बृहन्मुंबई महानगरपालिका
Municipal Corporation of Greater Mumbai




Mithi River Water Quality Improvement Project

Package 3: Dry Weather Flow Interception at Tidal Outfalls (including Gate Pumps), Transfer Sewer, Training of River (Retaining wall and Service Road), Beautification including Promenades and Allied Works from CST Bridge to Prem nagar outfall, Kurla including Vakola River.

Design Build Operate Contract

Volume 2A - General Technical Specification

Employer:
Municipal Corporation of Greater Mumbai

Municipal Head Office Building, Mahapalika Marg,
Fort, Mumbai - 400 001.

Consultant:
Frischmann Prabhu (India) Pvt. Ltd.

315, Balgovind Wadi, New Prabhadevi Road,
Prabhadevi, Mumbai - 400 025

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Municipal Head Office Building,
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India

Consultant:
Frischmann Prabhu (India) Pvt. Ltd.
315, Balgovind Wadi, New Prabhadevi Road,
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1 NOTES TO THE GENERAL TECHNICAL SPECIFICATION

The General Technical Specification includes the general requirements for the design, construction and operation of those projects included within the Mithi River Water Quality Improvement Project.

This General Technical Specification shall apply for all works associated with the provision of new, refurbished or updated parts of the Facilities.

The General Technical Specification forms an integral part of the Contract Documents and should be used in conjunction with all the Volumes which form the Contract Documents, especially the detailed project requirements included within the Employer's Requirements, which take precedence over the General Technical Specification.

Before order for bulk supply is placed, samples of various materials, fittings, etc. proposed to be incorporated in the work shall be submitted by the Contractor to the Employer's Representative for approval.

Prior to manufacture or delivery of fabricated items, the Contractor shall submit to the Employer's Representative copies of manufacturer's drawings covering all type/details of work as generally shown in design drawings and envisaged under these specifications. The drawings shall show all dimensions, details of construction, installation of fixtures and connections and relation to adjoining and related works. No fabrication or manufacturing work shall be undertaken prior to obtaining approval of drawings from the Employer's Representative.

2 CODES OF PRACTICE

Unless specifically otherwise stated, all the applicable codes and standards published by the Indian Standard Institution and all other standards which may be published by them up to the date of receipt of tenders, shall govern in all respects of design, workmanship, quality and properties of materials and methods of testing, etc., unless specifically quoted.

In case there is no IS specification for the particular work, such work shall be carried out in accordance with this General Technical Specification and the instructions in all respects and requirements, of the Employer's Representative. Wherever any reference to any Indian Standard occurs in the documents relating to this Contract, the same shall be inclusive of all amendments issued thereto or revisions thereof, if any, up to the date of receipt of tenders.

The following table includes various pertinent standards, relevant to the Contract, (all latest versions of codes shall be referred, unless a different code and standard system is referenced). All standards, tentative specifications, specifications, codes of practice, referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of discrepancy between this specification and those referred to' herein, this specification shall govern.

Table 2-1 Standards

IS Code No.	Subject
Carriage of Materials	
4082-1996	Recommendations on stacking & storage of construction materials and components at site.
Earth Work	
3764	Safety Code for Excavation Work
2720	Part II - Determination of Moisture Content
2720	Part VII - Determination of Moisture content dry density relation using light compaction
2720	Part VIII - Determination of Moisture Content Dry Density using heavy compaction
2720	Part XXVIII - Determination of Dry Density of soils, in place, by the sand replacement method
2720	Part XXIX - Determination of Dry Density of soils, in Place, by the core cutter method
6313 – 1981	Code of Practice for Anti Termite Measure in Buildings
Road Works	
Section 900	MORT Specifications for Road and Bridge Works (IV Revision)
Section 902	MoSRT&H Specifications for Road and Bridge Works (IV Revision).
Construction Materials	
196-1966	Atmospheric conditions for testing (Reaffirmed - 1990)
269-1989	33 Grade Ordinary, rapid hardening and low heat Portland cement

IS Code No.	Subject
383-1970	Coarse and fine aggregates from natural sources for concrete
455-1989	Portland blast furnace slag cement
650-1991	Standard sand for testing of cement
1489-1991	Portland pozzolana cement fly ash based
1514-1990	Methods of sampling & Test for Quick Lime & Hydrated Lime. (Reaffirmed - 1996)
1542-1992	Sand for Plastering
1727-1967	Methods of tests for pozzolanic materials
2116-1980	Sand for masonry mortars. (Reaffirmed – 1998)
2250-1981	Code of practice for preparation and use of masonry mortar. (Reaffirm- 1990)
2386-1963	Methods of Test for Aggregates for Concrete
2386 Pt.I-1963	Particle size and shape
2386 Pt. II-1963	Estimation of deleterious materials and organic impurities
2386 Pt.III-1963	Specific gravity, density, voids, absorption and bulking
2686-1977	Cinder as fine aggregate for use of Lime Concrete. (Reaffirmed – 1992)
3025-1964	Methods of sampling & test (Physical & Chemical) water used in industry. (Reaffirmed-2003)
3068-1986	Broken brick (burnt clay) coarse aggregate for use in lime concrete (II-R.)
3182-1986	Broken brick (Burnt clay) fine aggregate for use in lime mortar
3812-1981	Fly Ash using as pozzolana and admixtures (Reaffirmed - 1999)
4031-1996	Methods of physical tests for hydraulic cement (Reaffirmed - 1996)
4032-1985	Method of chemical analysis of hydraulic cement (Reaffirmed - 1990)
4098-1983	Lime pozzolana mixture (Reaffirmed - 1989)
4443	Code of practice for use resin type chemical resistant mortars
8042	Specification for white Portland cement
8112	Specification for 43 grade ordinary Portland Cement
12269	Specification for 53 grade ordinary Portland Cement
12330	Specification for sulphate resisting Portland Cement
Concrete Work	
SP 23	Handbook on concrete mixes (based on Indian Standards)
269	Specification for 33 grade ordinary Portland Cement

IS Code No.	Subject
280	Specification for mild steel wire for general engineering purposes
343-1980	Code of practice for pre-stressed concrete
383-1970	Coarse and fine aggregate from natural sources for concrete (Reaffirmed - 1990)
432	Specification for mild steel and medium Tensile (Part 1 & 2) steel bars and hard-drawn steel wire for concrete reinforcement
455	Specification for Portland slag cement
456-2000	Code of practice for plain and reinforced concrete
457-1957	COP for general const. of plain & reinforced concrete for dams & other massive structure
458	Specification for pre-cast concrete pipes (with and without reinforcement)
516-1959	Method of test for strength of concrete (Reaffirmed in 2004)
650	Specification for standard sand for testing cement
780-1961	Specifications for cold twisted steel bars for concrete reinforcement*
875	Code of Practice for structural safety of buildings, loading standards
1139	Deformed bars for concrete reinforcement, hot rolled for mild steel or medium tensile steel
1161-1963	Specifications for steel tubes for structural purposes
1199-1959	Methods of sampling and analysis of concrete. (Reaffirmed - 1999)
1322-1993	Bitumen felts for waterproofing and damp proofing. (Reaffirm - 1998)
1343	Code of practice for pre-stressed concrete
1566-1982	Hard drawn steel wire fabric for concrete reinforcements (II Rev.) (Reff.1998)
1661-1987(Pt.III)	Code of practice for application of cement lime plaster finishes. (Reaffirm - 1999)
1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
1893	Criteria for Earthquake Resistance Design of Structures
2386-1977 (Pt.1 to 8)	Methods of test for aggregate for concrete
2386 (Pt.I)-1963	Test for particle size and shape
2386 (Pt.II)-1963	Test for estimation of deleterious materials and organic impurities
2386 (Pt.III)-1963	Test for specific gravity, density, voids, absorption and bulking
2386 (Pt.IV)-1963	Mechanical properties

IS Code No.	Subject
2502	Code of practice for bending and fixing of bars for concrete reinforcement
2645-1975	Specification for integral waterproofing compounds
2686-1977	Specification for cinder aggregate for use in lime concrete (Reaffirm - 1992)
2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction
3025	Methods of sampling and test (physical and chemical) (Parts 1 to 49) (Physical and chemical) for water and wastewater.
3201	Criteria for design and construction of pre-cast trusses and purlins
3370	Code of practice for concrete structures for the storage of (Parts 1 to 4) Liquids
3414	Code of practice for design and installation of joints in Buildings
3812-1981	Fly Ash using as pozzolana and admixtures for concrete. (Reaffirmed - 1999)
7861-1975	(Pt. I Hot weather concreting (Reaffirmed -1990)
7861-1981	(Pt. II Cold weather concreting (Reaffirmed -1992)
9103-1999	Admixture for concrete
3935-1966	Code of practice for composite construction. (Reaffirmed – 1998)
4014-1967	(Pt. & II) COP for steel tubular scaffolding (I: Definition/Material; II: Safety Resolutions) (Raffir 1999)
4926-2003	Code of practice for Ready Mix Concrete
4990-1993	Specifications for plywood for concrete shuttering work. (Reaffirmed - 1998)
10262-1982	Code of practice for design mix (Reaffirmed - 1999)
1785-1983 (Part-I& II)	Specifications for plain hard drawn steel wire for pre-stressed concrete
1786-1985	H.Y.S.D./ Cold twisted steel bars for concrete reinforcement Reaffirmed - 1990)
2090-1983	Specifications for high tensile steel bars used in pre-stressed concrete
2204-1962	Code of practice for construction of reinforced concrete shell roof (Reaffirmed – 1990)
2210-1988	Criteria for the design of shell structure and folded plates (Reaffirmed - 1998)
2502-1963	COP for bending and fixing of bars for concrete reinforcement (Reaffirmed - 1999)
2751-1979 (Reaf-1992)	COP for welding of mild steel bars used for reinforced concrete construction
2911-1984	Code of practice for design & Construction of pile foundations

IS Code No.	Subject
2911(Pt.I)-1979 (Reaf-97)	Design & construction of Pile Foundations - Bored pre-cast concrete piles
2911 (Pt.III)-1980	Under reamed pile foundations
2911 (Pt.IV)-1985	Load test on Piles
3201-1988	Criteria for design and construction of pre-cast concrete trusses (Reaffirmed - 1995)
3370 (Part I to IV) -1965	Code of practice for concrete structures for storage of liquids. (Reaffirmed - 1999)
3385-1965	Code of practice for measurement of Civil Engineering works - Pile Foundation)
3414-1968	Code of practice for design and installation of joints in buildings. (Reaffirmed - 1990)
3558-1983 (Reaf-91)	Code of practice for use of immersion vibrators for consolidating concrete
6932 (Pt.I to X)	Methods of Test for Building Lime
6932 (Pt.I)-1973	Determination of insoluble residue, loss of ignition, silicon-dioxide, ferric & Alum. Oxide, calcium oxide & magnesium oxide insoluble matter
6932 (Pt.II)-1973	Determination of carbon dioxide content
6932 (Pt.III)-1973	Determination of residue on slaking of quick lime
6932 (Pt.IV)-1973	Determination of fineness of hydrated lime
6932 (Pt.V)-1973	Determination of unhydrated oxide
6932 (Pt.VI)-1973	Determination of volume yield of quick lime
6932 (Pt.VII)-1973	Determination of compressive and transverse strength
6932 (Pt.VIII)-1973	Determination of workability
6932 (Pt.IX)-1973	Determination of soundness
6932 (Pt.X)-1973	Determination of popping and pitting of hydrated Lime
10262	Recommended guidelines for concrete mix design
13620	Fusion Bonded Epoxy coated Reinforcing Bars specification
13290	Code of Practice for Earthquake Resistance Design and Construction of Buildings
9417	Recommendations for welding cold worked steel bars for reinforced concrete construction
ASTM. A615	Grade 40, but with bend tests conforming to 1971 ACI Supplement
ASTM A.185	Welded wire mesh. or latest version

IS Code No.	Subject
Equipment	
14687-1999	Code of Practice for Formwork
460-1985 (Pt-I,II& III)	Specification for test sieves. (Reaffirmed - 1998)
1791-1985	Specification for batch type concrete mixer. (Reaffirmed - 1990)
2430-1986	Methods for sampling of Aggregates for concrete
IS 2438	Specification for roller pan mixer
2505-1992	General requirements for concrete vibrators, immersion type
2506-1985	General requirements for screed board concrete vibrators
2514-1963	Specification for concrete vibrating tables. (Reaffirmed - 1991)
3366-1965	Specification for pan vibrators. (Reaffirmed - 1991)
4656-1968	Specification for form vibrators for concrete. (Reaffirmed-1991)
2722-1964	Specification for portable swing weigh batchers for concrete (single and double bucket type) (Reaf-95)
2750-1964	Specification for steel scaffolding. (Reaffirmed - 1991)
4990	Specification for plywood for concrete shuttering work
Brickwork	
1077-1992	Common burnt clay building bricks
2185	Specification for concrete masonry units (parts 1, 2 & 3)
2212-1991	Code of practice for brick work
2572	Code of practice for construction of hollow concrete block masonry
2691	Specification for burnt clay facing bricks
3102-1971	Classification of burnt clay solid bricks
3495 (Pt I to IV)-1992	Method for test for burnt clay building brick
4832	Specification for acid resistant bricks
4860	Specification for acid resistant bricks
5454-1978	Method for sampling of clay building bricks.(Reaffirmed - 1995)
6041	Code of practice for construction of autoclaved cellular concrete block masonry
6042	Code of practice for construction of light weight concrete block masonry
Stonework	
1121 (Pt I)-1974	Methods for determination of compressive, transverse & shear strengths of natural building stones

IS Code No.	Subject
1122-1974	Methods for determination of specific gravity and porosity of natural building stones
1123-1975	Methods for identification examination of natural building stones
1124-1974	Methods of test for water absorption of natural building stones
1125-1974	Methods of test for weathering of natural building stones
1126-1974	Methods of test for durability of natural building stones
1129-1972	Dressing of natural building stones
1130-1969	Marble (blocks, slabs and tiles)
1597-1992	Code of practice for construction of stone masonry
1597 (Pt I)-1992	Code of practice for construction of Rubble stone masonry. (Reaffirmed 1996)
1597 (Pt II)-1992	Code of practice for construction of ashlar masonry (Reaffirmed - 1996)
1805-1973	Glossary of Terms relating to stone Quarrying and dressing. (Reaffirmed - 1993)
4101 (Pt I)-1967	Stone facing. (Reaffirmed - 1990)
Architectural	
204-1991/92	Tower bolts (Part I - 1991: ferrous metals; Part II - 1992 : Non ferrous metals)
205-1992	Non-ferrous metal butt hinges
420-1953	Putty used on metal frame (withdrawn)
1734 – 1983	Methods of tests for plywood (IIR) (Ref 1993)
206-1992	Tee and strap hinges
207-1964	Gate and shutter hooks and eyes. (Reaffirmed - 1996)
208-1987	Door handles
281-1991	Mild steel sliding door bolts for use with padlocks
287-1973	Recommendation for maximum permissible moisture contents of timber used for Different purposes. (Reaf-98)
303-1989	Plywood for general purpose
362-1991	Parliament hinges
363-1993	Hasps and staples
364-1993	Fanlight catch
401-1982	Code of practice for preservation of timber
419 – 1967	Putty for use on window frame (I Rv.) (and out 3)
451-1999	Technical supply condition for wood screws

IS Code No.	Subject
452-1973	Door springs, rat-tail type (II Rev.) (Reaffirmed 1990)
453-1993	Double acting spring hinges. (Reaffirmed – 1999)
710	Specification for marine plywood
712-1984	Specification for building limes. (Reaffirmed - 1995)
723-1972	Steel counter sunk head wire nails. (Reaffirmed - 1996)
729.1979	Drawer locks, cupboard locks and box locks (III Rev.) (Reaffirmed 1992)
733	Wrought aluminium and aluminium alloys, bars, rods and sections for general engineering purposes.
848-1974	Synthetic resin adhesive for plywood (phenolic and aminoplastic) (I Rev)
851-1978	Synthetic resin adhesive for construction work (Non-structural) in wood (I-Rev.) (amt)(Reaffirmed 1990)
852-1994	Specifications for animal glue for general wood working purposes. (II Rev)
875-PET 1987	Dead loads – Unit not of bldg. & stored materials
1003-1994	Timber panelled and glazed shutters
1003(Pt.I)-2003	Door shutters (III Rev.) (a 1)
1003 (Pt.II)-1994	Window and ventilator shutters (III Rev.)
1019-1974	Rim latches. (Reaffirmed - 1991)
1038	Specification for steel doors, windows and ventilators
1081	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators
1124	Method of test for degeneration of water absorption, apparent specific gravity and porosity of natural building stones
1141-1993	Code of practice for seasoning of timber (II Rev.)
1322-1993	Bitumen felts for waterproofing and damp proofing
1328-1996	Veneered decorative plywood
1341-1992	Steel Butt hinges (VI Rev.)
1346	Code of practice for waterproofing of roofs with bitumen felts
1361	Specification for steel windows for industrial buildings
1378-1987	Oxidized copper finishes. (Reaffirmed - 1998)
1397	Specification for craft paper
1568-1970	Wire cloth for general purposes.(Reaffirmed - 1998)
1580	Specification for bituminous compounds for waterproofing and caulking purposes

IS Code No.	Subject
1629-1960	Rules for grading of our size of timber. Superseded in IS 1331
1658-1977	Fibre hard board. (Reaffirmed - 1990)
1659-2004	Block boards
1708-1986	Method of testing of clear specimen of timber (II Rev) (Q.1) (Reaffirmed 1990)
1823-1980	Floor door stoppers. (Reaffirmed - 1992)
1837 – 1966	Specification for fanlight pivots (I Rev.) (Reaffirmed 1990)
1868-1996	Anodic coating on Aluminium & its alloy (II Rev.) (Reaffirmed 1991)
1948	Specification for aluminium doors, windows and ventilators
1949	Specification for aluminium windows for industrial Buildings
2095-1982	Gypsum plaster bow (I Rev) (an.1) (Ref. 1991)
2096-1992	A.C. flat sheet (I Rev.)
2191-1983	Wooden flush door shutters (cellular and hollow core type). (Reaffirmed - 1991)
2191 (Pt.I)-1983	Plywood face panels. (Reaffirmed - 1991)
2191 (Pt.II)-1983	Particle board face panels and hard board face panels. (Reaffirmed-1991)
2202-1999	Wooden flush door shutters (solid core type)
2202 (Pt.I)-1999	Plywood face panels for wooden flush door shutters
2202 (Pt.II)-1983	Particle board face panels for wooden flush door shutters. (Reaffirmed - 1991)
2209(Pt.I)-1976	Mortice locks (vertical type) (Reaffirmed 1992)
2380-1981	Method of test for wood particle board and boards from lignocellulosic materials (Reaf.1993)
2681-1993	Non-ferrous metal sliding door bolts (aldrop) for use with padlocks
2690	Specification for burnt clay flat terracing tiles. Part 1 Machine made
2835-1987	Flat transparent sheet glass (3rd Revision). (Reaffirmed - 1992)
3067	Code of practice of general design details and Preparatory work for damp proofing and waterproofing of buildings
3087-1985	Wood particle boards (medium density) for general purpose (1990)
3097-1980	Veneered particle boards (1st Revision)
3384	Specification for bitumen primer for use in waterproofing and damp proofing
3400 (Part I)-1987	Method of test for vulcanized rubbers (1991)
3400-(Pt II)-2003	Hardness (1981)

IS Code No.	Subject
3400-(Pt IV)-1987	Accelerated aging (1993)
3400 (Pt IX) - 2003	Relative density and density. (Reaffirmed - 1990)
3564-1996	Door closers (Hydraulically regulated)
3618-1966	Phosphate treatment of iron and steel for protection against corrosion. (Reaffirmed- 1991)
3813-1967	'C' hooks for use with swivels (1992)
3818-1992	Continuous (Piano) hinges
3828 – 1968	Ventilator chains (Reaf. 1990)
3847-1992	Mortice night latches
4020-1998 (1 to 16)	Methods of tests for wooden flush Doors (Type tests)
4021-1995	Timber door, window and ventilator frames
4101	Code of practice for External Facing and Veneers
4457	Specification for ceramic unglazed vitreous acid resisting tile
4827-1983	Electroplated coating of nickel and chromium on copper and copper alloys
4835 – 1979	Polyvinyl Acetate Dispersion Based Adhesives (1990)
4948-2002	Welded steel wire fabric for general use. (Reaffirmed - 1992)
4992-1975	Door Handles for mortice locks (vertical type). (Reaffirmed - 1990)
5187-1972	Flush bolts (1990)
5437	Wired and figured glass
5523-1983	Method of testing anodic coating on aluminium & its alloys. (Reaffirmed -1991)
5930-1970	Mortice latch (vertical types) (1991)
6318-1971	Plastic window stays & fasteners
6607-1972	Rebated mortice locks (vertical type)
6760-1972	Slotted countersunk head wood screws. (Reaffirmed - 1988)
7196-1974	Hold fasts (1992)
7197-1974	Double action floor springs (without oil check) for heavy doors
7534-1985	Sliding locking bolt for use with padlocks. (Reaffirmed – 1991)
8543	Methods of testing plastics
8756 – 1978	Mortice bell catches for use in wooden almirah (1992)

IS Code No.	Subject
9862	Specification for ready mixed paint, brushing Bituminous, black, lead-free, acid alkali, water and chlorine resisting
12200	Code of practice of water –stops at transverse Contraction joints in masonry and concrete dams
14856-2000	Glass fibre reinforced plastic (GRP) panel type door shutters for internal use – Specification
Steelwork	
12406 – 1988	Medium density fibre board for general purpose - (1992)
226	Structural Steel (Standard quality)
277-2003	Specification for galvanised steel sheets (plain and corrugated)
278-1978	Galvanised steel barbed wire for fencing. (Reaffirmed - 1991)
800-1984	Code of practice for use of structural steel in general building construction
806-1968	Code of practice for use of steel tube in general building construction
808	Dimension for hot rolled steel sections
813-1986	Scheme of symbols for welding. (Reaffirmed – 2003)
814-1991	Covered electrodes for metal arc welding of structural steel (Reaffirmed 2003)
814 (Pt-I)-1974	For welding products other than sheets. *
814 (Pt-II)-1974	For welding sheets. *
817-1966	Code of practice for training and testing of metal arc welders. (Reaffirmed – 2003)
818-1968 (Reaf-03)	COP for safety & healthy requirements in electric & gas welding & cutting operation
919	Recommendations for limits and fits for engineering
961	Structural steel (High Tensile)
1030	Specifications for steel casting for general engineering purposes
1038-1983	Steel doors, windows and ventilators
1079	Specifications for light gauge structural quality hot rolled carbon steel sheet and strip
1081-1960	COP for fixing & glazing of metal (steel & aluminium) doors, windows & ventilators (Reaf- 91)
1148-1982	Hot rolled steel rivet bars (up to 40 mm diameters) for structural purposes, (Reaf-92) (Reaffirmed 2001)
1149	High Tensile rivet bars for structural purposes
1161-1998	Steel tubes for structural purposes

IS Code No.	Subject
1182-1983	Recommended practice for radiographic examination of fusion welded butt joints in steel plates (Reaf-00)
1363-1992 (Pt. 1- 3)	Hexagon bolts, nuts & lock nuts (dia. 6 to 39 mm) & black hexagon screws (dia. 6 to 24 mm) (Reaf-98)
1442	Specifications for covered electrodes for metal are welding of high tensile steels
1599-1985 (Reaf-91)	Method for bend test for steel products other than sheet, strip, wire & tube (reaffirmed 1996)
1608-1995	Method for tensile testing of steel products (Reaffirmed 2001)
1730	Dimension for steel plate, sheet and strip for Structural and General Engineering purpose
1732	Dimensions for sound and square steel bars for Structural and General Engineering purpose
1821-1987	Dimensions for clearance holes for metric bolts. (Reaffirmed - 2003)
1852-1985	Rolling and cutting tolerance for hot rolled steel products. (Reaffirmed - 1991)
1977-1969	Structural steel (ordinary quality) (Reaffirmed 2001)
2062-1999	Structural steel (fusion welding quality). Supersedes IS 226-1975
3613	Acceptance tests for wire flux combination for submerged arc welding
3757	High tensile friction grip bolts
4351-2003	Steel door frames. (Reaffirmed – 1991)
4736-1986	Hot-dip zinc coatings on steel tubes. (Reaffirmed – 2001)
5624	Foundation bolts
6248-1979	Metal rolling shutters and rolling grills
6639	Hexagonal bolts for steel structures
6761	Countersunk-head screws with hexagon sockets
6572	Dimensions for pneumatic light rivet snap shanks
6649	High tensile friction grip bolt washers
7452-1990	Hot rolled steel sections for doors, windows & ventilators
7205	Safety code for erection of structural steel work
Flooring	
210-1993	Grey iron casting (Reaffirmed 1999)
653-1992	Sheet linoleum
777-1988	Glazed earthen-ware tiles

IS Code No.	Subject
809-1992	Rubber flooring materials for general purpose
1122-1974	Methods for determination of specific gravity (*and porosity of natural building stones)
1124-1974	Method of test for water absorption of natural building stones
1128	Lime-stone (slab and tiles)
1197-1970	Code of practice for laying of rubber floors. (Reaffirmed – 1990)
1198-1982	Code of practice for laying and maintenance of linoleum floors
1237-1980	Cement concrete flooring tiles. (Reaffirmed – 1990)
1443-1972	Code of practice for laying and finishing of cement concrete flooring tiles
1661-1972	Code of practice for application of cement and cement lime plaster finishes
2114-1984	Code of practice for laying in situ terrazzo floor finish
2571-1970	Code of practice for laying in situ cement concrete flooring
3400-1987 (Part 1 to 22)	Method of Test of vulcanized rubbers. (Reaffirmed – 2003)
3400 (Pt II)-2003	Hardness
3400 (Pt X)-1977	Compression set at constant strain. (Reaffirmed – 2003)
3461	Specification for PVC-asbestos floor tiles
3462-1986	Flexible P.V.C. Flooring.(Reaffirmed – 1991)
3622	Sand – stone slabs for use in flooring
4631-1986	Code of practice for laying of resin floor toppings (Reaffirmed – 2001)
5318-1969	Code of practice for laying of flexible P.V.C. sheet & tiles flooring
5389-1969	Code of practice for laying of hardwood parquet and wood block floors. (Reaffirmed – 1998)
5491	Code of practice for laying of in-situ granolithic concrete floor topping
9197-1979	Specifications for epoxy resin, hardeners and epoxy resin compositions for floor topping (Reaffirmed – 2001)
13630 (Pt.1 to 13)	Methods of tests for ceramic tiles (Part 1 to 13 : 1992-1993)
3370-2009	Amendment in Year of Publishing Code of Practice for concrete structures for the storage of liquids (Part I to II)
3370-1967	Amendment in Year of Publishing Code of Practice for concrete structures for the storage of liquids (Part III to IV)
2974	Code of Practice for design and construction of machine foundations (Part 1 to 5), Part 1 -1982, Part 2 -1980, Part 3 -1992, Part 4 -1979, Part 5 -1987

IS Code No.	Subject
4326-2013	Code of Practice for Earthquake Resistant Design and Construction of Buildings
13920-1993	Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces Code of Practice
IRC: 6-2014	Standard specification and Code of Practice for road bridges Loads and Stresses
SP: 16-1980	Design Aids for Reinforced Concrete to IS 456
SP: 34- 1987	Handbook on Concrete Reinforcement and Detailing
806-1968	Code of Practice for use of steel tubes in general building construction
SP: 38-1987	Handbook of Typified Design of Structures with Steel Roof Trusses
2721	Specification for Galvanized Steel Chain Link Fence Fabric
3502	Specification for steel chequered plates
4350	Specification for concrete porous pipes for under drainage
12709	Glass fiber reinforced plastics (GRP) pipes, joints and fittings for use for potable water supply
Tests	
2720	Methods of test for soils (Parts 1 to 39)
5807	Method of test for clear finishes for wooden furniture (Parts 1 to 6)
7318	Approval tests for welders when welding procedure approval is not required (Parts 1 and 2)
13311	Methods of Non-destructive testing of Concrete- Part 1 & Part 2
Codes of Practice for design/detailing	
783	Code of practice for laying of concrete pipes
816	Code of practice for use of metal arc welding for general construction in mild steel
1081	Code of practice for fixing and glazing of metal (steel and aluminum) doors, windows and ventilators
1172	Code of practice for basic requirements for water supply, drainage and sanitation
1742	Code of practice for building drainage
1904	Code of Practice for Design and Construction of Foundation in Soils General Requirements.
2065	Code of practice for water supply in buildings
2338	Code of practice for finishing of wood and wood based materials (Parts 1 & 2)
2394	Code of practice for application of lime plaster finish

IS Code No.	Subject
2395	Code of practice for painting, concrete, masonry and plaster surfaces (Parts 1 & 2)
2470	Code of practice for installation of septic tanks (Parts 1 & 2)
2502	Code of practice for bending and fixing of bars for concrete reinforcement
2595	Code of practice for radiographic testing
2974	Code of practice for design and construction of machine foundations (Parts 1 to 4)
3114	Code of practice for laying of Cast Iron pipes
3658	Code of practice for liquid penetrant flaw detection
3935	Code of practice for composite construction
4000	Code of practice for High strength bolts in steel structures
4014	Code of practice for steel tubular scaffolding (Parts 1 & 2)
4111	Code of practice for ancillary structures in sewerage system (Parts 1 to 5)
4127	Code of practice for laying of glazed stoneware pipes
4326	Code of practice for Earthquake Resistant Design and Construction of Buildings
4353	Recommendations for submerged arc welding of mild steel and low alloy steels
5329	Code of practice for sanitary pipe work above ground for buildings
5334	Code of practice for magnetic particle flaw detection of welds
5822	Code of practice for laying of welded steel pipes for water supply
7215	Tolerances for fabrication of steel structures
9595	Recommendations for metal arc welding of carbon and carbon manganese steels
10005	SI units and recommendations for the use of their multiples and of certain other units
Construction Safety	
3696	Safety code for scaffolds and ladder (Parts 1 & 2)
3764	Safety code for Excavation work
7205	Safety code for erection of structural steel work
Roofing	
73-1992	Paving Bitumen (Reaffirmed 1998)
277-2003	Galvanised steel sheets (plain and corrugated)
458-2003	Concrete pipes (with and without reinforcement)

IS Code No.	Subject
459-1992	Un-reinforced corrugated and semi-corrugated asbestos cement sheets
651-1992	Salt glazed stone ware pipes and fittings
702-1988	Industrial Bitumen
1199-1959	Method of Sampling & Analysis of concrete. (Reaffirmed - 1991)
13607 – 1992	Ready Mixed Paint, Finishing, General Purposes, Synthetic (Reaffirmed 2002)
1322-1993	Bitumen felts for waterproofing and damp-proofing. (Reaffirmed - 1988)
1346-1991	Code of practice for waterproofing of roof with bitumen felts
1609-1991	Code of practice for laying damp proof treatment using bitumen felts
1626-1994 (Part I-III)	Asbestos cement building pipes, gutters and fittings (Spigot and socket types)
1834-1984	Specification for hot applied sealing compounds for joints in concrete. (Reaffirmed - 1990)
1838-(Pt. I & II) - 1983	Preformed filler for expansion joints in concrete - non-extruding and resilient type Bitumen impregnated fibre). (Reaffirmed - 1990)
2115-1980	Code of practice for flat roof finish: mud phuska. (Reaffirmed - 1998)
2633-1986	Method of testing uniformity of coating on zinc coated articles. (Reaffirmed – 2001)
3007-(Pt I) -1999	Code of practice for laying of corrugated asbestos cement sheets. (Reaffirmed – 1991)
3007-(Pt II) -1965	Code of practice for laying of semi corrugated asbestos cement sheet. (Reaffirmed - 1991)
3348-1965	Fibre insulation boards. (Reaffirmed - 1990)
3607-1979	Magnesite for chemical Industry. (Reaffirmed – 2003)
7193-1994	Specifications for glass fibre base coal tar Pitch & Bitumen felts
8183-1993	Bonded mineral wool. (Reaffirmed 2004)
Finishing	
75-1973	Linseed oil, raw and refined. (Reaffirmed – 2003)
77-1976	Linseed oil, boiled, for paints. (Reaffirmed - 1999)
102-1962	Ready mixed paint, brushing, red, lead, non-setting, priming. (Reaffirmed - 1996)
104-1979	Specification for ready mixed paint, brushing, zinc chrome, priming. (Reaffirmed - 1999)
110	Read mixed paint, brushing, grey filler, for enamels for primers
133-1993	Enamel, interior (a) under coating (b) finishing colour as required

IS Code No.	Subject
137-1965	Ready mixed paint, brushing, matt or egg-shell flat, finishing, interior, to Indian Standard Colour, as required. (Reaffirmed – 1999)
158-1981	Ready mixed paint, brushing, bituminous, black lead free acid alkali, water and heat resisting for general purposes. (Reaffirmed – 1999)
168-1993	Ready mixed paint, air drying for general purpose. (Reaffirmed 2002)
217-1988	Cut back bitumen (reaffirmed 1999)
218-1983	Creosote and anthracene oil for use as wood preservatives (Reaffirmed 1998)
290-1961	Coal tar black paint. (Reaffirmed – 1996)
337-1975	Varnish, finishing interior. (Reaffirmed – 2001)
339	French Polish
341-1973	Black Japan, types A, B and C (Reaffirmed 2002)
347-1975	Varnish, shellac for general purpose. (Reaffirmed – 2001)
348-1968	French polish. (Reaffirmed – 2001)
349	Cement Paint, colour as required
412	Expanded metal steel sheets for general purposes
419-1967	Putty for use of window frames. (Reaffirmed – 2001)
427-1965	Distemper, dry, colour as required. (Reaffirmed – 1999)
428-2000	Washable distemper
524-1983	Varnish, finishing, exterior, synthetic. (Reaffirmed – 2000)
525-1968	Varnish, finishing, exterior and general purposes. (Reaffirmed – 2001)
533-1998	Gum spirit of turpentine (oil of turpentine) (Reaffirmed 2003)
702	Specification for industrial bitumen
1477	Painting of ferrous metals in buildings
2074	Ready mixed paint, air drying, red oxide-zinc chrome and priming
2095-1996 (Pt. I - III)	Gypsum plasters boards
2096-1992	Asbestos cement flat sheets
2338	Code of practice for finishing of wood and wood based materials – Part1-Operations and workmanship, Part 2-sechedules
2339-1963	Aluminium paint for general purposes, in dual container (Reaffirmed – 1999)
2402	Code of practice for external rendered finishes

IS Code No.	Subject
2395	painting concrete, Masonry & Plaster surfaces
2524	painting of non-Ferrous metals in buildings
2547-1976 (Pt I & II)	Gypsum building plasters (Reaff. 1992)
2932-2003	Enamel synthetic, exterior (a) Under coating (b) Finishing
2933-1975	Enamel, Exterior (a) Under coating (b) Finishing
3036	Code of practice for laying lime concrete for a waterproofed roof finish
3140	painting asbestos Cement Building Products
3536	Specification for ready mixed paint, brushing, wood primer
5410-1992	Cement paint (Reaffirmed 1999)
5411 (Pt.I)-1974	Plastic emulsion paint for interior use. (Reaffirmed – 1993)
6278-1971	Code of practice for whitewashing & colour washing. (Reaffirmed - 1991)
Safety Codes	
818-1968	(Reaf-03) Safety and healthy requirements in Electric and gas welding and cutting operations
1200	(Part III- 3rd Division) – Demolition and Dismantle – 1974
2750	Specification for steel scaffoldings
3696 (Pt I)-1987	Safety code for scaffolds
3696 (Pt II)-1991	Safety code for ladders
3764-1992	Safety code for Excavation works
4130-1991	Safety code for Demolition of Building
5916-1970	Safety code for construction involving use of hot bituminous materials
7293-1974	Working with construction machinery- safety code for
	National Building Code of India – 2005
	Safety Manual, Central Water and Power Commission, Ministry of Irrigation & Power, Govt. of India.

3 MANDATORY TESTS

Notes

Tests as specified and other tests for specialised works or important structures and as required by the Employer's Representative shall be carried out as specified and/or in accordance with the relevant IS.

In case of non-IS materials, it shall be the responsibility of the Contractor to establish the conformity of material with relevant IS and this specification by carrying out necessary tests.

The mandatory tests shall include, but are not limited to, the following:

Table 3-1 Mandatory Tests

Material	Test	Field/Lab	Test Procedure	Minimum quantity of material / Work for carrying out the test	Frequency of Testing
Reinforced Cement Concrete Work					
Water for construction purposes	Ph value, Limits of Acidity, Limits of Alkalinity, Percentage of solids, Chlorides, Suspended matter, Sulphates, Inorganic solids, Organic solids	Lab	IS 3025	Water from each source	Before commencement of work & thereafter: Mandatory – Once in one year from each source; Optional: once in 3 months from each source;
Reinforced Cement Concrete	a) slump test	Field	IS 1199	a) 20 cu.m. for slabs, beams, Rafts, walls and connected columns. b) 5 Cu.m in case of columns	a) 20 cu.m. Part there of or more frequently as required by the Employer's Representative. b) Every 5 Cu.m.
	b) cube test	Lab	IS 516	a) 20 cu.m. In slab, beams, Rafts, walls & connected columns. b) 5 cum in columns	a) every 20 cum of a day's concreting (Ref. as per frequency of sampling). b) Every 5 cum.
Ready mixed cement Concrete (IS-4926)	Cube test	Lab	IS 516 and as per para 6.3.2 of IS- 4926-2003	50 cum	One for every 50cum of production or every 50 batches, whichever is the greater frequency
Note: for all other small items and where RCC done in a day is less than 5 cum, test may be carried out as required by Employer's Representative.					

Material	Test	Field/Lab	Test Procedure	Minimum quantity of material / Work for carrying out the test	Frequency of Testing
Mortars					
Lime	Chemical & physical properties of lime	Lab	IS 6932 (part 1 to x)	5 M.T.	10 M.T. or part there of as decided by the Employer's Representative
Sand					
	Bulking of Sand	Field		20 CU.M	Every 20 cu.m or part there of or more frequently as decided by Employer's Representative
	Silt Content	Field	IS 383	20 CU.M	
	Particle Size and Distribution	Field/Lab as per the requirements of the Employer's Rep.	IS 383	40 CU.M	Every 40 cu.m or part there of or more frequently as decided by Employer's Representative
	Organic Impurities	Field	DO	20 CU.M	Every 20 cu.m or part there of or more frequently as decided by Employer's Representative
	Chloride & Sulphate Content Tests	Field	Optional		1 per 3 months
Cement					
	Fineness (m^2/kg)		IS 4031 (Part-II)	Each fresh lot	Every 50 MT or part thereof
	Normal Consistency		IS 4031 (Part-IV)	Shall be as per codal provision	Shall be as per codal provision
	Setting time (minutes)		IS 4031	Shall be as per codal provision	Shall be as per codal provision

Material	Test	Field/Lab	Test Procedure	Minimum quantity of material / Work for carrying out the test	Frequency of Testing
	a) Initial b) Final		(Part-V)		
	Soundness a) Le-Chat expansion (mm) b) Auto clave(%)		IS 4031 (Part-III)		
	Compressive strength (Mpa) a) 72+/-1 hr b) 168+/-2hr		IS 4031 (Part-VI)		
Stone Aggregate					
	a) Percentage of soft or deleterious materials	General visual inspection/ Lab test where required by the Employer's Rep to IS 2386 Part II		One test for each source	One test for each source
	Particle size distribution	Field/Lab	-	10 cu.m	Every 40 cum. or part thereof and:
		Once in three months for each source for coarse and fine aggregates required in RCC works, for a minimum quantity - 10 cum for coarse aggregate and 40 cum for fine aggregate.			
	a) Estimation of Organic impurities	Field/Lab	IS 2386 Part II	10 cu. m	as above
	b) Specific Gravity Field				
	c) Bulk Density				
	Aggregate crushing strength				

Material	Test	Field/Lab	Test Procedure	Minimum quantity of material / Work for carrying out the test	Frequency of Testing
	Aggregate Impact Value				
Timber					
	Moisture	Field (moisture meter) Lab, as required by ER		1 cum	Every 1 cum or part thereof
Doors					
Flush Door	End immersion test Knife test Adhesion test	Lab	IS 2202 part I & II	26 doors	As per sampling and testing as instructed by the ER
Aluminium door or window fittings	Thickness of anodic coating	Lab	IS 5523	If the cost of fittings exceeds Rs. 20,000/-	Rs. 20,000/- or part thereof as required by the ER
Bricks					
	Testing of bricks / brick tiles for dimensions Compressive strength Water absorption Efflorescence	Lab	IS 3495 Part I to IV	No of bricks to be selected & bricks lot	Permissible defective bricks in the sample
				20:2001-10000	1
				32:10001-35000	2
				50:35001-50000	3
				20: for every addl. 50000 or part thereof	1
				If < 2000, As per decision of the ER	
Steel for RCC					
	Physical Tests	**Lab/Field**		**< 100 tonnes**	**> 100 tonnes**
	Tensile Strength		IS 608	Dia < 10 mm 1 sample per	Dia < 10 mm 1 sample per 40

Material	Test	Field/Lab	Test Procedure	Minimum quantity of material / Work for carrying out the test	Frequency of Testing
	Retest		IS 1786	25 tonnes or part thereof Dia is >10 mm < 16 mm: 1 1 sample per 35 tonnes or part thereof. Dia >16 mm 1 sample per 45 tonnes	tonnes or part thereof Dia is >10 mm <16 mm: 1 1 sample per 45 tonnes or part thereof. Dia >16 mm 1 sample per 50 tonnes
	Rebound Test		IS 1786		
	Nominal Mass		IS 1786		
	Bend Test		IS 1599		
	Elongation Test		IS 1786		
	Proof Test		IS 1786		
	Chemical Tests		IS 786	As per Codal Provision	For every fresh lot of one truck or less as approved by the ER
	Carbon Constituent				
	Sulphur				
	Phosphorus				
	Phosphorus & Sulphur				
Soil Core Test					
	OMC Proctor Density		IS 12175	2 per 50 sqm	As per para 1.10 & 1.11 of IS 12175
Tiles					
Mosaic Tiles			IS 13801 Para 14.6	5000 tiles and more for each manufacturer & thereafter for every 10000 tiles or part thereof.	
Ceramic Tiles				3000 tiles and more for each manufacturer and thereafter for every 3000 tiles or part thereof.	

4 SITE SURVEYS

Topographical Surveys

Where a topographical survey is called for, or is otherwise necessary for the execution of the works, the survey shall establish the following information:

1 Site location relative to existing developments;
2 Location of reference points (temporary benchmarks, etc.) and datum levels for setting out and levelling;
3 Site boundaries;
4 Contoured plan showing existing site levels;
5 Drainage patterns;
6 Features of engineering significance, e.g. unstable ground, vegetation, contaminated lands, previous use for landfill etc.;
7 Means of access to site ; and
8 Positions of utility service mains, pipelines, cables, etc. if any.

Soil Investigations

Reports of sub-surface examinations made by the Employer will be made available to the Contractor on request, including reports of studies, where available, of the normal ground water level fluctuations. This information is being supplied in good faith but any conclusions drawn from them will be at the Contractor's responsibility.

The Contractor shall be wholly responsible for selection, design, construction and performance of any ground improvement measures, foundations for structures and for dealing with any related issues such as differential settlement, water uplift, or contaminated land, etc.

Prior to designing the foundations for structures that will impose a significant load, the Contractor shall carry out a geotechnical survey in sufficient detail to confirm the validity of the existing geotechnical data. The survey shall include boreholes under every structure that will impose a significant load, including:

a. Tidal dry weather flow interceptor;
b. Pumping stations.

Where geotechnical data is unavailable for the area in which a foundation is to be constructed, the Contractor shall carry out a full geotechnical survey and shall establish the following information:

- Sequence, thickness and lateral extent of the soil strata and level of bedrock (if appropriate);
- Soil parameters and soil chemistry, including identification and classification, contamination and toxic substances determined from tests on representative samples of the soils and rock;
- Groundwater conditions, variations and fluctuations; and
- In-situ load bearing capacity of the soil matrix.

Prior to commencing earthworks and foundation works, the Contractor shall submit the geotechnical interpretive report, calculations for earthworks and foundations and a detailed construction method statement and programme relating to this work.

Where off-site materials have to be used on the project, the Contractor shall, if the Employer's Representative so desires, make available certified soil test reports including information regarding sieve analyses, plastic limits, liquid limits, maximum density, optimum moisture contents and the credentials of the testing laboratory. The Contractor shall also submit a testing schedule to ensure uniformity of materials supplied. Certificates, when required, shall be submitted in triplicate.

Survey of Existing Underground Services

The Contractor is wholly responsible for the verification of information regarding existing utilities and their location.

The Contractor shall conduct a detailed survey to accurately define the line location and depth of existing buried pipes, ducts, cables and other services affected by the works and where required update the drawings.

The Contractor shall establish the location and identify the function of all existing services which:

a. Pass under the proposed location or within 1.5 metres of any proposed new structure or extension to an existing structure;
b. Cross the proposed route of any new road, footpath, buried pipe, duct, cable or other service; and
c. Run within 1 metre of the proposed route of any new road, footpath, buried pipe, duct, cable or other service.

Survey of Structures to be Modified or Demolished

Surveys to Establish Strength

The Contractor shall survey each existing structure for which:

a. The structure is to be maintained and incorporated into the new works;
b. The loads to which the structure will be subjected will be increased by more than 10% of the current worst case load conditions; or
c. The structure itself will be modified in such a way as to affect its ability to withstand loads

For each such structure, the Contractor shall measure structural components on site, expose parts of the foundations, examine the materials of construction etc to an extent which, in conjunction with any available drawings and design calculations for the structure, is sufficient for the strength of the structure to be confirmed.

Where drawings for the structure are available, the Contractor shall check the key dimensions on site. The Contractor shall check all existing structural design calculations made available to him prior to using the results of such calculations.

Structural Condition Survey

Prior to modifying any existing structure, the Contractor shall carry out a structural condition survey to establish the extent of any of the following parameters:

- Settlement and differential settlement;
- Corrosion;
- Distortion, abnormal deflections and cracking;
- Damage to and deterioration of surface finishes; and
- Damage to and deterioration of doors, windows etc.

Survey to Identify Hazards

For each structure which is to be modified or demolished under the Contract, in addition to reviewing any available information about the materials used in constructing the structure or which have been handled in the structure, the Contractor shall survey the structure to identify any potentially hazardous materials such as asbestos. Where appropriate, the Contractor shall carry out chemical or other appropriate tests to verify the identity of any materials that it is believed may be hazardous.

The Contractor shall also identify other features, e.g. fragile roofs, flammable materials etc., which could give rise to a hazard during the modification or demolition work.

Setting Out

Setting out and measurement shall comply with the methods and values of accuracy given in ISO 1134: ‘Setting Out Buildings’.

5 RELOCATION, ABANDONMENT AND PROTECTION OF EXISTING UTILITIES, SERVICES AND STRUCTURES

The buried services survey must be reconfirmed by the Contractor with the utility authorities involved. The Contractor is responsible for liaison with the relevant authorities responsible for the utilities, services and structures and establishing the authority's technical requirements and the protocols and planning requirements for their relocation, abandonment and protection and incorporating these requirements into the Contractor's programme.

Unless specifically required by the authority responsible for a particular service, the Contractor is responsible for the relocation (permanent or temporary), abandonment and protection of existing utilities, services and structures required to complete the works.

All utility lines and structures, whether indicated on any drawings or not, which remain in service shall be protected by the Contractor from any damage likely to result from his operations. The Contractor shall be solely responsible for any damage to other utilities as well as any consequential damage/loss as a result of such damage.

The Contractor is responsible for the design of any temporary or permanent works required to temporarily or permanently support or relocate services and structures during the works and demonstrate the adequacy of his designs. Any relocation of services and structures during the works shall be shown on the as-constructed drawings.

Before starting any section of the works, the Contractor shall disconnect or arrange for the disconnection of any utility services designated to be removed, performing such work in accordance with the requirements of the utility company.

The Contractor shall preserve in operational condition any active utilities traversing the site that are designated to remain in operation until the new facilities have been constructed and commissioned.

Where damage is likely to result from his operations, the Contractor shall relocate the utility to the approval of the Employer's Representative and the utility authority.

In the case of any utility whose location or existence is unknown, but which is encountered during the course of the work, the Contractor shall immediately inform the Employer's Representative of such discovery and the Contractor shall either relocate the utility or undertake to have it relocated.

6 DEMOLITION

General

Demolition work includes, but is not limited to, the following tasks:

1) Prior to commencement of the demolition, the Contractor shall carry out all necessary pre-demolition surveys to ensure that demolition will be carried out correctly and safely;
2) Demolition, removal and disposal of existing structures, mechanical and electrical installations, pipelines and other buried structures and services either described in the Employer's Requirements at the project sites, included within the project working areas or not required for future use;
3) The Contractor shall be responsible for determining the proper disposal route for all waste materials arising as a consequence of demolition and for paying all tipping fees and other associated costs;
4) The Contractor shall identify any building materials and take appropriate measures to handle them in a safe manner;
5) The Contractor shall dispose of any hazardous materials off-site in accordance with existing laws and regulations;
6) The Contractor may sell materials to obtain salvage value. However, prior to giving possession of the Site to the Contractor, the Employer may remove any equipment or materials he so chooses;
7) Temporary and/or permanent relocation of existing utilities and other buried services to be retained for future use which are either encountered or affected by demolition works;
8) Temporary and permanent support and protection of existing utilities and other buried services affected by or encountered during demolition works which are to be retained for future use;
9) Temporary and permanent support for existing above ground and buried structures affected by or encountered during demolition works;
10) Filling, backfilling and compaction to grade level further to demolition and removal, leaving the ground in a tidy finished state. The Contractor shall complete, at a minimum, the tasks included in the following paragraphs in the execution of dismantling, demolition and removal of the required items and shall submit a detailed execution and safety plan to the Employer's Representative for inspection prior to commencing his activities; and
11) The Contractor is forbidden to use explosives for blasting purposes.

Existing Services, Utilities and Structures

Work shall be carried out in such a way that no damage is caused to the adjoining utilities, work or property and precautions shall be taken to minimise dust-nuisance.

Temporary Fencing and Hoarding

The Contractor shall erect a fence around the perimeter of the safe working area required for demolition and shall demonstrate to the Employer's Representative that the extent of this area fulfils safety requirements.

The Contractor shall provide hoarding as required and to the satisfaction of the Employer's Representative, to protect all those who may be affected by those works.

Demolition and Reinstatement

The Contractor shall demolish the required structures in accordance with the detailed execution plan submitted to the Employer’s Representative.

Dismantling shall be commenced in a systematic manner. All materials which are to be dismantled at height, such as during the demolishing of roofs, shall be carefully lowered to the ground and not dropped.

The Contractor shall remove and dispose of demolition waste off-site, in accordance with the regulatory requirements.

The Contractor shall backfill excavated areas and voids due to demolition or the removal of materials, immediately. Backfilling and compaction shall be suitable for the final requirements at that location. As a minimum, backfilling shall include compacted hardcore to 300 mm below grade level and granular fill or topsoil to grade as appropriate.

Removal of Debris

Any serviceable material obtained during dismantling or demolition shall be separated out and stacked properly. All unserviceable materials shall be disposed of from the site and the site left in a neat and orderly condition, to the satisfaction of the Employer’s Representative and in accordance with prevailing regulations.

Treatment

All the demolition areas shall be rendered clean of all debris. After the removal of any doors, windows chowkhats, etc. and unless otherwise required, the sides of jambs, sills, soffits, etc. shall be plastered in 1:3 cement mortar with neeru finish to render sides, corners, edges, etc. true and square.

Asbestos Based Materials

Asbestos based materials may be present in buildings to be demolished under this contract.

If any suspected asbestos based materials are discovered during demolition work, this shall be reported immediately to the Employer’s Representative.

Removal of asbestos based materials shall be carried out by a specialist, licensed sub-contractor prior to any other works starting in the location.

7 LANDSCAPING

Clearance of Large Trees, Structures etc.

Clearance of large trees and structures shall include the removal of large trees, stumps and structures or parts thereof lying within the site of the works as demarcated at the site.

Removal of Top Soil

All shrubs, vegetation and other plants shall be removed and cleared from the site and disposed of.

Topsoil shall be carefully stripped and stored at a suitable location on the site, separate from other excavated material. Excess topsoil and topsoil unsuitable for landscaping and grassing shall be removed from the site and disposed of.

All debris and material unsuitable for re-use at the site shall be excavated to a depth of 30 cm shall be removed from the site.

Grading

Areas of exposed soil shall be graded, landscaped and planted to produce a neat and attractive environment not subject to ponding.

Where required, areas shall be refilled to correct grade with selected suitable excavated material from the site, or suitable material imported to the site. The quality and compaction of such fill or embankments shall be in accordance with the requirements of Section 7.

Backfilling and compaction shall be suitable for the final requirements at the given location. As a minimum, backfilling shall include compacted hardcore to 300 mm below grade level and granular fill or topsoil to grade as appropriate.

The Contractor shall, where necessary, refill and compact any existing pits, wells, existing dry-wells or other areas where the levels are below the general finished grade.

Grassing and Landscaping

Landscaping:

1 In addition to topsoiling, landscaping includes the supply, installation, laying-out and stocking of flower beds and rockeries, planting of trees and shrubs and for the seeding or turfing of lawns.
2 All parts of the site not covered by buildings or paving shall, as soon as practicable after the completion of the earthworks, be covered with topsoil and sown with grass, all as specified hereafter.

Top Soiling:

1 As far as practicable topsoil shall be obtained from material generated from excavations and separately stored in temporary spoil tips as approved.
2 If, in the Employer's Representative's opinion the Contractor cannot reasonably obtain sufficient topsoil of acceptable quality in this way, the Contractor shall if so approved by the Employer's Representative provide extra material from an approved source off the site.
3 Topsoil shall be evenly spread and trimmed over embankments and other areas to appropriate slopes and grades. The depth after spreading and trimming shall be 300

mm, measured perpendicular to the surface. All clods and lumps shall be broken up and any rubbish large stones, roofs and weeds shall be removed.

Grassing:

1 Areas to be grassed and which have been covered with 300 mm of topsoil shall be sown with an approved species of grass seed suitable for local conditions.
2 The Contractor shall be responsible for maintaining all landscaped areas including grassed areas, flower beds, rockeries, trees and shrubs in good condition throughout the Contract including all watering, rolling, fertilizing, weeding, cutting and re-sowing as necessary.

Fencing

Mild Steel Posts and Struts

Mild steel posts and struts shall be free from rust, scale, cracks, twists and other defects and shall be fabricated to the required shape and size out of the suitably sized sections. The posts and struts shall have split ends for proper fixing and shall be embedded in cement concrete of mix 1:3:6. The exposed surfaces of the posts and struts shall be painted with two coats of synthetic enamel paint of approved make and shade over a coat of approved primer.

Reinforced Concrete Posts and Struts

Reinforced concrete posts and struts shall be of a standard size and be cast in suitable bases in cement concrete 1:2:4 mix and shall have appropriate reinforcement and dimensions. The posts and struts shall be free from honeycombing, cracks and other defects.

After casting, the posts/struts shall be cured for a minimum period of 7 days without being moved. After 7 days curing the posts/struts shall be moved to a levelled area and stacked for 14 days of further curing. After 21 days of curing, the posts/struts may be transported for fixing in position.

Spacing of the Posts and Struts

Posts shall be installed at 3 m. centres unless otherwise specified or as approved by the Employer’s Representative, to suit the dimensions of the area to be fenced. Every 10th post, last but one end posts, corner posts and posts where the level of fencing changes in steps and end post when the fencing changes its direction shall be strutted on both sides, or as approved by the Employer’s Representative. End posts where barbed wire fencing is discontinued shall be strutted on one side only.

Fixing of Mild Steel/Reinforced Concrete Posts and Struts

Pits of size 45 x 45 x 45 cm. deep, shall first be excavated centrally in the direction of the proposed fencing work, true to line and level to receive the posts. For struts, the pits shall be excavated to receive a minimum of 15 cm concrete cover at any point to suit its inclination.

The pits shall be filled with a 15 cm layer of cement concrete of 1:2:4 mix. The posts and struts shall then be placed in the pits to the required height above ground level and held true to line, plumb and position by providing adequate temporary supports and then filled with cement concrete so that the posts are embedded. The concrete in foundation shall be watered for at least seven days to ensure proper curing.

Barbed Wire

Barbed wire shall conform to IS 278-1978.

Chain Link

The chain link shall be plastic coated galvanised mild steel of approved manufacture and colour and of appropriate size, gauge etc. The base materials of the wire shall be of good commercial quality mild steel. The wire shall be circular in section, free from rust, scale, cuts, welds and other defects and shall be uniformly galvanised.

Fixing of the Chain Link Fencing to Mild Steel/Reinforced Concrete Post

The chain link fencing shall be fixed first to the end post with the approved GI U type clamps threaded at both ends and GI nuts, bolts and washers and with a 6 mm diameter full height galvanised anchor bar. After fixing the chain link at the end post, it shall be stretched tightly and fixed to the next posts sequentially using the clamps and bars etc leaving 50 mm ground clearance, if soil, or 20 mm if surfaced. At points of change in the level of the fencing, the necessary links shall be adjusted suitably as per the manufacturers' recommendations.

Mild Steel Crimpnet Gate

All steel work, pipe frame work and crimpnet shall be galvanised and of suitable sizes and sections and shall conform to relevant IS specifications. The crimpnet shall be minimum 25 x 25 mm x 8 g unless otherwise stated and of approved manufacturer.

For each leaf of the gate, the crimpnet shall be welded to an internal angle iron frame of suitable size. The iron frame shall then be fixed to the 50 mm dia seamless pipe outer frame of by means of 65 mm long angle iron lugs welded together. Suitable cleats for the locking arrangement shall be welded at a convenient height. Both the leaves of the gates shall be fitted with suitable hinges provided on the galvanised mild steel channel posts. The side post shall be welded with mild steel plates 250 x 150 x 5 mm at the bottom. These posts shall be properly embedded in cement concrete foundations of suitable sizes and be allowed to set properly. All the assembly shall be properly erected correct to line, level, plumb and allow easy and proper movement of the gates.

The steel parts shall be thoroughly cleaned and painted with red oxide primer of approved make and shade. Final painting with two coats of synthetic enamel paints of approved shade and make shall be carried out to the approval of the Employer's Representative.

8 EARTHWORK AND EXCAVATION

Site Clearance

Before the earthwork is started, the areas coming under cutting and filling shall be cleared of all obstructions, loose stones, shrubs, vegetation, grass, brush-wood, trees and saplings of a girth up to 30 cm. measured at a height of one metre above ground and rubbish removed from of the area under clearance. The roots of trees shall be removed to a minimum depth of 60 cm below ground level, or a minimum of 30 cm below formation level whichever is lower and the hollows filled up with compacted earth.

The trees with a girth above 30 cm at a height of one metre above ground shall only be cut after permission of the Employer's Representative is obtained in writing.

Any useful materials obtained from the site will remain the property of the Employer and shall be properly protected and stored. The Contractor shall dispose of other materials off site.

Setting Out and Making Profiles

The Contractor shall erect masonry or concrete pillars at suitable points in the area to serve as bench marks for the execution of the work. These bench marks shall be connected with GTS or any other permanent bench mark approved by the Employer's Representative. Necessary profiles with pegs, bamboos and strings shall be made to show the correct formation levels before the work is started.

Excavation

Excavations shall be prepared with shallow side slopes to minimise the risk of slope failure. Where this is not possible and the depth exceeds 0.6m then the trench slopes must be stabilised. Prior to man entry into the excavation the Contractor must ensure the excavation is stable. Further checks should be made following periods of rainfall or when excessive loadings occur within close proximity to the excavation.

No excavated material shall be placed, even temporarily, nearer than three metres to the outer edge of an excavation.

The removal of obstructions that would interfere with the proper execution and completion of the work shall conform to the correct lines and grades or be limited generally to 60 cm beyond the outer limit of the structure. It shall be the Contractor's responsibility to provide all required pumping, ditching or other approved measures for the removal or exclusion of water from excavations.

The Contractor shall notify the Employer's Representative before any ground is disturbed and shall conduct a ground level survey. The ground levels shall be taken at 5 to 15 metres intervals in uniformly sloping ground and at closer distances where local mounds, pits or undulations occur. The ground levels shall be recorded in field books and plotted on plans, which shall be signed by the Contractor and the Employer's Representative, before the earth work commences.

When excavating to the required levels for the foundation of any structure or to the required limits for the face of any structure abutting undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing the constructional work. Should the Contractor have excavated to within 150mm above these specified levels or to within 150 mm of these specified limits before he is ready or able to commence the construction work, he shall excavate further to remove not less than 150mm of material immediately before commencing the construction work.

The excavations shall be carried out systematically. No under-pining or undercutting will be allowed. The bottom and sides of excavation shall be dressed to proper levels, slopes, steps, cambers etc. by removing high spots and filling and thoroughly as necessary.

The width of excavations shall generally be of the width of the mudmat concrete and depth as required by the design and according to availability of the desired bearing capacity of soil below. The minimum depth of foundations for all structures, equipment, buildings and frame foundations and load bearing walls shall be 1.50 m below average ground level, whether the foundation is in soil or in murrum. For any excavation, if taken below the required depth and level, the Contractor shall fill such over-cut to the specified level with 1:4:8 cement concrete in the case of all types of soils and with 1:2:4 cement concrete in the case of soft or hard rock.

The Contractor shall provide adequate ventilation and efficient apparatus to keep all excavation trenches, tunnels and heading structures, sewers and manholes free from all noxious gases and he shall take precautions to ascertain that they are in a safe condition before allowing workmen to proceed.

After the excavation is completed, the Contractor shall notify the Employer's Representative to that effect and no further work shall be taken up until the Employer's Representative has approved the depth and dimensions and also the nature of the foundation material. Levels and measurements of the excavation shall also be recorded prior to taking up any further work.

Classification of Earthwork

The earthwork shall be classified under the following main categories:

1 All types of Soils, Murrum, Boulders.
2 Soft Rock.
3 Hard Rock.

All types of Soils, Murrum, Boulders

This includes earth, murrum, top deposits of agricultural soil, reclaimed soil, clay, sand or any combination thereof and soft and hard murrum, shingle etc. which is loose enough to be removed with spades, shovels and pick axes. Boulders of not more than 0.03 m^3 in volume found during the course of excavation shall also fall under this classification.

Excavation in Soft Rock

This shall include all materials which are rock or hard conglomerate, all decomposed weathered rock, highly fissured rock, old masonry, boulders bigger than 0.03 m^3 in volume but not bigger than 0.5 m^3 and other varieties of soft rock which can be removed only with pick axes, crow bars, wedges and hammers with some difficulty.

Excavation in Hard Rock

This includes all rock other than that stated in Sections 8.4.1 and 8.4.2, occurring in masses, boulders having approximate volume of more than 0.5 m^3 plain or reinforced cement concrete, which can best be removed by chiselling and wedging.

The excavation of hard rock shall be done by chiselling and wedging or any other agreed method. Blasting shall not be allowed on this project.

All the excavated hard rock obtained shall be stacked properly and neatly by the Contractor as approved by the Employer's Representative.

Excavation Side Slopes

Loose soil or boulders shall be removed from the sides of the trenches before workmen shall be allowed into the excavation and the trench sides shall be stabilized with screening or other methods approved by the Employer's Representative.

Undercutting of Adjacent Works

In no case shall the Contractor undercut the foundations of adjacent facilities. Should such a situation be envisaged or develop the Contractor shall provide protection measures as necessary to ensure the safety of the adjacent facility.

The Employer's Representative shall be given every opportunity to review the methods adopted by the Contractor and where he requires, Contractor shall satisfy the Employer's Representative of the adequacy of the methods employed.

Shoring

The Contractor shall be responsible for the design of shoring for the proper retaining of the sides of trenches, pits etc. with due consideration to any traffic or other superimposed loads. Shoring shall be of sufficient strength to resist the pressure and ensure safety from slips and to prevent damage to work and property and injury to persons. Any shoring shall be removed after the items for which it is required are completed. Should slips occur, the slipped material shall be removed and slope dressed to a modified stable slope.

Trench Excavation

The Contractor shall not keep trenches open for unduly long periods, creating public hazards, such that laying and jointing of pipes can reasonably be expected to be completed and the trench refilled not later than three days after excavation of the trench, except by special permission of the Employer's Representative.

Loose soil or boulders shall be removed from the sides of the trenches before workmen shall be allowed into the excavation and the trench sides shall be stabilized with screening or other methods approved by the Employer's Representative.

Excavation for pipe trenches in hard rock shall be carried out so that the clearance between the pipe, when laid in position and the sides and trench bottom shall be kept to the minimum limits necessary to provide for the thickness of bedding and surround to the pipe.

The minimum width of trenches measured at the crown of the pipe shall permit adequate working space. The trenches may be widened at sockets and other structures as may be necessary.

Care should be taken to avoid excessive trench widths and thereby increasing the load on the pipes. Where this is the case the Contractor shall provide either special bedding or stronger pipes.

Over-excavation of Trench Bottoms:

1 All pipeline trenches shall be excavated to a depth of 150 mm below the bottom of the outside of the pipe and backfilled with the appropriate bedding.
2 All excavation below the required level shall be refilled with compacted bedding material.

Trenchless Excavation

General

The Contractor shall submit his proposals for excavating and constructing sewers and pipe lines in tunnel and obtain the approval of the Employer's Representative before any work may commence.

The Contractor shall be responsible for the security of any timbering or other temporary tunnel supports. The Contractor shall submit for approval full details of the support and timbering he proposes to use.

The excavation for the tunnel shall be of sufficient size for the proper execution of the construction work, all timbering must be driven and fixed in close contact with the ground to be supported.

Unless otherwise approved by the Employer's Representative, the tunnel shall be closed timbered and the timber shall be left in place on completion of the work. During excavation, securely fixed running boards shall be provided to the floor of the tunnel. On completion and after the formation has been cleaned and dried out, a concrete sealing coat shall be provided. The tunnel shall be driven complete between access points before the permanent work may commence and the work shall, at all times, be carried out as quickly as possible so that the excavation remains open for the shortest possible time.

The working face of the tunnel excavation shall be supported as necessary and shall be fixed up at the end of each point when continuous working is not in progress or whenever required by the Employer's Representative.

When work is in progress, proper access ladders shall be fixed and maintained at the tunnel access points and the tunnel lit by electricity of not more than 110 volts. Lamps shall be provided at not more than 9 m intervals and no flame or other naked light shall be used. Proper and adequate ventilation fans and ducts must be provided, maintained and operated at all times.

Method for Trenchless Excavation

i) General

The Contractor is required to take full cognisance of the physical site condition and available working space and select his method with due regard to the same in addition to other requirements for the method proposed.

There is a high likelihood of heavy seepage of water into the excavation.

If required, the Contractor may use sleeve pipes of a bigger diameter than necessary and lay the carrier pipe inside the sleeve pipe at the required grade and alignment.

The Contractor shall take into account the existing manholes to which the proposed pipeline is to be connected and take every precaution to avoid damage to the manholes and any existing sewers.

Where a connection is to be made to a functioning trunk sewer, the Contractor shall take all necessary steps for plugging the sewer and diverting the flows and restoration of the same after completion of the work.

ii) Jacking and Receiving Shafts

The Contractor shall take due cognisance of the available working space and provide jacking and receiving shafts at appropriate locations so not to cause any harm or danger to adjoining structures, as well as to not occupy additional space.

The Contractor must shore the sides of shafts securely as approved by the Employer's Representative.

iii) Jacking/Boring/Ramming

The jacking pipe and or carrier pipe should be of suitable length joined by properly designed leak proof joints as required for the method adopted by the Contractor.

The jacking pipe may be provided with arrangements for circulating bentonite solution for stabilization of the surrounding ground.

The grade and alignment of jacking shall be periodically checked by suitable instruments after jacking of individual units and correct grade and level will have to be ensured.

If the jacking pipe is other than the carrier pipe, the annular space shall be grouted with 1:3 cement sand grout.

iv) Tolerance

The pipes shall be installed in place, true to line and level. The maximum tolerance allowable in the displacement of the centreline of the laid pipe from the design centreline is 50 mm per 30 metres in the horizontal plane and 50 mm per 100 metres in the vertical plane. There shall be no back fall at any point.

Dewatering

The Tenderer shall keep excavations clear of water.

Clean Up

Upon completion of the work in this section, all rubbish and debris shall be removed from the site. All construction equipment and implements shall be removed and the entire area shall be left in a neat, clean and acceptable condition.

Disposal of Excavated Material

Materials suitable for re-use obtained from the excavation shall be properly stored, as approved by the Employer's Representative, and shall remain the property of the Employer.

Materials shall be stored in a convenient place that will not obstruct the free movement of materials, workers and vehicles or encroach on the area required for constructional purposes. Materials shall be used to the extent required to completely backfill excavations to the finished ground level.

Surplus and unsuitable materials shall be disposed of off-site.

Surface Reinstatement

Surface Reinstatement Outside Roads and Footpaths

In areas outside roads and footpaths, after backfilling trenches, the Contractor shall replace all top soil previously removed, spreading it evenly over the full stripped area. Areas grassed before commencement of work shall be suitably prepared and sown with grass seed of equivalent quality and maintained.

Road and Footpath Reinstatement

i) Unclassified Roads

Backfilling shall be carried out in accordance with this specification to within 300 mm of the finished ground level. The last 300 mm shall be backfilled with material, approved by the Employer's Representative, and which shall, as far as practicable, match the existing surface both in quality and level.

ii) Macadamised and Premixed Roads

Backfill, compaction and finishing of macadamised and premixed roads shall be reinstated in accordance with Section 7 of this specification. The finished surface shall match the undamaged sections in quality and level.

9 EXCAVATION DEWATERING

General

Continuous operation of dewatering systems shall be required to complete all portions of the works where dewatering is necessary to prevent inflow and collection of surface water or groundwater, or to protect adjacent properties or constructions from damage resulting from a rise or fall in groundwater levels.

Dewatering systems shall effectively intercept and remove water from the strata and thus enable the excavations to be kept dry when necessary.

The Contractors shall provide and operate all pumps, engines and machinery necessary to keep excavations clear of water. The pumping shall be continued until after the execution of any portion of the work and continued afterwards as necessary.

Where ground water is encountered or anticipated the Contractor shall provide sufficient pumps to handle the ingress of water and shall provide, and maintain in working order, standby pumping units to be available and employed in the event of mechanical failure. The Contractor shall also arrange for night and day management and operation of the pumps as necessary to ensure that at all times and weather the works may proceed.

The Contractor shall furnish for the Employer’s Representative review, the proposed drawings and method statements giving the intended plan for dewatering and re-charging operations. These should include locations and capacities of dewatering wells, well point, pumps, sumps, collection and discharge lines, standby units, recharge system (if any), water disposal methods, monitoring and settlement, measuring equipment and data collection.

Components of Dewatering Systems

Units of standard manufacture and in good working order shall be used. Unserviceable equipment shall be removed from the site. Major items of equipment for which spare parts are not available from local suppliers shall not be used. Adequate arrangements shall be made for the provision of under drain systems below grade slabs to give relief from hydrostatic pressure during construction activities.

Execution

Preparation

Coordination: The dewatering installation shall be laid out and installed outside the limits of the permanent works, without interfering with access or other activities.

Barricades, Shelters and Safety: Vital sections of the works shall be protected from accidental damage and barricades and suitable prominent signs shall be provided to indicate and where necessary, isolate hazardous areas.

Performance

Dewatering arrangements shall be adequate to enable underground and below-grade work to be performed in the dry except where sections of the work have been specified to be done in the wet. Dewatering shall, wherever required or approved, be continuous from commencement to completion, including placing and compaction of back-fill.

When and where approved by the Employer’s Representative, the Contractor shall provide an approved monitoring system to measure groundwater levels and settlement.

Maintenance of Existing Water Table

Where deep pits and heavy, continuous dewatering have to be maintained for long periods in developed areas, the possible effects of groundwater depletion beyond the range of usual fluctuations shall be given due consideration before commencement. Special methods shall be adopted, as necessary, to avoid such dangers. Any observations or complaints of subsidence in the vicinity shall be promptly brought to the notice of the Employer’s Representative and corrective measures adopted immediately.

Protection of Existing facilities

Adequate standby units and spares shall be provided by the Contractor to ensure uninterrupted dewatering. Where any sloped excavation potentially endangers any existing facilities or structures, the Contractor shall provide shoring, sheeting and bracing to the satisfaction of the Employer’s Representative.

Drainage

During the entire course of operations at any site, the Contractor shall provide and maintain an effective drainage system to prevent inundation of the site. The effluent from the drainage system shall be disposed of as approved by the Employer’s Representative.

Grading in the vicinity of excavations shall be such as to exclude rain/surface water from draining into the excavations. The excavation shall be kept clear of rain or such other water by suitably pumping out.

Care shall be taken to ensure that the water is discharged sufficiently away from existing foundations to keep it free from nuisance to other works.

Removal

When no longer needed for dewatering or control operations, the equipment used for such purposes shall be removed from the site. This shall be done after monitoring and settlement measuring operations, if any, are completed and the removal of the equipment is approved. Any underground components such as well-points may be abandoned in place only to the extent of the approval of the Employer’s Representative.

The Contractor shall not allow any accumulation of water either from the discharge of their dewatering pumps or their water connections on the site. If an accumulation is unavoidable, it shall be treated with insecticides to the satisfaction of the Employer’s Representative.

10 GROUND IMPROVEMENT BY VERTICAL DRAINS

General

Ground treatment works may be necessary to improve founding conditions for structures or areas of the site where piling is not required, but where the subsoil is predicted to undergo unacceptable consolidation settlement under loading. Installation of vertical drains in combination with surcharging is considered to be a suitable solution. Specific requirements for this ground improvement method are presented below. Use of alternative ground improvement methods may only be made with the prior approval of the Employer's Representative.

The Contractor shall carry out the detailed design of any ground improvement works in accordance with the Contract Conditions and Employer's Requirements, and shall determine the degree of ground improvement, optimum arrangement of vertical wick drains, and surcharging requirements in order to sufficiently improve the ground conditions. Additionally, an instrumentation programme shall be developed to demonstrate achievement of the required improvement.

At least 21 days before the Contractor intends to commence instrumentation installation ahead of the ground treatment works on the Site, the Contractor shall submit for the Employer's Representative's approval a Method Statement containing full details of his proposed ground improvement and monitoring works. No ground improvement or monitoring works shall commence on the Site until the Employer's Representative's approval to the Contractor's proposal has been received.

Notwithstanding the requirements outlined in this section, the ground improvement design shall be entirely the Contractor's responsibility.

Qualifications of Specialist Contractors

It is envisaged that the ground improvement works and the instrumentation monitoring works will be conducted by Subcontractors. The ground improvement Contractor and the instrumentation Contractor shall be experienced in installation work comparable to that proposed. The Contractor shall submit the Subcontractor's experience records to the Employer's Representative for approval as part of the ground improvement works Method Statement.

Working Platform

The Contractor shall provide and maintain a working platform of suitable material capable of supporting the placement equipment to allow proper installation of the drains, and subsequent placement of surcharge material.

The working platform material is not to be compacted to a degree that would preclude cone penetration testing or preclude band drains to be installed.

The Contractor shall be responsible for ensuring there is suitable drainage so as to prevent ponding of water over the working platform.

Fill materials for the working platform shall conform with the earthwork materials specifications in Clause 10.8.

Vertical Drains

Approved Products

Wick drains shall be Mebradrain MD7007 vertical prefabricated wick drains or similar accepted by the Employer's Representative.

General

The drain shall be sufficiently flexible to cope with the anticipated settlement of the soil while maintaining continuity and without offering any significant support to the ground. The drain material shall be inert and the drain shall retain its properties throughout the required period of consolidation.

The drain shall be flexible, capable of being wound without damage on a drum of 300 mm minimum diameter, and strong enough so as not to break tear or lose its drainage properties during installation.

The drain shall offer the minimum resistance to the passage of water from the surrounding soil without loss of fines from that soil.

The drain shall be capable of transmitting water along its length without significant resistance to flow and shall retain its required discharge capacity at the maximum required working depth.

Vertical drains shall be installed through the full depth of Marine Clay, and shall be cut off at the level of the working platform.

Tolerances

All drains shall be located within 100 mm of their proposed plan position.

The drains shall not deviate by more than 1 in 50 from the vertical. If required in order to achieve acceptable verticality the Contractor shall locally level the working platform prior to drain installation.

Core

The core shall be a continuous plastic material with grooved channels, a pattern of protruding studs, or mesh-type materials fabricated to promote drainage along the axis of the vertical drain.

Jacket

The jacket shall:

- be a synthetic, non-woven geotextile capable of resisting all bending, punching and tensile forces imposed during installation;
- not crack, peel or otherwise become damaged during installation;
- be sufficiently rigid when embedded to withstand lateral earth pressures and to ensure vertical flow capacity through the core; and
- allow free passage of pore water to the core without passage of soil material or piping.

The Contractor shall provide independent test data proving the jacket material conforms to the following requirements:

	Requirement	
Test	**Specification**	**Minimum Value**
Grab Tensile	ASTM D 4632	355 N
Trapezoidal Tear	ASTM D 4533	110 N
Puncture Strength	ASTM D 4833	220 N
Burst Strength	ODOT TM 814	900 kPa
Permeability	ASTM D 4491	0.05 mm/s
Pore size, O95	ASDM D4751	90µm (maximum)

Assembled Drain

The assembled drain shall:

- be resistant against wet rot, mildew, bacterial action, insects, salts, acids, alkalis, solvents and any other significant ingredients in the groundwater;
- be band-shaped with an aspect ratio (width divided by thickness) not exceeding 50;
- have a minimum tensile strength of 2kN; and
- have a minimum equivalent diameter of 50 mm (2 inches) using the following definition of equivalent diameter:

$$d = \frac{(a+b)}{W_2}$$

dW = diameter of a circular drain equivalent to the band shaped drain a = width of the band shaped drain

b = thickness of the band shaped drain

Splicing

Wick drain material may be spliced by stapling to ensure structural and hydraulic continuity of the drain. The jacket and core shall be overlapped a minimum of 150 mm at the splice.

Splicing shall only be permitted at the beginning and end of a manufacturer’s roll of band drain material. A maximum of one splice per drain installed is permitted.

Shipment, Transportation and Storage

The transportation, site storage and handling of prefabricated drains shall be in accordance with the manufacturer’s instructions. The drain shall be protected from harmful substances and environments, including sunlight, mud, dirt, dust and debris.

Each shipment of drain materials shall be accompanied by the manufacturer's Quality Control Certificate.

Each shipment of drain materials shall be identifiable with labels or tags that include the manufacturer's name, lot or control number, individual roll number and date of manufacture.

Equipment Requirements

The installation equipment and its operation shall be such as to minimize disturbance of the treated ground.

Drains shall be installed using a mandrel or sleeve that:

- Has a maximum cross-sectional area of 6,400 mm^2;
- Is sufficiently stiff to prevent wobble or deflection during use;
- Protects the drain material from tears, cuts and abrasion during installation; and
- Has an anchor shoe or similar arrangement at the bottom to prevent soil from entering the drain during its installation, and to anchor the drain tip at the required depth at the time of withdrawal. Anchors shall conform to the dimensions of the mandrel or sleeve.

Where used, the anchor shoe shall be of the minimum size capable of holding the drain in place at the required depth as the mandrel is withdrawn.

Instrumentation

Equipment instrumentation shall be provided to allow continuous monitoring and recording of data throughout the wick drain installation process.

As a minimum, the following shall be recorded versus level:

- Top and bottom levels of each drain;
- Ground level at installation;
- Verticality; and
- Installation driving force against level.

The Contractor shall provide details of the proposed installation and instrumentation equipment and plant to the Employer’s Representative for acceptance in the Method Statement.

Reporting of the installation process shall be in accordance with Clause 18.10.

Pre-drilling

Where pre-drilling is required to enable the Contractor’s placement apparatus to penetrate the ground, the pre-drilling unit shall be capable of pre-drilling the ground for the placement apparatus so that the latter may place the drain to the specified depth without damaging either the drain or the drain installation equipment.

The Contractor may use augering or alternative methods accepted by the Employer’s Representative to loosen the soil and remove any obstruction material before installing wick drains. Such predrilling shall not penetrate more than 0.6 metres into the underlying compressible soil.

If augering, the minimum outside diameter of the auger shall be equal to the largest horizontal dimension of the mandrel, sleeve, shoe or anchor, whichever is greatest. The maximum outside diameter of the auger shall not be more than 75 mm greater than the minimum outside diameter.

Water

The use of water to assist in the drain installation process shall be subject to the approval of the Employer’s Representative. Where used, the water used for drain installation purposes shall not have a deleterious effect on the performance of the drainage system.

Drainage

The Contractor shall ensure that water is free to drain away from the tops of the vertical drains, by means of providing a drainage layer or similar, to the approval of the Employer's Representative. The Contractor shall also provide a means by which the drained water shall then be drained or channelled away, and this means shall designed to prevent pooling of water on the Site.

Surcharging

Materials

Any materials used as part of the surcharging shall be subject to the acceptance of the Employer's Representative. Materials Data sheets for each material shall be submitted to the Employer's Representative for acceptance in the Contractor's Method Statement.

Fill materials for the surcharge material shall conform with the general Earthworks Specification and the additional requirements of Clause 11.8.

Equipment requirements

The installation equipment and its operation shall be such as to minimize disturbance of the treated ground.

The Contractor shall provide details of the proposed surcharging equipment and plant to the Employer's Representative for acceptance in the Method Statement.

Records

Reporting of the installation process shall be in accordance with Clause 11.10.

Earthwork materials

Fill materials shall comply and be placed and compacted in accordance with the requirements of the UK Highways Agency Specification for Highway Works, Series 600, Earthworks.

The types of materials that are acceptable for general fill, drainage and for surcharging the various areas of the site are set out on the Contract Drawings.

The frequency and type of testing of the materials shall comply with the requirements in the table below. This testing regime is in addition to requirements outlined in the Earthwork Specification:

Test	Frequency of Testing
Optimum mc (2.5 kg rammer/vibrating hammer method)	One set of six tests for each class or sub-class of material and each source of material.
Field dry density, bulk density and moisture content	1 per 5,000m^3

The use of in-situ nuclear density testing shall only be used following calibration by sand replacement testing and acceptance by the Employer's Representative. Where there is uncertainty over the in-situ density results from a nuclear density meter, sand replacement testing shall be undertaken.

Instrumentation of Ground Improvement Area

General

Large ground movements are anticipated as a result of surcharging. Following vertical drain installation, settlement plates and vibrating wire piezometers shall be installed to record the ground movements and pore pressures associated with the subsequent loading and surcharging.

The objectives of monitoring are:

- To determine any existing background movements;
- To verify the design assumptions;
- To record the ground movements generated as a result of surcharge loading. In particular to record the development of settlement with time; and
- To record the pore pressures in the Marine Clay to assist in the assessment of the progress of the dissipation of these pore pressures with time.

Settlement Plates

The surface monitoring system shall comprise Settlement Monitoring Plates to be read manually.

The plates are to be installed close to initial surface and shall have a riser pipe. Connections to the plate are to be extended as filling operations take place. Settlement shall be calculated by precise levelling of the top of the riser pipe.

