pipe bore.

27.3.9.3.3 Valves below 50 mm size shall have screwed ends while those of 50 mm and higher sizes shall have flanged end connections with drilled holes conforming to IS: 1538.

27.3.10 Hydrant Components

27.3.10.1 Hyderant Valve

27.3.10.1.1 Hydrant Valve shall be of single headed with 75 mm NB angled Inlet, 63 mm Oblique outlet as per IS:5290.

27.3.10.1.2 The material of construction shall be as follows :

(i)	Body	:	Gunmetal
(ii)	Trim	:	Leaded tin bronze as per IS : 318 Grade-2
(iii)	Hand Wheel	:	Cast Iron FG 200 as per IS:210.
(iv)	Washer, Gasket	:	Rubber as per IS 638
(v)	Quick coupling connection	:	Leaded tin bronze as per IS:318, Grade-2.
(vi)	Spring	:	Phosphor Bronze as per IS:7608.
(vii)	Male Blank Cap.	:	Leaded tin Bronze as per IS:318, Grade-2.
(viii)	Chain	:	G.I.

27.3.10.1.3 Hydrant Valve shall be of approved make and with IS mark

27.3.10.2 Branch Pipe

Branch Pipe shall be of gunmetal short, 63 mm made instantaneous inlet, made threaded outlet, 15 mm bore nozzle with IS Mark and TAC approval.

27.3.10.3 Hoses

Hoses shall be of Synthetic fibre, circular woven jacketed, treated against rot, Working Pressure 12 kg/sq cm. Burst pressure, 36 kg/sq cm .Coupling shall be male and female parts, gunmetal, 63 mm. (2 1/2") size, heavy quality bearing conforming to IS.903 with IS Mark and TAC approval.

27.3.10.4 Hose Reel

(i) Hose reel shall be type 'A', wall mounting type, swinging complete with 19 mm. bore, high pressure braided rubber hose. 36 m long, 6 mm bore shut off nozzle and 25 mm inlet valve, IS: 884 mark.
(ii) The material of construction for various components shall be as per IS:884 -1985.
(iii) Piping connecting for the hose reel shall be taken from the main riser above the landing valve

27.3.10.5 Hose Boxes

Hose Boxes shall be made of 18 gauge MS sheet 800 mm x 600 mm x 250 mm size with double door with glasses, lock, 2 keys and a break glass, recess for keys, painted in fire red. The door frames shall be of 16 gauge MS sheet. The hose box shall be painted fire red outside and brilliant white inside.

27.3.10.6 Fire Brigade inlet for the risers shall have two instantaneous pattern of 63 mm dia valve, complete with non-return valve, manifold etc , mounted in a suitable MS enclosure with glass fronted lockable doors.

27.3.10.7 All the hydrant components i.e. hydrant valve, hoses with coupling, branch pipe, hose reels shall have IS marking.

27.3.11 Instrumentation

27.3.11.1 Pressure Gauge

27.3.11.1.1 Pressure Gauge sensing elements shall be of continuous 'C bourdon type and duly glycerine filled.

27.3.11.1.2 Gauges shall be of 150 mm diameter dial stored enamel black finish case.

27.3.11.1.3 Normal processor pressure shall be gauged within 70% of full scale reading of the scale range.

27.3.11.1.4 All gauges shall be with stainless steel bourdon having rotary geared S/S movements

27.3.11.1.5. Accuracy shall be within ±1.0% of full scale range.

27.3.11.1.6 Gauges shall have internal and external stop pegs for cover range protection of 125% of maximum range and zero point respectively

27.3.11.1.7 All gauges shall have bottom connection for local mounting.

27.3.11.2 Pressure Switch

Pressure Switches shall be used to control the operating of the main fire pump and the jockey pump. The pressure switches shall be of bellows type with required differential as per the system (Scheme offered and the range shall be adjustable and suitable for the operation of the pumps).

27.3.11.3 Flow Switch

Flow Switch shall be used to monitor the flow of Sprinkler System and it shall be connected to the annunciation panel.

27.3.12 Execution

27.3.12.1 General

27.3.12.1.1 For Steel pipelines, welded construction shall be adopted unless specified otherwise.

27.3.12.1.2 Hangers and supports shall be capable of carrying the sum of all concurrently acting loads. They shall be designed to provide the required supporting effects and allow pipelines movements as necessary.

27.3.12.1.3 All piping system shall be capable of withstanding the maximum pressure arising from any condition of testing (as stipulated) and operation, including water hammer effects.

27.3.12.1.4 While erecting field run pipes, the contractor shall check the accessibility of valves, instrument tapping points, and maintain minimum head room requirement and other necessary clearance from the adjoining work areas.

27.3.12.1.5 Modification of prefabricated pipes, if any, shall have to be carried out by the contractor at no extra charge to the Govt.

27.3.12.1.6 All pipelines shall be given proper slope towards the drain point.

27.3.12.1.7 External and internal attachment to piping shall be designed so as not to cause flattering of pipes of excessive localised stresses.

27.3.12.1.8. All pipelines shall be identified by means of colour bands and direction arrows.

27.3.12.2 End Preparation

27.3.12.2.1 For steel pipes, end preparation for butt welding shall be done by machining / flame cutting.

27.3.12.2.2 Socket weld end preparation shall be sewing / machining.

27.3.12.2.3 For tees, laterals, mitre bends and other irregular details cutting templates shall be used for accuracy.

27.3.12.3 Pipe Joints

27.3.12.3.1 In general, pipes having sizes 50 mm and over shall be joined by butt welding and pipes having size 40 mm or less shall be jointed by socket welding / screwed. Joints shall have tapered threads and shall be assured of leak tightness without using any sealing compound.

27.3.12 3.2 Flanged joints shall be used for connection to vessels, equipment, flanged valves and also on straight lengths of pipelines at strategic points to facilitate erection and subsequent maintenance work

27.3.12.4 Above Ground Piping

Piping to be laid above ground shall be supported on supports. Support details shall have to be approved by the GE.

27.3.12.5 Painting

Above ground pipes shall be coated with one coat of red oxide primer and 2 (two) coats of synthetic enamel of 'Fire Red' colour. The pipe line surfaces shall be manually cleaned of rust / millscales by wire brush, carborandum tips etc. Use of whipping hammer, emery paper shall be done to clean pitted areas.

27.3.12.6 Welding

27.3.12.6.1 Before welding, the ends shall be cleaned by wire brushing, filling or grinding. Each weld-run shall be cleaned of slag before the next run is welded.

27.3.12.6.2 Welding at any joint shall be completed uninterrupted. If this cannot be followed for some reason, the weld shall be insulated for slow and uniform cooling.

27.3.12.6.3 Welding shall be done by manual oxy-acctylene or manual shielded metal arc process.

27.3.12.6.4. As far as possible welding shall be carried out in flat position. If not possible, welding shall be done in a position as close to flat position as possible.

27.3.12.6.5 The root of butt joints shall be such as to achieve full penetration with the complete fusion or root edges. The weld projection shall not exceed 3 mm inside the pipe.

27.3.12.6.6 On completion of each run crater, weld irregularities, slag etc., shall be removed by grinding or chipping.

27.3. 12.6.7 During the process of welding, all movements, shocks, vibration or stresses shall be carefully avoided in order to prevent weld cracks.

27.3.13 Testing

27.3.13.1 Piping

After the entire pipeline is erected, the pipe line shall be subjected to a hydrostatic test at 1.5 times the working pressure for a period of 2 (Two) hours. The test should be done in the presence of and to the satisfaction of the EIC. Defects noticed in the test should be repaired or if necessary, defective work should be replaced with new work. Tests shall be repeated until work is done satisfactorily.

27.3.13.2 Hydrant System

After erection at site the complete system shall be subjected to tests to show satisfactory performance in line with the requirements of specification and as per instruction of GE. The following tests shall be under taken in particular.

(a) Automatic starting of all fire pumps by operating the test valves.
(b) Operation of yard hydrant / internal hydrants and testing of sequential starting of all the fire pumps.
(c) Testing of the complete system / equipment.

27.3.14 Manuals

Three copies of manuals shall be submitted duly indexed with complete technical data sheet of each piece of equipment installed. The manuals shall be well bound and shall contain the following :

(i) Table of Contents.
(ii) Design data / standards.
(iii) 'As built' drawings.
(iv) Manufacturers catalogues, installation and maintenance brochure.
(v) Spare parts list

B. FIRE DETECTION AND ALARM SYSTEM

27.4 General Requirement

27.4 .1 The Contractor shall employ the services of the designated Fire Alarm Specialist Supplier for the design, supply and commissioning of the fire alarm system. It shall consist of fire alarm sounders, break-glass units, heat and smoke detectors and control units.

27.4.2 The fire alarm system shall be wired as 2 core signal loops. Alarm sounders may be either wired from the control unit, or in the case of loop powered sounders or interface units, connected via the signal loop. In the latter case, fire rated cable shall be used for signal cable and shall fully comply with the requirements of BS 5839 Part 1

27.4.3 The system shall incorporate a PA. System at the main control panel with selectors switch and Hooter/Speaker.

27.4.4 The fire alarm system shall conform to BS 5139 in respect of design and installation and shall give audio/Visual Alarm signals when the temperature in case of Heat Detector or smoke density in case of ionization detector exceeds the pre-set limits. The system shall give zone wise location of fire with warning system zone wise, two tone for alert and voice communication for commands and instruction if required.

27.4.5 The system shall be able to operate on 220 Volts AC ± 10% or 24 Volts DC. The design shall be modular so that additional zones can be added if required in near future. It shall have inbuilt power break and sequence logic hardware.

27.4.6 The system shall be fully supervised for all fault conditions with distinctive alarm operated for fault and fire conditions. All audible alarms either for fire or fault conditions shall have push button/cancellation arrangements with reset feature, to ensure that no alarm is inadvertently switched off. The fire or fault lamp shall however continue to glow until the fault condition has been corrected or the fire extinguished. Test push buttons on Main Control Panel shall be provided to test the electronic circuits in each zone.

27.4.7 Manufacturers Codes and Standards

The System shall meet the following design Standards as required by the law of the country. If no specific local laws are available National Fire Protection Association (NFPA) - USA shall be followed.

No. 72	National Fire Alarm Code
No 268	Smoke Detectors for Fire Protective Signaling Systems
No. 864	Control unit For Fire Protective Signaling Systems
No. 268A	Smoke Detectors for Duct Applications
No. 521	Heat Detectors for Fire Protective Signaling Systems
No. 464	Audible Signaling Appliances
No. 38	Manually Actuated Signaling Boxes
No. 346	Water flow Indicators for Fire Protective Signaling Systems
No. 1971	Visual Notification Appliances

BS 5839 & Local Fire Code

27.4 8 Approvals

The system shall have proper listing and/or approval from the following nationally recognized agencies:

EN-54	EU-Germany
UL	Underwriters Laboratories Inc
ULC	Underwriters Laboratories Canada
FM	Factory Mutual
MEA	Material Equipment Acceptance (NYC)
CSFM	California State Fire Marshal

27.4.9 All equipment supplied as part of the fire detection system shall conform to the following international standards:

- EN 54-European Standard for Fire Detection and Alarm Systems for Buildings.
- ISO 9001-Manufacturing Quality Management System, as certificated by the LPCB or other National Accreditation Agency.

27.5 Fire Detection and Alarm System

27.5.1 Fire Alarm Control Panel

27.5.1.1 Panel Compliance

The fire alarm control panel shall be compliant with BS EN 54 Part 2 (Control and Indication) and Part 4 (Power Supply).

27.5.1.2 Panel Construction

27.5.1.2.1 The housing containing the fire alarm control panel shall be minimum of 1.2 mm thick steel construction. The control panel shall confirm to IS-2119. It shall be totally enclosed dust and vermin proof type made of 16 gauge dust inhabited sheet with oven baked finish. The panel shall be of completely solid state design.

27.5.1.2.2 It shall be capable of being surface, semi flush or fully flush mounted.

27.5.1.2.3 Flush fixed knockouts shall be provided for all surface cable entries with the mains supply segregated from the low voltage entries. Rear entry knockouts shall also be provided as standard.

27.5.1.2.4 The housing shall afford a minimum ingress protection to IP30 and it shall not be possible to open the fire alarm control panel without the use of a special key. The logic circuitry shall be based on high noise immunity solid state hardware employing modular construction. Logic cards shall be of epoxy fiberglass construction. The system shall operate satisfactorily from 02 degree to 50 degree centigrade and 92% humidity. The components shall be suitable for satisfactory operation even when the auxiliary supply Voltage falls to 70% of their rated voltage. Earth return circuits shall not be used in the alarm system.

27.5.1.3 Panel - Functional Description

27.5.1.3.1 The fire alarm control panel shall be the central processing unit of the system, providing audible and visual information to the user, initiating automatic alarm response sequences and providing the means by which the user interacts with the system.

27.5 1.3.2 The fire alarm control panel shall be able to be easily configured to meet the exact detection zone and cause / effect output requirements of the building. Operating programs and configuration data shall be stored in a non volatile memory and fully configurable on-site by means of upload / download p.c. configuration software.

27.5.1.3.3 It shall be possible to expand the panel from 1 to a maximum of 2 loops with a "plug in" individual loop card. It shall be possible to expand the panel with a minimum of 248 programmable alarms / relays and 248 programmable fire / non-fire panel inputs.

27.5.1.3.4 A minimum of 126 individually addressed standard devices shall be capable of being configured on each addressable loop. Each loop card shall be capable of providing 500mA current and shall maintain a minimum of 24 volts on the loop up to the full extent of the battery standby period.

27.5.1.3.5 It shall be possible to fit a 20-column printer to the fire alarm control panel that will print system events automatically and log data upon request.

27.5.1.3.6 The fire alarm control panel shall have provision to drive and monitor a minimum of 13 repeater panels each providing full end user controls event display facilities.

27.5.1.3.7 The fire alarm control panel shall be capable of monitoring and controlling remote site devices, such as relays for the control of plants and dampers directly from the addressable loops.

27.5 1.3.8 The fire alarm control panel shall interrogate each addressable detection device and provide alarm indication within 3 seconds of a manual call point operation and 10 seconds for all other devices.

27.5.1.3.9 The fire alarm control panel shall have the ability to annunciate an alert or pre-alarm condition designed to give the earliest possible warning of potential fire condition without raising the full alarm condition

27.5.1.3.10 The Fire alarm control panel shall have a standard, automatic drift compensation to prevent false alarms due to detector contamination, and shall give warning when compensation limits are reached.

27.5.1.4 Indications

27.5.1.4.1 The fire alarm control panel shall monitor the status of all devices on the addressable loops for fire, short-circuit fault, open-circuit fault, incorrect addressing, unauthorised device removal or exchange, alert or device maintenance condition.The fire alarm control panel shall monitor all alarms circuits and remote silence alarms, reset, evacuate and fault inputs for open or short circuit faults. The fire alarm control panel shall also monitor the status of internal connections and interfaces including charges and batteries.