Installation of the settlement plates shall be as follows:

- Excavate a pit 300 mm deep with a level bottom.
- Place the plate in the pit with one section of riser 1 m in length attached.
- Ensure the plate has full bearing and the riser pipe is plumb before proceeding.
- A 150 mm diameter PVC pipe shall be placed around the riser pipe and the plate backfilled in maximum of 300 mm layers.

Settlement plate riser pipes shall be capable of extension, vertically, in screw-fit 1 m sections to suit backfilling operations. The extension pipes should be screwed in securely before being backfilled. The surrounding PVC sleeve shall be extended at the same time.

The plates and risers shall be installed at locations so as not to interfere with the vertical drains, and shall be installed before any filling to raise ground levels has been undertaken.

Plates shall be installed at a density of 1 plate/0.5 hectare.

Vibrating Wire Piezometers

The following clause relates to vibrating wire piezometers. The Contractor may propose an alternative type of piezometer installation, but the use of this alternative shall be subject to the approval of the Employer’s Representative.

The piezometers shall be installed at 10 No. locations, and are to be located between five and ten meters from respective settlement plates. The pressure sensing devices should be installed at approximately mid depth of the Marine Clay. The precise locations and depths shall be to the approval of the Employer’s Representative.

The pressure sensing device shall consist of an electrical transducer/transmitter. The transducer is to be absolute reading. The zero and stability of the pressure sensing device shall be not greater than 0.1 per cent per annum in the operating environment.

Interfacing and recording equipment shall be compatible with this requirement. The instruments shall be suitable for measuring a range of -10m to +50m head of water.

The instrument and associated equipment shall include the following primary components:

- Piezometer filters shall consist of a porous ceramic or other suitable element not less than 100 mm long with a diameter not less than 40 mm. The piezometer tips shall be of the high air entry resistance type with an average pore diameter of one micron, have an air entry value of approximately 1 atmosphere and a permeability of the order of 2 x 10-8 m/sec;
- Instrument cabinet readout equipment shall consist of transducer readout systems. Each system shall include a terminal panel and transducer unit to be read by a common portable digital readout unit. The combined accuracy of instrument and readout device shall be within +/- 1.0% of the true pressure. The instrument shall be capable of measuring pressures up to 15 bars;
- Leads from the piezometers shall terminate in remote terminal boxes to which a portable remote readout unit can be attached;
- Cabling shall be to the acceptance of the Employer's Representative, and shall be durable and suitable for the proposed locations. Cabling shall be supplied in lengths such that jointing is reduced to a minimum;
- The tip of each piezometer shall be air free and the porous stone of the tip shall be fully saturated by submergence in clean de-aired water for a period of at least 24 hours prior to installation. Complete de-airing of the porous stone shall be confirmed by periodic weighing;
- All piezometers shall be tested before installation by submergence at a series of depths appropriate to the anticipated pressure range of operation in still clean water to verify the calibration and accuracy of the instrument;
- Each piezometer shall be installed in a 100 mm diameter borehole. The complete installation shall be carried out as soon as practicable after drilling, so as to minimise the amount of deterioration or alteration of the ground at the location of the piezometer tip;
- Drilling to the required depth shall be carried out using percussive or rotary wash methods, but without the use of air-flush or drilling mud in the vicinity of the tip position. Casings, if used to maintain the hole open, shall be withdrawn carefully so as not to damage the instruments or cables, and concurrently with the progress of the backfilling;
- The hole shall then be flushed clean and partly filled with clean water, and a minimum of 250 mm depth of medium sand placed at the base by flushing using clean water and a tremie pipe. The piezometer tip shall be lowered using placing rods onto the sand, and more sand added by flushing through a tremie pipe to surround and cover the instrument to a minimum depth of 250 mm;
- Prior to installation of the sand filter surround, the borehole shall be flushed with clean water.
- The sand filter surround to the porous element shall consist of uniformly graded clean sand in the size range 500-1,200 microns. A sample of the proposed sand shall be submitted to the Employer's Representative for acceptance prior to the installation of any of the piezometers. The sand shall be carefully placed using a tremie tube and clean water in such a way as to minimise air entry into the sand;

- The sand filter shall be raised to the required level and the piezometer tip lowered into position and centralised. Piezometer readings shall be taken and the borehole water level dipped at 2m intervals as the instrument is lowered down the borehole. Confirmation of the correct operation of the piezometer shall be obtained prior to proceeding with the installation. The remaining sand shall then be tremied into position. Placing of the seal above the filter shall not be commenced until measurements to the upper surface show that the correct level has been reached and that all of the sand has settled. The final elevation of this sand and the volume of sand placed shall be recorded; and
- A 1 metre bentonite seal shall be placed above the sand filter. Bentonite mixed with sufficient clean water to form a cohesive paste shall be formed into balls of size 10-15 mm. These balls shall be placed in the hole and tamped with a suitable shaped tamper to form a homogeneous seal without voids between adjacent balls. The top level of the seal and the volume of bentonite placed shall be recorded
- The borehole shall be grouted to the top of the hole, to the final excavation level or next instrument location. The levels of all interfaces and the volumes of material placed shall be recorded. Temporary borehole casing shall be withdrawn in stages as the backfilling proceeds. The stiffness of grout should be similar to the in-situ material.

Accurate records of the depths of the piezometers, sand surrounds and seals shall be kept, and readings shall be recorded at each stage of the installation.

Records shall be kept of all calibration certificates. Copies of all certification shall be held on site.

All instruments, including readout boxes and data loggers, shall be maintained in a satisfactory working order for the duration of the monitoring programme.

General Provisions

All equipment and installation accessories shall be securely stored prior to installation where they will not suffer physical damage or damage arising from excessive moisture, extremes of temperature or any adverse conditions.

All instruments and measuring devices shall be manufactured by companies with proven experience in the field of geotechnical or survey instrumentation, as appropriate. All materials, designs and construction shall be of the highest quality to provide robust, corrosion and vibration resistant instruments. All instrumentation shall have a satisfactory proven working life and be new at the time of installation/contract commencement. The accuracy and dependability of the equipment shall not be significantly affected by changes in temperature, humidity, stray currents or contaminants that may be encountered.

The Contractor shall install and test the instrumentation in accordance with the manufacturer’s instructions and the Quality Assurance requirements. Testing shall be undertaken as necessary to ensure satisfactory functioning of the instrumentation at each stage of the installation. Instrumentation found to be malfunctioning at any time shall be replaced at the earliest opportunity, but in any case no later than 48 hours from the time of the fault being identified.

All instruments shall be operated in accordance with the manufacturer’s instructions.

All instruments and settlement markers shall be protected by high visibility stakes or similar measures to protect them from damage by construction vehicles. The main construction plant shall not be operated within 3m of the instruments. The fill immediately around the instruments shall be compacted by a hand-operated plate compactor to avoid damage to the instruments.

Instrumentation Reading and Records

A logical reference system for all the instrumentation equipment shall be established prior to installation, so that records for any particular location can easily be recovered for interpretation or review.

The instrumentation Contractor should satisfy himself that suitable provisions have been made for instrument installation, prior to commencement of installations.

Logger Stations

If the Contractor proposes to use automatic data collection systems, details of these systems and the associated logger stations shall be submitted to the Employer's Representative for approval.

Instrumentation Personnel

Readings shall be taken by the same personnel to maintain consistency. If personnel need to be replaced for any reason, a series of three duplicate readings shall be carried out by both the outgoing person and their replacement.

Datums/Benchmarks

Datums shall consist of stable points embedded in the underlying weathered rock. The deep datums shall not be susceptible to ground movements associated with the pre-loading construction activities or subsequent ground settlement.

A minimum of three deep datums are to be provided.

The datums are to consist of a pipe or rod, anchored at depth, surrounded by and disconnected from a sleeve pipe. The sleeve pipe is to protect the inner pipe or rod from drag caused by soil movement. The anchor may be mechanical or hydraulic and grouted into the bedrock. Spacers are to be used to ensure the inner rod is maintained within the centre of the outer sleeve pipe.

In the event of a benchmark datum apparently moving more than a total of 1 mm an additional level survey shall immediately be carried out to determine the correct value.

Monitoring Frequency

The frequency of monitoring for the instrumentation shall be as follows:

Period	Minimum Monitoring Frequency	
	Settlement Plates	Vibrating Wire Piezometers
4 weeks prior to placement of any fill material	Weekly	Weekly
During placement of fill	Twice weekly	Daily
Up to 2 months following the placement of fill	Weekly	Weekly
After 2 months following placement of fill until end of surcharging	Fortnightly	Fortnightly

Site Records and Reports

All site records and reports shall comply with the following requirements whether submitted electronically or in hardcopy.

The Contractor shall keep daily records of the improvement work and associated monitoring carried out and shall submit a copy of these records to the Employer's Representative within two working days.

During the monitoring period the records shall show:

- Day, month, year, time of the beginning and end of the work shift; names of all workers' (associated with each item of plant); and a summary of equipment used during the shift;
- Time of beginning and completion of each drain installed during the work shift;
- Coordinates, top and bottom level, depth, unique reference number and installation information for each drain;
- Coordinates, levels and records of materials used sufficient to fully record surcharging operations;
- Obstructions encountered;
- Summary of any unproductive time, including start and end time, duration, and reason;
- Number and type of test carried out;
- Details of changes to fill level, including surcharging;
- Results of all field tests;
- Readings from installed instruments, including the raw data in spreadsheet form, but also including graphs and plots of the data to clearly demonstrate filling level, settlement and pore pressure development with time.
- Site conditions that may affect the results.

On completion of the surcharge period the Contractor shall produce a factual report compiling the record information detailed above as well as detailing the following:

- A drawing of the 'As-built' location of all instrumentation points;
- A drawing of the 'As-built' levels of the settlement plates;
- Borehole logs detailing the piezometer installations;
- A summary of the raw settlement data in spreadsheet form
- A summary of the raw piezometer data in spreadsheet form;
- A summary of all the interpreted instrumentation data including the final graphs and plots showing the full history of filling, settlement and pore pressure development and dissipation;
- Calibration certificates; and
- Earthworks materials test results.

11 BACKFILLING AND FILLING

Materials

Fill material shall be free of rubbish, roots or debris of any sort. Boulders, rock or concrete fragments over 100 mm in size shall not be present in backfill material. The fill material shall be subject to the approval of the Employer's Representative.

Approved fill shall consist of suitable earth or granular material that has been retained from excavations, taken from designated borrow areas or been hauled from an approved off-site source. This material will be acceptably dry, free from roots, large stones, boulders or large broken rocks, refuse, vegetable matter, topsoil, silt or debris.

Pea gravel shall be washed, rounded durable stone, 9.5 mm to 4.74 mm in size with no more than 2% passing a 75 micrometer sieve.

Rip-rap material shall be durable stone with a mass of a single stone being between 25 and 50 kg. Stones smaller than 25 kg mass are unsuitable.

All other materials, not specifically described but required for proper completion of the work of this section, will be subject to the approval of the Employer's Representative.

The Contractor shall reserve, separate and stockpile suitable excavated materials for use in backfilling later.

If the Employer's Representative deems the native material to be unsound for the purpose of backfill and an adequate amount of suitable material cannot be so collected, or if the Contractor fails to collect and preserve the requisite quantity, the Contractor shall furnish the additional quantity required. The additional material shall be natural sand, gravel or crushed murrum and shall be readily incorporated in a 100 mm lift and containing not more than 25% by weight of material passing a No. 200 sieve.

If a portion of the excavated materials is found to be unsuitable for use as backfill, the Contractor shall provide suitable material from another source.

Execution

General

The use of stones, rocks or concrete fragments of more than 100 mm in their greatest dimension shall not be permitted in any trench backfill and stones, rock or concrete fragments larger than 60 mm shall not be permitted in the backfill within 300 mm of the pavement sub grade or within 300 mm of any utilities.

Some backfilling may have to be carried with sand, as approved by the Employer's Representative. The sand used shall be medium grain, clean, sharp, angular, hard and durable, free from clay, mica and soft flaky pieces and free from other impurities. Sea sand shall not be used except under special circumstances. All sands must be well washed and cleaned before use.

Sand fill shall be kept flooded with water for 24 hours to ensure maximum consolidation. The surface of the consolidated sand shall be dressed to the required level or slope. Construction of floors or other structures on sand fill shall not be started until the Employer's Representative has approved the fill.

Backfilling work shall be suspended at any time when satisfactory compaction results cannot be obtained due to rain, or other adverse conditions in the field. The surfaces of any fill shall be maintained with a slope at all times to provide proper surface drainage.

Materials shall be compacted in maximum 300 mm layers and shall be of the proper moisture content before compacting to facilitate obtaining the required compaction.

Temporary planking and formwork etc., shall be removed as backfilling progresses to avoid the formation of voids.

Excavated foundations shall be inspected and approved by the Employer's Representative before proceeding with further work, including placing of any mudmat, reinforcing steel etc.

Complete final grading at grassed or seeded areas shall be to within 50 mm.

The Contractor shall repair damage and correct deficiencies that may result from the settlement of backfilled areas.

Foundation Bedding

Unless otherwise specified, new concrete foundation floors and base slabs shall be constructed on a suitably prepared formation and 100 mm PCC mudmat.

Bedding material, except for clear crushed stone, shall be compacted by mechanical means at optimum moisture content to a value of 98% standard Proctor maximum dry density (SPD).

Backfill around Structures

Backfill under this item shall be considered as all replaced excavation or new embankments adjacent to structures. No backfill shall be placed against any structural elements until they have been approved by the Employer's Representative. Backfilling shall be done as soon as practicable after the required conditions are satisfied. Backfill against waterproofed surfaces shall be carefully placed to avoid any damage to the waterproofing material.

The scope of work for filling and backfilling shall include filling for all the buildings covered under the contract.

Mechanical tampers or other approved compactors shall be used to compact all backfill and embankments within 1.2m of a structure and heavy compaction equipment beyond 1.2m of this area. The backfill shall be placed in 200 mm un-compacted depth lifts.

Backfilling shall only be carries out after the concrete or masonry has fully set and shall be done in such a way as not to cause under-thrust on any part of the structure.

All timber shoring and formwork left in excavations shall be removed after use and waste materials shall be cleared out from the excavation.

All the space between foundation masonry or concrete and the sides of excavations shall be backfilled to the original surface level with approved materials in layers not exceeding 300 mm in thickness, watered and well consolidated by means of rammers to at least 90% of the consolidation obtainable at optimum moisture content (Proctor density). Flooding with water for consolidation will not be allowed.

Areas inaccessible to mechanical equipment such as areas adjacent to walls and columns etc. shall be tamped by hand rammer or by hand held power rammers to the required density.

Tests to establish proper consolidation as required will be carried out by the Contractor. Two tests per 50 m^2 will be taken to ascertain the proper consolidation.

Unless otherwise specified or approved by the Employer's Representative, the period of time after which the Contractor may place backfill against or on top of any cast-in-place structures is greater than or equal to the time periods as shown in the table below:

Operation	Location	
	Against Sides of Structures	On top of Structures
Placement of loose backfill	5 days	21 days
Compaction of backfill	7 days	28 days

The Contractor shall observe any special backfilling requirements or materials, such as those for sub-drains and perimeter drain filters and insulation/expansion material where required.

Where walls are waterproofed on the exterior, or where insulation/expansion material has been placed, backfill shall be placed by hand to prevent damage to the waterproofing membrane. Should any damage to waterproofing occur, such areas shall be re-excavated and the membrane or coatings repaired or replaced to the satisfaction of the Employer's Representative.

Where fill is required on both sides of a wall, foundation or culvert, it shall be deposited layer by layer at each side alternately.

Filling Beneath Plinths and Floors

Construction of floors or other structures on fill shall not be started until the Employer's Representative has inspected and approved the fill.

Suitable fill material shall be placed in 15 cm layers, each layer being well watered and consolidated by approved hand or mechanical tampers or other suitable means to achieve the required density.

Gravel if required to be filled under floors, shall be single washed gravel of approved quality and of size varying from 12 mm to 20 mm it shall be uniformly blinded with approved type of soil and/or sand to obtain full compaction. Gravel shall be placed in 15 cm layers and shall be well watered and rammed entirely to the satisfaction of the Employer's Representative.

Slab Base (Rubble Hard Core)

The rubble shall be of the best variety of black trap/granite/basalt or other approved stone available locally. The stone shall be hard, durable, free from defects and of the required size and shall be approved by the Employer's Representative before incorporation in the work.

The stone used for the work shall be broken rubble of fairly regular shape and free from weathered, soft or decayed pieces.

Workmanship

The bed on which rubble soling is to be laid shall be cleared of all loose materials, levelled, watered and compacted and approved by the Employer's Representative before laying the rubble soling. Cable or pipe trenches shall be completed before the soling is started.

Over the prepared surface, the stone shall be set as closely as possible and well packed and firmly set. The stones shall be of full height and shall be laid so as to have their bases of the largest area resting on the sub-grade. Soling shall be laid in one layer of 230 mm or 150 mm or other specified thickness and no stones shall be less than 230 mm or 150 mm depth or specified thickness of soling with a tolerance of 25 mm

After packing the stones properly in position, the interstices between them shall be carefully filled with quarry spoils or stone chips, to obtain a hard, compact surface.

The entire surface shall be examined for any protrusions and the same shall be knocked off by a hammer and all interstices shall be filled with approved murrum. Excess murrum over the surfaces shall be removed. The surfaces shall then be watered and consolidated with mechanical or sufficiently heavy wooden tampers and log-rammers, as approved by the Employer’s Representative, to give the required slope or level and density of sub-base. After compaction, the surface shall present a clean look.

Adequate care shall be taken by the contractor while laying and compacting the rubble soling to see that concrete surfaces in contact with soling are not damaged.

Trench Backfilling

Backfilling over pipes shall not take place until after the pipes have been successfully tested except for bracing purposes.

Trench backfilling shall start at the top of the pipe or conduit bedding. All materials below this elevation are considered as bedding.

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed.

The bedding between the bottom of the trench and up to a level of 300 mm above the top of the pipe shall consist of granular material or murum. The maximum size of coarse material or stone shall not exceed 20 mm. The bedding shall be placed in layers not exceeding 150 mm watered and consolidated, taking care that no damage is caused to the pipe. Placing the bedding around thin-walled pipes shall receive special consideration.

The backfill materials shall be suitable excavated material, gravel, crushed stone or murrum or sand, free from any boulders and lumps of hard earth larger than 100 mm in size. Backfill material shall be spread evenly in 225 mm horizontal layers, brought to approximately the optimum moisture content and then tamped or rolled until 95 percent of the maximum dry density is achieved as determined by the standard proctor Test as per IS 2720 (Part VII) or a higher value if one is required in particular circumstances.

Backfill for cast-in-place piping, appurtenances or structures such as manholes shall start at the sub- grade for the structure. Backfill shall be brought up simultaneously and equally on all sides of the structure.

Care shall be exercised during backfill operations to prevent damage or dislodging of the pipes or conduits. Any damage or dislodging of pipes or conduits shall be repaired to the satisfaction of the Employer’s Representative.

Site Grading

Generally site grading shall include the grading of un-surfaced areas to the final landscape profile with due allowance for topsoil and turfing or as approved by the Employer’s Representative. The grading shall ensure that the ground profile slopes away from the structures and does not create ponding.

The site grading shall be subject to the approved by the Employer’s Representative before any landscaping is commenced.

Fill for site grading shall be placed in 300 mm layers and compacted to 90% SPD.

Imported fill material shall be used if there is insufficient excavated material on the site.

Ditches and swales shall include trim, grade and slope ditches and swales, to the satisfaction of the Employer's Representative.

Roads and Parking Areas

The backfill in areas under roads and parking areas shall be filled to the underside of the sub-base using approved granular fill and compacted in layers of 150 mm to 98% SPD. In areas adjacent to structures thinner layers may be required to suit lighter compaction equipment.

In road cut sections, unsuitable material (silt, humus, topsoil etc.) shall be excavated and replaced to the level of the sub-base with approved granular fill, ensuring that the minimum excavation in cut sections extends to the depth of the road base.

12 EMBANKMENTS

General

This work shall include the clearing of the site, setting out and preparing the ground and forming the embankments required for the roads, paths etc. with approved excavated or imported material, spread in maximum 200 mm layers, watered and compacted to the 98% SPD, to line, curve, grade, camber and cross section and dimensions as approved by the Employer's Representative.

Embankments shall be set out by fixing batten pegs at regular intervals before commencing the earthwork. The pegs shall be fixed 0.5 metres back from the limits of the fill and painted in a distinctive colour.

The size of the coarse material in the fill shall not exceed 50 mm unless approved by the Employer's Representative. Such material shall be free of logs, brush, stumps, roots rubbish, organic matter, humus, or any other unsuitable material.

The Contractor shall carry out the tests to determine the maximum density of the material to be used by the proctor method before starting the work.

If the cross slopes are steeper than 1 in 3, steps with reverse slope shall be cut into the slopes to give proper hold and seating to the bank as approved by the Employer's Representative. The top 15 cm. of soil shall be scarified and watered and compacted to 98% SPD density before any embankment material placed.

Fill shall be placed extending to the full width of the embankment, including the slopes at the level of the particular layer, and 300 mm. more on both sides to allow for compaction of the full section. The extra loose earth at the edges shall be trimmed after completion of the embankment leaving the correct section fully compacted.

Each layer of the embankment shall be watered, levelled and compacted as specified before the succeeding layer is placed. The surface of the embankment shall, at all times during construction, be maintained in such a manner to prevent ponding. Water to be used shall be free from all harmful contaminants and approved by the Employer's Representative.

If the material for the embankment contains less than the optimum moisture content, water shall be added to the 100 mm embankment layers to bring moisture uniformly up to the optimum. If the excavated material contain more than required moisture, it shall be allowed to dry until the moisture is reduced to required extent. If due to the wetness, the moisture content of the soil cannot be reduced to the appropriate amount by exposure, embankment work shall be suspended until suitable conditions prevail.

When loose layer is placed, levelled and appropriately moistened or dried, it shall be compacted by 8 to 10 tonne power roller, sheep's foot rollers or heavy hauling or dozing equipment until 98 percent of the maximum dry density is achieved, as determined by the standard proctor Test as per IS 2720 (Part VII) or a higher. If on testing, the density is found to be less than 98% of the proctor density, the Contractor shall carry out additional compaction as necessary to get the specified density. If the density cannot be improved by such reasonable efforts, the work may be accepted as substandard work by the Employer's Representative, if he thinks it is not harmful for the purpose.

Embankments not accessible to rollers, such as those adjoining bridges, culverts and other works shall be carried out independently of the main embankments and shall have the layers placed in 150 mm height and each layer shall be moistened and thoroughly compacted with mechanical or manual tampers. Before placing the next layer, the surface of the under layer shall be moistened and scarified to provide a satisfactory bond with the next layer.

Embankments shall be finished and dressed to a smooth and even finish, in conformity with the alignment levels and cross sections and dimensions required. On curves, sections shall be provided with super elevations and increased widths as approved by the Employer's Representative.

The joining of old and new embankments shall be done by stepping in an overall slope of 1 to 5.

The surface of the embankment shall, at all times during construction, be maintained at such a cross- fall to shed water and prevent flooding. All rain water shall be drained away from the toe of the embankment. The Contractor shall maintain the embankment in an approved manner throughout the Contract.

Tests on the embankments shall include the following:

Sr. No.	Test	Frequency
1.	Plasticity	As directed by the Employer's Representative
2.	Density	Each soil type to be tested. 1 test per 8000 m^3 of soil
3.	Deleterious content	As directed by the Employer's Representative
4.	Moisture content	1 test for every 250 m^3 of soil
5.	CBR test	As required by the Employer's Representative

Density tests shall be carried out for the embankment work during the progress of the work. One set of three core samples for every 1,000 m^2 area of each layer of embankment work shall be taken and tested. The average density shall not be less than 90% of the proctor density, obtained in the laboratory.

The arrangements for obtaining the samples and transporting to a laboratory shall be made by the Contractor.

13 SHEETING SHORING AND BRACING

General

13.1.1 Description

The Contractor shall supply and install piling, diaphragm walls, bracing, underpinning shoring and dewatering systems to adequately protect existing buildings and facilities and to maintain the excavations required for the construction of facilities.

The Contractor shall be solely responsible for the adequacy of the piling, diaphragm walls, bracing and shoring on the site to maintain safety and prevent damage to existing buildings, facilities, excavation and new construction. The configuration of the proposed shoring and bracing shall be approved by the Employer's Representative.

To obtain the approval of the Employer's Representative, the Contractor shall, if so required, provide drawings of the proposed sheeting and bracing including sheeting sizes, waling, rakers, anchor systems, struts, earth anchors, anchor piles, tie rods and other components pertinent to the effectiveness and adequacy of the shoring and bracing.

Existing Conditions

Soils

Any information provided by the Employer relating to boring logs and soil tests carried out are supplied in good faith. Any conclusions drawn from them, however, shall be the responsibility of the Contractor.

Where slopes steeper than the natural angle of repose or other conditions inconsistent with the safety of personnel required to work within an excavated area are encountered such excavations shall be sheeted or shored as may be needed to provide adequate safety.

The Contractor's attention is specially drawn to the necessity for a thorough study of the site and soil conditions, groundwater levels and other relevant factors, particularly in the case of any wet wells, incoming sewer connections and force mains at great depths, before deciding on the necessity or otherwise of sheeting, shoring and bracing and if provided, the adequacy of same.

Obstructions

Prior to driving sheeting etc., the Contractor shall locate existing facilities in service, if any, and avoid sections that may interfere with such. If such avoidance is not possible the Contractor shall relocate the facility or arrange for its relocation as required to clear the interference. Any action proposed in such circumstances shall be subject to the prior approval of the Employer's Representative.

Products and Materials

Steel Pilling and Shoring

Steel sheet piles shall conform to the requirements of IS 2314 and the steel for walls, struts braces and tie rods shall comply with IS 226. Any materials to be incorporated into the permanent works shall be new.

Piles shall be of the types and sizes indicated in the approved shop drawings or as specified herein and shall be of a design that provides continuous interlocking throughout their entire lengths. Standard handling holes shall generally be provided located approximately 100 mm below the top of each pile.

Timber Shoring

Where the Contractor elects to use timber shoring for trench and structure excavations he shall provide details of the shoring he proposes to adopt, taking into consideration the nature and condition of the soil to be excavated and the depths to which the excavations are to be carried. The quality and strength of the timber and the cross-sectional details and spacing of the shoring, walling and struts together with the calculations, where required or requested by the Employer's Representative, demonstrating the structural adequacy of the proposed shoring and timbering shall be included in the submittals.

Approval of the submittals shall however not relieve the Contractor in any way from his sole responsibility for the stability of the works and the safety of the employees engaged on the work and of the general public.

Dimensions

Piles and ancillary structural members shall be as shown on the approved shop drawings. All procedures shall be subject to the approval of the Employer's Representative approval.

Execution

General

Piling shall be accurately located and driven to the required depths, plumb and true to line with each pile interlocking with the adjacent pile throughout its entire length. Frames, temporary walls templates, guide-frames and bracing as are necessary shall be installed to guide and support the sheet piling in the correct position and alignment.

The choice of specific construction procedure appropriate for any works or phase thereof shall be the Contractor's responsibility. The procedure adopted shall meet the requirement of the works and specific procedures adopted such as construction methods, shoring, sheet piling, bracing, dewatering etc. are at the option of the Contractor. He shall however submit to the Employer's Representative a detailed construction procedure prior to commencement of work.

Driving

Piling shall be driven by approved methods in such a manner as not to subject the piles to damage and to ensure interlocking throughout the length of each pile.

Pile hammers shall be of the size and type needed to achieve the required penetration with the minimum damage to the piles. Hammers shall be maintained in a proper alignment with the piles during driving by use of suitable leads or guides. A protective driving cap of approved design shall be used, as required, to minimise the damage to tops of piles. Unless otherwise approved by the Employer's Representative, pile driving shall be done without jetting.

The piles shall be driven plumb and if the sheet piling goes progressively out of plumb, corrective steps shall be taken. If necessary, the piles shall be withdrawn and re-driven so that no part of any pile is more than 75 mm from the design location of the alignment on completion of the work.

Piling shall be driven in stages. No sheet pile, or pair of piles if driven in pairs, shall be driven more than one-third of its length before the adjacent sheet pile is set. Piling that is damaged or driven without interlocking shall be withdrawn and re-placed. The Employer’s Representative is empowered to order withdrawal if he has reasonable grounds to suspect damage. Any encroachment of piles upon concrete piles shall be sufficient grounds for withdrawal and replacement.

If obstructions are encountered during driving, the piles in question shall be driven at least to the specified refusal driving resistance after adjacent piles have been set and driven. However, the number of sheet piles permitted to be driven short of the required depths shall be limited in the field by the Employer’s Representative and if so approved, the Contractor shall remove obstructions encountered by whatever means necessary.

Splices

Splices shall be avoided if practicable, but where unavoidable shall be designed to develop the full strength of the piling. Drawings of the proposed splices shall be approved prior to execution. Extreme care shall be exercised to align the spliced sections so that the axis of the pile will be straight and that the interlocks of the piles shall form a straight, smooth and continuous groove.

Driving Resistance

Steam, air or diesel hammers shall be provided with a rated energy not less than the hammer manufacturer’s recommendation for the total weight of pile and the type of subsurface material to be encountered. The Employer’s Representative may require the Contractor to change the hammer in use to obtain the required minimum penetration.

Piling shall be driven to such depth as required to provide the degree of protection needed.

Stressing Rods

All tie rods shall be stressed to minimum of 10 percent of their design load. The Contractor shall submit to the Employer’s Representative for his approval the proposed procedure for pre-stressing tie rods.

14 ANCHORS TO RESIST UPLIFT

The use of anchors to resist uplift shall not be permitted.

15 ANTI-TERMITE TREATMENT AND PESTICIDES

General

Anti-termite treatment shall be applied to structures during the early stages of construction in the foundation trenches for columns, plinth beams, pile caps, brick walls, service trenches, lift pits, steps, ramps, in the top surfaces of plinth filling, at junction of walls and floor, in expansion joints etc. in stages as detailed in this specification. Unless otherwise stipulated, the anti-termite treatment will be carried out as per IS6313 (part II) 1981 and/or as per direction of the Employer's Representative.

Soil treatment shall be applied during the construction stages of the sub-structure up to plinth level.

Products

Pesticide and/or termiticide emulsions, recommended by the Indian Pest Control Association (IPCA) and approved by the Employer's Representative, shall be used uniformly over the area to be treated. The Contractor shall comply with the requirements on Contractor's licensing, certification and record keeping.

The Contractor shall submit certification for the chemicals purchased and obtain verification that the containers of the chemicals are sealed from the Employer's Representative before preparing the emulsion for the treatment.

The pesticide shall be dispersed uniformly in the soil and to the required strength to form an effective chemical barrier.

Delivery, Storage and Handling

Pesticides shall be delivered to the site in sealed and labelled containers in good condition as supplied by the manufacturer or formulator. The pesticides shall be stored, handled and used in accordance with manufacturer's instructions. Labels shall bear evidence of registration as per the IS or appropriate regulations.

Site Preparation

In order to ensure uniform distribution of the chemical emulsion and to assist penetration, the following site preparation shall be carried out:

1) Remove all felled trees, stumps, logs or roots from the site.
2) Remove any concrete formwork, levelling pegs, timber off-cuts and other builder's debris from the area to be treated.
3) If the soil to be treated is sandy or porous, preliminary moistening will be required to fill capillary spaces in the soil to prevent the loss of emulsion through piping or excessive percolation.
4) In the event of water logging of foundation, the water shall be pumped out before application of the chemical emulsion and it should be applied only when the soil is absorbent.
5) On clays and other heavy soils where penetration is likely to be slow and on sloping sites, where the treating solution is likely to run-off, the surface of the soil should be scarified to a minimum depth of 75 mm.
6) All sub-floor levelling and grading shall be completed, all cuttings, trenches and excavations shall be completed with backfilling in place. If this is not done, supplementary treatments shall be carried out to complete the barrier.

At the time of application, the soil shall have sufficiently low moisture content to allow uniform distribution of the treatment solution throughout the soil. Application of the chemicals shall not be made during or immediately following heavy rains or when conditions may cause runoff and create an environmental hazard.

Application

The Contractor shall apply termiticide to the soil material which will be covered by or lie immediately adjacent to the buildings and structures to provide a protective barrier against subterranean termites.

The termiticide shall be applied as a coarse spray and in such manner as to provide uniform distribution onto the soil surface. This treatment shall be applied prior to placement of a vapour barrier or waterproof membrane and prior to concrete pouring. Where treated soil or fill material is not to be covered with a vapour barrier or waterproof membrane, the Contractor shall exercise adequate precautions to prevent its disturbance.

The chemical emulsion will be applied uniformly by sprayers at the prescribed rates as detailed below in all the stages of the treatment.

Treatment in Foundation Trenches

In case of normal wall load bearing structures, column pits, wall trenches and basements, the treatment shall be at 5 l/m^2 of surface area of the bottom and sides to a height of at least 300 mm. After the foundation work, the sides shall be treated at 7.5 l/m^2 of vertical surface of substructure on each side. After the earth filling is completed, treatment shall be by rodding the earth at 150 mm centres close to the wall surface and spraying the chemical at a rate of 7.5 l/m^2.

In the case of framed structures, the treatment shall start at a depth of 500 mm below ground level. From this depth the backfill around the columns, beams and RCC basement walls shall be treated at a rate of 7.5 l/m^2 for the vertical surface and at 5 l/m^2 for horizontal surfaces at the bottom of trenches/pits.

Treatment on Top Surfaces of Plinth Filling

The top surface of filled earth within plinth walls shall be treated with chemical emulsion at the rate of 5 l/m^2 of the surface area before sub-base to floor is laid. If filled earth has been well rammed and the surface does not allow the emulsion to seep through, holes up to 50 to 75 mm deep at 150 mm centres both ways shall be made with crow bars on the surface to facilitate saturation of the soil with the emulsion.

Treatment at Junction of Walls and Floors

Special care shall be taken to establish continuity of the vertical chemical barrier on the inner wall surfaces from the finished ground level (or from level where the treatment has stopped) up to the level of the filled earth surface. To achieved this, a small channel 30 x 30 mm shall be made at all the junctions of wall/column with the floor (before laying sub-grade) and rod holes made in the channel up to the finished ground level at 150 mm spacings and the iron rod moved backward and forward to break the earth and the chemical emulsion shall be poured along the channel at 7.5 l/ l/m^2 of the vertical wall/column surfaces to soak the soil right up to the bottom. The soil shall be tamped back into place after this operation.

Treatment for Expansion Joints

The soil beneath expansion joints shall be supplemented by treating through the expansion joint after sub-grade has been laid at the rate of 2 l/m length of expansion joint.

Precautions during Treatment

Utmost care shall be taken to ensure that the chemical barrier is complete and continuous. Each part of the area shall receive the prescribed dosage of chemical emulsion.

The treatment should not be carried out when it is raining or when the soil is wet with rain or sub-soil water.

The Contractor shall ensure that these chemicals do not enter water supply systems or potable water supplies or aquifers and that they do not endanger plants and animals. The Contractor shall notify the Employer’s Representative at least 48 hours prior to the beginning of treatment and perform any formulating, mixing and application.

Once formed, the treated soil barrier 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.

If soil or fill material has been disturbed after treatment, the Contractor shall provide further treatment before placement of slabs or other covering structures. Treatment of the soil on the exterior sides of foundation walls, grade beams and similar structures shall be coordinated with final grading and planting operations to avoid disturbance of the treated barriers by such operations.

Safety Requirements

The manufacturer’s warnings and precautions in the handling and use of materials and the manufacturer’s method of application shall be followed by the Contractor. Where the manufacturer’s method differs from this document then the Contractor shall submit his method statement to the Employer’s Representative for approval.

The Contractor shall formulate, treat and dispose of termiticides and their containers in accordance with the manufacturer’s instructions. The Contractor shall draw water for formulating only from sites as approved by the Employer’s Representative and fit the filling hose with a backflow preventer meeting local plumbing codes or standards. The filling operation shall be under the direct and continuous observation of a Contractor’s representative to prevent overflow. Pesticides and related materials shall be kept secure under lock and key when unattended. Proper protective clothing and equipment shall be worn and used during all phases of termiticide application. Used pesticide containers shall be disposed of in accordance with guidelines and to the satisfaction of the Employer’s Representative.

All the chemicals are poisonous and hazardous to health. These chemicals can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mist or swallowed. Persons handling or using these chemicals shall be instructed of these dangers and advised that absorption through the skin is the most likely source of accidental poisoning and cautioned to observe carefully, as a minimum, the safety precautions given in this document and as recommended by the supplier, particularly when handling these chemicals in the form of concentrates.

These chemicals are usually brought to the site in the form of emulsifiable concentrates. The containers shall be clearly labelled and kept securely closed.

Particular care shall be taken to prevent skin contact with concentrates. Prolonged exposure to dilute emulsions shall also be avoided. Workers shall wear clean clothing and wash thoroughly with soap and water especially before eating and smoking. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemicals splash into the eyes they shall be flushed with plenty of soap and water and immediate medical attention sought.

The concentrates are oil solutions and present a fire hazard owing to the use of petroleum solvents. There shall be no naked flames in the proximity during mixing.

Care should be taken in the application of chemicals/soil-toxicants to ensure that they are not allowed to contaminate wells or springs.

Inspections

For the duration of the Contract, following the treatment, the Contractor shall perform annual inspections of all buildings treated.

If during the inspections, or at any other time, live subterranean termite infestation or subterranean termite damage is discovered and the soil and building conditions have not been altered in the interim, the Contractor shall:

1 Excavate the soil and perform other treatment as may be necessary for elimination of subterranean termite infestation;
2 Repair damage caused by termite infestation; and
3 Re-inspect the building approximately 180 days after the additional treatment.

In the event of a reappearance of termites within the building area due to defective materials or workmanship or due to any other reason, the Contractor will carry out the necessary post construction treatment to keep the entire area free from termites once again.

The Contractor shall maintain a Pest Management Maintenance Record, identifying target pest, type of operation, brand name and manufacturer of pesticide, formulation, concentration or rate of application used and submit copies of records when requested by the Employer’s Representative.

16 ROADS AND PAVEMENTS

General

The construction and reinstatement of roads and parking areas shall be carried out in accordance with the specifications for road works, Kerb stone and water table works of the Municipal Corporation of Greater Mumbai.

Materials

General

All materials shall be obtained from local sources and shall be subject to approval by the Employer's Representative prior to use.

Substitution of material shall be on an approved equivalent basis as determined by the Employer's Representative and shall result in finished roads as designated in this specification.

Material aggregates shall consist of natural or crushed stone, gravel or sands, shall be of reasonably uniform quality throughout and shall be clean and free from soft or decomposed particles, excess clay, foreign, organic or other deleterious matter.

Coarse Aggregate for Sub-Base, Base and Semi-grout

Coarse aggregate shall be crushed or broken stone and shall conform to the physical requirement given in the following table.

Physical requirements of Crushed Stone for Road Work

Sr. No.	Test	Limiting Value	
		For aggregates to be used for Road base and surfacing	For aggregate to be used for sub-grade
1.	Specific Gravity	Not less than 2.6	Not less than 2.0
2.	Water Absorption	Not more than 2%	Not more than 5%
3.	Flakiness Index	Maximum 25%	----
4.	Elongation Index	Maximum 40%	----
5.	Aggregate Impact Value or Aggregate Crushing Value	Not more than 30%	Not more than 40%
6.	Los Angeles Abrasion Value	Not more than 30%	Not more than 50%
7.	Stripping Test	Maximum 15%	----

Crushed or broken stone shall be hard, durable and free from an excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter.

Crushed or broken stone shall conform to the grading given in the following table.

Grading Requirements of Coarse Aggregates

Grading No.	Size Range	IS. Sieve Designations	Percent by Weight passing the sieve
1.	90 mm to 40 mm	100 mm 80 mm 63 mm 40 mm 20 mm	100 65 - 85 25 - 60 0 - 15 0 - 5
2.	63 mm to 40 mm	80 mm 63 mm 50 mm 40 mm 20 mm	100 90 - 100 35 - 70 0 - 15 0 - 5
3.	50 mm to 20 mm	63 mm 50 mm 40 mm 20 mm 10 mm	100 95 - 100 35 - 70 0 - 10 0 - 5

Screenings

Screenings shall consist of predominantly non-plastic materials such as sandy gravelly murrum or gravel (other than rounded river borne material) with Liquid Limit and Plasticity Index below 20 and 6 respectively and the fraction passing 75 micron sieve not exceeding 10%. The materials shall be sound and hard, of a quality not affected by weather and shall be screened at the quarry and shall be free from all impurities. Any large lumps of murrum shall be broken to pass gradation given in the above table. Gravel shall be composed of large, coarse, silicious grains, sharp and gritty to the touch, thoroughly free from dirt and impurities.

Screenings shall conform to the grading indicated in the following table.

Grading for Screenings

Grading Classification	Size of Screenings	IS Sieve Designations	Percent by Weight passing the sieve
A	12.5 mm	12.5 mm 10.0 mm 4.75 mm 150 microns	100 90 - 100 10 - 30 0 - 8
B	10.0 mm	10.00 mm 4.75 mm 150 microns 75 microns	100 85 - 100 10 - 30 0 - 10

Blinding Material

To fill in the voids in the coarse aggregates, any non-plastic material such as gravel/ grit/ sand/ brick powder may be used. The plasticity index of the material shall not exceed six.

Binder

The binder shall be straight run bitumen of grade S35 or S65 and shall conform to the requirements specified in IS 73 and the following table.

Requirements of Bitumen Binder

Sr. No.	Characteristic	Requirement for Grade		Method of Test Reference to
		S 35	S 65	
1.	Specific gravity at 27 °C, Min.	0.99	0.99	IS : 1202
2.	Water prevent by weight, Max.	0.2	0.2	IS : 1211
3.	Flash point, Pensky Martens closed type °C, Min.	175	175	IS : 1209 (Method A)
4.	Softening point, °C	50 - 65	40 - 55	IS : 1205
5.	Penetration, at 25°C, 100 g, 5 sec in 1/100 cm	30 - 40	60 - 70	IS : 1203
6.	Ductility at 20 °C in cm, Min	50	75	IS : 1208
7.(a)	Loss on beating, percent by weight, Max.	1	1	IS : 1212
7.(b)	Penetration of residue (expressed as percentage of item 5), Min	60	60	IS : 1203
8.	Matter soluble in carbon disulphide, percent by weight, Min.	99	99	IS : 1216

Setting Out

The Contractor shall provide all labour and materials such as lines, strings, pegs, nails, bamboo, stones, mortar, concrete etc., required for setting out, establishing benchmarks and giving profiles. The Contractor shall be responsible for maintaining the benchmarks, profiles, alignments and other stakes and marks as long as they are required for the works.

The surface of the installed layers will be parallel and have the same grade as the designed asphalt surface and all subsequent layers.

Earthworks for Roads

Profiles of road excavation shall be laid at 25 m intervals to conform to the required alignment, sections, grades and side slopes and the lines of cuts shall be clearly marked.

The Contractor shall, on no account, excavate beyond the slopes or below the specified grade on the drawings unless so directed by the Employer's Representative in writing.

Preparation of Sub-grade

Immediately prior to the laying of the sub-base metal, the sub-grade shall be cleaned of all foreign substances and vegetation etc. Any ruts or soft yielding patches that appear shall be corrected and the sub-grade dressed off parallel to the finished profile. The camber of sub-grade shall conform in shape to that of the finished road surface. Camber boards shall be used to get the required section.

The prepared sub-grade shall be lightly sprinkled with water, if necessary, and rolled with a power roller of 10-12 tonnes. The roller shall pass over the same area of the sub-grade a minimum of five runs. Any undulations in the surface that develop due to rolling shall be made good with approved earth and sub-grade re-rolled.

Granular Sub-base

A. Scope

This work shall consist of laying and compacting well-graded material on prepared sub-grade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the Drawings or as directed by the Engineer.

B. Material specification

The material to be used for the work shall be natural sand, Murrum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to one of the three grading given in Table 16-1.

While the grading in Table 16-1 are in respect of close-graded granular sub-base materials, one each for maximum particle size of 75 mm, 53 mm and 26.5 mm, the corresponding grading for the coarse-graded materials for each of the three maximum particle sizes are given at Table 16-2. The grading to be adopted for a project shall be as specified in the Contract.

Physical requirements

The material shall have a 10 percent fineness value of 50 KN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part III). The water absorption value of the coarse aggregate shall be determined as per IS:2386 (Part 3); if this value is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:383. For Grading II and III materials, the CBR shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 per cent.

Table 16-1 Grading For Close-Graded Granular Sub-Base Materials

IS sieve	Percent by weight passing the IS sieve		
Designation	**Grade I**	**Grading II**	**Grading III**
75.0 mm	100	-	-
53.0 mm	80-100	100	-
26.5 mm	55-90	70-100	100
9.50 mm	35-65	50-80	65-95
4.75 mm	25-55	40-65	50-80
2.36 mm	20-40	30-50	40-65
0.425 mm	10-25	15-25	20-35
0.075 mm	3-10	3-10	3-10
CBR Value (Minimum)	30	25	20

Table 16-2 Grading For Coarse Graded Granular Sub-Base Materials

IS sieve	Percent by weight passing the IS sieve		
Designation	**Grade I**	**Grading II**	**Grading III**
75.00 mm	100	-	-
53.0 mm		100	
26.5 mm	55-75	50-80	100
9.50 mm			
4.75 mm	10-30	15-35	25-45
2.36 mm			
0.425 mm			
0.075 mm	< 10	< 10	< 10
CBR Value (Minimum)	30	25	20

Note: The material passing 425 micron (0.425 mm) sieve for all the three grading when tested according to IS:2720 (Part 5) shall have liquid limit and plasticity index not more than 25 and 6 per cent respectively.

Strength of Sub-base

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

When directed by the Engineer, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content and any other tests for the "quality" of materials, as may be necessary.

Construction Specifications

Preparation of sub grade

Immediately prior to the laying of sub-base, the sub grade already finished shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water if necessary and rolled with two passes of 80-100 KN smooth wheeled roller.

Spreading and compacting

The sub-base material of grading specified in the Contract shall be spread on the prepared sub grade with the help of mechanical grader, of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation or other means as approved by the Engineer.

When the sub-base materials consist of combination of materials mentioned in section 2.70 mixing shall be done mechanically by the mix-in-place method.

Manual mixing shall be permitted only where the width of laying is not adequate for mechanical operations, as in small-sized jobs. The equipment used for mix-in-place construction shall be a rotavator or similar approved equipment capable of mixing the material to the desired degree. If so desired by the Engineer, trial runs with the equipment shall be carried out to establish its suitability for the work.

Moisture content of loose material shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted by sprinkling additional water from a truck mounted or trailer mounted water tank and suitable for applying water uniformly and at controlled quantities to variable widths of surface or other means approved by the Engineer so that, at the time of compaction, it is from 1 per cent above to 2 per cent below the optimum moisture content corresponding to IS:2720 (Part 8). While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means like disc harrows, rotavator until the layer is uniformly wet.

Immediately thereafter, rolling shall start. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 KN weight may be used. For a compacted single layer up to 225 mm. the compaction shall be done with the help of vibratory roller of minimum 80 to 100 KN static weights with plain drum or pad foot drum or heavy pneumatic typed roller of minimum 200 to 300 KN weight having a minimum tyre pressure of 0.7 MN/m^2 or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional cross fall (camber) and super elevation and shall commence at the edges and progress towards the centre for portions having cross fall (camber) on both sides.

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 cross fall (camber) shall be checked and any high spots or depressions which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material determined as per IS:2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Section 902 of MoSRT&H Specifications for Road and Bridge Works (IV Revision).

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900 of MORT Specifications for Road and Bridge Works (IV Revision).

Arrangement for Traffic

During the period of construction, the arrangement of traffic shall be done accordingly, by providing proper diversions as per the directives of Engineer.

Wet Mix Macadam (WMM) Sub Base

Providing and laying WMM (wet mix macadam) Sub-base / base for required depth with black stone metal, size specified in detailed specification on sub base. Metal shall be mixed by approved mixing plant of suitable capacity having provision for controlled addition of water and forced / positive mixing arrangement like pug mill or pan type mixer of concrete batching plant, laying and spreading with mechanical spreader for required consolidated depth. Including rolling with 8 / 10 MT power roller to required slope and camber, etc. complete as per instruction of Engineer.

A. Scope

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water to a dense mass on a prepared sub-grade /sub- base / base or existing pavement as the case may be in accordance with the requirements of these specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be increased to 200 mm upon approval of the Engineer.

B. Materials specification

a. Aggregates Physical requirements

Coarse aggregates shall be crushed stone. If crushed gravel / shingle are used, not less than 90 percent by weight of the gravel / shingle pieces retained on 5.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table

Table 16-3 Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Sub-Base / Base Courses

	Test	Test Method	Requirements
1.	*Los Angeles Abrasion value	IS : 2386 (Part-4)	40 percent (Max)
	OR		
	*Aggregate Impact value	IS: 2386 (Part-4) or IS : 5640	30 percent (Max)
2.	Combines Flakiness and Elongation Indices (Total)	IS : 2386 (Part-1)	30 percent (Max)

* Aggregate may satisfy requirements of either of the two tests.

If the water absorption value of the coarse aggregate is greater than 2 per cent, the soundness test shall be carried out on the material delivered to site as per IS: 2386 (Part-5)

Grading requirements:

The aggregates shall conform to the grading given in Table

Table 16-4 Grading Requirements of Aggregates for Wet Mix Macadam

IS Sieve Designation	Per cent by weight passing the IS sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	--
22.40 mm	60-80
11.20 mm	40-60
5.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-8

Materials finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

Frequency of tests for Subgrade GSB and WMM

Section	Type of Construction	Test	Spec. Limits	Frequency (min.)
1.4.1	Sub Grade	Sand content	-	2 tests / 3000 m^3
		Plasticity Index test	-	2 tests / 3000 m^3
		Density of Compacted Layer	97%	2 tests / 3000 m^3
		Deleterious content test	-	Once per source
		Moisture content test	-	1 /250 cum
		C.B.R. test	As specified in RFP	1 / 3000 cum
1.4.2	Granular sub base	Gradation	MORTH Table no.400.1, grading– I	1 /200 cum
		Atterberg Limit	PI - < 6%, LL - <25%	1 /200 cum
		Moisture Content Prior to compaction	+1%, -2% of the OMC	1 /250 cum
		Density of compacted layer	97%	1 /500 cum

Section	Type of Construction	Test	Spec. Limits	Frequency (min.)
		Water absorption of aggregate	2%, if water absorption more than 2% do soundness test as below	Initially one set of 3 representative specimen for each source of supply subsequently when warranted by changes in the quality of aggregates
		Soundness (Magnesium & Sodium Sulphate)	Max 12% Max 18%	Initially one set of 3 representative specimen for each source of supply subsequently when warranted by changes in the quality of aggregates
1.4.3	Wet Mix Macadam	Aggregate Impact value Los Angeles abrasion value	Max 30% Max 40%	
		Quality of Screening Material	LL max – 20%, PI – Max – 6%	Once per source
		Shape and Size	As per tech. spec.	Once per source
		Grading		1 test per 200 cum

C. Construction Specifications

a. Preparation of base

As per clause 405.3.1 MoSRT&H specification.

b. Provision of lateral confinement of aggregates

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in Clause 407.5.1 of MoSRT&H Specification.

c. Preparation of Mix:

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced / positive mixing arrangement like pugmill or pan type mixer of concrete batching plant.

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 5.75 mm to 22.4 mm size. 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 from the optimum value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

d. Spreading of Mix:

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub grade / sub-base / base in requirement quantities. In no case should these 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 mix may be spread either by a pavers finisher or motor grader. For portions where mechanical means cannot be used, manual means as approved by the Engineer shall be used. The motor grader shall be capable of spreading the material uniformly all over the surface. Its blade shall have hydraulic control suitable for initial adjustments and maintaining the same so as to achieve the specified slope and grade.

The paver finisher shall be self-propelled, having the following features: Loading hoppers and suitable distribution mechanism.

The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface profile.

The paver shall be equipped with necessary control mechanism so as to ensure that the finished surface is free from blemishes.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedies by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

e. Compaction

After the mix has been laid to the required thickness, grade and cross fall / camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 KN weight may be used. For a compacted single layer up to 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 KN or equivalent capacity roller. The speed of the roller shall not exceed 5 Km/hr

In portions having unidirectional cross fall / super elevation, rolling shall commence from the lower edge the progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding tracks by at least one- third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done 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.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS:2720 (Part-8).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, 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.

f. Setting and drying

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

g. Opening to Traffic

Preferably no vehicular traffic of any kind should be allowed on the finished wet mix macadam surface till it has dried and the wearing course laid.

h. Surface Finish and Quality Control of Work

Surface evenness:

The surface finish of construction shall conform to the requirements of Clause 902 of MoSRT&H specification.

Quality control:

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900 of MoSRT&H specification.

i. Rectification of Surface Irregularity

Where the surface irregularity of the wet mix macadam course 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 premixed material or removed and replaced with fresh premixed material as applicable and re-compacted in accordance with Clause 406.3 of MoSRT&H specification. 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 un-graded material or fines.

j. Arrangement for Traffic

During the period of construction, arrangement of traffic shall be done as per Clause 112 of MoSRT&H specification.

Tack Coat

(i) Preparation of Base

The base on which a tack coat is to be applied shall be prepared, shaped and conditioned to the specific line, grade and cross section by repairing all potholes or patches and ruts. The potholes shall be drained of water and cut to regular shape with vertical sides. All loose and disintegrated materials shall be removed. The potholes shall then be filled either with (i) coarse aggregate and screenings and compacted with heavy hand rammers or approved mechanical tempers or (ii) premixed chippings binders (bitumen grade S 35/ S 65) content of 3 percent by weight of total mix, after painting the sides and bottom of the holes with a thin application of bitumen, or a combination of both (i) and (ii) as approved by the Employer's Representative. The surface shall be thoroughly swept and scraped clean and free of dust and other foreign matter.

(ii) Application

The binder used for tack coat shall be bitumen of suitable penetration grade within S35 to S65 conforming to IS:73. The binder shall be heated to the temperature appropriate to its grade and as approved by the Employer's Representative. The binder shall be sprayed on the prepared base at the rate of 1.0 kg/m^2. The binder shall be applied uniformly with the aid of either self-propelled or towed bitumen pressure sprayer with self-heating arrangement and spraying nozzle arrangement capable of spraying bitumen at the above specified rate and temperature to provide a uniform unbroken spread of bitumen. The tack coat shall be applied just ahead of laying asphalt macadam.

Asphalt Macadam

(i) Brushing

Prior to spreading of the asphalt surface, the water bound surface shall be swept clean to remove blinding to expose the metal surface.

(ii) Application of Macadam

The bituminous macadam shall be laid by mechanical compactor and finisher, the final consolidation being by means of power roller weighing not less than 10 tonnes. The finished surface shall not vary by more than 12.5 mm above or below the designed level and the average thickness shall not be less than 65 mm after consolidation. The grading, composition and characteristics of the bituminous macadam shall be as follows:

Aggregate Grading

IS Sieve Designation	Percentage Passing
50 mm	100
40 mm	60 - 100
25 mm	30 – 70
20 mm	20 - 70
6.3 mm	10 - 20
2.36 mm	0 – 5

Bitumen (Grade S 65) Content: 3.7% to 4.3% by weight of total mix.

The bituminous macadam may be prepared in a hot mix plant or the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case mixing shall be carried out in a power driven pugmill mixer and shall be continued until all the aggregate is coated.

The Contractor shall ensure that the installation temperature is adequate during the rolling / compaction of asphalt.

(iii) Protection of Pavement

During the period between initial compaction of the coarse aggregate and completion of the seal coat, the surface shall be protected from all traffic other than that which is absolutely essential to its construction.

(iv) Premixed Seal Coat

After the full grout has been rolled, the interstices shall be completely filled with pre-coated grit of the following composition.

Aggregate Grading

IS Sieve Designation	Percentage passing
6.3 mm	100
2.36 mm	70 - 100
600 micron	25 – 50
300 micron	0 - 10

Bitumen (Grade S 65) Content : 7% to 8% by weight of total mix.

The premixed seal coat may be prepared in a hot mix plant or the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case, mixing shall be carried out in a power driven pugmill mixer and shall be continued until all the aggregate is coated.

The premixed seal must be brushed to fill in the interstices, additional material being applied during rolling if found necessary. The quantity of premixed seal required for this purpose shall be approximately 1.22 m^3 per 100 m^2.

(v) Liquid Seal

On the completion of consolidation, which may be assisted by opening the road to traffic, a liquid seal coat of Grade 565 bitumen shall be applied at a temperature of between 163 ^{O}C to 191 ^{O}C (325 ^{O}F to 375 ^{O}F) at the rate of 1.25 kg/m^2. The application of bitumen shall be immediately followed with a cover coat of clean dry ¼ cubical chippings at the rate of 1.22 m^3 per 100 m^2. The surface shall then be rolled with a power roller weighing not less than 10 tonnes. The composition of this seal coat shall be as follows :

Aggregate Grading

IS Sieve Designation	Percentage passing
12.5 mm	100
10 mm	70 - 100
4.75 mm	20 – 40
2.36 mm	7 – 20
75 micron	0 - 4

Bitumen (Grade S 65) Content : 4.5% to 5% by weight of total mix.

Quality Control

General

All works performed shall conform to the lines, grades, cross sections and dimensions as specified or as approved by the Employer's Representative subject to the permitted tolerances described hereinafter.

Horizontal Alignments

These shall be reckoned with respect to the centreline of the carriageway as specified. The edges of the carriageway as constructed and all other parallel alignments shall be corrected within a tolerance of ± 20 mm.

Longitudinal Profile

The level of any point on the various surfaces after compaction shall comply with the following :

Surface Tolerance from the specified

	Level
Sub-grade	± 25 mm
Sub- base	± 20 mm
Base-course	± 15 mm
Wearing course	± 10 mm

The negative tolerance for wearing course, shall not be permitted in conjunction with the positive tolerance for the base course, if the thickness of the wearing course is thereby reduced by more than 6 mm.

The longitudinal profile shall be checked with a 3.0 m long straight edge, along the centreline of the road. The transverse profile shall be checked with a camber board at intervals of 30m. Permitted tolerances are specified in the table below:

Permitted tolerances of surface regularity for pavement courses

No.	**Type of construction**	**Longitudinal profile (Maximum permissible undulation when measured with a 3 m straight edge) (mm)**
1.	Sub-grade	18
2.	Sub- base	18
3.	Base-course	12
4.	Asphalt macadam	10

Rectification

Where the surface irregularity of the sub-grade and the various pavement courses falls outside the specified tolerances, the Contractor shall rectify these in the manner described below and to the satisfaction of the Employer's Representative.

(i) Sub-grade

Where the surface is high, it shall be trimmed and suitably compacted. Where it is low, the deficiency shall be corrected by adding fresh material.

(ii) Stabilised Sub-base

Where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. Where the surface is low, the same shall be corrected as described below.

When the time elapsed between detection of irregularity and the time of mixing is less than two hours, the surface shall be scarified to a depth of 50 mm, supplemented with freshly mixed material as necessary and re-compacted to the relevant specification. When this time is more than two hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to the specification. In either case the area treated shall not be less than 5m long and 2m wide.

Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and re-compacted. The area treated shall not be less than 5m long and 2m wide.

(iii) Bituminous Construction

For bituminous construction other than for a wearing course where the surface is low, the deficiency shall be corrected by adding fresh material and compacting in accordance with the specification. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to the specification.

For wearing course where surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where removal and replacement of bituminous layer is involved, the area treated shall not be less than 5m long and 2 m wide.

Quality Control Test During Construction

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control test, as described hereinafter, by the Employer's Representative. The testing frequencies set- forth are the minimum required and the Employer's Representative shall have the authority to carry out tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications. The tests and their frequency to be used for different materials and works shall be as detailed in the following Table:

Sr. No.	Type of Construction	Test		Frequency
1.	Sub-base	i)	Gradation	1 test per 2000 m²
		ii)	Plasticity	As required
		iii)	Deleterious Constituents	As required
		iv)	CBR test	As required
		v)	Moisture content prior to compaction	1 test per 250m²
		vi)	Dry density	1 test per 500 m²
2.	Water Bound Macadam	i)	Gradation	1 test per 1000 m²
		ii)	Flakiness index	1 test per 2000 m²
		iii)	Plasticity of binding material	1 test per 1000 m²

Sr. No.	Type of Construction	Test		Frequency
3.	Bitumen Macadam	i)	Quality of binder	As required
		ii)	Aggregate impact value	1 test per 50 – 100 m² of aggregate
		iii)	Flakiness index	1 test per 50 - 100 m² of aggregate
		iv)	Grading of Aggregates	2 tests per day plant, both on the individual constituents and mixed aggregates from the dryer (one at plant and one at Municipal Lab)
		v)	Binder content	Periodic subject to 2 tests per day per plant
		vi)	Control of temp. of binder and aggregate for mixing and of the mix at the time of laying and rolling	All regular close intervals
		vii)	Rate of spread of mixed material	Regular control through checks on layer thickness
4.	Seal Coat	i)	Quality of binder	As required
		ii)	Aggregate Impact Value	1 test per 2000 m²
		iii)	Flakiness Index	1 test per 2000 m²
		iv)	Aggregate grading	2 tests per day
		v)	Temp. of application	At regular close intervals
		vi)	Rate of spread 2 materials	2 tests per day

Where a specific procedure is not indicated for quality control tests in these specifications, the same shall be carried out as per prevalent accepted engineering practice and to the approval of the Employer's Representative.

Control shall be exercised by taking at least one measurement of density for each 1000 m^2 of compacted area or as required to yield the minimum number of test results for evaluating a day's work on a statistical basis. The determination of density shall be in accordance with IS: 2720 (Part 28). Test locations shall be chosen only through random sampling techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5 – 10 density determinations. The number of tests in one set of measurements shall be five, as long as it is felt that sufficient control over material and the method of compaction is being exercised. If considerable variations are observed in individual density results, the minimum number of tests in one set of measurement shall be increased to ten. The acceptance of work shall be subject to the condition that the mean standard deviation for any set of results is below 0.08 g/cc.

For earth work in shoulders and in the top 500 mm portion of an embankment below the sub-grade, at least one density measurement shall be taken for every 500 square metres of each set of measurements. In other respects the control shall be similar as described earlier.

Slab Culvert

(For Cross Sections refer MCGM circular u/no Dy.ChE/8696/SWD/WS dtd 16.07.2020**)**

General

Where slab culverts are provided for cross drainage purposes, these shall conform to the following specifications. The concrete works specifications for construction of RCC slab and the rubble masonry specification for the supporting rubble walls are given in this specification.

Bitumen at Location of Contact

Two coats of grade S 35 bitumen shall be applied to the top of the bed concrete at the point of contact with the RCC slab above.

Free Draining Graded Gravel Backfill

On each side of un-coursed rubble walls supporting the slab culvert, a free draining backfill of thickness 200 mm shall be provided. The material shall be granular, consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become powdery under loads or in contact with water. The material shall be free from soft, thin, elongated or laminated pieces and vegetation or other deleterious substances. The material shall be graded and shall meet the grading requirements given above.

Weep Holes

Weep holes as required or as directed by the Employer’s Representative shall be provided in the masonry to drain water from the backfilling. Weep holes shall be of PVC pipe in rubble walls with M-10 concrete cushioning 75 mm thick. The weep holes shall extend through the full width of the masonry at a spacing of 1.5 mm c/c and with a slope of 1 vertical to 20 horizontal towards the draining face.

Rough / Natural Faced Shahabad Stone Pavement

Materials

Hand cut rough/natural faced Shahabad stone shall be of the best quality and of suitable thickness, size etc. and shall be subject to the approval of the Employer’s Representative. The stone shall be hard, sound, durable, tough, free from flaws, cracks, decay and weathering. The edges shall be hand cut and dressed true and squares. The evenness of surfaces and edges of the slabs shall not be marred by careless dressing or handling and no patching up shall be allowed.

The under face may be left as required or rough dressed. Before taking up the work, samples of stone slabs to be used and their dressing shall be subject to the approval of the Employer’s Representative. The work shall be carried out strictly in accordance with the approved samples.

Bedding/Backing Coat

In case of plinth protection or other pavements over a concrete sub base, the bedding shall be of 12 mm thick 1:2 cement mortar

In case of pavement work for footpaths, approaches and other similar works, to be laid directly over levelled and consolidated ground, the bedding shall be of 150 mm thick quarry spoil and 60 mm thick stone grit or as otherwise approved by the Employer's Representative.

Laying and Fixing Stone Slabs and Tiles

The specifications for Kotah stone flooring/skirting/facia described in Clause 22.17 shall apply except that the joints shall be pointed with 1:3 cement mortar and finished flush or with grooves as approved. The joints shall be raked out uniformly to a depth of not less than 12 mm before grouting and pointing the same.

Curing

The pavement work shall be kept well wetted for at least seven days.

Cleaning

When the bedding and joints have been completed, set and attained the required strength, the surface shall be thoroughly cleaned and handed over free from any mortar stains, dust, dirt etc.

Surface Water Drainage Systems

General

All surface storm water drains shall be constructed to the correct sizes and shapes as required for a sustained storm of 100 mm per hour. The finished product shall be sound and shall have smooth inside surfaces for optimum flow and be to the approval of the Employer's Representative.

Materials

(i) Common Bricks

All common bricks shall be sound, hard, thoroughly baked, clean, of proper rectangular size and give a clear ring when tapped. They shall comply with IS 2212. All bricks shall be obtained from a manufacturer subject to the approval of the Employer's Representative.

Testing of bricks shall be in accordance with IS 2212. Mortar shall be composed of one part cement to three parts sand, mixed thoroughly on a clean watertight platform before the appropriate amount of water is added. Mortar shall be used within one hour of adding water to the mix and no softening or revival of mortar shall be permitted after one hour of mixing.

(ii) Plaster

Where specified, plaster shall be rendered 20 mm thick in cement mortar consisting of one part cement to three parts sand. Plasticiser may be used with cement with the approval of the Employer's Representative.

Setting Out

As soon as the embankments or fill areas are completed in accordance with the requirements of Sections 10 and 0 the Contractor shall set out the lines for road-side and surface storm-water drains. The centre lines shall be marked with pegs at not more than 30 metre intervals and at turning points and positions of manholes, with the lines and levels of cut for drain laying clearly set out.

Execution

Surface drains shall be laid in trenches dug to the correct levels and alignment and constructed to produce an even alignment and gradient. Over-excavation shall be made good by selected fill well compacted and to the satisfaction of the Employer’s Representative.

17 CONCRETE

Definitions

Liquid Retaining structures shall be construed to mean any structure of which any part contains water or other process liquids, or which are designed or intended to protect spaces from ground water.

Materials

General

The quality of material and method and control of manufacture and transportation of all concrete work irrespective of mix; whether reinforced or otherwise shall conform to the applicable portions of this specification.

The Employer's Representative shall have the right to inspect the sources of materials, the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment and the quality control system. Such an inspection shall be arranged and the approval of the Employer's Representative obtained, prior to starting any concrete work.

The ingredients to be used in the manufacture of standard concrete shall consist solely of a standard type Portland/Portland pozzolana cement, clean sand, natural coarse aggregate, clean water, ice and admixtures if specially called for.

Where walkways or platforms are to be made of concrete, the walkways/platforms shall be designed and sized to suit with not less than 1m clear space between the handrails.

Storage

All materials shall be stored in the required manner immediately upon delivery to the site. It will be the responsibility of the Contractor to provide and maintain requisite stocks, handle the materials with care and store them in such a manner that the materials will remain fresh for use at the appropriate time.

Cement shall be stored in silos or in dry weather proof and well ventilated structures the floors of which shall be at least 450 mm above ground level with adequate precautions to prevent moisture absorption. The storage arrangements shall be subject to the approval of the Employer's Representative and shall provide easy access for inspection. The different consignments shall be identifiable and shall be utilized in the order in which they are received at site or as instructed by the Employer's Representative.

Aggregates shall be so stored that different specified sizes are kept separate and protected against contamination by soil or other impurities. Adequate storage facilities shall be provided to prevent the possibility of intermixing of the different sizes of aggregates.

The use of wet fine aggregates shall be permitted if the moisture content is uniform and after such content is accurately determined to adjust the batching and the water content of the proposed mix. Wherever possible, the fine aggregate shall be kept dry.

All coarse and fine aggregates shall be stacked separately in stock piles in the material yard near the work site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign materials and earth during storage and while heaping the materials shall be avoided. The aggregate shall be of specified quality, not only at the time of receiving at site but also at the time of loading into mixer. Rakers shall be used for lifting the coarse aggregate from bins or stock piles. Coarse aggregate shall be piled in layers not exceeding 1.00 metre in height to prevent coning or segregation. Each layer shall cover the entire area of the stock pile before succeeding layers are started. Aggregates that have become segregated shall be rejected. Rejected material after remixing may be accepted, if subsequent tests demonstrate conformity with the required gradation.

Cement

Cement shall be as per the latest version of IS 269. Cement for use in concrete for sewage treatment works and pumping stations shall be sulphate resistant. Tests shall be carried out as and when approved by the Employer's Representative. The cement shall be tagged for identification at location for sampling.

Unless otherwise specified or called for in the contract, the cement to be used shall be selected from the following and the type selected shall be appropriate for the intended use and as per the Contract.

1 Sulphate resisting Portland cement conforming to IS 12330.

2 53 Grade ordinary Portland Cement conforming to IS 12269

3 Portland Slag Cement (with GGBS content of 30%) confirming to IS 455.

4 Portland pozzolana cement (fly ash based) conforming to IS 1489 (Part I)

5 Portland pozzolana cement (calcined clay based conforming to IS 1489 (Part 2)

Should the project require specific use of any of the following cements the same shall be used with the prior consent of the Employer's Representative and necessary precautions with regard to their setting and hardening time, time required for removal of shuttering and curing etc. shall be taken after carefully complying with specific literature with regard to those types.

1 High alumina cement - conforming to IS 6452

2 Low heat cement - conforming to IS 12600

3 Super sulphate cement - conforming to IS 6909

4 Rapid hardening cement - conforming to IS 8041

5 Blended cement for finishing work as below

Other combinations of Portland cement with mineral admixtures of quality conforming to relevant Indian Standards laid down may also be used in the manufacture of concrete provided that there are satisfactory data on their suitability, such as performance test on concrete containing them and only in such case where it is specifically called for in the contract.

No pre-hardened cement shall be used on any permanent works.

(i) Mineral Admixtures for Cement

Pozzolana: Pozzolanic materials conforming to relevant Indian Standards may be used with the permission of Employer's Representative, provided uniform blending with cement is ensured.

Fly ash (Pulverized Fuel Ash): Fly ash conforming to IS 3812 may be used as part replacement of ordinary Portland cement provided uniform blending with cement is ensured.

Silica Fume: Silica fume can be used as part replacement of cement provided it is of sufficient quality approved by the Employer's Representative and uniform blending with the cement is ensured.

Rice Husk Ash: Rice husk ash giving required performance and uniformity characteristics may be used with the approval of the Employer's Representative.

Metakaoline: Metakaoline having fineness between 700 to 900 m^2/kg may be used as a pozzolanic material in concrete.

Ground Granulated Blast Furnace Slag: Ground granulated blast furnace slag obtained by grinding granulated blast furnace slag conforming to IS 12089 may be used as part replacement of ordinary Portland cement provided uniform blending with cement is assured.

Quality Assurance of Cement: A certified report attesting to the conformity of the cement to IS specifications by the cement manufacturer's chemist shall be furnished to the Employer's Representative, if demanded. The Contractor, shall make his own arrangements for the storage of adequate quantities of cement at the site of work.

Storage of Cement: Cement in bags shall be stored and stacked in a shed, which is dry, leak-proof and moisture proof as far as possible. Storage under tarpaulins will not be permitted. Flooring of the shed shall consist of the two layers of dry bricks laid on well consolidated earth to avoid contact of cement bags with the floor. Stacking shall be about 150 to 200 mm clear above the floor using wooden planks. Cement bags shall be stacked at least 450 mm clear of the walls and in rows of two bags leaving a space of at least 600 mm between two consecutive rows. In each row the cement bags shall be kept closed together to reduce air circulation. Stacking shall not be more than ten bags high to avoid lumping under pressure. In stacks more than eight bags high, the cement bags shall be arranged in header and stretcher fashion i.e. alternately lengthwise and crosswise to tie the stacks together and minimize the danger of toppling over.

Damaged or reclaimed or partly set cement will not be used and shall be removed from the site. The storage arrangements shall be such that there is no dead storage consignments so cement shall be stored as received and shall be consumed in the order of their delivery.

Cement held in store for a period of ninety days or longer shall be retested before used in work. Should the Employer's Representative have reasons to consider that any cement is defective, then irrespective of its origin and/or manufacturers test certificate, such cement shall be tested immediately at a National Test Laboratory or other approved laboratory and until the results of such tests are found satisfactory, it shall not be used in any work.

Aggregates

Aggregate in general designates both fine and coarse inert materials used in the manufacture of concrete.

Fine aggregate is aggregate most of which passes through 4.75 mm IS sieve.

Coarse aggregate is aggregate most of which is retained on 4.75 mm IS sieve. Aggregate shall comply with requirement of IS 383. As far as possible preference shall be given to machine broken and graded aggregate.

All fine and coarse aggregates proposed for use in the work shall be subject to the Employer's Representative's approval and after specific materials have been accepted, the source of supply of such materials shall not be changed without prior approval of the Employer's Representative.

Aggregate shall, except as noted above, consist of natural sand, crushed stone and gravel from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, strong, hard, durable against weathering, of limited porosity and free from deleterious materials that may cause corrosion to the reinforcement or may impair the strength and/or durability of the concrete. The grading of aggregates shall be such as to produce a dense concrete of specified strength and consistency that will work readily into position without segregation and shall be based on the mix design and preliminary test on concrete specified.

The maximum percentages of permissible deleterious materials shall be as follows, subject to total combined impurities, limit of 5 percent by weight.

Impurity	Coarse Aggregate		Fine Aggregate	
	Crushed	Uncrushed	Crushed	Uncrushed
Clay lumps	1	1	1	1
Soft fragments	3	-	-	-
Fine material passing through 75 micron sieve	3	1	3	3
Shale	-	-	1	-
Coal, lignite	1	1	1	1

(i) Specific Gravity

Aggregates having a specific gravity below 2.6 (saturated surface dry basis) shall not be used without special permission of the Employer's Representative.

(ii) Fine Aggregate

Fine aggregate except as noted above and for other than light weight concrete shall consist of natural or crushed sand conforming to IS 383. The sand shall be clean, sharp, hard, strong and durable and shall be free from dust, vegetable substances, adherent coating, clay, loam, alkali, organic matter, mica, salt or other deleterious substances which can be injurious to the setting qualities, strength or durability of the concrete.

Machine Made Sand: Machine made sand will be acceptable, provided the constituent rock composition is sound, hard, dense, non-organic, uncoated and durable against weathering. Machine made sand shall be accepted provided grading and fine particle limits conform to IS 383.

Screening and Washing: Sand shall be prepared for use by such screening or washing or both, as necessary, to remove all objectionable foreign matter while separating the sand grains to the required size fractions. Sand with a silt content of more than 3 percent will not be used unless the same is washed and silt content is brought within 3% by weight.

Foreign Material Limitations: The percentages of deleterious substances in sand, delivered to the mixer shall not exceed the following:

	Foreign Material	Percent by Weight	
		Uncrushed	Crushed
i.	Material finer than 75 micron IS sieve	3	15
ii.	Shale	1	---
iii.	Coal and lignite	1	1
iv.	Clay lumps	1	1
v.	Total of all above substances including items (i) to	5	2

	Foreign Material	Percent by Weight	
		Uncrushed	Crushed
	(iv) for uncrushed sand and items (iii) and (iv) for crushed sand		

Gradation: Unless otherwise approved, the grading of sand shall be within the limits indicated. Where the grading falls outside the limits of any particular grading zone of sieves, other than the 600 micron (IS) sieve by not more than 5%, the grading shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron (IS) 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. Fine aggregates conforming to Grading Zone IV shall not be used unless mix designs and preliminary tests have shown its suitability for producing concrete of specified strength and workability.

IS Sieve Designation	Percentage passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
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

Fineness Modulus: The sand shall have a fineness modulus of not less than 2.2 or more than 3.2. The fineness modulus is determined by adding the cumulative percentages retained on the following IS sieve sizes (4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron and 150 micron) and dividing the sum by 100.

(iii) Coarse Aggregate

Coarse aggregate for concrete, except as noted above and for other than light weight concrete, shall conform to IS 383. This shall consist of natural or crushed stone and gravel and shall be clean and free from elongated, flaky or laminated pieces, adhering coatings, clay lumps, coal residue, clinkers, sag, alkali, mica, organic matter or other deleterious matter.

Screening and Washing: Crushed rock shall be screened and/or washed for the removal of dirt or dust coating, if so required by the Employer’s Representative.

Grading: Coarse aggregates shall be either single size or graded. The grading shall be within the limits on the table below. The aggregate pieces shall be angular in shape and shall have granular or crystalline surfaces.

Friable, flaky and laminated pieces, mica and shale, if present, shall be only in such quantities that will not, in the opinion of Employer’s Representative, affect adversely the strength and/or durability of concrete.

The maximum size of coarse aggregate shall be the maximum size specified, but in no case greater than 1/4 of the minimum thickness of the member, provided that the concrete can be placed without difficulty to surround all reinforcement thoroughly and fill the corners of form.

Cobbles above 160 mm and up to any reasonable size can be used in plain mass concrete work of large dimensions up to a maximum limit of 20% by volume of concrete when specifically approved by the Employer's Representative.

For heavily reinforced concrete members, the nominal maximum size of the aggregate shall be 5 mm less than the minimum clear distance between the reinforcing main bars or 5 mm less than the minimum cover to the reinforcement whichever is smaller. The amount of fine particles occurring shall not exceed 1% when determined by laboratory sedimentation tests as per IS 2386. After 24 hours immersion in water, a previously dried sample shall not have gained more than 10% of its oven dry weight in air, as determined by IS 2386.

IS Sieve Design	**Percentage passing for single sized aggregate of nominal size**					**Percentage passing for Graded aggregate of nominal size**			
	40 mm	**20 mm**	**16 mm**	**12.5 mm**	**10 mm**	**40 mm**	**20 mm**	**16 mm**	**12.5 mm**
63 mm	100	--	--	--	--	100	--	--	--
40 mm	85 - 100	100	--	--	--	95 - 100	100	--	--
20 mm	0 – 20	85–100	100	--	--	30 – 70	95–100	100	--
16 mm	--	--	85–100	100	--	--	--	90–100	--
12.5 mm	--	--	--	85-100	100	--	--	--	90- 100
10 mm	0 – 5	0 - 20	0 - 30	0 - 45	85-100	10 - 35	25 - 55	30 – 70	40 - 85
4.75 mm	--	0 – 5	0 – 5	0 – 10	0 – 20	0 – 5	0 – 10	0 – 10	0 – 10
2.36 mm	--	--	--	--	0 – 5	--	--	--	--

Foreign Material Limitations: The percentages of deleterious substances in the coarse aggregate delivered to the mixer shall not exceed the following:

	Foreign Material	**Percent by weight**	
		Uncrushed	**Crushed**
i.	Material finer than 75 micron IS sieve	3	3
ii.	Coal and lignite	1	1
iii.	Clay lumps	1	1
iv.	Soft fragments	3	--
v.	Total of all the above substances	5	5

Water

Water for mixing concrete shall be clean and free from harmful impurities, such as silt, organic materials, acids, alkalis, salts and oils. In general the water used shall be of potable quality. In case of doubt, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time test specified in IS 456 - 2000. The sample of water taken for testing shall be typical of the water proposed to be used for concreting with due account being paid to seasonal variations. The samples shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.

Average 28 days compressive strength of at least three 150 mm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water as per IS -516.

The initial setting time of test blocks made with the cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by more than (+/-) 30 minutes from the initial setting time of control test blocks prepared with the same cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of IS 4031(Part 5).

Where water contains an excess of acid, alkali, sugar or salt, the Employer's Representative may refuse to permit its use. The following concentrations represent the maximum permissible values:

1 **Limits of acidity:** To neutralize 100 ml sample of water, using phenolphthalein as an indicator, it should not require more than 5 ml. of 0.02 normal NaOH. The details of test shall be as per IS 3025 (Part 22)

2 **Limits of alkalinity:** To neutralize 100 ml sample of water, using mixed indicator, it should not require more than 25 ml. of 0.02 normal H_2SO_4. The details of test shall be as per IS 3025 (Part 23).

3 **Limits for Solids:** Permissible limits for solids in the water shall be as below:

Solids	Percent	Method of Test (ref IS : 3025)
Organics	0.02	10 and 11 (organic solids = total solids minus ignited residue)
Inorganics	0.30	11 (ignited residue)
Sulphates (as SO_4)	0.05	20
Alkali chloride (as Cl)	0.20	24
Suspended matter	0.20	12

4 **pH:** The pH value of water shall be not less than 6.

Admixtures

Admixtures may be used in concrete only with the approval of Employer's Representative based upon evidence that, with the passage of time, neither the compressive strength nor the durability will be reduced. When admixtures are used, the concrete mix design shall be amended accordingly. Admixtures shall be used as per manufacturers' instructions and in the manner and with the control as necessary or as specified by Employer's Representative.

The addition of admixtures during mixing to alter the properties of the concrete mix shall only be with the approval of the Employer's Representative in regard to quality, quantity and redesign of the mix and accompanied by separate preliminary tests.

Admixtures, if used, shall comply with IS 9103. Previous experience with and data on such materials should be considered in relation to the likely standards of supervision and workmanship to the work being specified. Admixtures should not impair durability of the concrete or combine with the constituent to form harmful compounds or increase the risk of corrosion of reinforcement.

The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

The relative density of liquid admixtures shall be checked for each drum containing admixtures and compared with the specified value before acceptance.

The chloride content of the admixtures shall be independently tested for each batch before acceptance. If two or more admixtures are used simultaneously in the same concrete, mix data should be obtained to assess their interaction and to ensure their compatibility.

(i) Calcium Chloride

Calcium chloride shall not be used for accelerating the setting of the cement for any concrete containing reinforcement or embedded steel parts.

(ii) Air Entraining Agents

Neutralized vinsol resin or any other approved air entraining agent may be used to produce the specified amount of air in the concrete mix and these agents shall conform to the requirements of ASTM standard 6.260, Air Entraining Admixtures for Concrete if approved by the Employer's Representative. The recommended total air content of air entrained concrete is 4% (+/-) 1%. The method of measuring air content shall be as per IS1199.

(iii) Retarding Admixtures

Where prior approval has been given by the Employer's Representative, retarding agents may be added to the concrete mix in quantities in accordance with the manufacturer's recommendations.

(iv) Water Reducing Admixtures

Where prior approval has been given by the Employer's Representative, water reducing lignosulfonate mixture shall be added in quantities in accordance with the manufacturer's recommendations. The admixtures shall be added in the form of a solution.

(v) Waterproofing Agents

Where prior approval has been given by the Employer's Representative, chloride and sulphate free waterproofing agents shall be added in quantities in accordance with the manufacturer's recommendations.

(vi) Other Admixtures

The Employer's Representative may, at his discretion, approve the Contractor to use any other admixture in the concrete.

Fly Ash

The fly ash should have consistent quality satisfying the requirements of IS 3812 Parts I and II.

The source of fly ash should be so selected that test results of fly ash samples collected from these sources during last one year at a frequency of maximum one month intervals should satisfy the requirements of above codes.