27.5.1.4.2 The following LED indications shall be provided

- POWER SUPPLY ON — Green LED
- FIRE — Red LED-
- ALERT — Amber LED
- SYSTEM FAULT — Amber LED

• GENERAL FAULT	Amber LED
• ALARM FAULT/DISABLEMENT	Amber LED
• DELAY ON MAINTENANCE	Amber LED
• GENERAL DISABLEMENT	Amber LED
• BUZZER SILENCED	Amber LED
• TEST	Amber LED
• MORE MESSAGES	Amber LED
• ZONE FIRE	Red LED per zone
• ZONE FAULT	Amber LED per zone

27.5.1.4.3 In addition to the indications above, the fire alarm control panel shall also have an integral 4 x 20 character LCD alphanumeric display. The LCD display shall be arranged as follows

Line 1: Loop number, Device Number, Zone Number, Device Type, Device Status.

Line 2: Alpha numeric text message definable by client / installer.

Line 3 and 4 shall be as above and used to display the second and any subsequent events. The first event to display shall remain on the display. The user may then scroll the lower part of the display for the third and subsequent events.

27.5.1.4.4 A "Test Display " facility shall provide a facility to manually check all the discrete LED indicators.

27.5.1.4.5 The fire alarm control panel shall provide facilities for remote signalling of fire and fault conditions.

27.5.1.5 Fault Reporting

27.5.1.5.1 The fire alarm control panel shall monitor system components and interconnections in accordance with BS EN 54 part 2, such that a failure shall cause a fault indicator to light and a message to be given on the alphanumeric display within 100 seconds of occurrence.

27.5.1.5.2 The following faults shall be reported: -

- Loop Fault
- Loop Device "Double Addressed"
- Loop Device Removed
- Alarm Circuit Fault
- Repeater Fault
- PSU Fault
- Earth Fault
- Battery Fault
- Mains Failure

27.5.1.5.3 To help fault finding and repair, the fire alarm control panel shall provide text messages to indicate the location of where a fault has occurred in the system.

27.5.1.6 System Management

27.5.1.6.1 The fire alarm control panel shall incorporate the following end user system management facilities:-

- Disable / enable an individual loop device
- Disable / enable a group of devices
- Disable/ enable a zone of devices
- Disable /enable panel inputs
- Disable / enable alarm signalling devices
- Disable / enable printer
- Configure fire relay on evacuate
- One person silent test for detectors
- One person test for alarm devices
- View devices disabled
- View event log
- Print event log

27.5.1.6.2 The fire alarm control panel shall have an event log capable of storing up to the last 200 events. These events shall be individually time and date stamped. It shall be possible to view and print the content of the event log.

27.5.1.6.3 Events shall be displayed in chronological order with the newest events first. It shall be possible to scroll through the events when viewed on the LCD display.

27.5.1.6.4 The fire alarm control panel shall be capable of disabling an individual detector, a group of detectors, and/or zone of detectors for building maintenance purposes.

27.5.1.6.5 The fire alarm control panel shall have a facility to enable the user to easily change the time and date settings of the system 'real time clock.

27.5.1.6.6 It shall be possible for the end user to perform a non-latching one person device test without sounder or cause/effect operation or access to the engineers' configuration menu.

27.5.1.7 Panel and System Configuration

27.5.1.7.1 Operating programs and configuration data shall be stored in a non volatile memory and fully configurable on-site by means of upload / download p.c. configuration software.

27.5.1.7.2 The panel shall provide 32 indication zones with a minimum of 255 groups overall available for cause / effect programming. It shall be possible to allocate every loop and panel input into at least 8 different groups for indication and cause / effect programming

27.5.1.7.3 The following categories shall be available for cause / effect purposes:-

- Zone Fire Single Knock Operate Until Reset
- Zone Fire Single Knock Operate Until Silence Alarms
- Zone Fire Double Knock Operate Until Reset
- Zone Fire Double Knock Operate Until Silence
- Zone Alert Operate Until Causes Clear
- Zone Fault Operate Until Causes Clear
- Zone Indication Operate Until Causes Clear
- Common Fire Operate Until Reset
- Common Fire Operate Until Silence
- Common Alert Operate Until Causes Clear
- Common Fault Operate Until Causes Clear

- Common Indication Operate Until Causes Clear
- Alarms Silenced Operate Until Causes Clear
- System Reset Operate Until Causes Clear
- Evacuate Operate Until Causes Clear

27.5.1.7.4 The fire alarm panel shall have, as standard, the ability to set the detector sensitivity for each discovery detection device on a day-night basis by a seven-day programme.

27.5.1.7.5 The fire alarm panel shall have, as standard, the ability to use a minimum of two loop inputs for changing the sensitivity of devices manually in areas requiring random sensitivity changes. Operation of these inputs shall be in addition to the seven-day sensitivity programme.

27.5.1.7.6 It shall be possible for the end user to switch between day only, night only, automatic (seven-day programme) and off.

27.5.1.7.7 The fire alarm panel shall have, as standard, the ability to configure a daytime delay of all alarm and relay outputs for up to 10 minutes. The daytime period and delay function shall be fully configurable. It shall be possible for the end user to enable or disable this delay function.

27.5.1.8 Panel Sounder Control

27.5.1.8.1 The fire alarm control panel shall provide the necessary output to operate a minimum of two monitored circuits of common system sounders. Each output shall be capable of driving a sounder load of up to 1A

27.5.1.8.2 The fire alarm control panel shall be capable of providing a two-stage alarm sounder facility that can be programmed, either by device, zonal or common system basis. This facility shall be provided by the use of additional 8 way programmable alarm cards. The panel shall be capable of controlling a minimum of 31 x 8 way alarm cards. Sounder output shall be available as follows:

- Alert, intermittent pulsed tone
- Evacuate, continuous tone

27.5.1.8.3 All fire condition shall visually and audibly indicate on all panel displays immediately upon receipt of the signal but the fire alarm control panel shall also have the ability to delay all sounder and relay outputs on a day / night time basis. A sounder / relay output delay of up to 10 minutes shall be possible from all smoke and heat devices. Call points and Evacuate signals shall automatically override any delay. A user "Delay Override" shall also be provided. When the system is outside the delay-enabled time then all devices shall provide instant signalling.

27.5.1.8.4 Panel and remote display functions and indications, printer and radio pager operations shall not be inhibited or delayed at any time.

27.5.1.9 Hooter

27.5.1.9.1 Dual tone hooter shall be of electronic type and shall give discontinuous/intermittent audible alarm automatically when ever smoke detector or heat detector operates. Hooter shall be complete with magnetic coil (sound coil) and accessories, ready for mounting (fixing). The hooter shall also have facilities for speaker announcement. Hooter shall also have the capability for adjusting the sound output.

27.5.1.9.2 Hooter casing shall be fabricated from 16 gauge MS sheet stove enameled to smooth finish. The line matching transformer shall be provided.

27.5.1.10 Manual Push Button

27.5.1.10.1 Manual push button shall be break glass type units, completely encased in a cast aluminium housing with provision for cable or conduit coupling

27.5.1.10.2 The manual push buttons shall have words prescribed in clear bold letters on the facia window " IN CASE OF FIRE BREAK GLASS".

27.5.1.10.3 Installation of manual push button shall be as per IS-2119. It shall be provided with a push butlon of 330V, 3 Amps rating and with two sets of NO and NC contacts.

27.5.1.10.4 The Manual push button shall be mounting type and shall be provided with aluminium chain and hammer attached.

27.5.1.10.5 The box shall be spray painted with post office red colour and stove enameled. It shall also have two Nos of red LEDS to indicate fire signal. The chain and the hammer shall be chrome plated or powder coated while the clip holder to hold the hammer shall be anodized. All manual call boxes shall be flush type.

27.5.1.11 Response Indicator

27.5.1.11.1 Response Indicator shall be housed in a 16-gauge aluminium casing. It shall glow clearly incase the detector to which it is connected gives an alarm signal. The word "FIRE" shall be clearly written on the visible face of the box.

27.5.1.11.2 It shall have two numbers of red LED to compensate for fusing of either LED.

27.5.1.12 Amplifier

27.5.1.12.1 The control panel shall also have the facility for Public Address system with the Microphone. The PA system shall be coupled with the Fire Alarm Panel. The PA system shall have floor wise selector switch to provide announcement to that particular area.

27.5.1.12.2 There shall be 4 amplifiers of 100 watts each, 3 in working state and one as reserve. All the terminals shall be soldered firmly onto solder tags or terminated on good quality connector strips. The Amplifier shall be multi channel mixing type and capable of running on 240 V AC or 12/24 Volts DC. It shall have dual tone control, level indicators and cater to complete frequency range.

27.5.1.12.3 All Amplifiers shall be Rack mounted with in the housing of the Fire Alarm Panel. It shall have Microphone channel volume control, Microphone/Auxiliary selector, Volume, Base and Treble control with LED type level Barograph.

27.5.1.12.4 The Audio signal quality shall have a frequency Response from 10 Hz to 20000 Hz. Distribution shall be less than 2%.Output for loud speakers shall be operatable from 100V terminal for line matching transformer type speaker

27.5.1.13 Power Supply

27.5.1.13.1 The control panel shall derive 230 Volts AC power from main supply. The standby battery supply shall be of such type when charged by associated battery charging equipment

27.5.1.13.2 Visible and audible annunciation for troubles or failure in the power supply system like "Charger failure", Battery low Voltage" etc shall be provided.

27.5.1.14 Battery and Battery Charger

27.5.1.14.1 The batteries shall be lead acid sealed type maintenance free and suitable for indoor Installation. All the metal parts of the terminal shall be of lead or lead coated type. The function between terminal posts & cover & between cover & container shall be so sealed so as to prevent any seepage of electrolyte. The electrolyte shall be battery grade sulphuric acid.

27.5.1.14.2 The battery charger shall be 220 V, single phase and shall have all necessary accessories such as transformer, switches, fuses, starters, contractors, rectifiers, ammeters, Voltmeter indicators and other items as required for trouble free operation.

27.5.1.14.3 The charger shall have static automatic voltage regulator and load limiting feature. It shall be float cum boost type. It shall have automatic and manual control for charging.

27.5 1.14.4 It shall be capable of;

(i) Float charging the battery and supplying the full DC load.
(ii) Boost charging the battery and supplying the full DC load.

27.5.1.14.5 The charger shall have the capacity to restore a fully discharged battery to a state of full charge in 10 hrs time with some spare margin over maximum charging rate. Visual and audible annunciation for troubles or failure in the power supply system such as charger failure, battery low voltage etc shall be provided,

27.6 Detection Devices

27.6.1 General

27.6.1.1 Detectors shall comply with and be type certified to EN 54 Part 7 for smoke detectors and Part 5 for heat detectors.

27.6.1.2 Detectors shall have five response modes which cover a range of sensitivities and response times. The mode for each individual detector shall be set via the fire alarm control panel. The response mode of any detector may be changed from the control panel at any time.

27.6.1.3 If, within one second of last being polled by the fire alarm control panel a detector reaches its own predetermined fire threshold the detector will place an alarm flag and its own address on the data stream to facilitate location by the fire alarm control panel.

27.6.1.4 Each detector shall have its own mounting base which, with the exception of isolating bases, will not contain any electronic components. Detectors will be capable of being locked into the mounting bases to avoid unauthorised removal of the detector.

27.6.1.5 The loop address of detectors shall be set by inserting a coded plastic card into each mounting base, allowing up to a maximum of 126 unique address codes. The address will be a simple seven bit binary code, set at the time of commissioning. The detector address card will be held in the base so that it cannot be accidentally removed with the detector. Each address card will provide a space visible from below when the detector is in place. The loop number and individual address or any other information specified by the client will be marked in the identifier provided.

27.6.1.6 Two alarm LEDs shall be provided on each detector. The LEDs will be controlled by the fire alarm control panel independently of the device. LEDs shall be capable of being reset by the fire alarm control panel without removing power from the loop.

27.6.1.7 Detectors shall be capable of being remotely tested from the control panel by transmission of a single bit in the communication protocol. Detectors will respond by providing an analogue value in excess of the recommended fire threshold to indicate a healthy condition The control panel shall recognise this response as a test signal and will not raise a general alarm.

27.6.1.8 Detector housings shall be moulded in pure white self-extinguishing polycarbonate, V-O rated to UL94. Detectors will be unobtrusive when installed.

27.6.2 Ionisation Type Smoke Detector

27.6.2.1 Smoke detectors shall be working on ionization principle and shall be of dual chamber and dual source type. These shall be completely solid state with LED indication at the base lonisation smoke detectors shall be analogue addressable, suitable for detection of visible and invisible products of combustion, and will be of the dual chamber single source type. The detector shall be capable to sense incipient fire by detecting the pressure of visible and invisible products of combustion. The detector shall be suitable for low voltage (24 V DC) two wire supply.

27.6.2.2 The radioactive source used in the detector shall not emit Beta or Gamma rays and the strength of the radioactive source shall not exceed 1 micro curie. The source will be mounted securely and shall require the use of special tools to permit extraction by authorised personnel only. Detectors shall be type certified by the National Radiological Protection Board or a similar body.

27.6.2.3 Smoke entry points shall be protected against ingress of dust and insects by corrosion resistant gauze. The detector shall be suitably protected against dust accumulation/ingress and shall be free from maintenance and factional test at intervals. All detectors shall be identical in construction design and easily replaceable. The detector housing shall be damage resistant made of polycarbonate or aluminium with plug in housing base or universal type suitable for either surface or recessed mounting.

27.6.2.4 The detector shall be provided with response indicator and the sensitivity of the detector shall not vary with change in ambient temperature, humidity, and pressure of voltage variation its performance shall not get effected by air current upto 2m/second.

27.6.2.5 It shall have inbuilt arrangement of a time constant of 4 second, so that puffs of smoke or hot air pockets do not inadvertently trigger the alarm.

27.6.2.6 The detector shall have in- built safety device to monitor the removal and pilferage of the detector. It shall also have facility for remote Indication.

27.6.3. Optical (Photoelectric) Smoke Detector

27.6.3.1 The optical detector shall work on light scattering principle, and capable of responding to any heavy smoke particles of size exceeding 1 mi crons. One optical detector shall have coverage of approximately 60 square meters of flat surface area. Optical smoke detectors shall be analogue addressable, suitable for detection of visible products of combustion, and will be of the light scattering type using a pulsed internal infra-red LED and a silicon photodiode receiver.

27.6.3.2 The optical sensing chamber shall be configured such that, the horizontal optical bench housing, the LED emitter and sensor is arranged radially to detect forward scattered light. The body of the detector shall be of white and of polycarbonate material.

27.6.3.3 Smoke entry points shall be protected against ingress of dust and insects by corrosion resistant gauze. It shall have inbuilt safety device to monitor the removal and pilferage of the detector.

27.6.3.4 Build-up of dirt or other environmental contamination in the optical chamber may cause a variation to the analogue output from the detector. The detector shall apply compensation to this variation and will record the level of compensation in non-volatile memory. When drift compensation reaches a preset level, the detector will set the drift compensation flag, which the fire alarm control panel will identify and initiate a visible signal to indicate that the detector is in need of service.

27.6.4 Temperature (Heat) Detectors

27.6.4.1 Temperature detectors shall be analogue addressable, suitable for detection of rate-of-rise of ambient temperature and fixed temperature threshold. Detection shall be by means of a single NTC thermistor.

27.6.4.2 Temperature detectors shall be capable of protecting an area of up to 50m^2 when mounted at heights of up to 13.5m using the maximum sensitivity setting.

27.6.5 Multisensor Detectors

27.6.5.1 Multisensor detectors shall be analogue addressable, suitable for detection of visible products of combustion (smoke), rate-of-rise of ambient temperature and a fixed temperature threshold. The response modes, which combine the smoke and temperature sensor outputs of the detector in different ways, shall be controlled via the fire alarm control panel.

27.6.5.2 Modes are numbered 1 to 5 and characteristics are as follows:-

- Mode 1 has a very high smoke sensitivity combined with high temperature sensitivity.
- Mode 2 has a smoke sensitivity similar to that of a normal optical smoke detector, but has no response to temperature.
- Mode 3 combines moderate smoke sensitivity with moderate heat sensitivity.
- Mode 4 has a lower than normal smoke sensitivity combined with moderate sensitivity to heat.
- Mode 5 has no smoke sensitivity at all but gives a pure heat detector response.

27.6.5.3 Build-up of dirt or other environmental contamination in the optical chamber may cause a variation in the analogue output from the detector. The detector shall apply compensation to this variation and will record the level of compensation in non-volatile memory. When drift compensation reaches a preset level, the detector will set the drift compensation flag, which the fire alarm control panel shall identify and initiate a visible signal to indicate that the detector is in need of service.

27.7 Manual Call Points (MCP)

27.7.1 Each MCP installed on the loop shall have a unique address, set at the commissioning stage by means of a seven-segment DIL switch.

27.7.2 The elapsed time between activation of the MCP and initiation of the sounders in an alarm condition via command from the fire alarm control panel shall not exceed three seconds

27.8 Installation

27.8.1 A system schematic wiring diagram shall be obtained from the fire alarm specialist supplier and submitted to the Engineer-in charge prior to commencement of work.

27.8.2 A full set in duplicate of all relevant maintenance manuals, systems wiring diagrams and 'as fitted' drawings showing details of the route of the loop circuits and the device label numbers are to be provided and handed over to the EIC on completion of the work.

27.8.3 The complete fire/alarm system shall be tested and commissioned by the specialist installer and a certificate issued to this effect.

27.8 4 The installer shall ensure that system is fitted as drawing shows details of the route of the loop circuits and the device label numbers, and shall provide cable test certification prior to commissioning.

27.8.5 The system shall be supplied via a SP/N switch fused at 5A fully conforming to the requirements of BS 5839 Part 1.

27.8.6 The devices shall be connected and wired sequentially and marked on the "as fitted" drawings to assist future engineering functions.

27.8.7 For 24 volt powered units the contractor shall be responsible for provision of suitable battery backed.

27.8.8 The Contractor shall undertake the labeling of the fire alarm system by the fire alarm specialist supplier. Each software address shall be supplemented by a hard address label mounted local to each remote/device.

27.8.9 The Contractor shall arrange for the fire alarm specialist supplier to properly programme the fire alarm system. The exact requirements for programming shall be agreed with the EIC on site.

27.8 10 The Contractor shall be responsible for providing the complete programming sheets to the fire alarm specialist supplier to enable the manufacturer to programme the control panel correctly.

27.9 Inspection,Testing And Commissioning

27.9.1 The Contractor shall arrange for the complete commissioning of the fire alarm system by the specialist fire alarm supplier.

27.9.2 Commissioning must be carried out in the presence of the EIC and a certificate issued to this effect.

27.9.3 The whole of the fire alarm installation should be inspected, tested and commissioned in accordance with clause 26 of BS 5839 part 1 and as further described.

27.9.4 Commissioning shall be carried out in accordance with Clause 26.5 of BS 5839 part 1 which shall include:-

(i) An audibility test of the alarm devices. Audibility level readings shall be taken in each room. Any sound levels found to be lower than 65 dba shall be reported to the Engineer-in charge in writing

(ii) All trigger devices i.e. manual call points, heat and smoke detectors shall be tested for correct operation,

(iii) A mains failure test shall be carried out to verify correct operation of the backup battery system.

27.9.5 Prior to commissioning, the Contractor shall provide a certificate of installation and cable test certificates of the system to the EIC.

27.10 Fire Designation Drawing

27.10.1 The Fire Alarm Specialist Supplier shall supply and install a fire zone chart showing plans of the building with all fire alarm control and indicating equipment clearly indicated. Each fire compartment/zone shall be easily identified by means of clearly marked colour codes.

27.10.2 The fire zone chart shall be as a minimum sized A3, coloured and suitably framed to be handed over on completion of the works.

27.10.3 The Contractor shall include for the specialist fire alarm supplier to carry out on behalf of the GE the first three quarterly (3 monthly) inspections and tests as called for in clause 29.2.4 of BS 5839 after the date of handover and completion of the contract and also the annual inspection test on behalf of the GE as defined in clause 29.2.5 of BS 5839.

SECTION 28

INCINERATOR

28.1 Indian Standards : The following IS shall apply to incinerators

IS Code.	*Subject*
8-1994	Specification for refractory bricks (First Revision)
2042-2006	Specification, for insulation bricks (Second Revision)
2062-2006	Hot rolled low, medium and high tensile structural steel (Sixth Revision)
4682 Part 1-1994	Code of Practice for lining of vessels and equipment for chemical purposes rubber lining (First Revision)
6533 - Part 1 and 2 - 1989	Code of practice for design and contruction of steel chimneys. Part I mechanical aspects Part 2 structural aspects (First Revision)

28.2 Operational Standards

(a) Combustion efficiency (CE) shall be at least 99.00%

(b) The combustion efficiency shall be computed as under:-

$$CE= \frac{\%CO2}{\%CO2 + \%CO} \times 100$$

(c) Destruction and removal efficiency (Pathogens) 100%

(d) The temperature of primary chamber shall be 800° + 50°C

(e) The secondary chamber gas residence time shall be at least 1 (one) second at 1050°+ 50°C with minimum 3% oxygen in the stack gas.

28.3 Emission Standards

Parameters : Concentration mg/Nm3 at (12% of CO2 correction)

(i) Particulate matter = 150

(ii) Nitrogen Oxide = 450

(iii) HCL = 50

(iv) Minimum Stack height = 30 mtrs above groundlevel

(v) Volatile organic compound in ash shall not be more than 0.01%

(vi) Toxic metals in incineration ash shall be limited within the regulatory quantities as defined under the Hazardous Waste (Management & Handling Rules) 1998

(vii) Suitably designed pollution control devices shall be installed with the incinerator to achieve the above emission limits.

(viii) Waste to be incinerated shall not be chemically treated with any chlorinated disinfectant

(ix) Only low sulfur fuel like LDO/LSHS/Diesel shall be used as fuel in the incinerator

28.4 The incinerator shall meet the CPCB (Central Pollution Control Board) emission norms. The incinerator shall consist of the following components:-

- Primary Chamber
- Waste Feeding in Primary Chamber Automatic waste feeding system for primary chamber

- Forced Draft Fan
- Secondary chamber for 1 second residence time for flue gases
- Venturi Scrubber as Air Pollution Control Device
- Droplet Separator for removal for moisture
- Induced Draft fan
- 30 mtr high rubber lined chimney
- Fuel oil tank
- Control panel
- Fully Automatic pressure jet type burners
- Tools and tackles
- PLC based Control panel with display and recording device to continuously monitor and print critical parameters like date, time, temperature in both chambers and batch number during the incineration cycle
- CO/CO2/O2 measuring device

28.4.1. Incinerator : General

I. incinerator shall be designed and installed with an air pollution control system.

II. The size of the opening through which the waste is charged shall be larger than the size of the waste bag to be fed. The volume of the primary chamber shall be atleast five times the volume of one batch.

III. The double chamber incinerator shall preferably be designed on "controlled-air" incineration principle, as particulate matter emission is low in such incinerator. Minimum 100% excess air shall be used for overall design. Air supply in the primary and secondary chamber shall be regulated between 30%-80% and 170%- 120% of stoichiometric amount respectively. Primary air shall be admitted near / at the hearth for better contact. Flow meter / suitable flow measurement device shall be provided on the primary & secondary air ducting. The combustion air shall be supplied through a separate forced draft fan after accounting for the air supplied through burners.

IV. A minimum negative draft of 1.27 to 2.54 mm of WC (Water Column) shall be maintained in the primary chamber to avoid leakage of gaseous emissions from the chamber and for safety reasons. Provision shall be made in the primary chamber to measure the Water Column pressure.

V. The waste shall be fed into the incinerator in small batches after the fixed interval of time in case of fixed hearth incinerator and continuous charging using appropriate feeding mechanism incase of rotary kiln incinerator or as recommended by the manufacturer. The size of the hearth i.e. primary chamber shall be designed properly.

VI. The sides and the top portion of the primary and secondary chambers shall preferably have rounded corner from inside to avoid possibility of formation of black pockets/dead zones.

VII. The size of the secondary chamber shall be properly designed so as to facilitate a minimum of one second of residence time to gas flow. For the estimation of residence time in the secondary chamber its volume shall be calculated starting from the secondary burner tip to the thermocouple.

VIII. The refractory lining of the chamber shall be strong enough to sustain minimum temperature of 1000° C in the primary chamber and 1200° C in the secondary chamber. The refractory & insulation bricks shall have minimum 115 mm thickness each & conform to IS:8-1994 & IS:2042-2006 respectively.

IX. The Incinerator shell shall be made of mild steel plate of adequate thickness (minimum 5 mm thick) & painted externally with heat resistant aluminum paint suitable to withstand temperature of 250°C with proper surface preparation. Refractory lining of the hot duct shall be done with refractory castable (minimum 45 mm thick) & insulating castable (minimum 80 mm thick). Ceramic wool shall be used at hot duct flanges & expansion joints.

X. The thermocouple location shall be as follows:

In Primary chamber - Before admission of secondary air

In Secondary chamber - At the end of secondary chamber or before admission of dilution medium to cool the gas

XI. There shall be a separate burner each for the Primary & Secondary chamber. The heat input capacity of each burner shall be sufficient to raise the temperature in the primary and secondary chambers as 800±50°C and 1050±50°C respectively within maximum of 60 minutes prior to waste charging. The burners shall have automatic switching "off/on" control to avoid the fluctuations of temperatures beyond the required temperature range.

(a) Each burner shall be equipped with spark igniter and main burner.
(b) Proper flame safeguard of the burner shall be installed.
(c) Provide view ports to observe flame of the burner.
(d) Flame of the primary burner
   (i) shall be pointing towards the centre of the hearth.
   (ii) shall be having a length such that it touches the waste but does not impinge directly on the refractory floor or wall.
(e) The secondary burner shall be positioned in such a way that the flue gas passes through the flame.

XII. There shall not be any manual handling during charging of waste in to the primary chamber of the incinerator. The waste shall be charged in bags through automatic feeding device at the manufacturer's recommended intervals ensuring no direct exposure of furnace atmosphere to the operator. The device shall prevent leakage of the hot flue gas & any backfire. The waste shall be introduced on the hearth in such a way so as to prevent the heap formation. Suitable raking arrangement shall be provided for uniform spreading of waste on the hearth.

XIII. A tamper-proof PLC(Programmable Logic Control) based control system shall be installed to prevent:

- Waste charging until the required temperature in the chambers are attained during beginning of the operation of the incinerator.
- Waste charging unless primary & secondary chambers are maintained at the specified temperature range.
- Waste charging in case of any unsafe conditions such as - very high temperature in the primary & secondary chambers; failure of the combustion air fan, ID fan, recirculation pump; low water pressure & high temperature of the flue gas at the outlet of air pollution control device.

XIV. The incineration system must have an emergency vent. The emergency vent shall remain closed i.e it shall not emit flue gases during normal operation of the incinerator.

XV. Each incineration system shall have graphic or computer recording devices which shall automatically and continuously monitor and record dates, time of day, batch sequential number and operating parameters such as temperatures in both the chambers. CO, CO2 , and O2 in gaseous emission shall also be measured daily (atleast 1/2 hour at one minute interval).

XVII. Structural design of the chimney / stack shall be as per IS:6533-1989. The chimney/ stack shall be lined from inside with minimum of 3 mm thick natural hard rubber suitable for the duty conditions and shall also conform to IS:4682 Part 1-1994 to avoid corrosion due to oxygen and acids in the flue gas.

XVIII. The location and specification of porthole, platform ladder etc. shall be as per the Emission Regulations, Part-3 (COINDS/20/1984-85), published by CPCB.

28.4.2 Main Combustion Chamber (Primary Chamber)

Main chamber shall be fabricated out of Mild Steel 5 mm thick and shall be refractory lined from inside with refractory bricks 115mm thick backed by insulation bricks 115mm thick conforming to IS-8 and IS-2042 respectively. The primary chamber waste feeding door shall be provided with a safety to switch off the burner if the door is opened so as to avoid any accident to the operators. Chamber shall be equipped with auto feeder, manual loading door for emergency loading, ash removal door and automatic burner operated by temperature indicating controller to be set at 800+50°C. It shall have arrangement for providing high pressure air from a blower through number of nozzles fitted in the walls of the primary chamber. The primary chamber shall be provided with a hydraulic ram pusher system for waste charging. The method of ash removal shall be manual. For capacities greater than 150 kgs/hr, a conveyor shall be provided for ash transportation from the room into an ash bin outside. Hydraulic system shall be provided for automatic waste feeding. The waste feeder shall be located in a way that the loading of waste is done from outside of the incinerator room to protect the incinerator operator from risk of infection due to exposure to medical waste inside the room. A conveyor system shall be introduced for transporting the waste into the hydraulic ram feeder. The primary burner shall point at the centre of hearth. Length of flame of primary burner shall be so much that it touches the waste and not the wall or floor. Primary burner operation shall have an electrical interlock with door opening limit switch.

28.4.3 Hydraulic Waste Feeding

The hydraulic waste feeding system shall be fabricated out of heavy duty angles, channels and Mild Steel plates. It shall consist of hydraulic cylinders, power pack, control panel for ram feeder, hydraulic oil tank, waste charging lid, waste feeding door, hydraulic piping, valves etc. The hydraulic waste feeding system shall be installed horizontally. The waste is to be charged on the conveyor placed outside the incinerator room which shall load the waste in the feeding system through the waste charging lid which opens horizontally. The lid shall close automatically. Thereafter the feeding door shall open vertically and the ram feeder installed in the horizontal position should push the waste bag in the primary chamber of the incinerator for incineration. As soon as the waste is charged in the chamber the ram feeder shall retract to its original position and the feeding door should also close. The feeding door and waste charging lid shall be interlocked with each other.