The characteristics of fly ash to be used shall be as per the above two codes for each batch of fly ash.

If more than 15% fly ash is used, IS 3812 shall apply and specific care shall be taken in terms of curing, protecting, repairing, finishing, de-shuttering etc. as detailed in Section 17.6.

Materials Testing

The Employer’s Representative shall have the right to inspect the sources of materials, the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment and the quality control system. The Contractor shall arrange such an inspection and the Employer’s Representative approval shall be obtained prior to starting any concrete work.

The Employer’s Representative, if he so requires, may order tests to be carried out, at the Contractor’s expense, on cement, sand, coarse aggregate, water etc. in accordance with the relevant Indian Standards.

Tests on Cement

Tests on cement shall include (i) fineness tests, (ii) tests for normal consistency, (iii) tests for setting time, (iv) tests for soundness, (v) tests for compressive strength, (vi) tests for heat of hydration (by experiment and by calculations) in accordance with IS269.

Tests on Sand

Tests on sand shall include (i) sieve tests, (ii) tests for organic impurities, (iii) decantation tests for determining clay and silt content, (iv) specific gravity tests, (v) tests for unit weight and bulkage factor, (vi) tests for sieve analysis and fineness modulus.

Tests on Aggregate

Aggregates shall be tested before and after the concrete mix is established and whenever there is a change of the source or character of the materials.

Sampling of the aggregates for mix design and determination of suitability shall be taken under the supervision of the Employer’s Representative and delivered to the laboratory, well in advance of the schedule for placing of concrete. Records of tests which have been made on proposed aggregates and on concrete made from this source of aggregates shall be furnished to the Employer’s Representative in advance of the work for which it is to be used, in determining suitability of the proposed aggregate.

Tests on coarse aggregate shall include (i) sieve analyses, (ii) specific gravity and unit weight of dry, loose and rodded aggregate, (iii) soundness and alkali aggregate reactivity, (iv) petrographic examination, (v) deleterious materials and organic impurities, (vi) tests for aggregate crushing value.

Additional tests on aggregates would normally only be carried out if the Employer’s Representative feels the materials are not in accordance with the specifications or if the specified concrete strengths are not obtained and shall be performed by the Contractor, at the Contractor's expense, at an approved test laboratory.

Tests on Water Stops

The water stops shall be tested in accordance with the Central Water Commission (India) standards and shall have the following properties:

Characteristics	Properties
Tensile strength	116 kg/cm^2 minimum (162 kg/cm^2 min. for rubber)
Ultimate elongation	300% minimum (500% minimum for rubber)
Tear resistance	49 kg/cm^2 minimum
Stiffness in flexure	25 kg/cm^2 minimum
Accelerated extractions	105 kg/cm^2 minimum (150 kg/cm^2 Minimum for rubber)
Ultimate elongation	250% minimum (350% minimum for rubber)
Effect of alkali (7 days):	
Weight increase	0.25% maximum
Weight decrease	0.10% maximum
Hardness change	+ 5 point
Effect of alkali (28 days):	
Weight increase	0.40% maximum
Weight decrease	0.30% maximum
Dimension change	+ 1%

Concrete Grades

The concrete used on the works of this project shall be of one of the following grades:

Grade	Minimum Crushing Strength of 150 mm cube at 28 days. In kg/cm^2	
	Preliminary and Trial Mix Tests	Work Tests
M-10	135	100
M-15	200	150
M-20	260	200
M-25	320	250
M-30	380	300
M-35	440	350

1 The characteristic strength is defined as the strength of material below which not more than 5% of the test results are expected to fall.

2 In the designation of a concrete mix, the letter M refers to the mix and the number to the specified characteristic compressive strength of 150 mm size cubes at 28 days expressed in N/ mm^2.

All concrete used on the work shall be dense, sound, homogeneous and durable and free from air voids, bleeding, honeycombing and other allied defects. For grade M-100 the Contractor may be allowed to use an approved nominal mix but for all other grades of concrete, mix designs are obligatory and preliminary test results shall be submitted to the Employer's Representative for approval before the commencement of concreting.

Mixes designed with ordinary Portland cement shall be redesigned if Pozzolona or other cement is to be used. In any event, whether Pozzolona or other cement is used or not, new mix designs shall be submitted for the Employer's Representative's approval for each new batch of cement that is received. To enable this, the cement stocks shall be so stored as to enable easy identification of different batches. Similarly, new mix designs will be required if the source of supply of aggregate is changed or a variation exceeding 10 percent in the sieve analysis is observed from the analysis of the aggregate used in the mix design.

Standard Deviation

The standard Deviation for each grade of concrete shall be calculated separately.

Standard Deviation Based on Test Results

Number of Test Results - The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 test results, as early as possible, when a mix is used for the first time.

Standard deviation to be brought up to date - The calculation of the standard deviation shall be brought up to date after every change of mix design and at least once a month.

Determination of Standard Deviation:

1 Concrete of each grade shall be analysed separately to determine its standard deviation.

2 The standard deviation of concrete of a given grade shall be calculated using the following formula from the results of individual tests of concrete of that grade obtained as specified for test strength of sample:

3 Estimated standard deviation $S = \sqrt{\{\Sigma \Delta^2 / (n-1)\}}$

4 Where Δ = Deviation of the individual test strength from the average strength of a sample and n = Number of sample test results.

5 When significant changes are made in the production of concrete (for example changes in the materials used, mix design, equipments or technical control), the standard deviation value shall be separately calculated for such batches of concrete.

Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in the table below may be assumed for a design of mix in the first instance. As soon as the results of samples are available, actual calculated standard deviation shall be used and the mix designed properly. However, when adequate past records for a similar grade exist and justify to the designer a value of standard deviation different from that shown in table below, it shall be permissible to use that value.

Grade of Concrete	Assumed Standard Deviation N/mm^2
M 10 M 15	3.5
M 20 M25	4.0

Grade of Concrete	Assumed Standard Deviation N/mm^2
M30 M35 M40 M45 M50	5.0

Note: The above values correspond to the site control having proper storage of cement: weigh batching of all materials: controlled addition of water: regular checking of all materials: aggregate grading and moisture content: and periodical checking of workability: and strength. Where there is a deviation from the above, the values given in the above table shall be increased by 1 N / mm^2.

Mix Designs

The quality of materials and method and control of manufacture and transportation of all concrete work in respect of a mix, whether reinforced or otherwise, shall be Design Mix Concrete as defined in IS 456-2000 and conform to the applicable portions of these specifications. The provision of IS 456-2000 with amendment no.3 should be followed scrupulously for cement concrete and R.C.C.

The different concrete mixes shall be designed by the Contractor for strength, workability and durability of the concrete and shall be strictly in compliance with the relevant standards. If it is found that an increase in the proportion of cement is necessary, the requisite adjustment shall be made. Batching shall be by weight and the combined aggregate shall have a continuous grading. The mixes should produce an average 28 day cube strength not less than that specified in Section 17.3 for trial mix tests for the relevant grade. In the case of concrete for water retaining structures, the cement content shall be a minimum of 400 kg/m^3 of concrete. When admixtures are used, the mixes shall be redesigned with the test strengths conforming to those specified in Section 17.3. The workability of the mix shall permit satisfactory compaction with vibration, with no tendency to aggregate during handling, transporting and compaction.

In exceptional cases, where the reinforcement is so crowded that the compaction is difficult, the value of slump may be increased with the explicit approval of the Employer's Representative, but in no case shall it exceed 15 cm. Any increase in the slump beyond the values given shall be obtained by the use of additional cement in such quantities as to restrict the water-cement ratio to the maximum specified values. Special care shall be taken in the case of M-25 concrete where the water-cement ratio should not exceed 0.45 under any circumstances.

The minimum cement contents of the different grades shall be as follows, in kg/m^3 of concrete mixed and ready to be placed:

Grade	Cement Content (kg/m^3)
M-15	240
M-20	300
M-25	300
M-30	320
M-35	400

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions stated in mineral admixtures. The additions of such as fly ash

or ground granulated 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 pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

Adjustment of Minimum Cement Content

The adjustments to minimum cement contents should be made for aggregates other than 20 mm nominal maximum size as shown in the table below:

No	Nominal maximum aggregate size mm	Adjustments to minimum cement content kg/ m^3
i)	10	+40
ii)	20	0
iii)	40	-30

1 For concrete of compressive strength greater than M-55 given design parameters may not be applicable and the values may be obtained from specialized literature and experimental results.

2 The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than the appropriate values given in the table above.

Degree of Control

Selection of Water Cement Ratio: Since different cements and aggregates of different maximum size, grading, surface texture, shape and other characteristics may produce concretes of different compressive strength for the same free water cement ratio, the relationship between strength and free water-cement ratio should be established for the materials actually to be used. In the absence of such data, the preliminary free water-cement ratio (by mass) corresponding to the target strength at 28 days may be selected from the relationship shown in Fig.1 of IS 10262.

Alternatively, the preliminary free water cement ratio (by mass) corresponding to the target average strength may be selected from the relationship in Fig.2- IS 10262, using the curve corresponding to the 28 day cement strength to be used for the purpose.

Other relevant items to be used with design of mix should strictly conform to the relevant clauses and appendices of IS 10262.

The calculated mix proportions shall be checked by means of trial batches as per IS 10262.

The free water cement ratio, selected as above, should be checked against the limiting water cement ratio for the requirement of durability and the lower of the two values should be adopted.

Whenever there is a change either in required strength of concrete or water cement ratio or workability or the source of aggregates and/or cement, fresh tests shall be carried out to determine the revised proportion of the mix to suit the altered conditions. While designing mix proportions, over-wet mixes shall always be avoided.

While fixing the value for water cement ratio for the design mix, assistance may be derived from the standard graph showing the relationship between the 28 day compressive strength of concrete mixes with different water-cement ratios and the 7 day compressive strength of cement tested in accordance with IS 269.

It will be the Contractor's sole responsibility to establish the concrete mix designs for different grades of concrete required in the work consistent with the workability required for the nature of work and also taking into consideration the assumed standard deviation to be expected at the site or by establishing the standard deviation based on 30 test results for each grade of concrete to produce concrete of the required strength, durability and surface finish. The materials and proportions used in making the tests to be carried out either at site or under laboratory conditions shall be similar in all respects to those to be actually employed in the works, as the object of these tests is to determine the proportions of cement, aggregates and water necessary to produce the concrete of the required consistency to give such specified strength.

Proportioning

(i) Aggregate

The proportions to be determined by conducting preliminary tests, shall be by weight. These proportions of cement, fine and coarse aggregates shall be maintained during subsequent concrete batching by means of weigh batchers conforming to IS 2722, capable of controlling the weights within one percent of the desired value. Except where it can be shown to the satisfaction of the Employer's Representative, that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions. The different sizes shall be stacked in separate stockpiles. The gradings of coarse and fine aggregates shall be checked as frequently as practicable, as determined by the Employer's Representative, to ensure maintaining of grading in accordance with samples used in the preliminary mix design. The materials shall be stockpiled well in advance of use.

(ii) Cement

The cement shall be measured by weight. Every facility should be provided to the Employer's Representative for sampling and inspection of stored cement at the site.

(iii) Water

Only such quantity of water shall be added to the cement and aggregate in the concrete mix as to ensure dense concrete, specified surface finish, and satisfactory workability consistent with the strength stipulated for each class of concrete. The water added to the mix shall be such as not to cause segregation of materials or the collection of excessive free water on the surface of the concrete.

Definition of Water Cement Ratio

The water cement (W/C) ratio is defined as the weight of water in a mix (including the surface moisture of the aggregates) divided by the weight of the cement in the mix.

Water Cement Ratio

The actual water cement ratio to be adopted shall be determined in each instance by the Contractor and approved by the Employer's Representative.

Proportioning by Water-Cement Ratio

The W/C ratios as approved by the Employer's Representative shall be maintained. Contractor shall determine the water content of the aggregate as frequently as approved by the Employer's Representative as the work progresses and as specified in IS 2386 part III and the amount of mixing water added at the mixer shall be adjusted as approved by the Employer's Representative to maintain the specified W/C ratio. To allow for the variation in their moisture content, suitable adjustments in the weights of aggregates shall also be made.

(iv) Concrete in Alkali Soils, Water & Aggregates

Some aggregates containing particular varieties of silica may be susceptible to attack by alkalis (Na_2O and K_2O) originating from cement and other sources, producing an expansive reaction which can cause cracking and disruption of concrete. Damage to concrete from this reaction will normally only occur when all the following are present together.

1 A high moisture level, within the concrete;

2 A cement with high alkali content, or another source of alkali;

3 Aggregate containing an alkali reactive constituent.

Where the service records of particular cement / aggregate combination are well established and do not include any instances of cracking due to alkali-aggregate reaction, no further precautions should be necessary. When the materials are unfamiliar, precautions should take one or more of the following forms:

1 Use of non-reactive aggregate from alternate sources

2 Use of low alkali ordinary Portland cement having total alkali content not more than 0.6 per cent (as Na_2O equivalent).

Further advantages can be obtained by the use of fly ash (Grade I) conforming to IS 3812 or granulated blast furnace slag conforming to IS 12089 as part replacement of ordinary Portland cement (having total alkali content as Na_2O equivalent not more than 0.6 percent), provided that the fly ash content is at least 20 % or slag content is at least 50%.

1 Measures to reduce the degree of saturation of the concrete during service such as the use of impermeable membranes

2 Limiting the cement content in the concrete mix and thereby limiting total alkali content in the concrete mix as approved by the Employer's Representative.

(v) Chlorides in the Concrete

Whenever there are chlorides in concrete, there is an increased risk of corrosion to the embedded metal. The higher the chloride content, and if subsequently exposed to warm moist conditions, the greater the risk of corrosion. All constituents may contain chlorides and concrete may be contaminated by chlorides from the external environment. To minimise the chance of deterioration of concrete from harmful chemical salts, the levels of such harmful salts in concrete materials, as well as by diffusion from the environment should be limited. The total amount of chloride content (as Cl) in the concrete at the time of placing shall be as given below in the table.

Limits of Chloride Content of Concrete

Sr. No.	Type or Use of Concrete	Maximum Total Acid soluble Chloride Content Expressed as kg/m^3 of Concrete.
i)	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete	0.4
ii)	Reinforced concrete or plain concrete containing embedded metal	0.6

Sr. No.	Type or Use of Concrete	Maximum Total Acid soluble Chloride Content Expressed as kg/m^3 of Concrete.
iii)	Concrete not containing embedded metal or any material requiring protection from chloride	3.0

The total acid soluble chloride content should be calculated from the mix proportions and the major chloride contents of each of the constituents. The total chloride content of the concrete should be determined to the approval of the Employer's Representative.

(vi) Sulphates in Concrete

Sulphates are present in most cements and in some aggregates. Excessive amounts of water-soluble sulphate from these or other mix constituents can cause expansion and disruption of concrete. To prevent this, the total water-soluble sulphate content of the concrete mix, expressed as SO_3, should not exceed 4 % by mass of the cement in the mix. The sulphate content should be calculated as the total from the various constituents of the mix to the approval of the Employer's Representative.

The 4% limit does not apply to concrete made with super sulphated cement complying with IS 6909 or as otherwise approved by the Employer's Representative.

Consistency and Slump

Concrete shall be of a consistency and workability suitable for the conditions of the job. After the amount of water required is determined, the consistency of mix shall be maintained throughout the progress of the corresponding parts of the work and approved tests e.g. slump tests, compacting factor tests etc. in accordance with IS 1199, which shall be conducted from time to time to ensure the maintenance of such consistency.

The following tabulation gives a range of workability which shall generally be used for various types of construction unless otherwise instructed by the Employer's Representative.

Workability of Concrete:

Placing Condition	Degree of Workability	Slump (mm)
Blinding concrete; Shallow sections; Pavement using pavers	Very low	See note 1
Mass concrete; lightly reinforced sections in slabs, beams, walls, columns; floors; hand placed pavements; canal linings; strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns, slip form work; pumped concrete	Medium	50-100 75-100
Trench fill, in-situ piling	High	100-150
Tremie concrete	Very high	See notes

1 For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete, vibrators are not required to be used.

2 The 'very low' category of workability where strict control is necessary, for example pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (see IS 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

3 In the 'Very high' category of workability, measurement of workability by determination of flow will be appropriate (see IS 9103).

When tested in accordance with IS 1199, the consistency of the concrete should be such that the maximum slumps, unless otherwise specified or permitted by the Employer's Representative do not exceed the following values.

Part of Structure	Maximum Slump (mm)
Footings and un-reinforced mass concrete	76
Slab and Floors	76
Columns, walls over 200 mm thick	102
Walls up to 200 mm thick	102
Equipment bases	127

Batching

To avoid confusion and error in batching, consideration shall be given to using the smallest practical number of different concrete mixes on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass; admixture, if solid, by mass; liquid admixture may however be measured in volume or mass; water shall be weighed or measured by volume in a calibrated tank (see also IS4925).

For large and medium project sites, concrete shall be sourced from ready-mixed concrete plants or from on-site or off-site batching and mixing plants (see IS 4926).

Except where it can be shown to the satisfaction of the Employer's Representative that supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading of aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending it in the right proportions when required, the different sizes being stocked in separate stockpiles.

The accuracy of the measuring equipment shall be within +/- 2% of the quantity of cement being measured and within +/- 3 percent of the quantity of aggregate, admixtures and water being measured.

Volume batching shall be allowed only where weigh-batching is not practical and provided accurate bulk densities of materials to be used in concrete have already been established. Allowance for bulking shall be made in accordance with IS 2386 (Part 3). The mass volume relationship shall be checked as frequently as necessary, the given frequency being subject to the approval of the Employer's Representative to ensure that the specified grading is maintained.

The water-cement ratio shall be maintained at its correct value. To this end, determination of the moisture content in both the fine and coarse aggregates shall be made as frequently as possible, the given frequency being subject to the approval of the Employer's Representative according to weather conditions. The amount of the added water shall be adjusted to compensate for any observed variations in the moisture content. For the determination of moisture content in the aggregates IS 2386 (Part 3) shall be followed. To allow for the variation in the mass of aggregate due to variation in its moisture content, suitable adjustments in the masses of aggregates shall also be made. In the absence of exact data, and in the case of nominal mixes the amount of surface water may be estimated from the values given in table below.

Surface water carried by aggregate

Aggregate	Approximate quantity of surface water	
	Percent by mass	**l/m^3**
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist gravel or crushed rock	1.25-2.5	20-40
The coarser aggregate the less water it will carry		

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

Mixing

Concrete shall be mixed in a mechanical mixer. The mixers shall comply with IS 1791 and IS 12119. The mixers shall be fitted with water measuring devices. 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 remixed.

The mixing time shall be at least two minutes. For more efficient mixers, manufacturers recommendations shall be followed.

The dosage of retardants, plasticisers and super-plasticisers shall be restricted to 0.5, 1.0 and 2.0 % respectively by weight of cementitious materials unless a higher value is agreed between the manufacturer and the Contractor based on performance tests.

Each time the work stops, the mixer shall be cleaned out and when next commencing the mixing, the first batch shall have 10% additional cement to allow for sticking in the drum.

Cast-in-Place (In-Situ) Concrete

Execution

i) Preparation for Placing

All excess water shall be removed from the forms before concrete is placed. No flow of water shall be admitted to the section being concreted. The interior faces of forms shall be cleaned and any hard concrete, debris or foreign material shall be removed. The inner faces of the mixing and conveying equipment shall be similarly cleaned.

Reinforcement shall be secured, inspected and approved in compliance with the relevant specifications and shall be inspected and approved. Embedded metal shall be clean and free of old mortar, oil, mill scale and other encrustations and coatings. Wheeled concrete handling equipment shall pass over reinforcement nor shall walkways be supported on reinforcement.

Any earth sub-grade on which concrete is to be deposited shall be wetted lightly 24 hours in advance of concreting but not muddied. Re-rolling shall be carried out, where necessary, to create a smooth surface and all loose materials removed.

Where placement of concrete is directly onto a rock base, the rock surface shall be cleaned and washed and loose material removed with air blower or hosed before concreting. All stagnant water collected on the rock surface shall be removed before concreting.

Where a bond between old and new concrete surfaces is required, the steps and precautions stipulated for construction joints shall be adopted. Where no bond is necessary, the existing surface shall be cleaned, removing any dirt or deleterious material which might interfere with the concreting.

Before concrete is poured, the inside of the formwork shall be inspected to ensure that it has been cleaned and oiled. Temporary openings shall be provided where necessary to facilitate inspection, especially at the bottom of columns and wall forms, to permit removal of sawdust, wood shavings, binding wire, rubbish, dirt etc. Openings shall be placed or holes drilled so that these materials and water can be removed easily. Such openings / holes shall be later suitably plugged.

The Contractor shall install drainage and plumbing lines, floor and trench drains, conduits, hangers, anchors, inserts, sleeves, bolts, frames and other miscellaneous embedments to be cast in the concrete as necessary for the proper execution of the work. All such embedments shall be correctly positioned and securely held in the forms to prevent displacement during the depositing and vibrating of concrete.

Slots, openings, holes, pockets etc. shall be provided in the concrete work in the positions as necessary.

Prior to concrete placement, all works shall be inspected and approved by Employer's Representative and if found unsatisfactory, concrete shall not be poured until all defects have been corrected.

Approval by the Employer's Representative of any and all materials and work as required herein shall not relieve contractor from his obligations to produce finished concrete in accordance with the Contract.

ii) Foundation Bedding and Jointing

All surfaces upon or against which concrete will be placed shall be suitably prepared by thoroughly cleaning, washing and dewatering to meet the various situations encountered in the work.

Soft or spongy areas shall be dug out and back-filled with either a soil cement mixture, lean concrete or clean sand fill compacted to a minimum density of 90% modified Proctor.

iii) Preparation of Rock Strata of Foundations

To provide a tight bond with rock foundations, the rock surface shall be prepared and the following general requirements shall be observed:

Concrete shall not be deposited on large sloping rock surfaces. Where required, the rock shall be cut to form rough steps or benches to provide roughness or a more suitable bearing surface.

Rock foundation stratum shall be prepared by picking, barring, wedging or similar methods which will leave the rock in an entirely sound and un-shattered condition.

Shortly before concrete is placed, the rock surface shall be cleaned with high pressure water and air jet even though it may have been previously cleaned in that manner.

Prior to placing concrete, the rock surface shall be kept wet for a period of at least two hours unless otherwise approved by the Employer's Representative.

Before placing concrete on rock surfaces, all water shall be removed from depressions to permit thorough inspection and proper bonding of the concrete to the rock.

iv) Preparation of Earth Strata of Foundations

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft, yielding soils shall be removed and replaced with suitable earth and well compacted and as approved by the Employer's Representative. Where specified, lean concrete shall be placed on the earth stratum for receiving concrete. The surface of absorptive soil against which concrete is to be placed shall be moistened thoroughly.

v) Preparation of Concrete Surfaces

Preparation of concrete surfaces upon which additional concrete is to be placed, shall be scarified and cleaned while the concrete is between its initial and final set. This method shall be used wherever practicable and shall consist of cutting the surface with picks and stiff brooms and by use of an approved combination of air and water jet and as approved by Employer's Representative. Great care shall be taken in performing this work to avoid removal of too much mortar and the weakening of the surface by loosening of aggregate. When it is not practicable to follow the above method, air tools shall be employed to remove laitance and roughen the surface.

The required final result shall be a pitted surface from which all dirt, unsound concrete, laitance and glazed mortar have been removed.

vi) Cleaning and Bonding of Formed Construction Joints

Vertical construction joints shall be cleaned as specified above or by other methods and as approved by Employer's Representative. In placing concrete against formed construction joints, the surfaces of the joints, where accessible, shall be coated thoroughly with the specified bed-joint bonding mortar immediately before being covered with concrete or by scrubbing with wire brushes, dipped into the fresh concrete. Where it is impracticable to apply such a mortar coating, special precautions shall be taken to ensure that the new concrete is brought into intimate contact with the surface of the joint with the aid of vibrators and other suitable tools.

vii) Positioning of Water Stops

Water stops shall be provided in the available maximum lengths and as far as possible, jointing shall be avoided. All joints, when unavoidable, shall be field jointed for water tightness as per manufacturer's specifications.

The water stops shall be positioned with suitable temporary supports to render adequate rigidity to the water stops while concreting. The exposed surfaces of water stops revealed after first concreting shall be cleaned thoroughly of all the droppings, mortar splashings etc. before the next pour of concrete.

viii) Bonding Treatment (Mortar)

All rock or concrete surfaces upon which new concrete is to be placed shall be scarified, cleaned and wetted as specified herein.

Immediately prior to placing new concrete, the scarified surface of the existing concrete shall be thoroughly wetted.

ix) Cleaning of Equipment

All equipments used for mixing, transporting and placing of concrete shall be maintained in clean condition. All pans, buckets, hoppers, chutes, pipe lines and other equipments shall be thoroughly cleaned after each period of placement.

x) Conveying and Placing Concrete

Concrete shall be poured or placed only after the forms and reinforcement have been inspected and approved, for which purpose the Contractor shall give the Employer's Representative at least two day's notice. Generally, the use of aluminium equipment shall not be permitted in any operation where the equipment and concrete are likely to come in contact with each other, unless the aluminium surfaces have to be adequately treated to prevent reaction with and having a harmful effect on the concrete.

All buckets, containers or conveyers used for transporting concrete shall be mortar-tight. All means of conveyance shall be adopted to deliver concrete of the required consistency and plasticity without segregation or loss of slump whatever method of transportation is employed. Chutes shall not be used to transport the concrete without the approval of the Employer's Representative and concrete shall not be re-handled before placing.

Conveying - Concrete shall not be released from a mixer, hopper, frame or other conveyance or device through a height exceeding two metres or through reinforcement, in a manner likely to cause segregation. Tremmies discharging close to the point of concreting shall be provided as required. The use of chutes will be restricted to specific locations approved by the Employer's Representative. Concrete shall be deposited directly into the conveyance and from the conveyance directly into the locations in the structure. Deposition of concrete shall be so done to maintain, as far as possible, a level surface throughout. Manual labour may be used for conveying and placing mixed concrete provided the above requirements are not contravened.

Placing Concrete - Concrete shall be placed in position and compacted within 30 minutes after the first addition of water to the mix and no concrete showing signs of initial set shall be used. Re- tampering of set concrete is prohibited.

1 Lifts: Concrete shall be poured into forms after mixing in a manner that will prevent segregation of the ingredients. In order to minimise lateral movement of the concrete in the forms, the points of deposition of the concrete shall not be greater than 2m apart.

   a. Walls: Concrete for walls of water retaining structures, including tank exterior walls, shall be poured, where practicable, as one continuous operation from footing to top of the wall. Each section shall be left in place at least seven days before the adjoining section in similarly concreted.

   b. Slabs: Concrete between approved joints shall be poured in one continuous operation in checker-board fashion and shall be allowed to stand at least seven days before adjoining sections are concreted.

   c. Concreting of beams and slabs shall be continuous and monolithic with the floor.

2 Pumping Concrete: No increase in the water-cement ratios or specified slumps will be permitted to pumped concrete. The minimum conveyance tube shall be minimum diameter of 100 mm and capable of maintaining the specified pour rates.

3 Pour Rules:

   a. Vertical Elements: concrete shall be placed in lifts as specified at a rate that does not cause excessive stresses in the formwork or a hardening of the top layer before next lift is poured.

b. Slabs :Concrete shall be poured at an appropriate time that ensures that all new concrete poured is adjoined to concrete that is still plastic and before the initial set of the previous placing.

c. Construction Joints: Concreting adjoining a construction joint shall not be until the existing surface has been cured for at least seven days, unless otherwise approved by the Employer's Representative.

Before any concrete is placed, the entire placing programme, consisting of equipment, layout, proposed procedures and methods shall be submitted to Employer's Representative for approval and no concrete shall be of such size and design as to ensure a practically continuous flow of concrete during depositing without segregation of materials, considering the size of the job and placement location.

xi) Time Interval between Mixing and Placing

Concrete shall be placed in its final position before the cement reaches its initial set and concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer and once compacted, it shall not be disturbed. On no account shall water be added after the initial mixing. Concrete which has become stiff or has been contaminated with foreign materials shall be rejected.

xii) Avoiding Segregation

Concrete shall, in all the cases, be deposited as nearly as practicable directly in its final position and shall not be re-handled or caused to flow in a manner which will cause segregation, loss of material, displacement of reinforcement, shuttering or embedded inserts or impair its strength. For locations where direct placement is not possible and in narrow forms, the Contractor shall provide suitable props and discharge pipes to confine the movement of concrete. Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in columns and thin walls.

xiii) Placing by Manual Labour

Except as otherwise approved by Employer's Representative, concrete shall be placed using approved implements and shall not be dropped from a height of more than 2.0 m or handled in a manner which will cause segregation.

xiv) Placing by Mechanical Equipment

The following specifications shall apply when placing of concrete by use of mechanical equipment is specially called for or is warranted, considering the nature of work involved.

The control of placing shall begin at the mixer discharge. Concrete shall be discharged by a vertical drop into the middle of the bucket or hopper and this principle of a vertical discharge of concrete shall be adhered-to throughout all stages of delivery until the concrete comes to rest in its final position.

All concrete shall be conveyed from the mixer to the place of final deposit in suitable buckets, dumpers or containers which shall be leak-tight. All means of conveyance shall be adopted for delivering concrete to the required consistency/ workability and plasticity without segregation.

Central bottom-opening buckets of a type that provides for positive regulation of the amount and rate deposition of concrete shall be employed.

In placing concrete in large open areas, the buckets shall be located directly over the position designated and then lowered for dumping. The open bucket shall remain clear of any concrete already in place and the height of drop shall not exceed 2.0 m.

The bucket shall be opened slowly to avoid high vertical bounce. The placing of concrete in any manner which results in separation of ingredients or disturbance of previously placed concrete will not be permitted.

xv) Placement in Restricted Forms

Concrete placed in restricted forms shall be subject to the requirements for vertical delivery of limited height to avoid segregation and shall be deposited as nearly as practicable in its final position.

xvi) Chuting

Where it is necessary to use transfer chutes, specific approval of the Employer's Representative must be obtained with regards to the type, length, slopes, baffles, vertical terminal and timing of operations. These shall be arranged so that almost continuous flow of concrete is obtained at the discharge and without segregation. To allow for the loss of mortar against the sides of the chutes, the first mixes shall have less coarse aggregate. During cleaning of chutes, the waste water shall be kept clear of the forms. The concrete shall not be permitted to fall from the end of the chutes by more than 1.0 m. Chutes, when approved for use, shall have slopes not flatter than 1 vertical to 3 horizontal and not steeper than 1 vertical to 2 horizontal. Chutes shall be metal and of rounded cross section. The slopes of all chute sections shall be approximately the same. The discharge end of the chutes shall be maintained above the surfaces of the concrete in the forms.

xvii) Placing by Pumping/ Pneumatic Placers

Concrete may be conveyed and placed by mechanically operated equipment e.g. pumps or pneumatic placers, with the approval of Employer's Representative. The slump shall be held to the minimum, necessary for conveying concrete by this method.

When pumping is adopted, before pumping of concrete is started, the pipelines shall be lubricated with one or two batches of mortar composed of one part cement and two parts sand. The concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

When pneumatic placing is used, the manufacturer's advice on the layout of pipelines shall be followed to avoid blockages and excessive wear. Restraint shall be provided at the discharge box to cater for the reaction at the end.

The manufacturer's advice shall be followed regarding concrete quality and all other related matters when pumping or pneumatic placing equipment is used.

xviii) Concrete in Layers

Concreting, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive horizontal layers of uniform thickness ranging between 150 and 900 mm as approved by Employer's Representative. These shall be placed as rapidly as practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit, shall be located progressively along the face of the layer with such overlap to facilitate spreading the layer of uniform depth and texture with a minimum of shovelling.

The top surface of each pour and bedding planes shall be approximately horizontal unless otherwise instructed.

xix) Compaction

Effective compaction of newly placed concrete shall be obtained by vibration, agitation, spading and rodding the concrete within the forms. At least two vibrators in dependable working condition shall be available before commencement of concreting and kept in working condition during the scheduled concreting period, each under the charge of an experience workman.

All concrete, excepting slabs of thickness 10 cm or less, shall be compacted with high frequency, mechanical vibrating equipment supplemented by hand spading and tamping. Concrete slabs 10 cm or less in thickness shall be compacted by wood or metal tampers, spading and settling with a heavy levelling straight edged beam.

Vibrators shall be designed to operate with the vibrating element having a frequency of not less than 7,000 impulses per minute. The equipment shall, at all times, be adequate, in terms of units and power, to consolidate the poured concrete. The depth of immersion shall be appropriate for the structure being concreted and the location of concreting.

The vibrators shall not touch the reinforcement. When vibrating a freshly placed layer, the vibrator shall be pushed down vertically into the preceding plastic layers and withdrawn gradually, producing a dense concrete free of set concrete. The intervals at which the vibrator should be immersed shall not exceed 2/3 of the apparent effective area of vibration of the unit used. Excessive vibration and segregation of aggregates shall be avoided.

For concrete containing an approved retarding admixture for structural walls, each layer of concrete shall be in place and compacted for at least 30 minutes before the next layer is placed. Bleed water on the surface of the concrete shall be removed before additional concrete is placed and the concrete in place shall be re-vibrated before the next lift is placed. At the top of walls and columns, concrete containing excess water or fine aggregates cause by vibration shall be removed while still plastic and the space filled with compacted concrete of the correct proportion and vibrated in place.

xx) Slabs

For slabs, screeds shall be set at maximum of 2.5 metres. Centres and the correctness of elevations shall be checked with an instrument level. The concrete shall be compacted and tamped to bring ten mm of mortar to the surface and wood floated to straight edges and screeds. The finished surfaces shall be level or sloped as required and the maximum deviation permissible being 6 mm from 3 m straight edge for the exposed finishes. No steel or plastic floats shall be used for initial floating. Unless otherwise specified, special finishes shall be applied only after the surface has sufficiently hardened. All laitance and bleed water shall be removed as it appears.

Concrete shall be compacted during placing with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, is free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms or against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution is to be exercised to not over vibrate the concrete to the point of segregation.

xxi) Vibrators

Vibrators shall conform to IS specifications. The type of vibrators to be used shall depend upon the structure where concrete is to be placed. Shutter vibrators, to be effective, shall be firmly secured to the formwork which must be sufficiently rigid to transmit the vibrations and strong enough not to be damaged by it. Immersion vibrators shall have load frequency amplitude and acceleration as per IS 2505 depending on the size of the vibrator. Immersion vibrators, in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

The exact manner of application and the most suitable machines for the purpose shall be selected and be operated by experienced operatives. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention shall be paid to vibration at the top of lift in a column or wall.

When placing concrete in layers which are advancing horizontally as the work progress, great care shall be exercised to ensure adequate vibration, blending and melding of the concrete between the successive layers.

Immersion vibrators shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. Immersion vibrators shall not come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

Form attached vibrators shall be used only with specific authorisation of Employer’s Representative.

The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, surface vibration by specifically designed vibrators may be permitted, upon approval of Employer’s Representative.

Formation of stone pockets or mortar ponding in corners and against faces of forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to a sufficient depth and shape for thorough bonding as approved by Employer’s Representative.

xxii) Placement Intervals

Each placement of concrete shall be allowed to set for a period of 48 hours or longer when required, before the start of subsequent placement. A time gap between the two adjoining pours in the horizontal plane and the two adjacent pours in the vertical plane shall be seven days and three days respectively.

Except when placing with slip forms, each placement of concrete in multiple lift work shall be allowed to set for at least 24 hours after the final set of concrete and before the start of a subsequent placement.

xxiii) Special Provision in Placing

When placing concrete in walls with openings, in floors of integral slab and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slabs as the case may be. Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined by Employer's Representative.

xxiv) Placing Concrete through Reinforcing Steel

When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congregation of steel makes placing difficult, it may be necessary to temporarily move the top steel aside to get proper placement and then restore the reinforcing steel to design position.

xxv) Bleeding

Bleeding or free water on top of concrete being deposited into the forms shall require stopping the concrete pour and the conditions causing this shall be corrected before any further concreting is resumed.

xxvi) Rain or Wash Water

No concrete shall be placed in wet weather or on a water covered surface. Any concrete that has been washed by heavy rain shall be entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage which may be caused by rain, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work unattended. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such water is removed. To avoid water flowing over or around freshly placed concrete, suitable drains and sumps shall be provided.

xxvii) Concreting in Hot Weather

The Contractor's methods shall comply with the recommendations ACI 305, Hot Weather Concreting, as modified and supplemented below.

The Contractor shall take great care during hot weather to prevent the cracking or crazing of concrete. The Contractor shall arrange for concrete to be placed in the early morning or late evening as directed by the Employer's Representative.

The Contractor shall have particular regard to the requirements specified herein for curing.

Formwork shall be shaded from direct exposure to the sun both prior to placing of the concrete and during its setting. The Contractor shall take appropriate measures to ensure that reinforcement in and projecting from the section to be concreted is maintained at the lowest temperature practicable.

Concrete at placing shall have a temperature of not more than 32 ^{O}C. If necessary, the Contractor shall cool the aggregates and mixing water by methods approved by the Employer's Representative.

Where necessary, the Contractor shall design, install and operate a cooling system by which cooling water is pumped through a piping system in order to decrease the heat of hydration during concreting. The proposal for such a cooling system shall be submitted to the Employer's Representative for his approval two weeks prior to the concreting operations.

The temperatures of ambient air, concrete at various levels and at intervals not exceeding 5 metres and cooling water where applicable shall be measured by means of thermocouples and recorded with a Philips type PR 3210 A/00 recorder or similar approved.

xxviii) Placing of Concrete Under Water

Under all ordinary conditions all foundations shall be completely dewatered and concrete placed in the dry. However, when concrete placement under water is necessary, all work shall conform to IS 456 and procedure shall be as follows:

Concrete shall be deposited under water by means of tremies or bottom-drop buckets of approved type.

All work requiring placement of concrete underwater shall be designed, approved and inspected with regard to the local circumstances and purposes. All under water concrete shall be placed according to the specifications and as approved by the Employer's Representative.

xxix) Protection

All concrete shall be protected against damage.

xxx) Corrosion Resistant Lining

Where required, corrosion resistant linings shall be applied strictly according to the manufacturer's instructions. The work shall be performed by experienced personnel under the supervision of a qualified representative of the manufacturer. The completed lining shall be securely bonded to the substrate and provide the required corrosion resistant protection.

xxxi) Installation of Pipes, Electrical Conduits etc. through Concrete Structures

Wherever required, the Contractor shall install in place, before concreting, any pipe, electrical conduit or other special item that passes through or terminates at any concrete wall. Alternatively the Contractor shall obtain the prior approval of the Employer's Representative of shop drawings of the methods he proposes to adopt, particularly if he intends to leave an opening and install the special item later

After approval that a special item may be concreted in later, the opening shall be accurately fashioned to receive it. Pipes passing through walls or floors of water retaining or earth supporting structures shall be provided with welded puddle flanges and the opening provided shall take this into account.

1 The opening provided shall be of sufficient size to permit accurate final alignment of the embedded fitting without deflecting any part and allowing adequate space for satisfactory spacing where the pipe passes through openings so formed.

2 The box-outs shall be provided with continuous keyways to hold the concrete filling in place and ensure water-tightness.

3 The space left within the box-outs and around the special item positioned in place, shall be filled with non-shrink grout or non-shrink concrete as approved by the Employer's Representative.

xxxii) Mass Foundations

Mass foundations shall be poured in lifts not exceeding 1.5 m. in height unless otherwise approved by Employer's Representative.

xxxiii) Treatment of Construction Joints on Resuming Concreting

All laitance and loose stones shall be thoroughly and carefully removed by wire brushing/ hacking and surface washed.

Just before concreting is resumed, the roughened joint surface shall be thoroughly cleaned and loose matter removed and then thoroughly wetted. The new concrete shall be well worked specially against the prepared face. Special care shall be taken to obtain thorough compaction and to avoid segregation of the concrete along the joint plane.

xxxiv) Water

Clean water in pipes under pressure shall be provided by the contractor with all necessary equipment for giving a nozzle pressure of not less than 2.0 kg/cm^2 for the convenient and effective jetting of rock foundations and concrete surfaces, for cooling aggregate required for concrete, for curing concrete and other requirements.

xxxv) Protecting Fresh Concrete

Fresh concrete shall be protected from the elements, from defacement and damage due to construction operations by leaving forms in place for ample periods. Newly placed concrete shall be protected by approved means, such as tarpaulins, from rain, sun and winds. Steps, as approved by the Employer's Representative, shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion or contact with other materials or otherwise disturbed. If it is necessary that workmen enter the area of freshly placed concrete, bridges shall be placed over the area.

Concrete for Large Pours

This clause applies to large concrete pours where measures need to be taken to deal with the generation of heat and attendant volume change to minimise cracking.

If available, coarse aggregate shall be of limestone or other aggregate with a low coefficient of thermal expansion and of angular shape.

Measures shall be taken to limit the effects of thermal movement in the concrete.

The maximum temperature during hydration shall not exceed 65 ºC.

The concrete mix may include an approved type of water reducing /workability admixture.

Form-work for the sides shall be of minimum 19 mm thick plywood or equivalent thermal resistant to ensure that the maximum specified thermal gradient is not exceeded during curing.

All formwork for pits, ducts, rebates and holding down bolts shall be constructed so that it can be easily collapsed to facilitate removal after the initial set of the concrete. The top of formwork for holes shall be covered to prevent entry of excess grout or other substances.

Standby plant shall be available for all plant used for the construction of the foundations. For compressors, vibrators, cranes, concrete pumps, lighting equipment and the like, standby plant shall be on site before concreting commences.

Concrete shall be placed in single pours lasting no more than 16 hours. The sequence of placing shall be such, that exposed concrete shall be covered with fresh concrete within one hour of first mixing of the exposed concrete. Re-compaction of the original with the fresh concrete shall be undertaken to ensure a homogenous mass without a cold joint.

The concrete shall be placed and compacted in such a manner as to ensure that cracking due to plastic settlement does not occur.

On completion of a pour, the top surface shall be steel trowel finished and the exposed concrete shall be sprayed with an approved curing compound. Space shall be arranged around the pour to allow the free flow of air during curing.

The poured concrete shall be protected if necessary with insulation to limit the thermal gradient between the core and the surface to below 20 °C. The pour shall contain thermocouples distributed within the concrete in accordance with the Contractors design. The Contractor shall measure and record the internal and surface concrete temperatures daily until the formwork is stripped.

The formwork and insulation shall be left in place until the surface temperature is at the average ambient daily temperature.

The method statement for the construction of each large pour shall include the following information:

1. Details of the mix design and source of supply.
2. Full details of the formwork with particular reference to the installation of holding down bolt formers.
3. Details of the placing procedure including method of placing, standby arrangements, number of vibrators and number of supervisors and operatives.
4. Details of insulation for the pours and how the pours are to be cured.
5. Details of how the concrete is to be placed and compacted without cold joints and without cracking resulting from plastic settlement.

Within six weeks after construction of large pours, the Contractor shall issue a construction report containing full details of the construction, materials testing results and as-built drawings.

Concrete for Machine Foundations

Design and construction of machine foundations shall be carried out in accordance with IS 2974.

After commissioning rotating machines, the Contractor shall carry out a full vibration survey to record the vibrations of the foundations. The results of the survey shall be submitted to the Employer’s Representative.

Joints in Concrete

(i) General

Provision shall be made for expansion and contraction in concrete by the use of special joints located as necessary. Construction joint surfaces shall be as specified or as approved by Employer’s Representative.

Concrete shall be placed without interruption until completion of the part of the work between predetermined construction joints. The time lapse between the pouring of adjoining units shall be as specified or as approved by Employer’s Representative.

Construction joints shall be avoided if possible or their number minimised. Concreting shall be carried out continuously up to construction joints the position and arrangement of which shall be indicated by the Contractor’s designer. Construction joints shall comply with IS 11817.

Construction joints shall be placed at accessible locations to permit cleaning out of laitance, cement slurry and unsound concrete in order to create rough/uneven surface. Laitance and cement slurry shall be cleaned out by using wire brushes on the surface of the joint immediately after initial setting of the concrete. The prepared surface should be in a clean saturated surface dry condition when fresh concrete is placed against it. In the case of construction joints at locations where the previous pour has been cast against shuttering, the aggregate of the previously poured concrete shall be exposed using a high pressure water jet or by another appropriate means.

At least 3 weeks prior to commencement of concreting, the Contractor shall supply drawings to the Employer's Representative indicating all expansion or other movement joints both vertical and horizontal including details of the type of joint to be provided, the method of concreting, the concreting lifts to be achieved in a single continuous operation and any other relevant details. One copy of the drawing, approved or modified, shall be returned to the Contractor.

Expansion joints shall be indicated on the Contractor's drawings. The width of the joint shall generally be 13 mm. Except where synthetic rubber (sealant) sealed joints are specified, joint filler and joint sealer shall be provided, with the filler to between 13 mm and 19 mm from the concrete face and then the sealer finished flush with surface. At synthetic rubber sealed joints, the filler shall be to 13 mm from the concrete face to receive sealant, unless otherwise specified.

All Construction joints shall be provided with suitable keyways or other keying methods. The old surface shall be roughened until the clean aggregate embedded in the mortar matrix is exposed, by chipping, sand-blasting or application of a surface mortar retardant followed by washing and scrubbing with a stiff brush. Reinforcement and water-stops shall be effectively protected. The prepared surface shall be kept wet for at least 24 hours before placing new concrete. Immediately prior to commencement of the new concreting, water shall be deposited on the prepared horizontal surface of the old concrete. If water-stops are not used, the coarseness amplitude of the prepared surface shall be at least 6 mm.

Roof and floor slabs shall be poured in alternating checker-board fashion between approved construction joints. Concreted sections shall be fully cured before adjoining sections are concreted. All construction joints in floor slabs and rafts shall be painted with a 230 mm wide strip of bitumen paint to be applied in two thick layers.

Fresh concrete should be thoroughly vibrated near construction joints so that mortar from the new concrete flows between large aggregates and develops a proper bond with old concrete.

Where high shear resistance is required at the construction joints, shear keys shall be provided.

Sprayed curing membranes and release agents should be thoroughly removed from joint surfaces.

If the stopping of concreting becomes unavoidable, a properly formed construction joint shall be made where the work is stopped. Joints shall be either vertical or horizontal. In the case of an inclined or curved member, the joints shall be at right angles to the axis of the member. Vertical joints in walls shall be kept to a minimum. Vertical joints shall be formed against a stop board, horizontal joints shall be level and wherever possible, arranged so that the joint lines coincide with the architectural features of the finished work. Battens shall be nailed to the formwork to ensure a horizontal line and if approved, shall also be used to form a grooved joint. For tank walls, similar work joints shall be formed as per IS 3370. Concrete that is in the process of setting shall not be disturbed or shaken by traffic either on the concrete itself or upon the shuttering. Horizontal and vertical construction joints and shear keys shall be located and shall conform in detail to the Contractor's approved drawings unless otherwise approved by Employer's Representative. The joints shall generally be in accordance with the following:

(ii) Column Joints

In a column, the joint shall be formed 75 mm below the lowest soffit of the beams, including haunches if any. In flat slab construction, the joint shall be 75 mm below the soffit of column capital. At least two hours shall elapse after depositing concrete in column, piers or walls, before depositing in beams, girders or slabs supported thereon.

(iii) Beam and Slab Joints

Concrete in a beam shall be placed throughout without a joint but if the provision of a joint is unavoidable, the joint shall be vertical and at the centre or within the middle third of the span unless otherwise approved. Where a beam intersects a girder, the joints in the girder shall be offset a distance equal to twice the width of the beam and additional reinforcement provided for shear. The joints shall be vertical throughout the full thickness of the concrete member. A joint in a slab shall be vertical and parallel to the principal reinforcement. Where it is unavoidable at right angles to the principle reinforcement, the joint shall be vertical and at the middle of span.

(iv) Joints in Liquid Retaining Structures

Vertical construction joints in watertight construction will not be permitted. Where a horizontal construction joint is required to resist water pressure, special care shall be taken in all phases of its construction to ensure maximum water-tightness.

(v) Expansion and Movement Joints

Joint filler shall consist of a proven bituminous compound approved by the Employer's Representative. Application of the filler shall be strictly in accordance with the manufacturer's instructions.

The Contractor shall supply, for the Employer's Representative's approval, details of the proposed materials including the mechanical properties. The manufacturer shall design the width and thickness of the elastomeric compound to accommodate the maximum designed thermal shrinkage movement at the joint.

Joint Sealers shall be of impermeable ductile material providing a water-tight seal through the full joint movement range. Details of joint sealing are given in Section 22.16.

(vi) Water-Stops

Water bars or water stops shall be extruded from a polyvinyl chloride compound containing the plasticizers, resins, stabilizers and other ingredients needed to import the required characteristics or from synthetic rubber.

The Contractor shall supply to the Employer's Representative, details of the thickness of the water- stop offered by him to indicate its adequacy to withstand the design pressures.

All water-stop interactions such as ells, tees, crosses etc. shall be fabricated by the manufacturer and shall have sufficiently long legs to permit field butt splicing.

Water-stops shall be provided in all expansion and movement joints. Water-stops shall be continuous in joints, following offsets and angles in joints until spliced to water-stops at intersections and thereby completely sealing the structure. The flanges of water-stops shall be secured to the reinforcement with 18 gauge wire ties at a maximum spacing of 45 centimetres or with a PVC binding where that is Specifically recommended by the water-stop manufacturer.

PVC water-stops shall be neatly fused and synthetic rubber water-stops vulcanized at joints and connections unless explicitly otherwise specified by the manufacturer.

Water stops shall be provided at all vertical construction joints in walls of water retaining structures and all expansion joints in water retaining structures and wherever specified or directed by the Employer's Representative.

Water stops shall not be exposed to direct sunlight for long periods. Before being concreted, water stops shall be cleaned of all foreign materials. Wherever provided, water stops shall be placed in such a manner that they are embedded in the adjacent sections of the panels for equal width.

The storage, fixing in position, splicing of water stops shall be as per manufacturer's instructions.

Water stops shall be fully supported in the formwork, be free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place concrete so that water stops do not bend or distort.

The different type of water stops to be used in liquid retaining structures shall be as follows:

	Type of Joint	Type of Water Stops
1.	Partial/ complete construction joint in walls and slabs	150 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
2.	Expansion joints in walls and slabs	225 mm wide, ribbed with hollow centre bulb and 9 mm minimum thickness
3.	Construction joint in raft	225 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
4.	Construction joint in wall	150 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
5.	Partial/ complete construction joint in raft	225 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
6.	Expansion joint in raft	225 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness

(vii) Dowels

Dowels for concrete work, not likely to be taken up in the near future, shall be wrapped in tar paper and burlap.

Curing

(i) Curing Formed Concrete

All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Curing shall be by use of the water curing method, specified liquid membrane forming compound or concrete curing paper, the specified use of any method being subject to the approval of the Employer's Representative.

Preference shall be given to the use of continuous sprays or ponded water, continuously saturated covering of sacking, canvas, hessian or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even textured coat. Extra precautions shall be exercised in curing concrete during hot weather. The quality of curing water shall be the same as that used for mixing the concrete.

Certain types of finish or preparation for overlaying concrete must be made at certain stages of the curing process and special treatment may be required for specific concrete surface finishes.

Curing of concrete made of high alumina cement and super-sulphated cement shall be carried out as approved by the Employer's Representative.

The structural elements with concrete having water binder ratio less than or equal to 0.4 or partial replacement of cement by pozzolanic materials (5% or above replacement by silica fume or high reactivity metakaoline, or 15% or above by fly ash) shall be cured in two stages, initial curing and final curing.

The initial curing should be started not later than three hours or after the initial setting time, whichever is lower, after placement of concrete. The concrete surfaces exposed to the environment shall be covered by plastic sheet or other type of impermeable covers. The initial curing should be continued up to a minimum period of 12 hours or 2 hours plus final setting time of concrete, whichever is higher.

Final curing shall be with water and commence immediately after initial curing and continue for a minimum period of 14 days.

(ii) Continuous Spraying

Curing shall be assured by the use of an ample water supply under pressure in pipes, with all necessary appliances of hose sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by Employer's Representative.

(iii) Alternative Curing Methods

Whenever, in the judgment of the Contractor's designer and with the approval of the Employer's Representative, it may be necessary to omit the continuous spray method, covering of clean sand or other approved means such as wet gunny bags, which will prevent loss of moisture from the concrete, may be used. Any type of covering which would stain or damage the concrete during or after the curing period shall not be used. The covering shall be kept continuously wet during the curing period.

For curing of concrete in pavements, side-walks, floors, flat roofs or other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by Employer's Representative. Special attention shall be given to edges and corners of slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

(iv) Curing Equipment

All equipments and materials required for curing shall be on hand and ready for use before the concrete is placed.

(v) Membrane Curing

Approved curing compounds may be used in lieu of moist curing with the permission of Employer's Representative. Such compounds shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. Impermeable membranes such as polyethylene sheeting covering, the concrete surface closely may also be used to provide an effective barrier against evaporation.

For concrete containing Portland pozzolona cement, Portland slag cement or mineral admixtures, an increased period of curing may be required.

Repair and Replacement of Unsatisfactory Concrete

Immediately after shuttering is removed, the surfaces of concrete shall be very carefully inspected and all defective areas called to the attention of Employer's Representative who may permit patching of the defective areas or else reject the concrete either partially or entirely. Rejected concrete shall be removed and replaced by the Contractor. Holes left by form bolts etc. shall be filled and made good with mortar composed of one part of cement to one and half parts of sand, that passes through a 2.36 mm IS sieve, after removing any loose stones adhering to the concrete. Mortar filling shall be struck off flush at the face of the concrete. The concrete surface shall be finished as described under the particular item of work.

Superficial honey combed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of Employer's Representative and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by Employer's Representative, the surface of exposed concrete placed against shuttering shall be rubbed down immediately on removal of shuttering to remove fine or other irregularities. Care shall be taken to avoid damaging the surfaces. Surface irregularities shall be removed by grinding.

If reinforcement is exposed or the honey combing occurs at vulnerable positions. such as at the ends of beams or columns, it may be necessary to cut out the member completely or in part and reconstruct. The decision of Employer's Representative shall be final. If in the opinion of the Employer's Representative only patching is necessary, the defective concrete shall be cut out until solid concrete is reached (or to a minimum depth of 25 mm), the edges being cut perpendicular to the affected surface or with a small undercut if possible, anchors, tees or dowels shall be provided in slots whenever necessary to attach the new concrete securely in place. An area extending several centimetres beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

(i) Use of Epoxy Mortar

The use of epoxy mortar for bonding fresh concrete used for repairs will be permitted upon written approval of Employer's Representative. Epoxy mortar shall be applied in strict accordance with the instruction of the manufacturer.

(ii) Method of Repair

Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of form bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows:

The hole to be patched shall be roughened and thoroughly soaked with clean water until absorption stops.

A 5 mm thick layer of grout of equal parts of cement and sand shall be well brushed into the surface to be patched followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly proud of the surrounding surface. The concrete patch shall be built up in 10 mm thick layers. After an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finish obtained by wiping with hessian. Steel trowels shall not be used for this purpose. The mix for patching shall be of the same materials and in the same proportions as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible.

Mortar filling by air pressure (guniting) shall be used for repair of areas too large and/ or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so approved by Employer's Representative, to match the shade of the patch with the original concrete.

(iii) Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining water-saturated material such as gunny bags, which shall be kept continuously wet and protected against the sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray of water for not less than 10 days.

(iv) Approval by Employer's Representative

All materials, procedures and operations used in the repair of concrete and also the finished repair work shall be subject to the approval of Employer's Representative. All fillings shall be tightly bonded to the concrete and shall be sound and free from shrinkage cracks after the fillings have been cured and dried.

Finishing

This specification is intended to cover the treatment of concrete surfaces of all structures.

(i) Finishes for Formed Surfaces

The type of finish for formed concrete surfaces shall be as follows, unless otherwise approved by the Employer's Representative:

For surfaces against which backfill or concrete is to be placed, no treatment is required except repair of defective areas.

For surfaces below grade, which will receive waterproofing treatment, the concrete shall be free of surface irregularities which would interfere with proper application of the waterproofing materials which is specified for use.

Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless a horizontal surface is specially specified or a particular slope required, the tops of narrow surfaces such as staircase treads, walls, curbs and parapets shall be sloped across the width at 1 in 30. Broader surfaces such as walkways, roads, parking areas and platforms shall be sloped at 1 in 50. Surfaces that will be covered by backfill or concrete, sub floors to be covered with concrete topping, terrazzo or quarry tile and similar surfaces shall be smooth, screeded and levelled to produce even surfaces. Surface irregularities shall not exceed 6 mm. Surfaces which will not be covered by backfill, concrete or tile topping such as external decks, floors of galleries and sumps, parapets, gutters, sidewalks, floors and slabs shall be consolidated, screeded and floated.

Excess water and laitance shall be removed before final finishing. Floating may be done by hand or power tools and started as soon as the screeded surface has attained a stiffness to permit finishing operations and these shall be the minimum required to produce a surface uniform in texture and free from screed marks or other imperfections. Joints and edges shall be tooled as required or as approved by the Employer's Representative.

(ii) Standard Finish for Exposed Concrete

Exposed concrete shall mean any concrete other than floors or slabs exposed to view upon completion of the job. Unless otherwise specified on the drawings, the standard finish for exposed concrete shall be of smooth finish.

A smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces and edges. Panels and form linings shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms, the joint marks shall be smoothed off and all blemishes, projections etc removed, leaving the surfaces smooth and unmarred.

(iii) Integral Cement Concrete Finish

When required, an integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithically or bonded, as specified in IS-2571. The surface shall be compacted and then floated with a wooden float or power floating machine. The surface shall be tested with a straight edge and any high and low spots eliminated. Floating or trowelling of the finish shall be permitted only after all surface water has evaporated. Dry cement or a mixture of dry cement and sand shall not be sprinkled directly on the surface of the cement finish to absorb moisture or to stiffen the mix.

(iv) Rubbed Finish

A rubbed finish shall be provided only on exposed concrete surfaces as required. Upon removal of forms, all fins and other projections on the surfaces shall be carefully removed, offsets levelled and voids and/ or damaged sections repaired. The surfaces shall then be thoroughly wetted and rubbed with carborundum or other abrasive. Cement mortar may be used in the rubbing, but the finished surfaces shall not be brush coated with either cement or grout after rubbing. The finished surfaces shall present a uniform and smooth appearance.

Field Quality Control

All concreting shall be supervised by the Employer's Representative and in order to enable the Employer's Representative to make the requisite arrangements, the Contractor shall give him adequate notice of the proposed concreting operations which, except under special circumstances, shall not be less than 24 hours after checking reinforcement and formwork. Any concreting done in the absence of, or without the express permission of the Employer's Representative is liable to rejection.

Tests

All tests specified in the Indian Standards shall be regularly carried out together with any additional tests the Employer's Representative may require to satisfy himself regarding the quality of the work done.

If the results of any tests indicate the concrete in question is unsatisfactory in any respect, the Contractor shall take any steps indicated by the Employer's Representative to rectify the same and if such rectification is not found to be satisfactory or adequate, the section in question shall be removed and re-concreted.

While all the tests stipulated in the Indian Standards are necessary, the carrying out of the field slump- tests and the making of the specified works test cubes from every batch of concrete, or as otherwise specified by the Employer's Representative, shall be carried out as an invariable general rule.

The following requirements in respect of concrete testing will be rigidly applied throughout the duration of the Contract to all permanent works.

(i) Sampling Procedure

Sampling and testing shall be in accordance with IS 1199 and IS 516. Evaluation of the results and acceptance or rejection of the concrete will be done as described below.

Two cubes pre 150 Cum. Or part there of or minimum six cubes per days work whichever is more shall be taken at work site. Half the number in each sample shall be tested at 7 days and the balance at 28 days. Where the tests are carried out in the site laboratories, companion cubes shall be tested on the dates on which the representative samples are tested at site at an independent laboratory approved by the Employer's Representative. If a significant difference is noticed between the two sets of results all further testing shall be done at the approved laboratory until the site equipment is rectified satisfactorily. No reduction in the frequency or number of samples taken shall be made without the explicit approval of the Employer's Representative who, if agreeing to any reduction, shall have such a decision mainly on the consistency of good results achieved over an acceptable period. Any deterioration in quality will result in the more rigorous schedule being re-implemented.

The values given in table below may be taken for general guidance in the case of concrete made with ordinary cement. In all cases, the 28 day compressive strength specified shall alone be the criterion for acceptance or rejection of the concrete. If however, from tests carried out for a particular job over a reasonably long period, it has been established to the satisfaction of the Employer's Representative that a suitable ratio between 28 days compressive strength and the modulus of rupture at 72 (+/-) 2 hours or 7 days or compressive strength at 7 days may be accepted, the Employer's Representative may suitably relax the frequency of 28 day compressive strength tests, provided the expected strength values at the specified early age are consistently met.

Optional Tests Requirements of Concrete:

Grade of Concrete	Compressive strength on 15 cm cubes min. at 7 days N / mm^2	Modulus of rupture by beam test min.	
		At 72 (+/-) 2 hours N / mm^2	At 7 days N / mm^2
M 10	7.0	1.2	1.7
M 15	10.0	1.5	2.1
M 20	13.5	1.7	2.4
M 25	17.0	1.9	2.7
M 30	20.0	2.1	3.0
M 35	23.5	2.3	3.2
M 40	27	2.5	3.4

(ii) Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7days or at the time of striking the form work or to determine the duration of curing or to check the testing error. Additional cubes may also be required for testing cubes cured by accelerated methods as described in IS 9013 - 1978. The specimen shall be tested as described in IS 516 - 1959.

(iii) Frequency

The minimum frequency of sampling of concrete of each grade shall be in accordance with following table:

Quantity of Concrete m^3	Number of Samples
1 – 5	1
6 – 15	2
16 – 30	3

Quantity of Concrete m^3	Number of Samples
31 – 50	4
51 & above	4 + one per additional $50m^3$

At least six samples (Cubes) shall be taken from each shift. Where concrete is in continuous production, such as at a ready-mixed concrete plant, the frequency of sampling may be agreed upon mutually by suppliers and purchasers.

(iv) Test Strength of Samples

The test strength of the samples shall be the average of the strength of three specimens. The individual variation should not be more than (+/-) 15 percent of the average.

(v) Standard Deviation

This section should be read in conjunction with Section 17.3 & 17.4.1 of this specification.

The standard deviation and coefficient of variation shall be computed for a set of any 10 consecutive tests. The probable minimum strength of the batch, as calculated from the results of the 10 tests, based on failure probability of 1 in 10, shall then be compared with the specified minimum strength for the relevant grade of concrete.

1. If the calculated minimum strength exceeds the specified minimum strength by 10 percent or more, the Contractor will be permitted to redesign the mix with a lower cement content, if feasible.
2. If the calculated strength exceeds the specified minimum strength by not more than 10 percent, the mix design shall be used for subsequent batches of concrete.
3. If the calculated strength falls short of the minimum specified strength but by not more than 10 percent, the decision to accept or reject the representative batch of concrete will be at the sole discretion of the Employer’s Representative. The location of the batch in the structure, the maximum stresses likely to occur therein, the calculated strength of the cubes and other relevant factors will be taken into consideration, but his decision, once given shall not be subject to question or dispute nor shall it be subsequently quoted as a precedent.
4. If the calculated minimum strength falls short of the specified minimum strength by more than 10 percent, the representative batch of concrete shall be rejected.
5. All water retaining structures shall be tested for water-tightness in conformance with the requirements of IS 3370 (Part I) – 1965, section 9 to the satisfaction of the Employer’s Representative.

Acceptance Criteria

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 column 2 of the table below

b) Any individual test result complies with the appropriate limits in column of Table below.

Characteristic Compressive Strength Compliance Requirement:

Specified Grade	Mean of the group of 4 non overlapping consecutive test results in N / mm^2	Non-overlapping consecutive test results in N / mm^2 Individual test results in N/ mm^2
M 15	= / > fck + 0.825 x established standard deviation (rounded off to nearest 0.5 N/ mm^2 Or = / >fck + 3 N / mm^2 whichever is greater	= / > fck –3 N/ mm^2
M 20 or above	= / > >fck + 0.825 x established standard deviation (rounded off to nearest 0.5 N/ mm^2 Or = / > fck + 4 N / mm^2 whichever is greater	= / > fck – 4 N / mm^2

Note – In the absence of an established value of standard deviation, the values given in (assumed standard deviation) may be assumed and an attempt should be made to obtain the results of 30 samples as early as possible to establish the value of standard deviation.

(i) Flexural Strength

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

1. 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.
2. The strength determined from any test result is not less than the specified characteristic strength less 0.3 N/mm^2.

(ii) Quantity of Concrete Represented by Strength Test Results

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.

For the individual test result requirements given in column 2 of above table or in item (b) of flexural strength, only the particular batch from which the sample was taken shall be at risk.

Where the mean rate of sampling is not specified the maximum quantity of concrete that four consecutive test results represent shall be limited to 60m^3.

If the concrete is deemed not to comply pursuant to the above, the structural adequacy of the parts affected shall be investigated and any consequential action as needed shall be taken.

Concrete of each grade shall be assessed separately.

(iii) Alterations and Concreting against Surfaces

Existing concrete surfaces which are to receive new concrete shall be heavily sand-blasted to expose the coarse aggregate and produce a clean, coarse textured surface. Such prepared surfaces shall be coated with an epoxy bonding or other approved coating immediately prior to concreting. The compound shall be equal or superior to “Sikastix Adhesive” manufactured by the Sika chemical company and shall be mixed and applied strictly in accordance with the manufacturer’s recommendations under different conditions.

Ready Mixed Concrete

General

Ready mixed concrete (RMC) shall comply with the requirements of IS 4926 or the latest Indian Standard.

Concrete delivered at site shall be in a plastic condition and requiring no further treatment before being placed in the position in which it is to set and harden.

The continuing mixing of concrete during transport shall be at a reduced speed to prevent segregation.

Concrete shall be produced by completely mixing cement, aggregates, admixtures (if any) and water at a stationary central mixing plant and delivered in transit mixers.

Concrete may be produced in a transit mixer at the batching plant, with the mixing being carried out entirely in the transit mixer either during the journey or on arrival at the site of delivery. No water shall be added to the aggregate and cement until the mixing of concrete commences.

Manufacturing

The ready-mixed concrete shall be manufactured and supplied on either of the following bases:

1 Specified strength based on 28-day compressive strength of 15 cm cubes tested in accordance with IS: 456-2000.

2 Specified mix proportion.

Where the contract requires using ready mix concrete of designated strength, the Contractor shall procure the same from approved suppliers only and Section 16.6 shall also apply to concreting done with ready mix concrete.

When the concrete is manufactured and supplied on the basis of specified strength, the responsibility for the design of mix shall be that of the manufacturer and the concrete shall conform to the requirements specified.

When the concrete is manufactured and supplied on the basis of specified mix proportions, the responsibility for the design of the mix shall be that of the mix designer and the concrete shall conform to the requirements specified.

Supply

Ready mix concrete prepared and transported will be as per IS 4926 of 1976 or the latest 1S. Code.

Water is not to be added to ready mixed concrete on site.

Ready mix concrete will be brought to the site from the RMC plant only by transit mixers (agitators).

Every transit mixer will carry a delivery ticket, stating the minimum following details:

a. Name of manufacturer and depot

b. Serial number of the ticket.

c. Date

d. Truck number

e. Name of Contractor to whom the RMC is being supplied

f. Location of contract

g. Grade of concrete.

h. Specified werkabi1ity

i. Cement content and grade of cement

j. Time of loading

k. Quality of concrete.

When the truck arrives on site, the drum, should always be rotating at about 10 to 15 rev/min, for at least three minutes, to ensure that the concrete is thoroughly mixed and uniform before discharge.

When a truck mixer or agitator is used for the mixing or transportation concrete, no water from the truck-water system or from elsewhere shall be added after the initial introduction of the mixing water for the batch,

Unless otherwise specified, when a truck or agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and the discharge shall be complete within 1½ hour when the prevailing atmospheric temperature is above 20 ºC and within 2 hours when the prevailing atmosphere temperature is at or below 20 ºC of adding the mixing water to the mix of cement and aggregate or adding the cement to the aggregate whichever is earlier.

Plain Cement Concrete

For plain cement concrete work, the specification for cement, sand, fine and coarse aggregates and water shall be the same as that specified in reinforced concrete but the proportion of mix will be nominal and the ratio of fine and coarse aggregate may be slightly adjusted within limits, keeping the total value of aggregates to a given volumes of cement constant to suit the sieve analysis of both the aggregates. Cement shall not be measured by volume and shall always be used directly from the bags (i.e. 50 kg/bag).

The nominal maximum size of coarse aggregate for 1:2:4 mix shall be as specified for reinforced concrete and for 1:3:6 and 1:4:8 mix shall be 40 mm for concrete 300 mm and more thick and 25 mm for concrete less than 300 mm thick.

The quantity of water used shall be such as to produce concrete of the consistency required by the particular class of work and shall be decided by the use of a slump cone. Sufficient care should be taken to ensure that no excess quantity of water is used.

Mix Proportion	**Cement in bags**	**Sand m^3**	**Coarse Aggregate m^3**			**Water**
Ordinary mix in volume			**40 mm**	**20 mm**	**12mm**	
1:5:10	2.60	0.475	0.6623	0.2583	-	156
1:4:8	3.40	0.500	0.6883	0.6883	-	153
1:3:6 (with 40 mm aggr.)	4.4	0.485	0.672	0.672	0.262	176
1:3:6 (with 20 mm aggr.)	4.4	0.485	-	0.727	0.242	162.5

Mix Proportion	Cement in bags	Sand m^3	Coarse Aggregate m^3			Water
Ordinary mix in volume			**40 mm**	**20 mm**	**12mm**	
1:2:4 (with 20 mm aggr.)	6.4	0.47	-	0.705	0.235	205
1:2:4 (with 40 mm aggr.)	6.4	0.47	0.544	0.241	0.126	235
1:1.5:3	8.0	0.441	-	0.6615	0.2205	240
1:1:2	12.20	0.45	-	0.675	0.225	330

The slump shall be specified for each class of work and shall in general be as follows:

Type of Concrete	Max. Slump (in mm)
Mass concrete	50
Concrete below water proofing treatment	50
Coping	25
Floor paving	50

All plain concrete shall be mixed in a drum type powder driven machine with a loading hopper which will permit the accurate measure of various ingredients. If hand mixing is authorised, it should be done on a watertight platform.

The mixing of each batch in the concrete mixer shall continue for not less than 1.5 minutes after the materials and water are in the mixer. The volume of mixed materials per batch shall not exceed the manufacturers rated capacity of the mixer. The mixer shall rotate at a peripheral speed of about 60 metres per minute.

Pre-Cast Concrete

General

Pre-cast concrete and pre-cast reinforced concrete shall comply with IS 456 and with the following requirements.

Pre-cast concrete units shall incorporate sufficient lifting points and reinforcement to ensure the safe handling, transport and erection.

Where necessary, the Contractor's shop drawings shall include details of the lifting inserts, methods to be adopted to join the pre-cast units to other structures or parts thereof and the allowances made to receive work of other engineering specialties employed on the works.

Pre-cast concrete cladding panels shall be cast in formwork capable of producing a uniform fair faced finish.

Where appropriate, indelible identification and orientation marks shall be put on pre-cast concrete components in such a position that the marks shall not show or be exposed in the finished work.

Execution

(i) Casting

The pre-cast units shall be cast to the size and configuration required or otherwise specified.

The units shall be reinforced as necessary for the stresses likely to be caused by the methods of handling, transport and installation envisaged by the Contractor.

The longitudinal reinforcement shall have a minimum cover of 12 mm or twice the diameter of the main bar, whichever is more, unless otherwise approved, except for fencing or electric posts where the minimum cover shall be 25 mm.

The units shall be equipped with approved lifting devices for safe handling and easy installation.

Concrete used for pre-casting the units shall be thoroughly compacted by vibration or tamping to give a dense concrete free from voids and honeycombing.

The exposed surfaces shall be finished as specified or with dense, smooth trowel led finish free from flaws and irregularities and true to the required configuration.

All angles of the pre-cast units, with the exception of any angles resulting from the splayed or 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 to the required lines. On being fractured, the interior of the units should present a clean homogenous appearance.

Pre-cast units shall be cured to the maximum compressive strength for the specified class of concrete before the units are handled or lifted for transport or installation.

(ii) Curing

After having been cast in the mould or form, the concrete shall be adequately protected during setting in the first stages of hardening from shocks and from harmful effects of sunshine and wind. The concrete shall be cured at least for 10 days from the date of casting.

All pre-cast work shall be protected from the direct rays of the sun for at least 7 days after casting and during that period each units shall be kept constantly watered or completely immersed in water if the size of unit so permits. Otherwise curing practices as given in clauses stated earlier shall be followed.

The pre-cast articles shall be matured for 28 days before being incorporated into the Works so that the concrete shall have sufficient strength to prevent damage when handled. Side shutters shall not be struck in less than 24 hours after depositing the concrete and no pre-cast unit shall be lifted until the concrete reaches a strength of at least twice the stress to which the concrete may be subjected at the time of lifting.

Pre-cast units shall be clearly marked to indicate the top of member and its location and orientation in the structure. The reinforced side of the units shall be distinctly marked.

Pre-cast units shall be stored, transported and placed in position in such a manner that they will not be overstressed or damaged. The lifting and removal of pre-cast units shall be undertaken without causing shocks, vibration or being put under bending stresses. Before lifting and removal takes place, the Contractor shall satisfy Employer’s Representative that the methods he proposes to adopt for these operations will not overstress or otherwise affect the strength of the pre-cast units.

(iii) Installation

The installation shall be fully coordinated with the works of the other engineering specialities comprising the Works and the units shall be installed and secured at such times as to prevent any delay in the progress of the works.

Pre-cast units shall be aligned and secured in accordance with the approved shop and working drawings.

The installation shall be in a neat, workmanlike manner. On completion, all surplus materials or debris arising out of the work shall be removed from the site.

Reinforcement

General

All steel shall be FE 500 D CRS procured from 'Original producers' who manufacture billets directly from iron ores and roll the billets to produce steel confirming to IS 1786. No re-rolled material shall be accepted. If instructed by the Employer's Representative, the Contractor shall submit the manufacturer's test certificates for the steel. Random tests on steel supplied by the Contractor may be performed by the Employer as per relevant Indian Standards. Each steel bar shall be identified by the number duly moulded on the bar itself.

Submittals

Bar bending schedules for reinforced concrete works shall be provided by the Contractor. The submittals for extra or modified work shall also be made by the Contractor at least two weeks prior to commencement of bending. Dimensions shown on the submittals furnished by the Contractor shall be his responsibility and approval of the submittals shall not constitute approval of the dimensions thereon.

Tie Wire

Tie wire shall be of annealed steel, 16 gauge minimum.

Supports and Accessories

Support blocks shall be of concrete with embedded wire ties or dowels for placement on grade or on membranes. Reinforcement for footings, grade beams and slabs on sub-grade shall be supported on pre-cast concrete blocks as approved by the Employer's Representative. The use of pebbles or stones shall not be permitted. The blocks are to be embedded.

Plastic coated spacers or accurately dimensioned concrete blocks shall be used in all water retaining surfaces, roofs of water retaining structures and in all interior or exterior surfaces exposed to weather after completion of the structure. Plastic cover blocks of approved manufacture will be permitted at the discretion of the Employer's Representative.

Dowels

Where so required, reinforcing bar dowels shall be provided in new work and for anchorage to existing concrete. Where anchorage to existing concrete is required, a non-shrinking epoxy type grout or approved equal or deferred bolting devices shall be provided in each case, conforming to the relevant requirement specified in the section for cast-in-situ concrete.

Testing

Testing of materials shall be at the Contractor's expense and as instructed by the Employer's Representative and when so tested, shall conform to the relevant standards. Tests may be ordered on bars as selected by the Employer's Representative from material at the site or from any place of distribution. Each sampling selection shall include at least two pieces, each 500 millimetre long.

The Contractor shall submit the manufacturer's test certificates. Regular tests on the steel supplied shall be performed by the Contractor at an approved laboratory in the presence of the Employer's Representatives as per relevant Indian Standards. The Employer's Representative may require the Contractor to perform tests of samples at random as per relevant Indian Standard. The quality, grade, colour coding embossing marks etc. shall all be to the entire satisfaction of the Employer's Representative. Steel not conforming to the above test criteria shall be rejected.

The chemical, physical and mechanical properties of the steel reinforcement bars shall be as per IS 1786. Unless otherwise specified, the selection and preparation of test samples shall be as per the requirements of IS 2062.

All test pieces shall be selected either from the cuttings of bars or from any bar after it has been cut to the required or specified size and the test piece taken from any part of it. In either case, the test piece shall be detached from the bar in the presence of the Employer's Representative.

The test pieces shall be full sections of the bars and shall be subjected to physical tests without any further modifications. No reduction in size by machining or otherwise shall be permissible, except in case of bars of size 28 mm and above. No test piece shall be annealed or otherwise subjected to heat treatment. Any straightening which a test piece may require shall be done cold.

For the purpose of carrying out tests for tensile strength, proof stress, percentage elongation and percentage elongation at maximum force for bars of 28 mm in diameter and above, deformations of the bars only may be machined. For such bars, the physical properties shall be calculated using the actual area obtained after machining.

Title	IS No.	ISO No.
Mechanical testing of metals - Tensile testing	1608	6892
Methods for bend test	1599, 7438 & 1786	15630-1
Method for re-bend test for metallic wires & bars	1786	15630-1

Chemical Composition of the bars shall conform to the following requirement

Constituents	Maximum permissible percent							Permi-ssible max. Variation
	Fe 415	Fe 415D	Fe 500	Fe 500D	Fe 550	Fe 550D	Fe 600	
Carbon	0.300	0.250	0.300	0.250	0.300	0.250	0.300	0.020%
Sulphur	0.060	0.045	0.055	0.040	0.055	0.040	0.040	0.005%
Phosphorus	0.060	0.045	0.055	0.040	0.050	0.040	0.040	0.005%
Sulphur & Phosphorus	0.110	0.085	0.105	0.075	0.100	0.075	0.075	0.010%

Notes:

1 For welding of deformed bars, the recommendations of IS 9417 shall be followed.

2 In case of deviations from the specified maximum, two additional test samples shall be taken from the same batch and subjected to the test or tests in which the original sample failed. Should both additional test samples pass the test, the batch from which they were taken shall be deemed to comply with this standard. Should either of them fail, the batch shall be deemed not to comply with this standard.

Mechanical Properties of High Strength Deformed Bars

Nominal Size in mm	Tolerance on the nominal mass in percent		
	Batch	Individual sample	Individual sample for coils only
Up to and including 10	± 7	-8	± 8
Over 10 up to and including 16	± 5	-6	± 6
Over 16	± 3	-4	± 4

Note: To satisfy Clause 26 of IS 456 -2000, no mixing of different types of grades of bars shall be allowed in the same structural members as main reinforcement, without prior written approval of the Employer's Representative.

Fabrication and Delivery

Tagged reinforcement bundles which can be easily identified shall be stored at the site in sufficient quantities to enable uninterrupted progress of the work. These shall be so stored as to prevent damage or undue exposure to harmful weather conditions.

Stacking and Storage

Steel for reinforcement shall be stored in such a way as to prevent distorting and corrosion. The steel for reinforcement shall not be kept in direct contact with ground. Fresh / fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deteriorations. Care shall be taken to protect steel from exposure to saline atmospheres during storage, fabrication and use. This may be achieved by treating the surface of the reinforcement with a cement wash or by other suitable methods. Bars of different classification, size and length shall be stored separately to facilitate their issue in such sizes and lengths to cause minimum wastage in cutting from standard lengths.

Bending and Forming

Bars shall be fabricated accurately to dimensions, forms and shapes indicated by methods that will not damage the bars. Heating for purposes of bending will not be permitted. Field-bending of bars that are partially embedded in concrete shall not be done unless such procedure is specifically approved by the Employer's Representative.

All bars shall be accurately bent according to the sizes and shapes shown on the approved detailed working drawings and bar bending schedules. Bars shall be bent gradually by machine or other approved means. Reinforcing bars shall not be straightened and re-bent. Bars containing cracks or splits shall be rejected. Bars shall be bent cold unless specifically approved by the Employer's Representative.

Where approved, bars bent hot shall not be heated beyond a cherry red colour (not exceeding 645 ^{O}C) and after bending shall be allowed to cool slowly without quenching. Bars incorrectly bent shall be used only after straightening and re-bending, such as shall not, in the opinion of the Employer's Representative, injure the material. No reinforcement bar shall be bent when in position in the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those required by design shall not be used.

Where reinforcement bars are necessarily bent aside at construction joints and afterwards bent back into their original position, care shall be taken to ensure that, at no time, the radius of the bend is less than 4 bar diameters for plain mild steel or 6 bar diameters for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bar is not damaged.

Laps

Laps and splices for reinforcement shall be as shown on the approved Contractor's drawings. Splices in adjacent bars shall be staggered and the locations of all splices shall be subject to the approval of the Employer's Representative. Bars shall not be lapped unless the length required exceeds the maximum available lengths of bars at site.

Reinforcing Bars for Masonry

Reinforcing bars for masonry shall be shop fabricated.

Exposure conditions

Exposure conditions are defined in the table below:

Environment	Exposure Conditions
Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal areas.
Moderate	Concrete surfaces sheltered from severe rain Concrete exposed to condensation and rain Concrete continuously under water Concrete in contact or buried under non-aggressive soil/ground water Concrete surfaces sheltered from saturated salt air in coastal areas
Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or severe condensation. Concrete completely immersed in sea water Concrete exposed to coastal environments
Very severe	Concrete surfaces exposed to seawater spray or corrosive fumes. Concrete in contact with or buried under aggressive sub- soil/ground water. Concrete exposed to sewage, sewage effluent, sewage sludge and digester gases.
Extreme	Concrete surfaces in tidal zones Members in direct contact with aggressive liquid or solid chemicals

Fusion Bonded Epoxy Coating

Where fusion bonded epoxy coating (FBEC) is to be applied to reinforcement bars, it shall conform to IS 13620.

The coating material shall conform to Annex A1 of IS 13620.

The surface of the steel reinforcing bars to be coated shall be cleaned by abrasive blast cleaning to near white metal.

The protective coatings shall be applied by the electrostatic spray method.

The film thickness of the coating shall be evaluated by bending production-coated bars around a mandrel as prescribed in IS 13620.

Tests, retests and permissible coating damage shall be in accordance with IS 13620. Coating damage shall be repaired with the repair compound supplied by the coating manufacturer.

Nominal Cover to Reinforcement

Nominal cover is the design depth of concrete cover to all steel reinforcements, including links. The dimension shall be used in the design and indicated on the Contractor's detailing drawings. Cover shall be not less than the diameter of the bar. Unless otherwise specified, cover to reinforcement shall be provided generally as per guidelines of IS 456.

Minimum values for the nominal cover of normal weight aggregate concrete which should be provided to all reinforcement, including links depends on the condition of exposure. The nominal cover to meet durability requirements is shown in the table below:

Environment	Nominal concrete cover in mm not less than
Mild	20
Moderate	30
Severe	45
Very severe	50
Extreme	75

1 For main reinforcement of up to 12 mm diameter subject to mild exposure, the nominal cover may be reduced by 5 mm

2 Unless specified otherwise, the actual concrete cover should not deviate from the required nominal cover by +10 mm

3 For exposure conditions severe and very severe, a reduction of 5 mm may be made, where concrete grade is M 35 and above.