28.4.4 Primary Chamber Burner

Primary Burner shall be fully automatic complete with ignition transformer, ignition electrodes, necessary fuel lines, photocell, blower, fuel pump and fuel oil nozzle. The burner operates automatically on the temperature set on the digital temperature controller fixed on the control panel. Fuel pressure indicator gauge shall be provided for the burner.

28.4.5 Secondary Chamber

Secondary chamber shall be fabricated out of Mild Steel 5 mm thick and shall be refractory lined similar to primary chamber. This shall be equipped with automatic burner. A temperature controller shall be provided, connected to the control panel. The operating temperature shall be 1050+50°C. The secondary chamber shall be so designed so as to ensure a minimum of 1 second residence time to gas flow. View ports to observe flame of burner shall be provided.

28.4.6 Secondary Chamber Burner

Secondary Burner shall be fully automatic complete with ignition transformer, ignition electrodes, necessary fuel lines, photocell, blower, fuel pump and fuel oil nozzle. The burner operates automatically on the temperature set on the digital temperature controller fixed on the control panel. Fuel pressure indicator gauge shall be provided for the burner.

28.4.7 Electrical Control Panel

The control panel supplied alongwith the Incinerator shall be placed separately. The panel shall be powder coated. It shall house the primary and secondary burner controls, all the temperature controllers, motor starters, isolator switches, overload relays for burners and fans and audio-visual alarms for abnormal workings. All electrical power, earth and control cabling from the control panel to the individual drivers and components shall be provided with control panel. The control panel shall be pre-wired and PLC based with complete display and recording facilities as required by Central Pollution Control Board. Temperature indicator cum controller for primary and secondary chamber, water in scrubbing system, and flue gas at the outlet of the ID fan, 1 for each shall be provided. A level switch to sense water level in the re-circulation tank shall also be provided.

28.4.8 High Pressure Venturi Scrubber

(i) No incinerator shall be allowed to operate unless equipped with Air Pollution Control Device (APCD).

(ii) The incinerator shall be equipped with High Pressure Venturi Scrubber System as ordinary APCD such as wet scrubber or cyclonic separator cannot achieve the prescribed emission limit. For the facilities operating for 24 hrs a day, APCD in terms of dry lime injection followed by bag filter can be considered.

(iii) The venturi scrubber shall have minimum pressure drop of 350 mm WC to achieve the prescribed emission limit. The temperature of the flue gas at the outlet of the venturi scrubber shall be approx 70-80° C to ensure the saturation of the flue gas.

(iv) The venturi scrubber shall preferably be made of stainless steel - 316L grade or better material or mild steel lined with acid resistant bricks to avoid corrosion.

(v) The water to be used in venturi scrubber shall be added with caustic soda solution to maintain the pH of the scrubbing liquid above 6.5.

(vi) The scrubbing medium shall be circulated @ 2-2.5 ltrs/m3 of saturated flue gas at venturi outlet. This shall be done using a pump & piping made of stainless steel - 316 grades or better material. The scrubbing medium shall be recirculated as far as possible.

(vii) Venturi scrubber shall be followed by centrifugal type droplet separator to remove water droplets from flue gas.

(viii) The material of construction of the droplet separator and interconnecting ducting from venturi scrubber to droplet separator, droplet separator to ID fan & ID fan to stack, shall be mild steel lined from inside with minimum 3 mm thick natural hard rubber suitable for the duty conditions and shall also conform to IS:4682 Part 1-1994 to avoid corrosion due to oxygen and acids in the wet flue gas.

(ix) The wastewater generated from the air pollution control device shall be properly handled so as to avoid any non-compliance of the regulatory requirements.

(x) Stack emission monitoring and ash analysis as per the requirement of the Bio-medical Waste (Management & Handling) Rules, 1998, shall be done quarterly i.e. once in every three months and record shall be maintained by the facility operator.

28.4.9 Droplet Separator

The flue gases shall enter tangentially into the droplet separator, which shall be of cyclonic type. By the action of centrifugal force, the larger droplets present in flue gases settle down. The droplet separator shall be manufactured out of Mild Steel rubber lined 3mm thick from inside.

28.4.10 Circulating Pump

A re-circulating pump shall be provided. The pump shall be coupled to an electric motor . It shall be stainless steel/PP construction.

28.4.11 Re-circulation Tank

Re-circulation tank of suitable capacity shall be provided and integral with the droplet separator. This shall be manufactured out of Mild Steel 3 mm thick.

28.4.12 Interconnecting Piping

All interconnecting piping between scrubber, droplet separator and re-circulation tank shall be provided.

28.4.13 ID. Fan

The I. D. Fan shall be dynamically balanced and shall have a pressure of 450mm WC with an impeller of SS-316 construction. The casing shall be mild steel rubber lined from inside. The ID Fan shall be belt driven and connected to an electric motor. It shall be of high pressure centrifugal type with 3 phase electric motor. In case ID fan fails to work, the burners and FD Fan shall trip automatically.

28.4.14 F.D. Fan

A forced draft fan shall be provided to supply air inside the primary and secondary chambers. The F.D. Fan shall be dynamically balanced and connected to the electric motor. Electric motor shall be 3 phase.

28.4.15 Fuel Oil Tank & Piping

Fuel oil tank of suitable capacity fabricated out of mild steel shall be provided. The fuel tank shall have all connections for supply, return, drain and visual checking of the quantity of fuel present in the tank. Complete fuel oil piping from the fuel tank to both burners shall be provided alongwith the return line. The fuel line shall consist of one main stop valve, one individual valve for each burner for supply and one individual valve for each burner for return. Two non-return valves shall be provided in the fuel oil line. Fuel oil filters shall be provided in the fuel oil line.

28.4.16 Chimney

Self supported chimney of 30 mtr height shall be provided. The chimney shall consist of all its accessories like port hole, platform, ladder, stack drain etc. It shall be provided with cage ladder, gas sampling platform, gas sampling nozzles, painting trolley, rain cowl, manhole, stack drain, base plate and foundation bolts. Chimney shall be connected to incinerator by an interconnecting duct.

28.5 Emergency Stack

An emergency stack to vent out the gases in case of power failure shall be provided. The emergency stack height shall be as per site requirement. Usually this shall be 6 mtr high from the ground level/2 mtr high from the roof of incinerator building whichever is more. It shall be made of 3mm thick mild steel sheet and refractory lined from inside.

28.6 Tools

One set of tools consisting of hoe, shovel, rake, poker etc. shall be supplied if indicated with each incinerator.

28.7 Instruments, valves, dampers and fittings

All necessary instruments, valves, dampers and fittings shall be supplied if indicated alongwith the incinerator.

28.8 Guarantee

The contractor shall withstand a guarantee for the oil fired incinerator and all its components provided in this contract for a period of 1 (one) year from the certified date of completion of contract.

28.9 Documents

The contractor shall submit three sets of Operation and Maintenance/Instruction Manuals complete equipment layout drawing duly bound before commencing the testing of the incinerator. The contractor shall also supply a standard board made with PGI sheet with DOs and DONT's NOT's legibly drafted in "English" and "Hindi"

28.10 Training

The contractor shall impart training to MES/User staff regarding operating, running and maintenance of the plant for a period of 1 week. The material required for imparting the training shall be supplied by the contractor without any extra cost to the department. On completion of training, GE shall issue certificate for training imparted.

28.11 Incinerator room and waste storage room

(i) The incinerator structure shall be built in a room with proper roofing and cross ventilation. There shall be minimum of 1.5 m clear distance in all the directions from the incinerator structure to the wall of the incinerator room.

(ii) Adjacent to the incinerator room, there shall be a waste storage area. It shall be properly ventilated and so designed that waste can be stored in racks and washing can be done very easily. The waste storage room shall be washed and chemically disinfected daily.

(iii) The floor and inner wall of the incinerator and storage rooms shall have outer covering of impervious and glazed material so as to avoid retention of moisture and for easy cleaning.

(iv) The incineration ash shall be stored in a closed sturdy container in a masonry room to avoid any pilferage. Finally, the ash shall be disposed in a secured landfill.

SECTION 29
RAIN WATER HARVESTING

IS. No.	Subject
2065: 1983	Code of practice for water supply in buildings (Second revision)
3076:1985	Specification for low density polyethylene pipes for potable water supplies (Second revision)
4984:1995	Specification for high density polyethylene pipes for potable water supplies (Fouth revision)
4985:2000	Specification for unplasticised PVC Pipes for potable water supplies (Third revision)
6295: 1986	Code of practice for water supply and drainage in high altitudes and/or sub-zero temperature regions (First revision)
7634 (Part 2) 1975	Code of practice for plastics pipe, work for potable water supplies: Laying and jointing polyethylene (PE) pipes
7634 (Part 3) 2003	Code of practice for plastics pipe, work for potable water supplies: Laying and jointing of PVC pipes(First revision)
10500:1991	Specification for drinking water (First revision)
11208:1985	Guide lines for registration of plumbers
13592: 1992	Specification for UPVC pipes for soil and waste discharge systems inside buildings including ventilation and rainwater system
14333:1996	Specification for high density polyethylene pipe for sewerage
14735:1999	Specification for unplasticized polyvinyl chloride (UPVC) injection moulded fittings for soil and waste discharge system for inside and outside buildings including ventilation and rain water system.
14961:2001	Guidelines for rainwater harvesting in hilly areas by roof water collection system

29 Rain Water Harvesting

29.1 Design of Efficient Artificial Recharge Structures

29.1.1 The design shall involve consideration of data on hydrological and hydro-geological aspects and hydro meteorological parameters

29.1.2 The background information which shall be collected

(a) Layout plan of the area
(b) Demarcation of the roof, paved and open areas
(c) Delineation of storm water drains and flow of storm water
(d) Details of the existing ground water abstraction structures in and around the vicinity of the project site.
(e) Computation of the runoff for recharge.
  a. Annual rainfall (for estimating approx rainwater recharge per year)
  b. Peak intensity and duration of each storm.
  c. Type of soil and sub-soil conditions and their permeability factor.
  d. Ground slopes and runoff, which cannot be caught.
(f) Availability of space for construction of recharge structures and invert levels of storm water drains at inlets to recharge structures.
(g) Availability of runoff, depth of storm water drainage and space availability in an area.

29.1.3 In case the recharge scheme is prepared by the consultant engaged by MES same shall be vetted by Central Ground Water Board.

29.2 Composition

29.2.1 Rainwater Harvesting System shall comprise of following components:

(i) Roof catchments
(ii) Gutters
(iii) Down pipe and first flush pipe
(iv) Filter unit
(v) Storage tank
(vi) Collection pit
(vii) Recharge structure

29.2.2 Roof Catchments

29.2.2.1 The roof of the house shall be used as the catchments for collecting the rainwater. Roofs made of corrugated iron sheet, asbestos sheet, tiles or concrete shall be utilized as slope for harvesting the rainwater.

29.2.3 Gutters

29.2.3.1 Gutters shall be fixed to the edges of roof all around to collect and transport rainwater from the roof to the storage tank.

29.2.4 Down pipe and First Flush Pipe

29.2.4.1 Down pipe:

29.2.4.1.1 Down pipe shall be joined with the gutters at one end, and the other end shall be connected to the filter unit of the storage tank.

29.2.4.1.2 PVC or Gl pipes of diameter 50 mm shall be used for down-pipe. The size of the shall be as per table below:-

Sizing of Rain Water Pipes

Dia of Pipe (mm)	**Average rate of rainfall (mm)**					
	50	75	100	125	150	200
	Roof Area (m2)					
50	13.4	8.9	6.6	5.3	4.4	3.3
65	24.1	16.0	12.0	9.6	8.0	6.0
75	40.8	27.0	20.4	16.3	13.6	10.2
100	85.4	57.0	42.7	34.2	28.5	21.3
125	159.71	106.73	80.50	64.3	53.5	40.0
150	249.60	166.82	125.27	100.00	83.6	62.7

29.2.4.1.3 For rainwater pipes of other materials, the roof areas shall be multiplied by 0.013/ coefficient of roughness of surface of that material.

29.2.4.2 First Flush Pipe

29.2.4.2.1 First flush system shall be incorporated in the Rooftop Rainwater Harvesting System to dispose off the 'first flush' water so that it does not enter the tank.

29.2.5 Filter Unit

29.2.5.1 The container shall be provided with a perforated bottom to allow the passage of water.

29.2.5.2 The filter unit shall be placed over the storage tank.

29.2.5.3 Generally two types of filters shall be used.

29.2.5.3.1 On line filter:

This filter shall be used when availability of runoff as well as recharge rate of recharge well is less.

29.2.5.3.2 Purpose built filter:

The filter material shall consist of coarse sand of 1.5 to 2mm size at the top, followed by gravel of 5 to 10 mm size and boulders of 5 to 20 cm at bottom. The thickness of each layer shall be about 0.5 m. Coarse sand shall be placed at the top so that the silt content that will come with runoff will be deposited on the top of the coarse sand and can easily be removed. After excavation of filter chamber, boulders and gravel shall be filled first up to the foundation of wall of the structure to be constructed immediately. After filling of boulder and gravel, filter materials shall be covered with polythene jute bags to avoid spilling of construction material. Filter media shall be free from silt and any other foreign materials. Before putting the filter material into the chamber, filter material shall be sieved and washed to remove all the finer material from the filter.

29.2.6 Storage Tank

29.2.6.1 Plain cement concrete and reinforced cement concrete shall be used for tank capacities usually more than 60,000 litre.

29.2.6.2 Brick, stone, cement brick shall be used for capacities ranging between 16,000 litre to 60,000 litre.

29.2.6.3 The storage tank shall be provided with a cover on the top to avoid the contamination of water from external sources. The cover shall be in dome shape having a rise of about 20-30 cm. in the middle. The dome shall be provided with two circular openings, one for manhole and another for accommodating the filter.

29.2.6.4 The storage tank shall be provided with pipe fixtures at appropriate places to draw the water, to clean the tank and to dispose of the excess water.

29.2.7 Collection Pit

29.2.7.1 A small pit shall be dug in the ground, beneath the tap of the storage tank and constructed in brick masonry to make a chamber, so that a vessel could be conveniently placed beneath the tap for collecting water from the storage tank.

29.2.7.2 A small hole shall be left at the bottom of the chamber, to allow the excess water to drain-out without stagnation.

29.2.7.3 Size of collection pit shall not be less than 60 cm x 60 cm x 60 cm.

29.2.8 Recharge structures

29.2.8.1 Rainwater available in the open spaces around the building shall be recharged into the ground through the following simple effective methods.