Unless otherwise approved by the Employer's Representative, clear concrete cover for reinforcement (exclusive of plaster or other decorative finish shall be as follows:

1 At each end of a reinforcing bar not less than 25 mm or less than twice the diameter of the bar.

2 For a longitudinal reinforcing bar in a column, nominal cover shall in any case not be less than 40 mm or less than the diameter of such bar. In the case of column of maximum dimensions of 200 mm or less, whose reinforcing bars do not exceed 12 mm, a cover of 25 mm may be used.

3 For longitudinal reinforcing bars in a beam cover shall be not less than 25 mm, or less than diameter of the bar.

4 For tensile, compressive, shear, or other reinforcement in a slab, cover shall be not less than 25 mm, or less than the diameter of the bar.

5 For any other reinforcement not less than 15 mm, or less than the diameter of the bar.

6 For footings and other principal structural members in which the concrete is deposited directly against the ground, the cover to the bottom reinforcement shall be 75 mm. If concrete is poured on a layer of lean concrete the bottom cover may be reduced to 50 mm.

7 For concrete surfaces exposed to the weather or the ground after removal of forms, such as retaining walls, grade beams, footing sides and tops etc, not less than 50 mm for bars larger than 16 mm diameter and not less than 40 mm for bars 16 mm diameter or smaller.

8 Increased cover thickness may be provided when surfaces of concrete members are exposed to the action of harmful chemicals (as in the case of concrete in contact with earth faces contaminated with such chemicals), acid, vapour, saline atmosphere, sulphurous smoke (as in the case of steam-operated railways) digester gases etc and such increase of cover may be between 15 mm and 50 mm beyond the figures given above (1 to 6) as may be specified by the Employer’s Representative. The interior of sludge digestion tanks will fall into this category.

9 For reinforced concrete members, totally immersed in sea water, the cover shall be 40 mm more than specified (1 to 6) above.

10 For reinforced concrete members, periodically immersed in sea water or subject to sea spray, the cover of concrete shall be 50 mm more than that specified (1 to 6) above.

11 For concrete of grade M 25 and above, the additional thickness of cover specified in (8), (9) and (10) above may be reduced to half. In all such cases the cover should not exceed 75 mm

12 Protection to reinforcement in cases where concrete is exposed to harmful surroundings may also be given by providing dense impermeable concrete with an approved protective coating. In such cases, the extra cover, as stated in (7) and (8) above, may be reduced with the approval of the Employer’s Representative.

13 The minimum clear distance between reinforcing bars shall be in accordance with IS 456.

The minimum values of nominal cover for normal-weight aggregate concrete to be provided to all reinforcement including links to meet specified period of fire resistance is shown in the table below:

Fire resis-tance	Nominal cover						
	Beams		Slabs		Ribs		Col-umns
	Simply Supported	Conti-nuous	Simply Supported	Conti-nuous	Simply Supported	Conti-nuous	
Hr	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**	**mm**
0.5	20	20	20	20	20	20	40
1	20	20	20	20	20	20	40
1.5	20	20	25	20	35	20	40
2	40	30	35	25	45	35	40
3	60	40	45	35	55	45	40
4	70	50	55	45	65	55	40

1. The nominal covers given relate specifically to the minimum member.

Placing of Reinforcement

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position by the use of blocks, spacers and chairs as per IS 2502 to prevent displacement during placing and compaction of concrete.

Any steel not conforming to the specifications shall be rejected. All reinforcement shall be clean, free from grease, oil, paint, dirt, loose mill scale, loose rust, dust, bituminous material or any other substances that will destroy or reduce the bond. All rods shall be thoroughly cleaned before being fabricated. Pitted and defective rods shall not be used.

Unless otherwise specified, reinforcement shall be placed within the following tolerances:

1. For effective depth, 200 mm or less + /- 10 mm
2. For effective depth, more than 200 mm + /- 15 mm

The correct cover shall be maintained by cement mortar blocks or other means approved by the Employer's Representative, as described in Section 17.10.4.

(i) Cleaning

Before placing reinforcement and again prior to concrete placement, the reinforcement shall be cleaned of loose mill scale, rust, oil or other coating that would reduce strength or bond. Steps shall be taken to ensure that the reinforcement shall not contact form coatings, release agents, bond breaker or curing compounds.

(ii) Positioning of Reinforcement

Reinforcement shall be kept in the correct position using the following methods:

For beam and slab construction, pre-cast cover blocks in cement mortar 1:2 (1 cement : 2 coarse sand) about 4 x 4 cm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, to secure and maintain the requisite cover of concrete over reinforcement.

For cantilevered and doubly reinforced beams or slabs, the vertical distance between the horizontal bars shall be maintained by introducing chairs, spacers or support bars of steel at 1.0 metre or shorter spacing to avoid sagging.

For columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them; or with 1:2 cement mortar blocks (1 cement : 2 coarse sand) of the required size suitably tied to the reinforcement to ensure that they are in correct position during concreting.

For other RCC structures such as arches, domes, shells, storage tanks etc. a combination of cover blocks, spacers and templates shall be used as approved by Employer's Representative.

(iii) Tying in Place

The reinforcement shall be accurately placed and tied securely with tying wire at all points where bars cross. Stirrups shall be tied to bars at both the top and bottom. The loose ends of the tying wire shall be bent inwards to prevent them projecting out of the concrete cover provided, taking special care at surfaces where a form finish has been specified. Bars and fabric shall be supported as described in Section 17.10.4.

Bars intended to be in contact at crossing points shall be securely bound together at all such points with 16 gauge annealed soft iron wire. When epoxy coated reinforcement is used, the wire shall be plastic coated. The vertical distances required between successive layers of bars in beams or similar members shall be maintained by the provision of spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bars.

(iv) Splices

Unless otherwise approved, splices shall be wired contact lap splices and conform to the relevant local standard or to IS 2502.

No splicing of vertical bars will be allowed except at approved horizontal construction joints.

Splices in horizontal bars shall be lapped with at least one continuous bar between adjacent splices. The minimum spacing of splices in any one run of bar shall be 6 m and in slabs which contain two layers of reinforcement, splices in opposite layers shall be offset by at least 1.5 m.

(v) Welding

Welding of reinforcement shall not be permitted unless specifically approved. If welding is approved, the work shall be carried as per IS 2751, according to best modern practices and as approved by the Employer's Representative. Where permitted, the bars shall be shop or field welded by experienced welders by the direct electric arc process, using low hydrogen electrodes. In all cases of important connections, tests shall be made to prove that the joints are of the full strength of bars welded. The completed weld shall develop a minimum strength of 125 percent of the bar yield strength.

All surfaces close to the weld shall be cleaned free of loose mill scale or other foreign material. The same precautions shall be taken each time an electrode is charged. Chip burned edges shall be cleaned before welds are deposited.

When wire-brushed, completed welds shall exhibit uniform section, smoothness of welded metal, feather edges without undercuts or overlays, freedom from porosity and clinker and good fusion, with penetration into the base metal. Defective welds or parts of welds shall be cut out and re-done satisfactorily. Defective welds or parts thereof shall not be removed by using a cutting torch.

(vi) Welded Wire Mesh

Welded fabric shall be placed on approved supports to hold it in place during concreting. The fabric shall be laid flat in one plane and bent as required to fit the work. Laps shall be a minimum of one mesh. At laps, alternate wires shall be tied with tying wire.

(vii) Additional Reinforcement

Additional reinforcement shall be provided at sleeves and openings as required.

(viii) Inspection

Erected and secured reinforcement shall be inspected and approved by the Employer's Representative prior to placement of concrete.

Field Quality Control

The Contractor shall appoint an experienced officer to make continuous inspections of the reinforcement during cutting, bending, placing in position, tying and cleaning before the pouring of concrete. He shall effect any corrections or irregularities noted or requested by the Employer's Representative.

Welding for all shop and field welded reinforcing steel bars shall be inspected by the assigned Contractor's officer and regular inspections may be required by the Employer's Representative who shall be given the fullest opportunity to witness the welding operations.

Formwork

General

The Contractor shall submit to the Employer's Representative sufficient details of the proposed shoring and formwork to enable the Employer's Representative to satisfy himself about their general adequacy and effectiveness. Forms, shoring and false work shall be adequate for imposed live and dead loads, including equipment, the height of concrete drop, concrete and foundation pressures, stresses, lateral stability and other safety factors during construction.

The formwork used in the works shall, unless otherwise specified herein, or approved or permitted by the Employer's Representative, comply with IS 14687.

Materials

All formwork shall be constructed of timber, sheet metal or other approved materials, capable of providing the required finish. Where a special finish is required, the Contractor shall provide, before commencement of fabrication, all details of the materials and means he proposes to adopt to obtain the finish. All materials used shall be dimensionally stable on exposure to extremes of weather. Sliding forms and slip forms may be used with the approval of Employer's Representative.

Formwork Requirements

The design of formwork shall take into account all the vertical and lateral loads that the forms will be carrying including live and vibration loadings.

Forms shall conform to the shapes, lines, grades and dimensions including camber of the concrete as necessary. Ample studs, waler braces, straps, shores etc. shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of the forms. Forms shall be strong enough to permit the use of immersion vibrators. In special cases, form vibrators may also be used. The shuttering shall be close boarded. Timber shall be well seasoned, free from sap, loose knots, worm holes, warps or other surface defects in contact with the concrete. Faces coming in contact with concrete shall be free from adhering grout, plaster, paint, projecting nails, splits or other defects. Joints shall be sufficiently tight to prevent loss of water and fine material from the concrete.

Plywood shall be used for exposed concrete surfaces, where called for. Sawn and wrought timber may be used for unexposed surfaces. Inside faces of forms for concrete surfaces which are to be rubbed finished shall be planned to remove irregularities or unevenness in the face. Form work with lining will be permitted.

All new and used form lumber shall be maintained in a good condition with respect to shape, strength, rigidity, water tightness, smoothness and cleanness of surfaces. Form lumber unsatisfactory in any respect shall not be used and if rejected by Employer's Representative shall be removed from the site.

Shores supporting successive stories shall be placed directly over those below or be so designed and placed that the load will be transmitted directly to them. Trussed supports shall be provided for shores that cannot be secured on adequate foundations.

Formwork, during any stage of construction, showing signs of distortion or distorted to such a degree that the intended concrete work will not conform to the exact contours required, shall be repositioned and strengthened. Poured concrete affected by faulty formwork shall be entirely removed and the formwork corrected prior to placing new concrete.

Excessive construction cambers to compensate for shrinkage settlement etc. that may impair the structural strength of members will not be permitted.

Forms for substructure concrete may be omitted when, in the opinion of Employer's Representative, the open excavation is firm enough to act as the form. Such excavations shall be slightly larger than required by the drawings to compensate for irregularities in excavation and to ensure the design requirements are met.

Forms shall be so designed and constructed that they can be stripped in the order required and their removal does not damage the concrete. Face formwork shall provide true vertical and horizontal joints conforming to the architectural features of the structure as to location of joints and be as approved by Employer's Representative.

The formwork shall be so constructed that up and down vertical adjustment can be made smoothly. Wedges may be used at the top or bottom of timber shores, but not at both ends, to facilitate vertical adjustment or dismantling of formwork.

Where exposed smooth or rubbed concrete finishes are required, the forms shall be constructed with special care so that the desired concrete surfaces can be obtained which require a minimum finish.

Form Coating

Form coating shall be non-grain raising and non-staining resin type coating or other suitable non- staining mould oil which will not leave residual matter on the surface of the concrete or adversely affect bonding to concrete of paint, plaster, mortar, protective coatings, waterproofings or other applied materials. The coatings shall not contain any mineral oils, paraffin, waxes or other non-drying ingredients, nor, in the case of surfaces in contact with potable water, any toxic ingredients of any type whatsoever.

Metal Forms

Metal forms shall be true to detail in condition, clean, free from dents, bends, rust and oil or other defects likely to impair the specified finish.

Round Column Forms

Forms for round columns shall be of metal tubes of materials described for metal forms, fibre glass reinforced plastic or other approved material.

Tie Bolts

Only tie bolts which avoid embedding any metal parts permanently within 50 mm of the concrete surface, shall be permitted. Voids remaining after the removal of all or part of each tie bolt shall be filled flush with the surrounding concrete using a freshly prepared non-shrink cement and fine aggregate paste.

In the case of structures designed to retain an aqueous liquid, the Contractor shall ensure that the measures adopted shall not impair the water tightness of the structure. Tie bolts which form a continuous hole through a structure designed to retain an aqueous liquid shall not be used.

Form Joint Sealers

Effective precautions shall be taken to ensure that joints between form panels are sufficiently water tight to prevent honey combing resulting from the escape of mortar during the placing and vibration of concrete. The joints shall be sealed with resilient foam rubber strips, non-hardening plastic type caulking compound free from oil or other such material or compound as may be approved by the Employer's Representative. Form tie holes shall be plugged with plastic caulking compound, tight fitting rubber plugs or equal.

Moulds

Moulds for grooves, drips, rebates, profiles, chamfers and other similar items shall be of a smooth-milled approved timber or standard extruded polymer plaster units of the required shapes.

Bracing Shuttering and Props

Shuttering shall be braced, strutted, propped and so supported that it shall not deform under weight and pressure of the concrete and also due to the movement of men and other materials. Bamboos shall not be used for props or cross bracings.

The shuttering for beams and slabs shall be so erected that the shuttering on the sides of beams and under the soffits of slabs can be removed without disturbing the beam bottoms.

Re-propping of beams shall not be done except when props have to be reinstated to support construction loads anticipated to be in excess of the design load. Vertical props shall be supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the shuttering.

If the shuttering for a column is erected for the full height of the column, one side shall be left open and built upon sections as placing of concrete proceeds, or windows may be left for pouring concrete from the sides to limit the drop of concrete to 1.0 m. or as otherwise approved by Employer’s Representative.

Chamfers & Fillers

All corners and angles exposed in the finished structure shall be formed with mouldings to form chamfers or fillers on the finished concrete. The standard dimensions of chamfers and fillets, unless otherwise specified, shall be 20 x 20 mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

Vertical Construction Chamfers

Vertical construction joints on faces which will be exposed at the completion of the work shall be chamfered as above except where not permitted by Employer’s Representative.

Form Types for Surface Finishes

Concrete surface finishes shall generally be of the following types

1. All interior faces of walls and exposed roofs of structures of above and below grade and exterior surfaces above finished grade shall have a smooth form finish.
2. All exterior walls below finished grade and other surfaces not included in category (1) above, shall have a rough finish, unless otherwise specified.
3. Metal, plywood or forms of other approved material shall be used to provide a smooth finish.
4. Plywood or board forms of lesser quality may be used to provide rough finishes.

Shoring and Falsework

Shoring and false work shall be designed to distribute loads safely over the base area on which the shoring is erected. Adequate precautions shall be taken against undermining or settlement particularly against wetting of soils, when cleaning forms or curing concrete or by any other cause.

(i) Alignment and Camber

All forms shall be constructed to produce the required lines, grades and camber as required, in the finished structure. The tolerance on line and level shall not exceed 3 mm. In the absence of any specific camber, the forms for soffits of beams, other than pre-stressed beams, shall under normal circumstances be constructed to provide an upward camber of 6 mm for every 3 metres of clear span.

(ii) Means Adopted

S-Jacks, wedges or similar approved means shall be used to induce the required camber in the forms and to correct any settlement which may occur either before or during the placing of concrete.

Construction

Form windows shall be provided as necessary to provide access for placement and vibration of concrete. The windows shall be adequately sized to admit chutes and vibrators and should generally be spaced at 2 metre intervals. The windows shall be firmly closed and braced before placing concrete at higher levels.

Temporary openings shall be provided in wall and column forms for inspection and cleaning. All inner surfaces of forms shall be cleaned before any concrete is poured.

Reglets and rebates to receive flashing, frames and other equipment shall be properly formed. Dimensions, details and precise positions of all such reglets and rebates shall be ascertained from the suppliers of the flashings, frames or equipment, if supplied under a separate contract.

If form materials are found to be fit for reuse, they shall be cleaned and re-conditioned before re-erection.

Embedded Piping and Other Hardware

Before the commencement of fabrication of the formwork, all trades requiring openings for the passage of pipes, electrical conduits and other inserts shall be consulted and the necessary pipe sleeves, anchors or other inserts shall be properly and accurately installed by the representative trades or adequate details obtained which would enable the requisite openings to be correctly positioned. Pipes and conduits, when embedded shall not weaken the construction and no pipes, other than electric conduits, shall be permitted to be embedded within a slab not exceeding 12 cm thick. Conduits placed in a concrete slab shall not have an outside diameter exceeding 1/3 the thickness of the slab and shall be placed between the upper and lower layers of reinforcement. Conduits may be embedded in walls if the outside diameter is less than 1/3 the wall thickness and they are not spaced closer than at three diameters centre to centre and do not otherwise weaken the wall.

Field Quality Control

Tell-tale devices or other methods shall be adopted, where approved, to detect movements and deflection of forms during concrete placement. The required slab and beam cambers and verticality and the specified batter of column sides shall be regularly checked, corrected and maintained as concrete loads are applied on the forms. Workmen shall be assigned to check forms and seal all mortar leaks discovered during concreting.

Inspection of Formwork

Any member which is to remain in position after the general dismantling is completed should be clearly marked.

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 the formwork, corrective and strengthening action shall be taken.

The bearing soil must be sound and well prepared and sole plates shall bear well on the ground and;

1. Sole plates shall be properly seated on their bearing pads or sleepers.
2. The bearing plates of steel props shall not be distorted.
3. The steel parts on the bearing members shall have adequate bearing areas.

Safety measures to prevent the impact of traffic, scour due to water etc. should be taken. Adequate precautionary measures shall be taken to prevent accidental impacts etc.

Bracing, struts and ties shall be installed along with the progress of formwork to ensure the strength and stability of the formwork at intermediate stages. Steel sections (especially deep sections) shall be adequately restrained against tilting, overturning.

When adjustable steel props are used, they shall:

1. Be undamaged and not visibly bent;
2. Be complete with the steel pins provided by the manufacturers;
3. Be restrained laterally near each end; and
4. Have means for centralising beams placed in the fork-heads.

Screw adjustment of adjustable props shall not be over extended.

Double wedges shall be provided for adjustment of the form to the required position wherever any settlement / elastic shortening of the props may occur. Wedges should be used only at the bottom end of single props. Wedges should not be too steep and one of the pair should be tightened / clamped down after adjustment to prevent shifting.

The number of nuts and bolts shall be adequate.

All provisions of the design shall be complied with.

Cantilever supports shall be adequate.

Props shall be directly under one another in multistage constructions as far as possible.

Guy ropes or stays shall be properly tensioned.

There shall be adequate provision for the movement and operation of vibrators and other construction plant and equipment.

The required camber shall be provided over long spans.

Supports shall be adequate and in plumb within the specified tolerances.

Removal of Forms and Shoring and Striking

Contractors shall record on the drawings or a special register, the date upon which the concrete is placed in each part of the work and the date on which the shuttering is removed there from.

In no circumstances shall forms be struck until the concrete reaches a strength of at least twice the stress due to self weight and any construction erection loading to which the concrete may be subjected at the time of striking the formwork.

The striking of formwork shall be as approved by the Employer's Representative. Generally, however, the following table gives the minimum periods that must elapse before the formwork is removed, reckoned from the time the pouring of concrete was completed.

Position of Formwork and Props	Minimum days for Removal
Walls	1
Sides of beams and columns	1
Slabs (props left under)	3
Props to slabs (spans not exceeding 4 ½ metres)	7
Props to slabs (spans exceeding 4 ½ metres)	14
Beam soffits (props left under)	7
Props to beams (spans not exceeding 6 metres)	14
Props to beams (spans exceeding 6 metres)	21

The stripping time recommended above may be modified subject to the approval of the Employer's Representative.

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

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

Striking shall be done slowly with utmost care to avoid damage to arises and projections and without shock or vibration, by gently easing with wedges. If, after removing the formwork, it is found that timber has been embedded in the concrete, it shall be removed and made good.

Reinforced temporary openings shall be provided, as approved by Employer's Representative, to facilitate removal of formwork which otherwise may be in-accessible.

Tie rods, clamps, form bolts etc. which shall be entirely removed from walls or similar structures shall be loosened not sooner than 24 hours nor later than 40 hours after concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties withdrawn from walls and grade beams shall be pulled towards the inside face. Cutting ties back from the faces of walls and grade beams will not be permitted.

Restrictions

No permanent load or loads from construction equipment shall be imposed on columns, supported beams or supported slabs until the concrete has attained at least twice the compressive strength necessary to sustain the imposed loads.

Surface Finishes

Surface Finishes produced without Formwork

1. Screeded Finish

   The concrete shall be levelled and screeded to produce a uniform plain or ridged surface as required. No further work shall be applied to the surface unless it is a first stage for a wood float or steel trowel finish.

2. Wood Float Finish

   The screeded finish shall be wood floated under light pressure to eliminate surface irregularities.

3. Steel Trowel Finish

   When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, the surface to the wood float finish shall be steel-trowelled under firm pressure to produce a dense, smooth, uniform surface free from trowel marks.

4. Power Float finish

   Power floating shall be undertaken by steel floating the concrete to an even finish with no ridges or steps. When the concrete has taken a primary set it shall be power trowelled to a uniform smooth polished surface free from trowel marks or other blemishes. Once power floating is complete the surface finish must be adequately protected from construction traffic.

5. Where the type of finish is not specified it shall be wood float finish.

Surface Finishes produced with Formwork

1. Rough Finish

   This finish shall be obtained by the use of moulds or properly designed forms of closely jointed sawn boards. The surface shall be free from substantial voids, honeycombing or other large blemishes.

2. Fair Finish

   This finish shall be obtained from forms designed to produce a hard smooth surface with true, clean arises. Only very minor surface blemishes shall be permitted and there shall be no staining or discolouration. Any projections shall be removed and the surface made good.

3. Fair Worked Finish

   This finish shall be obtained by first producing a fair finish and then filling all surface blemishes with a fresh, specially prepared cement and fine aggregate paste whilst the concrete is still green, where possible. After the concrete has been properly cured the faces shall be rubbed down, if required to produce a smooth and even surface. If the surface is to be exposed in the final work, every effort shall be made to match the colour of the concrete.

4. Liquid retaining surface and other surfaces exposed in the completed Works shall receive a fair worked finish. All other structural concrete surfaces shall receive a fair finish.

HDPE Liners

Where concrete structures are required to be lined with HDPE, the materials and construction methodology of the HDPE lining shall comply with the following requirements.

The thickness of the HDPE liner shall be 3.0 mm or more. Light-coloured lining materials are to be chosen to allow for easier internal and visual inspections.

The HDPE liners shall be secured by integral anchors in order to maintain the adhesion between the HDPE and the concrete. The height of each anchor shall be minimum 13 mm to minimise the risk of pull out of the liner.

The liner anchors and locking system shall resist the full hydrostatic head of water pressure acting upon the exterior of the structure to be lined.

The liners are required to achieve the required resistance to degradation and durability over the design life and are expected to have a design life equal to that of the structure to which they are applied. The liners shall not impact upon the structural integrity of the structure to be lined and shall not hinder its physical performance.

The HDPE liner shall be chemically inert and able to resist chemical attack.

Joints and welding strips shall have the same corrosion resistance as the liners.

The HDPE liner shall comply with the physical properties given in the below table:

Characteristic	Standard	Test Method
Density	0.94 g/cm^3	ASTM D1505
Elongation at yield	15 %	ASTM D638 Speed D (50 mm/min)
Elongation at break	800 %	
Tensile strength at yield	18 N/mm^2	
Tensile strength at break	24 N/mm^2	
Stud pull-out strength	>670 kN/m^2	
Water absorption	0.085 percent maximum	ASTM D570
Water soluble matter	Zero	
Porosity	No pin holes	Spark Tester 8 kV/mm
Coefficient of Liner Thermal Expansion	0.00012 / degree C	ASTM D696
Plasticiser	Nil	Nil

The manufacturer of the HDPE liner shall be ISO 9001 certified.

The seaming of the installed liners shall be performed by extrusion welding. All HDPE welded joints shall be carried out by a competent welder, certified in such welding, and authorised by the manufacturer.

Polyurea Liner

Polyurea Coating

General

All segmental lining pieces shall be coated internally using Polymer urea (Polyurea) coat of suitable approved makes conforming to the relevant ASTM / BIS standards and the technical properties stated therein.

Application methodology shall be as per the manufacturer's specifications or as approved by the Employer

The internal or external concrete surfaces wherever required shall be coated with the Polyurea coating to a minimum 1.5mm thickness. The protective coating shall be Polyurea, a 100% solids, flexible, two components, rapid curing, pure Polyurea coating system providing high corrosion, abrasion and thermal shock resistance.

Technical Properties

The Polyurea coating shall meet the following technical properties:

1	Solids by volume	100%
2	Density at 25deg C	g/ml sprayed film
3	Tensile Strength ASTM D-412	19 Mpa
4	Tear Strength ASTM D624C	90 +/- 4 (N/mm)
5	Elongation ASTM D412	>300%
6	Shore –D ASTM D2240	46
7	Abrasion (1kg, H22 wheels) ASTM D4060	0.4 mg / 1,000 cycles
8	Abrasion (1kg, CS17 wheels) DIN En ISO 5470	10 mg / 1,000 cycles
9	Abrasion (1kg, H22 wheels) ASTM D4060	36mg / 1,000 cycles
10	Service temperature	-30deg C +/- 135deg C
11	Modulus 100/200/300% D412	>9/13/16 Mpa (Nmmsq) ASTM

The Contractor shall submit test certification from the manufacturers for approval by the Engineer.

Application Methodology

The Polyurea coating shall only be applied to the required concrete surfaces after completion of casting and placing the concrete and after the relevant section of the structure has been cleared of construction materials and plant.

The Contractor shall grout any bolt holes in the RCC works using a freshly prepared non-shrink cement and fine aggregate paste.

The Contractor shall prepare the concrete surface by pressure washing and cleaning to ensure a good bond between the coating and the substrate.

Upon completion of the preparation works the Contractor shall seal off the section of structure and install dehumidifiers to reduce the relative humidity at the surface to 75% or less when measured with a hygrometer to BS 8201 Appendix A, for the duration of the application process and in accordance with supplier guidance.

When the relative humidity at the surface is achieved, the Contractor shall apply primer, if required, and Polyurea conforming to the specified standards utilising high pressure, heated two component spray proportioning equipment with an application pressure between 2000-2500 PSI.

Polyurea shall be applied to achieve a minimum required thickness of 1.5 mm. A coverage rate of 3 litres / m^2 is the maximum permitted coverage rate for a single coat application.

The proportioning equipment utilised must be capable of supplying correct pressure and heat for the appropriate hose length on a consistent basis.

The Contractor shall submit the application methodology for the approval of the Engineer.

Quality Control Requirements:

A sample or mock up patch of surface area shall be prepared for guidance and as reference for the project. This sample patch of coated surface area shall be prepared on a RCC structure for an area of at least 10 – 20 Sqm or to the satisfaction of the Employer. This sample patch shall be prepared within the constructed portion of the structure after surface preparation and dehumidifying as detailed above. The sample patch must be stepped down to show each coat / procedure. All work standards shall be measured against this approved sample.

Product batch numbers shall be recorded on delivery together with the compilation of certificates of conformity.

Construction Tolerances

General

Tolerances are a specified permissible variation from the designed lines, grade or dimensions as approved by the Employer's Representative. No tolerances specified for horizontal or vertical building lines or footings shall be constructed beyond the legal boundaries. Unless otherwise approved by the Employer's Representative, the following tolerances shall be permitted:

Tolerances for Reinforced Concrete Buildings

(i) Variation from plumb

In the line and surfaces of columns, piers, walls and in buttresses: 5 mm per 2.5 m, but not more than 25 mm.

For exposed corner columns and other conspicuous lines.

In any bay or 5 m maximum:	(+/-) 5 mm
In 10 m or more:	(+/-) 10 mm

(ii) Variation from the design levels or grades

In slab soffits, ceilings, beam soffits and in arises.

1.	In 2.5 m.:	(+/-) 5 mm
2.	In any bay or 5 m. maximum:	(+/-) 8 mm
3.	In 10 m. or more:	(+/-) 15 mm

For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines.

4.	In any bay or 5 m. maximum:	(+/-) 15 mm
5.	In 10 m or more	(+/-) 10 mm

(iii) Variation in linear building lines

In any bay or 5 m. maximum:	(+/-) 10 mm
In 10 m. or more:	(+/-) 20 mm

(iv) Sizes and locations of sleeves, openings in walls and floors

Allowable tolerance	(+/-) 5 mm (excludes anchor bolts)

(v) Variation in cross-sectional dimensions of columns, beams slabs and walls

Allowable tolerance	+10 mm/5 mm

(vi) Footings

Variation in dimensions in plan:	+50 mm/-5 mm
Misplacement or eccentricity:	2% of footing within the direction of misplacement but not more than 50 mm
Reduction in thickness:	(-) 5% of specified thickness subject to maximum of 50 mm

(vii) Variation in steps

Rise in a flight of stairs	(+/-) 3.0 mm
Tread in a flight of stairs	(+/-) 5.0 mm
Rise in consecutive steps	(+/-) 1.5 mm
Tread in consecutive steps	(+/-) 3 mm

Tolerances in other Concrete Structures

(i) All structures:

Variation of the constructed linear outline from established position in plan.

In 5 m.:	(+/-) 10 mm
In 10 m. or more:	(+/-) 15 mm

Variation of dimensions to individual structure features from established positions in plan.

In 20 m. or more:	(+/-) 25 mm
In buried constructions:	(+/-)150 mm

Variation from plumb, from specified batter or from curved surfaces of all structures.

In 2.5 m.:	(+/-) 10 mm
In 5.0 m.:	(+/-) 15 mm
In 10.0 m. or more:	(+/-) 25 mm
In buried constructions:	(+/-) Twice the above limits.

Variation from level or grade indicated on drawings in slabs, beams, soffits, horizontal grooves and visible arises.

In 2.5 m.:	(+/-) 5 mm
In 7.5 m. or more:	(+/-) 10 mm
In buried constructions:	(+/-) Twice the above limits.

Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members.

Allowable tolerance	(+)12 mm/(-) 6 mm

Variation in the thickness of slabs, walls, arch sections and similar members.

Allowable tolerance	(+)12 mm/(-) 6 mm

(ii) Footings for columns, piers, walls, buttresses and similar members:

Variation of dimensions in plan:	(+)50 mm/(-)12 mm
Misplacement or eccentricity:	2% of footing within the direction of misplacement but not more than 50 mm
Reduction in thickness:	5% of specified thickness subject to a maximum of 50 mm

(iii) Other Tolerances

Tolerances in other types of structures shall generally conform to those given in Clause 2.4 of Recommended Practice for concrete form work IS 14687.

Cement Grouting

General

These specification clauses refer to grouting where required in excavated rocky strata.

Requirements

The Contractor shall furnish all tools, equipment, materials and labour for furnishing and placing grout to stop leaks and permanently control the inflow of water through rock faces when necessary for the proper construction of the Works or if instructed to do so by the Employer's Representative.

The Contractor shall carry out the works in accordance with the requirements of IS 6066 – 1971.

Construction Plant and Products

(i) Equipment

The equipment used shall be of type, capacity and mechanical condition suitable for satisfactorily completing the work. The power and equipment and their layouts shall conform to all relevant regulations and safety codes applicable to the Mumbai Sewage Disposal Project- Stage II. All motors shall be equipped with suitable mufflers and scrubbers.

Standard drilling equipment of the rotary type shall be used to perform the drilling. Rotary percussion drills of any type will not be permitted to be used. The drilling equipment utilized within subsurface structures shall be capable of drilling at any orientation to a maximum depth of 7.5 metres.

Holes shall be grouted using the shortest practicable length of line. Fouling of the equipment shall be prevented by maintaining a continuous flow of grout and by periodically flushing with water. A water supply shall be directly connected into the grout supply line. Pressure gauges and adequate valves required for by-pass and shut-off shall be attended constantly by qualified operators at the collar of the hole being grouted.

Additional grout headers, to a maximum of six, shall be available to interconnect holes. Such interconnected holes shall be grouted simultaneously as long as the capacity of the mixing and pumping system permits the design grouting pressure to be maintained.

The Contractor shall be equipped to continuously flush with fresh water, as approved by the Employer’s Representative, those interconnected holes he is not able to grout, if the grout take in a series of interconnected holes exceeds the pump capacity.

The general requirements for the cement grout plant shall include two independent, operational grout pumps connected to allow switching from one to the other in the event of mechanical failure without interrupting the grout flow, operational stand-by equipment for each element of the operation shall be available at the job site.

(ii) Materials

Mixes consist of cement, water, sand and an approved fluidifier in the proportions as designated by the Contractor’s designer and approved by Employer’s Representative. The mix may, from time to time, be amended to suit the conditions encountered in particular locations. The water cement ratio by volume shall be varied to meet the characteristics of each holes as revealed by the grouting operation and may range between 10.0 and 0.6. If after mixing, the grout cannot be placed for any reason whatsoever, it shall be wasted.

The proportions of grout shall produce a flowable mixture consistent with a minimum water content and shrinkage. The grout proportions shall be limited as follows:

Use	Grout thickness	Mix. proportions	W/C. Ratio in (Max.)
a) Fluid mix	Under 25 mm	One part Portland cement to one part sand.	0.44
b) General	more than 25 mm but less than 50 mm	One part Portland cement to 2 parts of sand.	0.53
c) Stiff mix	50 mm and over	One part Portland cement to 3 parts of sand.	0.53

Variations in grout mixes and procedures shall be permitted if approved by the Employer's Representative.

Special grout shall be provided in strict accordance with the manufacturer's instructions.

1. **Cement Water and Sand**

   All cement, water and sand shall be as that used in concrete.

2. **Fluidifier**

   Fluidifiers shall be compounds possessing characteristics which will improve the fluidity of the mixture and assist in dispersing shrinkage of the grout. Bentonite or other clay like materials are not acceptable as fluidifiers. Fluidifiers shall be furnished in moisture resistant sacks, shipped in dated sealed containers and shall be handled and stored to avoid absorption of moisture, damage or waste. Material which has become caked due to moisture absorption shall not be used in the work. No fluidifier shall be used that has exceeded the manufacturer's recommended shelf life.

3. **Pipes**

   All metal pipes and fittings required for grouting operations shall be furnished, cut, threaded, fabricated and embedded by the Contractor. The pipes shall conform to IS 6631 – 1972.

Execution

(i) General

All holes for cement grouting shall be drilled at the locations, in the directions and to the depths approved by the Employer's Representative, as the grouting operations proceed. Grouting shall be performed in the presence of the Employer's Representative. The actual number, depth sequence and spacing of holes and the pressures, pumping rates and grout mixes to be used for grout injections will depend upon the nature of the rock, the results of the water pressure tests or observations and the results of previous grouting operations. They will be determined by the Contractor and subject to the approval of the Employer's Representative.

(ii) Supervision

The Contractor shall have an experienced supervisor directing his grouting operations. The supervisor shall be experienced in cement grouting in rock.

(iii) Grout Hole Drilling and Preparation

The holes at the maximum required spacing are referred to as primary holes, hereafter. The number of grout holes shall be increased progressively by split spacing between the primary holes as approved by the Employer's Representative. The type of bit used for drilling shall be at the discretion of the Contractor. The minimum diameter of the hole shall be 38 mm at the point of maximum penetration. Only clean water may be used as a circulating medium when drilling grout holes. Recirculated water shall not be used. Grout hole drilling ahead of the grouting operation shall be limited to the extent that can be grouted within two calendar weeks.

Grout pipes shall be installed in a workman like manner and shall be thoroughly cleaned of all dirt, grease, oil grout and mortar immediately before embedment. All grout pipes shall be sealed to the rock. On completion of grouting, grout pipes shall be cut off flush with the rock line and the holes shall be thoroughly washed before grouting, to the approval of the Employer's Representative. Drill cuttings, fragments and slurry shall be removed from the hole by an air/water jet applied at the bottom of the hole and returned through the hole to the surface. Washing shall continue until all debris is removed from the hole and the return water is clear.

Surfaces to be grouted shall be thoroughly roughened and cleaned of all foreign matter and laitance. Prior to grouting, hardened concrete surfaces to be grouted shall be saturated with water.

The cleaning of bedding planes, joints and fractures shall be accomplished by pumping water through the grout connection at the anticipated grouting pressure. Such pressure washing shall continue at the desired pressure as long as there is an increase in the rate of water intake.

Holes in which the optimum pressure cannot be reached shall be washed for as long as the fracture filling is being removed, as will be revealed by the escape of muddy water through nearby openings and for not less than five minutes unless otherwise approved. Open holes in which no pressure can be built up shall be washed for a minimum of five minutes or for such a period as fractures or joint filling, as determined by the Employer’s Representative.

Each grout hole shall be water pressure tested immediately prior to grouting. Water shall be injected through the test apparatus and through the grout connection. All holes shall be tested at pressures to be determined by the Employer’s Representative, but not to exceed 7 kgf/cm^2. Water tests shall consist of water absorption under designated grouting pressures for a maximum of 10 minutes. This procedure is designated as the water pressure check. Expandable rubber packers shall be provided to seal off the portion of the hole to be tested as instructed. Atmospheric or open hole testing may be required in addition to the pressure testing. A selected number of holes will be utilized for water pressure check holes to determine the grouting effectiveness after the primary holes are grouted.

(iv) Grouting under equipment and base plates

Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot, strong, caustic solution for this purpose shall be permitted.

Water in anchor bolt holes shall be removed before grouting is started.

Forms around base plates shall be tight to prevent leakage of the grout.

Adequate clearance shall be provided between forms and base plates to permit grout to be worked properly into place.

(v) Grouting

Unless specifically approved by the Employer’s Representative, each grout hole shall be grouted individually. Approval may be given to grout adjacent holes penetrating the same geologic stratum up to a maximum of six, if communication is established between the holes during grouting and if the water pressure test results in each hole have revealed similar requirements for grout mix and pressure.

Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and breakdown of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more release from entrapped air, link chains shall be used to work the grout into place.

Grouting through holes in base plates shall be by pressure grouting.

Grouting pressure to be used in the work will vary with conditions encountered in different holes and the pressures used for each holes will be as approved by the

Employer's Representative. It is anticipated that pressures will range from 0.7 to 7 kgf/cm^2, but in no event will pressures exceeding 10.5 kgf/cm^2 be required.

(vi) Grout Inspection

Once started, the grouting of a hole shall not be interrupted without approval of the Employer's Representative. If necessary to prevent premature stoppage, periodic applications of water under pressure shall be made. Under no conditions shall the pressure or rate of pumping be increased or decreased suddenly. The grouting of any hole shall not be considered complete until refusal. Refusal is defined as a grout injection rate of zero litres per minute measured over a five-minute interval at 100 percent grouting pressure, although in no case will the Contractor be required to pump into a hole in which the grout takes below 30 litres per hour for more than four hours.

The Contractor shall caulk all grout leaks as they develop, as approved by the Employer's Representative. Caulking shall begin on the leaks with the highest volume and progress to those of lesser volume until all leaks are caulked. Prior to grouting, the Employer's Representative may require caulking of leaks which have shown high volume during water pressure testing. If due to the size and continuity of fractures, it is found impossible to reach the required pressure after pumping a reasonable volume of grout at the minimum workable water-cement ratio, or a mortar grout with the maximum volume of sand at the minimum workable water-cement ratio, the speed of pumping shall be reduced or pumping shall be stopped temporarily and intermittent grouting shall be performed, allowing sufficient time between grout injections for the grout to stiffen. If the desire result is still not obtained, grouting the hole shall be discontinued when approved. In such an event, the hole shall be cleaned, the grout allowed to set and additional drilling and grouting shall then be continued to the this hole or in the adjacent area as approved until the desired resistance is developed.

After grouting refusal is reached, the pressure on the hole shall be maintained by means of a stop-cock or other suitable device until the grout has set.

Grout check holes shall be drilled after the primary hole has been grouted to assess the grouting effectiveness. Additional grouting and drill holes shall be placed between the primary holes as approved by the Employer's Representative.

(vii) Clean-up

During grouting operation, the Contractor shall take such precautions as may be necessary to prevent drill cuttings, equipment oil, wash water and grout from defacing or damaging the permanent structure. The Contractor shall furnish such pumps as necessary to care for waste water and materials from his operations and clean up waste water and materials from his operations. The clean-up procedure shall be to the satisfaction of the Employer's Representative.

(viii) Records

The Contractor shall keep records of all grouting operations including:

1. logs of grout holes;
2. hole locations and depths;
3. results of washing and pressure testing operations;
4. time of each change of grouting operation;
5. pressure;
6. rate of pumping;

7. amount of cement for each change of water cement ratio; and
8. any other data which he considers pertinent and important.

All records shall be in a form approved by the Employer's Representative and shall contain all data as required by the Employer's Representative.

Damp Proof Courses

The surface to receive a damp proof course shall be cleaned and carefully swept to remove all dust, laitance etc. and shall be approved by the Employer's Representative. Damp proof courses shall be cement concrete. An approved waterproofing compound at 3%by weight of cement or as otherwise approved by the manufacturer shall be mixed into the cement mortar for this concrete. The damp proof course shall be laid to the full width of the wall and the edges shall be straight, even and truly vertical. Wooden forms shall be used to obtain good edges. No masonry work shall be commenced onto a freshly laid damp proof course until it has cured for 48 hours but the curing of cement concrete shall be continued along with the masonry work. Specifications for cement, sand, aggregate and water shall be as described for concrete works.

The concrete of ground floors shall be laid in two layers. The top of the lower layer of concrete shall be painted with two coats of A-90 grade bitumen (conforming to IS: 1580) applied at the rate of 1.5 kg/m^2. The top surface of the lower layer shall be finished smooth while laying the concrete so that the bitumen can be applied uniformly. The bitumen shall be applied after the concrete has set and is sufficiently hard. Bitumen felt conforming to IS:1322 shall be sandwiched in the sub-floor laid in two layers.

Bunds

Bunds shall be provided around every storage vessel may contains materials potentially harmful to the environment.

The capacity of every bund shall be at least 120% of the volume of the largest vessel contained in the bund.

Each bund floor shall drain to a sump into which a portable submersible pump could be lowered.

The bund lining shall be resistant to the chemical being stored. The walls of the bund shall be a maximum of 1200 mm high and designed to support any load induced by the bund being full.

No pipe, cable or duct shall pass through the floor or walls of a bund.

Testing of Structures

Inspection of Structures

Immediately after stripping formwork, all concrete shall be carefully inspected and any defective work or small defects, either removed or made good before concrete has thoroughly hardened, as instructed by Employer's Representative.

In case of doubt regarding the grade of concrete used or results of cube strength are observed to be lower than the designed strength as per specifications at 28 days, compressive strength test of concrete based on core test, ultrasonic test and/or load test shall be carried out by the digital ultrasonic concrete tester as approved by the Employer's Representative.

The Contractor shall also conduct conclusive tests such as ultrasonic pulse test, core test etc. to prove the suitability of concrete, in case cube tests give unsatisfactory results.

Core Test

The points from which cores are to be taken and the number of cores required, shall be at the discretion of the Employer's Representative and shall be representative of the whole of the concrete concerned. In no case shall fewer than three cores be tested. Cores shall be prepared and tested as described in IS 516.

Concrete in the member represented by a core test shall be considered acceptable if the average equivalent cube strength of the cores is equal to at least 85% of the cube strength of the grade of concrete specified for the corresponding age and no individual core has a strength of less than 75%.

In case the core test results do not satisfy the requirements as above, or where such tests have not been done, load testing may be resorted to.

Load Tests on Parts of Structures

Load tests should be carried out as soon as possible after expiry of 28 days from the time of placing of concrete. The structure should be subjected to a load equal to the full dead load of the structure plus 1.25 times the imposed load for a period of 24 hours and then the imposed load shall be removed.

The deflection due to imposed loads only shall be recorded. If, within 24 hours of removal of the imposed load, the structure does not recover at least 75% of the deflection under the imposed load, the test may be repeated after a lapse of 72 hours. If the recovery is less than 80%, the structure shall be deemed to be unacceptable.

If the maximum deflection in mm during 24 hours under load is less than $40L^2/D$, where L is the effective span in metres and D the overall depth of the section in mm, it is not necessary for recovery to be measured and the recovery provision as above will not apply.

Other Non-destructive Test Methods

Other non-destructive test methods may be adopted, in which case the acceptance criteria shall be agreed upon between the Employer's Representative and the Contractor and the test shall be done under expert guidance.

Non-destructive tests are used to obtain an estimation of the properties of the concrete in the structure. The methods adopted include ultrasonic pulse velocity [see IS 13311 (Part 1)] and rebound hammer [IS 13311 (Part 2)], probe penetration, pull out and maturity. Non-destructive tests provide alternatives to core tests for estimating the strength of concrete in a structure, or can supplement the data obtained from a limited number of cores. These methods are based on measuring a concrete property that bears some relationship to strength. The accuracy of these methods, in part, is determined by the degree of correlation between strength and the physical quality measured by the non-destructive tests.

Any of these methods may be adopted, in which case the acceptance criteria shall be agreed upon prior to testing.

Members other than flexural members should be investigated by analysis.

Hydraulic Testing of Water Retaining Structures

For a test of liquid retention, concrete structures should be cleaned and initially filled to the normal maximum level with the specified liquid (usually water) at a uniform rate of not greater than 2 m in 24 hours.

When first filled, the liquid level should be maintained by the addition of further liquid for a stabilizing period while absorption and autogenous healing take place. The stabilizing period may be 7 days for a maximum design crack width of 0.1 mm or 21 days for 0.2 mm or greater. After the stabilizing period, the level of the liquid surface should be recorded at 24 hour intervals for a test period of 7 days. During this 7-day test period the total permissible drop in level, after allowing for evaporation and rainfall, should not exceed 1/500 of the average water depth of the full tank, 10 mm or another specified amount.

Notwithstanding the satisfactory completion of the test, any evidence of seepage of the liquid to the outside faces of liquid-retaining walls should be assessed against the requirements of the specification. In the case of tanks whose external faces are exposed or can be left exposed prior to testing, all leakages, wet patches and the like, shall be marked out on the outside of walls during test. The tank shall then be emptied and any necessary remedial treatment of the concrete, cracks or joints shall be carried out from the liquid face by grouting, waterproofing, plastering etc. as necessary to the entire satisfaction of the Employer’s Representative. The tank shall again be tested for leakage after rectification. The work shall not be accepted unless the water tightness is established.

When a remedial lining is applied to inhibit leakage at a crack, it shall have adequate flexibility and have no reaction with the stored liquid.

Should the structure not satisfy the 7-day test, then after the completion of the remedial work it should be refilled and if necessary left for a further stabilizing period; a further test of 7 days’ duration should then be undertaken in accordance with this clause.

The external surfaces of the structure shall then be plastered and cured as per the specification. The water from the compartments shall then be drained and the inner surface of the tank in all compartments be checked and any defects rectified. After satisfactory completion of checks, internal coatings shall be applied as required.

Backfilling, in case of underground sumps, and waterproofing the roof where specified, shall be carried out after testing and rectification of defects.

Unsatisfactory Tests

Should the results of any test prove unsatisfactory, or the structure shows signs of weakness, undue deflection or faulty construction, the Contractor shall remove and rebuild the member or members involved or carry out such other remedial measures as may be required to the approval of the Employer’s Representative.

The completion certificate shall not be given unless the test for water tightness as described above is carried out to the entire satisfaction of the Employer’s Representative.

18 PILING

General

Pile foundations may be necessary for supporting structures where the subsoil is considered to have insufficient bearing capacity. The Contractor shall carry out the detailed design of these structures in accordance with the Contract Conditions and Employer's Requirements and shall determine the type of foundation required, the number of piles and their working loads and the optimum arrangement of piles required for supporting the structures.

Piles shall be designed, constructed and tested in accordance with the relevant sections of IS 2911.

Excavation, concrete, steel reinforcement and steel casing, where applicable, shall conform to the relevant Clauses of the Specification. At least 21 days before the Contractor intends to commence piling work on the Site, the Contractor shall submit for the Employer's Representative's approval full details of his proposed piling system including the type and dimensions of piles, reinforcement details and full design and driving calculations. The details to be submitted shall include the Contractor's proposals for equipment, temporary works and construction methods.

No work on piling shall commence on the Site until the Employer's Representative's approval to the Contractor's proposal has been received.

Notwithstanding the requirements outlined in this section, the design shall be entirely the Contractor's responsibility.

Types of Piles

Bearing piles shall be driven reinforced pre-cast concrete or cast in-situ concrete piles.

All concrete for piles shall be in sulphate resisting cement, unless the Contractor can document that a lesser quality complies with the actual aggressiveness of soil and ground water. The use of a lower quality is subject to the approval of the Employer's Representative.

Design of Piles

Piles shall be designed to sustain the required loads with settlements not exceeding those specified. Allowance shall be made in the design for the incidence of negative skin friction where appropriate and for resisting the necessary tensile forces due to the swelling and heave of any soil stratum.

Piles shall be designed to have a bearing capacity of at least 2.5 times the working load (working load = design load).

The permissible loading of piles shall be modified where necessary to allow for particular conditions: piles in close proximity or in groups, soil strength, groundwater level and other relevant factors.

The piles shall be of sufficient cross-section and length, and configured in a way to sustain the loads designed or specified without settlement (of single piles combined with additional settlements due to group action) exceeding the following:

- Working load allowable settlement 8 mm
- 1.5 × Working load allowable settlement 10 mm
- 2 × Working load allowable settlement 12 mm

These settlements shall include both permanent and elastic deflections. Measurement of the settlement shall be made on first achieving the specified load. Measurement of the settlement shall be made at the point of application of the load.

Where piles in place are subjected to handling, stacking and pitching or bending moments and/or shear forces, these shall be combined with the vertical loads (either in compression or tension) to satisfy the design requirements of BS 8110 Parts 1, 2 and 3.

The average compressive stress in the concrete of bearing piles under working load shall not exceed 25% of the characteristic cube strength at 28 days, calculated on the total cross sectional area of the pile shaft.

Preliminary Test Piles

After the Employer’s Representative has approved the Contractor’s proposals and calculations for the piling system, preliminary test piles shall be constructed to the approval of the Employer’s Representative.

These shall be loaded to two times the working load to prove the design and system and to demonstrate that the safe load requirements can be achieved by the piling method proposed.

The preliminary test piles shall be located in places proposed by the Contractor and approved by the Employer’s Representative. The Employer’s Representative shall be given at least 48 hours notice of commencement of construction of the preliminary pile which is to be test-loaded.

The preliminary test piles shall be constructed and installed in a manner similar to that to be used for the construction of the working piles by the use of similar equipment and materials. Any variation will only be permitted with the prior approval of the Employer’s Representative.

For the preliminary piles that are to be test loaded, a detailed record of the progress during construction/installation shall be made and submitted to the Employer’s Representative daily.

The pile shafts shall be terminated at the normal cut-off level or at some other level as required by the Employer’s Representative.

The pile shafts shall be extended where necessary above the cut-off level of working piles so that gauges and other apparatus to be used in the testing process will not be damaged by water or falling debris and to permit exposure of the reinforcement.

Where the pile shaft is extended above the cut-off level of the working piles in soils that would influence the load bearing capacity of the pile, a sleeve shall be left in place during testing to eliminate friction that would not arise in working piles.

If the cut-off level is below ground level and the shaft is not extended and there is a risk of the borehole collapsing, a sleeve shall be left in place or inserted above the pile shaft or other means satisfactory to the Employer’s Representative shall be employed. Adequate clearance shall be given between the top of the pile shaft and the bottom of the sleeve to permit unrestricted movement of the pile.

For a pile that is tested in compression, the pile head or cap shall be formed to give a plane surface, which is normal to the axis of the pile and sufficiently large to accommodate the loading and settlement measuring equipment. The pile head or cap shall be adequately reinforced or protected to prevent damage due to the concentrated application of load from the loading equipment.

The pile cap shall be concentric with the test pile and the joint between the cap and the pile shall have a structural strength equivalent to that of the pile.

A sufficient clear space shall be made under any part of the cap projecting beyond the section of the pile so that at the maximum anticipated settlement, load is not transmitted to the ground except through the pile.

The connection between the pile and the loading equipment shall be constructed in such a manner as to provide strength equal to the maximum load that is to be applied to the pile during the test with an appropriate factor of safety on the structural design.

If the preliminary test pile fails to meet the requirements, the piling system proposed will be considered unsatisfactory. The Contractor shall then submit revised proposals and calculations for the approval of the Employer’s Representative. Unless otherwise agreed by the Employer’s Representative, any test pile that has failed the preliminary test will be rejected and the Employer’s Representative and the Contractor shall provide one or more further test piles and tests to prove his modified system.

Lengths and Tolerances

The Contractor shall determine the approximate lengths of piles by examination of the available geotechnical information.

In case the available geotechnical information does not describe the ground conditions to a sufficient depth to ensure safety, additional soil investigations shall be carried out by the Contractor to the Employer’s Representative’s approval.

Piles shall be constructed within the following tolerances:

- in plan, at the working level of the piling rig 0.15 × B in any direction from the designed position; B = pile dimension (diameter or side);
- 1 in 75 from the vertical for a vertical pile;

The cross-sectional dimensions of the pile shall not be less than those proposed by the Contractor nor shall they exceed them by more than 0.015 × B (B = pile dimension, diameter or side).

No face of a pre-cast pile shall deviate by more than 6 mm from a straight edge 3 m long joining two points on that face, nor shall the centre of area of the pile at any cross section deviate more than 1/500 of the pile length from a line joining the centres of area of the ends of the pile. The deviation / tolerance for piles shall be as per IS 2911 (Part I / Section I).

Sequence for Constructions

The sequence of construction of piles shall be to the approval of the Employer’s Representative and shall be arranged to minimise the vertical and lateral displacement of piles already installed. Levels of the tops of adjacent piles or the structures founded upon them or any other structures shall be measured at intervals while a pile is being installed. Driven piles which have risen, shall be re-driven or forced down to the original resistance.

Driving Piles

The Contractor shall submit for the Employer’s Representative’s approval, details regarding the suitability, efficiency and energy of his driving equipment.

Pre-cast concrete piles shall not be driven until the concrete has achieved the specified characteristic strength.

Cast-in-situ piles driven with steel casing shall be bottom driven using a casing that shall not distort or buckle during driving. Concrete casing shall be driven on the pile shoe using a mandrel.

Each pile shall be driven continuously until the approved set and/or depth has been reached except that the Employer's Representative may permit the suspension of driving if he is satisfied that the rate of penetration prior to cessation of driving will be substantially re-established on its resumption or if he is satisfied that the suspension of driving was beyond the control of the Contractor.

A follower (long dolly) shall not be used except with the approval of the Employer's Representative who will then require the set to be revised to take into account the reduction in the effectiveness of the hammer blow.

The final set of each pile shall be recorded either as the penetration in millimetres per 10 blows or as the number of blows required to produce a penetration of 25 mm.

When a final set is being measured the following requirements shall be met:

1. The exposed part of the pile shall be in good condition without damage or distortion;
2. The dolly and packing, if any, shall be in sound condition;
3. The hammer blow shall be in line with the pile axis and the impact surfaces shall be flat and at right angles to the pile and hammer axis;
4. The hammer shall be in good condition, delivering adequate energy per blow and operating correctly; and
5. The temporary compression of the pile shall be recorded, if required by the Employer's Representative.

The Contractor shall give adequate notice and provide all facilities to enable the Employer's Representative to check driving resistances. A set for purposes of the Contract shall only be taken in the presence of the Employer's Representative unless otherwise agreed.

At the start of the work and in new areas or sections, a detailed driving record shall be obtained over the full length of the first pile and during the last 3 m of driving of subsequent piles to establish the behaviour of the piles.

The Contractor shall inform the Employer's Representative without delay if an unexpected change in driving characteristics is noted. A detailed record of driving resistance over the full length of the nearest available pile shall be taken.

Re-drive checks, if required, shall be carried out by a procedure to be agreed by the Employer's Representative.

Piles shall be driven in an approved sequence to minimise the detrimental effects of heave and lateral displacement of the ground.

Measurements shall be taken to determine the movement of ground or any pile resulting from the driving process when required by the Employer's Representative.

Where piles have risen as a result of driving adjacent piles, the Contractor shall submit to the Employer's Representative his proposals for correcting detrimentally affected piles and for avoidance or control of heave effects in subsequent work

Jetting may be carried out only when approved by the Employer's Representative and the Contractor shall submit detailed proposals and it shall not normally be undertaken over the last 3 m of penetration.

Repair and Lengthening of Piles

In preparation for repairing the head of a pile, the concrete shall be cut off square at sound concrete to expose the reinforcement and all loose particles shall be removed by wire brushing followed by washing with water.

If the pile is to be subjected to further driving the head shall be replaced with concrete of an approved class.

If the pile has been completely driven but the sound concrete is below cut-off level, the pile shall be made good to cut-off level with concrete of a class not inferior to that of the concrete of the pile.

In preparation for lengthening a normal reinforced pile, the concrete shall be cut off square to expose a sufficient length to ensure that the full strength of the bars will be developed across the joint.

For lap or splice joints, sufficient link bars shall be provided to resist eccentric forces.

If the pile is to be subjected to further driving the additional length shall be of an approved grade of concrete.

Other methods of lengthening shall be subject to approval by the Employer's Representative.

Repaired or lengthened piles shall not be driven until the added concrete has reached the specified characteristic strength of the concrete of the pile.

Reinforcement

Unless otherwise required by the design, cast in situ piles shall be reinforced over the whole of their length.

The minimum longitudinal reinforcement shall be 1.0% of the gross concrete area in the top 3 m of the pile and 0.8% of the gross concrete area in the remainder of the pile. Lateral ties shall be provided to maintain the alignment of the longitudinal reinforcement at centres not closer than 150 mm.

Unless otherwise required by the design, reinforcement in pre-cast concrete piles shall comply with the following minimum requirements:

Area of longitudinal reinforcement of 12 mm diameter minimum shall be at least 1% of the gross concrete area (cast in-situ and pre-cast concrete piles);

Lateral reinforcement shall be in the form of hoops or links not less than 6 mm diameter. Over a distance of 3 times the width of the pile measured from each end of the pile the volume of lateral reinforcement shall be not less than 0.6% of the gross volume. In the body of the pile, the lateral reinforcement shall not be less than 0.4% spaced at not more than half the width of the pile. The transaction between the close spacing near the ends and the maximum spacing shall be made gradually over a length equal to 3 times the width.

Piles of rectangular cross section shall have a minimum of 4 longitudinal reinforcement bars and piles of circular cross section shall have a minimum of 6 longitudinal reinforcement bars. Bars shall be 12 mm diameter minimum. The main longitudinal bars shall be level at the top of the pile and fit tightly into the shoe if one is used.

Hoops and links shall fit tightly against longitudinal bars and be bound to them by welding or soft iron wire with the free ends turned inwards. The longitudinal bars shall be held apart by spreader forks not more than 1.5 m apart.

The main longitudinal reinforcing bars in piles not exceeding 12 m in length shall be in one continuous length unless otherwise required. In piles exceeding 12 m in length, joints will be permitted in main longitudinal bars at 12 m nominal intervals. Joints in adjacent bars shall be staggered at least 1 m apart along the length of the pile. Joints shall be such that the full strength of the bar is effective across the joint.

The cover to the outermost reinforcement, including binding wire shall not be less than 60 mm measured to the inside of the casing. Lap or splice joints shall be provided with sufficient link bars or other elements to resist eccentric forces. Laps shall have a minimum length of 40 times the diameter of the main longitudinal reinforcement.

Main longitudinal reinforcement shall project a minimum of 40 times the bar diameter above the cut- off level of the pile. For pre-cast piles, compliance with this requirement will necessitate breaking down of the pile head after driving.

Pile Shoes

Driven piles shall be provided with flat or pointed co-axial shoes of cast iron if driving is liable to damage the concrete at the tip of the pile.

Records

The Contractor shall maintain a complete record of all piling works that shall include the following where relevant:

- Pile type and number
- Nominal diameter or dimension, pile length
- Date of casting and date driven
- Depth from ground level to toe of pile
- Depth from ground level to bearing stratum
- Set of pile or pile tube in mm per 10 blows or blows per 25 mm of penetration for first piles in new areas or sections, sets taken at intervals during the last 3 m of driving for subsequent piles
- Final set, weight and drops of hammer
- Details of any obstructions observed.
- Ground level at pile position at commencement of pile installation
- Pile cut-off level
- Length of temporary or permanent casing
- Length and details of reinforcement
- Concrete mix
- Volume of concrete supplied to pile where this can be measured in practice

All records shall be accurately kept in duplicate as the work proceeds and one copy shall be handed to the Employer’s Representative at the completion of each day’s work.

Pre-cast Reinforced Concrete Piles

Pre-cast reinforced concrete piles shall be designed cast and cured to develop the strength necessary to withstand the transporting, handling and driving stresses without damage. Square piles shall have chamfered corners.

Cast-In-Situ Piles

Driven or Bored Cast-in-situ Piles

Driven or bored cast-in-situ piles shall comprise a temporary or permanent casing of steel, or a permanent casing of pre-cast concrete, augured or driven to a set and completely filled with dense concrete reinforced with steel bars.

All joints in the casing and between the casing and shoes, where applicable, shall be watertight during driving and completion of driven cast-in-situ piles. Permanent casing shall be inspected. by using a light lowered from the top after installation to ensure that the casing is neither damaged nor deformed and that all loose soil has been removed from the bottom of bored piles.

Drilling mud shall not be used unless otherwise approved by the Employer's Representative.

Casing for Cast-in-situ Piles

The casing shall be suitable for the method of installation and for the purpose of jointing piles. The casing may either be permanent or temporary.

Steel casing shall be delivered to Site in as a long length as can be conveniently handled. Ends shall be prepared for butt-welding and designed to maintain true alignment of the pile.

Joints between steel casings shall be made by butt-welding so that the full strength of the original section is developed. Welded joints shall be watertight.

Concreting Cast-in-situ Piles

Concrete in cast-in-situ piles shall be in accordance with the requirements. The slump for the concrete shall be agreed with the Employer's Representative prior to concreting preliminary test piles. Concrete filling in cast-in-situ piles shall be placed continuously. Removal of temporary casings must be complete before the placed concrete loses its workability to ensure that the concrete is not lifted, but placing of concrete shall keep in advance of withdrawal of casing to prevent necking.

Pile heads shall be stripped down and bonded into the pile caps as specified for pre-cast concrete piles.

Pile Load Tests

General

Pile load tests shall be carried out in the following situations:

- When using a type of pile or installation method that is outside comparable experience and which has not been tested under comparable soil and loading conditions;
- When using a piling system which is outside the experience of the operatives carrying out the work;
- When the piles will be subject to loading for which theory and experience do not provide sufficient in the design. The pile testing procedure should then provide loading similar to the anticipated loading; and

- When observations during the process of installation indicate pile behaviour that deviates strongly and unfavourable from the behaviour anticipated on the basis of the site investigation or experience when additional ground investigations do not clarify the reasons for this deviation.

Load test can be as a static test or a dynamic test.

If one pile load test is carried out, it shall normally be located where the most adverse ground conditions are believed to occur. If this is not possible, an allowance shall be made when deriving the characteristic value of the bearing resistance.

If load tests are carried out on two or more test piles, the test location shall be representative of the site of the pile foundations, and one of the test piles shall be located where the most adverse ground conditions are believed to occur.

Between the installation of the test pile and the beginning of the load test, adequate time shall be allowed to ensure that the required strength of the pile material is achieved and the pore pressures have regained their initial values.

Static Load Tests

(i) Loading procedure

The pile load test procedure, particularly with respect to the number of loading steps, the duration of the loading steps and the application of load cycles, shall be such that conclusions can be drawn about the deformation behaviour, creep and rebound of a pile foundation from the measurements on the pile. For trial piles, the ultimate loading shall be such that conclusions can also be drawn about the ultimate failure load.

Devices for the determination of forces, stresses or strains and displacements shall be calibrated prior to the test.

The direction of the applied force to compression or tension pile tests shall coincide with the longitudinal axis of the pile.

In general, pile load tests for the purpose of designing a tensile pile foundation should be carried out to failure. Extrapolation of the load-displacement graph for tension tests should normally not be used, especially in the case of transient loading.

(ii) Trial Piles

The number of trial piles required to verify the design shall be selected on the following aspects:

- The ground conditions and their variability across the site;
- Type of structure;
- Documented evidence of the performance of the same type of pile in similar ground conditions; and
- The total number and types of piles in the foundation design.

The ground conditions at the test site shall be investigated thoroughly. The depth of borings or files tests shall be sufficient to ascertain the nature of the ground both around and beneath the pile tip. It shall include all strata likely to contribute significantly to pile deformation behaviour, at least five times the diameter beneath the pile tip, unless sound rock or very hard soil is found at a lesser depth.

The method used for installation of the trial piles shall be fully documented.

(iii) Working Piles

The number of working pile load tests shall be selected on the basis of the recorded findings during construction.

The load applied to working test piles shall be at least equal to the design load governing the design of the foundation.

Dynamic Load Tests

(i) General

The results of dynamic load tests may be used for design provided an adequate site investigation has been carried out and the method has been calibrated against static load tests on the same type of pile of similar length and cross-section, and under comparable soil conditions.

Dynamic test results shall always be considered in relation to each other.

Dynamic load tests may be used as an indicator of the consistency of the piles and to detect weak piles (integrity testing).

In a dynamic load test the pile is instrumented with accelerometers and strain gauges within two pile diameters of the top of the pile.

The gauges are connected to a recording and data processing device. During blows on the pile signals from the gauges are recorded and processed for assessment of pile bearing capacity. The data processing will be of two kinds: one simple (CASE or likewise method) and one more exact method based on signal matching (CAPWAP or likewise program).

In the CASE method or likewise the following data shall be registered and reported:

- Bearing capacity;
- Toe resistance and skin friction;
- Maximum compression stress, acceleration, velocity and displacement;
- Maximum tension stress in pile;
- Pile structural integrity; extent and location of damage;
- Maximum energy transferred to the pile;
- Blows per minutes for hammer check;
- Blow number;
- Input and reflection of force, velocity, upward and downward force waves; and
- Load versus deflection of cushions and of pile toe bearing'

CAPWAP or likewise program determines that set of soil resistance parameters which produces the best match between measured and computed pile top force and velocity. After CAPWAP analysis, additional information produced than from CASE is:

- Deformation properties, ultimate capacities and soil damping parameters for each soil segment of normally 1 m length;
- Unit skin friction for each segment and end bearing;
- Maximum of tension and compression forces and stresses;
- Pile structural damping;

- Dynamic pile toe displacement; and
- Graph on bearing capacity and pile stresses versus blow count.

An introductory program (WEAP) can be utilised before pile driving to assess preliminary combinations of sets and bearing capacities for specified pile driving equipment and soil conditions.

Well-experienced experts shall carry out the data processing.

(ii) Dynamic Load Test Procedure

The Contractor shall notify the Employer's Representative at least two weeks prior to dynamic testing.

The Contractor shall submit a qualified testing consultant and his experience to the Employer's Representative for approval.

The Employer's Representative shall determine if the test is to be performed or if some pile waiting periods at the proposed site is required before a decision will be made.

The Employer's Representative will establish a date for the tests and will also determine the location of all piles to be dynamically load tested.

(iii) Dynamic Load Test Procedure on Driven Piles

The Contractor shall supply all personnel and equipment needed to strike the test pile with the hammer.

The Contractor shall provide the hammer (drop, diesel, etc.) or the crane to lift a steel ram weight by a single non-twisting cable and be able to strike the pile top by means of full-gravity-fall.

The testing consultant personnel will drill holes into the pile to be tested so that transducers (two accelerometers and two strain gauges) can be attached.

When the transducers have been placed in position and the recording and processing equipment has been made ready to receive the acceleration and strain measurement, the Contractor shall strike the driven pile with the hammer as many times as is required to obtain adequate measurements as determined by the Employer's Representative.

The Employer's Representative may ask the Contractor to provide surveying instrument to monitor the pile set after each strike.

After the dynamic testing measurements have been obtained and analysed the Contractor shall prepare and submit a complete report to the Employer's Representative.

(iv) Dynamic Load Test Procedure on Bored Piles

The Contractor shall prepare the pile top and, if necessary, improve the structural integrity of the pile top to resist a sharp impact force. All loose concrete at the pile top shall be removed. The top portion of the bored pile shall be extended a length of at least two times the diameter of the bored pile with the same diameter as the bored pile. The extended portion of the bored pile shall be cast with concrete having a minimum compressive strength of 40 MPa.

Additional shear reinforcement such as spiral hoops at the pile top is recommended for the impact force. The Contractor shall provide the windows for the installation of instruments by means of burring $0.35 \times 0.35\ m^2$ to the steel casing using a cutting torch.

On top of the bored pile, a timber cushion shall be placed under a steel plate to act as a hammer cushion. Adhesive material may be applied between the pile top and the timber.

The Contractor shall provide an additional steel casing inserted into the pile top. This casing shall act as a guide for the steel ram weight, having a length not less than the summation of the drop height and the length of the steel ram weight. A vibrating hammer shall be used to secure and stabilise the steel casing.

The Contractor shall supply all personnel and equipment needed to strike the test pile with the steel ram weight. The Contractor shall provide a crane which has the capability to lift the steel ram weight by a single non-twisting cable and be able to strike the pile top by mean of full-gravity-fall.

The testing consultant personnel will drill holes in the windows of the left-in-place steel casing into the pile to be tested so that transducers (two accelerometers and two train gauges) can be attached.

When the transducers have been placed in position and the recording and processing equipment has been made ready to receive the acceleration and strain measurement, the Contractor shall strike the driven pile with the hammer as many times as is required to obtain adequate measurements as determined by the Employer's Representative.

The Employer's Representative may ask the Contractor to provide surveying instrument to monitor the pile set after each strike.

After the dynamic testing measurements have been obtained and analysed the Contractor shall prepare and submit a complete report to the Employer's Representative.

(v) Load Test Report

The Contractor shall, within 24 hours of the completion of the tests, submit to the Employer's Representative a complete record of each pile test. Where appropriate, this report shall include:

- A description of the site;
- The ground conditions with reference to ground investigations;
- The pile type;
- A description of the loading and measuring apparatus and the reaction system;
- Calibration documents of the load cells, the jacks and the gauges;
- The installation record of the test piles;
- Photographic records of the pile and the test site;
- Test results in numerical form;
- Time settlement plots for each applied load when a step loading procedure is used;
- The measured load-settlement behaviour; and
- Justification of the reasons for any departures from the recommendations.

Piles in Compression

(i) Ultimate Bearing Resistance from Static Pile Load Tests

Trial piles to be tested shall be installed in the same manner as the piles that will form the foundation and shall be founded in similar stratum.

In the case of a very large diameter pile, it is often impractical to carry out a load test on a full size trial pile. Load tests on smaller diameter trial piles may be considered provided that:

- The ratio of the trial pile/working pile diameter is not less than 0.5;
- The smaller diameter trial piles are fabricated and installed in the same way as the piles used for the foundations; and
- The trial pile is instrumented in such a manner that the base and shaft resistance can be derived separately from the measurements.

In the case of a pile foundation subjected to down drag, the pile resistance at failure or at a displacement which equals the criterion for the verification of the ultimate limit state determined from the load test results shall be corrected by subtracting the measured or the most unfavourable design positive skin friction force in the compressible stratum from the forces measured at pile head.

When deriving the ultimate characteristic bearing resistance R_{cc} from values R_{cms} measured in one or several static pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installation. As a minimum, both conditions of the table below shall be satisfied using the equation:

$$R_{cc} = \frac{R_{cms}}{\gamma_{ns}}$$

Factors γ_{ns} to derive R_{cc}:

Number of load tests	**1**	**2**	**>2**
γ_{ns} on average R_{cms}	1,5	1,35	1,3
γ_{ns} on lowest R_{cms}	1,5	1,25	1,1

In order to derive the ultimate design bearing resistance, the characteristic value, R_{cc}, should be divided into components of base resistance, R_{cbc}, and shaft resistance, R_{csc}, such that:

$$R_{cc} = R_{cbc} + R_{csc}$$

The design bearing resistance, R_d, shall be derived from

$$R_{cd} = \frac{R_{cbc}}{\gamma_{bs}} + \frac{R_{csc}}{\gamma_{ss}}$$

where γ_{bs} and γ_{ss} are taken from the table below.

Values of γ_{bs}, γ_{ss} and γ_{ts}:

Component factors	γ_{bs}	γ_{ss}	γ_{ts}
Driven piles	1,3	1,3	1,3
Bored piles	1,6	1,3	1,5
CFA piles	1,45	1,3	1,4

Normally the load test only provides the pile load test versus settlement and time versus settlement diagrams without distinction between point and shaft resistance. Therefore, it is often not possible to distinguish between partial factors for the assessment of the design value of base resistance and shaft resistance. Instead a partial factor on the ultimate characteristic pile resistance R_{cc} may be taken as the values γ_t given in the table above.

(ii) Ultimate Bearing Resistance from Pile Driving Formulae

If pile-driving formulae are used to assess the ultimate bearing resistance of individual compression piles in a foundation, the validity of the formulae shall have been demonstrated by previous experimental evidence of good performance or static load tests on the same type of pile of similar length and cross-section and in the similar ground conditions.

Pile driving formulae shall only be used if the stratification of the ground has been determined.

In the design, the number of piles to be re-driven shall be specified. If re-driving gives lower results, these shall be used as the basis for ultimate bearing resistance assessment. If re-driving gives higher results, these may be taken into consideration.

Re-driving should usually be carried out in silt soils, unless local comparable experience has shown it to be unnecessary.

(iii) Ultimate Bearing Resistance from Dynamic Load Tests

Dynamic load tests and their evaluation can be used to assess pile-bearing resistance of individual compression piles. The validity of the evaluation shall have been demonstrated by previous evidence of acceptable performance or static load tests on the same pile type of similar length and cross-section and in similar soil conditions. The input energy level during the dynamic load testing shall be high enough to allow for an appropriate interpretation of the pile capacity at a correspondingly high enough strain level.

When deriving the ultimate characteristic bearing resistance R_{cc} from values R_{cmd} measured in two or several dynamic pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installation. As a minimum, both conditions of the4 table below shall be satisfied using the equation:

$$R_{cc} = \frac{R_{cmd}}{\gamma_{nd}}$$

Factors γ_{nd} to derive R_{cc}:

Number of load tests	2	4	>4
a) γ_{nd} on average R_{cmd}	1,5	1,35	1,3
b) γ_{nd} on lowest R_{cmd}	1,5	1,25	1,1

In order to derive the ultimate design bearing resistance, the characteristic value, R_{cc} should be divided into components of base resistance, R_{cbc}, and shaft resistance, R_{csc}, such that

$$R_{cc} = R_{cbc} + R_{csc}$$

The design bearing resistance, R_{cd}, shall be derived from

$$R_{cd} = \frac{R_{cbc}}{\gamma_{bd}} + \frac{R_{csc}}{\gamma_{sd}}$$

where γ_{bd} and γ_{sd} are taken from the table below. Values of γ_{bd}, γ_{sd} and γ_{td}

Component factors	γ_{bd}	γ_{sd}	γ_{td}
Driven piles	1,4	1,4	1,4
Bored piles	1,7	1,4	1,6

In case R_{cbc} and R_{csc} are not known the design bearing resistance R_{cd} is derived from

$$R_{cd} = \frac{R_{cc}}{\gamma_{td}}$$

Piles in Tension

(i) Ultimate tensile resistance from static pile load tests

Pile load tests to determine the ultimate tensile resistance R_{tc} of an isolated pile shall be carried out in accordance with Clause 18.14.

When deriving the ultimate characteristic resistance R_{tc} from values R_{tm} measured in one or several static pile load tests, an allowance shall be made for the variability of the ground and the variability of the effect of pile installation. As a minimum, both conditions of the table below shall be satisfied using the equation:

$$R_{tc} = \frac{R_{tms}}{\gamma_{nt}}$$

Factors γ_{nt} to derive R_{tc}:

Number of load tests	**1**	**2**	**>2**
a) γ_{nt}on average R_{tms}	1,5	1,35	1,3
b) γ_{nt}gnt on lowest R_{tms}	1,5	1,25	1,1

Normally when piles are loaded in tension, more than one pile shall be tested. In the case of a larger number of tension piles, at least 2% shall be tested.

The design tensile resistance, Rtd, shall be derived from

$$R_{td} = \frac{R_{tc}}{\gamma_m}$$

Where $\gamma_m = 1.6$.

Supervision of construction

A pile installation plan shall be the basis for the construction work. The plan should give the following design information:

- The pile type with designation if standardised or technical approval otherwise;
- The location and inclination of each pile and tolerances on position;
- Pile cross-section;
- Pile length;
- Number of piles;
- Required pile load carrying capacity;
- Pile toe level or the required penetration resistance;
- Installation sequence;
- Known obstructions; and
- Any other constraints on piling activities.

The installation of all piles shall be monitored and records shall be made at site and as the piles are installed. A record signed by the supervisor of the work and the pile manufacturer shall be kept for each pile.

The record for each pile shall include the following, where appropriate:

- Pile type and installation equipment;
- Pile number;
- Pile cross-section, length and reinforcement;
- Data and time of installation (including interruptions to the construction process);
- Concrete mix, volume of concrete used and method of placing for cast-in-situ piles;
- Pumping pressures of the grout or concrete, internal and external diameters, pitch of screw and penetration per revolution (for continuous flight auger piles or other injection piles);
- For driven piles, the values of driving resistance measurements such as weight and drop or power rating of hammer, blow frequency and number of blows for at least the last 0.25 m penetration;
- The power take-off of vibrators (where used);
- The torque applied to the drilling motor (where used);
- For bored piles, the strata encountered in the borings and the condition of the base, if the performance of the base is critical;
- Obstructions encountered during piling; and
- Deviations of positions and directions and as-built elevations.

Records shall be kept for at least a period of five years after completion of the works. As-built record plans shall be compiled after completion of the piling and be kept with the construction documents.

If site observations or inspection of records reveal uncertainties with respect to the quality of installed piles, additional investigations shall be carried out to determine the as-built conditions of the piles and whether remedial measures are necessary. These investigations shall include either re-driving or pile integrity tests, in combination with soil mechanics field tests adjoining the suspected piles and static pile load tests.

Tests shall be used to determine the integrity of piles for which the quality is sensitive to the installation procedures if the procedures cannot be monitored in an alternative reliable way.

Dynamic low-strain integrity tests can be used for a global evaluation of piles that might have severe defects or that may have caused a serious loss of strength in the soil during construction. Since defects like insufficient quality of concrete and thickness of concrete cover, affecting the long-term performance of a pile, often cannot be found by dynamic tests, other tests such as sonic tests, vibration tests or coring may be needed in supervising the execution.

19 STRUCTURAL STEEL

Materials

All structural steel shall be of standard sections and shall be free of scale, blisters, laminations, cracked edges and defects of any sort. The Contractor shall furnish duplicate copies of all mill orders and/ or the test report received from the mills, to the satisfaction of the Employer's Representative.

All structural steel and electrodes shall comply in all respects with IS for structural steel.

Any other quality may be used only if approved by the Employer's Representative. Such permission shall be preceded by yield point stress, ultimate tensile stress, ductility, weld-ability tests or any other characteristics as required by the Employer's Representative.

Steel castings shall conform to Grade III of IS 1030 - Specifications for steel casting for general engineering purposes.

Dimensions and Tolerances

(i) General

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852 for indigenous steel and equivalent applicable codes for imported steel.

An acceptable deviation from flatness in girder webs in the length between the stiffeners or in a length equal to the girder depth shall be 1/150th of the total web depth.

A reasonable limit for combined warping and tilt on the flange ends of a built up member is 1/200th of the total width of flange or 3 mm whichever is smaller measured with respect to centreline of flange.

Lateral deviation between centreline of web plates and centreline of flange plates at the contact surface, in the case of built up sections, shall not exceed 3mm

Columns bearing on each other or resting on base plates and compression joints designed for bearing shall be milled true and square to ensure proper bearing and alignment. Base plates shall also have their surfaces milled true and square.

(ii) Rolled Shapes

The dimensions, form, weight and tolerances of all hot rolled shapes (and other members) shall comply with the relevant Indian Standards.

(iii) Cold Formed Sections

The dimensions and tolerances of all cold formed light gauge structural steel sections shall conform to clauses 4 and 5 of I.S 811- Specification for cold formed light gauge structural steel sections.

(iv) Castings

All steel castings shall conform to IS 4899 and grey iron castings shall comply with IS 210 and malleable castings with IS 2108 or latest version.

Execution

General

In general, fabrication shall conform to the requirements of IS 800.

The Contractor shall deliver the component parts of the steelwork in an undamaged state at the site of the works and the Employer's Representative shall be entitled to refuse acceptance of any portion which has been bent or otherwise damaged before actual delivery.

Workmanship

All workmanship shall be of first class quality in every respect to the greatest accuracy being observed to ensure that all parts fit together properly on erection.

All ends shall be cut true to planes and shall fit the abutting surfaces closely. All stiffeners shall fit tightly at both ends.

All butt ends of compression members shall be in close contact through the area of the joints.

All holes in plates and section between 12 mm and 20 mm thick shall be punched to such diameter that 3 mm of metal is left all around the hole to be cleaned out to correct size by reaming.

Base connections shall be provided as required and the greatest accuracy of workmanship shall be ensured to provide the best connections.

Erection and Marking

Erection and fabrication shall be according to IS 800-1984 section-11. During erection, the work shall be securely braced and fastened temporarily to provide safety for all erection stresses etc. No permanent welding shall be done until proper alignment has been obtained.

Any parts which do not fit accurately or which are not in accordance with the approved fabrication drawings and specifications shall be liable to rejection and if rejected.

Straightening

All materials shall be straight and free from twists. If rectification is necessary, this shall be affected by cold working and applying pressure, but not by hammering or any other method that will affect or damage the metal. Material with sharp kinks or bends shall be rejected.

Cutting

Cutting shall be effected by shearing, sawing, cropping or gas cutting and shall be reasonably square and free from distortion with all burrs removed. If approved by the Employer's Representative the edges shall be ground afterwards.

For gas cutting of high tensile steel, sufficient steel shall be left over beyond the required profile to enable all metal hardened by heat to be removed by machining.

Except where material is subsequently joined by welding, no load transmitting surface shall be gas cut.

Plates in built-up members shall be end edge planed, except where flats with square edges are used. Plates specified to be planed milled or chipped, shall be cut in the first instance to such a size as to allow 3 mm to be planed, milled or chipped from the sides or ends.

Edges or gussets not exceeding 8 mm thickness may be sheared in a machine which can take the full side in one cut. Edges of thicker gussets shall be prepared by planning milling or grinding.

Edge preparation for welding of surfaces shall be carried out by grinding, planing or milling but not by shearing or cropping.

Holing

Holes for rivets or bolts shall not be formed by gas cutting. Drilled or reamed holes shall be cylindrical and perpendicular to the surface. Finished holes shall not be more than 1.5 mm larger than the specified diameter of bolts and rivets up to 25 mm diameter. For larger sizes the finished holes shall not be more than 2 mm larger than the specified diameter of the bolts and rivets.

Holes for turned and fitted bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to H8 tolerances specified in IS:919.

Holes through more than one thickness of material shall, where possible, be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly provided the holes are punched 3 mm less than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not be more than 16 mm.