(i) Percolation Pits
(ii) Recharge Trench
(iii) Recharge Wells

Based on the size /area of the building and the underlying litho logical nature of the formation the said methods shall be used either individually or in combinations.

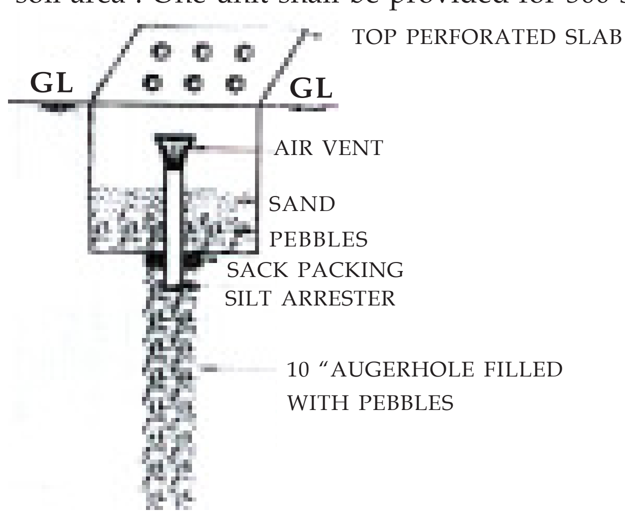
29.2.8.2 Detailed knowledge of geological and hydrological features of the area shall be considered for adequately selecting the site and the type of recharge structure.

29.2.8.3 In particular, the features, parameters and data to be considered are: geological boundaries-hydraulic boundaries, inflow and outflow of water-storage capacity; porosity hydraulic conductivity-transmissivity; natural discharge of springs-water resources available for recharge; natural recharge; water balance; lithology; depth of the aquifer; and tectonical boundaries.

29.2.8.4 The aquifers best suited for artificial recharge shall be those aquifers which absorb large quantities of water and do not release them too quickly

29.2.8.5. Percolation /Absorption Pit Method

29.2.8.5.1 It shall be constructed in the open space at required intervals. The size shall not be less than 1m x 1m x 1.5m (depth). It shall be filled with broken bricks / pebbles and shall be suitable for sandy sub - soil area . One unit shall be provided for 300 sq.ft area (approx.)



PERCOLATION PIT

29.2.8.6 Percolation Pit With Bore Method

29.2.8.6.1 A borehole shall be drilled at the bottom of the percolation pit. Bore hole size shall be 150 -300 mm dia with 10 -15 ft depth (approx.).It shall be filled with broken bricks. It shall be suitable for clay area.

29.2.8.6.2 Above structures shall be for area with small catchments like individual houses. RCC slab cover shall be optional. Top 300mm portion shall be filled with sand.

29.2.8.7 Recharge Trench With Bore Method

29.2.8.7.1 Along the recharge trench boreholes shall be drilled. Borehole interval shall be 10-12 feet

29.2.8.7.2 Above structures shall be for area with large catchments like apartments / big complexes. RCC slab cover shall be optional. Top 300mm portion shall be filled with sand.

29.2.8.8 Recharge Well Method (Shallow/Small)

29.2.8.8.1 The method shall be for large areas with heavy run-off. The size of well shall be 3 feet dia with 5 feet - 10 feet depth constructed with brick / concrete rings as indicated. Sidewalls shall be perforated and bottom 1 feet shall be filled with broken brick. Well shall be covered with RCC slab /manhole cover. It shall be used for sandy sub-soil area.

29.2.8.8.2 For areas with clay/hard rock formations recharge wells with large diameter 5 feet depth (10-15 feet) shall be constructed. Run-off water shall be diverted through a filter media preferably. One well shall be sufficient for areas with one ground extent. Rain Water from the open spaces shall be diverted through small trenches.

29.2.8.8.3 Site characteristics and design guidelines shall be as under;

(a) To be dug manually if the strata is of non-caving nature
(b) If the strata is caving, proper permeable lining in the form of open work, boulder lining shall be provided.
(c) The diameter of shaft shall normally be more than 2m to accommodate more water and to avoid eddies in the well.
(d) In the areas where source water is having silt, the shaft shall be filled with boulder gravel and sand from bottom shall have inverted filter. The upper most sandy layer shall be removed and cleaned periodically. A filter shall be provided before the source water enters the shaft.
(e) The injection pipe shall be lowered below the water level.

29.3 Construction

29.3.1 Recharge Well

29.3.1.1 A well assembly of pipes with minimum diameters of 102 mm shall be lowered throughout the depth. The pipes shall be either MS or PVC . M.S Pipes shall be coated with bituminous coating to avoid the rusting of MS pipes.

29.3.1.2 After excavation of the recharge trench /shaft or filtration chamber is over, the slots of recharge wells shall be checked again. Depth sounding of recharge wells shall be taken with tape to make sure that no silt or soil has gone into the recharge wells during the excavation trench/shaft. Width of slots in recharge well shall be as per the aquifer system encountered.

29.3.1.3 Slotted pipes shall be placed against the aquifer or dried up aquifers encountered the recharge wells. A slotted pipe at the top of the recharge well shall be placed to permit entry of clean/clear water into the recharge well.

29.3.1.4 The annular space around the well assembly shall be shrouded with appropriate size gravel. The gravel shall be washed so that it becomes silt free. The recharge tube well shall be developed by low capacity air compressor or by bailing method as the case may be. A vent pipe of about one inch diameter shall be provided to act as escape for gases and for measuring the water levels. Once the recharge trench or shaft is constructed around the recharge tube well, recharge wells shall be developed with hand bailers to avoid the disturbance of filter media.

29.3.2 Recharge Pits

29.3.2.1 In alluvial areas where permeable rocks are exposed on the land surface at very shallow depth, recharge pits shall be suitable for artificial recharge of water collected from the roof tops.

29.3.2.2 The buildings having a roof area of 100 sq.m, the recharge pits shall be constructed for recharging the shallow aquifers.

29.3.2.3 Recharge Pits shall be of any shape and size and are generally construed 1 to 2 m wide and 2 to 3 m deep which shall be back filled with boulders (5-20cm) gravels (5-10 mm) and coarse sand (1.5- 2 mm) in graded form - Boulders at the bottom gravels in between and coarse sand at the top so that the silt content that will come to runoff will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof area, pit shall be filled with broken bricks/cobbles.

29.3.2.4 A mesh shall be provided at the roof so that leaves or other waste/debris is prevented from entering the pit and a desilting/collection chamber shall also be provided at the ground to arrest the flow of finer particles to the recharge pit.

29.3.2.5 The top layer of sand shall be cleaned periodically to maintain the recharge rate.

29.3.3 Recharge Trenches:

29.3.3.1 Recharge trenches shall be provided for buildings having roof area of 300 Sq.m. and where permeable strata is available at shallow depths.

29.3.3.2 Trench shall be 0.5 to 1 m wide, 1 to 1.5 m deep depending upon availability of water to be recharged.

29.3.3.3 These shall be back filled with boulders (5-20 cm), gravels (5-10 mm) coarse sand (1.5-2 mm) in graded form - boulders at the bottom, gravel in between coarse sand at the top so that the silt content that will come with runoff will deposit on the top of the sand layer and can easily be removed.

29.3.3.4 A mesh shall be provided at roof so that leaves or any other solid waste/debris is prevented from entering the trench and desilting/collection chamber shall also be provided on ground to arrest flow of finer particles to the trench.

29.4 Recharge Ability Test

To test the recharge ability of the tube well, a slug test shall be conducted which also gives the approximate estimation of transmissivity of aquifer system. If slug cannot be conducted, then the recharge well shall be tested by pouring water at constant rate for sufficiently long period and recording the recharge rate of the tube well.

29.5 Care to be taken in rainwater harvesting

29.5.1 Water conservation shall be constructed with due care taking following precautions:-

(a) No sewage or wastewater shall be admitted into the system.

(b) No wastewater from areas likely to have oil, grease or other pollutants shall be connected to the system.

(c) Each structure /well shall have an inlet chamber with a silt trap to prevent any silt from findings its way into the sub soil water.

(d) The wells shall be terminated at least 5 m above the natural static sub soil water at its highest level so that the incoming flow passed through the natural ground condition and prevents contamination hazards.

(e) No recharge structure or a well shall be used for drawing water for any other purpose.

SECTION 30
MARINE AND HARBOUR WORKS

30.1 Indian Standards.—The following IS apply to this section:

I.S. No.	*Subject*
456 - 2000	Plain and reinforced concrete - Code of practice (Third revision).
4651 (Part 1)-1974	Code of practice for planning and Design of ports and harbours. Part 1- Site investigation (First revision)
4651 (Part 2) - 1989	Ports and harbours - Planning and design - Code of practice. Part 2- Earth pressure (First revision)
4651 (Part 3) - 1974	Code of practice for planning and design of ports and harbours. Part 3- Loading (First revision)
4651 (Part 4) - 1989	Code of practice for planning and design of ports and harbours. Part 4- General design considerations (Second revision)
4651 (Part 5)-1980	Code of practice for planning and design of ports and harbours. Part 5- Layout and functional requirements
7314-1974	Glossary of terms relating to port and harbour Engineering
9527 (Part 1)-1981	Code of practice for design and construction of port and harbour structures. Part 1 - Concrete monoliths
9527 (Part 3)-1983	Code of practice for design and construction of port and harbour structures. Part 3 - Sheet pile walls
9527 (Part 4)-1980	Code of practice for design and construction of port and harbour structures. Part 4 - Cellular sheet pile structures
9527 (Part 6)- 1989	Design and construction of port and harbour structures - Code of practice. Part 6 - Block work

30.2 Definitions

30.2.1 Important definitions as per IS 7314 - 1974

(a) Admiralty Tide Tables

Admiralty Tide Tables - The Tide Tables published annually by the Admiralty giving daily tidal predictions for standard ports and data for predictions at secondary ports either in the form of harmonic constants or non-harmonic constants, such as time differences and or ratio or ratio of ranges on a standard port in UK and other ports of the world.

(b) Advance (of a Beach) (also Progression)

(a) A continuing seaward movement of the shoreline.
(b) A net seaward movement of the shoreline over specified time.

(c) Air Chamber

A hollow watertight chamber provided in caisson in which ballast to the required amount is placed, to have the required floatation of the caisson for its operation.

(d) Amplitude (of a Wave) (also Wave Amplitude)

(a) The magnitude of the displacement of a wave from a mean value. An ocean wave has an amplitude equal to the vertical distance from still water level to wave crest. For a sinusoidal wave, amplitude is one-half the wave height.

(b) The semi range of a constituent tide.

(e) Anchor

An implement for retaining or fastening a ship by chaining it to the bed of a water course.

(f) Anchorage

A place or location for anchoring a vessel. For every port there are some such fixed places where vessels are anchored, waiting for their turn to enter the port or sail out of the port area.

(g) Back beach (Backwash) (also Backshore)

That zone of the shore or beach lying between the foreshore and the coastline and acted upon by waves only during severe storms, especially when combined with exceptionally high water. It comprises the berm or berms.

(h) Bar

A submerged or submersible area of sand, gravel, or other unconsolidated material built on the sea floor or river bed in shallow water by waves, currents, tidal flow, etc.

(i) Barge

Small floating craft used for aiding the sea- going ship in loading and unloading, which may be self-propelled or dumb.

(j) Bathymetry

The measurement of depths of water in oceans, seas and lakes; also information derived from such measurements.

(k) Bay

A recess in the shore or an inlet of a sea between two capes or headlands, not larger than a cave.

(l) Beach

The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach - unless otherwise specified - is the mean low water line. A beach includes foreshore and backshore.

(m) Beacon

Any prominent objects or structures, natural or artificial, on a coastline or river bank, which act as an aid to navigation.

(n) Beaufort Scale

A wind force scale classified by Admiral Beaufort in 1805 for maritime purposes. The intensity of winds is expressed in twelve numbers forming a scale, each number representing a wind strength of a designated range of velocities.

(o) Berth

A ship's station at anchor or at wharf or alongside a structure.

(p) Berth - cargo

A berth for loading and unloading of cargo to and from the ship.

(q) Berth Occupancy (also Occupancy Factor of Beth)

The duration over which a ship lies anchored at the berth for loading and unloading operations in a specified period of time. It is usually expressed as ratio of the actual time of occupation of the berth by ships to the total period specified.

(r) Bollard

Fixed to the quay at cope level, these are employed for securing a vessel in position with rope moorings. These also provide a means of checking vessels entering or leaving the dock. These may be of concrete, cast iron or steel of different sizes and shapes.

(s) Bow-Well Dredger

A type of bucket-ladder dredger in which the ladder and buckets protrude some distance in front of the hull so that the dredger may cut its own floatation for a twenty four hours dredging in a shallow water where neither the dredger, tug, nor spoil barges can float that low water over the area before dredging.

(t) Breakwater

A structure protecting a shore area, harbour, anchorage or basin from wave disturbance.

(u) Breakwater, Composite

A breakwater constructed by combination of a rubble-mound base and vertical wall or other form of superstructure. It is adopted at a location where the depth of water is great or there is a wide tidal range so that the quantity of rubble stone required to construct a mound breakwater of the full height would be too large and uneconomical. Of these, there is wide variety of types.

(v) Breakwater, Floating (also Bombardon)

A removable break-water constructed by caissons or pontoons with valves for trimming whilst afloat and for sinking when in position and pump connections for refloating, moored to the sea bed.

(w) Breakwater, Mound (also Rubble Mound Breakwater)

A breakwater constructed by a heterogeneous assemblage of natural rubble or undressed stone, in pieces of varying size, supplemented in many cases by artificial blocks of bulk larger than can be conveniently quarried in the natural state, the whole being deposited pell-mell without any regard to bond or bedding. The material may, however, be graded as to sizes.

(x) Breakwater, Vertical Wall

A breakwater formed by the construction in a regular and systematic manner of a vertical wall of masonry, concrete blocks or mass concrete, with vertical or nearly vertical harbour and seaward faces.

(y) Bucket Ladder Dredger

An endless chain connecting a series of buckets which traverse in succession on inclined orbit, approximately elliptical, about two pivots or tumblers, excavating material at the lower tumbler and discharging it into a chute while passing over the upper tumbler. Bucket dredgers of this type have either one or two ladders (the central ladder type and the side ladder type respectively), that is, the flame, with its roller bearings, on which the buckets travel. This dredger is especially suitable for steady continuous work in hard material and in very stiff clay.

(z) Bulk Cargo

Cargoes like foodgrain, coal, ore, fertilizer, oil, minerals, etc, which are imported and exported in bulk quantities and usually handled by mechanical appliances for loading and unloading to and from vessels.

(aa) Bulk Carriers

Vessels of larger capacity specially designed for carrying bulk cargoes in large quantities for economic transportation.

(ab) Bulk Head

A structure separating land and water area, primarily designed to resist earth pressures.