When holes are drilled in one operation through two or more separable parts, these parts shall be separated after drilling and all burrs removed.

Matching holes for rivets or black bolts shall register with each other so that a gauge 1.5 mm or 2 mm, depending of bolt size, less in diameter than the diameter of the hole shall pass freely through the assembled members in a direction perpendicular to the member surface.

For parts connected with turned and fitted bolts or close tolerance barrel bolts, the matching holes shall be drilled through all the thickness in one operation after securing the parts firmly together and subsequently reamed to size. Where this is not practicable, the parts shall be drilled and reamed separately through hard bushes steel jigs. All holes not drilled through all thicknesses at one operation shall be drilled to a smaller size and reamed out after assembly.

All holes, whether for shop or field connections, shall be accurately centred and matched to render reaming or drifting unnecessary during erection. Members with poorly matching holes shall be rejected.

Bolting

Installation of high strength friction grip bolts in joints shall comply with IS: 4000. The diameter of the bolt holes must not be more than 1.5 mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the nut heads, nuts and washers shall be free of scale, burrs, dirt and other foreign matter tending to inhibit uniform sealing of the joint components.

Riveting

Rivets shall be heated uniformly throughout their lengths and shall, when driven, completely fill the holes.

Riveted members shall have all parts firmly drawn and held together before and during riveting, for multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

All loose, burred or otherwise defective rivets shall be cut out and replaced before loading the structure.

Testing and Inspection

All structural steel and other materials supplied by the Contractor shall be supported by a manufacturer's test certificate conforming compliance with the relevant specifications. The Employer's Representative may order further sampling and testing on any item brought to site.

The Employer's Representative shall have free access at all reasonable times to the Contractor's manufacturer's fabrication shop or yard and shall be provided with all co-operation and facilities for inspection and no work shall be taken down, painted or despatched until it has been inspected and passed. All gangs, templates, tool etc. required shall be supplied by the Contractor.

Inspection by the Employer's Representative and testing by approved authorities will not relieve the Contractor of his liability to fulfil his contractual obligations.

Tolerances for Steel Structures

Tolerances stated below shall be achieved after the entire structure, or part thereof, is in line, level and plumb.

Deviation of column axes at foundation top level with respect to true axes

a) In longitudinal direction	± 5 mm
b) In lateral direction	± 5 mm
Deviation in the level of bearing surface of columns at foundation top with respect to true level	± 5 mm

Out of plumbness (verticality) of column from true vertical axis, as measured at column top

a) For columns up to and including 15 m in height	height ± 1/1000 of column height in mm or ± 15 mm whichever is less
b) For columns exceeding 15 m in height	± 1/1000 of column height in mm or ± 20 mm whichever is less
Deviation in straightness in longitudinal and transverse planes of column at any point along the height	± 1/1000 of column height or ~ 10 mm whichever is less
Difference in erected position of adjacent pairs of columns along length or across width of building, prior to connecting trusses/ beams with respect to true/ distance	± 10 mm

Deviation in any bearing or seating level with respect to true level	± 5 mm
Deviation in differences bearing levels of a member on adjacent pair of columns both across and along the building	± 10 mm

Beams:

Deviation in difference of bearing levels of beams from the true difference	Depth <1800 mm i 6 mm Depth >1800 mm i 10 mm
Deviation in sweep of beams in the horizontal plane	1/1000 of span in mm subject to a maximum of 10 mm

Crane girders and rails:

Shift in the centreline of crane rail with respect to centreline of web of crane girder	± 5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	± 5 mm
Differences in alignment of crane rail in plan measured between any two points 2 metres apart along rail	± 1 mm
Deviation in crane track with respect to true gauge: For track gauges up to and including15 metres	± 5 mm
For track gauges more than 15 metres	± [5 + 0.25 (S – 15)) where S in metres is true gauge
Deviation in the crane rail level at any point from true level	1/1200 of the gauge distance or +10 mm whichever is less
Difference in the crane rail actual levels between any two points 2 metres apart along the rail length	± 2 mm

Difference in levels between crane tracks rails at:

Supports of crane girders	± 15 mm
Mid span of crane girders	± 20 mm
Relative shift of crane rail surfaces at a joint in plan and elevation	2 mm subject to grinding of surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in m	1/1000 of track gauge S subject to maximum of 20 mm

20 ANCHOR BOLTS

Materials

Anchor bolt materials shall be as specified in the table below.

Anchor Bolt Materials

Material	Specification
Steel bolts	ASTM A307, Grade A
Fabricated steel bolts	ASTM A36
Stainless steel bolts, nuts, washers	ASTM A320,Type 304/316 as required

Anchor bolts for equipment frames and foundations shall be designed in accordance with the project seismic zone requirements.

Anchor bolt holes in equipment support frames shall not exceed the bolt diameters by more than 25 percent, up to a limiting maximum over sizing of 6 mm. Minimum anchor bolt diameter shall be 12 mm. Anchor bolts for equipment mounting and vibration isolation systems shall be provided as required.

Tapered washers shall be provided where the mating surface is not square with the nut.

Expansion, wedge or adhesive anchors set in holes drilled in the concrete after the concrete is placed will not be permitted in substitution for anchor bolts except where otherwise specified. Upset threads are not acceptable.

The following information shall be provided for all bolt systems not cast-in-place:

1. Data indicating load capacities.
2. Chemical resistance
3. Temperature limitations
4. Installation instructions
5. Evaluation report for expansion and wedge type anchors.

Execution

General

A. Fieldwork, including cutting and threading, shall not be permitted on galvanized items. Dissimilar metals shall be protected from galvanic corrosion by means pressure tapes, coating or isolators, grouting of anchor bolts with non-epoxy grouts as required.

Cast-In Place Anchor Bolts

Anchor bolts to be embedded in concrete shall be placed accurately and held in correct position while the concrete is placed or, if specified, recesses or blackouts shall be formed in the concrete and the metalwork shall be grouted in place in accordance with Section 17. The surface of metalwork in contact with concrete shall be thoroughly cleaned.

After anchor bolts have been embedded, their threads shall be protected by greasing and placing the nuts.

Adhesive Anchor Bolts

Use of adhesive or capsule anchors shall be subject to the following conditions;

1. Use shall be limited to locations where exposure, on an intermittent or continuous basis, to acid concentrations higher than 10 percent, chlorine or to machine or diesel oils, is extremely unlikely.
2. Use shall be limited to applications where exposure to fire or exposure to concrete or rod temperature above 120^{O}F is extremely unlikely. Overhead applications (such as pipe supports) shall not be allowed because of the above concerns.
3. Approval from the Employer's Representative for specific application and from the supplier of equipment to be anchored, if applicable.
4. Anchors shall be threaded or deformed for the full length of embedment and shall be free of rust, scale, grease and oils.
5. Embedment depth shall be as per manufacturer's recommendations. Adhesive capsules of different diameters may be used to obtain proper volume of the embedment, but no more than two capsules per anchor may be used. When installing different diameter capsules in the same hole, the larger diameter capsule shall be installed first. No extension or protrusion of the capsule from the hole is acceptable.
6. All installation recommendations by the anchor system manufacture shall be followed carefully.
7. Holes shall have rough surfaces.
8. Holes shall be cleaned with compressed air and be free of dust or water prior to installation.
9. Anchor shall be left undisturbed and unloaded for the adhesive curing period.
10. Concrete temperature (not air temperature) shall be compatible with curing requirements of the adhesives.

21 PAINTING AND PROTECTIVE COATING

General

Surfaces to be Painted

The following, in general, are the surfaces to be painted.

1. All exposed piping and other metal surfaces, interior and exterior.
2. All submerged metal surfaces.
3. All Structural and Miscellaneous steel.
4. Exterior, above ground concrete and brick masonry as specified and shown on the drawings.
5. The interior of structures as specified and shown on the drawings.
6. Equipment furnished with and without factory finished surface except as specified hereafter.
7. Door woodwork and architectural trim work.

Surfaces not to be Painted

Unless otherwise approved by the Employer's Representative, the following surfaces shall in general not be painted.

1. Concrete surfaces subject to pedestrian traffic
2. Plastic surfaces, except for colour code labelling.
3. Non-ferrous metals (galvanised metal shall not be considered as a non-ferrous metal in this context).
4. Mechanical equipment and electrical equipment with approved factory finishes.
5. Non-ferrous piping.
6. Chain link fencing

Products

Materials

Paints, oils, varnishes etc. of approved brand and manufacture shall be used. Ready mixed paints as received from the manufacturer without any admixture shall be used.

If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Employer's Representative shall be used. Approved paints, oils or varnishes shall be brought to the site of work by the Contractor in their original containers in a sealed condition. The materials shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnights work. The empty containers shall not be removed from the site of work until the relevant item of work has been completed and permission obtained from the Employer's Representative.

The Contractor shall consult with the paint manufacturer before commencement of the work to certify the suitability of the surface to receive paint and the paint to be used.

Service Conditions and Applicable Systems – Non-Architectural

(i) General

This clause refers to the painting of items other than items of mechanical and electrical plant and equipment.

The painting systems specified herein have been chosen with regard to the different service conditions and shall not be changed except with the explicit permission of the Employer's Representative. All paint materials shall be first quality products of the required type and composition. Trade names, where given; are only meant to clarify the quality required and are not meant to be restrictive in any other sense. Products of other reputed manufacturers complying with the following requirements shall be eligible for use.

(ii) Service Condition A

Service condition A includes ferrous metals other than stainless steel, subject to corrosive moisture or atmosphere and condensation.

Surface preparation shall be carried out so that all metal surfaces are field sand blasted to near–white metal blast cleaned quality. Weld surfaces, edges and sharp corners shall be ground to a curve and all weld splatter removed.

A near-white metal blast cleaned surface finish is defined as a surface with a grey-white, uniform metallic colour, slightly roughened to form a suitable anchor pattern for coatings. The surface, when viewed without magnification, shall be free of all oil, grease, dirt, visible mill scale, rust, corrosion products, oxides, paint or any other foreign matter.

Coat	Description	Thickness
Primer	Zinc rich epoxy primer, equal or superior to Apcodur CP 686 of Asian paints or Epilux 4 zinc rich primer	50 microns
Intermediate	Universal type primer, same as above acceptable	50 microns
Finish	Epoxy enamel, equal or superior to Apcodur CF 697 or Epilux 4 High Build.	100 microns
Total Minimum Thickness		**200 microns**

A minimum of 12 hours shall elapse prior to the application of additional coats to the prime coat. A minimum of 2 hours shall elapse prior to the application of the intermediate coat and a minimum of 2 hours for the finish coat.

(iii) Service Condition B

Service condition B includes ferrous and other metals other than stainless steel, not subject to chemical attack, normal indoor and outdoor exposure, except as specified for buildings.

Surface preparation shall be carried out so that all surfaces shall be free of dirt, dust, grease and other foreign matter before coating. Surfaces shall be cleaned to brush-off blast cleaning quality and weld surfaces and rough edges shall be ground and weld splatter removed.

Coatings shall include the following:

Coat	Description	Thickness
Primer	Zinc rich epoxy primer, equal or superior to Apcodur CP 686 of Asian paints or Epilux 4 zinc rich primer	50 microns
Intermediate	Universal type primer, same as above acceptable	50 microns
Finish	Epoxy enamel, equal or superior to “Apcodur CF 697” or “Epilux 4 High Build	100 microns
Total Minimum Thickness		**200 microns**

Coatings shall be applied in strict accordance with the manufacturer’s recommendations. All sharp edges, nuts bolts and other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat.

(iv) Service Condition C

Service condition C includes ferrous metals and other metals other than stainless steel wholly or intermittently submerged in water or corrosive liquid.

Surface Preparation shall be carried out so that all metal surfaces shall be field sand blasted to near– white metal blast cleaned quality. Weld surfaces, edges and sharp corners shall be ground to a curve and all weld splatter removed and welds neutralized with thinner.

Coatings shall include:

Coat	Description	Thickness
Primer	Zinc rich epoxy primer, equal or superior to Apcodur CP-686 or Epilux 4 zinc rich primer in 2 coats aggregating 75 microns.	75 microns
Intermediate	Coal tar epoxy polyamine coating equal or superior to Apcodur CF 651 or Epiliux 5	Adequate coats to aggregate dry film thickness 400 microns
Finish	As intermediate	
Total Minimum Thickness		**475 microns**

Coatings shall be applied in strict conformance with the manufacturer’s recommendations. All sharp edges, nuts, bolts and other items difficult to coat shall receive a brush-applied coat of the specified coating prior to application of each coat.

(v) Service Condition D

Service condition D includes concrete surfaces subject to intermittent submergence including the entire interior surfaces of wet wells and manholes.

Coatings shall include:

Coat	Description	Thickness
Primer	Not required	
Intermediate & Finish Coats	Coal tar epoxy polyamine coating equal or superior to Apcodur CF 651 or Epilux 5 adequate number of coats to give total dry film thickness	400 microns
Total Minimum Thickness		**400 microns**

(vi) Service Condition E

Service condition E includes exterior or interior concrete surfaces exposed to view, not subject to immersion and designated for painting and not covered under architectural painting.

Surface preparation shall be carried out so that all surfaces shall be free of dust, grease and other foreign matter before coating. Cracks and voids shall be repaired or filled with suitable material compatible with the paint used.

Coatings shall include:

Coat	Description	Thickness
1st Coat	Equal or superior to Snowcem, or Durocem	224 microns
Intermediate Coat	Best quality plastic emulsion paint available dry film thickness of not less than 38 microns.	38 microns
Finish Coat	As above	38 microns
Total Minimum Thickness		400 microns

Time between coats -The filler coat may be recoated in 12 hours, the finish coat if dry for a recoat in 2 hours.

A minimum of 12 hours shall elapse prior to the application of additional coats to the filler coat, a minimum of 2 hours shall elapse prior to the application of the finish coat.

(vii) Service Condition F

Service condition F includes interior and exterior metal not painted under service conditions A, B and C, but designated for painting. Surface preparation shall be:

1. Ferrous Metals - Prepare surface as for Service Condition B.
2. Non-Ferrous Metals - Wash surfaces with solvent thinner

Coatings for Ferrous Metals shall include:

Coat	Description	Thickness
Primer	Red lead primer, equal or superior to Bisow Synthetic Red Lead Primer	50 microns
Intermediate	Exterior synthetic enamel equal or superior to Apcolite or Luxol	50 microns
Finish	As intermediate	50 microns
Total Minimum Thickness		**150 microns**

Coatings for Non-Ferrous Metals shall include:

Coat	Description	Thickness
Primer	A wash primer equal or superior to Apconil WP-636 or Bison Wash Primer	10 microns
Intermediate and Finish	As for ferrous metals above, adequate coats to give 140 microns	140 microns
Total Minimum Thickness		**150 microns**

(viii) Service Condition G

Service Condition G includes plastic pipes, coating for purpose of colour coding and label-stencilling. Coatings to be used for this category shall be certified by pipe manufacturer and to be completely acceptable and non-injurious to pipe.

Surface preparation shall be too lightly sand the pipe and wipe with a solvent to degrease and clean surface.

Coating shall include two coats of paint approved by the Employer's Representative and certified by pipe manufacturer as non-injurious to the pipe, of total dry thickness not less than 150 microns.

Application shall be in strict accordance with manufacturer's recommendations.

(ix) Service Condition H

Service condition H includes interior and exterior wood. Unless already properly hand-sanded, surface preparation shall include sand–paper smooth by hand and clean off dust. Neatly fill nail holes, cracks and depressions with approved filler, coloured to match the wood. When dry, sandpaper smooth and flush.

Coatings shall include:

Coat	Description	Thickness
Primer	White or pink primer equal or superior to Parrot Wood Primer or Woodrite	n/a
Intermediate	Synthetic enamel coating equal or superior to Apcolite or Luxol High Gloss	50 microns
Finish	As intermediate	50 microns
Total Minimum Thickness		**100 microns**

Coating Schedule

The following list specifies the coating system required for each item. The list shall not be construed as complete, list of all surfaces to be coated but as a guide as to the coating systems applicable.

Where reference is made to ferrous metal in this schedule it does not include stainless steel and galvanized iron pipes. Coatings and finishes for architectural work and items are given separately on the drawings.

Description	Service Condition
General	
Exposed ferrous metal	A
Exposed plastic pipe	G
Galvanized metals to be painted	F
Designated Interior concrete walls	E
Designated Exterior concrete walls	E
Submerged ferrous metals	C
All non-submerged structural steel and miscellaneous metals (Unless A is specified)	B
Interior of surge tanks	D

Description	Service Condition
Screenings and wet well Area	
Structure above floor level	A
Screenings hopper	A
Interior of wet wells and all Screen Chambers	D
Walls and roof slabs of all channels	D
Exposed ferrous metals	A
	F
Pump Rooms	
Exposed ferrous metals	A

Painting and Coatings - Architectural

(i) General

The painting and coatings required for architectural work including doors windows and trim work. The systems required for different items and service conditions are given below.

(ii) Service Condition I

Service condition I includes un-plastered interior or exterior concrete surfaces designated for painting shall conform to requirements of service condition E.

(iii) Service Condition J

Service Condition J includes interior plastered brickwork and concrete surface or concrete block work. All concrete block surfaces to be painted shall be filled with putty of a composition approved by the manufacturer of the paint to be used. Service condition K includes five alternative specifications

Alternative 1 is for synthetic enamel paint and is specified below:

1. Surface preparation shall be that all surfaces shall be free of dirt, dust, grease and other foreign matter before coating. Cracks and voids shall be repaired with a suitable compound compatible with the paint to be used.
2. Coating shall include:

Coat	Description	Thickness
Primer	Cement primer, equal or superior to Decoprime or Bison cement primer solvent or water thin-able.	Total dry film thickness not less than 75 microns
Intermediate	Synthetic enamel paint with matt finish equal or superior to Apcoliteor a Luxol synthetic enamel paint	
Finish	As intermediate	
Total Minimum Thickness		**75 microns**

3. Each coat shall be completely dry before subsequent coat is applied

Alternative 2 is for emulsion paint and shall be as specified below:

1. Surface preparation: As for Alternative 1.
2. Coatings: Three coats of an emulsion paint equal or superior to Pentalite Emulsion Paint A 383 line or Luxol Silk Acrylic Emulsion. Total dry thickness should not be less than 190 microns.
3. Application: as for Alternative 1 and conforming to requirements of the manufacturer.

Alternative 3 is for an approved brand of oil-bound distemper or vinyl wall paint. Surface preparation, application and minimum dry thickness shall be as for Alternative 1. The paint shall be of a quality acceptable to the Employer's Representative and shall have been used extensively under similar circumstances satisfactorily.

Alternative 4 is for an approved brand of water-bound distemper such as Castle Dry Distemper. Surface preparation, application and minimum dry thickness shall be as for Alternative 1. The minimum dry film thickness shall be 100 microns, obtained by applying an adequate number of coats.

Alternative 5 is for colour wash of approved tint. The surface shall be prepared as for Alternatives 1 and an adequate number of coats of an approved tint of colour wash shall be applied in accordance with the best current practice to ensure a minimum dry film thickness of 100 microns.

(iv) Service Condition K

Service Condition K is for exterior plastered brickwork and concrete surfaces or concrete block work and is specified below:

1. Surface Preparation - The preparation of surface shall be as for Service Condition E.
2. Coatings - Shall be the same as for Service Condition E.
3. Application - Shall be as recommended by the paint manufacturer.

(v) Service Condition L

Service Condition L is for the woodwork of doors and windows and is as for Service Condition H unless woodwork is to be varnished or French polished.

Where varnishing is specified, the varnish used shall be the best quality copal varnish mixed with turpentine if required and applied in three even coats.

French polishing, if specified, shall be in accordance with the requirements of I.S 348 French polish.

Execution

Manufacturers Recommendations

Unless otherwise specified or approved by the Employer's Representative, the paint and coating manufacturer's printed recommendations and instructions for thinning, mixing, handling applying and protection of the coating materials, preparation of surfaces for coating and for all other procedures relating to coating shall be strictly observed.

Delivery and Storage

Materials shall be delivered in manufacturer's original sealed containers, with labels and tags intact and decipherable. Coating materials and equipment shall be stored in designated areas. Coating containers shall be opened only when required for use. Coating shall be thoroughly stirred or agitated to uniformly smooth consistency and prepared and handled in a manner to prevent deterioration and inclusion of foreign matter. Unless otherwise specified or approved, no materials shall be reduced changed, or used except in accordance with the manufacturer's instructions.

Safety Requirements

Respirators shall be worn by all persons engaged in and assisting in spray painting.

Cloth and cotton waste that might constitute a fire hazard shall be placed in closed metal containers or destroyed at the end of each day's work.

Storage Mixing and Thinning

Paint and coating materials shall be shall be thoroughly stirred, strained and kept at a uniform consistency during application. Materials of different manufacturers shall not be mixed together. Packaged materials may be thinned immediately prior to application in accordance with the manufacturer's directions.

Preparation for Painting and Protective Coating

All surfaces to receive paint and protective coating shall be cleaned as specified prior to application of coating materials. The Contractor shall examine all surfaces to be coated and shall correct all surface defects before application of any coatings. All marred or abraded spots on shop-primed and factory finished surfaces shall be touched –up prior to application of any other coating.

Workmanship

Skilled craftsmen and experienced supervisor shall be employed on all work.

All paint and coatings shall be applied in a workman like manner to produce an even film of specified uniform thickness. Edges, corners, crevices and joints shall receive special attention to ensure that they have been thoroughly cleaned and receive an adequate thickness of paint. The finished surface shall be free of runs, drops, ridges, waves, laps, brush marks and variations in colour, texture and finish. All coats shall be applied to produce a film of uniform thickness. Special attention shall be given to ensure that edges, corners, crevices, welds and similar areas receive a film thickness equivalent to adjacent areas. Installation shall be protected by the use of drop cloths or other approved precautionary measures.

Painting, except the priming coat, shall generally be taken in hand after all other builders work is completed.

The rooms should be thoroughly swept and the entire building cleaned at least one day in advance of the paint work being started.

Hardware, hardware accessories, machined surfaces and similar items not to be coated but which are in contact with coated surfaces shall be removed or masked prior to surface preparations and painting operations. Following completion of coating of each area or unit, removed items shall be re-installed by workmen skilled in the respective trades.

Doors, windows, floors, articles of furniture and such items not to be painted or coated shall be protected from being splashed. Splashes and droppings, if any, shall be removed by the Contractor and the surfaces cleaned.

Application

Each paint application shall be carried out strictly in accordance with the manufacturer's instructions.

Application of Protective Coating

(i) Shop Coatings

Fabricated metal work and equipment which requires coating may be shop-primed with specified primer. Any such work delivered to the site with any other shop coat shall have this coat removed and the specified coating applied in the field if so instructed by the Employer's Representative. Manufactured equipment with approved corrosion resistant factory finishes and galvanized finishes shall be exempt from this requirement.

Thickness of Coating

Where a dry film thickness (in micron) has been specified, such thickness shall be achieved and verified for each coat.

Testing and Inspection

The Contractor shall conduct thickness measurements and inspection of the coated surfaces with equipment supplied by him and acceptable to the Employer's Representative and shall recoat and repair as necessary for compliance with these specifications.

Any surfaces or parts thereof found to be unsatisfactory shall be rectified by the Contractor to the satisfaction of the Employer's Representative.

Concrete Roof

The reinforced concrete roofs shall be made waterproof by application of an approved roof polythene / bitumen membrane / brick bat coba. The finished roof surface shall have adequate slope to drain quickly the rain water to R.W down take inlet points.

All roof floors shall have minimum 1100 mm height solid concrete block parapet wall where access is provided and shall have minimum 300 mm height solid concrete block parapet wall where access is not provided

For roofing drainage, cast iron or uPVC rainwater down takes with C.I. bell mouth or uPVC bend and C.I. or uPVC grating at top shall be provided. For roof areas up to 40 sq m minimum two nos. 100 mm diameter down take pipes shall be provided. For every additional area of 40 sq m or part thereof, at least one no. 100 mm dia. down take pipe shall be provided.

Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rain water.

Flooring

Toilet floor slab shall be filled with brick bat coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.

The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.

The flooring in all areas except toilets, staircases, pumping stations, chlorination building, centrifuge building, workshop, D.G. Room shall be in 250 mm x 250 mm x 20 mm thick marble mosaic tiles of approved make unless otherwise specified, shade and pattern and placed in cement mortar 1:4 to give overall thickness of 50 mm. Half tile skirting shall also be provided in these areas.

The flooring in the pumping stations shall be 60 mm thick cement flooring with Metallic concrete hardener topping, under layer of 42 mm thick cement concrete 1:2:4 (1 cement : 2 coarse : 4 graded stone aggregate 16 mm thick nominal size) and top layer of 18 mm thick metallic concrete hardener consisting of mix 1:2 (1 cement : 2 stone aggregate 6 mm nominal size) by volume & mixed with metallic hardening compound of approved quality @ 3 kg/m^2. Including cement slurry and rounding off edges.

The flooring in operator's room, loading/unloading bay, MCC cum Panel room shall be in 25 mm thick Kota stone slab of approved shade and pattern and placed over 20 mm thick base of cement mortar 1:4 to give overall thickness of 45 mm. Half tile skirting shall also be provided in these areas.

Toilet areas shall have 450 mm x 450 mm x 25 mm thick polished Kota stone tiles placed in cement mortar 1:4 to give an overall thickness of 50 mm. 2100 mm high dado, in 150 mm x 150 mm x 6 mm thick glazed tiles (approved make, shade and pattern) placed in cement mortar 1:3 shall also be provided in these areas.

Surfaces

HDPE liner of suitable specification; as approved by the Employer should be used in all inner wall faces of the plant structure at the fluctuating water levels as protective resistant to corrosion due to sulphate & chloride chemical content of liquid during operating condition.

Accessories

All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and windows shall be provided to prevent the rain water splashing into the building. Chajja shall be projected 150 mm on either sides from size of doors/windows/rolling shutters.

All windows and ventilators shall have 25 mm thick Kota stone sills bedded in cement mortar (1:3).

All doors and windows shall be painted with two coats of synthetic enamel paint over a priming coat (ready mixed

Zinc Chromate Yellow primer of approved brand and manufacturer conforming to IS: 127-106, 341 and 340).

All doors, windows and ventilators shall be made of aluminum conforming to latest version of IS:1948. All fixtures for doors, windows and ventilators shall also be of aluminum. Aluminum grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/unglazed. Minimum weight of aluminum doors & windows shall be as follows

Single Glazed Window	:	(Weights indicated shall be aluminum)
Openable		
Outer Frame	:	Weight 0.70 kg/Rmt

Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.97 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt

Fixing Louvers windows/ventilators

Outer Frame	:	Weight 0.46 kg/Rmt

Double Glazed Window

Outer Frame	:	Weight 0.72 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.98 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt

Sliding Windows

Bottom & Top Frame	:	Weight 0.70 kg/m
Shutter Frame	:	Weight 0.42 kg/m
Interlocking Section	:	Weight 0.47 kg/m

Aluminum Door

Outer Frame	:	Weight 2.508 kg/Rmt
Shutter Frame	:	Weight 2.508 kg/Rmt
Bottom Stile	:	Weight 2.508 kg/Rmt

Glazing shall be 5.5 mm thick glass.

Openings of the windows & ventilators shall be minimum 25% of the external wall area.

Ventilator shall be provided where height of floor is more than 3m.

All windows and ventilators shall have wire mesh. Frame of doors, windows and ventilators shall be of aluminium of standard rolled section. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Engineer. The minimum size shall be as per below:

Door of opening size 1.2m x 2.1m

Door of opening size 0.75m x 2.1m for toilets

Glazed windows of minimum size 1.2m x 1.2m

Ventilators of minimum size 0.6m x 0.6m

Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 5.0m wide x 5.0m high. Rolling shutter shall be provided in MCC cum panel room, chlorine tonner shed, at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required.

22 GENERAL ARCHITECTURAL SPECIFICATIONS

Materials

Lime

Hydrated lime shall be obtained by burning "Kankars" in the manner approved by the Employer's Representative. It shall be properly burnt or calcined. It shall be free from unburnt pieces, ashes and other impurities. It shall be brought in an unslaked condition on site and shall be slaked in fresh clean water on site. Fat or un-hydrated lime shall be from Katni or Satna or any other approved place.

Lime that has been in any way spoiled by rain, moisture, dirt or by any other cause will be rejected and all material that has been rejected shall be removed within 24 hours from the site of the work.

Recommendations of IS: 712 Building limes shall be followed.

Lime Cream Putty

Lime cream putty shall be made from best description of fat lime slaked with excess of water and stored in a pit.

Lime Mortar

Lime mortar shall consist of

1. One part of fat lime, one part of surkhi and one part of sand or:
2. One part of hydrated lime and one part of sand

The mortar shall be ground in a mechanical mill or in bullock mill fitted with Beal's tell-tale. It shall be ground for 200 revolutions. The mortar shall be used as soon as possible after grinding. All mortar prepared and not used for four days shall be rejected and shall be removed from the works within 24 hours of its rejection.

Stone for Masonry

Stone shall be selected from quarries selected by the Employer's Representative. It shall be hard, durable and tough. Each stone must be laid in the work, in its quarry natural bed. Dumb-bell shaped bond stones or headers shall not be used in the work.

Timber

Timber shall be of the best description, well-seasoned and free from sapwood. Timber shall be sound, straight, free from unsightly or loose knots, cracks, shakes, rot and other defects.

Wrought Iron

Wrought iron shall be of good tough metal with an even, silky fibrous grain which will be apparent if broken gradually. It shall be neither cold-short (i.e. brittle when cold) nor hot-short (i.e. tendency to cracking at surface edges when worked at red heat.)

Plates, bars and angles shall be well and clearly rolled, sound and free from flaws, cracks, crop ends and defects of any description.

Concrete Tiles

All concrete tiles shall be subject to the approval of the Employer's Representative and shall be of the best quality. Floor tiles shall be 250 mm x 250 mm with a thickness of 20 mm to 25 mm. Tiles for wall linings and skirting shall be 250 mm x125 mm with 12 mm to 16 mm thickness and shall be provided with a protective cover. All tiles shall be perfectly plain with sharp and plain arises and sharp edges. Any tile which is warped or in which the edges are not square or arises are broken or the angles are not perpendicular shall be rejected.

Plain cement concrete tiles shall be manufactured with a mix of cement and hard-wearing aggregate for grey tiles and white cement and pigment mixed with hard-wearing aggregate for coloured tiles. Tiles shall be cast in steel moulds, vibrated for compaction and thereafter, subjected to hydraulic pressure. The tiles shall be properly cured. The tiles shall be provided with keyed backs.

Marble mosaic tiles shall be formed with a mix of white cement mixed with pigments and thoroughly washed and cleaned, chips of marble of 10 mm to 20 mm size, set on a normal concrete backing of cement and aggregate. Tiles shall be manufactured in the same manner as the plain cement tiles. The tiles shall conform to IS: 1237 cement concrete flooring tiles.

Glazed Tiles

White glazed tiles shall conform in every respect to the requirements of IS: 777 glazed earthenware tiles. Tiles shall be 6 mm thick and subject to the approval of the Employer's Representative. Any tile which is warped or in which the edges are not straight shall be rejected.

Glazing

Unless otherwise specified, glazing shall be flattened sheet glass of the best quality, plain or ground as necessary and free from flaws, specks or bubbles. Glass shall weigh 24 oz. per square foot up to a size of 600 mm x 600 mm and above that size 26 oz per square foot.

Stone Masonry

Workmanship

All stones shall be wetted before laying in masonry. Concrete surfaces of columns, beams, lintels, chajjas etc. coming in contact with masonry shall be properly chipped, washed and wetted before start of masonry work. The concrete surface coming in contact with masonry shall be given a thick coat of cement slurry as the masonry work progresses in height.

Clean chips and spalls carefully selected to fit in the space shall be wedged into the mortar joints and beds wherever necessary to avoid thick beds or joints of mortar. However, proper shaping and dressing of stones shall be done prior to their laying and there shall be no hammering after the stones are laid in position.

The bond stones shall be used in every square metre area of masonry wall and shall extend from front to back in walls having width of up to 600 mm and shall overlap by at least 150 mm in walls having a thickness of more than 600 mm when laid from both sides. The Employer's Representative may permit cement concrete 1:2:4 to act as bond stone, as required. When work starts on an old or long completed section, care shall be taken to roughen and clean the old surface satisfactorily without disturbing the masonry before laying the new. The old masonry shall be wetted before laying the bedding mortar.

Care shall be taken to ensure that no dry work or hollow space is left in the masonry. The joints at the face shall be finished off neatly, being struck and smoothed with a trowel, while the mortar is fresh. The upper surface of the work shall be brought to a uniform level at the height of each course. The faces of masonry walls shall be kept plumb and, where batter has to be given, it shall be uniform. The stones at all corners and junctions of wall shall be of large sizes and hammer dressed to the correct angle.

Completed masonry shall be kept wet for a minimum period of 14 days. In wet weather, newly laid masonry shall be protected from the effects of heavy rainfall.

Joints in exposed masonry faces shall be formed while the mortar is still green and shall be finished as flush joints, weathered joints, round-recessed joints or square-recessed joints as directed by the Employer's Representative. Masonry which is to be rendered or plastered shall have the joints raked out to a depth of 15 mm to form a key.

Khandki Facing

Khandki facing shall be built in regular uniform horizontal courses. The length and depth of each stone shall not be less than half the height of the courses. All horizontal and vertical joints shall be square, true and well dressed for at least 50 mm from the face. The joints shall not exceed 6 mm in thickness. Each Khandki shall be staggered at least 75 mm with the stone above and below it.

One header shall be inserted every 1.5 metres apart in every course for the full width of the wall.

The quoin stones to be laid header and stretcher alternately and their horizontal joints to be square and dressed to a depth of 150 mm

The face work and the brick, rubble or concrete backing shall be built at the same time to the level of each course. The interstices between the tails of the stones shall be solidly filled in.

On completion of the work, the whole face shall be washed with acid and joints to be cement pointed in the manner required.

Ashler or Cut Stone Masonry

Stones shall be of uniform colour and free from defects. All stone work shall be worked to such sizes and shapes as appropriate or as instructed by the Employer's Representative. The stones shall be fine dressed on face and to a depth of at least 75 mm from the face on the joints and rough tooled on beds. All stones shall be set in cement and fine sand and the joints shall not exceed 3 mm in thickness. In the case of non-homogeneous walls and ashler facing, the stones shall break joint with masonry at back and the joints shall be broken vertically not less than half the height of the course. The joints shall be properly supported by dovetailing, hooks, clamps etc., attached to the steel or concrete frame.

All mouldings, cornices and enrichments shall be executed with care being taken and that the arises are sharp and clean. All mouldings and projections etc. shall be carefully boxed up during the progress of the works as well as such stones as the Employer's Representative may deem necessary to protect. All stone work shall be covered with a layer of earth while the work is in progress and after completion of the work, the whole surface shall be washed with acid. The quality of the dressing shall be as per sample to be approved by the Employer's Representative.

Pre-Cast Cement Concrete Block Masonry

Manufacturing

Pre-cast cement concrete blocks shall be of best quality locally available or manufactured at site and should be approved by the Employer’s Representative before incorporation in the work. The ingredient and the cement concrete used shall conform to the relevant IS as stipulated in specification for cement concrete works.

Minimum crushing strength of the solid blocks shall be 40 Kg/ cm^2 28 days after curing. The type of the bond to be adopted will be decided by the Employer’s Representative but vertical joints shall be staggered. The size of the blocks shall be 390 x 190 x 140 mm and 390 x 190 x 100 mm.

Concrete blocks, whether made on or off site shall be manufactured to the shapes, sizes and finishes as approved by the Employer’s Representative and shall comply with the requirements of IS: 2185. Concrete for blocks shall be made generally in accordance with Section 17 except that the combined aggregate shall have a fineness modulus lying between 3.6 and 4 and shall conform with the following grading:

IS Sieve	Percentage passing by weight
12.5 mm	100
10 mm	>85
4.75 microns	>60
300 microns	>10

Concrete for blocks shall be minimum Class M-20. Hand mixing shall not be permitted. When ordered by the Employer’s Representative, sample blocks from any batch shall be tested as specified in IS: 2185.

The Contractor shall submit full details of his proposed manufacturing arrangements to the Employer’s Representative for his approval before making any blocks for use in the works and shall submit such samples as may be needed to demonstrate the quality of the finished product. Production of blocks shall be of equal standard to the approved sample blocks.

The blocks shall be cured for at least for 14 days before incorporation in the work. The cement mortar for concrete blocks masonry shall be 1:4 and joints shall not be more than 10 mm thick.

Finished blocks shall be neatly stacked for storage on a firm dry support and shall be covered to protect them from dirt, sun and rain. Damaged blocks shall not be used in the works.

Workmanship

Concrete blockwork shall be laid generally as specified or as directed by the Employer’s Representative. The construction of hollow block masonry shall be generally in accordance with IS: 2572. Blockwork for partition walls shall be laid in stretcher bond. Fair face blockwork which is not to be plastered shall be neatly pointed.

Brickwork

Manufacturing

Bricks provided for common brickwork shall be whole, sound, well burnt clay bricks free from cracks and shall comply with the requirements of IS: 1077. Clay engineering bricks shall comply with the requirements of IS: 2180. Samples of the proposed bricks to be used shall be submitted to the Employer's Representative for his approval.

Bricks shall be class designation 35 of size 22.5 x 11.1 x 7 cm. Permissible tolerance on dimensions shall not be more than (+/-) 8%.

The minimum crushing strength shall not be less than 35 kg/cm^2 and water absorption shall not be more than 25% by weight.

Workmanship

Brickwork shall be built in accordance with the requirements of IS: 2212.

Bricks shall be carefully stacked by hand in separate stacks. Broken or damaged bricks shall not be used.

Every brick shall be thoroughly soaked in water before use until the bubbles cease to come up. No broken bricks shall be used except as closures.

All the courses shall be laid truly horizontal and where required all vertical joints shall be truly vertical. Joints shall be broken vertically and they shall not exceed 12 mm in thickness.

Bricks shall be thoroughly bedded and flushed with mortar. Specified mortar of good and approved quality shall be used. Lime shall not be used where reinforcement is provided in brick work. The mortar shall completely cover the bed and sides of the bricks. Proper care shall be taken to obtain a uniform mortar joint throughout the construction.

The brickwork shall not be raised by more than 12 single courses per day.

The walls shall be raised uniformly in a proper approved bond. The walls shall be uniformly raised in all cases not leaving any part one metre lower than another. When circumstances render it necessary to carry on the same section of a building in uneven courses, the bricks shall be raked back to maintain a uniform and effectual bond.

In construction of a wall, firstly the two end corners shall be carefully laid to line and level and then the interim portion shall be built using a cord stretching along the headers or stretchers held in position at the ends to keep the correct alignment and level of the courses. Care shall be taken to keep the perpendiculars properly aligned within following maximum permissible tolerances:

1 Deviation from vertical within a storey shall not exceed 6 mm per 3 m height.

2 Deviation in verticality in total height of any wall of building more than one storey in height shall not exceed 12.5 mm

3 Deviation from position shown on plan of any brick work shall not exceed 12.5 mm

4 Relative displacement between load bearing wall in adjacent storeys intended to be vertical alignments shall not exceed 6 mm

5 A set of tools comprising of a wooden straight edge, a masons spirit level, square, a 1 metre rule, line and plumb shall be kept on the site of work for every three masons for proper checking during the progress of work.

String courses, cornices and mouldings shall be straight and true by projecting brick work with properly cut and shaped bricks wherever necessary with as fine joints as possible.

In all brick arches and other curved work, the bricks shall be shaped to the slope, joints radiating correctly to the centre, from front to back of walls and not smaller than 10cm thick.

The adhesion between brick masonry and the concrete surfaces of columns, beams, chajjas, lintels etc. shall be ensured by the concrete being hacked/ chipped/keyed, cleaned and with a cement slurry applied so that a proper bond is achieved.

The joints of all surfaces which are to be finished in plaster shall be raked out to depth of 20 mm as the work progresses and before the cement mortar has set. All joints shall be thoroughly flushed with mortar at every course. Care shall be taken to ensure that the bricks are bedded effectively and all joints completely filled to the full depth.

Newly laid brickwork shall be protected from the harmful effects of sunshine, surface water and impacts. The work shall be watered three times a day for 14 days and afterwards twice a day for a month.

In the event that cracks in the brickwork appear, they shall be made good by cement grouting or epoxy putty grouting/ polysulphide compound grouting or as otherwise approved by the Employer’s Representative.

Half Brick Work

Materials and workmanship for a half brick or brick on edge partition wall shall be as specified above. The wall shall be stiffened by RCC stiffeners 115 mm wide x 80 mm thick to the full length of the wall and shall be provided with two 6 mm diameter mild steel bars or as otherwise approved by the Employer’s Representative. These bars shall be securely anchored at their end where the partition ends. The free ends of the reinforcement shall be keyed into the mortar of the main brick work to which the half brick work is joined. Overlaps in reinforcement, if any, shall not be less than 30 cm.

Carpentry Work

All timber shall be uniform in texture, straight in fibre and shall be well and properly seasoned. Timber shall be free from all defects or damage of a nature which will affect the strength, durability, appearance and fitness for the purpose for which it is required.

Samples of the timber to be used shall be submitted by the Contractor to the Employer’s Representative for approval before commencement work. The Contractor shall produce cash vouchers and certificates from the kiln seasoning plant to show the timber sections to be used on the work as having been kiln seasoned. Seasoning of timber shall be judged from its moisture content as laid down in IS 287. The seasoning of timber shall conform to IS1141-1993. Scantling of all types of timber shall be straight. Warped scantling shall not be used. Before use in the works, the scantling shall be kept in a covered and well ventilated store.

Teak

Best quality Balarsha well-seasoned C.P. Teak shall be used for all carpentry work. The timber shall be properly planed and wrought in a workmanlike manner. Joints shall be true and fit properly and be subject to the approval of the Employer’s Representative.

(i) First Class Teak Wood

Individual hard and sound knots shall not be more than 25 mm in diameter and the aggregate area of all knots shall not exceed one percent of the area of the piece.

(ii) Second Class Teak Wood

Individual hard and sound knots shall not be more than 40 mm in diameter and the aggregate area of all knots shall not exceed one and half percent of the area of the piece. Wood shall be generally free from sapwood, but traces of sapwood may be allowed.

Workmanship

The workmanship shall be of best quality. All wrought timber is to be sawn, planed, drilled or otherwise machine worked to the correct sizes. All joinery work shall fit truly and without wedging or filling. Woodwork in frames shall be wrought. All frame joints shall be put together with white lead and pinned with hard wood pins securing with corrosion resistant star shaped metal pins as approved by the Employer’s Representative. If after fixing in position, any shrinking or substandard materials or bad workmanship is detected, the Contractor shall remove them and replace the same, as approved by the Employer’s Representative.

Individual members shall be of continuous length. The heads and posts of frames shall be through tennoned into the mortices to the full widths. All necessary mortising, tennoning, grooving, matching, tonguing, housing rebate and other necessary works for correct jointing shall be carried out in the best workmanship like manner. Joints shall be of a recognised form of approved joints for each position.

All parts of woodwork resting on or set in masonry or concrete shall be well painted with two coats of bituminous paint or as otherwise approved by the Employer’s Representative, prior to installations. All nails, screws, hold fasts, plates, plugs, pins required for woodwork joinery and fixing work, shall be provided by the Contractor. All materials shall be approved by Employer’s Representative before use in works.

Plaster

The joints of all masonry work shall be raked out to 20 mm. The surface of all concrete and reinforced concrete work shall be roughened in the manner specified for reinforced concrete work before plaster is applied. All the surfaces shall be thoroughly washed and well-watered before plaster is applied.

A long straight edge shall be freely used to ensure an even surface. All corners and angles shall be plumb and true and soffits of arches shall be true arcs of circles. All exposed angles with door and window frames shall be carefully finished. Internal angles shall be rounded and arises shall be rounded, splayed or beaded as required and as approved by the Employer’s Representative.

A sample of plaster shall be approved by the Employer’s Representative as regards the texture etc. before proceeding with the work. All subsequent work shall generally conform to the approved sample panel. The finished work shall be cured for a minimum period of seven days.

Sand Faced Plaster

Cement mortar shall consist of 1 part of cement to 3 parts of screened and washed sand and shall be placed in 2 coats. The undercoat shall be similar to the undercoats for cement plaster.

The surface of the undercoat shall be scratched by special wire tools for forming the key for the finishing coat before the mortar has set and hardened.

The second or finishing coat shall be 1 part of white cement, 3 parts of properly graded washed sand to give a grained texture. The finishing coat shall be 6 mm thick, uniformly applied and surface finished with special cork thapies and tools recommended for coloured cement plaster work. When finished the surface shall be even and shall have a grained texture.

Adequate time interval shall be allowed between the applications of successive coats for hardening. The coats shall be kept moist by watering for 7 days and shall not be allowed to dry out.

Three coats of approved cement paint shall be applied on the finished surface of sand faced plaster. Cement paint application shall be in accordance with the manufacturer's specifications.

Cornices & Enrichment

All plaster cornices, string courses, label courses, beading and mouldings around door and window openings, consoles, key stones, base mouldings, imports, moulded panels, foliated caps and enrichments etc. to the exterior and interior walls (if of greater projection than 20 mm be laid with projecting masonry and/or concrete work) shall be rough cast in mortar, clear cut, rubbed perfectly smooth until a high polish is obtained and finished with clean sharp arises in strict accordance with the details supplied. All lines of mouldings shall truly parallel.

All plaster cornices shall be laid with projection masonry and /or concrete work as the case may be. Nailed cornices shall not be allowed.

Ceiling Fibrous Plaster of Paris

Fibrous plaster of Paris boards shall be made from the best quality plaster of Paris reinforced with jute fibres. The boards shall be 12 mm thick and shall be cast on plate glass to obtain a perfectly smooth surface on one side.

The board shall be fixed to ceiling joists and battens with brass screws. The joints in the boards shall be flushed and filled in with a paste of plaster of Paris and the whole surface shall be smooth, uniform and even on completion.

Cornices and other enrichments shall be provided wherever required. They shall be cast to the precise profile with clean and sharp edges, arises, moulds and shall be made of plaster of Paris reinforced with jute fibres.

Cement Plaster

Blended cement, sand and water required for the work shall conform to Section 17.2, except that sand for the finishing coat shall be fine sand conforming to IS 1542. The plastering works shall generally conform to IS 1661 (Pt. III) (Code of practice for cement and cement plaster finish on walls and ceilings). All general precautions as specified in IS 1661 (Pt. III) clause-8, shall be taken and preparation of the background shall be as laid down in IS 1661 clause 12 and IS 2402 shall be followed for rough cast and sand faced plaster work.

Preparation of Surface

The surface to be plastered shall first be thoroughly cleaned. All joints shall be raked out in case of brick work / stone masonry and closely hacked in case of concrete, under the relevant masonry / concrete items. The surface to be plastered shall be well wetted for a minimum period of 6 hours before commencing the work.

The surface to be plastered shall first be dubbed out with cement mortar to cover all irregularities and faces up to the proudest part. The dubbing coat which shall be 12 mm thick and be applied/scored and keys shall be formed on the surface by thoroughly combing it with heavy horizontal lines about 12 mm apart and about 3 mm deep when mortar has just set.

The cement mortar for sand faced plaster shall have washed and approved sand with slightly larger proportions of coarse materials, but not exceeding 3 mm. The water shall be gradually added to make the mixture homogenous. The thickness of the finishing coat excluding the key shall be 8 mm. After application, the surface shall be finished with a wooden float lined with cork closely pricked on with a wet sponge tapped gently to bring sand particles into prominence.

Any other horizontal portions shall be cleaned of any mortar splashes. Junctions between walls and chajjas shall be rounded off simultaneously as approved by the Employer’s Representative.

The Contractor shall ensure that all service pipes, electrical conduits, boxes, switch boxes etc. have been installed in position and the plastering surface is duly approved by the Employer’s Representative.

In order to avoid the formation of cracks and for the dispersion of cracks at the junctions between concrete surfaces and brick masonry work and between junction of windows/door frames and brick masonry works, cautionary measures such as fastening and lapping of chicken mesh over the junction areas shall be carried out over which the plastering work shall be taken up as required by the Employer’s Representative.

Gaps between window/door frames with cills and jambs shall be filled up/caulked by plaster of Paris/epoxy putty/silicon sealants, rubber based sealants by caulking guns or by approved methods as approved by Employer’s Representative.

Before plastering work is taken up, all the ceilings and walls etc. shall be marked indicating the thickness of plaster required and which shall be in true line, level and plumb and shall be approved by the Employer’s Representative.

Grooves

The grooves shall be of required dimensions. The same shall be made to turn wherever necessary. The finish, inside, shall be of the same finish as that of the plaster. The lines of the grooves shall be well defined and rounded. The grooves shall be provided in plastering in internal and external surfaces.

Mixing

Cement and fine aggregates shall be mixed dry in the required proportions to obtain a uniform colour. Water shall then be added to get the required consistency for the plaster.

Mixing shall be done mechanically. Manual mixing may be allowed only in exceptional circumstances at the discretion of the Employer’s Representative. Manual mixing, where adopted, shall be carried out on a clean watertight platform. After water is added during mixing, the mix shall be mixed for 10 to 15 minutes.

In machine mixing, the mixer shall run at least five minutes after placing all the ingredients in the drum. Only so much quantity of mortar which can be used within half an hour after the addition of water shall be prepared at a time. Any mortar for plaster which is set or partially set shall be rejected and shall be removed forthwith from the site.

Application

The plaster on walls shall consist of two coats. The undercoat shall be 20 mm thick and be of one part cement and 4 parts coarse sand and shall be dashed against wall. It shall be uniformly applied and shall be floated and the surface shall be made even. The surface of the undercoat shall be scratched by wire brush to form a key for the finishing coat, before cement has set or hardened. The second coat or finishing coat shall be a thin coat to produce a smooth and even surface.

Plaster to concrete ceilings may be finished in two coats, the first coat of 1 part cement and 4 parts of sand dashed and floated to make the surface uniform and even. The ceiling plaster shall be completed before commencement of wall palster. The surface shall be scratched as above to form a key for the finishing coat. The second or finishing coat shall be a thin coat of cream of lime putty evenly applied and trowelled smooth to produce a smooth and even surface.

Rough cast plaster shall be carried out in two coats. The first coat shall consist of 1 part of cement to 3 parts of clean sand or as specified otherwise. The finished thickness of the first coat shall be 12 mm and shall be laid by throwing the mortar (by using strong whipping motion) on the prepared surface with a trowel in a uniform layer but shall not be smooth. The second coat shall consist of 1 part of cement and 3 parts of 6 mm to 10 mm gravel all as approved by the Employer’s Representative. The gravel shall be thoroughly cleaned with water removing all dirt and organic materials. All these ingredients shall be mixed into a paste which shall be flung upon the first coat with large trowels to form an even protective coat. The thickness of this coat shall be 10 mm. Due care shall be taken to avoid concentration of either large size or small size of gravel in one place.

Plaster to other concrete surfaces shall be as for walling.

An adequate time interval shall be allowed between the applications of successive coats for hardening. The coats shall be kept moist by watering and shall not be allowed to dry out for seven days.

The finished plastered surface shall be free from cracks, fissures, crevices, hair cracks, blisters, local swellings and flakes. The finished surface shall be true to line, level, plumb and be plain and durable.

Finishes

(i) Neeru Finish

Wherever required, the surface render shall be finished smooth with good quality lime neeru class ‘C’ conforming to revised IS 712-1984. The lime shall be tested in an approved testing laboratory for the chemical analysis of the lime and test certificate submitted regarding suitability of lime for plaster work. Neeru shall be prepared at site out of best quality pure fat lime slaked at site with fresh water and slaked in accordance with the relevant IS code. The slaked and sifted lime shall be reduced to a fine paste by grinding 150 turns in a mortar mill. Sufficient quantity, which can be used within 10 days only shall be prepared at a time. Chopped hessian or jute fibre in the required quantity may also be added to neeru and properly ground to pure paste.

An entire unobstructed area shall be plastered in one operation. Neeru shall be applied to the prepared and partially set but somewhat plastic surface with a steel trowel to a thickness slightly exceeding 1.5 mm and rubbed down to 1.5 mm. It shall be polished to a smooth and even finish working from top to bottom for at least 3 days. All corners shall be truly brought to the desired lines and levels in the base plaster and the thickness of neeru shall not exceed 1.5 mm at these locations.

Moistening shall be commenced as soon as the plaster has hardened sufficiently and is not susceptible to damage. The surfaces shall be kept sprinkled with water for 7 days to prevent excessive evaporation. On the sunny or wind-ward sides of buildings in hot dry weather, matting or gunny bags shall be hung over on the outside of the plaster and kept wet. If blow holes are observed in neeru plaster at any time during the contract period and during the defect liability period, the Contractor shall rectify the defective plaster work including the redoing of the whitewashing/colour washing/distempering work etc. as the case may be.

(ii) Terol Finish of Terraco

Wherever required, the surface render shall be finished smooth with a 0.5 to 3 mm thick coat of Terol of Terraco as per manufacturer's specification. It shall be ensured that the surface to be covered is free of loose particles, dust, dirt, grease, oil and paint. Terol shall be applied on top of finished coat of plaster which should be levelled without any scratch/key marks. Adequate care should be taken that the first coat is levelled well to enable the thin layer Terol plaster to give a smooth finish, substrata/sub base should be moistened with water prior to the application of the Terol.

Mixing

Put water into a clean empty drum. Add Terol start stirring with paddle. Gradually add water and Terol alternatively in the required proportion to get desired creamy consistency, convenient for application and stir continuously and ensure that no lumps remain. Terol should not be allowed to stand without stirring for longer than 60 minutes. In normal condition Terol shall stand for 5 minutes then stirred and used. Where rapid drying conditions are prevalent, Terol shall be mixed 20 minutes before using.

Application

Terol shall be sprayed or hand applied and smoothened with a steel float. Smooth finishing shall be achieved with wooden float or trowel when Terol has set. The float should be moistened during the smoothening operation.

Curing the surface shall be carried out after 24 hours of application for at least 4 days using light water spray.

Wherever required, the surfaces shall be finished smooth with approved quality plaster of Paris (PoP). PoP shall be mixed in water for hydration at site. A quantity which can be used within half an hour only shall be prepared at a time.

PoP shall be applied immediately after the under coat of cement plaster has set. An entire unobstructed area shall be finished in one operation. PoP shall be applied on top of the finished coat of plaster which shall be flat and smooth without any scratch/key marks to the prepared and partially set. It shall be ensured that the surface to be covered is free of loose particles, dust, dirt, grease, oil and paint. PoP shall be applied with steel trowel to a thickness slightly exceeding 2 mm and rubbed down to 2 mm. PoP shall be polished to a silk smooth and even finish working from top to bottom. All corners shall be truly brought to the desired lines and levels in the base plaster along and the thickness of PoP shall not exceed 2 mm, at these locations.

Cement Pointing

Surface Preparation

The joints shall be raked out properly with dust and loose mortar brushed out. Efflorescence, if any, shall also be removed by brushing and scraping. The surface shall be thoroughly washed with water, cleaned and kept wet before pointing is commenced.

Application of Mortar Finishing

The mortar shall be pressed into the raked out joints with a pointing trowel, either flush, sunk, ruled or raised according to type of pointing required. The mortar shall not spread over the face of brick work or stone work, corners, edges of the masonry but restricted to the width of joints only.

Superfluous mortar shall be the struck off and the surface of the masonry shall be cleaned completely. The finish shall be such that the pointing is to the exact size and shape required and the edges shall be straight, neat and clean. The pointing lines shall be straight, regular and uniform. No false joints shall be allowed.

Curing

The pointing shall be kept wet for at least seven days and be suitably protected from all damage.

Types

(i) Raised and Cut Pointing

Raised and cut pointing shall project from the wall facing with its edges cut parallel to have a uniformly raised band about 6 mm raised and width 10 mm or as otherwise approved.

(ii) Flush Pointing

The mortar pressed into the joints shall be finished off flush and level with the edges of bricks, tiles or stones to give a smooth appearance. The edges shall be neatly trimmed with a trowel and straight edges.

(iii) Ruled Pointing

The joints shall be initially formed as for flush pointing and then while the mortar is still green, a groove of shape and size as approved shall be formed by running a forming tool straight along the centre line of the joints. This operation shall be continued until a smooth and hard surface is obtained. The vertical joints shall also be finished in a similar way. All vertical lines shall make true right angles at their junctions with horizontal lines and shall not project beyond the same.

Wall Care Putty

General

Wall care putty shall consist of white cement, high quality polymers and special chemicals and mineral fillers and shall be formulated to make it suitable to apply even on damp surfaces. Wall care putty shall be suitable for application to both interior and exterior plastered surfaces and have a water resistant base coating to provide a fine flat and protective base for the surfaces to be painted.

Wall care putty shall have superior water resisting properties to prevent paint from flaking even if the walls are damp and it shall fill-up fine pores in walls and ceilings to get the smooth and dry surface. Wall care putty shall have better properties in terms of water-resistance, adhesive strength and durability compared to the ordinary putties. The putty shall provide a breathable surface and allow any trapped moisture to move out keeping the wall dry and clean.

Material

Wall care putty shall be in dry free flowing powder form. The putty shall conform to the International standards (viz. HDB-Singapore Standards with Water-resistant properties).

The putty shall be procured in the form of fine or coarse (matt) finish.

Preparation of Surfaces

Surfaces should be clean of loose particles, dirt, grease and traces of foreign material. Sand papering or chipping shall be done if so required.

Loose plastered areas/defective materials shall be removed and the surface re-plastered and cracks filled.

Uneven ceiling/wall surfaces shall be made even by re-plastering.

Surfaces should be pre-wetted prior to application to provide a strong bond with substrate.

Mixing

12 to 16 litres of clean water shall be required for a bag of 40 kg of wall care putty. Required quantity of putty (which is required to be used at a time) shall be added to the water in right proportion. (considering pot life of the mix is 60 minutes).

The mix shall be stirred continuously by using an electric mixer or by hand to obtain a homogeneous lump-free paste.

The paste shall be allowed to stand for about 10 minutes for the additives to dissolve.

The paste shall be re-mixed again for about 2 minutes.

This mix should be used within 60 minutes.

Application

The plastered surface shall be dampened with clean water and excess water shall be allowed to be drained off.

Using a steel trowel/blade, the above mix shall be applied to a thickness of about 1 – 2 mm then the surface shall be levelled and smoothed. This first coat shall be cured lightly after it dries.

The second coat shall be applied after the first coat is fully dried and set. The second coat shall be cured lightly for two days.

Over plastered / coarse putty substrate, fine wall care putty of about 1 to 1.5 mm thickness shall be applied and a steel trowel used to smooth the surface. The finished surface of wall care putty shall not require any further dressing.

The thickness of each coat should not exceed 1.5 mm and total wall putty thickness should not exceed 3 mm

If necessary, coarse wall care putty of about 6 to 10 mm thickness shall be applied to remove the undulations and level the surface. More coats of coarse putty shall be applied to cover up undulations, only after approval of the Employer's Representative.

Coverage of wall care putty depends upon surface quality, however, approximate coverage for fine wall care putty shall be 20-22 ft^2/kg and for coarse wall care putty, it shall be 9-10 ft^2/kg.

Application of primer before painting is not necessary over the surfaces finished with wall care putty.

Specification:

Specification of wall care putty – for smooth finish		
Property	**As per HDB (Housing Development Board), Singapore**	**Test method**
Dry Adhesion	>=0.8 N/mm^2	EN 1015-12
Wet Adhesion	>=0.3 N/mm^2	Chinese Std.
1. Tensile Adhesion Strength ($N/sqmm^2$) @ 28 Days	>0.8 N/mm^2	EN-1348
2. Compressive Strength (N/mm^2) @ 28 Days	7-12 N/mm^2	EN 1015-11
3. Setting Time (Minutes) - Initial & Final	<360 <500	EN 196
4. Water Absorption Coefficient – Kg/m^2. H1/2	<=0.13 for W2 / <=0.26 for W1	EN 1015-18
5. Water Capillary Absorption (ML) @ 24 Hrs.		Karsten Tube
6. Water Retentivity %	>=95%	EN 1015-8
PH	Alkaline	

Aluminium Curtain Wall System

General

Aluminium Curtain Wall System shall be designed for the following effects:

1. Permanent deformation, thermal expansion
2. Wind and seismic loads
3. Air and water infiltration or leakage.
4. Lateral deflection per floor height.

Materials used for Curtain Wall

Specification for Materials used for Curtain Wall

Materials	Specification
Glazing	Glazing work shall be as specified.
Framing system	Aluminium anodized extruded sections manufactured by reputed approved manufacturers, for all types of members like brackets, mullions, transoms etc.
Sealant	As specified in the item or silicon sealant
Insulation	50 mm thick glass wool of minimum density 48 kg/m^3 sandwiched with black polythene sheet 100 micron on one side and aluminium foil of 100 micron on the other side or as specified by manufacturer at spandrel area. The surface after fixing insulation shall be plain without any distortion
Heat Reflective Toughened Glass	a. St. Gobain - Reflectosolar as specified. b. Glaverbel / Glavermass - Super Siliver. c. Viste on Ford. Brown or Grey Colour of any shade approved by the Employer's Representative

Aluminium Alloy Extruded Sections

Extruded sections to be used for fabrication of framing system for curtain walls shall be manufactured and supplied by approved reputed companies. In absence of specific extruded section, sections available conforming to BIS specification, manufactured by approved reputed companies, shall be used in the works.

Components, Glazing, Panelling etc. for Curtain Wall System

The basic design and architectural requirements shall consist of the size of window, net glass area, ventilator, configuration of windows and spandrels to be retained.

The curtain wall system shall provide for expansion and contraction of components which will be caused by an ambient temperature range without causing buckling, stress on glass, failure of joint sealants, undue stress on structural elements or other detrimental effects, specific details shall accommodate thermal and building movements.

Quality Consideration and other Activities

The Contractor, while submitting his design calculations, should provide the following information on the quality of materials to be used and other aspects as detailed below:

1. Metal quality, finishes and thickness
2. Glass quality, coating and thickness and proposed manufacturer's brand names.
3. Aluminium extruded sections including mullions and transoms together with structural calculations and proposed manufacturer's brand name.
4. Arrangement and jointing of components.
5. Field connections especially mullion to mullion and transom to mullion.
6. Fixing and anchorage system of typical wall unit together with structural calculations.
7. Drainage system and provision in respect of water leakage in the curtain wall system.

8. Provisions for thermal movements.
9. Sealant and sealing methods.
10. Glazing method
11. Wind load and seismic load and any other specific load considered in the design

Design concept over the lightning protection link-up system for the curtain wall for connection and incorporation into the lightning conductor system of the building.

The maximum permissible structural tolerances of the building that the system has been designed to accommodate in case these tolerances exceed those in the specification.

Tolerances

Any parts of the curtain wall, when completed, shall be within the following tolerances:

1. Deviation from plumb level or dimensioned angle must not exceed 3 mm per 3.5 m length of any member, or 6 mm in any total run in any line.
2. Deviation from theoretical position on plan or elevation, including deviation from plumb, level or dimensioned angle must not exceed 9mm total at any location.
3. Change in deviation must not exceed 3 mm for any 3.5 m run in any direction.

Samples

The Contractor shall submit samples of aluminium extruded sections; mullion and transom sections in lengths of 300 mm with the proposed finish and workmanship and 300 mm x 300 mm samples of glass for approval of the Employer’s Representative (samples to include exposed screws and other exposed securing devices if any).

Execution of work

(i) Performance Testing - General Requirements

Mock-up units shall be constructed by the Contractor and tested to determine the structural stability as well as air and water infiltration or leakage at glazing beads and all other joints designed into the face of the building.

After the approval of structural calculations and the drawing for construction of the curtain wall, one test unit for performance testing of the curtain wall shall be constructed by the Contractor at an independent laboratory or at a laboratory approved by the Employer’s Representative.

The mock-up shall be erected under the manufacturer's / fabricator's direct supervision and employ workmen as they would be employed during the actual erection at the job site.

The Contractor shall submit to the Employer’s Representative the test procedures to be adopted, test schedule and location for testing before the testing commences.

Prior to the fabrication of the test units, the Contractor shall submit shop drawings and design calculations of the test unit for approval of the Employer’s Representative.

The Contractor shall not start the work of erection of curtain wall on site until approval is received for the successful completion of the mock-up test and clear instruction in writing to start the work is received from the Employer’s Representative.

(ii) Test of Wind Pressure

The equivalent load of wind pressure or wind suction shall be given to the test unit as increasing or decreasing the inside pressure in the pressure chamber at which the test unit is fixed.

The static wind pressure shall be applied up to 1.5 kPa at maximum wind pressure.

The variation of dynamic pressure shall be of an approximate sine curve line.

Deflection on each observational points of the test unit shall be observed and recorded under static pressure as described above.

Any damage and harmful permanent deformation on any parts except sealing materials shall not be found at maximum wind pressure.

The deflection on the main structural parts in this condition shall not exceed:

1. 1/175 of the span between supports or 20 mm, whichever is less for vertical elements.
2. 1/250 of the span between supports for horizontal elements.
3. The extent of recovery of deformation, 15 minutes after the removal of the test load, is to be at least 95%.

(iii) Test of Lateral Deflection per Floor Height

Lateral deflection per floor height shall occur on the test unit, when the structural frame which fixes the test unit is deflected horizontally.

The deflection of every ± 2.5 mm shall be increased up to ± 13 mm on the test unit (static deflection test)

The dynamic deflection shall be applied up to ± 13 mm

The variation of dynamic deflection shall be of an approximate sine curve, one period of 3 seconds.

The dimensions of the deflection on each observational point of the test unit shall be measured under the condition as described above and the damage shall be observed.

Any damage and harmful permanent deformation shall not be found in any parts of the curtain wall except any damage to sealants at maximum deflection.

(iv) Water-tightness Test

Water shall be sprinkled onto the test unit under wind pressure.

Pressure shall not be applied to the test unit.

The volume of the sprinkling water in one minute shall be 5 litres per m^2 minimum.

All water leakage and drainage system at the joint and the openable sash of the curtain wall system shall be observed from the outside of the chamber.

Hold the test two times, in sequence as described below, conforming to the above stated conditions.

Water leakage shall not be observed inside at all parts of the test unit during first water-tightness test.

1. Install the test unit.
2. Hold first water-tightness test.
3. Hold test of wind pressure as described above.

4. Hold second water-tightness test.
5. Lateral deflection test.

(v) Record of Test and Drawings

The testing laboratory shall keep the approved copy of the shop drawings and calculations of the test unit at testing laboratory during testing of test unit.

The testing laboratory shall accurately and clearly record on the shop drawings all changes, revisions, modifications etc. made to the test unit, which shall become the record drawing.

On completion of testing and after approval of the test reports the testing laboratory shall submit the final record drawings to the Employer's Representative.

Fabrication and Erection

Frames shall be square and flat, both the fixed and openable frames shall be constructed of sections, which have been cut to length, mitred and mechanically joined at the corners, sub-dividing bar of units shall be tenoned and riveted into frames.

All frames shall have corners welded to true right angles. For jointing hollow sections flash butt welding, argon arc welding or mechanical jointing by inserts shall be used. Gas welding or brazing shall not be done. Concealed screws shall be used for joining the sub-units.

The grid for the curtain wall system shall be fabricated carefully with aluminium extruded sections like mullions and transom in the exactly same pattern as per the final drawings with amendments if any from the laboratory after conducting the mock-up unit test.

The sizes of different members of the curtain wall system shall be exactly as adopted for the mock-up unit tests and the grid shall be fixed to the building member as shown in the drawing, received after conducting the mock-up unit test.

Care shall be taken to ensure that any gap between the frame and support and the frame itself is sealed with silicon sealant.

Finish of grid frame shall be either anodized, organic coating, backed enamel finish or as specified in the item of work, no visual variation in anodizing / colour shall be accepted.

Care shall be taken to ensure that the curtain wall system is not deformed or damaged during erection and it shall be protected from direct contact with wet or intermittent wet cement concrete mortar etc.

Glazing

Materials

This shall be the same as described for aluminium curtain wall system.

Aluminium extruded sections shall be from an approved and reputed / renowned manufacturer. In absence of specific extruded section, sections available conforming to BIS specification, manufactured by approved reputed companies, shall be used in the works.

Tolerances for Aluminium Extrusions

(i) Circumscribing Circle Diameter (CCD)

The product range shall be broadly as categorized below;

1. For solids up-to 190 mm
2. For hollows up-to 135 mm

Sections with higher CCD, if required, shall be produced from reputed / renowned manufacturer as approved by the Employer's Representative.

(ii) Manufacturing Tolerance

Dimensional extrusions shall be normally as per IS / BSS. Special tolerances shall be mutually agreed upon.

(iii) Tolerance on cut length:

The standard cut length is 3.66m the tolerance on cut length shall be as follows:

Length	Up to 6 metres	Over 6 metres
Tolerance	+ 5 mm	+ 7 mm

Sections shall also be acceptable in random lengths between 1500 to 5000 mm depending upon actual requirements.

(iv) Tolerance in Weights

A tolerance of ± 10% shall be acceptable on sectional weight per metre.

Fabrication

There is a slight difference in the actual fabrication of the aluminium curtain wall system and structural glazing though quantity of materials required for execution in both the cases is the same except the quantity of sealant.

Tubular Trusses, Purlins etc.

Structural Steel Tubes

These shall be of:

1. hot finished welded (HFW) type, or
2. hot finished seamless (HFS) type, or
3. electric resistance or induction butt welded (ERW), having carbon content less than 0.03%, yield stress of 21.5 kg./mm (YST 22) type, conforming to the requirement of IS 1161-63.

The steel tubes when analysed in accordance with the method specified in IS 226-1959.

Tubes shall be designated by their nominal bore. These shall be light, medium or heavy as specified, depending on the wall thickness.

Tubes shall be cleanly finished and reasonably free from scale. They shall be free from cracks, surface flaws, laminations and other defects. The ends shall be cut cleanly and square with the axis of tube.

Minimum Thickness of Metals

The tubular steel work shall be painted with one coat of approved steel primer after fabrication. Wall thickness of tubes used for construction exposed to weather shall be not less than 4 mm and for construction not exposed to weather, it shall be not less than 3.2 mm, where structures are not readily accessible for maintenance, the minimum thickness shall be 5 mm

Fabrication

(i) Component Parts

The component parts of the structure shall be assembled in such a manner that they are neither twisted nor otherwise damaged and be so prepared that the specified cambers, if any, are maintained.

(ii) Straightening

All material before being assembled shall be straightened, if necessary, unless required to be of a curvilinear form and shall be free from twist.

(iii) Bolting

Washers shall be specially shaped where necessary, or other means used, to give the nuts and the heads of bolts a satisfactory bearing.

In all cases where the full bearing area of the bolt is to be developed, the threaded portion of the bolt shall not be within the thickness of the parts bolted together and washers of appropriate thickness shall be provided to allow the nut to be completely tightened.

(iv) Welding

Where welding is adopted, it shall be done as per relevant IS 820.

(v) Caps and Bases for Columns

The ends of all the tubes for columns, transmitting loads through the ends, should be true and square to the axis of the tube and should be provided with a cap or base accurately fitted to the end of the tube and screwed, welded or shrunk on. The cap or base plate should be true and square to the axis of the column.

(vi) Sealing of Tubes

When the end of a tube is not automatically sealed by virtue of its connection by welding to another member, the end shall be properly and completely sealed. Before sealing, the inside of the tube shall be dry and free from loose scale.

(vii) Flattened Ends

In tubular construction the ends of tubes may be flattened or otherwise formed to provide for welded, riveted or bolted connections, provided that the methods adopted for such flattening do not damage the material. The change of sections shall be gradual.

Hoisting and Erection

Tubular trusses shall be hoisted and erected in position carefully, without damage to themselves, other structures, equipment and injury to workmen. The method of hoisting and erection proposed to be adopted shall be approved by the Employer's Representative. The Contractor shall however be fully responsible for the work being carried out in a safe and proper manner without unduly stressing the various members.

The Contractor shall grout the bolts in column tops to receive the truss wall plates, hoist the trusses in position, erect to line, level and plumb, fix in position with nuts, bolts etc, cure the grouted portion and paint the truss with two coats of paint of approved colour and shade over a coat of approved steel primer.

Corrugated / Trafford Roofing

Precautions

Prior to commencing any work involving asbestos the Contractor is required to present to the Employer’s Representative evidence that his insurance policies permit the use of asbestos in his works.

Laying

The sheets shall be laid on the purlins and other roof members as indicated on the approved shop drawings or as instructed by the Employer’s Representative.

The top bearing surfaces of all purlins and of other roof members shall be in one place so that the sheets, when being fixed, shall not require to be forced down to rest on the purlins. The finished roof shall present a uniform slope and the lines of corrugations shall be straight and true. The sheets shall be laid with the smooth side upwards. The sheets shall be laid two ridges of corrugation at each end and an end lap of 150 mm minimum.

Side laps should be laid on the side facing away from the prevailing monsoon winds.

Mitres shall be cut on the sheet corners as described below to provide a snug fit where four sheets meet at a lap. It is cut from a point 15 cm. (or whatever the length of the end lap may be) up the vertical side of the sheet to a point 5 cm along the horizontal edge.

The free over-hang of the sheets at the eaves shall not exceed 30 cm. Corrugated sheets shall generally be laid from left to right starting at the eaves. The first sheet shall be laid uncut, but the remaining sheets in the bottom row shall have the top left hand corners cut or mitred. The sheets in the second and other intermediate rows, except the first and last sheets, shall have both the top left hand corner and bottom right hand corner cut. The first sheets in those rows shall have only the bottom right hand corner mitred, while the last sheets shall have only the top left hand corner cut. The last or top row sheets shall have the bottom right hand corner cut with the exception of the last sheet which shall be laid uncut.

If for any reason such as considerations of the direction of prevailing winds, laying must be started from the bottom right hand corner, then the whole procedure should be reversed.

Fixing

Sheets shall be secured to the purlins and other roof members by means of 8 mm diameter galvanised iron J or L hooks bolts and nuts. The grip of the J or L hooks bolts on the side of the purlin shall not be less than 25 mm. Each J or L hook bolt shall have a bitumen washer and galvanised iron washers placed over the sheet before the nut is screwed down from above. On each purlin there shall be one hook bolt on the crown adjacent to the side lap on either side. Bitumen washers shall be of approved manufacture.

Each nut shall be screwed loosely at first. After a dozen or more sheets are laid, the nuts shall be tightened to ensure a leak proof joint.

Holes for hook bolts etc. shall be drilled and not punched in the ridges of the corrugations in the exact positions to suit the purlins while the sheets are on the roof in their correct position. The diameter of holes shall be 2 mm more than the diameter of the fixing bolts. No hole shall be nearer than 40 mm to any edge of a sheet or any accessory.

Roof ladders or planks shall always be used when laying and fixing the sheets, to avoid damage to the sheets and to provide security to the workmen.

Wind ties shall be of 50 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eave ends of the sheets. The fixing shall be with the same hook bolts which secure the sheets to the purlins.

The completed roof shall present a neat and uniform appearance and shall be leak proof.

Ridges

Corrugated ridges shall be supplied in pairs. The ridges in pairs shall be transported to the site of work, hoisted, placed and fixed in position at the junction of the two sloping sides of a roof. Care shall be taken to match the corrugations of the sheets with the ridges. The ridges shall be embedded in the end wall to the same extent of the roofing sheets. If any small gap remains between the ridges and the roofing sheets, the same shall be rendered waterproof by the Contractor with cement mortar 1:2 and as approved by the Employer's Representative. The overlapping of adjacent ridges shall be as per manufacturer's specifications.

Eave Curves

The eave curves shall be transported to site of work, hoisted, placed and fixed in position to line and level with hooks, nuts, washers etc. with the over laps provided as per manufacturer's instructions. The holes for hooks shall be drilled and not punched. The areas around hooks shall then be made water tight. The eave curves shall be embedded in the gable walls to the same extent as that of the sheets.

Mangalore Tile Roofing

Materials

Mangalore tiles (Basel mission or equivalent approved make) shall be double channelled tiles and shall conform to IS 654-1957 for class-AA or class-A type tiles, with 1:2 lime mortar with a mixture of red ochre to preserve uniformity of colour of the mortar joints.

Mangalore tiles shall be made of the best malabar clay, well dried and thoroughly burnt in patent kilns. The tiles shall be well burnt, close grained homogeneous without segregated lumps of clay and shall have a breaking strength of not less than 102 kg applied at a centre of span when supported on battens at 350 mm centres. The absorption co-efficient after 24 hours soaking shall not exceed 1/6th of its own weight.

Laying

Mangalore tiles shall be well soaked in water for four hours before installing. The mortar of specified proportion and thickness shall be spread and the Mangalore tiles fully embedded thereon, without any air spaces, where the tiles breaking joints.

The tiles shall be laid from the eves towards ridge. Where full tiles are not necessary, half tiles manufactured for the purpose only shall be used. The laying of Mangalore tiles and laying of lime mortar shall go on concurrently. The ridge Mangalore tiles shall be of standard type duly approved and shall be set in lime mortar as specified. Finished top slope of roof shall be uniform from ridge to eaves. The eaves line and the ridge line and all intermediate lines shall be straight, horizontal and parallel to each other. The lowest layer of tiles at the eves shall have cut edges instead of round edges and/or as approved by the Employer's Representative. All joints shall be pointed with lime mortar made secure and water tight.

Curing

After laying of Mangalore tiles, roofing shall be watered and cured for a minimum period of 7 days and as per specifications specified for curing for flooring. After curing, the roof shall be thoroughly cleaned and all excess stays of mortar etc. shall be scraped off.

False Ceiling with Gypsum Boards

Material

The plain boards shall be of suitable thickness and the size of panels and the arrangement of panels etc. for different area of the building shall be as approved by the Employer's Representative. Plain sheet boards shall be of approved quality and shall be free from cracks, bends and other defects. Samples of materials to be used on the work shall first be furnished by the Contractor and approved by the Employer's Representative. All materials which are used on the works shall strictly conform to the samples submitted and approved.

The plain boards shall be fixed to an angle iron framework by means of suitable counter sunk brass self tapping screws at not more than 200 mm centres or as otherwise approved. All holes after fixing the screws be filled with approved filler. Necessary openings in the ceiling shall be left for trap doors, ducts etc.

Erection

When brought to site, the boards shall be stacked carefully over wooden sleeper supports on the floor. The boards shall be cut to the required sizes either by sawing or by scoring and snapping. The edges shall be smoothened by wood rasp file or emery paper. Wherever required, the edges of each panel may require bevelling which also shall be done carefully to the correct line and dimensions.

The boards shall be fixed to ridge frames with either wooden or metallic fixings or as otherwise required. In case of metallic frames, the boards shall be held to the frame by means of self-tapping screws or by the ordinary machine screws and nuts, as approved by the Employer's Representative.

Teak wood or aluminium beadings if required and shall be carried out in best workman-like manner.

Pressed Steel / Anodized Aluminium False Ceiling Framework

(i) Materials

Fabrication of Pressed Steel Frame

The frame work for snap grid false ceiling shall be made out of tested special spring grade steel or approved cold rolled sheets of specified gauge, accurately formed and die caste with identical ends in an automatic machine with precision tools. All workmanship shall be best quality as followed in a modern sheet metal shop equipped with all machines such as press, dies, spot welding machine, baking oven etc.

All materials shall be manufactured, handled and installed by a process approved by the Employer's Representative and in a manner that will not damage the materials.

All work shall be accurately formed to the required dimensions, true to line, level and plane in all directions and properly sized to suit the required dimensions within permissible tolerances.

Twisted or bent sections shall not be used. Main runners and cross tees shall be of sizes as required for their duty. The main runners shall be slotted for cross tees and punched for hangers/suspenders. Cross tees shall have identified die formed ends accurately cut for easy, correct and proper fit assembly.

Shearing and cropping shall be clean, square and free from distortion. Surfaces and joints to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign materials. The surface shall be wire brushed vigorously. A suitable welding sequence shall be followed to avoid needless distortion and minimise shrinkage stresses. Holes to be made in pressed MS sheet shall not be made by flame cutting. Where for practical reasons greater clearances are necessary, suitably designed seating shall be provided.

Suspended Aluminium Grid System

The suspended aluminium grid system shall be subject to the approval of the Employer's Representative. The suspended ceiling grid shall be of self-interlocking anodised aluminium T bars for main runners and cross runners of suitable section and pattern as required to suit the spans.

(ii) Fixing

The Contractor shall take all necessary field measurements before the commencement of the frame work to ensure proper fittings of the work to actual conditions at the site. Particular care should be taken to examine the positions of all recessed lighting, trap doors and other openings and as approved by the Employer's Representative. The correct panel sizes shall be selected to suit each location.

The false ceiling levels shall be marked on walls. The position of the runners shall be marked to suit the span of the area. The wall angles shall be fixed with approved metal fasteners and levelled correctly. The position of suspender shall then be marked on the ceiling as per the sizes of the panels selected for each area with due consideration to location of air-conditioning ducts, grills etc. Suspenders of type and design fabricated as per the approved shop drawings shall then be securely fixed at correct points with approved metal fasteners/expansion bolts, as per manufacturer's specifications. It shall be ensured that the hanger/suspender shall remain perpendicular and not pulled by the suspension system to any side. The runner to the suspenders shall be fixed before completing the levelling which shall start from fixed points and proceed towards the other end. The cross tees to every runner joints shall be fixed and shall be stable for levelling. Neoprene rubber gasket shall then be fixed all along the frame work with an approved adhesive.

Approved sheets, cut to correct sizes, shall then be placed on the runner, starting from the centre of the width and working sideways. All cross tees shall be connected with the approved spring type hold down clip/pins as manufacturer's instructions. Holes if required to be provided in sheets shall be drilled not punched. The runners, tees and tiles shall be locked with hold down clips/pins as required. Wherever grouting for frameworks, suspenders etc. is required to be done in masonry walls columns/beams etc., this shall be done after the entire frame work is properly levelled.

After fixing the sheets, all holes of screws etc. shall be filled with approved putty, levelled with the sheets and sand papered, so that no sign of screw is visible on the sheets.

Trap doors/lighting recesses/troughs of approved size and shape with approved matching work, shall be provided in the false ceiling and vertical masking at the required places.

During the execution of this work, the Contractor shall take all the precautions to prevent damage to painted surfaces, plaster, floor tiles, doors etc. The Contractor shall specifically note that the area where the false ceiling is required to be provided will be in an advanced stage of completion with various finishing items such as painting, floor polishing etc. in place.

Lighting Troughs / Fixtures

Lighting troughs/fixtures shall be fabricated out of anodized aluminium or mild steel sheet of suitable gauge and shall be free from scale, blisters, laminations, cracked edges, defects of any sort and shall conform to relevant IS specifications.

Lighting troughs shall be fabricated in a modern, well equipped workshop, in accordance with the approved shop drawings. Mild steel lighting troughs shall be stove enamelled in the shop with approved type of colour and shade on both the surfaces. Aluminium troughs shall be anodized as per standard practice. Samples of the proposed lighting troughs fabricated shall be subject to the approval of the Employer's Representative before manufacturing on large scale. Aluminium/ mild steel frame work sections and sizes shall be fabricated and approved before fixing in position.

The aluminium or mild steel lighting troughs and frames shall be fixed in position to correct line and level with mild steel suspenders. One or more sample lighting troughs shall be fixed in position and be approved before fixing all the lighting troughs. The end of the lighting troughs on both sides shall be provided with mild steel covers.