(aab) Caisson

Meaning a box or chest, but its meaning has been extended, in maritime engineering, to include all hollow structures.

(ac) Caisson Breakwater

Large boxes of steel framework encased in concrete or built or reinforced concrete are constructed in a sheltered place, temporarily strutted in the interior, launched and towed out to site of constructions, sunk in position admitting water to the interior, filled with fluid concrete, stone rubble, small blocks or sand so as to form ultimately a solid monolith.

(ad) Caisson, Floating

May be either 'box' or 'ship' type caisson with air chambers, ballast chambers and tidal chambers, and moved entirely by floatation, without guides or rollers.

(ae) Caisson, Pneumatic

Caisson constructed of steel or concrete with working chamber, ballast chamber and vertical shafts for passage of workmen and materials, a continuous amount of air at the required pressure being supplied to the working chamber to balance the hydrostatic pressure at the lower or cutting edge of the chamber. This is used for construction of under water foundations and may be removed after construction or all or part of this may be incorporated in the structure built.

(af) Caisson, Rolling

A caisson with rectilinear motion achieved by rollers which are attached either to the underside of the caisson or to the pathway on which the caisson travels, whereby abrasion is reduced due to lesser friction than a sliding motion, but may get jammed diagonally due to slight side clearance between the caisson and its sliding ways.

(ag) Caisson, Sliding

A caisson with keels or rubbing plates on its underside by which this is hauled over sliding ways set on the floor of the caisson berth. This method gives rise to a certain amount of friction which may be diminished by suitable floatation adjustment.

(ah) Caisson, Swinging

This is an intermediate class of structure possessing characteristics common to both gates and caissons. Like the gate, it turns or swings upon a vertical axis fixed at one side of a waterway and requires excessive length of side recess for its accommodation when out of use. On the other hand this is built with much broader beam than a gate and this gives it the compensating advantage of a wide roadway at quay level.

(ai) Caisson, Traversing

This includes all those whose motions rectilinear and, according to the mode of traveling it may be the sliding, rolling or floating type but in any case it occupies a rectangular recess in side wall at right angle to the 4 axis of the waterway and in direct line with the path along which the caisson travels to close the entrance. It is almost universally of the box type consisting of a floor, side and end plating, and a watertight deck, the whole being divided into compartments.

(aj) Cap Log

A horizontal timber on a quay or pier, bolted to the vertical timbers or secured to the masonry to receive the impact of vessels lying alongside.

(ak) Clearance

The space allowance between the keel of a vessel and the bed surface of a navigable channel to prevent grounding of the vessel.

(al) Coast

A strip of land of indefinite width (may be several kms) that extends from the shoreline inland to the first major change in terrain features.

(am) Coastal Area

The land and sea area bordering the shoreline.

(an) Coffer Dam

A temporary dam constructed of timber, either single skin or double skin, parallel-sided with puddle clay or other filling, or interlocking steel sheet-piling, either single skin or double skin, parallel sided with the interior pumped dry and strutted, enclosing the site of structure to be built, for the exclusion of water from the site for an underwater construction.

(ao) Controlling Depth

The least depth in the navigable parts of a waterway, generally over a crossing or bar, governing the maximum draft of vessels that can enter.

(ap) Dead Weight Tonnage (DWT)

It is the weight in tones of 2 240 Ib of cargo, stores, fuel, passengers and crew carried by the ship when loaded to her maximum summer load line.

(aq) Deck

The top working platform of a structure/ship. A ship may have several decks used for accommodation, storage of cargo and as working decks.

(ar) Deck Load

The dead and live load on the deck.

(as) Design Wave

The wave whose characteristics are considered for the design of a maritime structure to withstand the wave action.

(at) Dock, Dry (also Graving Dock)

A dock from which water can be temporarily excluded by natural or artificial means, in order that repairs to the hulls and keels of vessels may be effected.

(au) Dock Sill

The platform or flooring at the entrance of a dry dock. The timber or foundation against which the gates of a dock or lock shut.

(av) Dock, Wet

Area of impounded water within which vessels can remain afloat at a uniform level, independent of external tidal condition.

(aw) Dolphin

An isolated marine structure for mooring or guiding vessels.

(ax) Draft (Draught)

The depth to which a vessel is submerged above the keel in water during navigation.

(ay) Dragline Dredger (Tension Cable Dredger)

Developed on the principles of dragline and used primarily for digging sand and gravel out of deep pits.

(az) Dredger

A plant employed for an operation involving the removal of material under water from the bed of a water area whether the mode of action be dragging, sucking or digging.

(ba) Entrance Width

The minimum width provided for the entrance channel at the entry to dock either between breakwaters enclosing the dock or in the lock entrance.

(bb) Estuary

The wide stretch of a river near the sea, which is affected by the tides.

(bc) Estuary, Stratified

An estuary is where the fresh water of the river and the saline water of the sea form distinct layers or strata.

(bd) Fender

A type of resilient buffer system provided at a berthing face to protect the structure and the ship from damage due to force of impact of berthing vessel.

(be) Fender, Floating

A floating body, like a timber truss, tied in front of a quay surface and extending quite a distance from the quay surface, so that the impact force of a berthing vessel is first taken up by the floating body without the vessel coming indirect contact with the quay edge.

(bf) Fender, Pile

A system of piles, vertical and / or raker, provided in front of a quay surface to take up the direct impact force from a berthing vessel.

(bg) Flexible Wall

A wall, like a sheet pile wall, which can take considerable deflection with differential movements induced in the active and passive wedges of soil, without failure of the structure.

(bh) Floating Dock

A repairing dock working on hydraulic lift principle. It is a hollow structure of steel or reinforced concrete with air chambers to fill with water to sink the dock to the requisite depth for receiving its charge, the water being pumped out when the vessel is berthed. It has the advantage of mobility and less maintenance cost but requires a large depth of water inside a sheltered area for its operation.

(bi) Gate, Lock

A gate used for maintaining a constant water level in enclosed waster area.

(bj) Gate, Mitre

A lock gate with two hinged flaps meeting at a point when the gate is closed.

(bk) Groyne (also Groin)

A short protection structure of permeable or impermeable type, built usually perpendicular to the shore line or at a small angle from the perpendicular to trap littoral drift or retard bank or shore erosion.

(bl) Groyne System

A series of parallel groins constructed at a fixed spacing acting together to protect a section of river bank or sea beach. Commonly called a groins field.

(bm) Harbour

Any protected water area affording a place of safety for vessels (see also Port).

(bn) Harbour, Commercial

This forms essential feature of ports engaged in foreign and coastal traffic. This constitutes the great terminus of the highways of the sea, providing accommodation for the mercantile marine during the operations of loading and discharging cargoes and for the transaction of trade.

(bo) Harbour, Riverine

A harbour situated inland on a river away from the sea.

(bp) Hi-Fix

An electronic arrangement used for finding out the position of vessels.

(bq) Hinterland

The area or part of the country which directly influences the commerce through a port.

(br) Hull

The body of a vessel exclusive of masts, yards, sails, rigging, machinery and equipment.

(bs) Hurricane

An intense tropical cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 120 km/h for several minutes or longer at some points. Tropical storm is the term applied if maximum winds are less than 120 km/h.

(bt) Hurricane Path or Track

Line of movement (propagation) of the eye of the hurricane through an area.

(bu) Hydrographic Survey

Survey of underwater surface of a water area including its alignment, bank profile, etc.

(bv) Impact Force on Berthing

The force exerted on a berth or quay face or on the ship by berthing vessel due to its great momentum. A good quantum of the impact force is generally absorbedly adequate fendering system so that the structure is not damaged.

(bw) Impact Work

The work done on the fendering system and berth structure and the consequent energy expended or absorbed due to impact force of a berthing vessel.

(bx) Impounded Dock

A dock, the entrance to which is closed by structures like lock gates or caissons, to maintain a constant level of water inside the dock irrespective of the outside water level and tidal or wave effects.

(by) Isobath

A contour line connecting points of equal water depths on a chart.

(bz) Keel

The bottom of a vessel.

(ca) Leading in Lights

Lights placed at each side of dock and harbour approach channels to enable pilots to position vessels in channels.

(cb)Leading Jetty (Warping Jetty)

A structure provided at the entrance of a dock or lock for easy manoeuvring of vessels to and out of the dock. The structure may be a solid masonry monolith, piled or sheet piled as in a dock wall. This is provided with necessary appliance like capstans, fairleads, etc, for stowage and with adequate fendering arrangement.

(cc) Light House

A structure situated in a vantage position and rising to a considerable height above water level and provided with a light at the top of the structure for navigational guidance.

(cd) Limnoria

A minute crustacean, attacking timber structures used in marine works between' wind and water' and eating the timber from the outside surface.

(ce) Marigram

A graphic record of the rise and fall of the tide.

(cf) Marine Borers

Marine organisms which eat up underwater marine structures by boring activity and thus reduce the life of the structure.

(cg) Mean High Water (MHW)

The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water height are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

(ch) Mean High Water, Neaps (MHWN)

The average height of the high water occurring at the time of neap tides.

(ci) Mean High Water, Springs (MHWS)

The average height of the high water occurring at the time of spring tides. Frequently abbreviated to high water springs.

(cj) Mean Higher High Water (MHHW)

The average height of the higher high waters over a 19-year period. For shorter periods of observation, corrections are applied to eliminate known variations and reduce the result to the equivalent of a mean 19-year value.

(ck) Mean Low Water (MLW)

The average height of the low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All low water heights are included in the average where the type of tide is either semidiurnal or mixed. Only lower low water heights are included in the average where the type of tide is diurnal. So determined, mean low water in the latter case is the same as mean lower low water.

(cl) Mean Sea Level (MSL)

The average height of the sea level for all stages of the tide over a 19-year period, usually determined from hourly height readings.

(cm) Mole

In coastal terminology, a massive land-connected, solid fill structure of earth (generally reverted), masonry, or large stone. It may serve as a breakwater or pier.

(cn) Monolith

A hollow foundation piece of concrete; brickwork, or masonry with a number of open wells passing through it. It is sunk in a manner similar to the cylindrical caisson, the wells being finally filled with concrete to form a solid foundation.

(co) Mooring

The place in a river, harbour or dock in which a vessel may be moored; also, that to which vessels may be secured.

(cp) Nautical Almanac

Astronomical ephemeris containing more or less similar data are prepared and published in advance by seven countries - India, U.K., U.S.A., U.S.S.R., France, Spain and Japan. As regards stars other than 68 important stars published in Indian Ephemeris and Nautical Almanac, the apparent places of the 1535 stars in the FK 4 are now published by the Astronomisches Rachen Institute of Heidelberg entitled apparent places of Fundamental Stars.

(cq) Navigation

The science of ascertaining the position of ships and directing their course by astronomical observation and other calculations- the general process involved in operating ships.

(cr) Pharology

The science of light house construction, the name derived from the lighthouse or tower built at the island of Pharos in Alexandria by about 270 B.C.

(cs) Pier

A structure, usually of open construction, extending out into the water from the shore, to serve as a landing place, a recreational facility etc, rather than to afford coastal protection.

(ct) Pier Apron

The apron or open paved area adjacent to a pier.

(cu) Pier Head

The termination of a breakwater, mole or training work extending into water from the shore, which is generally wider than the main body of the structure, with a definite geometrical shape, like circular, octagonal, hammerhead, etc, as convenient. This part of the structure is open on three sides.

(cv) Port

A terminus of great ocean trunk lines of communication; a place where vessels may discharge or receive cargo; may be the commercial part of a harbour where the quays, wharves, jetties facilities for transfer of cargo, docks and repair shops are situated, or may be the entire harbour including its approaches and anchorages.

(cw) Quay

A stretch of paved bank, or a solid artificial landing place parallel to the navigable waterway, for use in loading and unloading vessels.

(cx) Rock Breakers

Employed in dredging operation in rock beds for breaking up of hard masses of rock into small fragments so that the material may be removed either by multibucket dredger, dipper or grab dredger, and also where blasting operations are impracticable. The breaker is usually in rectangular pontoon form, self propelled or dummy, very similar to a pile barge in its equipment, having a tripod derrick with winches for hoisting long pointed steel rams which are allowed to fall freely, and by succession of blows pierce the rock, compressed air or steam-operated hammers being also used in modern crafts. Some modern type of rock breakers combine dredging facilities with rock breaking.

(cy) Sea Wall

A structure separating land and water areas, primarily designed to prevent erosion and other damages due to wave action (see also Bulkhead).

(cz) Seismic Sea Wave (Tsunami)

A long period wave caused by an underwater seismic disturbance or volcanic eruption. Commonly misnamed ‘ tidal wave’.

(da) Shoal

A detached elevation of the sea bottom or river bed, comprised of any material except rock or coral, which may endanger surface navigation.

(db) Slip

A berthing space between two piers.

(dc) Slip Dock

A repairing dock in which the vessel is partially withdrawn from the water by means of ways, the remaining water being removed by natural or artificial means, for repair to the hull and keel of the vessel.

(dd) Slipway

A sloping platform used for hauling up and repairing of vessels, usually of smaller capacity than those repaired in dry docks.

(de) Storm

A wind of intensity less than a hurricane but higher than a gale, occupying No. 11 position in Beufort scale of wind forces with an average velocity between 103 to 117 km/h.

(df) Strait

A relatively narrow waterway between two larger bodies of water.

(dg) Tetrapod

A patented form of concrete block consisting of four legs disposed in triangular form so that when three points are resting on the ground the fourth leg is vertical. This shape possesses excellent interlocking qualities and provides high roughness as well as permeability effecting a very great degree of dissipation of wave energy. This is extensively used for revetting the exposed faces of rubble mound breakwaters and beach protection works.

(dh) Tidal Day

The time of the rotation of the earth with respect to the moon, or the interval between two successive upper transits of the moon over the meridian of a place, approximately 24.84 solar hours or 1.035 times the mean solar day. Also called lunar day.

(di) Tide

The periodic rising and falling of the water that results from gravitational attraction primarily of the moon and sun, acting upon the rotating earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as Tidal Current reserving the name tide for the vertical movement

(dj) Wharf

A structure built on the shore of a harbour, river or canal, so that vessels may lie alongside to receive and discharge cargo and passengers.

30.3. Materials

30.3.1 Cement

The cement used shall be any of the following, unless otherwise indicated

(a) Sulphate resistant cement conforming to IS-12330
(b) Blast furnace Slag cement conforming to IS - 455
(c) Portland Pozzolana cement conforming to IS 1489.

Notes

1. Regarding suitability of type of cement for marine structures, reference be made to clause 8.2.2.1, 8.2.2.4, 8.2.3, 8.2.4 to 8.2.5.3, 8.2.8 to 8.2.8.4 and Table 3, 4., 5 & 7 of IS 456-2000.

30.3.2 Storage of cement shall be all as specified herein before in Section 4 and IS 4082.

30.3.3 Aggregate

30.3.3.1

(a) Good concrete for dock and harbour marine structures and civil-engineering work in general must possess three qualities namely strength, density, and workability; and to attain these properties consideration must be given to the cement, the aggregates and their grading, the proportioning of the materials, the water/cement ratio, the workmanship, that is to say mixing and placing, and to ensuring the correct conditions for hardening or" curing " of the concrete when in place.

(b) The properties of strength and density are principally influenced by the aggregates and their grading, which means that their sizes should be nicely proportioned from fine to coarse, with the fine and medium in such quantity as at least to fill all interstices.

(c) The value of cement in concrete lies in its power of uniting the aggregate into a mass by reason of its adherence to the surfaces of the sand particles and stone; if, however, the surfaces are already coated with a film of some deleterious substance, direct adhesion cannot take place, and the porosity and strength of the concrete are at once affected. The setting-time and hardening of concrete is also affected by dirty aggregates : the clay, mud, etc. which they contain mixes with the cement, and in cold damp weather the concrete remains in a liquid or gelatinous state, retarding setting and hardening.

30.3.3.2 For other details reference may be made to Section 4 hereinbefore.

30.3.4. Water

30.3.4.1 Water used for mixing and curing shall be all as per clause 4.9 to 4.9.2 of Section 4 hereinbefore and clause 5.4 to 5.4.4 of IS- 456-2000.

30.3.5 Steel

30.3.5.1 Unless otherwise specified, structural steel shall conform to IS 226 or IS 2062 and steel reinforcement shall conform to IS - 1786.

30.3.5.2 The corrosion of steel varies in different conditions of sea air or sea water exposure. Severe corrosion, however, occurs in saline water and under marine growth, specially in the splash zone and in the reaches of the tidal range with alternate wetting and drying. Steel buried in ground is also subjected to corrosion under certain conditions.

30.3.5.3 Any one or a combination of the following remedial measures may be taken against the corrosion:

(a) Protective Coatings

Protective Coatings form a barrier to the environmental exposure and thereby delay the corrosion. These barriers invariably break down after a number of years, specially under the suction and growth of barnacles. The choice of coatings, method of application, thickness of coats, possibility of recoating, etc, are important in ensuring optimum performance of coatings.

(b) Cathodic Protection

Corrosion of steel completely immersed under water or buried in ground (where possibility of electrolytic corrosion exists) can be substantially eliminated, and corrosion of steel alternatively exposed to wet and dry condition can be significantly protected by cathodic protection using an impressed current system or sacrificial anode system.

(c) ***Increased Section/ Reduced Stresses***

Where the above mentioned measures are not practical or their maintenance a doubtful, extra thickness of metal or section may be considered for providing an economic solution.

The actual recommendations as to the minimum metal thickness depend upon the nature of the structure and its projected life. As a general rule, it may be considered that any mild steel used in marine structure, should have a minimum thickness of 6 mm when cathodic protection is provided, and a minimum thickness of 10mm when cathodic protection is not provided. In any case, no structural steel should be used in marine conditions without protective coatings.

(d) ***Use of Special Steel***

Special alloy steels, such as, like those with 2 percent copper content can significantly arrest corrosion.

(e) ***Jacketing with Concrete or Other Suitable Synthetic Material***

Special care has to be taken in the splash zone where the protection could be given by a concrete lining applied by guniting or by jacketing with suitable synthetic material.

30.3.6 Concrete

30.3.6.1 Concrete has extensive use in harbour structures, such as, dock walls and floors, piles, sheet piles, caissons and monoliths, deck structures for jetties and wharves and breakwater armour blocks, apart from the use in dock buildings and in other structures above ground.

30.3.6.2 The concrete structures built in aggressive environment are subject to attack by sea water penetrating into the mass. Concrete shall be made impermeable to such a degree that it is not penetrated by the constituents of sea water. The most dense concrete will give the best result. From the point of view of the dock and harbour engineer, however, the utility of reinforced concrete has certain limitations, seeing that maritime structures, including piers and jetties, quays, wharfs, and coastal embankments are subject to a far wider array of destructive influences than are inland works. Partial immersion in water, with alternations of dryness and wetness due to the flux and reflux of the tide; exposure to the fiercest storms, to the onset of heavy seas, and to the penetrating drift of wind driven spray; subjection to heavy blows from passing vessels and to the abrading action of craft moored alongside - all these contingencies go to form an ordeal of strength and endurance which none but the most substantially built structures could survive. The characteristics required in any material which is to resist these exceptional conditions are, first, a combination of hardness and tenacity to resist local concussion, distributed pressure of considerable intensity, and abrasion; and secondly, great durability and freedom from deterioration under the influence of sea-water, alternations of dryness and moisture, fluctuations of temperature, and the attacks of living organisms such as infest the waters of most ports.

There is relatively little resilience or elasticity in concrete, certainly little in comparison with the elasticity and recuperative powers of steel. Consequently when blows or heavy pressures are brought to bear upon the thin outer covering of concrete which encloses a steel reinforcement, there is a tendency for pieces of the former material to be chipped away. This may constitute a serious and possibly vital defect in a maritime structure, since the removal of perhaps a small piece of concrete at a corner or an edge would be sufficient to expose the inner steelwork to corrosive influences of a powerful character.

Even when fracture does not actually take place, the effect of any sudden and intense stress is to produce a number of hair-cracks which must inevitably become avenues for the passage of moisture to the interior. Another danger is that much larger cracks and even chippings, occurring below the water-line, may escape notice in spite of careful observation. Where they are detected they can, of course, be made good, but in any case it is a troublesome matter to effect such repairs, and there will probably be uncertainty as to the existence of further undiscovered damage. To avoid these dangers, therefore, it is necessary to have the steelwork amply covered with concrete, and also to protect the concrete work itself by means of timber fendering and runner, which will take up a certain amount of the compression due to sudden concussion and distribute the pressure over a larger area.

The same expedient is effective in counteracting the effects of abrasion and chafing due to the mooring of vessels in a tideway against a wharf or quay. It is easier and cheaper to replace a worn-out timber rubbing piece than to effect continual repairs to a lacerated concrete facing. No vessel, therefore, should be allowed to come into actual contact with reinforced-concrete work.

30.3.6.3 Prestressd concrete

Prestressed concrete is a most important new medium in structural and civil engineering, and one which has many applications to constructional work in docks and harbours. With conventional reinforced concrete the development of fine cracks is an ever-present risk, though it must be admitted that, as a rule, they are not of serious consequence. With prestressed concrete, on the other hand, absence of fine cracks can to a great extent be permanently assured-a factor which lengthens the life of all concrete work and is an especial benefit to concrete structures exposed to fresh and sea-water.

Owing to the higher stresses used in prestressed concrete, the quality of the mixture must be considerably higher than that normally associated with reinforced concrete work. This is accomplished by greater exactitude in proportioning the materials and the amount of water, the use of vibrators, and the adoption of correct curing methods. The nett results are that permeability reduced, and both density and compressive strength are increased. A further advantage is the greater ease of handling, due to the ability of prestressed members to withstand shock and appreciable deflections without cracking. Such properties render the use of prestressed concrete peculiarly applicable to maritime structures where some flexibility is a desideratum, as for example in jetties, dolphins and similar structures.

30.3.6.4 The precautions normally prescribed for maritime works are as follows-

"(a) Strict control in the selection of the materials forming the concrete, as well as quality and compactness of the latter.

(b) Fairly rich mixture, good grading, and care in the execution of the works in order to obtain a compact and watertight conglomerate.

(c) Richer mixture in the area subjected to tidal action and in the part immediately above this.

(d) In reinforced-concrete structures the mixtures must be richer than in plain concrete, and the covering of the steel must be all as per relevant IS provisions.

(e) Reduction of the quantity of mixing water by adding certain admixtures to make the concrete workable.

(f) Use of steel shuttering and vibration of the concrete or shuttering (according to the circumstances) to obtain better compactness and water tightness.

(g) For works requiring large quantities of concrete one should select cements that give off little heat, and should carry out contraction tests with pure cement mortar and concrete, and finally, adopt special constructional appliances.

(h) Preventive measures to be adopted for protecting concrete-especially in the area subjected to tidal influence- by using fenders.

(i) The primary requirement for concrete to be used in sea-water is impermeability, which means compactness. Cements low in lime are particularly suitable. The water/cement ratio should be as small as possible. Any means, such as vibrators, which contribute to the compactness of the concrete should be adopted.

(j) The aggregate should be well-graded so that the resulting concrete shall be more workable and, therefore, more easily compacted. Wherever possible, construction in the dry is to be preferred. Where this is not possible, the concrete should at least be poured through hoppers using watertight forms. "Block construction" methods offer a comparatively good safeguard against sea-water action. Concrete pumping methods are not recommended because the dry mixes required for compact concrete do not readily pump, and water must not be added to facilitate this.

(k) The above conclusion, namely that a dense and impermeable concrete is essential in marine structures, is perhaps an obvious requisite. Density and strength in concrete are informal circumstances usually obtained together, but concretes which would be accepted for ordinary reinforced concrete work will not satisfy the requirements of marine structures.

(l) The use of too high proportion of cement must be avoided, as over-rich mixtures may well invalidate all the other precautions by causing contraction cracks.

(m) Concrete grade not less than M 30 for RCC and M 40 for prestressed concrete construction shall be used.

30.3.6.3.5 Minimum cement content of 400 kg/m^3 and a maximum water cement ratio of 0.45 shall be maintained for all grades of concrete for RCC and prestressed concrete construction. However, for trimmed concrete, the maximum water cement ratio can be relaxed upto 0.5 at the discretion of the engineer-in-charge. In case of plain cement concrete, a minimum cement content of 310 kg/m^3 and a maximum water cement ratio of 0.5 shall be maintained.

30.3.6.6 As cracking insincere members is to be minimized, reduced/stresses are recommended for concrete and steel to be used in the design of RCC members subject to marine environments unless the structure is checked against the formation of cracks. The stresses in steel may be reduced to 165 N/mm^2 in working stress design. As a guide, assessed surface width of crack at points nearest to the main reinforcement should not exceed 0.004 times the cover of the main reinforcement.

30.3.6.7 Adequate thickness of cover is to be provided for the structures in marine atmosphere. It is recommended for structures immersed in sea water, in splash zone, or exposed to marine atmosphere, that the thickness of cover should be 25 mm more than the cover specified according to clause 26.4 of IS 456: 2000.

30.3.6.8 The use of precast concrete elements is preferred for marine structures as they are cast under strict quality control and, therefore, are able to withstand the destructive influence of marine environments better.

30.3.7 Timber

30.3.7.1 Timber has wide use in dock and harbour structures. It can be used for sheet piles, bearing piles, structural members in jetties, fenders, transit sheds and warehouses, as structural members and/or for door and window frames.

30.3.7.2 The hazards which face timber are the attack by fungi and insecticides; and in sea water the attack by the marine borers. When used in dockside buildings the design shall be primarily guided by provisions of the relevant standards and protection against the attack of fungi and insecticides. The timber used in marine structure, particularly if subjected to fluctuating tides, is prone to attacks by marine borers and require preservative treatment.

30.3.7.3 An effective preservative treatment of timber is creosoting which is normally applied by pressure impregnation (see IS 401 : 1982).

30.4 Site Investigation

30.4.1 Docks are frequently massive structures, built, as a rule, on low-lying ground on rivers or estuaries or the sea-coast, where the ground may often be alluvial deposit of poor quality and of diverse kinds, and where water- either subsoil or surface - is factor to be reckoned with both in design and during construction; thus the importance of adequate foundation work precede by an accurate preliminary survey of the strata underlying the site, needs no emphasis. The most elaborate calculations for the stability of dock or quay walls may be nullified if the information from the site as to the ground and subsoil is either inaccurate or insufficient. The investigation will vary only according to the type and character of the proposed works and the extent to which survey of the site of new works must therefore be carried out with great thoroughness, and the scope of the subsoil and geological information already available. Such information is essential not only to the engineers but also to the contractors, from the points of view of design, cost, and construction. Otherwise, failures of engineering works, delays in completion, and serious increases in costs may result.

30.4.2 Site investigations having been begun, the interpretation of the information obtained together with the study of the reaction of soils to changing stress conditions is usually carried out in the laboratory in close collaboration with the investigations in the field.

30.4.3 In order to carry out site investigation, a brief description of the site including its latitude, longitude, geographical location, accessibility, etc, should be given. Historical background of the area, purpose of the project, type of hinterland and communications may also be briefly described. Wherever possible, advantage should be taken of existing local data onsides, storms, wave heights, littoral drifts, mud banks, etc, and records of previous investigations in the vicinity and information compiled. The behaviour of existing structures which maybe of similar nature to the ones proposed, and the influence of the soil and water on the materials of construction should be studied and recorded. At such places, site exploration, soil investigation and the examination of the materials of construction may be limited to confirm that site data that may be expected in the neighbourhood of proposed work.

30.4.4 The following information required for site investigation is grouped under the following headings:

(a) Survey
(b) Meteorological data
(c) Oceanographic data
(d) Geological data
(e) Soil investigation
(f) Seismic data
(g) Local resources

30.4.5 Survey

30.4.5.1 Topographical survey of adequate area covered by the project is the first requirement and should be obtained at the earliest. In no case shall the survey maps for detailed planning be of scale less than 1:5 000 with contour interval of one meter, depending on topography of the area.

30.4.5.2 Hydrographic survey charts for the coastal region extending to continental shelf (up to the line at which the depth of water is 200 m) and of scale 1 : 50 000 or 1 : 25 000 (whichever is available) are required for general planning. Hydrographic charts required for detailed planning shall be drawn to a scale as large as possible but in no case shall be less than 1 : 5 000. Recommended scales are 1:1250.

30.4.6 Meteorological Data

30.4.6.1 Meteorological data to be collected should cover the following:
(a) Winds,
(b) Cyclones,
(c) Rainfall,
(d) Relative humidity,
(e) Temperature, and
(f) Barometric pressures.

30.4.6.2 Winds

For preliminary studies, information maybe obtained from the available meteorological records of the area. Recording of velocity and direction of wind at the proposed site shall be obtained by installing continuous and self-recording anemometers. The data shall be collected for at least a period of one year and shall also be correlated with the data available at places nearest to the site. From the data so collected wind roses should be prepared for each month in the form given in Fig. 1 and presented as shown inFig.2 of IS 4561 (part 3).

30.4.6.3 Cyclones

Information should be compiled regarding track of cyclones. The velocity of maximum winds, radius of maximum wind velocity, duration, pressure drop at the cyclone centre and speed of movement of cyclone centre is required. From this a design cyclone is adopted and waves that could be incident at a place be computed.

30.4.6.4 Rainfall

Data on rainfall as available should be collected from India Meteorological Department for a minimum period of 3 years as follows:
(a) Annual average rainfall,
(b) Months in which the maximum rainfall occurs,
(c) Maximum intensity of rainfall and duration, and
(d) Average number of wet days in a year.