The mild steel work shall be painted with two coats of synthetic enamel paint of approved make and shade over a coat of approved primer.

Fibre Glass Thermal Insulation in Ceilings

(i) Materials

Thermal Insulation Media

Thermal insulation media shall be of fibre glass Crown 150 or equivalent approved with K value of 0.0285 K. Cal/m^2. hr. ºC, 50 mm thick and density of 24 kg/m^3 or as otherwise approved. Samples of the fibre glass to be used on the work shall be furnished by the Contractor and subject to the approval of the Employer's Representative.

Fire Resisting Paint

The fire resisting paint shall conform to IS 163. Ready mixed paint as received from the manufacturer without any admixture shall be used.

(ii) Erection / Fixing of Insulation

Frame Work

The workmanship shall be of best quality. All wrought timber shall be sawn, drilled or otherwise machine worked to the correct sizes. All joinery work shall fit truly and without wedging or filling. All necessary mortising, tennoning, grooving, matching, tonguing, housing rebates and other necessary work for correct jointing shall be carried out in the best workmanship like manner. The framework shall be made in the required form as shown on the approved shop drawings. The framework shall be rigidly screwed to the ceiling with 100 mm long G.I. wood screws and rawl plugs at 300 mm centres both ways by drilling holes in the ceiling through the frame work.

The wood work shall be painted all over with fire resisting paint before erection of the same in position as per manufacturer's specifications and as approved by Employer's Representative.

Filling of Insulation Material & Fixing of Boards

After fixing of the frame work as above, a thick coat of bitumen of approved grade shall be applied as vapour barrier in the grids of frame work and then fibre glass of required thickness shall be stuck to the ceiling and the panel of grids as approved by the Employer's Representative. The panels of fibre glass shall be cut exact to grid size and evenly pressed.

Approved boards cut to correct sizes shall then be placed on the frameworks starting from the centre of the width and work side-wards. Holes required in boards shall be drilled and not punched. Boards shall be fixed to the wooden framework with suitably sized brass screws @ 300 mm c/c in a 4 mm wide grooves and shall be kept to the correct line, level and plane at the junctions of sheets.

Waterproofing

Brick Bat Coba Waterproofing

(i) Materials

The aggregate for brick bat coba shall be broken from good and thoroughly well burnt bricks. These shall be strong, durable, clean and free from impurities and not contain any soft or powdery materials. The aggregate shall be 20 mm to 10 mm size and shall be approved by the Employer's Representative before use.

Lime to be used for preparing brick bat coba shall be of lime class B, conforming to IS 712-1959. Lime burnt from lime stone shall be used. All impurities, ashes or pieces improperly burnt shall be screened or picked out before slaking. Lime shall be in the form of lumps when brought to site and not in powder form. The lime shall not be slaked with water less than one week or more than two weeks before use.

(ii) Storage

The slaked lime, if stored shall be kept in a weather proof and damp proof closed shed with impervious floor and sides to protect against rain, moisture, weather and extraneous materials mixing with it and shall be approved by the Employer's Representative.

(iii) Proportion

The proportion for brick bat coba shall be 0.906 m^3 of brick bat to 0.34 m^3 of slaked lime.

(iv) Laying

The concrete surface shall be thoroughly rubbed, cleaned of all set mortar, all dirt and dust and slightly wetted. The brick aggregate shall be soaked in water before mixing with lime. The brick bat coba shall be laid in an even layer and to the required thickness and slope to form ridge, hip or valley line as may be necessary and as approved by the Employer's Representative. The compaction shall be started immediately with wooden beaters and during the above process, the surface shall be constantly kept wet by sprinkling water observing the following precautions:

1. Brick bat coba shall not be rammed with heavy iron rammers as brick aggregates are likely to be crushed into powder thereby, but shall be beaten lightly and rapidly with wooden beaters to get the required compaction and to obtain complete integration of brick bats and lime.

2. While beating, fresh fracture may take place which may cause absorption of water from the mortar. Additional water may be sprinkled with beating in such cases as considered necessary by the Employer's Representative. The beating work shall continue for at least 7 days.
3. The top of the coba shall be given a slope or made level and edges taken into the brick masonry parapet or rounded off at junctions as approved by the Employer's Representative.

China Mosaic Waterproofing

(i) General

This type of waterproofing shall consist of setting in thick cement slurry selected colour/white broken glazed tile pieces of approved make and size over 20 mm thick bedding of 1:4 cement mortar with approved waterproofing agent, to the required slope and level, over brick bat coba and finishing with neat cement and cleaning to the required degree of fineness and evenness.

The surface of brick bat coba shall be thoroughly cleaned of dust, dirt and loose particles removed and adequately watered. A thick coat of cement slurry of honey like consistency shall be sprayed on the base before the lime mortar screening of specified thickness is laid.

(ii) Laying

Over the prepared surface of brick bat coba, a layer of cement mortar, 20 mm thick or as specified, shall be laid and cement slurry of consistency of honey, shall be spread over it using cement at a rate of not less than 0.01 m^3 per 10 m^2. While the bed is fresh, broken pieces of 6 mm thick selected white/colour glazed tiles not less than 25 mm and not more than 50 mm in any direction shall be set closely by hand at random. The glazed tile pieces shall be soaked in water before setting in position. The glazed surfaces shall be kept exposed and pressed with a wooden mallet.

Over the glazed tile pieces, a neat cement slurry, using cement not less than 0.01 m^3 per 10 m^2 shall be spread and the surface brushed in and lightly rolled with wooden roller, taking care that no air pocket is left between brick bat coba and china mosaic flooring.

The top surfaces shall be cleaned with saw dust and cotton waste. Finally the surface shall be cleaned with weak acid solution to remove cement marks over the glazed tile pieces.

The finished work shall be cured for at least 7 days. Care shall be taken to ensure that cement in joints does not get dissolved due to acid washing. At corners and junctions with parapets, the waterproofing course shall be rounded off with cement mortar.

Tar Felt Waterproofing

(i) General

All materials and workmanship for waterproofing with tar felt shall conform to IS 1346-1959 & 1322-1965. The tar felt shall be of type and of grade-I as specified in IS 1322-1965.

(ii) Preparation of Surfaces

The existing roof surface shall be prepared by cutting cracks, if any, to a v-section, cleaned and filled flush with cement sand slurry or a suitable grade of bitumen or both and the surface shall be allowed to set and dry. The surface of the roof and that part of the parapet and gutters drain mouths etc., over which the waterproofing treatment is to be laid shall be cleaned of all foreign matters including fungus, moss, dust etc. by wire brushing and dusting.

(iii) Laying

The felt shall be laid in lengths at right angles to the run off gradient commencing at the lowest level and working up to the crest, thus providing adequate overlap of the adjacent lower felt.

The bituminous primer shall be brushed @ 0.42 l/m^2 over the roof surface thus prepared and allowed to dry. The bitumen bounding material (60/70 grade) shall be prepared by heating to the correct working temperature and conveyed to the point of work in a bucket.

The felt shall be first cut to required the length, brushed clean of dusting material and laid out flat on the roof to eliminate curls and subsequent stretching. Each length of the felt prepared for laying as described shall be laid in position and rolled up for a distance of half of this length. The hot bonding material shall be poured on to the roof across the full width of the rolled felt @ 1.2 kg/m^2 as the latter is steadily rolled out and pressed down. Light rollers as required on the work shall be used to even up the treatment. The excess bonding material shall be squeezed out at the ends and be removed as the laying proceeds.

When the first half of the strip of felt has been bonded to the roof, the other half be rolled up and unrolled on to the top bonding material in the same way. Minimum overlaps of 10 and 7.5 cm. shall be allowed at the end and sides of strips of felt. All overlaps shall be firmly bonded with hot bitumen.

After the specified number of layers of felt has been laid, hot bitumen (60/70 grade) shall be applied over the top surface @ 1.2 kg/m^2. Pea size gravel shall be uniformly spread on this hot bitumen layer@ 0.06 m^3 to 0.075 m^3./10 m^2 on horizontal surfaces and over the rounded junctions, a coat of cement slurry shall be applied and grit shall be pressed into the slurry coat followed by curing.

For flashing in existing parapet walls, a groove or chase of a minimum height of 15 cm above the roof level shall be cut in the vertical face of the wall and shall be filled with cement mortar 1:3 after waterproofing compound is thoroughly set. This groove shall be of dimension 7.5 cm wide and 6.5 cm deep. In case of low parapets where the height does not exceed 45 cm, grooves shall be provided and waterproofing treatment shall be carried right over the top.

Felt shall be laid as flashing in widths wherever junctions of vertical and horizontal structures occur with a minimum overlap of 10 cm. The lower edge of the flashing shall overlap the felt laid on flat portion of the roof and the upper edge of the flashing shall be taken along the entire vertical face of the tucked groove made in the parapet and over the top surface to provide a continuous waterproof layer. Each layer shall be so arranged that the joints are staggered with those of the layer beneath it.

Drain mouths, gutters, drain outlets, projections, pipes etc. shall be given the special treatment conforming to IS 1346-1959.

Cement Based Waterproofing of Roof Terraces

(i) General

The waterproofing treatment shall be essentially a cement based waterproofing treatment.

The waterproofing treatment shall consist of providing cement slurry mixed with waterproofing compound, at desired proportions including grouting the cracks and crevices with cement slurry mixed with waterproofing compound, laying brick bats over cement mortar bedding to the required slopes for roof drainage, filling and grouting the joints with cement mortar, finishing the surface smooth/chequered with cement plaster mixed with waterproofing compound etc. as approved.

(ii) Preparation of Surfaces

After removal of this rubbish, debris etc., the surface to receive the waterproofing treatments shall be thoroughly cleaned with wire brushes including removing of scales and laitance, set mortar etc. by the waterproofing Contractors. If any honeycombing including cracks and crevices are observed at column junctions/and elsewhere, the same shall be grouted with cement slurry mixed with approved waterproofing compound.

(iii) Treatment

The waterproofing treatment shall be generally as per manufacturers own specifications, method and procedure. A typical cross section of the waterproofing treatment shall generally consist of the following:

1. Applying cement slurry mixed with waterproofing compound for the entire surface to be treated.
2. Laying of broken brick bat of required thickness over cement mortar bedding to give proper roof drainage, grouted with cement mortar with waterproofing compound.
3. Laying of jointless cement based waterproofing cement mortar layer of uniform thickness.
4. Final rendering to give a smooth finish of cement colour with false lines at 300 x 300 mm or nearer convenient dimensions.

The Contractor shall ensure that sufficient slope for effective roof drainage is provided within the average thickness of waterproofing treatment proposed by the Contractor.

The rain water down take pipes if any, shall be fixed by the Contractor prior to commencement of waterproofing operation. Curing of the finished surface by ponding shall be done for 7 days at least.

(iv) Testing

The Contractor shall test the surface for the bone dry condition by ponding water over roof for a minimum seven days period to the entire satisfaction of the Employer's Representative. Alternately, the curing of the finished surface done by ponding of water on the entire surface for seven days can also be used for testing water tightness.

After a period of two months, once again the roof shall be ponded with water to check its efficiency of waterproofing treatment against leakage.

Waterproofing Treatment of Expansion Joints at Roof Level

(i) Treatment

The expansion joint treatment at roof level shall be provided with approved cement based waterproofing treatment. This treatment shall be 20 mm thick waterproof plaster on top sides and ends of RCC covering hood over expansion joint.

(ii) Testing

The Contractor shall carry out the test for waterproof joint provided for expansion joint at roof level by any approved method.

Internal Waterproofing Treatment of Concrete Structures

(i) General

The waterproofing treatment of concrete structure shall be essentially a cement based waterproofing treatment, consisting of providing waterproof cement plaster after preparing the surface, filling the cracks and crevices by means of injection and surface method, using proprietary waterproofing compound as per their own specifications and as per recommended proportions etc. and testing of water-tightness of the waterproofing treatment.

(ii) Preparation of Surfaces

The surface to receive the waterproofing treatment shall be thoroughly cleaned of scales, laitance, set mortar etc. The surface shall be roughened with close hacking to provide adequate key for the waterproofing treatment. All honeycombs in concrete surface shall be carefully hacked and loose materials removed and all pockets plugged suitably well before commencing waterproofing treatment.

(iii) Treatment

Before any work of waterproofing is taken in hand, all the surface preparation stated above shall be approved by the Employer's Representative. All plumbing work will be completed before commencing the treatment.

The treatment shall then be commenced with injection into RCC members wherever required by cement slurry mixed with waterproofing compound of appropriate consistency to fill up all cracks and crevices if any. A layer of waterproofing plaster in the proportion as per manufacturer's recommendations with admixture of approved manufacture waterproofing compound shall then be laid over floor from inside and will be continued along the sides and partition walls to their full height. The thickness of this treatment on the floor shall not be less than 50 mm and on walls not less than 20 mm. The entire surface shall be finished smooth with steel trowel in cement colour. The plastered surfaces shall be kept continuously wet immediately after 24 hours to cure it properly for at least seven days.

External Cement Based Waterproofing Treatment of Concrete Structures

(i) On Horizontal Surfaces

Preparing the Surface

The waterproofing treatment over the lean concrete/levelling course surface should adhere to the surface firmly. The surface of the levelling course should be roughened when the concrete is still green. In case the surface is not made rough in the initial stages itself i.e. before the concrete is set, the work of waterproofing shall not be permitted until proper key is provided for the 25 mm thick base layer. If this key cannot be achieved by hacking the already set concrete surface, instead a spatter-dash key should be provided.

Blending Cement/Water with Waterproofing Compound

Mixing waterproofing compound in powder or liquid form, to already prepared cement mortar shall not be allowed. Preparing cement with waterproofing compound shall be prepared as followed:

1. The required quantity of cement bags to be used for a particular portion of work shall be sorted out and the contents of each bag should be emptied on a suitable dry platform. Waterproofing compound in powder form manufactured by a reputed approved manufacturer, bearing ISI mark and conforming to IS 2645 should be mixed with the contents of each bag. The quantity of waterproofing compound to be mixed should be as prescribed by the manufacturer but not exceeding 3% by weight of cement.
2. The quantity of cement and waterproofing compound in powder form should be mixed thoroughly, blended by employing skilled labourers and the cement thus blended should again be packed in gunny bags so that the material can be readily used for preparing mortar/slurry for the waterproofing works, to achieve best results.

Unless otherwise specified, all waterproofing works shall be carried out using blended / PPC cement.

Blending Water with Liquid Waterproofing Compound

In case the waterproofing compound to be used is in liquid form then instead of blending cement with waterproofing compound the water to be used in the particular mix should be blended with waterproofing compound.

This shall be done by taking just required quantity of water to be mixed in the particular batch of dry cement mortar. The required quantity of water thus collected per batch of dry cement mortar to be prepared should be mixed with liquid waterproofing compound from sealed tins with ISI mark and manufactured by reputed approved manufacturer.

The water thus mixed with waterproofing compound shall be stirred so that the water is blended with waterproofing compound well.

The quantity of blended water thus prepared should only be used per batch of dry cement mortar/dry cement to make slurry to be used for waterproofing works to achieve the best results.

Use of cement mixed with waterproofing compound is referred as blended cement in this chapter which shall mean use of waterproofing compound in powder/liquid form for use in cement mortar/slurry.

Rough Shahabad Stone

The stone slabs to be used for this item shall be carefully selected for uniform thickness. Stones with varying thicknesses shall not be permitted to be used. Unless otherwise specified, the size of rough Shahabad stone shall not be less than 300 x 300 mm and thickness 22 mm (+/-) 3 mm

Preparation of Cement Slurry

Cement slurry shall have a thick honey like consistency. Only the quantity of slurry that can be used within half an hour shall be prepared at a time. Slurry prepared and remained un-used for more than half an hour shall be rejected.

Preparation of Cement Mortar

The cement mortar 1:3 (1 blended cement : 3 sand) shall be prepared with cement / water duly blended. Each time only that much quantity of cement mortar that can be consumed within half an hour, shall be prepared. Any quantity of cement mortar that is prepared and remains unused for more than half an hour shall be rejected.

Laying Waterproofing Course

First layer : 25 mm thick base course in cement mortar 1:3

1. Before laying the first course of cement mortar 1:3 base the lean concrete surface shall be cleaned neatly with water and cement slurry shall be applied only on the area of the concrete surface that can be covered with the cement mortar (1:3) base course within half an hour.
2. The cement slurry shall cover every spot of the surface and no place shall remain uncovered.
3. Just after the application of cement slurry on the surface, the cement mortar should be used for laying the base course.
4. For laying the base course to a level at least three 25 mm high wooden strips with three legs shall be placed on the concrete surface at suitable distances and the cement mortar shall be laid to the level of the strips and tamped gently. The top surface should be finished neatly and later scratched when green with a suitable instrument.
5. Before the base course dries and gets hard that is just before the base course takes up initial set, the 2nd layer of Shahabad stone/slab cladding shall be taken up immediately.
6. As far as possible work of different layers of this waterproofing treatment shall be taken up in immediate succession without allowing any time gap in between the layers, otherwise it would be difficult to achieve homogenous treatment.

Second layer: Shahabad stone.

1. When the 25 mm thick base course is just getting set the cement slurry should be spread over the base course up to the area that shall be covered with just two to three stone slabs.
2. The cement slurry shall be spread in such a way that the area of base course to be covered immediately shall be covered with slurry without any gap, or dry spots.
3. Each time only the area that is required to clad two to three stone slabs shall be taken up for spreading the slurry and only after fixing the stone slabs over the slurry shall a further area shall be taken up.
4. Immediately on applying cement slurry on the base course the Shahabad stone slabs shall be laid over the base course and pressed gently so that the air gap can be removed.
5. The slurry applied on the surface which gets spread when the stone slab is pressed shall accumulate in the joints and if any gap still remains between the stone slabs the same should also be filled with additional quantity of cement slurry.
6. To lay the stone slabs level, two slabs at adjacent corners/ends shall be fixed firmly to the required level and a string stretched over the two slabs, the intermediate slabs shall then be set to the level of the string.

Third layer : 25 mm thick course in cement mortar 1:3

1. On filling all the joints of the Shahabad stone slabs with cement slurry and after a gap of 6 to 8 hours, the area of stone slabs shall be clad with 1:3 cement mortar.
2. The surface of stone slabs shall be cleaned and lightly watered. The cement mortar (shall be used for laying this course, no cement slurry need be used and the mortar can be laid on the slab surface directly.

3. For laying this course level, 25 mm high wooden strips with legs used for laying base course shall be used and the top surface shall be finished smooth without using additional cement or slurry.

Fourth Layer : Top Finish with Stone Aggregates 10 to 12 mm Size

1. Immediately after laying 3rd course and before the clad mortar takes the initial set, stone aggregate of 10 mm to 12 mm nominal size shall be pressed into the finished surface at a rate of 0.008 m^3/m^2.
2. The aggregates though embedded shall be clearly visible on the surface, i.e. the stone aggregates shall not be embedded totally inside the mortar.
3. This treatment shall be provided over the surfaces which are at their proper slope or level the profile shall not be altered by varying the 25 mm thickness of base course.
4. In case a slope is to be provided for the waterproofing layer on a surface which is level, grading with additional cement concrete/cement mortar shall be provided and then the waterproofing layer shall be laid on the graded surface.

Curing

Immediately after completing the fourth layer, arrangements shall be made to lay the top RCC slab as quickly as possible and in the mean time until the top slab is concreted the waterproofing treatment shall be kept wet continuously. In case the concreting of the slab gets delayed for more than two weeks the curing can be stopped after 14 days.

The waterproofing treatment done on the offset of the floor slab shall be kept wet continuously for 14 days minimum.

(ii) On Vertical Surfaces

The vertical waterproofing treatment either from inside or outside shall be undertaken only when the entire work is structurally complete.

Preparing the Surface and Providing Ancillary Arrangements

The surface of the structure to be treated shall be roughened properly either by raking joints when the mortar is still green in case of brick/stone masonry structures, or by preparing the cement concrete surface with a scabbler just after removing the shuttering.

In case the raking joints/hacking concrete surface is not done properly the only alternative method to make the surface rough by a scabbler.

While doing the waterproofing to vertical faces from inside, particular care shall be taken to ensure that the waterproofing layer of the floor slab does not get damaged while resting the vertical props of any scaffolding. Alternatively waterproofing for vertical surface shall be provided before horizontal floor slab waterproofing. In order to arrest any leakage through junctions of vertical/horizontal waterproofing, a proper haunch in cement concrete shall be provided.

For the stone slabs that are used for arresting leakage, while executing this type of waterproofing treatment, the first and foremost mandatory condition is that the number of joints in the portion covered by the stone slabs shall be kept to a minimum and this condition can be achieved only by using the maximum size of stone slabs. Normally the size of stone slabs used for the purpose is 600 x 600 mm x 90 mm each stone slab weighing approximately 16 kg to 25 kg.

The rough stone slabs used for such works are usually rough on the surface but such roughness will not be sufficient for the stone slabs to remain in a vertical position held by cement slurry. Therefore the grip for the stone slabs shall be increased by planting 12 mm to 15 mm nominal size stone aggregate fixed with Araldite (or equivalent) on the face of each stone slab.

A 20 mm thick clear gap shall be formed between the masonry/concrete surface and the stone slabs erected in a vertical position for pouring the cement slurry. This gap shall be maintained by fixing with Araldite (or equivalent) the 20 mm x 20 mm cover blocks made out of rich cement mortar on the four corners and the centre of the stone slabs.

Preparation of Cement Mortar (1:4)

Cement mortar shall be prepared as explained above except that the proportion shall be 1:4 (1 blended cement : 4 coarse sand) instead of 1:3.

Fixing Waterproofing Courses on Vertical Surfaces

Normally the item of work prescribes executing the first layer as base course with cement slurry, second layer fixing rough Shahabad stone slab, third layer as plastering the surface and the fourth layer as finishing surface with neat cement punning, but a gap of 20 mm width shall to be formed for pouring cement slurry. The 20 mm wide gap shall be formed by erecting the 20 mm thick Shahabad slab at a distance of 20 mm from the masonry/concrete surface, over which the cement slurry is to be clad.

The sequence of layers shall be considered as per actual construction layers rather than the chronological sequence in which they were placed. To avoid confusion and to distinguish between the two different layers laid and the actual work executed, actual working is termed as Step I, Step II etc.

Step I: Erecting Shahabad Stone Slab forming 20 mm wide gap.

1. The Shahabad stone slab duly fixed with 20 x 20 mm cover blocks and 12 to 15 mm size stone aggregate on the surface shall be erected against the masonry/concrete surface to be treated by abutting the 20 mm thick cover block against the surface, thus forming a clear gap of 20 mm
2. The joints of stone slabs shall be temporarily closed from outside with cement mortar so that the cement slurry poured in the gap does not escape through the joints. The bottom portion of the stone slabs shall also be closed with cement mortar.
3. While erecting the stone slabs, proper care shall be taken to ensure that stone slabs are of uniform size. In case similar width slabs are used, it shall be ensured that these are not fixed at the corners but the same should be at the middle portion.
4. Interlinking of the Shahabad stones of horizontal layers of waterproofing with this vertical layer of waterproofing shall be done very carefully, as per standard practice.
5. The Stone slabs shall be erected plumb and fixed in position and it will be considered as 2nd layer of waterproofing on completion.
6. Further lifts of Shahabad stone slabs up to the full height of the masonry/ concrete wall shall be erected only after filling the gap of each lift erected, with cement slurry.

Step II : Filling Cement Slurry in the gap formed by erecting Shahabad Stone Slabs:

1. When the first lift of stone slabs are erected and checked to be plumb, cement slurry shall be poured in the gap until the gap is filled completely.
2. The further filling of slurry in the second lift shall be done when the second lift of stone slabs are erected in position and thus the work on 2nd and 1st layer of the item shall be completed sequentially until the cladding over the entire height of the wall is complete.
3. Thus on completion of filling cement slurry and erecting stone slabs for the entire height of the wall, it shall be considered that the first layer (i.e. the layer of cement

slurry) and the second layer (i.e. the layer of erecting Rough Shahabad Stone Slabs) is complete as per the item.

Step III : 3rd Layer: Plastering Over 2nd layer with Cement Mortar 1:4 (1 Blended Cement : 4 Sand)

1. Immediately on completion of the work of cladding the entire masonry/ concrete wall with Shahabad Stone slabs, the cement mortar applied over the joints shall be removed and the joints exposed. The entire surface shall be cleaned with water neatly to start the plastering work.
2. Cement mortar 1:4 (1blended cement: 4 coarse sand) shall be used for the purpose. Care shall be taken to ensure that the 20 mm thickness of cement plaster over the entire surface is maintained correctly.
3. The work of plastering shall be taken up immediately on completion of cladding the wall surface, so the work shall be a continuous process from the day of starting the erection of stone slabs until the finishing work of plastering is done.
4. The plastering shall be from top to bottom without leaving any joint. As far as possible the joints in plaster shall be minimised. In case a joint has to be left to continue the work on the subsequent day, cement slurry shall be applied over the entire joint and then only the further work of plastering shall be taken up.

Step IV: 4th Layer: Finishing with Neat Cement Punning:

5. When the surface of plastering is still green, the cement slurry shall be applied over the plastered surface and the surface shall be finished neatly to a smooth surface with specially made semi-rounded thapis. The surface should show a smooth and neat finish without any undulations.

Curing and Testing

On completion of the waterproofing course from outside, the tank shall be cleaned from inside, scaffoldings shall be removed and the tank gradually filled with water for testing, which shall commence within two or three days. The exposed faces of the waterproofing course shall be kept wet for 14 days. No back filling shall be done before expiry of 14 days from the date of completing the waterproofing course from outside.

(iii) Thickness and Treatment

The only difference between treatment of horizontal and vertical surfaces is the thickness and the type of treatment per layer that is to be provided. The same is tabulated below for clear understanding:

Horizontal Surfaces			**Vertical Surfaces**		
Layers	**Details of Layer**	**Thickness**	**Layers**	**Details of Layer**	**Thickness**
First Layer	25 mm thick base course in C.M 1:3	25 mm	First layer	Base course with cement slurry	20 mm
Second Layer	Shahabad Stone Slab	22(+/-) 3 mm	Second Layer	Shahabad Stone Slab	22(+/-) 3 mm
Third Layer	Finishing with CM 1:3	25 mm	Third Layer	Plastering II Layer with CM 1:4	20 mm
Fourth Layer	Embedding 10 to 12 mm	----	Fourth Layer	Punning with neat cement	---

Horizontal Surfaces			Vertical Surfaces		
Layers	Details of Layer	Thickness	Layers	Details of Layer	Thickness
	Aggregates in third layer				
	Total Thickness	72 (+/-) 3 mm		Total Thickness	62 (+/-) 3 mm

Expansion Joint Fillers

Materials

Materials for expansion joint filler boards shall be of best quality bitumen impregnated preformed non-extruding, resilient type of appropriate thickness in the standard sizes available.

The sealing compound to close the gaps at the edges shall be of best quality rubberized bituminous hot pour, made from special grades of bitumen and shall not show flowing tendency in hot weather and is resilient in the cold weather. The liquid primer shall be made from blown grade bitumen of approved quality.

The aluminium plates for fixing at floor level shall be of appropriate size and made out of extruded sections, free from any rolling defects.

The aluminium sheet for fixing on the underside of beams or the sides of columns shall be of appropriate size without any defects.

Preparation of Surfaces

All the concrete surfaces already cast and where the expansion joint is to be formed, shall be properly cleaned of all dirt, mortar/concrete, dust etc. One coat of primer shall be applied by brush to the entire concrete surface, just prior to the next concreting.

Workmanship

Soon after the primer is applied, the filler board shall be placed at the side and held tight with the concrete surface, by suitable means. Care shall be taken that the boards do not get damaged or warped during all the operations. Utmost care shall also be taken to ensure that the board is held tightly to the concrete surface and no stone chip, concrete etc. shall enter between the board and the existing concrete surface against which the board is placed.

The aluminium plates shall have round holes at 300 mm c/c. of required diameter on one side of the joint through which screws shall be fixed into the concrete. On the other side, slotted holes at 300 mm c/c shall be provided so that when screwed, these shall render smooth movement of plates during expansion/contraction. The plates shall be fixed correctly to the required level, line, plumb etc. and as approved by the Employer's Representative.

In case of plates fixed on floors, they shall be fixed when the floor mortar screed is laid to the required level over the expansion joint duly filled up with sealing compound.

In case of roofs, the expansion joints in beams placed vertically, shall be extended upwards, when RC/brick masonry curbing is laid to the desired height (approximate 450 mm) over which horizontal flat board is laid to the extent of 150 mm, as per procedure laid down previously.

Floor Pavement

General

The sub-floor shall be cleaned, brushed, washed and prepared as recommended in the Codes of Practice.

Finishes

(i) Floor Screeds

Where specified, dense concrete floor screeds shall be placed over the structural concrete floor. Before the structural concrete is fully hardened, the surface shall be roughened by wire brushing in order to expose the aggregate. Immediately before laying the screed, the concrete shall be cleaned with stiff brushes and then thoroughly dampened. Before the screed is laid and after the excess water has been removed, a thin layer of stiff cement grout shall be well brushed into the roughened surface.

Where approved by the Employer’s Representative, a waterproofing admixture shall be added to screed concrete in accordance with the manufacturer’s recommendations.

Heavy duty screeds shall be in M15 grade plain concrete with coarse aggregate of size 20 mm downgraded. Light duty screeds shall also be in M15 grade plain concrete but with coarse aggregate of size 10 mm downgraded. Water content shall be kept to the minimum consistent with providing adequate compaction. Unless otherwise specified, screeding shall be finished to class U2.

Screeds shall be laid to a minimum fall of 1 in 120. The minimum thickness of screed shall be 80 mm for heavy duty and 50 mm for light duty.

(ii) Surface Hardeners on Concrete Surfaces

Application of approved surface hardeners to the finished concrete surface shall be carried out in accordance with the manufacturer’s recommendations.

Cement Concrete Flooring (Indian Patent Stone)

(i) Preparation of Base

The base concrete surface shall be thoroughly chipped to remove laitance, caked mortar, loose sand, dirt etc., cleaned with wire brush and washed clean and watered until no more water is absorbed. Where the base concrete has hardened so much that roughening the surface by wire brushes is not possible, the same shall be roughened by chipping or hacking at close intervals.

Concrete flooring shall be laid in a chess board alternate panel fashion. The edge of each panel shall be separated by wooden strips duly oiled to prevent sticking.

The panels shall be of uniform size and, unless otherwise specified, no dimension of panel shall exceed 2 m. and the area of a panel shall not be more than 4 m^2. The joints in the floor finish shall extend through the edges and skirting/dado. The edges shall have mitred joints at the corners of the room.

The depth of dividing strips shall be the thickness as proposed for the finished floor.

(ii) Mixing

The cement concrete shall be mixed in the proportion of 1:2:3 with an admixture of approved waterproofing compound. The maximum size of coarse aggregate shall be

10 mm. The fine aggregate shall consist of properly graded sand. The least amount of mixing water that will produce a workable mix and will allow finishing without excessive trowelling shall be used. Generally a water cement ratio of 0.5 should suffice. Concrete shall be mixed preferably by machine and hand mixing shall be avoided as far as practicable.

(iii) Laying

The free water on the surface of the base shall be removed and a coat of cement slurry to the consistency of thick cream shall be brushed on the surface. On this fresh grouted base, the prepared cement concrete shall be laid immediately after mixing. The concrete shall be spread evenly and levelled carefully. The concrete shall be completed and brought to the required level by means of a heavy straight edge resting on the side forms and down ahead with a sawing motion in combination with a series of lifts and drops alternatively with small lateral shifts, either mechanically or manually as approved by the Employer's Representative.

While concreting the adjacent bays, care shall be taken to ensure that the edges of the previously laid bays are not broken by carelessness or hand tamping. Immediately after laying the concrete, the surface shall be inspected for high or low spots and any needed correction made up by adding or removing the concrete and the whole surface shall be levelled again. Before the initial set commences, the surface shall be trowelled to smooth and even surface free from defects and blemishes and tested with straight edges.

In the case of flush joins, alternate panels only may be cast on the same day. At least 48 hours shall elapse before the concreting of an adjacent bay is commenced.

(iv) Finishing the Surface

Finishing operations shall start shortly after the compaction of concrete and shall be spread over a period of one to six hours depending upon the temperature and atmospheric conditions. Immediately after laying, only just sufficient trowelling shall be carried out to give a level surface. The surface shall subsequently be trowelled intermittently at intervals several times to produce a uniform and hard surface and to close any pores in the surface and to bring to surface and remove any excess water or laitance.

The final trowelling shall be carried out before the concrete has become too hard but at such a time that considerable pressure is required to make any impression on the surface. Dry cement and fine aggregate shall not be added to the surface. Trowel marks shall not be seen on the finished surface.

Where a broom finish is required, after the concrete has been thoroughly compacted and the surface water has been removed, the surface shall be given a broom finish with an approved type of brass or mild steel fibre broom. The broom shall be pulled gently over the surface from edge to edge in such a manner that corrugation shall be uniform in width and depth, the depth shall be not more than 1.5 mm Brooming shall be done when the concrete is in such a condition that the surface will not be torn or unduly roughened by the operation. Coarse or long bristles which cause irregularities or deep corrugation shall be trimmed out. Brooms which are worn or otherwise unsatisfactory shall be discarded.

After the concrete in the bays has set, the joints of the panels should be filled with cement cream and neatly floated smooth or jointed. Care should be taken that just the minimum quantity of cream for the joint is used and excess spilling over the already finished surface shall be removed when the cream is still green.

In case of wide joints the same shall be filled with pigmented cement concrete (1:2:4) using approved pigment.

(v) Curing

The completed flooring shall be protected from the sun, wind and rain for the first two days and movement of persons over the floor is prohibited during this period. The finished surface shall be covered and cured continuously for a minimum period of seven days. The surface shall then be allowed to dry slowly. All corners, junctions of floor with plastered wall surface shall be rounded off when required. Bunding with murrum for curing is prohibited.

Ironite (or Hardonate) Flooring

(i) General

To withstand heavy wear and tear, concrete flooring with metallic concrete hardening compound such as Ironite or Hardonate shall be laid as wearing layer as detailed below:

(ii) Metallic Concrete Hardening Compound

The metallic compound shall be Ironite or Hardonate of or similar of approved quality consisting of uniformly graded iron particles, free from non-ferrous metal particles, oil, grease and soluble alkaline compound.

(iii) Cement Concrete Under Layer

Cement concrete flooring of specified thickness and mix shall be laid as specified and generally conforming to specifications laid down for cement concrete flooring. The top surface shall be roughened with brushes while the concrete is still green and the form shall be kept projecting up 12 mm over the concrete surfaces, to receive the metallic hardening compound topping.

(iv) Metallic Concrete Hardening Topping

This shall consist of a 12 mm thick layer of mix 1:2 (1 part of cement mixed with hardener: 2 parts of stone aggregate of 6 mm nominal size by volume). The metallic concrete hardener compound being mixed with cement in the ratio of 1:4 (1 metallic concrete hardener: 4 cement used by weight) or as specified by the manufacturer. The concrete hardener shall be dry mixed thoroughly with cement on a clean dry pucca platform. This dry mixture shall then be well mixed with the 6 mm stone aggregate in the ratio of 1:2 (1 cement mixed with hardener: 2 stone aggregate) by volume. Just enough water shall then be added to this dry mix as required for floor concrete, water cement ratio not exceeding 0.4.

The mixture so obtained shall be laid in to the 12 mm thickness, on cement concrete floor within 1 to 4 hours of its laying.

The topping shall be laid true to provide a uniform and even surface. It shall be firmly pressed into the bottom concrete to have a good bond with it. The concrete shall be compacted well mechanically. Manual compaction will not be permitted unless approved by the Employer's Representative. After the initial set has started, the surface shall be finished smooth and true to slope with steel floats.

(v) Curing, Precautions etc.

Specifications for curing, precautions etc. shall be same as specified for cement concrete flooring.

Cement Concrete Flooring with Red Oxide Topping

(i) General

Red oxide of iron when used, gives an improved appearance to concrete flooring.

(ii) Red Oxide Iron

Red oxide powder shall be obtained in adequate quantity and stored in clean dry place.

(iii) Under Layers

The under layer of flooring of specified thickness shall be of cement concrete 1:2:4 mix using 10 mm maximum size coarse aggregate. The dividing strips of aluminium or glass if required to be retained shall not be removed and kept in position properly. After the consolidation is over, the top surface shall be left rough by drawing diagonal lines 2 mm deep at 75 mm centres both ways.

(iv) Top Layer

Mortar

The top layer shall consist of a uniform and smooth layer of specified thickness and of mix 1.3 (1 cement: 3 coarse sand) and finished with a floating coat of neat cement. The cement shall be mixed dry with red oxide powder in the proportion of 3.5 kg. of red oxide to 50kg of cement. This mixture shall be used both for mixing mortar for top layer and also for floating coat. Full quantity of materials required for one room shall be mixed and kept ready to ensure uniform colour.

Laying of Top Layer

The top plaster shall be done the following day after the under layer is laid. The plaster shall be 10 mm thick and finished smooth with cement and red oxide slurry. The surface shall be polished smooth with polishing stones.

Alternate panels shall be placed for laying under layers and top layers as process is repeated. Rounding at the junction with the wall shall be to a radius of 25 mm.

Granolithic Concrete

Floor slabs upon which a granolithic concrete finish is to be laid shall be screeded. Before the concrete is fully hardened the surface shall be roughened by wire brushing or picking in order to expose the aggregate.

Before laying the finish, the concrete shall be thoroughly cleaned with stiff brushes and then soaked overnight. After the excess water has been removed, a thin layer of stiff cement grout shall be well brushed into the roughened surface a few –minutes before the granolithic concrete is laid.

Granolithic concrete shall consist of two parts of cement to five parts of granite by volume. The aggregate shall be graded from 10 mm down with not more than 20 % passing a No.200 sieve and shall be free from dust. The water content shall be just sufficient to produce a dense firm concrete of adequate workability. Mixing shall be as for concrete.

The granolithic concrete to floors shall be laid 40 mm minimum thickness in panels not larger than 3m square. Panel joints shall be formed with approved aluminium or sheet glass strips 3 mm wide finishing flush with the surface. Corners shall be formed with a 75 mm radius and stand 90 mm above finished floor level. The arrangement of the panels shall be symmetrical and shall be approved by the Employer’s Representative. Granolithic concrete shall be compacted and checked for any irregularities with wooden straight edges 1.5m long. Irregularities shall not exceed 3 mm. After checking, the granolithic concrete shall then be allowed to stand until sufficiently hard to permit final hard steel trowelling, in the course of which any laitance collecting on the trowel shall be removed and not trowelled back. The flooring shall be kept damp and not exposed to any traffic for a period of seven days.

Tiled Flooring

(i) Materials

Clay floor tiles shall be heavy duty fully vitrified tiles 25 mm thick at least equal to Class 1 of IS: 1478 or light duty fully vitrified tiles 15 mm thick at least equal to Class 3 of IS:1478. Coved bull nosed skirting with radiussed internal and external angles and other special tiles shall be supplied to match the floor tiles. Water absorption shall be less than 3% and hardness as measured by the Moh’s scale shall be greater than 6. The tiles shall resist acidic action and staining by oil. Jointing material shall be acid resistant where shown.

Vitrified tiles shall be of approved make like Marbonite / Granamite or equivalent and shall conform to the approved standards. They shall be flat and true to shape, free from cracks, crazing spots, chipped edges and corners.

The tiles shall be square or rectangular of nominal sizes such as: 600 x 600 mm; 900 x 900 mm or as otherwise approved by the Employer’s Representative. Thickness shall be as per recommendations of the approved manufacturers.

Technical specifications of the tiles shall be generally conforming to the following standards: Technical Specifications for Vitrified Tiles

Property	Expected standards
Deviation in length	(+/-) .6%
Straightness of sides	(+/-) .5%
Rectangularity	(+/-) .6%
Surface flatness	(+/-) .5%
Water absorption	<0.50%
Mohs. hardness	> 6
Flexural strength	> 27 N / mm^2
Abrasion resistance	< 204 mm^2
Skid resistance (friction coefficient)	> 0.4
Glossiness	Min. 85% reflection

The tiles shall conform to the relevant standards in all respects. Samples of tiles shall be approved from the Employer’s Representative before bulk procurement for incorporation in the work.

(ii) Mortars

Mortar shall be used as soon as possible after mixing and before it has begun to set and in any case within 30 minutes after the water is added to the dry mixture. Mortar unused for more than 30 minutes shall be rejected and removed from the site of work.

For lime mortar, lime from burnt stone shall be used. It shall be free from ash and impurities and be in the form of lumps and not powder when brought to site. Lime which is damaged due to rain, soaking, moisture or air slaking will be rejected.

(iii) Proportioning

The unit of measurement for cement shall be a bag of cement weighing 50 kg and this shall be taken as 0.035 m^3. Sand in the specified proportion shall be measured in boxes of suitable size on the basis of its dry volume. In case of damp sand, its quantity shall be increased to allow for bulking which shall be determined as per IS specifications.

(iv) Mixing

The mixing of mortar shall be done at site of work in mechanical mixer. Hand mixing, if permitted, shall be done as approved by the Employer's Representative.

(v) Mixing in Mechanical Mixer

Cement and sand in the specified proportion shall be mixed dry thoroughly in the mixer. Water shall then be added gradually and wet mixing continued for at least one minute. Care shall be taken not to add more water than that shall bring the mortar to the consistency of a stiff paste.

(vi) Hand Mixing

The measured quantity of sand shall be levelled on clean masonry platform and cement bags emptied on top. In hand mixing the quantity of cement shall be increased by 5% above that specified. The cement and sand shall be thoroughly mixed dry by being turned over and over backwards and forwards several times until the mix is of a uniform colour. The quantity of dry mix which shall be used within 30 minutes shall then be mixed in thoroughly with just sufficient quantity of water to bring the mortar to the consistency of a stiff paste. Mortar shall not be mixed on floor slabs or landings of staircase.

(vii) Cleaning of Surface & Laying of Cement Mortar Bedding

Before laying the cement mortar bedding, the concrete floor surface shall be thoroughly hacked, cleaned of all mortar scales, concrete lumps etc. brushed, washed with water to remove mud, dirt etc. from the surface and shall be thoroughly wetted. Until and unless the surface is approved by the Employer's Representative, the flooring shall not be started.

The mortar shall be evenly spread on the sub-floor, 25 to 30 mm thick. Over this mortar bed, 5kg. of cement per m^2 of floor area shall be spread.

(viii) Laying of Tiles

The tiles shall then be laid immediately after laying the mortar.

All tiles shall be truly and evenly set in a thick slurry of cement of honey like consistency applied to the sides and bottom and over the prepared base at the rate of 4.4 kg/m^2 over such an area that accommodates about 20 tiles. The tiles shall be fixed on this bed one after another, each tile being gently tapped with a wooden mallet until it is properly bedded and level with the adjoining tiles. The joints shall be straight and uniform in thickness and not be greater than 1.5 mm. The tiles shall be laid level unless otherwise specified or required by the Employer's Representative.

Tiles shall extend up to un-plastered surfaces of walls and columns. All tiles shall be laid to have continuous lines from various rooms to the passage. Wherever full tiles / half tiles cannot be fixed, tiles shall be cut from full tiles to the required size and their edges rubbed smooth to ensure a straight and true joint. Freshly laid tiles shall not be walked upon.

After laying the tiles the joints shall be finished with white cement or cement of approved colour.

(ix) Curing, Polishing & Finishing

After laying, the flooring shall be allowed to cure undisturbed for seven days.

About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to determine if it gives a hollow sound; if it does, such tiles along with any other cracked or broken tiles shall be removed and replaced with a new tile to proper line and level. The same procedure shall be followed again after the tiles are finally polished. For the purpose of ensuring that such replaced tiles match with those earlier laid, the Contractor shall order enough extra from the factory to meet this contingency. The tiles shall be cleaned and polished by using dilute oxalic acid or another method recommended by the manufacturer and approved by the Employer's Representative.

After the joints have developed sufficient strength the floors shall be machine polished to the desired finish as approved by the Employer's Representative. Sufficient quantity of water shall always be used for polishing to prevent scratching.

For dado and skirting work, the vertical surface shall be thoroughly cleaned and wetted. Thereafter it shall be evenly and uniformly covered with about 12 mm thick 1:2 cement mortar. For this work the tiles as obtained from the factory shall be of the size required and practically fully polished. The back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet. This shall be done from the bottom of the surface to upwards. The joints shall be tight and not larger than 1.5 mm and the work shall be vertical and flush.

After the work has set, hand polishing with carborundum stones shall be carried out so that the surface attains a high glossy finish, corners and junctions shall be finished true. The workmanship shall confirm to IS: 1443.

(x) Sampling and Testing

Tiles required for carrying out tests shall be taken by random sampling. Each tile sample shall be marked to identify the consignment from which it was selected. The minimum quantity of tiles for carrying out the test and frequency of test shall be as per IS:13801.

Mandatory tests	No. of samples	Results
a) For conformity to requirements of shape and dimensions, wearing layer and general quality.	12 tiles	Concavity & convexity shall not exceed 1 mm Perpendicularity shall not exceed 2% of the length of edge. Straightness shall not exceed 1% of the length of the edge.
b) For wet transverse strength test	6 tiles	Strength shall not be less than 30 kgf/cm^2
c) For resistance to wear test	6 tiles	Average wear shall not exceed 3.50 mm and wear on individual specimen shall not exceed 4 mm
d) For water absorption test	6 tiles	Shall not be more than 10%

Stone Flooring, Skirting and Facia

(i) Materials

Stone should be of approved quality, hard, sound, durable and of uniform thickness. Slabs should be of standard sizes and shapes.

Slabs supplied should meet all the required properties and test requirements as stipulated in IS 1124. Edges shall be chisel dressed and the top surface shall be machine polished with joints running true and parallel from side to side.

(ii) Bedding / Backing Coat

Stones should be laid on a bed of lime mortar of proportion 1:2 or cement mortar of proportion 1:3. Thickness of mortar bedding should not be less than 12 mm and not more than 25 mm

(iii) Fixing the Stone Slab / Tile

Before laying, the stone slabs should be thoroughly wetted with clean water. Thick cement slurry should be spread over the mortar bed over as much area as could be covered with the slabs within half an hour. The slabs are then laid and gently tapped with mallet until they are firmly and properly bedded.

There shall be no hollows left. If there is a hollow sound on gently tapping the slab, such slab shall be removed and reset properly. The joints shall be grouted with matching cement slurry. Approved pigment shall be used in cement slurry to match with shade of stone. Stones adjoining the walls shall go 12 mm under the plaster, skirting or dado of the wall. All stone slabs tiles shall be laid to have continuous lines from various rooms to the corridors.

No change of lines shall be permitted at junctions between rooms and corridors. Only one piece machine cut, Kotah stone shall be used for treads and risers, unless otherwise specified.

(iv) Polishing and Cleaning

When the bedding and joints have completely set and attained required strength, the surface shall be machine polished to give smooth, even and true plane to the flooring. All flooring shall be thoroughly cleaned and handed over free from any mortar stains etc. Polishing shall be as per IS-14223 (Specification for polished building stones).

(v) Skirting and Dado / Facia

The specifications and workmanship for Kotah stone skirting shall be the same as per Kotah stone flooring.

Kotah stones in skirting shall be laid against a bedding of cement mortar (1:3) 20 mm thick to the full height of the skirting, to a true plane, level and plumb. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. Continuous horizontal grooves at the top of the skirting shall be provided if required. The skirting surfaces shall be re- polished with hand to satisfaction of the Employer's Representative. Top of exposed skirting shall be machine cut and polished tiles used at projecting corners shall be suitably bevelled to present a neat corner.

The Contractor shall touch up the plaster at the junction of skirting / dado after the skirting/ dado/ facia work is completed.

(vi) Other Materials

The specifications for Tandur Stone / Cuddappa Stone / Polished Shahabad Stone / Blue Wadi Stone flooring/skirting/dado shall be similar to those for Kotah stone as above.

PVC Flooring

(i) Material

PVC Flooring material gives a resilient and non-porous surface which can be easily cleaned with a wet cloth as dust and grime do not penetrate the surface. Since a burning cigarette will damage the neat surface of the PVC sheet, special care should be taken to prevent burning cigarette stumps to come in contact with the PVC flooring materials.

The PVC shall be laid on a base that is finished even and smooth such as concrete, metal or timber boarding. Unevenness or undulations in the base will show badly on the surface and are liable to damage the PVC sheet /tiles.

The PVC flooring material shall conform IS:3462 and may be in the form of tiles, sheets or rolls. The PVC shall consist of a thoroughly blended composition of thermoplastic binder, filler and pigments. The thermoplastic binder shall consist substantially of one or both of Vinyl chloride polymer and Vinyl chloride copolymer. The polymetric material shall be compounded with suitable plasticizers and stabilizers

The preferred thickness of PVC tiles for normal floor covering shall be 1.5, 2.0, 2.5, 3.0 or 4.0 mm.

The thickness of PVC sheets shall be measured with a micrometer or a dial gauge graduated to 0.02 mm. The micrometer shall have flat bearing surfaces of at least 6.5 mm diameter at both contact points.

For sheets and rolls the thickness of the specimen shall be measured at twenty scattered points.

The width of flooring sheets and rolling in continuous length shall be 1000, 1500 and 2000 mm. When supplied in rolls the length of the rolls shall not be less than 10 metres. Each tile shall be measured for length and width at the three quarter point in each direction.

Tolerances

(a) In Thickness:	(+/-) 0.15 mm
(b) In Width: as under:	
(i) 300 mm square tiles	(+/-) 0.2 mm
(ii) 600 mm square tiles	(+/-) 0.4 mm
(iii) 900 mm square tiles	(+/-) 0.6 mm
(iv) Sheets and rolls	(+/-) 0.1 per cent

Rubber based adhesives may be used for fixing PVC flooring over concrete, wood and metal floors. PVA based adhesives may be used for concrete and wooden sub floors only. PVA based adhesives are not suitable for metallic surfaces or for locations where there is the likely spillage of water.

(ii) Preparation of Sub-Floors

Before laying PVC flooring, the floor shall be thoroughly dry and damp proof. In the case of new work a period of 4 to 8 weeks shall be allowed for drying the sub-floor under normal conditions.

For new concrete floors, the smooth finish required shall be produced by using cement slurry spread on fresh concrete floor and finished smooth. If the concrete floor is old and surface not even, the surface should be made smooth by first cleaning it free of all foreign material and then a layer of cement mortar 1:2 of average thickness of 6 mm shall be applied on the surface to give a smooth finish. The finished surface shall be cured for 7 days and then allowed to dry thoroughly.

Where it is expected that dampness may find its way from the surrounding walls, the same shall also be effectively damp-proofed up-to at least 150 mm above the level of the sub-floor and the damp proof treatment below the floor shall be extended over the walls.

(iii) Laying and Fixing

PVC flooring shall be laid after completion of plastering, painting and other decorative finish works to avoid any accidental damage to the flooring.

Prior to laying, the flooring shall be brought to the temperature of the area in which it is to be laid by stacking in a suitable manner within or near the laying area for a minimum period of 24 hours.

Where air-conditioning is installed, the flooring shall not be laid on the sub-floor until the conditioning units have been in operation for at least seven days. During this period, the temperature shall neither fall below 20 ºC nor exceed 30 ºC. These conditions shall be maintained during laying and for 48 hours, thereafter.

Dryness of the sub-floor shall be tested conforming to relevant IS codes and manufacturers recommendations as approved by the Employer’s Representative.

The layout of the PVC flooring on the sub-floor to be covered should be marked with guidelines. The PVC 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 PVC sheet tile flooring. When set sufficiently for laying, the adhesive will be sticky to touch, but will 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 films and other causes.

Care shall be taken while laying the flooring under high humidity conditions so that condensation does not take place. Laying PVC flooring shall be avoided under high humidity conditions.

In case of a small room, adhesive may be spread over the entire area but relatively small areas of tiles/sheets flooring should be treated in a larger room.

When the adhesive is just tack free the PVC flooring sheet shall be carefully taken and placed in position from one end onwards 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 weighing about 5 kg to develop proper contract with the sub-floor. The next sheet with its back side applied with the adhesive shall be laid edge to edge with the sheet already laid and fixed in exactly the same manner as the first sheet was fixed. The sheets shall be laid edge to edge so that there is a minimum gap between joints.

The alignment shall be checked after the laying of each row of sheet is completed. If the alignment is not satisfactory, the sheets may be trimmed by using a straight edge.

Tiles shall be fixed in exactly the same manner as for the sheets. The laying of tiles shall commence from the centre of the area. Care shall be taken that the tiles are laid close to each other with minimum gap between joints. The tiles shall always be lowered in position and pressed firmly on to the adhesive. Care shall be taken not to slide them as this may result in adhesive being squeeze up between the joints. After laying, PVC tiles shall be rolled with a light wooden roller weighing about 5 kg to ensure full contact with the under layer. Any undulations on the surface shall be rectified by removing and relaying the tiles after thorough cleaning of the underside of the affected tiles. The adhesives 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 in order to ensure that all the edges of adjacent tiles meet accurately.

Any adhesive which may squeeze up between sheets or tiles shall be wiped off immediately with a wet cloth before the adhesive hardens. If, by chance, adhesive hardens on the surface of the sheet or tile, it shall be removed with one part of commercial butyl acetate and three parts of turpentine oil.

A minimum period of 24 hours shall be given after laying the flooring for developing proper bond of the adhesive. During this period, the flooring shall not be put into 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 litres of warm water).

When the edges of the PVC sheets or tiles are exposed, as in doorways and on stair treads, protection shall be provided against damage of flooring materials using metallic edge strips securely fastened to the floor.

Linoleum Flooring

(i) Materials

Linoleum may be used on any base that is finished even and smooth, such as concrete, timber boarding or mastic asphalt. Unevenness or undulations in the base will show badly on the surface even and are liable to damage the linoleum. Linoleum flooring is suitable only for locations wholly inside the building. Linoleum is not resistant to indentations from heels or static load. Heavy objects left in one position may leave indentations. As linoleum flooring can become dangerously slippery when highly polished or wet, care should be taken to use polish with reduced tendency to slipperiness. If full damp proofing of the base surface cannot be ensured, the linoleum should not be used for floor covering. Linoleum is a combustible material and should not be used where an incombustible flooring is required. Linoleum flooring is a specialised work, which shall be carried out through specialist firms.

Linoleum shall conform in all respects to IS: 653 and shall be of either plain, moire, jaspe or marble type or a combination of the above types as approved by the Employer’s Representative.

Linoleum shall be stored in a clean, dry & well-ventilated place without exposure to direct sunlight as approved by the Employer’s Representative. Before starting the work the Contractor shall provide samples of the proposed linoleum to the Employer’s Representative for approval.

Linoleum used shall be of a thickness adequate for the conditions of surface and situation.

The adhesive used for laying the linoleum shall be those recommended by manufacturers of the floor covering and shall conform to specifications laid down for adhesive in IS: 1198. The adhesive shall be of heavy consistency and of reasonably short drying time.

(ii) Installation

Installation shall conform to IS: 1198.

Before laying linoleum the base shall be thoroughly dry and damp proof as per relevant IS and/or as approved by the Employer's Representative.

Linoleum shall be kept at a temperature of not less than 20 ºC for at least 48 hours before it is unrolled. Linoleum shall be unrolled and loosely laid out flat for 2 to 3 days before it is cut to size. Until the expansion of the spread rolls stops, two adjacent widths of linoleum should be allowed overlap and after the expansion stops it should be cut to fit. Laying should be taken up only after the sheets are finally cut to size after expansion is stopped. Linoleum pieces shall be cut to the required size and shapes with a sharp straight edge and gauge as described below and laid dry to the required edges and pattern as approved by the Employer's Representative.

The length for borders shall be first cut and adjusted. Linoleum shall then be adjusted in the central portion with the edges overlapping the adjacent pieces by 12 mm. The edges shall then be cut with the help of a special tool which enables the marking of the edge of the top pieces exactly over edge of the adjacent piece, so that when the overlapping is cut along the line, the edges of adjacent sheets butt against each other without any gap.

The adhesive shall then be brushed over the base, which shall have been thoroughly cleaned in advance and shall be allowed to become tacky. The sheets shall then be firmly pressed down and rolled with a light cast iron 70 kg roller, to ensure that they stick evenly to the base and no air pockets are left under them. If any air pockets are left, the sheets shall be removed and re-laid after brushing more adhesive on the base and roll. The sheets shall be laid with butt joints throughout and the joints shall be very fine. Sandbags shall be placed over the edges and joints to keep the sheets pressed down and prevent curling. Linoleum shall not be used for coves, skirting and dado.

Coves of wood or metal may be formed to cover or mask the joints between linoleum flooring and the wall facing where so required.

(iii) Finishing

After laying, any adhesive contaminating the face of the sheets shall be removed immediately with kerosene oil or spirit. The flooring shall be cleaned with soap and wet cloth wiped dry. The flooring shall then be wax polished to give a smooth shiny surface, taking care to ensure that the flooring does not become slippery due to excessive polish.

(iv) Precautions

Linoleum shall not be creased, as it will crack. Excess water or strongly alkaline soaps shall not be used for cleaning. Mild bar soap may be used. Linoleum shall be handled carefully with its exposed face protected from damage by sharp points.

Wooden Flooring

(i) Seasoning and Preservation:

All timber used for timber floors shall be thoroughly seasoned in accordance with IS:1141. After seasoning, the timber shall be treated with preservative in accordance with IS:401.

(ii) Supporting Joists

Main beams and joists of the class of wood sections as required and as approved by the Employer's Representative shall be fixed in position to dead levels. The width of joints shall not be less than 50 mm.

(iii) Boards

The timber shall be as specified wood work. Only selected boards of uniform width shall be used. Unless otherwise specified, the width of boards shall not be less than 100 mm or more than 150 mm The same width of boards shall be maintained throughout except where the width of the room is not an exact multiple of the boards. In the latter case, the difference shall be equally adjusted between the two end boards (adjacent to walls). The length of the boards shall not exceed 3 metres anywhere. Ordinarily, the minimum length of boards shall be such that the boards shall rest at least on three supports,

The boards shall be planed true on the top face only. The longitudinal joints of planks shall be tongued and grooved to a minimum depth of 12 mm while the heading joints shall be square butt type and shall occur over the centre line of the supporting joists. Heading joists in adjacent boards shall be placed over the same joists.

(iv) Iron Screws

Iron screws shall be of the slotted countersunk head type, of length not less than the thickness of planks plus 25 mm subject to a minimum of 40 mm and of designation of No.9 conforming to IS:451

(v) Fixing

The joists on which the planks shall be fixed shall be checked and corrected to levels. The end boards shall be accurately fixed with the sides parallel and close to the walls. Each adjoining board shall be carefully joined and shall be tightened in position and screwed. For fixing the boards to the joists, two screws shall be used at each end of the boards and one screw at each of 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 a metal strip (brass or aluminium) 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 joints shall be truly parallel and or perpendicular to the walls. The floor shall be planed in both directions and made perfectly even, true and smooth.

Provision shall be made for ventilating the space below the floor in case of ground floors and between and top of the ceiling in the case of upper floors.

(vi) Finishing

The surface of the floor shall be bees waxed or finished otherwise as approved by the Employer's Representative.

Wall Linings

Recommendations contained in following Indian standards codes shall be complied with in carrying out wall lining in addition to those stated in the section for floor pavements.

Glazed Tiles

Where walls are to be finished with glazed tiles, walls shall be lined with glazed tiles set in cement and sand (1:3) mortar and pointed in neat cement.

Tiles shall be soaked in water before fixing them.

All external and internal angles shall be of angle bead fitting of radius approved by the Employer's Representative. Angle bead internal angles shall be provided at all junctions of wall tiling with floor pavements, whatever be the material of the floor pavement.

The wall tiling shall be finished with a border of approved coloured tile, budded and pointed as glazed tile, with all necessary internal and external angles and stopped ends.

Marble Mosaic Tiles

Marble Mosaic tiles shall be set in 1:3 cement and sand mortar and shall be pointed in neat cement.

A cove of standard radius shall be provided at the junction of wall tiling and floor pavement.

Skirting shall match the floor tiles and shall be set in 1:3 cement mortar.

Marble Chip Granolithic

Marble chip granolithic finish shall be a 6 mm to 12 mm thick mixture of 2 parts of marble chips of required colour and one part of cement on a 20 mm, 1:3 cement plaster. Rounded internal and external angles shall be provided. The wall lining shall be polished after it has set. The wall lining shall be of a colour to the approval of the Employer's Representative.

Steel Doors, Windows and Ventilators

Materials

Doors, windows, frames etc. shall be fabricated from IS standard sections. Glazing used will be clear sheet glass of special selected quality, unless otherwise specified. Steel sections shall be free from rolling or other defects.

Steel sections shall be easily welded and punched and shall be cold straightened and shall conform to latest IS 1038 - 1983.

The anticorrosive shop coat of paint shall be given before the materials are brought to site.

Coupling Bars for Composite Doors, Window and Ventilators

All doors, windows and ventilators units shall be so constructed that they may, if required, be coupled together by means of the standard mullion and weathered transom bars and coupling pieces.

All steel hinges shall be projected steel hinges with non-magnetic stainless steel pins and washers to permit complete ease in cleaning the glass and shall be welded or riveted to the frame.

Fabrication

The frames shall be square and flat and shall be constructed of sections cut to length, mitred and welded at the joints. All welding shall be electric flash butt welding except for the welding of steel sheets for shutters.

Sections shall be formed true with clean straight, sharply defined profiles and free from defects that may impair durability. All works shall be accurately formed to the required dimensions, line and level. All joints shall be continuously reinforced, fitted and continuously welded at the edges. Surfaces along joints shall be ground to attain a smooth level surface even and flush with adjoining surfaces.

All frames shall be properly reinforced for the attachment of hardware. The heads of frames for openings wider than 1.2 m. shall be reinforced to prevent sagging or deflection when installed.

Installation

The doors, windows and ventilators brought to site shall be stacked upside down on wooden runners under cover. Fixing shall be done as per latest Indian Standard Specifications. The size of the prepared openings shall be checked first and these should be cleaned of all obstructions.

The doors, windows and ventilators shall not be forced into the walls but shall be fixed into prepared openings in a workmen like manner.

All joints between masonry/concrete and the metal shall be fully filled with approved mastic filler/putty in order to ensure water tightness. The joints shall be neatly pointed with matching cement and excess material shall be removed.

All brick jambs and sill holes shall be cut 50 mm square and 100 mm deep for fixing hold fasts. All concrete jamb and lintel holes shall also be carefully drilled and if reinforcing steel is encountered, the length of the hold fasts may be decreased and existing surface made good to the original condition.

Any hardware, if fixed in position, shall be removed before fixing the frames in the structural openings and moving parts shall be secured with wire or string during erection and while the building work is being completed to prevent damage to the moving parts. Hardware shall be fixed as late as practicable and preferably just before the final coat of paint is applied. Hardware shall be fitted in workmanlike manner so that it may not be marked and mutilated by hammers and screws and pins are not marked and mutilated by hammers and screwdrivers.

Doors

Doors shall be hung on projecting hinges of 100mm size and shall be fitted with mortice lock and two brass or bronze lever handles. In the case of double leaf doors, the first closing leaf shall also be provided with brass or bronze tower bolts concealed in the section at the top and bottom. These shall be constructed so not to work loose or drop by their own weight and, if necessary, lugs, fittings, screws etc shall be provided and fitted properly at site.

Windows

Windows shall be hung on projecting hinges. One leaf of the hinges shall be welded into a slot in the outer frame and the other leaf of the hinges riveted to the opening window. Hinges may be of the friction type in which case the window shall not be fitted with peg stays. In case of non-friction projecting hinges, a brass or bronze three holes peg stays 300 mm long with pegs and brackets, welded or riveted to the frame shall also be provided.

Handles shall be of brass or bronze and shall be mounted on a mild steel handle plate welded to the window in such a way that it can be fixed after the window is glazed. The handles shall have a two point nose which shall engage with the striking plate on the fixed frame so that it can hold the shutters in a slightly open as well as in a fast position.

Ventilators

(i) Top hung Ventilators

These shall be fixed with plain hinges, riveted to the fixed frames or welded after cutting an appropriate slot. A peg stay 300 mm long of brass or bronze with three holes, as in case of windows shall be provided. The locking bracket shall be either fitted to the fixed frame or to the ventilators.

(ii) Centre Hung Ventilators

These shall be hung on two pairs of cup pivots, riveted to the inner and outer frame of the ventilators to permit these to swing through an angle of approximately 85 deg. The opening portion of the ventilators shall be so balanced that it remains open at any desired angle under normal weather conditions.

A bronze or brass spring catch shall be provided at the top centre of the ventilator. A brass cord pulley wheel in mild steel or malleable iron brackets shall be fitted with screws or welded at the sill and a cord eye shall be fixed to inner frame of ventilators to facilitate opening of ventilators.

(iii) Composite Units

Composite units consist of a combination of two or more units of doors, windows, ventilators etc. as the case may be. The different units shall be coupled by using coupling sections. The coupling sections shall be made from mild steel sheet 3.15 mm in thickness and 56 mm wide as per IS 1038-1957 para 5.2 and these shall be fixed with bolts and nuts.

Wherever the ventilators, windows and doors shall have coupling section, mastic cement shall be applied between the junctions to make the joints watertight.

To calculate height or width of composite units, 2.5 cm shall be added for each mullion or transom coupling bar for each unit.

Finishing

All steel surfaces shall be thoroughly cleaned of rust, scale and dirt by pickling and marking. A shop priming coat of superior quality red oxide or equivalent shall then be given before despatch. Alternatively, where approved by the Employer’s Representative, the steel surfaces shall be treated for rust proofing by the hot dip zinc spray or electro galvanising process, having a coating of not less than 60 microns. Zinc sprayed articles shall be given one coat of priming coat of superior quality red oxide or equivalent.

Final finishing with two coats of synthetic enamel/flat oil paint of approved make and shade shall be given after the doors, windows and ventilators are fixed in final position.

In the case of galvanised doors, windows and sashes, their surfaces shall be treated with copper acetate solution or other approved mordant solution to ensure proper adherence of paint, unless the galvanised surface has weathered adequately at the time of final painting.

Non-ferrous parts and working parts such as handle stays, catches, handle pins, hinge pins etc. shall not be painted.

Aluminium Entrance Doors, Wall Spans, Glazing etc.

General

The material, fabrication and hardware shall conform to the IS:1948.

Materials

Aluminium alloy for extruded sections for the above work shall correspond to IS:733 & 737 specifications or any further revision thereof (extruded sections shall conform to IS Designation HE9-WP. Hollow sections shall conform to IS Designation HV9-WP) and shall be anodised before incorporating in the work. Anodic coating shall conform to IS: 1868.

The frame work, stiles, mullions, beadings, transoms and handles etc shall be of aluminium anodised sections. The sections shall be structurally suitable to withstand all loads the members have to sustain. Counter sunk screws, nuts, bolts, washers, rivets and other miscellaneous fastenings devices shall be of approved cadmium plated brass or stainless steel.

Each door leaf shall be prepared to receive glazed panels of required thickness. Glazing shall be done with neoprene dry set glazing gasket (of best quality and approved make) with snap-in-bevelled white anodised matt finish aluminium metal glazing stops inside and outside. All doors shall have off- set pivots, double action (1800 minimum swing) floor springs with oil check boxes of approved manufacture. All doors shall have 4 lever concealed brass body mortice lock with concealed flush cadmium plated brass tower bolts provided at suitable locations. All doors shall have push plates.

All entrances shall be without thresholds.

All aluminium surfaces in contact with masonry or concrete shall be given a thick coat of bitumastic paint.

After fabrication, aluminium sections shall be protected from construction hazards that may damage their appearance or finish. All exposed surfaces of aluminium entrance doors shall be protected by masking tape during trans-shipment and erection. All sections and hardware shall have anodic film and cover a minimum thickness of 0.015 mm.

Fabrication

The frames shall be manufactured square and flat, the corners of the frame being fabricated to true right angles. All the fixed, sliding and opening frames shall be constructed of sections which have been cut to length, mitred, welded and mechanically fixed at the corners.

Where hollow sections are used with welded joints, argon-arc welding or flash butt welding shall be employed (not gas welding or brazing). In the case that welded joints are used, anodising shall be done after fabrication as a whole. All welding shall be on unexposed sides in order to prevent pitting/discolouration or other surface imperfections after fixing etc. Necessary allowances shall be made while manufacturing the aluminium door entrances, wall spans and glazing for receiving plaster.

A thick layer of clear transparent lacquer based on methacrylates or cellulose butyrate shall be applied on the finished sections of the aluminium work to protect the surfaces from wet cement, lime, dirt, dust etc. during the construction activities. The size for door, window or ventilator frames shall not vary by more than (+/-) 1.5 mm.

Fixing

Fixing and glazing of doors, windows and ventilators shall conform to IS 1081, unless otherwise specified. The frames shall be accurately fixed to the flooring, brick masonry or RCC works. The fixing of the frame shall be withhold fasts as approved by the Employer’s Representative. All aluminium works shall be fixed in position as per relevant Indian Standard Specifications and code of practice for fixing and glazing of aluminium work. Joints between metal and masonry shall be fully caulked with mastic / polysulphide compound in order to ensure water tight joints as approved by the Employer’s Representative.

Joints shall be neatly painted with matching cement and excess materials shall be removed. Fixing of aluminium door entrances, hardware etc. shall be done using the best workmanship like manner true to line, level, plane, plumb etc. and all as approved by the Employer’s Representative.

Aluminium Windows, Ventilators, Composite Units etc.

General

The material, fabrication and hardware shall conform to IS 1948 & 1949.

Materials

The aluminium alloy used in the manufacture for extruded window section shall correspond to IS 733. Extruded sections shall conform to IS designation HE9-WP and hollow sections shall conform to IS Designation HV9-WP. The frame work, stiles, mullions, beadings, transoms, hinges, pegstays, handles etc. shall be of aluminium anodised sections. All sections and hardware shall have minimum anodic film thickness of 0.015 mm

The sections shall be structurally suitable to withstand the full load, the members have to sustain. Countersunk screws, nuts, bolts, washers, rivets and other miscellaneous fastening devices shall be of approved cadmium plated brass or stainless steel.

Fabrication

The frames shall be manufactured square and flat. The corners of the frames shall be fabricated to true right angles. All the fixed, sliding, openable frames shall be constructed from sections which have been cut to length, mitred and mechanically jointed or welded at the corners. Where hollow sections are used with welded joints, argon arc welding or flash butt welding shall be employed (not gas welding or brazing). Sub-dividing bars of units shall be tennoned and riveted into the frames. In the case welded joints are used, all welding shall be on unexposed sides in order to prevent pitting, discolouration and other surface imperfections after finishing.

The side hung shutters shall have projected friction type hinges of aluminium alloy. Concealed projected hinges having structural stability and of good quality will also be considered after the inspection and approval of samples submitted by the Contractor. The necessary pegstays, handles, window fasteners etc. shall be of aluminium. The handle shall be mounted on a handle plate riveted to the opening frame. The pegstays shall be 300 mm long or as required complete with peg and locking bracket and shall have holes for keeping the shutter open in three different positions.

The complete fabricated assembly shall be anodised in approved satin finish with minimum film thickness of 0.015 mm for the entire surface. A thick layer of clear transparent lacquer based on methacrylate or cellulose butyrate shall be applied on the finished sections of the aluminium windows etc. by the supplier to protect the surfaces from wet cement, lime, dirt, dust etc. during the installation. This lacquer coating shall be removed after installation is complete, if approved by the Employer's Representative and all sections of the windows shall be protected by PVC film covering.

Fixing

The fixing of the frame shall be with holdfasts. All aluminium windows shall be fixed in position as per IS 1081-1960: Code of practice for fixing and glazing of aluminium windows. All joints between metal and masonry or concrete shall be fully caulked with mastic or polysulphide compound in order to ensure water tight joints. Joints shall be neatly painted with matching cement and excess materials shall be removed.

Rolling Shutters

Materials

Rolling shutters shall be suitable for fixing in position outside or inside as appropriate on or below lintels or between the jambs of the opening. Rolling shutters shall be hand/gear operated.

Hand operated shutters shall be push and pull type. Gear operated shutters shall be provided with reduction gear operated by mechanical device with chain, crank, shaft and handle.

The shutter shall consist of 80 mm wide mild steel laths 1.25 mm thick of best quality machine rolled mild steel sheet. Laths shall be inter-locked together throughout their entire length and jointed together at the end with end locks. These shall be mounted on specially designed shaft. The spring shall be of best quality and shall be manufactured from tested tensile spring steel wire or strip of adequate strength to balance the shutter in all positions. The spring, shaft etc. shall be supported on strong mild steel or malleable cast iron brackets. Both the side guides and bottom rails shall be jointless and of single piece of pressed steel of minimum 16 gauge thickness. The top cover of the shaft, spring etc. shall be of the same materials as that of lath. The reduction gear arrangement operated by the mechanical device shall be of the best quality and shall be easy in operation.

Fixing

Brackets shall be fixed on or under the lintel beam as required with rail plugs and screws, bolts, washers etc. The shaft along with the spring shall then be fixed on the brackets. The lath shutters shall be laid out and the side guide channels shall be bound with it. The shutter shall then be placed in position. The side guide channels shall be fixed to the wall through the plates welded to the guides. These plates and brackets shall be fixed by means of steel screws, bolts and rail plugs drilled into the wall. The plates, screws and bolts shall be concealed in plaster to make their locations invisible. Fixing shall be done accurately in a workmanlike manner such that the operation of the shutter is easy and smooth.

All the members of the rolling shutter shall be thoroughly cleaned of dust, scales, rust etc. and shall be given approved priming coat of red oxide paint before fixing the shutter in position and shall then be painted with two coats of flat/synthetic enamel paint of approved quality and shade.

Fitting and Fixtures

General

All fittings and fixtures shall conform to relevant IS code and be made of brass, anodized aluminium, mild steel stainless steel or as otherwise approved. These shall be well, made smooth and free from sharp edges, corners, flaws and other defects. Screw holes shall be counter sunk to suit the heads of the appropriate screws.

All hinges pins shall be of steel for brass hinges and aluminium alloy NR-6 or steel pins for aluminium hinges with nylon washers. All riveted heads pertaining to hinge pins shall be well formed. Screws supplied for fittings shall generally be of the same metal and finish as the fittings. However brass cadmium plated brass screws shall be supplied with aluminium fittings.

Fittings shall be fixed in their proper position as approved by the Employer’s Representative. These shall be truly vertical or horizontal as the case may be. Screws shall be driven home with a screwdriver and not hammered in. Recess shall be cut to the exact size and depth for the counter sinking of hinges.

Mild steel fittings shall be bright satin finish black stone anodized or copper oxidised (black finish), nickel chromium plated or as otherwise approved.

Brass fittings shall be finished bright satin finish or nickel chromium plated or copper oxidised or as specified.

Aluminium fittings shall be anodized to natural matt finish or dyed anodic coating less than grade AC 10 of IS: 186

Stainless steel fittings shall be non-magnetic, rust and moisture proof, strong and sturdy. Pins of hinges shall also be of stainless steel.

Butt Hinges

Brass and aluminium hinges shall be manufactured from extruded sections and shall be free from cracks and other defects. Mild steel butt hinges shall be cranked and manufactured from sheet steel. Butt hinges shall generally conform to IS 1341 (MS) IS : 205 (Cast brass & aluminium, IS : 362 (Parliament hinges); IS : 453 spring hinges, IS : 3818 (Piano hinges) etc. The size of butt hinges shall be taken as the length of the hinge measured from the centre line of hinge pin to end of the flange.

Parliamentary Hinges

These shall be manufactured from extruded section for brass and aluminium and from MS sheets for iron oxidised and shall be free from cracks and other defects. The size of the parliamentary hinges shall be taken as the width between open flanges, while the depth shall be as specified.

Piano Hinges

These shall be generally conform to IS 3818 and shall be made of either brass, aluminium anodized, mild steel or as otherwise approved. Piano hinges shall be fixed along the entire length of the item in a single piece. No joints shall be allowed.

Tower Bolts

Tower bolts shall generally conform to IS 204 (Part II & I). They shall be well made and shall be free from defects.

Tower bolts shall be of the following types :

1 Mild steel semi barrel tower bolt with mild steel sheet pressed barrel and G.I. or mild steel bolt.

2 Oxidised brass barrel tower bolt with brass sheet barrel and rolled or drawn brass bolt.

3 Anodised aluminium tower bolt with barrel and bolt of extruded sections of aluminium alloy.

In case of mild steel tower bolts, plates and straps shall be firmly anodize or spot welded properly after assembly.

The knobs of brass tower bolts shall be cast and the bolt fixed into the knob firmly as per IS specifications.

Tower bolts shall be finished to the correct shape and pattern to have a smooth action.

Knobs shall be properly screwed to the bolt and riveted at the back. The size of the tower bolt shall be taken as the length of barrel without top socket.

Door Latch

Door latches shall be of mild steel, cast brass or as otherwise approved and shall have a smooth sliding action. Mild steel latches shall be copper oxidised (black finish) or as otherwise approved. Brass latches shall be finished bright, cadmium plated or oxidised or as otherwise approved.

Aldrops

Aldrops (brass sliding door bolts) shall be oxidised brass or anodized aluminium, mild steel or as otherwise approved and shall be capable of smooth sliding action and shall be as per relevant IS. Brass aldrops shall be made from rolled brass generally confirming to IS: 2681. Mild steel sliding door bolts shall generally conform to IS 281. The hasp shall be of cast brass and screwed to the bolt in a workman like manner or the hasp and the bolt may be in one piece. All components shall be smooth and polished. The leading dimensions of an aldrop shall be the length and diameter of the bolt.

Door Handles – Bow/Plate Handles

These shall generally conform to IS: 208. Unless otherwise approved, door handles shall be of 100 mm size and windows handles of 75 mm size. All edges and corners shall be finished smooth and correct to shape and dimensions. Brass handles shall be finished bright, chromium plated or oxidised as specified. The size of the handle is taken as the inside grip of the handle. Mild steel handles shall be manufactured from mild steel sheet pressed into oval section as per IS.

Mortice Lock and Latch

Mortice locks and latches shall generally conform to IS 2209. Handles shall conform to IS 4992. Mortice locks with latches and a pair of level handles shall be 6 levers with zinc alloy pressure die cast/brass or as otherwise approved and shall be right or left handed as required.

The pair of handles shall be either brass chromium plated or anodized aluminium of approved shape and pattern or as otherwise approved. The handles shall be of the best Indian make of approved quality. The size of the lock shall be determined by its length. The lock for single leaf door shall have plain face and that for double leaf door a rebated face. Level handles with springs shall be mounted on plates and shall be of approved quality, anodized aluminium or as otherwise approved.

Hydraulic Door Closer

Hydraulic door closers shall generally conform to IS: 3564. Hydraulic door closers shall be of approved quality and make. The operation of the hydraulic door closer shall be very smooth.

Hydraulic door closers should be of HD 66 for external/main doors and Elegant 63 for all internal doors. The overall height should not be more than 170 mm for HD 66 and 160 mm for Elegant 63. The base shall be 110 x 60 mm for HD 66 and 100 x 55 mm for Elegant 63. The units shall weigh not less than 4.5 kg for HD 66 and 4 kg. for Elegant 63. The speed of the hydraulic door closer shall be adjustable and the closing latch shall also be the adjustable type. Suspension and lubrication of door closer shall be in to approved line and level.

Mortice Night Latch

This is a mortice lock having a single spring bolt withdrawn from the outside by using the key and from inside by turning the knob 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 lock should generally conform to IS: 3847 and shall be cast or sheet brass, cast or sheet aluminium alloy or mild steel as otherwise approved and of an approved make. The locks shall be bright finished or copper oxidised (black) finish as approved. The normal size of the latch shall be denoted by the length of the face over the body in millimetres.

Floor Door Stopper

Floor door stoppers shall conform to IS: 1823 and be made of aluminium, brass finished bright, chromium plated or oxidised or as cast brass of overall size as approved by the Employer's Representative and shall have a rubber cushion. The size of door stopper shall be determined by the length of its plate. The body of the door stopper shall be cast in one piece. All parts of the door stopper shall be of good workmanship and finish and free from surface and casting defects. Aluminium stoppers shall have anodic coating of not less than grade AC-10 of IS 1868.

Hardware

All cut outs, recesses, mortising or milling and operations required for fixing the hardware shall be accurately made reinforced with packing plate as required to ensure adequate strength of the connection.

All the hardware accessories shall be of best approved type and of a finish the same as for the frames and other sections.

Each lock shall be supplied with two keys and each key shall be with a number stamped thereon matching the number on doors so installed. All hardware shall be free from defects, which may affect the appearance and serviceability. Working and moving parts of locksets shall be accurately fitted to smooth, close bearings and shall be free from rattle.

Floor springs shall be of heavy-duty type and should allow door operation smoothly and shall conform to IS 6315.

Incidentals

The Contractor shall provide for all the incidentals required for fixing these fixtures and fittings such as cadmium plated screws etc. Mortice plates shall be used over holes where the bolts enter in the wood work. Metal sockets shall be provided to all bolts where the shoot enter brick, stone, concrete etc.

Glass and Glazing

Materials

(i) Glass

The glass shall be either of special or ordinary quality glass as required for the usage. Toughened float glass of approved manufacturer shall be used wherever necessary. The glass shall be free from bubbles, flaws specks, waves, air holes, distortion, scratches, cracks or other defects.

(ii) Glazing

Glazing shall be with the approved selected glass and be cut to fit the rebates of the sashes truly and only slightly loose. The glass shall be fixed with double putty by means of tack beads and sprigged to the sashes in workmanlike manner. All glazing shall be properly cleaned from the outside and inside by means of chalk on completion of the work.

Beading

In the case of steel or aluminium doors and windows, the beading shall be anodised aluminium beading of channel section. The junction of the beadings shall be mitre jointed.

Dimensions, Thickness and Weight of Glass

Unless otherwise specified, the glass thicknesses shall be as per the table given below. All panes shall have properly squared corner and straight edges

Normal Thickness	Range of Thickness	Weight in kg /m^2
3.0 mm	2.8 to 3.2 mm	7.5
4.0 mm	3.8 to 4.2 mm	10.0
4.8 mm	4.6 to 5.1 mm	11.9
5.5 mm	5.2 to 5.8 mm	13.5
6.3 mm	6.0 to 6.6	15.5

Workmanship

The glass shall be cut to the required sizes of panels where it is to be fitted and it shall be so cut that it fits properly in the frames without rattling. Each frame shall be properly measured prior to the cutting of glass.

The beading shall then be fixed to glass panes and screwed at close intervals not more than 10 cm. from each corner and intermediately not more than 20 cm apart. When the glass panes are fixed with aluminium beading, epoxy resin or silicon sealant shall be applied covering the area in contact between the glass panes and sash bars and also between glass panes and the beading. In the case of louvres, all the exposed edges of the glass shall be ground properly.

All glass panes shall be fixed within the aluminium framing by use of cadmium plated brass or stainless steel screws and the joints sealed with epoxy resin or silicon sealant to make the unit completely waterproof. Glazing or caulking compound around the perimeter of glass shall not be permitted. Fixed glass panes shall be supported by setting blocks. There shall be no rattling.

After inspection and approval the Employer's Representative, glass panes shall be cleaned of any labels, paints smears and spots and shall be washed from both the sides and all glazing left clear, and free from rattling. In case of steel windows, any hardware if fixed in position shall be removed temporarily before fixing the glass panes and then shall be re-fixed back in position.

Architectural Louvres

General

Louvre dimensions shall be determined from both mechanical system requirements and the architectural requirements.

Louvres shall comply with pertinent fire regulations.

Materials

Louvre frames and blades shall be extruded aluminium alloy 6063 T52 sections, minimum 8-gauge material; louvre depth shall be 150 mm unless otherwise approved by the Employer's Representative.

Louvres up to 600 mm high shall have fixed horizontal storm proof blades and shall be 35 degrees from horizontal, complete with water baffle.

Louvres over 600 mm high shall have fixed horizontal drainable blades with gutters designed to catch and direct water to the jamb and mullion drains.

Frames shall be of all welded construction and shall be provided with a caulking recess all around.

Inter-crimped aluminium heavy-duty 13 mm x 13 mm bird screens (2.3 mm gauge) shall be provided folded in extruded aluminium frames to all louvres, mounted on the interior.

Continuous blade louvres shall be used with continuous blade mullions where required.

Execution

(i) Installation

Louvres shall be install plumb and true, flush with the outside of building surfaces or as otherwise approved.

The structural support or frame shall be designed by the louvre manufacturer to support the louvre against a basic wind load of not less than 1.0 kPa with the maximum deflection not exceeding 1/180 of the span.

Upon completion of installation, all louvres shall be left clean and free from dirt. All debris shall be removed from the job site.

Washroom/Toilet Accessories

Materials

Toilets shall be European pattern white porcelain with a 63cm soil of an approved make and pattern. The unit will be complete with trap and anti-syphon opening for a vent pipe. The seat shall be polished with a matching seat cover and brass hinges and shall operate smoothly and be stable when raised. The associated cistern shall have a 10 litre pull flush, chain, handle and stop tap.

Urinals shall be flat base type in white glazed earthenware and be complete with manual flushing arrangement.

Wash basins shall be 56cm x 41cm white glazed earthen ware with overflows and of an approved make and style. Basins shall be complete with 12mm swan neck nickel plated taps and an integral plug.

All required fixtures and fittings to fit the units and connect to the potable water and sewerage systems shall be included. Fitting shall be by an experienced plumber/ licence holder plumber and completed in a workmanlike fashion.

23 PIPELINES

Definitions

This section of the specification refers to buried pipes that are not in chambers or buildings. Pipes that are above ground, in chambers and buildings are covered by the relevant clauses in Volume 2B, the General Mechanical Specification.

The following terms shall have the meanings hereby assigned to them except where the context clearly renders these meanings inapplicable:

Term	Definition
Pipes	Pipes, bends, junctions and other specials including jointing parts
Valves	Valves, air valves, hydrants, metering devices and the like and includes jointing parts, operating gear, and associated fittings. These items are covered in the Mechanical Specification.
Manholes	Manholes, discharge chambers and inspection chambers on gravity pipelines including pre-cast concrete manhole sections, access covers and other fittings.
Installation	Handling, placing and fixing in position ready for jointing pipes and fittings within a trench.
Pipeline appurtenances	All items additional to pipes, required to complete a pipeline including, where relevant, internal and external protection systems, supports and anchorages, washouts, vent columns and marker posts.
Pressure pipelines	Pipelines for the conveyance of liquid under pressure, normally by pumping.
Gravity pipelines	Non-pressure pipelines for drainage and for the conveyance of liquids, inclusive of pipes, manholes and pipeline appurtenances.

Pipework Design

The pipework shall be laid out and designed to facilitate the installation and to give a constant and uniform flow of working fluid with a reasonable minimum of head loss.

Flexible spigot and socket type joints shall be provided except where otherwise necessary to facilitate removal of Plant. Wherever necessary, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipework as a whole.

Standard fittings shall be used in preference to fabricated or special fittings.

Facilities shall be provided for draining down the pipe system and releasing air. The drainage fluid shall be piped into the building drainage system and the period of time for drainage shall not exceed 30 minutes.

Flanges shall conform to IS 13159 and be drilled in accordance with the appropriate pressure rating. Where a pipe passes through a wall or is subject to thrust it shall incorporate a thrust flange which shall conform to the dimensions stated in IS 13159 but remain undrilled.

Materials and Equipment

General

The installed pipes and their joints shall be resistant to the corrosive effects of the fluid being carried and the ground conditions in which they are placed.

Pipes shall be solid walled concrete, PVC-U, GRP, glazed vitrified clay, ductile iron, steel or PE according to the duty required. Structured wall PVC-U pipe shall not be permitted. The particular type, size, class and jointing system of pipes and fittings for each part of the Works shall be as specified below or as approved by the Employer's Representative.

Pipeline materials shall be capable of withstanding all the loads and pressures to which they will be subjected. The Contractor shall consider compatibility with existing networks and other operational considerations. Structural design shall be carried out based on soil classifications and operating conditions such as internal pressures and external loads both temporary and permanent.

Ductile iron pipes shall be cement mortar lined and steel pipes shall be lined with either cement mortar or epoxy as detailed below.

Water and sewerage network materials (pipes, fittings, valves etc.) must support loads coming from earth weight, traffic or other special forces, as well maximum pressures that can arise during service.

All materials in contact with potable water shall be approved for use in drinking water supply systems.

Fabrication Tolerances

Tolerances for straight pipes and fittings shall conform to IS 3589.

(i) Straightness

Finished pipe sections shall be truly straight with walls parallel to the axis of the pipe and shall not be out of the alignment by more than 5 mm for every 3m of length.

(ii) Length

Straight pipe shall not vary from the specified overall length or effective length by more than plus or minus 1.0 percent; where exact or cut lengths are specified the tolerance on length shall not exceed plus 15 mm or minus 10 mm

(iii) Circumference

The outside circumference of the pipe shall not vary by more than 0.5 percent.

(iv) Outside Diameter

The outside diameter of a pipe of nominal diameter of over 500 mm shall not vary by plus or minus 0.5 percent.

The diameter of plain end of a pipe of nominal diameter over 500 mm shall not vary by more than plus or minus 0.5 percent. Notwithstanding these tolerances and the surface irregularities permitted, any dimensional variation or surface irregularity which permits leakage past the joints shall be cause for rejection.

Concrete Pipes

All concrete pipes and fittings shall comply with IS 458.

The concrete shall be in accordance with Section 17 of this document.

Installation and testing of RCC pipes shall be in accordance with IS 783.

(i) Concrete Pipes (pressure)

Non-circular concrete pipes shall not be used in pressure situations.

Higher pressure pipes shall be produced using a double layer of pre-stressing wires, with each layer wound over a thin layer of concrete and then covered by another layer.

Un-plasticised Polyvinyl Chloride (PVC-U) Pipes

PVC-U pipes shall comply with IS 15328.

PVC-U pipes used for potable water shall not contain any matter which could impart taste, odour, toxicity or be harmful to health or adversely affect the water conveyed.

Unless specified otherwise, joints shall be of the flanged solvent or push fit type complying with IS 15328 having an elastomeric sealing ring. Joints shall be made in accordance with the manufacturer's instructions.

Fittings shall be injection moulded in PVC-U to the requirements of IS 15328. Fabricated PVC-U fittings or fittings manufactured in other materials will only be permitted when the material and method of manufacture are approved by the Employer's Representative.

High Performance Polyethylene Pipes

All high performance polyethylene pipes (PE 100) shall comply with IS 7634.

The minimum pressure rating for pipes and fittings shall be 10 bar.

The density of the base polymer shall be determined on specimens prepared and tested in accordance with IS 7634.

The internal and external surfaces of the pipe shall be smooth, clean and free from grooving and other defects which might impair its functional properties. The pipe ends shall be cleanly cut square with the axis and free from deformity. The pipe shall be homogeneous throughout and uniform in colour, opacity, density and other physical properties.

The pipe shall be delivered in the longest lengths practicable to keep site jointing to a minimum.

Glass-fibre Reinforced Plastic (GRP) Pipes

Except where otherwise specified, glass-fibre reinforced plastic pipes and fittings shall be in accordance with IS 14402. Pipes shall have dense, void-free walls and be manufactured using the centrifugally-spun or externally-wound filament method.

The materials used in the manufacture of the pipes shall be resistant to abrasion and to chemical and biological attack and shall not react with or be soluble in the liquid being conveyed, or the surrounding ground or groundwater, within the temperature range to which they are exposed. The composition of the pipe materials shall be such as to avoid deterioration during transport or storage due to ultra-violet radiation.

All pressure pipes shall be tested at the manufacturer's works to the pressures required by the Employer's Requirements and in accordance with IS 14402.

Polypropylene Pipework

Polypropylene pipework shall comply with IS 15801.

Ductile Iron Pipework

(i) General

Ductile iron pipes and fittings shall generally comply with IS 1729, IS 8329 and IS 9523.

Except where indicated otherwise, all socket and spigot pipes and fittings and flanged pipes and fittings shall be to the standard class designation. Socket and spigot pipes and fittings shall be suitable for Tyton or Stantyte type joints or, where required, for Viking Johnson type couplings. Flanges shall be PN 16.

Tests on pipes and fittings shall be carried out in accordance with the requirements of the Ductile Iron Pressure Pipes and Ductile Iron Fittings for Pressure Pipes for Water, Gas and Sewage (Quality Control) Order 2006 and IS 8329 and IS 9523.

(ii) Gaskets and Sealing Rings

Gaskets and sealing rings for buried flexible joints shall comply with IS 5382, AWWA C111/A21.11, of Styrene Butadiene Rubber (SBR).

The joints shall be flexible and sealed with elastomeric seals or flexible gaskets and shall withstand the various tests specified for the appropriate class of pipe. Joints and materials shall comply with BS EN 545 and EN 681-1.

The seals shall be capable of withstanding the permissible deflections claimed by the manufacturer for the joint subject to a minimum deflection as per BS EN 545 or ISO 2531 depending on the manufacturing standard of the Supplier.

The Contractor shall provide an adequate supply of jointing lubricant suitable for use with the jointing materials supplied. The supplier shall provide certification to confirm that the lubricant will be non- injurious to public health when in continuous contact with potable water.

The joint gaskets and rings shall be suitable for use in the prevailing climate, soil conditions, transported water and ground water conditions.

A nominal additional quantity of spare jointing materials for pipes and fittings equivalent to 5% of the nominal requirement for such materials based on the pipes and fittings specified in the Contract.

(iii) Linings

All ductile iron pipes and fittings, unless otherwise indicated, shall be cement motor lined employing sulphate resisting cement to IS 12330 and shall comply with the requirements of IS8329 and IS 9523. A minimum thickness of 5 mm shall be applied.

(iv) Coatings

Factory-applied coatings shall be in accordance with IS 8329 suitable for tropical climates and applied in accordance with the manufacturer’s instructions. The external zinc spray and bituminous finishing this shall be in accordance with IS 8329.

Factory-applied and site-applied polyethylene sleeving shall be in accordance with IS 8329.

Bituminous coatings shall comply with IS 8329.

Buried pipes shall have an external zinc spray coating below the bituminous coat.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

(v) Sleeving

Where polythene sleeving is specified to be applied in addition to bitumen coating, the sleeving shall be heavy duty black polythene of not less than 0.25 mm thickness.

Tubular polyethylene film for use as a loose protective sleeving for buried iron pipes and fittings shall comply with the relevant provisions of IS 8329, except that the nominal layflat width shall be 280 mm for use with 80 mm and 100 mm nominal internal diameter pipelines incorporating push-in flexible joints and 400 mm for 150 mm nominal internal diameter pipelines.

Sleeving shall be stored under cover, out of direct sunlight and its exposure to sunlight during pipe laying shall be kept to a minimum.

Sleeving shall be drawn over the pipes during pipe laying. The sleeves over successive pipes shall be carefully lapped and the surplus material folded over the top of the pipe. Ends and overlaps shall be sealed and secured with nylon packaging tape or other approved grease or bitumen impregnated, rubberised or other tape.

Sleeving for pipes for below ground use for potable water shall be coloured blue and all other sleeving black. Joints in sleeving shall be taped to form a continuous barrier and any damage to the sleeving shall be repaired prior to backfilling.

Steel Pipework

(i) General

Steel pipes, fittings and joints shall conform to IS 3589 and IS 6631.

Pipes and specials shall be manufactured from seamless or welded carbon steel pipes made from materials with mechanical properties and weldability at least equivalent to those required by IS 3589.

The pipe thickness shall be suitable to comply with the required normal working pressure. Suitable thicknesses and recommended test pressures are given in IS 3589 for pipes up to 2,540 mm outside diameter.

All pipework and fittings shall be new and entirely fabricated and corrosion protected at the maker's works.

Steel pipelines shall have at least:-

a. An external coating comprising 3 layers: fusion bonded epoxy, fusion bonded epoxy adhesive primer and 3 mm of hot applied polyethylene or polypropylene
b. Additional external protection for regions of contaminated / aggressive ground
c. Additional wall thickness and external protection for any tunnel sections and pipe bridges.
d. An internal coating comprising a minimum of 500 microns of fusion bonded epoxy
e. A cathodic protection system
f. An effective means of repair to the internal coating subsequent to welding
g. An effective means to repairing external coating using heat shrink sleeving/ wrapping with an overlap onto undamaged external protection of at least 150 mm

The Contractor shall prepare a method statement for repair of the pipeline specific to the chosen range of pipe materials, diameters, coating systems and pipe depths.

(ii) Fusion Bonded Epoxy Coated Steel Pipe

All pipes and fittings shall be satisfactorily hydraulically pressure tested, prior to coating at the manufacturer's works, to a pressure of 1.5 times the design pressure.

Prior to coating, the pipes shall be degreased, blast cleaned to IS 3589 and if seam welded, the welds shall be ground smooth. Any grit or dust shall be removed by air blast.

Before any visible surface corrosion has occurred, the pipes shall be heated to a temperature not exceeding 245 °C and then epoxy powder applied inside and out either by immersion in a fluidised bed or by spraying. The coating shall then be cured.

The coating material shall be a semi-flexible thermosetting dry powder fusion-bonded amine-cured epoxy as approved by the Employer’s Representative.

The resulting coating shall have a minimum thickness of 0.3 mm. Spark testing shall be employed to check for any imperfection and any defects found shall be repaired using a compatible two-pack epoxy and the area re-tested.

In the event of a fusion-bonded epoxy coating being damaged after leaving the factory, the item shall be returned to the factory for repair or be repaired at Site. Repairs shall be effected in accordance with the following requirements:

1. Repair materials shall be compatible with the original factory-applied coating materials
2. The edges of the original factory-applied coating shall be ground off to a taper or feather edge
3. Exposed metal shall be treated
4. The relative humidity of the atmosphere in which the repair is to be effected shall be maintained (if necessary, by the use of hot air blowers and tenting) at less than 85%
5. The surface temperature of the exposed metal shall be raised to at least 3 °C above dew point and the coating shall then be applied in stages, as recommended by the manufacturer, to achieve a total thickness in accordance with Section 23.3.9(ii).

All repairs shall be checked with a holiday detector and any holidays shall be repaired, after which the repairs shall be re-checked.

(iii) Cathodic Protection

Cathodic protection (CP) shall be employed where steel pipes are used.

The Contractor shall propose an overall pipeline protection system relying on coatings as the main corrosion protection mechanism. However, cathodic protection shall be designed and installed by the Contractor to provide protection for the event that the coating system is breached.

The Contractor shall submit his design proposals for review of the Employer’s Representative prior to the commencement of pipe laying. Requirements for ensuring electrical continuity at joints and flanges shall be clearly detailed along with all operation and maintenance requirements.

Protective Cement Mortar Coating to External Surfaces (if required)

Where specified for steel pipeline to be laid underground, the external surfaces of pipes, specials and fittings shall be provided with a minimum of 40 mm thick cement mortar coating by guniting. A length of 150 mm at each end of the pipe shall be left un-coated to facilitate site welding. This portion shall be lined after laying, welding and field testing of the pipeline is completed satisfactorily.

Where the pipes/ specials are to be gunited externally or encased in concrete, the external surface of the pipe shall be given a coat of cement wash. The pipe surface shall be blast cleaned to the Employer's Representative's satisfaction. Immediately after the pipe/special is blast clean, the Contractor shall commence coating of the surface with cement wash.

(i) Mix Proportion

The proportion of cement and shall be 1: 3.5 by volume.

(ii) Reinforcement

The welded fabric used shall be BRC fabric conforming to IS 1566 or equivalent MS reinforcement. The welded fabric used shall be bent to proper shape to conform to the surface of the pipe to be coated and shall be securely held 20 mm away from the surface of the pipe by means of spacer blocks made from cement mortar (1:1) and binding wire. Spacers shall be placed at least 30cm centre to centre both ways. Adjacent sheets of fabric shall lap at least 80 mm and shall be securely fastened together by binding wire at intervals not exceeding 300 mm

(iii) Preparation for Surfaces

The interior surfaces of all pipes to be lined with Portland cement mortar shall be thoroughly cleaned by sand or steel grit blasting.

(iv) Hand Cleaning

Before blasting, all oil and grease on the surface of the metal shall be removed thoroughly by flushing and wiping using suitable solvents and clean rags. The use of dirty or oily rags will not be permitted. All other foreign materials shall be removed by buffing or by scraping and wire brushing. After cleaning, the pipe shall be protected and maintained free of all oil, grease and dirt that might fall upon the plate from whatever source until the plate has received its cement mortar coating.

(v) Mechanical Cleaning

All metal surfaces shall be thoroughly sandblasted to bright metal. Sandblasted surfaces which acquire a coat of rust shall be reblasted. Adequate air separators shall be used to remove all oil and free moisture effectively from the air supply to the blaster. Any plate showing pits or structural defects shall be kept aside during examination.

(vi) Rust Preventive Coating

Immediately upon completion of sandblasting, surfaces at the end of fittings which are to be left bare shall be given a brush coat of a suitable rust preventive material. Rust preventing coating shall be applied and shielded and maintained during the subsequent application and curing of mortar lining and application of the exterior coating to protect, from corrosion. Rust preventive material used shall be of such character that the quality of the weld and other functions of the steel plate will not be impaired by its presence.

(vii) Application of Mortar Lining by Guniting

The compressor used shall be of an adequate capacity to maintain a pressure of at least 2.8 kg/sq.cm at the gun end. The nozzle shall be held at such a distance (65 to 100 cm) and position that the stream of flowing materials shall impinge as nearly as possible at right angles to the surface being gunited. All deposits of loose sand shall be removed prior to placing any layer of gunite. Gunite shall be shot in one coat to the specified thickness. Every precaution shall be taken to prevent the formation of sand pockets and if any develop, they shall be cut out and replaced with satisfactory machine placed material. No hand patching will be allowed. The Contractor shall apply the coating in such manner that no sloughing shall occur at any time during or following its application.

Gunite shall be placed in the top and sides of the pipe, then screeded to a uniform thickness and the ground lines or blocks removed. All rebound and waste materials shall then be removed by air blowing and gunite placed in the bottom of the fittings and screeded. When completed, the lining shall be concentric with the barrel of an even thickness. The entire surface shall then receive a final flash coat of gunite and shall be steel trowelled to a true surface equal in smoothness to the spun lining in such a manner not to impair the bond between mortar and steel plate. The guniting and surface finishing shall complete in set and shall be applied continuously without the fuse of construction joints. In case, for any reason whatsoever, the cement does not adhere to the walls of pipes and sloughs off, swabbing the pipe with cement slurry shall not be permitted.

If for any reason it is necessary to interrupt the placing of the gunite for a length of time that will result in the material taking a permanent set, a square shoulder shall be formed at the ends of the sections and or elsewhere by shooting against a backing up strip or by cutting back with a trowel or other suitable tool the irregular edges of the material last place to a clean unbroken surface perpendicular to the face that will provide a suitable connection or construction joint between such material and the material to be placed subsequently. When performing this work, care shall be taken not to shatter or disturb the material remaining in place or disturb the embedded wire mesh. Before placing fresh material against the surface of such joints, the joint shall be carefully cleaned and wetted to ensure a good bond between the fresh material and that previously applied. The joint shall be thoroughly wetted by sprinkling and maintained in a moist condition.

The un-gunited portion at the ends of the pipe lengths left for the purpose of field welding or bolting shall be encased with M15 concrete after the connection is made and hydraulic testing is completed.

(viii) Curing of Lining and Coatings

Immediately upon the completion of lining of special fittings, the fittings shall be closed tightly at each end by bulkheads. After the mortar has set, but not later than twelve hours after the application of the lining, curing shall be commenced by the water spray method and continued thereafter for fourteen days. The water spray method shall consist of sprinkling the mortar lining with water by means of sprinkled heads placed within the barrel of fittings, of such capacity as to keep the entire surface of mortar lining continuously wet throughout the entire period of curing.

The application of the exterior coating shall begin not less that seventy two hours after the completion of interior lining but in any event, such water spray curing shall be continued inside without interruption during the application of exterior coatings and thereafter until the fitting is loaded for transportation to the trench, regardless of the lapse of time after loading. Each fitting shall be closed at both ends during transportation and storage and the Contractor shall continue the interior water spraying. All the fittings will be laid within 24 hours after such water spray has been discontinued.

The Contractor shall protect all cement mortar from damage during handling and transportation. After the internal mortar has been cured, internal bracings shall be placed at the ends of the fitting and elsewhere, if necessary, without damaging the mortar lining to preserve the roundness of the barrel of the pipe. All such bracings, except those that may interfere with the jointing operation, shall remain in position until the fitting has been installed and back filled.

Cast iron Drainage Pipes and Fittings

Cast iron drainage pipes and fittings shall conform to IS 1538 or IS 1729 depending on the application. Cast iron roof outlets shall be galvanised. Joints shall be caulked with tarred hemp and sealed with mastic.

Pipe Fittings

(i) Tees and Reducers

All welded tees, tees with flanged branch or all flanged tees shall be specifically selected for the locations required.

Equal tees, reduced branch and invert level tees shall be selected to simplify site installation and the number of site made joints required.

Reducers shall be concentric unless stated otherwise.

(ii) Bends

The use of bends turning through angles greater than 45 degrees shall not be permitted without the agreement of the Employer’s Representative.

Bends shall have the same, or better, internal and external protection as the relevant pipe specification.

(iii) Couplings and Flange Adaptors

Refer to Volume 2B, Mechanical Specification.

(iv) Concrete Pipe Joints

Concrete pipe joints shall be either spigot and socket or sleeve joints. Joints shall be sealed by elastomeric joint rings complying with IS 5382. Caulked joints shall not be used.

Wrapping Material

Wrapping material, where required for the external protection of buried ferrous pipelines and for site wrapping of completed joints or fittings shall be heavy duty, self-adhesive, rubber-bitumen compound with PVC carrier strip together with primer and moulding putty.

The primer shall be a fast-drying bitumen solution type compatible with the wrapping material and the pipeline materials including coatings to which it is to be applied.

The moulding putty shall be compatible with the wrapping materials and the primer and shall be capable of being moulded cold by hand.

The wrapping material shall possess the following minimum physical characteristics:

1.	Thickness (overall)	:	1.6 mm
2.	Compound thickness	:	0.85 mm
3.	PVC thickness	:	0.75 mm
4.	Tensile strength	:	12 N/mm
5.	Elongation	:	230 %

6.	Tear resistance	:	45 N
7.	Impact resistance	:	7 joules
8.	Adhesion (180° peel)	:	2 N/mm
9.	Dielectric strength (55% overlap)	:	20000 V minimum
10.	Insulation resistance	:	1000000 megohms

The materials shall be suitable for application in the environmental conditions at the site.

Wrapping for pipes shall be machine applied in controlled conditions. Tensile modulus of the PVC shall suit the method of application.

Chambers and Manholes

General

All access covers or opening covers shall be 600 mm x 900 mm and be capable of safe operation by one person and shall be fitted with locking devices and be secure against vandalism.

A permanent marker on the top of a chamber roof shall clearly indicate the direction of opening and closing of any isolation valves.

The requirements for anchors and thrust blocks in respect of excavation, backfilling and forming shear keys in the concrete blinding for horizontal thrust blocks shall also apply to valve chambers in which pipes are anchored.

If undisturbed ground has not been maintained next to a thrust bearing surface the gap shall be backfilled with mass concrete.

All chambers and manholes shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter and shall be free of any accumulation at the time of final inspection.

Manholes on Gravity Pipelines

At each alteration of gradient or direction, changes in sewer size, at each intersection with other sewers and at such other points as to comply with the Contractor's requirements, a manhole shall be constructed in accordance with the Employer's Representative's approval.

All manholes at the head of gravity sewers shall be vented.

Backfilling around manholes shall be carried out as construction proceeds. On no account shall the concrete work be built up so far ahead of backfilling as to impede proper compaction of the backfill material.

All manholes shall be watertight on completion. If any leaks appear in the manholes at the inside joints they shall be sealed.

All chambers and manholes shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter and shall be free of any accumulation at the time of final inspection.

Pre-cast Concrete Manholes

Pre-cast concrete circular manhole sections and cover slabs shall be manufactured from sulphate resisting cement.

All pre-cast cover slabs shall be heavy duty and shall be provided with 600 mm (minimum) tapered opening over which the manhole cover will be set. The slabs shall be provided with built-in lifting rings.

Manhole Covers and Fittings

The covers and frames for all manholes shall conform to IS 1726 or IS 12592.

Bricks

Where engineering brickwork is specified the bricks shall be in accordance with IS 2180.

All bricks shall be well-shaped, hard, sound, uniform in size and free from cracks and flaking.

Chemical Resistant Resin Mortar

(i) General

The mortar shall be an intimate mixture of liquid resinous material and a setting agent and may contain appropriately selected filler materials. When mixed these components shall form a mortar, with a workability suitable for the proposed method of application that subsequently hardens.

(ii) Composition

The liquid resin shall be any solvent free resinous material capable of forming a chemical resistant mortar when mixed with a suitable catalyst and, if required, a filler material. The filler material if used, shall be compatible with the liquid resin, of the chemical resistance required and of a size that will permit the preparation of a minimum joint thickness of 3.0 mm. The mixed mortar shall not adversely affect or be affected by other construction materials with which it will properly come into contact, including fixtures and fittings.

(iii) Colour

The colours of individual components of the chemical resistant resin mortar shall be sufficiently different from each other that complete, homogeneous mixing of the components will be apparent by visual inspection.

(iv) Packaging

The components of the chemical resistant resin mortar shall be pre-measured and packaged by the manufacturer in units sized to suit the method of application. All packages shall be clearly marked as to size, contents, mixing instructions, safety precautions, storage requirements and date of expiration of the contents.

(v) Shelf Life

The unmixed components of the chemical resistant resin mortar shall have a minimum shelf life after delivery to the site of 12 months when stored at a temperature between 5 ºC and 50 ºC.

(vi) Pot life

Where it is proposed to apply the mortar by trowel, the working time after initial mixing of the resin, filler material and hardener shall be a minimum of 60 minutes at a temperature of 20 ºC and 30 minutes at 50 ºC. The pot life of the mortar shall be considered exceeded when the mortar can no longer be applied to a prepared surface without curling behind the trowel. If it is proposed to apply the mortar by some other method (e.g. by gun), the working time after mixing shall be of a length suitable for the proposed method of application. Mortar applied at any time during the pot life shall have the specified properties when cured.

(vii) Bond Strength

The chemical resistant resin mortar shall form a bond with brick, tile or concrete or with a cured surface of itself, with a minimum strength subject to substrate cohesive capacity, of 3 N/mm^2. This bond strength shall be achieved regardless of whether the mortar is applied to a dry, a damp or wet surface without priming or other form of surface preparation. The bond strength shall be tested and measured using samples of the actual construction materials.

(viii) Compressive Strength

The chemical resistant resin mortar shall have a minimum compressive strength of 15 N/mm^2 when tested and measured.

(ix) Tensile Strength

The chemical resistant resin mortar shall have a minimum tensile strength of 5 N/mm^2 when tested and measured.

(x) Modulus of Elasticity

When tested and measured, the chemical resistant resin mortar shall have a maximum elastic modulus of 9 kN/mm^2.

(xi) Chemical Resistance

The cured chemical resistant resin mortar shall be capable of resisting attack by any constituents that may normally or occasionally be present in sewage or which may form within the system by a combination of physical, chemical and biological reactions. In particular, the mortar shall be capable of resisting attack from extended exposure to sulphuric acid in concentrations up to 15%, oils, greases and petrol. The chemical resistance of the mortar shall be tested and measured.

(xii) Shrinkage

The chemical resistant resin mortar shall have a shrinkage not exceeding 0.5% when tested and measured.

(xiii) Absorption

The cured chemical resistant resin mortar shall have an absorption not exceeding 3.0%.

(xiv) Thermal Compatibility

The cured chemical resistant resin mortar shall have properties of shrinkage and thermal expansion to withstand prescribed tests.

Coal Tar Epoxy Paint

Containers of epoxy paint shall be of a pack-size suitable for complete usage when thoroughly mixed by one operator within the pot life of the material at the highest likely ambient temperature. A mechanically operated mixer shall be used of a design which does not entrain air in the paint. Except where otherwise specified, epoxy resin paints shall be formulated so that the epoxy resin content together with its curing agent shall not be less than 40% by weight of the solid binder.

The coal tar epoxy paint shall have the following properties as a minimum:

1.	Pot life at 50 ºC	1 Hr
2.	Touch free time	8 Hrs at 35 ºC
3.	Initial cure	24 Hrs at 35 ºC
4.	Final cure	96 Hrs at 35 ºC
5.	Finished Film Thickness	300 microns per coat

Granular Bedding and Surround Material

Material for granular bedding and surround shall be broken stone or irregular shaped gravel with coarse sand and shall be inert to ground water, acids and sulphates. It shall have a compaction fraction value of less than 0.15 and shall be nominal single size complying to the following gradings:

1.	Pipe Diameter	Nominal Size
2.	DN 100	10 mm
3.	DN 150	10 or 14 mm
4.	DN 200 – 300	10, 14 or 20 mm
5.	DN 375 – 525	14 or 20 mm
6.	DN 600 & above	14, 20 or 40 mm

The material shall be tested and shall have a 10% fines value greater than 50 kN. Material retained on a 7 mm sieve shall have an index of flakiness less than 25% and an index of elongation less than 45%.

Whenever necessary, the test for compaction shall be carried out on the material for granular bedding.

Geotextile Fabric

Geotextile fabric shall be a pervious sheet of non-woven polyester, polyethylene, nylon, or polypropylene filaments and formed into a uniform pattern. The material shall be resistant to all naturally occurring acids and alkalis present in the soil and shall be resistant to biological degradation. The fabric shall be strong enough to withstand stresses occurring during placement and any subsequent pipe or soil movement.

The grade of the fabric shall be such that O95 (pore size) shall be smaller than D85 of the native soil as established by the Particle Size Distribution Analysis.

The geotextile fabric shall have the following minimum properties when measured in accordance with the reference standards:

Test	Minimum Property	Standard
Weight	125 g/m²	IS 14716
Thickness under 2 kN/m² load	4 mm	IS 13162
CBR test	4750 N	
Tensile Strength:		
Longitudinal direction	22 kN/m	IS 15060
Transverse direction	36 kN/m	

Test	Minimum Property	Standard
Elongation at rupture	50% - 80%	IS 13162
Grab strength	1500 N	IS 14293
Water permeability at 10 cm head	45 litres/m^2/sec	IS 14324

Workmanship

Storage

Pipes and fittings shall be stored raised at least 75 mm from the ground and shall be carefully supported, cushioned and wedged. Pipes shall not rest directly on one-another and shall not be stacked more than four pipes high, or two pipes high in the case of pipes larger than DN 500.

Valves shall be stored under cover until they are required for installation and particular care shall be taken for the protection of any associated electrical or mechanical equipment.

Couplings and joints (and all components thereof) and other similar items shall be stored in dry conditions, raised from the ground in sheds or covered areas.

Any period during which the pipes are strung out along the pipeline route or placed alongside, the Works shall be kept to a minimum. Jointing parts and materials shall in any case be stored under cover and jointing elements forming parts of the pipes shall be adequately protected to prevent accidental damage. Subject to the foregoing and to any restrictions on the duration of temporary occupation of parts of the Site, pipes may be strung out along the pipeline route prior to installation providing that any necessary temporary fencing has first been erected.

Storage areas shall be carefully set out to facilitate unloading, loading and checking of materials with different consignments stacked or stored separately with identifications marks clearly visible.

End covers and protection shall not be removed until incorporation into the works.

Transportation of Pipes and Fittings

Any vehicle on which pipes are to be transported shall have a body of such length that the pipes do not overhang. The pipes shall be transported and handled in accordance with the manufacturer’s recommendations.

Approved slings shall be used and all hooks and dogs and other metal devices shall be padded. Hooks engaged on the inner wall surface at pipe ends shall not be used.

Under no circumstances shall pipes be dropped, be allowed to strike one another, be rolled freely, or dragged along the ground.

Inspections of Pipes and Fittings

Before incorporation into the pipeline, each pipe shall be brushed out and carefully examined for soundness.

Damaged pipes which, in the opinion of the Employer’s Representative, cannot be satisfactorily repaired shall be rejected and removed from the Site.

If the Employer’s Representative considers that an unacceptable proportion of the pipes supplied by the Contractor within a test length has failed the Contractor may be required to hydraulically pressure test each pipe and joint on-site before pipe laying.

In this event, test results shall be submitted to and approved by the Employer's Representative before any further pipes are laid.

In addition to any inspection and tests made when delivery is taken, pipeline materials, including lining or protective paintwork, pipeline and manhole construction shall be inspected after installation and all damage identified shall be repaired.

Any special material required for the repair of pipe lining or necessary repairs shall be made using materials obtained from the appropriate supplier and shall be used in accordance with their recommendations.

Trench Preparation

Trench excavation and backfilling shall be co-ordinated with the construction of the pipeline as a whole to ensure expeditious completion of the whole operation and shall comply with Section 8.8 of this Specification.

For pressure and gravity pipelines the bottom of the trench shall be finished smooth and be free from irregularities, so that the pipes bear uniformly and are supported throughout their length. The holes required at each joint shall be made as small as possible.

Trench design shall comply with the standard trench details given in IS 3114 (steel pipes) and IS 5822 (concrete pipes) and other material specific pipe standards. Exceptions may be permitted where ground conditions dictate in which case the Contractor shall submit trench embedment details to the Employer's Representative for review prior to works on site.

Details of layered compaction shall be given, including proposed compaction layer thicknesses, with a view to ensuring minimal post construction surface settlement.

Tunnelling

Where tunnelling is required the tunnelling technique and construction materials shall be chosen to suit the ground conditions and the required pipe size and shall conform with the Tunnelling Specification.

Installation of Pipelines

Pipes shall be laid in accordance with IS 783, IS 3114, IS 5822 and other relevant Indian standards unless otherwise specified herein.

No metal tools or heavy objects shall be permitted to come into contact with the pipes or fittings.

Externally coated pipes shall be handled at all times with wide non-abrasive canvas, rubber, or leather belts or other equipment designed to prevent damage to the coating. The use of chains, wire slings, or any other handling equipment found to be injurious to the coating shall not be permitted. The timbers or skids used to support the coated pipe prior to installation shall be properly padded for the purpose of protecting the coating. Pipes and fittings shall be lowered into the trench with equipment suitable for the weight of pipes and fittings. Pipes and fittings shall be carefully cleaned before jointing. Any injury to the protective coating from any cause must be repaired before the pipes are tested.

Every precaution must be taken to prevent foreign material from entering the pipes or fittings. Whether installed or when in storage, the pipeline ends shall be capped at all times when not being worked on. During laying operations no debris, tools, cloth, or other material shall be placed in the pipe. The Contractor shall provide sufficient ends caps for this purpose and shall instil the practice of "If you leave it (unattended), seal it, no matter how brief the period is".

The equipment for checking and controlling the pipe alignment shall be robust and simple to use and check and installed in such a way that it is not liable to accidental disturbance and shall incorporate features to show whether any disturbance has taken place.

Pipes shall be laid accurately to the designed lines and levels within a tolerance of +/- 5 mm. Pipe alignments shall be straight between bends.

Pipelines on which work is being undertaken shall be kept thoroughly cleaned. Except when cleaning or water testing, water shall not be allowed to flow through the pipes.

Cutting of Pipes

Pipes which are required to be cut to form closing pieces in any portion of the pipeline or to terminate in manholes of other parts of the Works shall not be cut until after all adjacent pipes have been installed and jointed and shall be cut to allow a 20 mm gap between adjacent pipe ends.

Pipes shall be cut in accordance with the manufacturer's recommendations, by a method which provides a clean, square profile, without splitting or fracturing the pipe wall and which causes minimal damage to any protective coating.

Where necessary, the cut ends of pipes shall be formed to the tapers and chamfers suitable for the type of joint to be used. Any protective coatings shall be made good, the ends sealed and the external face of the pipe made smooth for a suitable distance.

Precautions against Flotation

When the pipeline laid underground or above ground in a long narrow cutting gets submerged in water collected in the trench of cutting it is subjected to an uplift pressure due to buoyancy and is likely to float if completely or partly empty. In the design of pipelines, provision is made to safeguard against flotation by providing sufficient overburden or by providing sufficient dead weight by means of blocks etc.

In the case of works extending over one or more monsoon seasons however, special care and precautions are necessary during the progress of work. The work of providing blocks, refilling the earth to the required level, compacting the same etc. shall always be done as soon as the pipeline in the cutting has been laid.

The Contractor shall ensure that water shall not be allowed to accumulate in open trenches. Where work is in an incomplete stage, precautionary work, such as blank-flanging in the open ends of the pipeline and filling the pipeline with water etc. shall be taken up as directed by the Employer's Representative.

Protection of the pipeline against flotation during the Contract period shall be the responsibility of the Contractor.

Installation of Pressure Pipelines

Pipes shall be laid to even grades for as long a length as practicable, with a minimum grade of 0.2%, irrespective of local changes of elevation of the ground surface. Changes in direction or in grade of the pipeline shall be carried out by making use of any permissible deflection of joints between straight pipes or by the introduction of bends.

Socket and spigot pipes shall normally be laid with sockets leading. Where the gradient exceeds 5%, installation shall proceed on an ascending grade with sockets leading. After laying and jointing, the invert level of each pipe shall be checked before the next pipe is installed.

Joint holes shall be excavated to provide adequate clearance to enable joints to be made satisfactorily and any specified wrapping to be completed and to provide a clearance of at least 50 mm from the trench bottom below the joints.

Installation of Gravity Pipelines

Sight rails or other suitable methods shall be used to control the accuracy of pipe laying. If used then strong sight rails shall be fixed and maintained at each change of gradient and at as many intermediate points as may be necessary, but not more than 20 m apart. Sight-rails shall be clearly painted in contrasting colours and be not less than 1 metre long and 150 mm deep, straight and level, rigidly supported by stout wooden posts at each end. Any pipes placed on end for affixing the base of the posts shall be not less than 225 mm in diameter and shall be filled and rammed solid with earth or sand. Posts shall otherwise have their bases concreted. Boning rods or travellers for use with sight rails shall be of robust construction, clearly painted and accurately made to the various lengths required, the lower ends being provided with shoes with sufficient projection to rest on the pipe inverts. A third sight-rail shall be used wherever possible for ease of checking against accidental displacement.

Where pipelines are to be bedded on concrete, pre-cast concrete bedding blocks shall be set to a level allowing for the thickness of the pipe barrel and side string lines shall be used for checking alignment.

Installation of Valves

Installation of valves shall include installation and fixing of any operating gear and associated fittings.

Valves shall be fixed in manholes before the benching is constructed and shall be coated with grease and with precautions taken against damaging and fouling during concreting operations.

Where a valve is built into the benching it shall be surrounded by a 75 mm casing of lime mortar to facilitate subsequent removal. The lime mortar shall be rendered with cement mortar 20 mm thick.

After installation valves shall be cleaned inside and out and shall be left in the closed position.

The spindles of all valves without actuators shall be arranged for ease of operation and bracketed 150mm below tops of walls and at intervals not exceeding 2,400mm

The provision for fixing sluice gates to walls shall be watertight on completion. Sluice gates shall be bedded on and pointed up with cement mortar. Sluice gates shall be maintained in the closed position during installation.

All bolts, nuts and washers on the sluice gates and the foundation bolts, nuts and washers shall be of stainless steel.

Concrete Bedding and Surround

Concrete bedding and surrounds shall not be placed until the joints at each end of the pipe have been completed. The full width and depth of bedding concrete shall be placed and carefully vibrated beneath the pipe followed at once by the addition of any haunching and surround concrete. Unformed surfaces shall be of spade finish. The pipe shall be prevented from floating or other movement during concreting.

Wherever pipes are provided with concrete protection, they shall be supported temporarily on pre-cast concrete blocks cast to the shape of the bedding and where they have a concrete surround the depth of the pre-cast concrete block shall be increased to suit. The pre-cast concrete blocks shall be positioned behind each socket. The width of the pre-cast concrete blocks shall be half the diameter of the supported pipe subject to a minimum and maximum of 115 mm and 300 mm, respectively. The blocks shall be left in and incorporated in the in-situ concrete.

To ensure flexibility of the pipeline, a divider of fibreboard or other suitable material cut to shape shall be placed at each pipe joint to make a complete break in the continuity of the concrete protection.

Where two or more pipelines are laid in the same trench the joints shall coincide at the points where the continuity of the concrete surround is broken, i.e. at the joints in the pipeline with the longest pipe. Any intermediate joints in the other pipelines with shorter pipes shall be surrounded in concrete.

Granular Bedding and Surround

Pipes for pressure and gravity pipelines shall be provided with a bed, embedment and surround in the locations and to the dimensions as recommended by the pipe manufacturer. Where required, granular pipe bedding and surround shall be wrapped in a geotextile fabric to prevent migration of fine material into the granular surround.

Granular bedding shall be well compacted to the correct levels so that pipes are given full support along the entire barrel length. Recesses shall be formed in the granular bedding to accommodate sockets, collars or other pipe joints.

Bedding, pipe surround and backfill shall be compacted to at least 95% maximum dry density except at road crossing where the compaction shall be at least 98%.

Pipes shall not be supported on timber wedges pre-cast concrete blocks, or similar materials. After pipes have been correctly laid further granular material for haunching or surround shall be placed and carefully compacted so no disturbance of the pipe occurs.

Compaction of backfill shall be suitably controlled to ensure that backfilling does not adversely affect the integrity of the pipeline.

Following pipe laying, further granular material shall be placed in the trench with special care being taken to fill under the sides of the pipe to ensure full contact with the barrel of the pipe. The granular material shall then be compacted evenly on both sides of the pipe.

Clay, or other approved impermeable material barriers shall be constructed to limit the uninterrupted length of granular bedding and backfill to a maximum of 500 m.

Joining Pipes

(i) General

Joints shall be made in accordance with manufacturers' instructions or as specified herein.

Before making any joint the interior of each pipe or fitting is to be cleaned. Immediately before starting a joint the end of each pipe to be jointed will be cleaned and shall be prepared as necessary.

Until required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold and kept flat to prevent any part of the rubber being in tension.

Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituent soluble in the liquid being conveyed in the pipe. They shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

All pipe ends shall be cleaned free from grit or other extraneous material before jointing.

Where the a change of direction is required to be achieved by the deflection of a flexible joint of any kind, the deflection shall not exceed 50% of the design value for the size and type of joint as recommended by the manufacturer.

After completing the joint, any protective or other coating shall be made good and any lining completed without delay.

(ii) Spigot and Socket Joints for Iron Pipes

Jointing iron spigot and socket pipes and specials with flexible joints will be carried out in accordance with the manufacturer’s recommendations as to the methods and equipment to be used in assembling the joints.

(iii) Couplings for Iron or Steel Pipes

In jointing iron plain-ended pipes with couplings the manufacturer’s recommendations as to the methods and equipment to be used in assembling the joint will be followed.

(iv) Flanged Joints for Iron or Steel Pipelines

For flanged joints, elastomeric components shall be checked for deterioration and damage immediately before installation and shall not be used if they are not in perfect condition. Gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made gradually and evenly, tightening the bolts in diametrically opposite positions. Only standard spanners and wrenches of a type approved by the Employer’s Representative shall be used.

(v) Welded Joints for Steel Pipelines

Welding of joints in steel pipes shall be carried out in accordance with the General Mechanical Specification.

(vi) Joints for Plastic Pipes

The joints for PVC-U, polythene and HDPE pipes shall be of the mechanical type, solvent welding or thermo-fusion techniques. The pipes shall be laid and jointed strictly in accordance with the manufacturer’s instructions and shall conform to CP 312.

External Wrapping

Where necessary, pipes, fittings and valves which are to be buried in the ground shall be protected with wrapping material.

All items not wrapped before installation shall be clean and dry and shall be given one coat of primer supplied by the manufacturer of the wrapping material. Joint and fitting profiles shall then be modified by the application of moulding putty supplied by the manufacturer of the wrapping material to provide a suitable profile for wrapping.

Wrapping shall then be carried out and shall lap with the works-applied protection on the pipes on each side of the joint. The wrapping shall be applied under tension to achieve conformability and intimate adhesion without trapped air pockets. Wrapping shall be carried out with a 55% overlap of adjacent strips.

End overlaps where a new roll joins a completed one shall be 150 mm minimum.

Pipelines in the Same Trench

Where two or more pipelines are detailed as being laid in the same trench the pipes shall be laid so that there is a minimum distance of 150 mm between the barrels of the pipes, measured in plan at mid- barrel height, unless a greater distance is required to enable jointing to be properly completed. The invert levels of the pipelines shall be the same at any cross section, unless otherwise required.

Firstly the larger of the pipelines shall be laid in a straight line. Where it is necessary to increase the distance between the pipelines from that specified above to allow the construction of air valve or washout chambers or for any other reason, the deviation of a pipe from the line of the preceding pipe shall be made by deflecting the flexible joints.

Anchor and Thrust Blocks

The Contractor shall design and construct permanent concrete anchor blocks to resist thrust according to the maximum permitted pipe pressures, the nominal pipe diameter and soil.

Anchors shall be designed to immobilise the pipe for all foreseeable loads conditions and cater, as required, for rotational forces as well as the orthogonal linear forces. The design life of the anchors shall be the same as the pipe section to which it is attached.

The faces of anchor blocks must bear against undisturbed ground.

The Contractor shall design and construct temporary anchor blocks for the ends of pipe sections being tested according to test pressure, nominal pipe diameter and soil. He shall also ensure their demolition and removal at the end of the tests, unless the Employer agrees otherwise.

Concrete thrust and anchor blocks shall be constructed at all tees, bends, tapers, valves and hydrants for the anchorage of the pipeline.

Thrust blocks shall be constructed with the bottom and thrust side surfaces bearing against undisturbed ground.

Shear keys shall be formed on the upper surface of concrete blinding for horizontal thrust blocks.

Pipelines Built into Structures

Any pipeline which is built into a chamber, manhole or other structure, including a thrust block, shall be provided with two flexible joints outside the face of the structure. Unless otherwise required and approved, the first joint shall be not more than one pipe diameter or 500 mm, whichever is the greater, from the outside face and the length of the short pipe between the flexible joints shall be equal to two pipe diameters or 1000 mm, whichever is the greater.

Pipes terminating in manholes and the like shall, except where otherwise specified, be cut so that the end of the pipe is flush with the face of the structure into which it is built.

The flexible joints shall be flexible spigot and socket joints or other appropriate flexible couplings.

The short lengths of pipe built into the wall shall be of the same material as the remainder of the pipelines material and shall be surrounded in concrete.

Pressure pipes passing through the walls of valve chambers or other structures shall be ductile iron, with anchorage flanges designed to transmit full end thrust with closed valve under test into the structure's wall. Boxouts, if used, shall be designed to fulfil the above requirements.

Where no anchorage flanges are required for pipes passing through the walls of structures the pipe shall be provided with a puddle flange integral with the pipe wall or bolted on to resist movement of water along the pipe to concrete interface. Such puddle flanges shall protrude at least 50 mm from the pipe barrel.

Where the pipeline is above ground level the short length of pipe providing flexibility shall be self- supporting.

Plugging of Dead Ends

The dead ends of pipes and fittings shall be plugged.

Cables Sharing Pipeline Trenches

Where cables are to be laid in pipeline trenches, the pipes shall be installed and fine backfill shall be placed to 150 mm above the crown of the pipe. The cable shall then be laid before the remainder of the trench is backfilled.

Construction of Manholes

General

Cast in-situ manholes shall be either circular or rectangular, with internal and external protective coatings. The manhole base shall be cast on a blinding layer of concrete not less than 100 mm thick. Sockets for connecting pipes shall be cast into the base of the manhole while casting the structure. The socket shall be positioned to provide a flexible joint at the outer face of the manhole. A further flexible joint shall be provided between one and two pipe diameters from the manhole.

If pipe laying from the manhole is not to proceed immediately, a temporary closure shall be provided to prevent material from entering the pipe and manhole. The closure shall be removed only when pipe laying is about to restart.

Benching

Benching shall be formed with plain concrete class M 35. The surface of benching and flow channel shall be protected with chemically resistant resin mortar, minimum thickness of mortar shall be 12 mm.

Manhole covers

The covers shall be carefully set to the slope of the ground or road surface. In open areas, manhole covers shall be set 150 mm above the surrounding general ground level.

After setting in position the lifting and prising holes provided in the cover shall be cleaned out and refilled with tarred hemp.

Brickwork

All brickwork shall be uniformly bedded, bricks always being laid frog upwards and each brick floated, rubbed in or hammered down upon such a sufficient quantity of mortar that the mortar may be squeezed up into the joints and each joint not already full shall be flushed up with the mortar of the next succeeding bed. The whole of the beds and joints shall be completely filled and compressed to ensure the greatest possible density.

Horizontal weathered jointing shall be provided to all external faces. Bricks with a very high suction may be wetted, but not saturated, immediately before laying. Engineering brickwork shall not be laid in wet weather.

All engineering brickwork shall be carried out using cement mortar.

Cement Mortar

The ingredients shall be thoroughly mixed while dry by machine or hand until the cement colour can no longer be distinguished from the fine aggregate in any part of the mass and then shall be uniformly wetted by means of a rose while undergoing further thorough mixing.

The mortar shall be prepared and used at such places and times and in such quantities that a longer time than thirty minutes shall not elapse between the first wetting and its completed use upon the Works. If mixed by hand, no single mixing shall exceed a quarter of a cubic metre.

The fine aggregate for cement mortar shall comply with IS 383, the grading being in accordance with IS 2386.

Washouts

Washouts shall provide drain pipework from a level invert tee on the main pipeline that is able to provide drain down facilities at all low points along the pipeline.

The washout shall be fitted with a metal faced, isolation gate valve with a sleeved valve spindle extension to the surface located in a standard valve surface box mounted in the centre of a slightly raised concrete plinth with plan dimensions of at least 750 mm square.

Drainage pipework shall rise from the isolation valve to a Bauer coupling at the surface, which can be attached to a potable pump suction main for drain down of the rising main.

Washouts shall provide a 600 mm x 900 mm lockable cover for the chamber.

The drainage pipework and Bauer coupling shall be appropriately sized for each specific rising main.

Drainage Work with NP2 Class Reinforced Concrete Pipes

Reinforced Concrete Spun Pipes

The pipes shall be Reinforced Concrete Spun pipes NP2 class, conforming to IS 458-2003 and shall be inspected by the Employer’s Representative for soundness before incorporation in the work.

Laying of RCC Spun Pipes

The laying of RCC spun pipes shall be executed in accordance with IS 783.

After the cement concrete cradle, if required, has been laid properly and approved by the Employer’s Representative, the pipes shall be lowered gradually into the trenches over the concrete cradle or bed. Laying of pipes shall proceed upgrade of the slope.

The pipe shall rest on the bed at every point through its length. It shall be ensured that the load of the pipes and the superimposed load of the earth filling is evenly distributed on the cradle or bed.

The Contractor shall take precautions to ensure that no dirt, earth or other foreign matter is allowed on the surface of the cradle or bed of the pipe resting there-on, all to the full satisfaction of the Employer's Representative. After the alignment and grading of the pipes are checked by the Employer's Representative, the grouting shall be carried with the specified mix of cement mortar.

The cradle of concrete shall be allowed to set at least for three days before any pipe is placed on it and the Contractor shall take due care in setting the pipe in the cradle so that no damage is caused to the cradle. If any damage to the cradle occurs, it shall be rectified to the satisfaction of Employer's Representative and in any particular case where damage to the cradle is beyond repair, in the opinion of the Employer's Representative, the Contractor shall cut out the damaged section of the cradle.

No pipe shall be laid or placed until the alignment of the pipe drain and its levels and gradient have been carefully checked and found correct/approved by the Employer's Representative.

The interior of the pipe drains shall be cleaned of all dirt, cement mortar and superfluous materials and joints shall be cured for at least 7 days.

Joints

The joints between concrete pipes shall be spigot and socket with elastomeric joint rings. Caulked joints shall not be used.

Construction Tolerances

The final location of the completed pipeline shall not deviate from the position detailed in the Contract by more than:

1.	Line	± 10 mm
2.	Level	± 5 mm
3.	Max. lipping between edges of adjacent pipes	± 2.5% of nominal internal diameter

No reverse gradient will be accepted on gravity pipelines.

Finished concrete surfaces shall not deviate from the positions detailed in the Contract by more than:

1. Screeded finish or rough formwork	± 10 mm
2. Any other finish	± 5 mm

Hydrostatic Testing of Pipelines

General

All pipelines shall be hydrostatically tested.

Test lengths greater than 1,000 m shall only be permitted in exceptional circumstances and shall require the test duration to be commensurately longer.

Variations to the test length, duration or acceptance criteria shall be at the Employer's Representative's sole discretion.

All tests shall be witnessed by the Employer's Representative as notified to the Contractor by the Employer at the relevant time.

If any pipeline fails to pass a test, the Contractor shall investigate the reason, carry out remedial work as necessary to the approval of the Employer's Representative, and re-test the pipeline. This process shall be repeated until the requirements of the specification are met.

If the result of a test is "invalid test" the Contractor shall remedy the test procedure to be compliant and re-test the pipeline.

Testing Pressure Pipelines

Pressure testing shall be carried out on all sections of pipeline as they are completed The fittings used at line valve and at break point for commissioning shall be such as to allow the temporary fitting of a blanking spade for pressure test purposes. Pressure testing against closed valves shall not be permitted. All air valves shall be removed after charging the main and a blank flange fitted. Testing shall not be carried out against the air valve isolation valve which shall be re-opened after fitting the blankflange.

The test pressure shall be 1.5 times the working pressure of the pipeline section or the rated pressure + 5 bar whichever is the lower. All pressure tests shall be recorded using an electronic data logger monitoring pressure and test water flow into the pipeline using calibrated equipment. Pressure shall be recorded to the nearest 0.01 bar and flow to +/- 2% or better.

Before filling for pressure testing, pipes and valves shall be re-checked for cleanliness and that all valves are operational. The open ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges. All thrust blocks and valve chambers shall have been completed with backfill placed around them and the concrete shall have attained its specified 28-day strength. All pipe straps and other devices intended to prevent the movement of pipes shall have been securely fastened and backfilling of the trench between pipe joints shall have been placed.

The test pressure shall be applied to the entire pipeline or section being tested in accordance with the following procedure:

a. Fill each pipeline or section with water and displace all air from the pipeline;

b. Raise the pressure in the pipeline by pumping water until the test pressure is attained in the lowest part of the section under test;

c. Maintain the pressure at this level by further pumping until it is steady for a period of not less than 24 hours;

d. Monitor the pipeline over a further period of 24 hours without additional pressurisation;

e. At the end of this period measure and record the reduced pressure in the pipeline. Restore the pressure in the pipeline to the original test pressure by pumping.

f. Draw off water or air to reduce the pressure in the pipeline to the pressure noted under (e) above. Measure the quantity of water so drawn off.

g. Compare the loss to the permissible loss calculated as:

PL = 0.02 * D * L * P * t

Where:

PL = Permissible loss in litres

D = Diameter of pipe in mm

L = Length of section of pipe under test in km

P = Test pressure in bar

t = Length of time for which pressure has been applied in days (should be 1)

h. If the actual loss is less than the calculated loss then the pipeline has passed the 24 hour test and the test can proceed to the next stage. If not then the Contractor shall locate the fault(s), repair the pipeline and retest.

i. After satisfactory completion of the 24 hour test, the pipeline shall be brought back up to test pressure and the pressure shall be maintained 1 hour by pumping if necessary;

j. At the end of 1 hour the pump shall be disconnected and no water shall be added to the pipeline for a period of 2 hours;

k. At the end of the 2 hour period the test pressure shall be restored by pumping and the volume of makeup water necessary to achieve this shall be measured;

l. If the actual amount of makeup water is less than the permissible loss calculated in accordance with the formula given at (g) above then the pipeline has passed the test. If not then the Contractor shall locate the fault(s), repair the pipeline and retest.

Testing Gravity Pipelines

Testing shall be carried out on all sections of pipeline as they are completed.

Gravity pipelines shall be proved by passing through them a train consisting of a leading element and a circular plastic foam plug followed by a wooden ball. The diameter of the wooden ball shall not be smaller than 25 mm less than the diameter of the pipes under inspection. Any obstruction found during these operations shall be removed.

Each length of gravity pipeline shall be carefully air tested after the trench is backfilled. The pipeline shall be tested in convenient lengths and all necessary tester junctions, expanding rubber plugs, testing equipment etc. shall be provided. Any defects, which may become apparent shall be repaired and re-tested.

The Contractor shall make the pipe drains water tight against the entrance of land/sub-soil water from outside and also against the leakages of water from the inside of the pipe drains at the test heads specified above to the full satisfaction of the Employer's Representative.

Water pressure testing as an alternative to air testing will be allowed in which case the pipeline shall be tested in accordance with the procedure for pressure testing.

24 BURIED UTILITIES

Marker Tape for Buried Services

Marker tape shall be placed above all buried services. Marker tape shall be placed at a suitable depth below existing road surfaces so that future resurfacing works do not adversely affect the marker tape. In open ground the marker tape shall be installed within the trench at a depth of 300 mm.

The marker tape laid above buried services shall be colour coded as detailed in the table below and shall be 500 mm wide and 0.1 mm nominal thickness coloured polythene, boldly printed throughout its entire length with the word 'CAUTION' and words to identify the particular service.

Type of Service	Tape Colour	Service Identification Wording
Pipe carrying potable water	Blue	Water Main Below
Pipe carrying wastewater, effluent or sludge of any type	Green	Waste Pipe Below
Fuel oil or gas pipe	Orange	Fuel Main Below
Electricity or earthing cable	Yellow	Electric Cable Below
Instrumentation, telephone or telemetry cable	Red	Control Cable Below

Route Marker Posts

In order to leave permanent indication of the routes and depths of pressure pipelines and cables where they are below ground, marker posts with aluminium indicator plates shall be provided.

The marker posts shall be set up as soon as practicable after trench excavations have been refilled.

Marker posts shall be provided at changes in direction of the main or cable and at field boundaries and elsewhere as may be necessary, indicating the diameter and depth of the main or cable below giving the ground level.

Cable Duct Systems

Cable ducts external to buildings and structures shall be provided wherever cables pass under roads and as otherwise called for in the Contract.

The internal diameter of each cable duct shall not less than both 100 mm and 1.6 times the overall diameter of the largest cable to be installed in it.

Draw pits shall be provided in appropriate locations to facilitate the installation and removal of cables. The plan dimensions of each draw pit shall be not less than:

1. 600 x 600 mm if personnel entry will not be necessary
2. 900 x 900 mm if personnel entry will be required or if the depth of the draw pit exceeds 1,000 mm

Larger plan dimensions shall be adopted, as appropriate, where large diameter cables are to be installed in the cable ducts.

Every cable duct shall be of a proprietary type with spigot and socket connections between successive ducts.

The minimum depth of cover for ducts shall be 500 mm. Ducts passing under roads or hardstanding shall be haunched in at least 100 mm of concrete.

Both ends of every cable duct shall be sealed after installation and a draw-rope shall be provided in the duct.

25 CORRIDOR DEVELOPMENT

Special Conditions of Contract

Similar experience - Experience in work of similar nature including RCC Building works, drainage works, Cement Concrete road and allied civil works. For electrical works, experience in Supply, installation and commissioning of LED streetlights/area lighting complete with cabling network, and allied works including maintenance and management in metro cities.

1) Removal of improper work - materials or plant - issue instructions from time to time for:

   a) Removal from the Site within such time or times as may be specified in the instruction of any materials or plant which in the opinion of the Engineer are not in accordance with the Contract.

   b) Substitution of proper and suitable materials or plant.

   c) Removal and proper re-execution notwithstanding any previous test thereof or interim payment therefore of any work which in respect of:

      i) Materials, plant or workmanship or

      ii) designed by the Contractor or for which he is responsible, is not, in the opinion of the Engineer in accordance with the Contract.

2) The Contractor shall remove the material arising from demolition / excavation. In such cases, a rebate as given below shall be deducted from the Contractor's payments:

   - Mild Steel- Rs. 14/Kg;
   - Galvanised steel- Rs. 14/kg;
   - Cast iron- Rs. 20/kg;
   - Stainless steel / cast steel- Rs. 20/kg; and
   - Copper- Rs. 355/kg.

All the cost of removing such material including loading, unloading, transportation, taxes, tolls etc. shall be borne by the Contractor. No extra payment whatsoever will be entertained during execution of Contract.

3) Manpower, wages, safety, tools / consumables etc. during Operation and Maintenance:

Operation and Maintenance will start from the date of the Taking Over certificate.

MANPOWER

- The Contractor shall ensure compliance with all provisions of the Labour Act / State / Central Govt. agreed procedures. The Contractor shall be solely responsible for compliance to provisions of various labour and industrial laws and all statutory obligations such as minimum wages as per Central Govt. rules, allowances, compensations, EPF, bonus, gratuity, ESIC, etc. relating to workers provided to MCGM. MCGM shall have no liability in this regard.
- The Contractor shall ensure police verification is obtained for all the manpower deployed by them and that the manpower deputed shall bear good moral character.

- All personnel provided by the Contractor shall be on the payroll of the Contractor / Company and there shall not be any Employee / Employer relationship between the personnel engaged by the Contractor and MCGM.
- The Contractor shall not sub-contract or permit any other person to perform any of the work or services agreed to without prior permission from MCGM.
- The Contractor shall ensure sufficient number of skilled manpower are provided.
- The Contractor shall ensure continuity of service whilst accommodating time off of his personnel and a substitute shall be provided should a person be absent. The Contractor shall arrange to replace his operatives to give time off to his workmen in accordance with labour rules.
- Contractor’s personnel or their family members shall not be allowed to stay / reside at site.

WAGES, SAFETY, SECURITY, ETC.

- MCGM shall not be liable for any compensation in case of any fatal injury / death caused to any other contractor’s employees while performing / discharging their duties / visiting site premises for inspection or otherwise. The Contractor alone shall be fully responsible for safety and security and insurance or life insurance of their personnel who are working on the operation and maintenance works.
- In no case, shall safety norms be violated. Even in case of urgency, when temporary rectification is undertaken, etc., no compromise is allowed with regard to safety provision.
- The Contractor shall ensure that his personnel comply with security regulations in effect from time to time at the Site premises and externally for materials belonging to MCGM at all times. The Contractor alone shall be fully responsible for safety and security and insurance or life insurance of their personnel working at the Site.
- The Contractor shall issue valid company identity cards to all their personnel providing services under this Contract.
- The Contractor shall provide and ensure that sufficient personal protection equipment such as safety shoes, hand gloves, ladders, etc. are being used by their workers while carrying out works.
- The timings of staff except personnel for electrical / mechanical maintenance shall be from 08.00 a.m. to 06.00 p.m. (one-hour recess) on all days of the week. MCGM shall reserve the right to deduct the pro-rata charges for the absence of any Contractor staff member.
- There shall be no increase in rates payable to the Contractor during the Contract period, should this be increased.
- In case of any lapse on the Contractor's part in properly maintaining the garden, MCGM shall have the right to deduct pro-rata charges for the period.
- The Contractor shall have full control over the employees engaged by him and he will be responsible for maintenance and upkeep of the work assigned under this Contract.
- The Contractor shall be responsible for any loss due to theft / pilferage / damage of MCGM property should these be due to negligence, carelessness, or any fault on the part of the Contractor or any of his employees. The Contractor shall be liable to pay to MCGM such amount of the loss as may be assessed.

- The Contractor shall be responsible for all the claims of his employees and the employees shall not make any claim whatsoever against MCGM. The Contractor's workmen shall not have any right whatsoever for absorption in MCGM.
- The Contractor shall be responsible for payment of wages and dues to his employees and shall be liable for any liability arising out of violation of any law, local, or central.
- The Contractor shall fully comply with all applicable laws, rules, and regulations relating to the Provident Funds Act including the payment of fund contribution / payment of Bonus Act, Workmen Compensation Act, and / or such of the Acts or laws or regulations passed by any Central / State Governments, Employees State Insurance Corporation including TDS as per the IT Act.
- The Contractor shall bind himself / executors or administrators and shall indemnify MCGM against all claims, damages, proceedings, costs, or any expenses whatsoever which may be imposed, enforced or brought against MCGM or any of its directors or employees for reasons or consequent upon any breach or default on the part of the Contractor in respect of violation of any provisions of Law / Act / Rule / Regulations having the force of Law.
- The Contractor shall obtain adequate insurance policy in respect of the workmen engaged by him for the work towards meeting the liability of compensation arising out of death, injury, disablement etc. The Contractor shall also be responsible for complying with statutory requirements including fire safety regulations.
- The Contractor shall be responsible for cleaning of debris and other related materials including leaves, branches, etc. from time to time for the entire area of the Works.
- The Contractor shall provide weekly off / holidays to his workmen as per labour laws but it shall be his responsibility to ensure uninterrupted services to MCGM on all days.

4) Failure in Performance

There shall be routine review regarding the performance of the Contractor by MCGM / MCGM's representative. In case at any stage, it is observed that the performance of the Contractor is unsatisfactory or discrepancies are found in the Works carried out by Contractor, MCGM reserves the right to cancel the Contract and blacklist the Contractor after giving due opportunity and forfeit the performance guarantee.

5) Penalty during the Operations and Maintenance period:

Sr. No.	Reasons	Amount of Penalty
1	Work not as per specification / defective work	20% of cost of respective bill of material work. The defective work shall be redone / rectified
2	Lapse in execution of work	Minimum Rs.5000.00 per day
3	Not following / disobedience of orders of site in-charge, consultant, visiting officers of the Engineer.	Rs.5000.00 per day
4	Absenteeism of staff	Rs.5000.00 per day

Scope of Work

General

- The Tenderer shall undertake a visit to assess the Site condition, study the General Arrangement Drawing (GAD) and carry out his own assessment on the overall proposal.
- The Tenderer shall follow the design philosophy described in subsequent sections and adhere to the theme and areas defined for development.
- The selected Tenderer shall prepare a plan for the given area of development, specifications, and other parameters in relation to the cost he has bid and present the same to the Engineer / Engineer's Representative for approval.
- The corridor plan shall be detailed in a suitable drawing format, to a sufficient level for undertaking construction at the Site. These drawings shall be submitted as Good for Construction (GFC) to the Engineer / Engineer's Representative.
- The GFC drawings shall take into consideration the following aspects:-
  - The requirements of the Specification;
  - Road alignment within the development area as per the GAD and Specification;
  - Erection of street light poles;
  - Construction of drains as per the GAD and Specification; and

Design Philosophy

A 6m wide corridor shall be provided on the eitherside of the Mithi river as part of this Contract. The plan extent and cross sectional details are provided in the GADs of the tender document. The detail cross sectional elements are defined in Vol 2-Employer's Requirements. Where required, turning heads shall also be provided at appropriate intervals. Where practical, finished ground levels shall be built up to 1.1m below the top of the river training wall to provide both the opportunity for views from the driveway.

Storm Water Drainage System

Drainage arrangement shall be established to direct the runoff from the paved surface along the kerb edge into chambers at intermediate intervals. These chambers shall direct the captured runoff into the Mithi River.. Refer to Contract Drawings in Volume 2D.

Electrical

The development envisaged along the Mithi river also demands provision of lighting arrangement for the security of the maintenance personnel as well as to prevent any unlawful activities during the night. Keeping this in mind, it is proposed to provide security lighting arrangement in the of form street light , using street light pole within built cable termination arrangement , energy efficient LED street lighting luminaries, power distribution through armoured cable laid directly buried in ground. Further it is proposed to distribute and control the switching ON/OFF of the lighting as per the sun rise and setting timing through a dedicated control panel.

In order to utilise the naturally available sun light, it is also proposed to install one third of total street lighting as solar power operated.

LED light poles of 6m height at 15-20m intervals are proposed all along the corridor..Further the solar luminaries proposed would be of integral type i.e. with inbuilt solar panel and Nickel cadmium batteries of suitable rating.

Safety

Maintenance work shall be undertaken in compliance with all applicable laws, by-laws, regulations and lawful orders of any public authority having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss. All safeguards for safety and protection, as required by the Worker's Safety Insurance shall be established and maintained while maintenance work is in progress. Barricades, safety guards, and warning devices shall be erected and maintained whenever necessary for the protection of persons and property. The posting of warning signs and proper advance notification to people in the area shall be undertaken before any spraying is to be carried out to comply with provincial legislation and Regulation 914 of the Ontario Pesticides Act. The applicator shall obtain suitable weather-proof signs in accordance with the Regulation, and completely fill in all required spaces. The applicator shall ensure that signs are posted 24 hours before application and shall remove the signs on the third day after application.

Reporting Damage

While it is recognised that the Maintenance Contractor is not responsible for reviewing the Site for general hazards, should any dangerous or potentially dangerous situations be observed, notification shall be given at once, verbally, and where necessary in writing, to the Employer and the appropriate public agencies or authorities responsible for the safety and repair of such property as public utilities or for the protection of the environment. Notification of damage to property site features of the environment shall be included in the site report and logbook.

Water

Water used for maintenance shall be free from organic or inorganic chemical contaminants which are detrimental to healthy plant growth and the environment. The contract for each Site should include accurate information regarding the availability of water for maintenance purposes. This information shall include:

1) Watering pattern and schedule;
2) Any restrictions on water use.

Non-Horticultural Elements

- Non-horticultural elements (hard landscaping elements) within the Site such as paving, lighting, kerbing, and other structures, fences, shall be maintained to guidelines which are consistent with the selected maintenance level
- Health and safety shall be considered in developing maintenance procedures, particularly in regard to potable water, play areas and equipment
- Deterioration or unsafe conditions in any element of the site shall be reported immediately to the proper authority
- Guidelines developed by appropriate trade professional organisations shall be used in developing maintenance procedures for elements not covered in this guideline

Equipment

- Equipment shall be suitable to the work at hand, and be maintained in a clean and safe working condition. Safety devices and guards shall be in place and functioning to the Worker's Safety Insurance.
- Equipment shall be kept clean to reflect a level of professionalism and prevent the spread of plant diseases
- Equipment shall be such that the risk of spillage, inadvertent spraying or misdirection of oil, gasoline, pesticides or any other chemicals is minimised

- Cutting and pruning equipment shall be kept clean, sharp and well adjusted
- All personal protective equipment shall meet the appropriate guideline and regulations

Programme of Work

The successful Contractor shall submit the schedule / work plan showing all the activities required as per the Scope of Work to the Engineer / Engineer's Representative. The Contractor shall adhere to the approved programme of work. If at any stage the previously approved programme is required to be modified, the Contractor shall do so, immediately as directed by the Engineer / Engineer's Representative. In case it is necessary to modify / alter the work programme, as directed, the Contractor shall do so without claiming any extra payment. The programme shall be reviewed periodically and rescheduled as directed.

MCGM shall ensure that the Contractor has reasonable access to all locations to enable the Contractor to execute his responsibilities within the terms of the Contract. If the Contractor finds that he encounters unexpected delays in executing his programme due to lack of access to relevant locations and / or sites, he shall bring this to the notice of the Engineer / Engineer's Representative through established reporting procedures immediately. MCGM shall in no way be liable to any delay due to the same.

Permissions

The Contractor shall obtain the relevant permissions of the concerned authorities / other agencies required for carrying out the work on their own. Only recommendatory letters will be issued by MCGM.

Contractor's Obligations

The clauses in this section are meant to provide general guidelines and compliance requirements to the Contractor. These do not however relieve the Contractor from taking sufficient steps and precautions as deemed necessary to complete the Works successfully within the specified Contract period and quoted cost of work. No monetary or other claims made by the Contractor on the grounds of want of knowledge will be entertained by the Employer. The Contractor is advised that it is his sole responsibility to ascertain for himself the extent of work required to be carried out on the Site and to obtain his own information on all matters affecting directly or indirectly the execution of the whole Works involved in the Contract to the complete satisfaction of the Engineer. No claim of extras in consequence of any alleged ignorance in any aspect will be entertained by the Engineer. It shall be clearly and definitely understood that the Contractor shall be held solely responsible for making all necessary arrangements and coordinating with the relevant authorities, competent agencies and specialist contractors etc., to ensure satisfactory completion of the Contract.

Personnel Capabilities

The successful Contractor shall provide the following staff for the operations and maintenance of the complete works.

Site Office

The Contractor will be allotted space at the Site for the Operation and Maintenance and Defect Liability period.

Environmental Conditions in Mumbai

The ambient conditions under which all equipment supplied as part of this Contract shall be required to function at the rated level upon which type tests will be based, unless otherwise stated are:

a) Outdoor ambient temperature up to 70 degrees Centigrade.

b) Relative humidity 95%.

There will be high moisture levels in the air where the equipment is to be installed and the atmosphere will be salt-laden and corrosive. Therefore the equipment supplied shall be manufactured to meet the following parameters:

1) Salt corrosion:- saline atmosphere as found in tropical coastal regions;

2) Chemical corrosion I - atmospheric vapours of sulphur combustion products;

3) Chemical corrosion II - atmospheric vapours of hydrogen sulphide;

4) Sealing - equipment shall be vermin proof. Outdoor items shall be weather and splash proof to a minimum of IP55 or better, to prevent ingress of rain. Items that are not fully sealed shall have adequate provision for ventilation;

5) Solar radiation - equipment located outdoors in direct sunlight shall be capable of withstanding the effects of solar radiation, which will significantly increase temperatures within enclosures above the ambient level,

6) Mould growth - materials shall not be used which promote mould growth;

7) Shock - equipment assemblies shall be capable of withstanding knocks and jolts likely to occur during repair work or rough handling on a workbench.

8) Vibration - equipment shall be capable of withstanding the effects of vibration from passing vehicles.

The Contractor shall take account of the environmental conditions applicable in Mumbai and shall ensure that all individual items of the plant supplied shall be suitable for operation and projected equipment life under the prevailing Mumbai conditions producing evidence of this to the Engineer.

Safe Working Conditions and Contractor's Compliance

The Contractor shall ensure that all necessary safety requirements are fully complied with including provisions in the Corporation's General Safety Precautions and the clauses in the Specification including requirements and precautions to be taken when working at height.

Caution and Information Boards

Before commencing excavation, caution boards and information boards shall be installed at Site. These boards shall remain as long as the trench remains open. The information board shall be installed on the Site or at the place where the excavation commences. The caution boards shall be installed as per MCGM trenching policy.

Safety Equipment

All necessary personal safety equipment as considered adequate by the Engineer shall be available for use of persons employed on the Site and maintained in a condition suitable for immediate use. The Contractor shall take adequate steps to ensure proper use of equipment by those concerned. Adequate provision shall be made for prompt first aid treatment of any injuries sustained during the course of the work.

Earthing

The Contractor shall provide earthing for his construction equipment wherever required as per standards.

Protective Requirements

All installations shall allow the operation of internal protective devices upon the occurrence of a fault. All non-current carrying metallic parts shall be connected to the appropriate earth terminal in such a manner as to ensure that hazardous voltage cannot exist on exposed conductive metalwork.

Liaison

The Contractor shall interact with different departments and agencies involved with regard to the co-ordination of civil engineering, and all other works associated with the Contract for successful execution of the Contract. It shall be the Contractor's sole responsibility to coordinate with different agencies and get the work done successfully. MCGM will provide the necessary help in respect of required letters to these agencies.

Compliance with Standards and Test Certificates

The Contractor shall provide evidence that the equipment offered has type approval in the original country of design and manufacture, that it fully complies with the standards and specifications quoted in sections of this Specification and is appropriate for international use and in India.

26 TRENCHLESS TECHNOLOGY

Being a special work, additional special directions regarding Technical specifications for laying sewer line by Trenchless technology. (i.e. Microtunneling boring and pipe jacking, manual boring and pipe jacking and HDD etc.) are as below,

Part I General

1.1 Specification

These specifications are intended for general description of quality and workmanship of materials and finished work. They are not intended to cover minute details. The work shall be executed in accordance with best modern practices and using special techniques of trenchless technology.

The Contractor shall read this Specification in conjunction with the standard specification of the Municipal Corporation of Greater Mumbai for sewerage and water pipe line works.

1.2 Contractor's obligations

The clauses in this section are meant to provide general guidelines and compliance requirements to the Contractor. It does not however relieve the Contractor from taking every other steps and precautions as deemed necessary to complete the installation of the pipelines successfully within the specified contract period and the bided amount.

Microtunneling and pipe jacking and any other methods under trenchless technology domain are the Trenchless Techniques adopted for minimizing excavations and avoiding conventional trenching. Unless otherwise provided or permitted Microtunneling and Pipe jacking should be considered to be the method required to be adopted for laying the pipelines under the contract. Any other trenchless method may be permitted in case of packages where such methods are found essential as per the conditions prevailing at the time of execution with prior approval by the Engineer without any extra cost to the Employer. However, the Contractor shall be solely responsible for adequacy and safety of any of the techniques to be used.

The Engineer reserves right to change the alignment to suit the site conditions, amend the scope of work, to delete any package, to replace any package or curtail scope of work without thus incurring any liability on the Engineer or the Employer.

Furthermore, the consideration that microtunneling method permitted as a suitable method of installing the sewer pipelines in the Specification shall not relieve the Contractor in any way from his prima facie obligation and responsibility under the contract to successfully install the pipelines without causing interruptions to train / vehicular / pedestrian traffic and within the specified contract period and contract amount.

The Contractor's rates in the Bill of Quantities shall be deemed to be for installing the pipelines successfully within the specified contract period regardless of the method considered in the specification as a suitable trenchless method.

If, in the opinion of the Contractor, other methods are considered suitable to achieve the desired objectives of installing the pipelines or sites with working space constraints within the specified contract period and quoted amount and without causing interruptions to train and road traffic at the sites across bridges and narrow roads, he shall make a detailed proposal of the method to the Engineer for his consideration and acceptance. Unless the method so proposed is considered superior to the specified method and essential considering the site conditions, no consideration will be given by the Engineer to accept the Contractor's proposal. It may however be noted that the bid shall be evaluated as per the response to the Engineer's BOQ's only.

1.3 Background information of the project

Mumbai is the capital of the State of Maharashtra in the Republic of India. It is located on the West Coast of India at latitude 19°N and longitude 72° 50'E. It is an island connected with main land by road, rail and air. The city and suburbs are administered by the Municipal Corporation of Greater Mumbai (MCGM).

The annual rainfall in Mumbai is of the order of 2500 mm, most of which is precipitated within 4 months of monsoon from June to September, leaving a dry working period of 8 months from October to May. Mean daily temperature varies from about 22° C to 36°C, the hotter months generally being March, April, May and June. The relative humidity is generally between 48% and 87% highest being in the monsoon period from June to September. Some of the suburban areas are reclaimed land and the water table is generally high.

MCGM is responsible for providing public sewerage and water supply facilities for the city and suburbs, covering an area of about 437.71Sq km.

As per the feasibility study carried out by consultant to control the pollution of Mithi River, the work of laying of Sewer Line along the banks of Mithi River has been proposed by HDD / Open Excavation Method as per the site conditions and underground strata.

It shall be obligatory for the Contractors to carry out geotechnical investigations as considered necessary by them and satisfy themselves of the adequacy of their testing. They shall ensure that the methods and equipment they proposed are in accordance with the geotechnical and other requirements pertaining to the sites. The Employer / Engineer shall not be responsible for any changes in method or equipment necessitated during execution of the work and it shall be contractors' sole responsibility to ensure deployment of proper method and equipment for the work.

The e-tenderers shall, on his own accord collect information about likely geotechnical conditions at the sites. Any risks assumed by the applicant by solely depending on his current knowledge of the sites of the information currently available on the ground condition any physical obstructions and geological and geotechnical data on soils/rock of the area shall be entirely his own and shall be wholly and fully responsible for any consequential expenses arising as a result of the risk he assumed. He shall not resort to any compensation claim under the contract for differing ground condition that he may encounter as a result of assuming the risk.

The extent and scope of the applicant's geological and geotechnical investigation along the final pipeline route would depend on the type and model of the systems that he proposes to use in the project. The applicant shall therefore carry out the necessary geological and geotechnical investigation of the sites and testing of the soils/rock (to determine compressive and tensile strength, abrasivity, mineral composition of the rock etc.) to be encountered along the pipeline route in the sites, as deemed necessary.

The applicant shall ensure that the Trenchless Technology system including where Microtunneling is stipulated as mandatory shall successfully excavate in the wide ranging ground conditions, from water charged clayey strata with boulder's to rocky strata, likely to be encountered at the sites.

1.4 Operational Facility

The Contractor is advised that there may be other Contractors (i.e. from PWD Railways or other authorities including MCGM) working within the site area. The Contractor may therefore be given joint possession, in some sections of the sites, with the other Contractors for the purpose of carrying out his contractual obligation and he shall in no way interfere with, impede or otherwise prevent these other Contractors, from carrying out their contractual obligations. The Contractor shall allow in his prices, when biding, for affording reasonable facilities to the other Contractors and for any interference with his work from these other contract operations.

1.5 Directions for the Manual Pipe Jacking Work

The Contractors shall make necessary arrangements for getting permission from Traffic Police Dept. Only recommendation letter will be issued by MCGM. The Contractor shall also provide safety barriers, warning signs, signboards, beacons, barricades, lighting, fencing , illuminated traffic diversion signs, flashers etc. well in advance of the work site etc. for ensuring smooth and properly guided traffic flow.

The circular / rectangular jacking pit of size capable to accommodate jacking equipment and pipes, up to required depth, shall be excavated.

The vertical face of the excavated pit shall be properly protected & stabilized by providing shoring M.S. Sheet piles / liner plates, ring beams, Solider piles with lagging, precast concrete segments, RCC piles or by any other method other than mentioned in BOQ which will not be paid. Necessary geotechnical survey shall be carried out and shoring shall be designed with respect to soil / rock properties encountered in the pit. In addition to above the contractors shall make necessary arrangement if required, for stabilization of soil / rock by shotcrete, grouting, slurry walls, tie rods, anchor rods, expansion bolts, wire mesh etc., for which no extra payment will be made. The contractors shall also allow in his rate for protecting, supporting any utilities in the excavation of jacking pit. Proper dewatering arrangement shall be made by the contractors for which no extra payment will be made.

Cement concrete base of grade M-20, of thickness 30 cm shall be provided in the pit. Thrust wall of M-40 grade concrete shall be provided within shaft to evenly transfer the jacking force. It shall be ensured that the thrust wall and the soil behind are in complete contact and there is no gap in between. The jacking frame shall be set up in the shaft in correct alignment. The jacking frame shall comprises of high thrust hydraulic jacks capable of exerting required jacking force against thrust wall to push the pipes forward, through the bored ground.

Initially, a circular bore for half length of jacking pipe shall be excavated in the correct line & level, for laying downstream side sewer pipes. The oversize allowable in the excavation shall not be more than 5% of pipe OD. After boring half pipe length, the RCC NP-4 class jacking pipe of 1200 - 1800 mm dia, is pushed by jacking in the bore. Further horizontal excavation shall then be carried out by sending skilled labour through the RCC jacking pipe by any means i.e. chiselling, using splitter machine, etc. The excavated material shall be removed from the bore and shaft simultaneously, and shall not be stacked around the pit.