30.4.6.5 Relative Humidity

Data on the maximum, mean and minimum relative humidity for every month shall be obtained for a minimum period of five years.

30.4.6.6 Temperature

The normal ambient air temperatures with emphasis on daily and seasonal variation may be noted.

30.4.6.7 Barometric Pressures

Data on monthly average barometric pressures should be collected for the nearest site from the India Meteorological Department.

30.4.7 Oceanographic Data

30.4.7.1 Oceanographic data to be collected should cover the following:

(a) Tides,
(b) Waves (wind waves and swells),
(c) Storm surges,
(d) Currents,
(e) Sea bed,
(f) Salinity,
(g) Suspended load and
(h) Sea water temperature

30.4.7.2 Tides

Record of the tidal information, over as long a period as possible from Port Authorities or Geodetic and Research Branch, Survey of India or Hydrographic Department of the Indian Navy , including any local information specific to the site of the works should be obtained. Based on this the data as given in Fig.3 of IS 4561 (Part I) should be compiled and presented

For most of the points, the information on tides is available and may be adopted. For a new place, tide tables could be predicted and furnished by the Survey of India on request.

For important structures, tide levels expected at a particular place may be required. For this purpose tides for at least 3 months shall be observed and correlation established between the observed tides and the predicted tides for the harbour in general.

30.4.7.3 Waves

For planning and preliminary design purposes, wave data collected by ships plying in the area can be obtained from the India Meteorological Department.

Wave heights can also be computed by hind casting studies using the storm data and synoptic charts from the Indian Meteorological Department.

For important projects, wave recorders may be installed and information collected on wave height and period for at least 2 years. Separate wave recorders should be installed for long period and short period waves from the Indian Tide Tables published yearly by the Survey of India, Dehra Dun.

Wave direction may be obtained by visual observation/aerial photographs and with pairs of wave recorders.

From the data collected as above, design wave parameters should be worked out after drawing refraction /diffraction diagrams for the type of structures.

Rose diagrams of wave heights and periods may be prepared in the form given in Fig.4 and presented as shown in Fig.5 of IS 4561 (Part I)

Long Period Waves - For the measurement of long period waves, separate long period wave recorders should be installed and at least one year’s record obtained. Where such time is not available, wave records during months when cyclones may occur in the fetch area may be taken. For accurate assessment of incidence of long period waves separate wave recorders are required; however, a rough assessment can be made from wind wave/swell recorders or even from tide gauges which plot curves on a graph sheet. From such records the periodic time range of long period waves could be assessed and recorded.

Storm Surges - Storm surges may be inferred from tidal gauges, if the gauges had functioned through the period of storm. In addition some special instruments can be installed for recording storm surges. They can also be calculated from synoptic charts.

30.4.7.4 Currents

The direction, strength and duration of current during complete tidal cycles at maximum spring and neap tide over a year should be recorded. In riverine ports where there is fresh water discharge, current pattern at highest expected flood should be assessed and recorded, Current pattern at the specific location of structures, should also be assessed for a period of at-least one year for purposes of alignment of berth, dock entrances, moorings, etc.

Current readings should be taken at a minimum of three points preferably at depths of 0.1 d, 0.5 d and 0.9 d where d is the depth of water, and recorded.

30.4.7.5 Sea Bed

Classification of sea bed material in the vicinity of structures and approaches and upto an area in the sea where depth of water is 6 m more than the maximum depth for which the harbour is being designed, should be ascertained and recorded. Sea bed slope which is also a design parameter may be ascertained from hydrographic survey charts.

30.4.7.6 Suspended Load, Salinity and Temperature

These observations shall be carried out both during the dry and wet seasons at different locations in the harbour and channels over the full tidal cycle during neap and spring tides. The suspended load and salinity shall be measured at depths of 0.1 d, 0.5 d and 0.9 d below the water level (where d the depth of water) at every hour during the tide cycle. Salinity and suspended load should be assessed from the water samples collected at these depths. Salinity may also be measured at the site by using direct meters which are available for this purposes. Sea water temperature shall also be measured during these observations.

The quantum of littoral drifts maybe estimated from observations at nearby harbour sites over a period of at least one year. The direction of drifts at the site may be ascertained from radio fluorescent tracer studies and other observations of the coast line in the vicinity of the structure, such as dredging records, shore line changes, accretion erosion, wave data and the orientation of river mouths. These studies may be conducted up to a location where the depth of water is 12 m more than the design depth.

30.4.8 Geological Data

30.4.8.1 Geophysics is a science concerned with the physical properties of the Earth's crust, such properties consisting mainly of magnetism, electrical conductivity, density, and elasticity. Variations in the sub-surface geology are accompanied by variations in one or more of these physical properties, which can be measured at the surface of the ground.

The *electrical resistivity* and the seismic methods of geophysical exploration are those most usefully applied to civil-engineering problems.

30.4.8.2 The resistivity of a rock is defined as the resistance offered by a unit cube of the rock to the flow of an electric current perpendicular to one of its faces. In the earth resistivity method the mean resistivity of the ground is measured by means of four electrodes driven into the soil, usually at equal distances along a straight line.

30.4.8.3 *Seismic methods* of sub-surface exploration are used primarily for determining the depth of the boundaries of formations and are the most extensive and successful of all geophysical techniques for oil prospecting. There are two quite distinct methods - the refraction system which uses the refractions of elastic waves at physical discontinuities in the earth; and the reflection method in which the reflection of elastic waves at such boundaries is observed. Of the two methods it is the latter that is most conveniently applied to the exploration of very deep formation boundaries; it is not suitable for exploration of the comparatively shallow depths involved in civil engineering projects. The refraction method, on the other hand, is readily adapted to such investigations and is particularly suitable for determining the depth to a consolidated stratum or bedrock.

30.4.8.4 The essential requirement in site investigations is to make a geological survey to determine the possible sub-surface conditions which may be expected. This should be followed by the geophysical survey, in order to obtain a general picture of the sub-surface geology, thus providing a basis for the subsequent drilling and testing programme to obtain detailed information where it is most required. Information from the first few boreholes is normally sufficient to provide a control on the interpretation of the geophysical data, from which a more detailed picture of the sub-surface conditions between the boreholes can be obtained. The advantage of a geophysical survey, it is claimed, lies in the speed and economy with which an area can be explored compared with other methods. Indeed, the object is to save money by eliminating unnecessary drill holes and to amplify the information obtained from the holes that are put down.

30.4.8.5 Objects of site exploration

The objects of a site exploration in the construction of docks and other maritime works maybe briefly summarized as follows:

(a) To ascertain the geological sequence of the strata beneath the site, and those upon which the foundations of the structures will rest.
(b) To obtain samples of the soils and rocks for identification and testing in order to assist in determining the general design of the structures and the method of carrying out the work.
(c) To ascertain the ground-water conditions.
(d) To investigate the possibility of using any of the materials composing the various strata for construction purposes.

30.4.8.6 Again, it may be possible that there are in existence the results of borings made in the vicinity of the proposed works, but it is never good policy to rely upon these to give an accurate picture of a neighboring site, though they may be used to confirm the information gained by actual investigation. Lands bordering on estuaries and rivers are usually composed of sand, gravel, silt and clays, i.e. alluvial deposits, which may themselves vary widely over comparatively short distance; moreover the harder stratum upon which they have been deposited may itself have been previously eroded into holes or dislocated in some manner to form a " washout " or a " roll ". On such sites, therefore, nearby observations should never be relied upon, and borings must be taken at close intervals. Often the preliminary scheme of borings may reveal conditions which indicate the desirability of further borings or more detailed information being obtained.

30.4.8.7 In general, the depth to which it is necessary to explore a site may be determined by the levels at which any of the metamorphic or igneous rocks occur, or at which sedimentary rocks are found which, according to the geology of the district, are indicated as being of great thickness. Or, again the geology of the neighbourhood may show that a particular stratum met with, other than rock, will be of considerable thickness and of suitable foundation quality; in such cases deep exploration may be unnecessary. In any case, however, the borehole should be deep enough to penetrate all strata or layers or pockets of material which will be stressed by the superimposed load of the proposed structures. In this connection, Professor Karl von Terzaghi, who is one of the foremost authorities on foundation problems, has stated that sub-soil to a depth below foundation level of 1½ time the width of the loaded area may be thus influenced.

30.4.8.8 The levels at which compressible strata - such as soft silt, peat, and soft clays-occur is important, for they are likely to give large settlement movement by consolidation under a superimposed load. Indeed, even under the influence of the weight of the strata above, they show evidence in many places of continuous consolidation. The nearer a soft layer is to the ground surface, and the more it is loaded, the greater is the likelihood of its being a source of trouble; also the greater the thickness of a soft layer, the larger will be the value of its maximum compression, but, on the other hand, it may take a long time for the maximum movement to be obtained.

30.4.8.9 It is sometimes found that a deep-seated stratum of soft material is overlain by a thick stratum of greater bearing strength, and care must then be taken to ensure that the loading of the latter is not high enough to impose any appreciable strain on the soft layer. The sequence of soiled strata is also important from the point of view of their relative permeability. A layer of soft clay maybe found between two layers of permeable sand, and in such a case its rate of consolidation will very much in excess of what it would have been had it been sandwiched between strata of a relatively impermeable nature. Where a sequence of strata such as this is indicated, the borings must establish whether the sand strata are continuous over a wide area or are in the nature of isolated pockets.

30.4.8.10 In the records of construction of dock works there are innumerable cases of trouble arising from unsuspected soft strata or water-bearing layers, owing to the borings made during site investigations not having been carried far enough below foundation level. The depth to which borings are taken will depend, of course, upon the magnitude of the proposed structures and their area, but unless there is good geological or other evidence to the contrary, it is always advisable for at least one of the borings one even small project to be taken to such a depth as will ensure full knowledge of the stratification within the construction area.

30.4.8.11 Compilation of Geological Data- The following data about the geology of the area should be compiled:

(a) Type of bedrock including information on its origin and method of formation:
(b) Any faults, fissures, folds and other unconformities in the area of the project; and
(c) Crushing strength and other properties of the rock in the project area and its suitability for use in marine works.

30.4.9 Soil Investigation

30.4.9.1 Earlier Uses of the Site - In a site which has been partially developed, enquiries should be made regarding the past structures layout of pipes and obstructions likely to be met in the area for new works. Enquiries should also be made regarding old creek let, excavated pits, etc, which might have either silted up or reclaimed. This information will be particularly useful in deciding the number and location of trial pits and borings; and assessing in general, the likely soil strata that may be met with.

30.4.9.2 Subsurface Exploration

It is not practicable to standardize the disposition and spacing of borings required for subsurface investigation as these depend upon the type of structure and the nature of the site. Broadly speaking the number of bore holes should be sufficient to give a picture of the probable variation in the subsurface strata over the site and their depth should be such as to include all strata likely to affect the stability of the structure. Any soft strata encountered below foundation level should require special study.

A few subsurface soundings like the standard penetration test and the cone penetration test may be conducted. The cone penetration test should be conducted in conjunction with at least one bore hole with sampling for correlation of soil type with the penetration resistance obtained from soundings.

The subsoil investigation should be carried out generally according to IS : 1892-1979.

Initially the main borings may be along the top edge of the shore. These borings may be spaced 50 m apart and taken to a depth of 3 m into hard strata or a depth equal to twice the difference in the elevation of the ground surface on either side of the structure. In a few cases, the borings may be taken deeper to investigate the nature of the underlying strata. It is desirable to use large diameter bores in reclaimed areas and where embedded boulder layers are encountered, depending on the size of the project.

The intermediate borings of the first order may be further drilled after the findings of the principal borings are known, to a depth at which the known uniform soil layer, identified by the principal borings is encountered, here also the spacing of the borings may be 50 m.

The intermediate borings of the second order may be drilled only when there is a considerable change in the upper layers. Normally, they are also located at 50 m spacing but off the areas. The spacing could be reduced if the subsoil conditions so require it. The boring depth depends on the result of the preceding borings and should extend at least to twice the design depth.

Bore hole data should be presented in the form of bore hole logs alongwith important longitudinal and cross-sectional soil profiles and bore holes location plan.

30.4.9.3 Mean Ground Water Level in Tidal Areas

This should be ascertained over a yearly cycle on the entire site under reference or may be assumed to at about 0.30 m above the mean tides water level. With a stronger ground water influx from the shore, the mean water level may lie higher as in rainy season and in areas with poor drainage characteristics.

30.4.10 Seismic Data

30.4.10.1 Past data regarding seismic activity in the particular site may be collected for use in design (see IS: 1893-1975).

30.4.11 Local Resources

This section deals with construction resources only. Local resources may be men, materials and machine.

30.4.11.2 Materials

A comprehensive assessment of the availability of the local construction materials and their costs should be made as regards to the following:

(a) Types of material like bricks, stones, timber, etc;
(b) Existing and proposed quarries; and
(c) Facilities for transport of materials by rail, road or other modes of transport.

30.4.11.3 Manpower Resources

The availability of the following should be judged and prevailing rates of daily wages recorded:

(a) Skilled labour, trade-wise;
(b) Unskilled labour; and
(c) Availability of local construction agencies with their resources.

30.4.11.4 Plant and Equipment

Availability of earth-moving and other machinery and workshop facilities with the local bodies like Public Works Department, etc, should be assessed so that advantage could be taken of these facilities in the initial stages of the project till the project machinery arrives and workshop facilities are set up.

30.4.11.5 Water and Power

The availability of water and power for the proposed facility and construction purpose should be ascertained and recorded.

30.4.11.6 Local Rates

For costing purposes, local rates of material, labour, transportation, hiring of plant, etc, should also be collected.

30.4.12 Other information

30.4.12.1 Before deciding the preliminary design of the proposed work, information on the following aspects should also be collected:

(a) Map indicating areas of inundation during highest high tide.
(b) Pollution and environmental effects:
  (i) Measurement of existing pollution level, and
  (ii) Pollution limit standards laid down by local bodies and other authorities.
(c) Any existing/proposed master plan for the development of the area including hinterland development.
(d) Other information useful in the general planning of the marine structure area, such as investigations of any river/stream which has outlet investigations regarding the Weber requiring diversion, etc.

30.4.13 Reporting of Site Data

30.4.13.1 A summary of site data may be reported on form as suggested and given at Appendix B of IS : 4561 (Part 1) for easy assimilation.

30.5. Lay out and functional requirements

30.5.1 Based on the data collected from site investigation as mentioned hereinbefore, layout and functional requirements of Marine Structures shall be finalized all as per IS : 4561 Part V.

30.6. Workmanship in Marine Structures

30.6.1 Provisions contained in IS : 9527 Part I of VI have to be complied in respect of following:

Part-I - Concrete monoliths
Part-II - Caissons
Part - III - Sheet pile walls
Part - IV - Circular steel pile structures
Part - V - Open pile structure
Part-VI - Block work