The horizontal bore excavation will be measured and paid only in R.M. length as per rate of the contract, and contractors shall allow in his rate for boring in wide range of ground, comprising of soil / clay / sand / soft rock / very hard rock with UCS more than 350 mpa / boulders. In case of soft soil / weathered or shattered rock, it shall be stabilized by any means stated in para 3 above, for which no extra payment will be made. Under any circumstances, the contractors shall be solely responsible for safety and security of life & limbs of workers and to arrest settlement so as to safeguard integrity of road surface above.

Proper safety accessories such as overhead cage, helmets, footwear, gloves, safety belts, oxygen cylinders & masks shall be provided by the contractors. Contractors shall also provide adequate ventilation by means of blowers etc. to keep the existing manholes and excavated bore, free from all dangerous gases.

The RCC jacking pipe 1200 -1800 mm dia, of minimum NP-4 class, shall meet the basic requirements specified in IS 458 & IS 3597 shall be tested and approved by Engineer. The spigot ended jacking pipe with recess to receive rubber ring & M.S. collars welded to reinforcement inside and the spigot & socket joint shall be flush from outside. The rubber ring shall meet the requirement of IS 5328 and testing shall confirm to IS 3400 & 5382. The M.S. collar shall be coated with anticorrosive & anti abrasive paint such as polymorphic resin or other material approved by the Engineer. The cyclical process of excavation, removal of excavated material and pushing the pipe forward will be continued till the sleeve pipe reaches existing manhole face, where sewer line is to be connected. The alignment & levels of the pipe shall be checked at every stage.

After completing the drive, annular space between outer face of jacking pipe and excavated surface shall be grouted by pumping cement mortar 1:3, (for which no extra payment will be made) so that there should not be any voids left in between.

The RCC NP-3 class carrier pipe if any is then inserted, jointed and pushed through RCC NP-4 class jacking sleeve pipe, and is then finally connected to the existing manhole by making hole from inside the manhole. The connection shall be made watertight.

Circular / Scrapper Manhole, shall then be constructed at jacking pit location.

The contractors shall carry out the reinstatement of the road foundation and road surface in accordance with existing road crust and as per specifications of MORTH / PWD / MCGM. The broken existing storm water drain shall also be reconstructed to its original shape and size.

Upon completion of work, the sewer line shall be hydraulically tested as per required pressure and after successful testing, contractor must clean the site to the satisfaction of Engineer. The sewer line shall be handed over to the user dept (Sewerage Operation Dept) under proper acknowledgement and certificate to this effect. Hydraulic testing and site cleaning is to be done by the contractors at his own cost and no extra payment shall be admissible.

1.6 GENERAL SPECIFICATIONS FOR HORIZONTAL DIRECTIONAL DRILLING (HDD) / HDPE PIPE :

1. Scope of Work

The Permanent Works under this contract shall include but not be limited to the following:

The installation complete of reinforced cement concrete / MS / HDPE pipeline pipes or other pipes including fittings or specials as specified and as approved by the Engineer in the following distinct fronts under the contact.

Testing under supervision of the MCGM’s Sewerage Operations department’s staff and handing over to that department upon successful testing.

The constructions complete of all the manholes, special chambers, drop arrangements pipes, vent shafts etc.

Transferring of existing working connections by appropriate enabling arrangements without unduly affecting the functioning of the existing sewer. The work may require trenchless technology/ Microtunneling or conventional open excavation for laying such connections.

Providing new connections by appropriate enabling arrangements. The work may require trenchless technology/ Microtunneling or conventional open excavation for laying such connections.

Ancillary and incidental works and all necessary works required to complete the work successfully and to entire satisfaction to the Engineer.

The work will have to be done in a planned manner so that sewage flow is not disrupted even partially for more than 24 hours.

The Engineer reserves right to change the alignment to suit the site conditions, amend the scope of work, to delete any package, to replace any package or curtail scope of work without thus incurring any liability on the Engineer or the Employer.

Furthermore, the consideration that Microtunneling method/ Horizontal Directional Drilling Method permitted as a suitable method of installing the sewer pipelines in the Specification shall not relieve the Contractor in any way from his prima facie obligation and responsibility under the contract to successfully install the pipelines without causing interruptions to train and motor traffic and within the specified contract period and contract amount.

The Contractor's rates in the Bill of Quantities shall be deemed to be for installing the pipelines successfully within the specified contract period regardless of the method considered in the specification as a suitable trenchless method.

Design Life. - For the purpose of designing the pipelines and the associated structures, the design life shall be 80 years. The materials incorporated in the works and the workmanship shall be of required quality to sustain the specified life span.

A. General:

It is the intent of this specification to define the acceptable methods and materials for installing sanitary sewer and water mains by the horizontal directional drilling method and the requirements for high density polyethylene (HDPE) pipe installed by directional drilling or in open cut trenches.

B. Installation Plan:

1. At least 7 days prior to mobilizing equipment Contractor shall submit his detailed installation plan to the Engineer. The plan shall include a detailed plan and profile of the bores and be plotted at a scale no smaller than 1 inch equals 20 feet horizontal and vertical.

2. The plan shall also include a listing of major equipment and supervisory personnel and a description of the methods to be used.

C. Variations in Plan or Profile:

The Contractor may request changes to the proposed vertical and horizontal alignment of the installation and the location of the entry and exit points. Proposed changes shall be submitted in writing to the Engineer and receive approval of the Engineer prior to construction.

D. Alignment:

The proposed plan and profile installation locations are based on alignments to accommodate acquired easements, to avoid obstructions, and to properly maintain operation flow velocities.

1.7 MATERIALS:

A. General:

High density polyethylene pipe in accordance with IS 14333 specifications shall be used in HDD installations. All piping system components shall be the products of one manufacturer.

B. Piping and Bends:

Piping and Bends shall be extruded from a polyethylene compound and shall conform to the following requirements:

1. The polyethylene resin shall meet or exceed the requirements of IS 7323
2. The polyethylene compound shall be suitably protected against degradation by ultraviolet light by means of carbon black, well dispersed by pre-compounding in a concentration of not less than 2.5 per cent.
3. The pipe manufacturer shall be listed with the Plastic Pipe Institute as meeting the recipe and mixing requirements of the resin manufacturer for the resin used to manufacture the pipe in this project.
4. The pipe and bends shall have a minimum standard dimension ratio (SDR) wall thickness as specified by the Engineer.

5. Joining shall be performed by thermal butt-fusion in accordance with the manufacturer's recommendations.

C. Procedures:

1. General:

All polyethylene pipe shall be cut, fabricated, and installed in strict conformance with the pipe manufacturer's recommendations. Joining, laying, and pulling of polyethylene pipe shall be accomplished by personnel experienced in working with polyethylene pipe. The pipe supplier shall certify in writing that the Contractor is qualified to join, lay, and pull the pipe or representative of the pipe manufacturer shall be on site to oversee the pipe joining. Expense for the representative shall be paid for by the Contractor.

2. Transportation:

Care shall be taken during transportation of the pipe to ensure that it is not cut, kinked, or otherwise damaged.

3. Storage:

Pipes shall be stored on level ground, preferably turf or sand, free of sharp objects which could damage the pipe. Stacking of the polyethylene pipe shall be limited to a height that will not cause excessive deformation of the bottom layers of pipes under anticipated temperature condition. Where necessary due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitably and of such widths as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

4. Handling Pipe:

The handling of the joined pipeline shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Ropes, fabric, or rubber protected slings and straps shall be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends shall not be used. Two slings spread apart shall be used for lifting each length of pipe. Pipe or fittings shall not be dropped onto rocky or unprepared ground. Slings for handling the pipeline shall not be positioned at butt-fused joints. Sections of the pipes with cuts and gouges exceeding 10 per cent of the pipe wall thickness or kinked sections shall be removed and the ends re-joined.

The open ends of all sections of joined and/or installed pipe (not in service) shall be plugged at night to prevent animals or foreign material from entering the pipe line or pipe section.

Waterproof nightcaps of approved design may be used but they shall also be so constructed that they will prevent the entrance of any type of natural precipitation into the pipe and will be fastened to the pipe in such a manner that the wind cannot blow them loose.

The practice of stuffing cloth or paper in the open ends of the pipe will be considered unacceptable.

Where possible, the pipe shall be raised and supported at a suitable distance back from the open end such that the open end will be below the level of the pipe at the point of support.

1.8 INSTALLATION:

<u>Selection of HDD Equipment</u>

The contractors shall be responsible for the selection of a suitable HDD machine capable of excavating the materials including hard rocks, clay, sand, mixed ground etc. that may be encountered at the sites.

The Engineer's representative shall have full authority to inspect any material or finished product and reject the same if not found conforming to the standards. The Contractors shall make his representative available to the Engineer's representative during such inspections and testing failing which the Engineers representative shall be at liberty to take ex-party decision which shall become binding upon the Contractor.

A. General:

1. The Contractor shall install the pipelines by means of horizontal directional drilling. The Contractor shall assemble, support, and pre test the pipeline prior to installation in the directional drill tunnel.
2. Horizontal directional drilling shall consist of the drilling of a small diameter pilot hole from one end of the alignment to the other, followed by enlarging the hole diameter for the pipeline insertion. The exact method and techniques for completing the directionally drilled installation will be determined by the Contractor, subject to the requirements of these Specifications.
3. The Contractor shall prepare and submit a plan to the Engineer for approval for insertion of the HDPE pipe into the opened bore hole. This plan shall include pullback procedure, ballasting, use of rollers, side booms and side rollers, coating protection, internal cleaning, internal gauging, hydrostatic tests, dewatering, and purging.
4. The required piping shall be assembled in a manner that does not obstruct adjacent roadways or public activities. The Contractor shall erect temporary fencing around the entry and exit pipe staging areas.
5. Hydraulic or pneumatic pipe rammers may only be used if necessary and with the authorization of Engineer.

B. Joining Pipe Sections:

1. Each length of pipe shall be inspected and cleaned as necessary to be free of debris immediately prior to joining.
2. Pipes shall be joined to one another by means of thermal butt-fusion. Polyethylene pipe lengths to be joined by thermal butt fusion shall be of the same type, grade, and class of polyethylene compound and supplied from the same raw material supplier.
3. Mechanical connections of the polyethylene pipe to auxiliary equipment shall be through flanged connections which shall consist of the following:

a. A polyethylene "sub end" shall be thermally butt-fused to the ends of the pipe.
b. Provide ASTM A240, Type 304 stainless steel backing flange, 125- pound, ANSI B16.1 standard, and gaskets as required by the manufacturer.
c. Stainless Steel bolts and nuts of sufficient length to show a minimum of three complete threads when the joint is made and tightened to the manufacturer's standard. Re-torque the nuts after 4 hours.
d. Butt-Fusion Joining: Butt-fusion of pipes shall be performed in accordance with the manufacturer's recommendations as to equipment and technique. Butt-fusion joining shall be 100% efficient offering a joint weld strength equal to or greater than the tensile strength of the pipe.

C. Tolerances:

1. Pipe installed by the directional drilled method must be located in plan as shown on the Drawings, and must be no shallower than shown on the Drawings unless otherwise approved. The Contractor shall plot the actual horizontal and vertical alignment of the pilot bore at intervals not exceeding 60 M. This "as built" plan and profile shall be updated as the pilot bore is advanced. The Contractor shall at all times provide and maintain instrumentation that will accurately locate the pilot hole and measure

drilling fluid flow and pressure. The Contractor shall grant the Engineer access to all data and readout pertaining to the position of the bore head and the fluid pressures and flows. When requested, the Contractor shall provide explanations of this position monitoring and steering equipment. The Contractor shall employ experienced personnel to operate the directional drilling equipment and, in particular, the position monitoring and steering equipment. No information pertaining to the position or inclination of the pilot bores shall be withheld from the Engineer.

2. For gravity sanitary sewer installations, sags in the pipeline shall not exceed 25 per cent of the nominal pipe diameter. Sags will only be allowed where the entering and exiting grades are adequate to provide velocities through the sag area sufficient for moving solids. No more than one (1) sag area shall occur between two (2) manholes. The alignment of each pilot bore must be approved by the Engineer before pipe can be pulled. If the pilot bore fails to conform to the above tolerances, the Engineer may, at his option, require a new pilot boring to be made.

3. After the pipe is in place, cleaning pigs shall be used to remove residual water and debris. After the cleaning operation, the Contractor shall provide and run a sizing pig to check for anomalies in the form of buckles, dents, excessive out-of-roundness, and any other deformations. The sizing pig run shall be considered acceptable if the survey results indicate that there are no sharp anomalies (e.g. dens, buckles, gouges, and internal obstructions) greater than 2 per cent of the nominal pipe diameter, or excessive ovality greater than 5 per cent of the nominal pipe diameter. For gauging purposes, dent locations are those defined above which occur within a span of 1.5 m or less. Pipe ovality shall be measured as the per cent difference between the maximum and minimum pipe diameters. For gauging purposes, ovality locations are those defined above which exceed a span of 1.5 m.

D. Ream and Pullback:

1. Reaming: Reaming operations shall be conducted to enlarge the pilot after acceptance of the pilot bore. The number and size of such reaming operations shall be conducted at the discretion of the Contractor.

2. Pulling Loads: The maximum allowable pull exerted on the HDPE pipelines shall be measured continuously and limited to the maximum allowed by the pipe manufacturer so that the pipe or joints are not over stressed.

3. Torsion and Stresses: A swivel shall be used to connect the pipeline to the drill pipe to prevent torsion stresses from occurring in the pipe.

4. The lead end of the pipe shall be closed during the pullback operation.

5. Pipeline Support: The pipelines shall be adequately supported by rollers and side booms and monitored during installation so as to prevent over stressing or buckling during the pullback operation. Such support/rollers shall be spaced at a maximum of 18 m. on centres, and the rollers to be comprised of a non-abrasive material arranged in a manner to provide support to the bottom and bottom quarter points of the pipeline allowing for free movement of the pipeline during pullback. Surface damage shall be repaired by the Contractor before pulling operations resume.
Pipe rollers shall be of sufficient size to fully support the weight of the pipe while being hydro tested and during pull-back operations. Sufficient number of rollers shall be used to prevent excess sagging of pipe. Rollers shall be used as necessary to assist in pull back operations and in layout/join ting of piping.

6. The contractor shall at all times handle the HDPE pipe in a manner that does not over stress the

pipe. Vertical and horizontal curves shall be limited so that wall stresses do not exceed 50% of yield stress for flexural bending of the HDPE pipe. If the pipe is buckled or otherwise damaged, the damaged section shall be removed and replaced by the Contractor at his expense. The Contractor shall take appropriate steps during pullback to ensure that the HDPE pipe will be installed without damage.

E. Handling Drilling Fluids and Cuttings:

1. During the drilling, reaming, or pullback operations, the Contractor shall make adequate provisions for handling the drilling fluids, or cuttings at the entry and exit pits. To the greatest extent practical, these fluids must not be discharged into the waterway. When the Contractor's provisions for storage of the fluids or cuttings on site are exceeded, these materials shall be hauled away to a suitable legal disposal site. The Contractor shall conduct his directional drilling operation in such a manner that drilling fluids are not forced through the sub bottom into the waterway. After completion of the directional drilling work, the entry and exit pit locations shall be restored to original conditions. The Contractor shall comply with all permit provisions.

2. Pits constructed at the entry or exit point area shall be so constructed to completely contain the drill fluid and prevent its escape to the beach or waterway.

3. The Contractor shall utilize drilling tools and procedures which will minimize the discharge of any drill fluids. The Contractor shall comply with all mitigation measures listed in the required permits and elsewhere in these Specifications.

4. To the extent practical, the Contractor shall maintain a closed loop drilling fluid system.

5. The Contractor shall minimize drilling fluid disposal quantities by utilizing a drilling fluid cleaning system which allows the returned fluids to be reused.

6. As part of the installation plan specified herein before, the Contractor shall submit a drilling fluid plan which details types of drilling fluids, cleaning and recycling equipment, estimated flow rates, and procedures for minimizing drilling fluid escape.

PART 2: DRILLING OPERATIONS

A. General:

The Contractor shall prepare a plan to be submitted for Engineer approval which describes the noise reduction program; solids control plant, pilot hole drilling procedure, the reaming operation, and the pullback procedure. All drilling operations shall be performed by supervisors and personnel experienced in horizontal directional drilling. All required support, including drilling tool suppliers, survey systems, mud cleaning, mud disposal, and other required support systems used during this operation shall be provided by the Contractor.

Drill pipe shall be sufficient for the torque and longitudinal loads and fluid capacities required for the work.

A smoothly drilled pilot hole shall follow the design centre line of the pipe profile and alignment described on the construction drawings. The position of the drill string shall be monitored by the Contractor with the down hole survey instruments. Contractor shall compute the position in the X, Y and Z axis relative to ground surface from down hole survey data a minimum of once per length of each drilling pipe (approximately 10 m. interval). Deviations from the acceptable tolerances described in the Specifications shall be documented and immediately brought to the attention of the Engineer for discussion and/or approval. The profile and alignment defined on the construction drawings for the bores define the minimum depth and radius of curvature. At no point in the drilled profile shall the radius of curvature of the bore be less than 500 m. The Contractor shall maintain and provide to the Engineer, upon request, the data generated by the down hole survey tools in a form suitable for independent calculation of the pilot hole profile.

Between the water's edge and the entry or exit point the Contractor shall provide and use a separate steering system employing a ground survey grid system, such as "TRU-TRACKER / Digital Tracker" or equal wherever possible. The exit point shall fall within a rectangle 3 m wide and 12 m long centered on the planned exit point. During the entire operation, waste and leftover drilling fluids from the pits and cuttings shall be dewatered and disposed of in accordance with all permits and regulatory agencies requirements. Remaining water shall be cleaned by Contractor to meet permit requirements. Any modification to the basic drilling fluid involving additives must describe the type of material to be used and be included in Contractor's drilling plan presented to the Engineer. The Owner retains the right to sample and monitor the waste drilling mud, cuttings and water.

B. Environmental Provisions:

The Horizontal Directional Drilling operation is to be operated in a manner to eliminate the discharge of water, drilling mud and cuttings to the adjacent creek or land areas involved during the construction process. The Contractor shall provide equipment and procedures to maximize the recirculation or reuse of drilling mud to minimize waste. All excavated pits used in the drilling operation shall be lined by Contractor with heavy duty plastic sheeting with sealed joints to prevent the migration of drilling fluids and/or ground water.

The Contractor shall visit the site and must be aware of all structures and site limitations at the directional drill crossing and provide the Engineer with a drilling plan outlining procedures to prevent drilling fluid from adversely affecting the surrounding area.

The general work areas on the entry and exit sides of the crossing shall be enclosed by a berm to contain unplanned spills or discharge.

Waste cuttings and drilling mud shall be processed through a solids control plant comprised as a minimum of sumps, pumps, tanks, desalter/desander, centrifuges, material handlers, and haulers all in a quantity sufficient to perform the cleaning/separating operation without interference with the drilling program. The cuttings and excess drilling fluids shall be dewatered and dried by the Contractor to the extent necessary for disposal in offsite landfills. Water from the dewatering process shall be treated by the Contractor to meet permit requirements and disposed of locally. The cuttings and water for disposal are subject to being sampled and tested. The construction site and adjacent areas will be checked frequently for signs of unplanned leaks or seeps.

Equipment (graders, shovels, etc.) and materials (such as groundsheets, hay bales, booms, and absorbent pads) for cleanup and contingencies shall be provided in sufficient quantities by the Contractor and maintained at all sites for use in the event of inadvertent leaks, seeps or spills.

Waste drilling mud and cuttings shall be dewatered, dried, and stock piled such that it can be loaded by a front end loader, transferred to a truck and hauled offsite to a suitable legal disposal site. Due to a limited storage space at the worksites, dewatering and disposal work shall be concurrent with drilling operations. Treatment of water shall satisfy regulatory agencies before it is discharged.

C. Construction Plant and Equipment

(a) Where reference is made in this Preamble to items of constructional plant and equipment, it is to be understood that the percentage rate entered over the Bill of Quantities shall include all costs incurred in the provision, transportation to site, setting to work, operation (including all manpower fuel and consumable stores), maintenance and removal from the site upon completion of the Works. The rates shall also include for the cost of all tests and other requirements in relation to such plant and equipment

(b) Contractor's specific attention is drawn with regard to the micro tunnel / HDD boring equipment to be used in the project. The Contractor shall carefully read relevant clauses in the Technical Specification and the requirements before selecting the micro tunnel / HDD boring equipment for the project. The Contractor shall provide adequate information on the tunnel boring machine he selected for the project with regard to its design capability for excavating the types of rocks/soil to be excavated in the project and its ability to micro tunnel / Bore through water charged mixed ground and rock/soil interface and hard basaltic rock. He shall also provide its operational history on similar rock/soil conditions and the description of the rock/soil including their geotechnical properties.

2.1 GENERAL SPECIFICATIONS FOR MICROTUNELLING AND PIPE JACKING METHOD :

TERMINOLOGY AND GENERAL DESCRIPTION

2.1 Definitions

For the purpose of this contract document, the technical terms pertaining to microtunneling works and their functional details are defined below. The definitions herein are meant only as guidelines. If other (or new) definitions or technical terms are used by the Contractor in his submittals, they shall be clearly defined by him.

2.2 Microtunneling

Microtunneling is a process of accurately excavating, non-man entry tunnels for installing underground pipelines, using laser guided remote controlled mini shields of diameters 600 -2400 mm. The microtunneling permits accurate monitoring and adjusting of the alignment and level (either manually or automatically) as the excavation proceeds.

2.3. Pipe jacking.

It is a process of lining a tunnel bore formed by a shield or other means by pushing especially designed jacking pipes (reinforced concrete or other pipes) into the tunnel bore, from a shaft (known as jacking shaft) to another shaft (known as receiving shaft).

2.4 Microtunneling and Pipe jacking:

It is an art of accurately installing smaller diameter pipelines (usually 600 mm diameter and above), without digging up of ground surface, using a laser guided remote controlled mini shields for tunnel boring and pipe jacking technique for lining the bore with the product pipe.

The process of installing a pipeline by microtunneling and pipe jacking system comprises five parts:-

(a) Micro tunnel boring machine (Shields)
(b) Automated spoil removal system
(c) Jacking system for pushing the jacking pipe and later on carrier pipe as needed
(d) Guidance system to guide the tunnel excavation
(e) Remote control system to operate the shield and other paraphernalia equipment.

2.4.1 MicroTunnel Boring Machine (shield)

It is mechanised, steerable mini boring machine (or shield) equipped with suitable cutter head in front to excavate smaller diameter tunnels under controlled conditions in which the tunnel face and ground water pressure are continuously balanced as the shield excavates and moves forward. The operation and steering of the shield are remotely controlled with the aid of laser and/or CCTV system

2.4.2 Automated spoil removal system

This system conveys the excavated spoil from the tunnel face to the ground surface for disposal. The spoil removal rate and the speed of the shield are fully or semi-automatically controlled in such a way to achieve minimal heave or settlement. There are three systems available for the conveyance of the spoil and they are slurry system, augur system, and vacuum system.

2.4.3 Jacking System

The jacking system comprise high thrust hydraulic jacks mounted in a jacking frame capable of exerting the required jacking force against a purpose built thrust wall to push the pipes and the shield forward through the ground. The jacking force is transferred evenly to the jacking pipe through a push ring connected to the pipe.

2.4.4 Guidance System

The guidance system comprises a laser beam device or a theodolite with laser beam attachment. The device is installed in the jacking shaft and the beam is set to the desired level, gradient and alignment.

Some machines have photo sensitive cells on the target panel located at the rear of the shield which converts the laser position into digital data. The data are then electronically transmitted to the operator’s control panel where digital readout of the location can be made. Some modern shields have built-in capabilities to use the digital data and automatically make necessary steering adjustments to guide the machine to the true alignment and level

The contractor shall submit complete details of the guidance system he proposes to use and shall incorporate appropriate check points and hold points in the Quality Assurance Manual that he shall implement in the contract.

The laser torch or theodolite shall be firmly supported in the jacking pit so that it is independent of any movement that may take place during the microtunneling operation.

2.4.5 Remote Control System

All microtunneling systems rely on remote-control capability. The control system monitors and controls the steering of the shield, spoil removal system (slurry or augur or vacuum), jacking system and guidance system. The system operation varies from totally manual to fully automated. The remote control system is usually housed in portable control cabin.

The control cabin shall be located near to the jacking pit so that the operator can visually monitor the activities in the pit. Where it is not possible to locate the control cabin near to the pit due to space limitations, a CCTV camera system shall be set up in the pit to allow the operator to monitor the activities in the pit.

For the manual operating system, the operator's skill is very crucial for a successful completion of the project. The operator shall monitor all the information and continuously feed into the control panel as necessary. He shall be alert at all time and shall observe the crew's activities and other site activities, evaluate the information and make appropriate operational decisions. The information relayed back to the operator shall be audible, tactile and visual as The MTBM shall have facility to transmit sounds and vibrations from the excavation face to the operators to enable him to make appropriate operational decisions. He shall monitor and keep record of position of the tunneling machine in relation to the design line &grade, cutter head face pressure & torque, jacking thrust, RPM, steering jack extension & their pressures, slurry pump flow rate, pressures of slurry systems, rate of MTBM advancement, Roll, Pitch, Installed length, Grout quantity etc.

In fully automated system, the machine acquires and evaluates the information and selects the operational steps for automatic steering of MTBM. The information collected shall be logged in a microprocessor to obtain a printout as necessary.

The contractor shall incorporate check points and hold points for the guidance control system in the Quality Assurance System that he shall implement in the contract.

2.4.6 Supplementary systems

The supplementary system required for microtunneling and pipe jacking operation shall include Muck disposal system, Pipe lubrication system, Grouting system, Guide rails, Entrance and Exit installations.

2.4.7 Jacking shaft (or Jacking Pit)

Jacking Shaft is an important temporary structure from where jacking operation is performed. The shaft is usually rectangular or circular in shape and built using liner plates, sheet piles or timber shoring. The size of the shaft shall be such that it is capable of accommodating the jacking equipment (and also the shield), jacking pipe and other paraphernalia or enable construction of manhole or chamber as needed. The requirement for jacking shaft shall take full cognisance of the available working space and intended equipment footprint, minimum disturbance to the traffic flow.

2.4.8 Receiving shaft (Receiving pit)

A purpose built temporary structure to receive and remove the tunnelling shield after its completion of a tunnel drive. The shaft is also rectangular or circular in shape and smaller than the jacking shaft. The size shall be sufficient enough to accommodate the tunnelling shield when it emerges into shaft after completion of a tunnel drive or construction of manhole or chamber as needed.

2.4.9 Footprint

The footprint of a microtunnel drive shall be taken as the net area occupied by the jacking or receiving shafts. The size of the footprint depends on many factors including the microtunneling system and the length of jacking pipe used. The footprint requirement shall be an important factor, especially in congested and narrow roads when selecting the microtunneling system for a project.

The Contractor shall take into consideration of the space constraints and restrictions along the pipeline route for location of shafts and he shall ensure that the microtunneling system selected for use in such sites shall require absolutely minimum space for the footprint.

2.4.10 Thrust wall

Thrust wall is a temporary concrete or steel structure built within the jacking shaft to transfer the jacking force to the ground during jacking operation. The jacking shafts may often have more than a single thrust wall and each thrust wall shall be perpendicular and square to the pipeline to be jacked. The thrust walls shall be in good contact with the soils behind so that wall can transmit the jacking force effectively to the ground without affecting the shoring system.

All the affected thrust wall shall be demolished fully or partly after completion of jacking operation involving in that wall.

2.4.11 Entrance Ring

A steel flange fitted with a rubber seal (a 10mm to 20mm thick circular rubber gasket whose outside diameter is same as that of the steel flange and the inside diameter is smaller than that of the jacking pipe) installed perpendicular to the pipeline at the entrance. The purpose of the rubber seal is to prevent the slurry or ground water from entering into the shaft through the pipe entrance.

2.4.12 Exit Ring

This is similar to the entrance ring except that the internal diameter of the rubber seal is much smaller than that of the jacking pipe and is installed to prevent the slurry or ground water from escaping the tunnelling machine when it emerges at the receiving shaft.

2.4.13 Guide Rails (or Jacking Table or Frame)

To facilitate placing of the microtunneling machine and pipes in the jacking shaft, a set of guide rails are installed in position on the base of the shaft. The guide rail assembly (also known as jacking table/ frame) shall be carefully set up in the shaft to correct alignment and gradient so that the pipe when placed on itstays in line with and square to the pipeline alignment. The guide rail assembly shall be independent of the thrust wall so that it is not disturbed due to jacking force exerted onto the thrust wall.

2.4.14 Thrust Pressure Plate

The thrust pressure plate is usually a 50mm or 100mm thick steel plate installed between the jacks assembly and the thrust wall. The pressure plate enables the concentrated jacking load from the jacks to be transmitted evenly to the thrust wall.

2.4.15 Intermediate Jacking Station.

For longer distance jacking, intermediate jacking stations, comprising a telescopic type jacking pipe assembly (usually made of steel), are used. A set of inter jacks and push ring are installed around the inner side of the female pipe of the telescopic pipe assembly. The intermediate jacking pipe assembly shall be installed at appropriate point and jacked-in along with the other jacking pipes.

2.4.16 Cutter head

It is usually a disc shaped wheel mounted on the face of the micro tunnelling machine (shield) and is driven by hydraulic or electrical motor, located within the machine. The excavation capabilities of a microtunneling machine depends very much on the type of cutter head used, its size, its speed of rotation and average and peak torque etc.

Cutter head can be equipped with picks, single / double disk cutters, cone shaped cutters, button bits, chisel points, scrappers etc. with sufficient openings & buckets.

Different types of cutter head configuration are used in microtunneling machines to suit the type and nature of the ground through which tunnelling is to be carried out.. For example in soft ground tunnelling the cutter head shall have bits arranged in such a way to cleave and guide the soil into a chamber behind the cutter head through the openings provided in the cutter wheel.

In the case of rock or hard ground tunnelling the cutter head shall be equipped with suitable bits, roller bits or disc cutters for effective transfer of cutting energy to rock. The cutter head shall be configured appropriately considering geotechnical parameters such as compressive strength, tensile strength, elasticity, abrasivity etc, about the material to be excavated. The tunnelling machine shall be equipped with a crushing chamber behind the cutter head with powerful crusher to crush the excavated rocks into smaller pieces. Moreover, the machine shall be capable of exerting a large thrust force/torque on to the tunnel face to facilitate excavation of rock. The speed of rotation, torque, bit arrangement (and its structural and mechanical characteristic to withstand rock excavation for longer drive) of the cutter head and the thrust force the tunnelling machine is capable of exerting on to the rock face are important features to consider when selecting machines for tunnelling inrock.

2.4.17 Jacking Ring

Jacking ring or thrust plate is a purpose made structural fitting which shall be installed between the jacking assembly and the jacking pipe to transfer the point loads from the individual jacks into evenly distributed jacking force to the pipes being jacked. The ring shall be fabricated and machined, if necessary, so that it fits exactly onto end of the jacking pipe.

2.2. General Specifications for Horizontal Directional Drilling Method

2.2.1 DEFINITION

Horizontal directional drilling (HDD) has emerged as a preferred crossing method in many situations for the installation of oil and gas pipelines as well as other utilities under watercourses, roads, rail lines, steep slopes and other obstacles.

Recognition of the advantages, limitations and potential risks of HDD is an important step in this evaluation.

The successful design and construction of an HDD is the result of a team effort combining the skills of the regulatory group, owner, engineering consultant, environmental consultant, inspection services and the specialist HDD contractor. Success in this endeavor is measured in more than the successful pull back of the pre-built pipeline drag section.

2.2.2 DRILLING EXECUTION PLAN

The selected contractor should develop and present to the engineer a written drilling execution plan that addresses all aspects of the HDD. A full list of components of the plan is provided in Appendix C. Key topics in the plan include:

a. Details of each step of the HDD;

b. Detailed drawings;

c. Equipment specifications;

d. Workspace and water requirements;

e. Monitoring plans including frequency and type; and

f. Contingency plans.

2.2.3 ENVIRONMENTAL PROTECTION PLAN

An environmental protection plan (EPP) should be developed by the owner to address mitigative measures to be implemented during execution of the HDD. Environmental protection planning should cover all aspects of the execution of the HDD including land, water and access needs. The EPP should address the following aspects and be closely linked to the drilling execution plan:

a. Notification and approvals;

b. Identification of environmental exclusion areas to be incorporated into No Drill Zones;

c. Environmental and social timing constraints;

d. Equipment inspection and servicing;

e. Clearing and grading of HDD sites and access;

f. Erosion and sediment controls; and

g. Monitoring.

In addition to having an EPP, it is essential to have qualified people onsite to enact the plan, to handle deviations to the plan and to report events properly to the authorities. Having an environmental specialist or biologist onsite to liaise directly with the DFO habitat biologist or other similar authority can prove useful. Effective communication of unintended events and subsequent mitigation actions to the authorities may reduce delays or unwarranted enforcement actions contingency planning, e.g., inadvertent returns and reclamation.

2.2.4 CONSTRUCTION CONSIDERATIONS

2.2.4.1 Drilling

2.2.4.1.1 Types of Rigs

The size of HDD rigs can vary substantially. This range in sizes should be considered when planning and developing specifications for an HDD project.

In general, rigs are sized according to their available pull force and rotary torque that can be applied to the drill stem and pipe string.

The capabilities of each rig should be assessed for each project. The assessment of rig capabilities should take into account the possibility that formations or other subsurface materials may be encountered that could cause difficulties with the HDD project.

2.2.4.1.2. Drag Section

The pipe installation should be designed so that, wherever possible, the pipe string or drag section can be laid out and pulled back in one continuous section.

The pipe will have to be lifted into place to match the exit angle of the drill to allow the drill rig to pull the section into place.

The pipe string is usually placed on rollers as it is pulled into the drilled hole. The drag section may be cradled through a vertical curve to achieve the proper angle at the exit point. This curvature should be no more than the limiting curvature of the pipe.

2.2.4.1.3 Steering / Survey of Drill Head

It is necessary to ‘steer’ the drill head or mud motor during the drilling of the pilot hole. A number of steering technologies are available.

2.2.4.1.4 Drilling Fluids

Drilling fluid is used for a number of tasks in the HDD process including:

a. Cooling and lubricating the drill stem, mud motor and bit;

b. Providing hydraulic power to the mud motor which in turn converts hydraulic power to mechanical power;

c. Carrying cuttings out of the bore hole;

d. Stabilizing the bore hole during the drilling process; and

e. Sealing fractures in the formation.

Drilling fluid is usually a mixture of freshwater and bentonite. Bentonite is naturally occurring clay that is extremely hydrophilic (i.e., has high swelling characteristics). Certain polymers may also be used that enhance the drilling fluid benefits.

A drilling fluid design plan should be established before the start of the project. This plan should also be modified, when warranted, throughout the project to ensure the drilling fluid is fulfilling its function.

The contractors’ drilling execution plan should identify the equipment to be maintained onsite to check drilling fluid properties. Alterations to the mix should be made, when warranted, to stay within the proposed boundaries in the drilling fluid management plan.

A mud handling system should be onsite to ensure drilling fluid parameters are within the set standards.

Additives

Various chemical and materials can be added to the drilling fluid to adjust its properties. This is done to control:

a. Density;

b. Viscosity;

c. Plugging and sealing capabilities; and

d. Specific conditions such as swelling.

All additives should be environmentally safe. A number of additives have been recognized as safe for the water well drilling industry and, with the proper approvals, could be used for the HDD industry. All additives must be approved before use.

2.2.4.2 Monitoring :

Monitoring and reporting are critical during an HDD since they provide a log of activities during the process to:

a. Provide early identification of issues;

b. Make appropriate changes;

c. Provide a basis for mitigation; and

d. Provide a record of decisions and actions to demonstrate due diligence.

It is important to ensure that sufficient records are maintained before, during and after construction to support subsequent reports prepared to satisfy engineer or government reporting requirements. This should include detailed notes and photographs of all areas monitored.

2.2.4.2.1 Drilling

The following monitoring and reporting activities should be reviewed for appropriateness for the size and complexity of the HDD crossing:

a. Inspector daily records – a day-to-day account of the entire construction of the project;

b. Contractor drilling records;

c. Steering report;

d. Drilling fluid volume balance report;

e. Drilling fluid parameters;

f. Drilling fluid additives list;

g. Annular pressure modeling and reporting;

h. Turbidity monitoring report;

i. Surface monitoring report;

j. Pull force monitoring; and

k. Inadvertent return report.

2.2.4.3 Contingency Plans

2.2.4.3.1 A site-specific contingency plan should be prepared by the project team for each HDD.

A well designed contingency plan should address the following:

a. General measures;

b. Equipment and personnel needs for containment and clean-up;

c. Emergency response procedures;

d. Plans for continuance of drilling or alternative plans;

e. Time lines of acceptable response and notification;

f. Clean-up methods and plans;

g. Regulatory and stakeholder contacts;

h. Monitoring plans; and

i. Disposal plans.

2.2.4.3.2 <u>Clean-up and Remediation</u>

An important decision may be required when plans to be prepared to clean-up an inadvertent release of drilling mud. The decision can involve determination of whether or not clean-up and reclamation of a site will incur greater adverse effects on the environment than leaving the mud in situ and allow natural processes to reclaim the area.

Clean-up

It is important for the, contractor to submit cleanup goals for a site subjected to an inadvertent release of drilling fluids prior to commencement of clean-up activities. If a net gain is not anticipated as a result of clean-up, alternative measures may need to be implemented.

2.2.4.4 Reporting:

2.2.4.4.1 <u>Monitoring Reports</u>

Prior to the start of construction, the contractor should be required to provide the proposed monitoring report forms as part of the drilling execution plan. Frequency and types of monitoring should also be presented in the drilling execution plan.

2.2.4.4.2 As-Built Reports

As part of project deliverables, the contractor should provide the engineer an as-built drawing in a format approved or determined by the engineer. The contractor should also provide a set of the monitoring reports at the end of construction.

PART 3: PERFORMANCE REQUIREMENTS AND SITE RESTRICTIONS.

3.1 Design Life.

For the purpose of designing the pipelines and the associated structures, the design life shall be 80 years. The materials incorporated in the works and the workmanship shall be of required quality to sustain the specified life span.

3.2. Level and Alignment Accuracy

The pipes shall be installed into place, true to line and level. The maximum tolerance allowable in the displacement of the centreline of the laid pipe from the design centreline is 50 mm in the horizontal plane and 25mm in the vertical plane but there shall be no back fall at any point.

There shall be provision to prevent the relative movement between pipes at the joints by the use of steel gaiters or other approved methods during jacking operation. A packing piece of compressible material shall be provided at each joint and shall be securely held before the pipes are lowered into the thrust pit. Details of proposals shall be submitted to the Engineer for approval.

3.3 Limits on ground settlement and upheaval

For the sections of pipeline crossing under nallas, roads and railways etc. the Contractor shall be required to incorporate in his tunnelling method measures to arrest the expected settlements so as to safeguard the integrity of the road surfaces, railway tracks and collapse of nalla bed. The Contractor shall ensure that the traffic flow along the roads is not affected in any way as a consequence of his work.

3.4 Limitation on Footprint:

The contractor shall be deemed to have visited the sites and carefully planned and located the shafts at convenient points along the roads so as to minimize the road area to be occupied by the footprint considering centre to centre distance of manholes. The contractor shall be deemed to have allowed for such site constraints and measures required, including working in the night and construction of decking over the shafts, provision of access roads for construction plant and machinery, to allow the traffic to flow, in his rates. He shall take the site constraints and restrictions into consideration when selecting the trenchless technology system.

3.5 Proper scheduling of operations:

It must be noted that the objective of the work is to Upsize the existing sewer line and also to provide alternative sewer line at a higher depth to increase the sewerage flow capacity.

Failure to ensure proper time scheduling by the contractors may lead to delays or total inability in taking up the work on further pipe lines. Such delay or inability shall be entirely attributable to the Contractors.

Providing connections as and when directed by the Engineer / User department.

PART 4 : CONTRACTOR'S SUBMITTALS

4.1 General information on submittals.

To ensure compliance with the requirements specified in the Contract, the contractor shall make a number of submittals as described in the following clauses to the Engineer for approval by the specified time. The contractor shall ensure that the submittals prepared are of good professional standard, comply with all the requirements specified in the contract and complete with all details and information to enable the Engineer to evaluate and approve the submission. It shall be clearly understood by the contractor that he shall not commence any work without the approval of the submittals by the Engineer.

Submittals by the contractor shall, interalia, include Contractor's method of construction, Microtunneling equipment description and literature, Jacking system and maximum jacking loads, Pipe designs and shop drawings and calculation demonstrating the ability to sustain maximum jacking loads, Intermediate jacking stations details, Lubrication system, Bentonite injection system details, Ground water control details, Entry and exit details, Jacking and receiving shaft design details, design & details for shoring of shafts, Thrust block design details, Muck removal and disposal, Horizontal Directional Drilling Equipment, buried services details, detection equipment or any other trenchless technology system equipment, etc.

All submittals shall be submitted by the Contractor in accordance with schedule given in 4.17.

4.2 Submittal on Contractor's method of construction

The submittal shall contain a detailed explanation of various steps involved in the construction process. They shall include details of the equipment, specific manufacturer's instructions and guidelines pertaining to the project, a methodology statement outlining the operation of the equipment and, details of materials including pipe materials, rubber ring, and compressible packers and jointing of pipes.

The submittal shall also include construction details of other permanent and temporary structures such as jacking and receiving shafts, cast in-situ and precast manholes, or brick masonry manholes, thrust walls, and entry and exit of the shaft. The details of other equipment such as intermediate jacking stations, spoil removal system including slurry and feed pumps, control systems, slurry tanks and associated machinery, jacking frames, spacers, thrust ring etc shall also be included in the submittal.

The submittal must accompany the bid failing which the bids shall be considered 'non-responsive' and rejected outright.

4.3 Submittal on geotechnical profile and geotechnical reports along the pipeline route.

The Contractor shall establish the subsurface ground conditions and their range of variability along the pipeline before embarking on the works. He shall clearly identify the types of soil or rock that is likely to be encountered during boring or tunnelling along the entire pipeline alignment. If found necessary he shall carryout simple probing techniques (Geophysical soundings or Seismic refraction method) at closer interval and determine accurately the types of ground to be expected during boring/ tunneling.

He shall prepare a comprehensive geotechnical profile along the pipeline route with detailed descriptions of the types of soil or rock to be expected during boring/ tunnelling.

The Contractor at his own cost shall carry out essential geotechnical investigations and tests (Field as well as laboratory) immediately after award of the work for enabling him to select appropriate equipment/ methods and to design the cutter head; for which no extra payment shall be admissible in this regard. The Contractor shall be solely responsible for geotechnical investigations and the inference drawn from such investigations as well as the adequacy of the equipment and method adopted by him. However, other progress of works like construction of shafts etc. may be continued simultaneously.

4.4 Submittal on jacking pipes design.

The contractor's attention is drawn to the requirement pertaining to the design, manufacture and handling of the jacking pipes in clause 5.3.

The contractor shall with the approval of the Engineer, engage a reputable pipe manufacturer to design and manufacture the jacking pipes. In which case, the submittal shall include the manufacturer's name, address, contact telephone and facsimile numbers and the manufacturer's quality assurance /control and testing plan for the jacking pipe. The manufacturer's representative's name shall be also included in the submittal. A dimensioned drawing of the jacking pipe with design calculations from the manufacturer shall be also submitted to the Engineer for approval.

In case the Contractor intends to manufacture the pipes in his own facility set up for this purpose, he shall submit all details of equipment, design and process to the Engineer for approval.

The pipes shall conform to latest versions of respective BIS standards and shall be fabricated with approved materials in case of MS pipes or shall be procured from a manufacturer having facility with BIS certification.

4.5 Submittal on microtunneling /HDD system.

The bidder / contractor shall furnish name of the microtunneling / HDD model, manufacturer's technical literature for the equipment and all other data along with their bid. Any amendments deemed necessary by the Contractors shall be submitted along with the geotechnical profile within 3 days of submission of geotechnical profile to MCGM. The submittal shall include information to ensure that the microtunneling equipment proposed for the project meet with the general requirements specified in these specifications and also the anticipated geological conditions as assessed by the contractors. The submittal shall also include a certification from the manufacturer of the equipment about adequacy in the anticipated geotechnical conditions as also design calculations showing maximum anticipated jacking or pullback force and torque needed for tunnelling/ boring.

4.6 Submittal on site layout.

Contractor's attention is drawn to various clauses in the document with regard to the site constraints and space availability in all the sites. The contractor shall carefully examine the site and prepare site layout plans showing the arrangement of various ancillary equipment required for works, such as approaches for equipment, spoil removal equipment and slurry tanks, Bentonite systems/ mud recycling system, generators, control cabin, tracking facilities, crane, storage of pipes etc for each drive and submit them progressively to Engineer for approval.

4.7 Submittal on existing pipe levels, location of shafts and new pipeline alignment.

The contractor shall survey and verify the as-built invert levels of the upstream and downstream pipelines and manholes shown on the contract drawings for all the sites. The contractor shall confirm or insert the correct as-built levels in the contract drawings and submit them to the Engineer for necessary amendments and re issue of the contract drawings for construction. Under no circumstances the contractor shall commence works without verifying the as -built levels and obtaining the approval of the Engineer.

The Contractor will be required to set out and plan the actual route for the pipe laying well in advance of actual excavations. Trial holes/ probing and other preliminary surveys must be carried out and the resulting information carefully plotted. A copy of all preliminary surveys and the results of exploratory excavations must be supplied to the Engineer.

For convenience of construction, if the Contractor prefers changes to the pipeline alignment or the location of manholes shown on the contract drawings, he shall incorporate such changes in his submittals to the Engineer for approval. The Engineer would evaluate and approve if the proposed changes are found to be economically and technically, and functionally acceptable. It shall be clearly understood by the Contractor that any construction risks and additional costs arising as a result of Contractor's changes made to the original pipeline design shall be entirely borne by the Contractor.

4.8 Submittal on jacking and receiving shaft design

The Contractor shall submit the design and construction details of the jacking and receiving shaft and their proposed locations along the pipeline route to the Engineer for approval. The Contractor's design shall ensure that the shaft dimensions are absolute minimum required and method of construction shall be such that the shafts are constructed without causing unacceptable obstruction to the existing traffic flow in the vicinity of the construction. The minimum size of the shaft shall, however, permit construction of appropriate manhole / valve chambers as per the requirements. The Contractors shall also submit design and construction details of decking, if required, for the shaft. The Contractor shall be deemed to have allowed for in his Bid for such decking work necessary to maintain the traffic flow.

The submittal shall also include design &details on shoring system, entry and exit arrangement, thrust wall layout and its design details, general layout of guide rail and jacking table arrangement etc.

4.9 Submittals for obtaining approval from authorities

The contractor shall submit separate schedule for obtaining approval of various authorities and obtain specific permission or approval through the engineer. The Contractor shall be responsible for obtaining permissions from traffic police, PWD, MMRDA and Railway authorities with due regard to the method of work and detailed designs involved. The contractor shall be responsible for submission of the detailed designs and clarification on time to the concerned authorities. The Employer shall arrange to pay for the way leave charges or supervision charges only as demanded by railway, PWD and any government authorities.

4.10 Submittal on buried services and obstructions

The contractors shall investigate and determine the actual location of the buried or over the ground services and physical obstructions, if any, along the pipeline route and at his chosen locations of the jacking and receiving shafts, and submit service location drawings to the authorities responsible for electricity, telecom, water, pipeline, gas etc and obtain their approval or permission to excavate in their vicinity.

The Contractor shall not interfere with the operation of any existing or proposed service. He shall carefully plan the pipeline route and the locations of the shafts and manholes and shall identify the services that require diversion well ahead so as to give ample time to the authorities to divert the services or give approval to carry out the diversion by others. Where applicable, the Engineer would assist the contractors in getting the approval as expeditiously as possible from authorities.

If in the opinion of the Engineer any services that are within the manhole proper or affecting the alignment and require permanent diversion, they shall be diverted at the expenses of the Corporation. Expenses for all other diversions and temporary protection of services shall be borne by the Contractor.

Any consequential delays or expenditure arising from Contractors' carelessness or lack of foresight on this matter shall be entirely borne by the Contractor.

The Contractor shall fully co-operate with the Engineer and the authorities and shall have no financial claim for delay due to such relocation of services.

The Contractor shall allow for sufficient time for getting the permissions from the authorities.

4.11 Submittal on monitoring of ground settlement and upheaval

The contractor shall monitor ground movement daily at the start of jacking operation, at the end of the jacking operation and during the jacking operation on that day and submit in an approved format the settlement or upheaval caused by the microtunneling and pipe jacking works to the Engineer.

4.12 Submittal on safety

The Contractor shall be solely responsible for safety of the workmen, Engineer's staff and third party. The contractor shall implement a comprehensive safety plan for his work people and Engineer's/ Employer's staff or Third party. He shall comply with all relevant acts governing safety on construction site. He shall submit to the Engineer the details of the arrangements he made with the fire brigade, local health authorities and the availability of medical staff, first aid equipment ambulance, sick bay etc. He shall give the names and contact telephone numbers (24 hours) of the occupational health and safety personnel. Beside he shall submit a list of safety equipment that he would provide to all the workers on site. The Contractor shall appoint a Safety Officer or Safety Engineer at all times who shall be the responsible person for all safety related matters pertaining to the contract. Name of such person shall be communicated along with the submittals on safety. The contractor shall comply with the guidelines issued by any competent authority regarding safety at work site especially safety of persons working inside any pipeline- new or functioning. The Contractor shall provide & maintain proper signboards, warning lights, beacons, barricades, lighting, fencing etc. at sites. Any accident/ mishap arising from the non observing of safety measures will be sole responsibility of contractor.

4.13 Submittal on quality assurance/control plan

The Contractor shall implement a Quality Assurance Program approved by the Engineer for the manufacture of jacking pipes and for actual installation of the pipes by microtunneling and pipe jacking method on site.. The Quality Assurance Programme shall be maintained in accordance with the provision of the manual. No works shall commence until the Quality Assurance Manual has been approved by the Engineer.

The Contractor's Quality Assurance System shall incorporate but not be limited to the following:

(i) The Quality Assurance and Quality Control procedures covering all materials, design, manufacture, supply and installation carried out by the Contractor and any of his sub-contractors.

(ii) Such tests necessary to demonstrate that materials comply with the requirements of this specification and the requirements of the relevant Standards and Codes.

(iii) Contemporary records to be maintained pertaining to progress of the work.

4.14 Submittal on Contractor's personnel

The Contractor shall appoint a dedicated Project Manager along with at least two dedicated site engineers experienced in microtunneling work for this contract.

The contractor shall note that the skill of MTBM operator and their assistants is crucial for successful execution of work. The contractor shall submit complete information for the operators proposed to be employed for the work.

The contractor shall submit a list of his key site staff including their CV to the Engineer along with the bid. No change in the personnel shall be permitted subsequently without written permission of the Engineer. He shall submit the diagram showing the communication link within the site to Contractor's Head Quarters along with designation and telephone numbers of key staff for the Engineer's record. The Engineer reserves his right to reject any person who he thinks not suitable for the contract and the Contractor shall be obliged to replace such person immediately.

4.15 Submittal on remedial measures to be adopted by the Contractor.

The Contractor shall take each and every precaution to ensure that the tunnelling or drilling equipment will successfully excavate along the chosen pipeline alignment before he commences the operation. Once the tunnelling/ drilling is commenced in a drive, the Contractor will be held fully and wholly responsible for the successful completion of the tunnel excavation and retrieval of the shield from the receiving shaft or for completion of pilot bore and hole enlargement upon back-reaming. In the event of inability to complete the drive, due to machine break down, non-favorable geology or any other reasons, the Contractor shall be fully responsible to recover the equipment safely from the ground and restore the incomplete work to the original condition at his risk and cost by a method approved by the Engineer and the concerned authorities within time stipulated by the Engineer or the concerned authority.

It shall be clearly understood by the Contractor that the occurrence of such an event is preventable as such an occurrence is generally due to Contractor’s negligence in the “preventive maintenance” of the equipment or driving of it to true level and gradient or his failure to determine accurately the expected ground conditions before commencement of the excavation.

The Contractor shall in his submittal clearly state the measures that he would implement to retrieve the shield without causing interruptions to railway or road traffic etc and without causing any damage to the property belonging to the PWD or Railways/ MCGM etc. The cost for such retrieval measures or any consequential expenditure or delays arising from thereof shall be entirely borne by the Contractor. Any failure to remedial measures shall be entirely at the risk and cost of the Contractor.

Any abandoned hole or tunnel must be grouted completely at the Contractor’s cost so as to prevent subsequent settlement.

4.16 Effect of Approval and Acceptance of Proposals

Approval or acceptance by the Engineer of any proposal for executing the Works, including drawings, specifications or resources employed under the Contract shall not relieve the Contractor of his responsibility for any errors thereon and shall not be regarded as an assumption of risk or liability by the Corporation. The Contractor shall have no claim under the Contract on account of the failure or partial failure or inefficiency of any plan, method of work or equipment approved or accepted by the Engineer. Such approval or acceptance shall be considered to mean only that the Engineer had no objection to these proposals.

Notwithstanding any approval or acceptance by the Engineer, the Contractor shall remain fully responsible for completing the Works correct in every detail.

4.17 Schedule of submittals

Sr. No	Clause Number	Description	Schedule of submission
1	4.2	Contractor’s method of construction.	Along with the e-tender

2.	4.3	Geotechnical profile along pipeline route.	Within 30 days of commencement date.
3.	4.4	Jacking pipe design	Along with the e-tender.
4.	4.5	HDD System.	Original submission along with the e-tender and any changes necessitated by the geotech investigation shall be submitted within 7 days of submission of geotech profile.
5.	4.6	Site layout	Within 14 days of commencement date.
6.	4.7	Existing pipeline levels, locations of shafts and new pipeline alignment.	Within 14 days of commencement date.
7.	4.8	Jacking & Receiving shaft design.	Along with the e-tender. Any changes necessitated by the geotech investigation shall be submitted within 3 days of submission of geotech profile.
8.	4.9	Approval from authorities.	Within 14 days of commencement date
9.	4.10	Buried Services & obstructions.	Within 14 days of commencement date
10.	4.11	Monitoring of Ground settlement & up heavel.	Along with the e-tender
11.	4.12	Safety.	Along with the e-tender
12.	4.13	Quality assurance/Central plan.	Along with the e-tender
13.	4.14	Contractors Personnel	Along with the e-tender
14.	4.15	Remedial measures.	Along with the e-tender

PART 5 : PRODUCTS

5.1 Standards and Codes

Except as otherwise stipulated in this Specification and in the MCGM's Standard Specifications, all materials and workmanship shall comply in all respects with requirements of such standard and specifications, codes and other standards issued by the Bureau of Indian Standards (BIS) and current at the date of bid as may be applicable to any part of the Works of this Contract. In the event there being no relevant Indian Standard Specification, other relevant standard, specification, current at the date of bidding such as the British Standards Institution, American Society for Testing Materials (ASTM), German Standards (DIN), Japanese Standard for Water and Sewerage (JSWAS), Standard Association of Australia (AS), or Singapore Standards (SS) and or of the or any other equivalent standard approved by the Engineer shall apply. If after the date of invitation to Bid there is an amendment to a standard specification relevant to the Contract, the Engineer will direct whether the amendment is to apply.

In the event of there being any conflict between this Specification, the Drawings and any Standard Specification forming part of this Contract, this Specification shall take precedence over the drawing, MCGM's Standard Specification, codes and other standards in that order of precedence.

5.2 Selection of Microtunneling Equipment

The contractors shall be responsible for the selection of a suitable micro tunnel boring machine capable of excavating the materials including hard rocks, soil and mixed ground that may be encountered at the sites.

The contractor shall ensure that geological and geotechnical information he obtains or possesses for the site is adequate to accurately determine the types of soil and rock that may be encountered during execution of the project. The contractor is deemed to have carried out sufficient geological and geotechnical investigation of the sites and testing of the soil and rock (to determine compressive strength, tensile strength, abrasivity, cuttability, mineral make up of the rock etc as may be necessary to determine the ability to successfully tunnel through the ground) as necessary at his own cost before the selection of the microtunneling system.

The contractor shall also ensure that the microtunneling system he selects for the project shall successfully excavate in the wide ranging ground conditions from clayey and sandy strata with boulders and loose / fractured rocks to very hard rocky strata including mixed face conditions, that may be encountered at the sites.

Contractors shall pay particular attention, when selecting the tunnelling equipment for the project, to ground water level fluctuation and the wide ranging subsurface soil strata from clays, sands, gravels, soft soils with boulders and loose rocks to basaltic hard rock that may be present at the sites. The tunnelling equipment selected for the project shall have appropriate cutter head equipped with suitable cutter bits to excavate soils and rock below the water table.

The tunnelling equipment shall be capable of balancing the ground water pressure supporting the excavated tunnel face at all times. The equipment shall be articulated to enable remotely controlled steering, in both the horizontal and vertical directions. It shall be capable of preventing rotation and rolling movement of shield's body during the drive. The tunnelling equipment shall, interalia, have the following features.

(a) Able to excavate and crush very hard rock formations, loose rocks, boulders of unconfined compressive strength in excess of 350 Mpa with no requirement for replacing the cutter head or bits and other components when geological and geotechnical conditions change during a drive. The compressive strength mentioned above shall not be construed as the maximum anticipated and the contractor shall be solely responsible for selection of appropriate equipment. The MTBM shall able to cut through rock having high tensile strength, elasticity, hardness and abrasivity.

(b) Capable of providing positive face support and capable of controlling heave and settlement by proper operation to acceptable tolerances.
(c) Powerful cutter head, capable of exerting large and/or surging torque to break up rocks and boulders.
(d) Powerful crushing force, preferably with eccentric radial motion of the crushing device, capable of crushing gravel, boulders and rock.
(e) Equipped with suitable steering and guidance system that ensures easy steering control and articulated to enable controlled steering in both directions.
(f) Equipped with a suitable lubricating system arrangement for injecting lubricant around the exterior of the pipe being jacked.
(g) Ability to provide for an Intermediate Jacking Station, if needed.
(h) Capable of controlling rotation
(i) Instrumentation to measure deviation from the designed level and grade, rolling and pitching of the equipment, cutter head torque and its percentage to the maximum torque, rpm, jacking thrust, jacking speed, tunnel face pressure, steering jack extension & their pressures, slurry pump flow rate, pressures of slurry systems and rate of advancement, Installed length etc. preferably with a computerised data logging and printing facility.

The microtunneling equipment proposed for the project shall meet the above mentioned criteria or otherwise it will not be permitted to use in the project.

5.3 Concrete Jacking Pipe (NP- 4 Class& Above)

The pipes for jacking operation may precast reinforced concrete pipes or other approved pipes. The concrete jacking pipes shall be manufactured by a centrifugal or vertical casting process to be approved by the Engineer. Design, manufacture and factory testing of the pipes and specials shall be to A.S. 1342 or S.S 183 or JSWAS A-6-1989/A-2-1973, ASTM C76M or other acceptable standard and shall also meet the basic requirement specified in I.S 458 & I.S 3597 or its equivalent standard as amended up to-date . The clear cover of concrete over steel reinforcement on the wet face shall not be less than 50mm.

The outside and inside diameters of the pipe shall be such that they match the dimensions of the tunnelling equipment or vice versa. The standard length of the pipe shall be 2.5m. However the length of the pipe shall be shortened if desired by the contractor to suit the site conditions subject to the Engineer’s approval.

Precast concrete pipes, if manufactured locally by the Contractor, shall be manufactured using Batch Mix Concrete of required grade. Complete details of the Batch of concrete like its Grade, WC ratio, maximum aggregate size, additives shall be maintained for each batch. Six cube samples shall be taken from each batch and tested for 7 & 28 days compressive strength in a laboratory situated at factory or any institution approved by the Engineer. If the tested cubes fail the requirements, the finished pipe shall be liable for outright rejection after confirmation from NDT test results.

The Engineer’s representative shall have full authority to inspect any material or finished product and reject the same if not found conforming to the standards. The Contractors shall make his representative available to the Engineer’s representative during such inspections and testing failing which the Engineers representative shall be at liberty to take ex-party decision which shall become binding upon the Contractor.

The pre-cast reinforced concrete pipes shall be sufficiently reinforced with steel to withstand all stresses induced by handling, jacking, earth and water pressures and all working loads at the depths at which they are to be used without cracking, spalling or distortion. The pipes shall be of at least strength Class NP4. A load factor (for the maximum jacking force) of not less than 2.0 shall be used in the calculations to determine the strength of the pipes required. The strength of the pipes shall be tested by the three edge bearing test. When subjected to the design load in such a test, the load required to produce the crack width of 0.25mm on the pipe shall be in accordance with IS Code 458. All such tests shall be carried out at the expense of the Contractor at pipe manufacturing unit or any other institution as suggested by the Engineer and Engineer's representative will witness the test. The frequency of the Three Edge Bearing test shall be at least once in 3 months or every 75 pipes or part thereof for each diameter.

When designing the jacking pipes, the contractor shall take into consideration jacking load, pipe stiffness, corrosion resistance, flexibility, durability, joint efficiency etc. The Contractor shall submit full details of his proposals for the pipes, giving detailed drawings showing sizes, reinforcement and type of joints, calculations, together with the name of the proposed manufacturer, the place of manufacture and the manufacturing process to the Engineer for approval along with a consent letter from manufacturer of the pipes from such manufacture. All workmanship and materials used in the manufacture shall be subject to the approval of the Engineer who shall be authorized to inspect materials at source and the manufacturing processes in the factory at any time.

Contractors shall allow for eccentric loading in the pipe, rather than an axial loading, during the installation of the pipe. The Contractor shall take precautions to minimise the resultant pipe stresses in a jacking pipe and to achieve a trouble free jacking operation. The eccentric loading shall account for maximum steerability.

The contractor shall make provision in contract either to manufacture for jacking pipes, in Mumbai as per specifications or procure them suitably. He shall provide information on contractors jacking pipe manufacturing or procurement capability along with his bid. In case of procurement from manufacturer, the contractor shall allow sufficient time for import & clearance of the consignment from various authorities and delivery to the site as applicable.

(a) Pipe shall be straight and uniform with square ends. The joints shall be well formed to allow efficient transfer of jacking load from pipe to pipe.
(b) Pipe joint shall be fitted with compressible packer for better distribution of jacking load.
(c) The jacking frame, jacks and steering head shall be properly aligned along the designed alignment and grade and the whole assembly shall be square and at right angles to the thrust wall

Steering corrections shall be made gradually to minimise abrupt misalignment angles between the pipes.

The pipes should be provided with well-formed arrangement for groove for rubber gasket.

The pipes which are to be used in the construction of the works shall be sufficiently cured before they are brought to the site of the Works. They shall be handled with extreme care to prevent the edges of the pipes from chipping. The pipes shall be stacked in shade or adequately protected from severe sunrays. The Engineer may reject any pipes he considers not suitable for the Works and these rejected pipes shall be removed from the site immediately. After factory testing and before despatch, every pipe shall be marked in accordance with the Standard used. In addition, each pipe shall be marked with a number corresponding with the order of manufacture and date of manufacture and Grade of Concrete. Test certificates from the manufacturers or other relevant authority shall be submitted to the Engineer.

Some of the sites may have limited or restricted storage space for stacking of jacking pipes. The Contractor shall therefore schedule the supply of pipes to the sites in such a way that only absolute minimum numbers of pipes are brought to the site at a time.

5.4 Pipe Joints

The jointing arrangement for the jacking pipes is crucial in terms water-tightness, flexibility and smooth transmission of jacking force. Spigot ended jacking pipe with recess to receive rubber rings and steel or stainless steel couplings (collars) or other acceptable joints shall be used in pipe jacking application. The spigot and socket joints shall be flush from outside as well. The contractor shall submit joint details to the Engineer for approval.

5.5 Rubber ring joints

The joint rubber rings supplied and installed shall be of the Cornelius rubber ring type or similar approved and shall be capable of accommodating 2 degree deflection at each joint. Joint rings shall meet with the latest edition of I.S. 5328 and B.S. 2494 part 2 or be of approved quality by the Engineer. The properties of the joint ring shall be between those specified in BS 2494 for grade D and grade B.

The testing of rubber ring shall conform to IS. 3400 and also IS. 5382.

The Contractor shall indicate the grade of rubber rings he intends to use and submit samples for approval prior to incorporation in the Works. The grade, type or source of supply of rubber rings shall not be changed without the written approval of the Engineer.

5.6 Pipe Couplings (Collars)

Where pipe couplings (collars) are used for pipe joints, it shall be made of weldable structural steel top BS 4360 Grade 43 or equivalent I.S. The steel coupling shall be of such dimension and thickness so that when inserted into the pipe, it fits exactly into the recesses in the pipe. The joint so formed shall be watertight. The joint details shall be approved by the Engineer. Before fitted to the pipes, the collars shall be coated with approved anti-abrasive and anti-corrosive materials such as polymorphic resin or other materials as approved by the Engineer. However, all collars in case of works across railway tracks shall be of stainless steel only.

5.7 Compressible packers.

Suitable compressible packers shall be used at the joints for distributing the jacking force evenly through the wall of the jacking pipes. Uneven transfer of jacking force from a pipe to another will result in concentrated and excessive stresses in the pipe which can cause the pipe to crack. Contractor shall submit details of the compressible packers for Engineers approval.

5.8 Identification of pipes, rubber rings etc

Every pipe made shall be clearly and indelibly marked upon it an identification number, class, batch of concrete, diameter and date of manufacture. Every finished pipe shall be tested for dimensional conformity and non-destructive testing with Schmidt Hammer or any other method as approved by the Engineer. Full records are to be maintained of each pipe test and for each individual pipe the date manufactured, cleared after testing and supplied.

If the pipes are to be procured from a manufacturer, the Contractor shall make arrangements for visits of the Engineer’s representatives for inspection and testing as and when deemed necessary by the Engineer. All expenses in connection with such visits shall be borne by the Contractors. After the satisfactory completion of testing and approval of the pipes by the Engineer the pipes shall be stored at factory premises during the period awaiting delivery.

No pipe shall leave the manufacturer’s yard for the site unless it is tested.

5.9. All works to be water tight

(a) The drains, manholes and all joints of pipes must be made thoroughly sound and water tight, and any joint which may be proved to be leaky at any time during the progress of the works or during the contractors' subsequent period of maintenance shall be immediately made sound by the contractors at their own expense. The contractors, when required by the Engineer shall at their own cost prove all works to be water tight by filling it with water to such height as the Engineer may determine. Any additional precautionary measure or appliances that may be found necessary to ensure the water tightness of the manholes, flush tanks, disc plug in junctions and the joints of pipes shall be adopted by the Contractor without extra charge, the responsibility of making them completely water tight resting upon the contractors.

(b) Immediately after the test with the double disc or cylinder as mentioned in clause No. 7.5.9 (a) has been completed and any defect hereby disclosed have been made good the Contractor shall prove the joints of the stretch of under-ground pipes whether of stoneware, cast iron or R.C. Pipes, to be water tight by filing in pipes with water before filling in the trench to the level of 1.50 M above the top of the highest pipe in the stretch and heading the water up for the period of one hour or such further time as the Engineer may direct. The apparatus used for the purposes of testing shall be approved by the Engineer. The contractor if required by the Engineer shall make the excavation dry and keep it so during the period of testing. No test applied to part of a stretch of pipes shall be considered conclusive nor shall it be deemed to obviate the necessity of an application of the test to the whole of stretch when completed. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes and noting the quantity required to maintain the original water level. For the purposes of this test the average quantity added should not exceed 1 litre/hour/100 linear metres/10 mm. of nominal internal diameter (0.2 gallons/hour/100 linear feet/inch of nominal internal diameter.

Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

The manholes when they have been raised above the highest subsoil water level expected in the monsoon shall similarly be tested for water tightness as for the pipe lines. The procedure for this shall be as follows:-

The mouths of all pipes entering the manhole shall be suitably plugged with brick, masonry or wooden or any other type of plug. The manhole under test shall then be filled with water upto the general sub-soil water level and observed for a period of one hour. If the level does not drop by more than 50 mm. in one hour it shall be assumed that the manhole is water tight.

During the period of the test the outside trench shall be kept free from any accumulation of subsoil water in case of a drop of more than 50 mm in the water level the contractor shall note the places from where the leakage is taking place & take steps to stop the leakage.

For R.C. pipes having diameter 1200 mm or more thorough visual inspection of inner side of pipe shall be carried out with a trained eye.

(c) Cleaning of the pipes : As soon as a stretch of pipes whether of stoneware or Cast iron or R.C. Pipes has been laid complete from manhole to manhole, the Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm. less in diameter than the internal diameter of the pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

(d) If as a result of the removal of any obstruction the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the length to be retested at the expense of the Contractor. Should such retest prove unsatisfactory, the contractor shall at his own expense amend the work and carry out such further tests as are required by the Engineer.

(e) It shall also be ascertained by the Contractors that each stretch from manhole to manhole is absolute clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

5.10 Fracture of pipes

a) In the event of pipes being fractured after being to all appearances properly laid whether due to imperfect loads have been formed or the material for refilling have been improperly selected or to any other cause, the Contractor in every instance will be held responsible and will be called upon to replace such defective pipes at his own cost, if such defect appears before the expiration of the period of maintenance.

(b) Any pipe or length of pipes found to be defective shall be immediately removed and replaced at the Contractor's expense and leaking joints shall be remade, the inspections and tests shall then be repeated as often as necessary until the whole line under inspection or test is accepted by the Engineer.

5.11 All works to be clear, clean and perfect

The contractors shall after completion or whenever required by the Engineer, prove all pipes and fitting to be clear clean and perfect, and for this purpose shall, at their own expense and in the presence of the Engineer or his appointee, provide suitable instruments and appliances and pass them through the pipes and shall if required, throw in water and show that it passes freely through every portion of the work. Brick, mortar and rubbish shall not be allowed to fall into the manholes of sewer lines while fixing or if allowed, shall be removed by the Contractors at their own expense.

"During the cleaning operations of newly constructed sewer and manholes, contractors shall take for the safety of labourers, all precautions, as detailed in General Specifications Part II."

5.12 Tests on Jacking Pipes (minimum NP – 4 Class)

Factory Tests

One pipe out of every 75 pipes or part thereof manufactured for each diameter shall be tested for Three Edge Bearing Test in a laboratory at pipe manufacturing unit or at any institution approved by the Engineer at the Contractor's expense.

Every pipe shall be subjected to following dimensional conformity tests and the tolerance shall be within limits as indicated below-

Length

Pipe Dia in mm	Tolerance for all types of pipes in mm
1000 and above	+25

Perpendicularity of faces

Pipe Dia in mm	Tolerances in mm	
	RC Jacking pipe	Steel Jacking Pipe
Above 1000	8	1.6

Deviation from straight

Pipe Dia in mm	Tolerance for all type of pipes in mm
Above 1000	±10

Deviation from pipe dia

Pipe Dia in mm	Tolerance for all type of pipes in mm
Above 1000	+0, -16

PART 6: EXECUTION

6.1 Information for the execution of works

Where specified in the Drawings and Bills of Quantities, sections of the pipeline shall be laid by microtunneling and pipe jacking or other method approved by the Engineer. The word tunnelling in this Contract implies microtunneling and pipe jacking

The Contractor shall be responsible for inspecting the sites and familiarising himself with the conditions under which the work will be performed and with all necessary details including geotechnical investigations and buried services location as to the orderly and successful execution of the work. The omission of any details shall not relieve the Contractor of full responsibility for the satisfactory installation of the work in its entirety. No monetary or other claims made by the Contractor on the grounds of want of knowledge will be entertained by the Corporation.

Plans and details of the equipment, materials and the method of construction to perform and complete the work shall be submitted by the Contractor and must be approved by the Corporation during the e-tendering stage and also by the Engineer during the construction stage before commencing these operations. Approval by the Engineer shall not relieve the Contractor of his sole responsibility for the efficiency, reliability, and soundness of the method employed in completing the work in a satisfactory manner.

The contractor is advised that it shall be his sole responsibility to ascertain for himself the extent of work that is required to be done in site and to generally obtain his own information on all matters affecting the execution of the whole of the works involved in this contract to the entire satisfaction of the Engineer. No claim of extras in consequence of any alleged ignorance in any aspect will be entertained by the Engineer. It must be clearly and definitely understood that the contractor shall be held solely responsible for making all necessary arrangements and co-ordinating with all relevant Authorities, Specialists, Sub Contractors, etc to ensure satisfactory and timely completion of this contract.

6.2 Execution of works-General

The Contractor shall be fully responsible for the design and construction of the jacking/ launching and receiving pits, thrust wall, installation of jacking equipment, installation of any other equipment, sheeting/ shoring, bracing, etc., and for the efficient execution of the work. Full details of his proposals, including plant, Micro Tunnel Boring Machine (MTM), ancillary equipment, operating procedures, jacking pit and intermediate jacking stations, rock cutting tools, repair of leakage etc. shall be submitted to the Engineer, and shall be fully satisfactory to him before construction. However, review of the plans shall not relieve the Contractor from his responsibility to provide a safe and satisfactory arrangement.

The Contractor shall be required to monitor closely the progress of the tunnelling/ jacking and drilling operation. Daily manual logs or site records of thrustingpressures, cutter head face pressure, torque, bentonite injection rate and the line and level measurements, pitch, roll, slurry system flow rates & pressures, steering jack readings, rate of boring etc. shall be properly maintained in addition to any computerised data logging and shall be available to the Engineer’s representative at all times. Such records shall be duly signed by the Contractor’s site in-charge. If the Contractor fails to maintain and produce such details before the Engineer’s representative on site, the Engineer’s representative may order suitable steps including suspension of the work without prejudice to any other rights of the Engineer. The Contractor shall be solely responsible for such actions ordered by the Engineer’s representative.

It is the responsibility of the Contractor to ensure that the completed tunnels are watertight. If leakage occurs before completion or during the maintenance period, the

Contractor shall carry out any remedial work that may be necessary to make the Works watertight all at his own expense.

6.3 Location and verification of buried services.

The Contractor will be held solely responsible for making his own investigations of any buried services in the vicinity of the Works and to protect them from getting damaged due to his work. Contractor shall allow in his rate for any extra costs for detecting all obstructions and buried services including appropriate measures to protect the services and temporarily divert the same in consultation with the concerned agency with its prior approval regardless of whether they are indicated on the drawings or not. It shall be the Contractor’s responsibility to obtain any permission from such agencies. The Engineer/ Employer may issue necessary recommendation letters if required.

The contractor shall engage at his own cost a competent service detecting technician or agency who shall have state-of -the -art detecting equipment to locate and verify all the buried services such as pipeline, water, telecom, electricity, gas and all other services, and abandoned services and structures well ahead of commencing the works.

The detector shall be able to receive narrow signal responses from buried services in order to pinpoint the position and direction of the services. It shall also be able to pick up the position and direction of different services in congested area and detect the buried services regardless of almost any environmental interference.

Combination of Ground Probing Radar (GPR) and Electromagnetic Location (EML) testing is considered effective for locating the underground utilities and buried objects. The lines tested using GPR and anomalies located using EML shall be topographically surveyed using a Total Station / Theodolite at the same time as the geophysical testing is carried out.

The information so collected shall be submitted to the Engineer after getting it confirmed from the respective agency in accordance with clause 4.10. It shall be clearly understood by the Contractor that no work shall be carried out without locating all the buried services and he will be held solely responsible for any consequential expenses and delays if he ignores this specific requirement or fails to locate any services along the route.

The Contractor shall take every precaution that in the opinion of the Engineer and as advised by the owner of the utility is necessary for the protection from injury of all existing and proposed water, drain, pipeline and other pipes, electric, optical fibre and telephone conduits, and other existing works, roads and services wherever encountered or which are adjacent to the works, and to maintain the same until in the opinion of the Engineer the general progress of the work renders further protection unnecessary. All damage occasioned by the Contractor to these works and services shall be repaired at once at the Contractor’s risk and cost, as directed by and to the satisfaction of the Engineer.

All the buried services shall be investigated / located as per the above requisite conditions and their location shall be plotted on drawings to be submitted to the Engineer. No extra payment will be admissible in this regard.

6.4 Site investigation

The Contractor’s site investigation for microtunneling or any other acceptable trenchless technology work shall be critical and the most important engineering work to be carried out before commencement of work on site. The contractor shall clearly understand the importance of establishing the subsurface ground conditions and their range of variability along the pipeline route well before embarking on the actual works. There should not be any room for unforeseen ground conditions and is absolutely necessary for the Contractor to know what is to be encountered during the tunnelling operation. The contractor shall be deemed to have accurately established the types of soil and rock strata along the tunnel bore and their range to enable him to select the equipment / machines and to set-up and operate correctly.

6.5 Subsurface investigation

The subsurface investigation shall includes study of all existing geological and geotechnical information for the area including the information pertaining to the project and the location maps of all the services in the area from the utility companies/authorities for initial planning. Data on abandoned and existing obstruction, foundation, piles and the structures in the vicinity of the alignment shall be also collected. Field survey using utility services locator and trial trenches may also be carried out to verify the location of the services and obstructions.

The effect of microtunneling through contaminated geotechnical conditions should be taken in to account, where potentially contaminated soil and / or ground water have been identified during the investigation process. A contingency plan identifying methods for handling contaminated soils shall be submitted for Engineer's approval.

Mapping out of the subsurface soils/rock profile along the pipeline alignment and locating underground utilities and buried objects by geophysical testing such as the combination of Ground Probing Radar (GPR) and Electromagnetic Location (EML) testing is considered useful in determining the nature of ground to be encountered. Investigations may include documentary survey; bore logs, geophysical investigations, in situ & laboratory soil / rock tests. Various geophysical investigations include but not limited to Ground Probe Radar (reflection of electromagnetic waves), Radio Magnetotellurgy (measurement of resistivity in electromagnetic field of a radio transmitter), Electrical Method (measurement of apparent resistivity by injection of direct current and measurement of potential difference), Seismic Refraction (refraction of seismic waves on layers at speed increasing with depth), Seismic Reflection (reflection of seismic waves on contrasting interfaces), Microgravimetry (local variation in gravitational field to detect cavities).

The Contractor is deemed to have allowed for any extra costs in his rates and to be aware of similar state of the art ground probing/mapping technology currently available on the market and to have made provision for its use in the project as part of his subsurface investigation works.

The contractor shall be deemed to have in possession of all the information and data required to accurately evaluate the subsurface conditions before commencement of any works.

6.6 Geological and geotechnical evaluation.

The contractor shall allowed for any extra costs in his rates to carry out full geotechnical investigation along the proposed alignment of sewer line, as necessary for microtunnelling operations including delivery of core samples to the Engineer in properly indexed core boxes and submission of report (5 copies) to the Engineer. No extra payment shall be admissible in this regard. He shall also obtained, studied and evaluated all the geological and geotechnical data for the sites including any data if available with the corporation for the sites and made his own judgement and conclusion on the types of soils and rock to be excavated along the pipeline route. The Contractor must supplement this information possessed by him with appropriate geotechnical investigation prior to selection of appropriate tunnelling/ drilling machinery.

The applicant shall inform himself thoroughly and make his own deductions as to the nature of the materials to be excavated, the difficulties of making and maintaining the required excavations and of doing other work affected by the geology of the Site and shall accept full responsibility thereof.

6.7 Bore logs and ground probing

Sufficient numbers of boreholes shall be taken by the Contractor, if deemed necessary, in areas where the soil strata are complex. The contractors shall also carry out simple probing techniques at closer interval to reaffirm the types of soils to be encountered along the pipeline route. The Contractor should submit Geotechnical profile along the route of the pipeline and buried services data for particular work package as per the schedule for submittals.

The Contractor shall collect soil/ rock samples at the level of the proposed pipeline in presence of the Engineer’s represent and get the same tested for sieve analysis, cohesion, angle of internal friction, ground water level, Unconfined Compressive Strength (UCS), abrasivity etc. in the Municipal laboratory or at any laboratory approved by the Engineer. Samples taken in absence of the Engineer’s representative and tested in a laboratory not approved by the Engineer shall not be valid for determination of the any parameters.

6.8 Groundwater investigation.

Ground water condition is one of the critical data required when selecting the microtunneling system. Ground water affects the safety of the excavation face, start and exits of the tunnelling/ drilling equipment from the shafts .Uncontrolled extraction of water from the surrounding during excavation can affect the adjacent structures. Piezometric pressure, water leakage, ground water level and etc shall be carefully checked before and during tunnelling/ drilling works.

6.9 Ground stabilisation

It shall be the responsibility of the Contractor to maintain stable soil conditions at the jacking face to prevent loss of ground above the jacking operation and movement of the surrounding earth. The methods of maintaining face stability and preventing ground movement and subsidence shall be by means of fluid slurry or earth pressure applied to the tunnel face. Alternatively, unstable ground ahead of the jacking face may be stabilised by the injection of suitable chemicals. Methods which require dewatering of the ground will not be accepted, nor will methods which may lead to significant ground loss.

Movement or settlement of structures, railways, utilities and pavement shall be monitored by the Contractor during the microtunneling operation and reported to the Engineers and railway or highway authorities.. The Contractor shall make provision to install peizometers, settlement plate etc within railway compounds in his rates for pipe installation If movement or settlement occurs, especially within the railway compounds, which in the opinion of the Engineers may cause damage, the Contractor shall take immediate action to prevent further movement, settlement or damage. The Contractor shall repair at his risk and cost any damage and restore structures, railway lines and pavements to the satisfaction of the Engineer. The contractor shall pay expenses if the owner or concerned agency such as Railway elects to carry out such repairs by themselves.

6.10 Setting out

The Contractor shall be deemed to have thoroughly examined the sites, the location of the buried services, geological profile, availability of space for footprint, traffic management thereat, access to sites &etc and adjusted the pipeline alignment as deemed necessary and obtained approval of the final pipeline alignment from the Engineer before commencement of the setting out. He shall set out and mark on the ground the proposed pipeline route and the locations of the jacking and receiving shaft and the area they occupy for the Engineer’s inspection and approval. The Contractor shall be solely responsible for the accuracy of the setting out and any expenses or delays arising from errors made in the setting out shall be borne by the Contractor. Any consequential work or abortive work carried out by the Contractor to rectify the errors shall be entirely borne by the Contractor.

6.11 Site layout

The working space at the sites is often restricted and hence the site layout has to be planned carefully in advance to set-up the equipment and accessories.

6.12 Construction of Jacking and Receiving Shaft

The excavations for Jacking or Receiving shafts may be used for construction of manholes or valve chambers if required. The Contractor shall submit to the Engineer for approval dimensioned drawings and calculations of the timbering or trench sheeting details for the shafts. Each shaft shall have a separate ladder bay for access which shall be isolated from the part of the shaft used for hoisting materials. The shaft trenching shall be watertight and shall prevent any pressurised slurry from the tunnel face reaching the shaft.

Soil improvement methods that can be used include grouting, ground freezing, and dewatering. If the ground consists of unstable soil, the same may be stabilized by vibro / dynamic compaction, by compressed air for sandy soils and by ground freezing, preloading, lime treatment for clayey soils. In certain instances, ground treatment or groundwater management methods may be required to enable the construction of the shaft to proceed. These include well pointing and deep wells, Compressed air, Suspension grouts, Chemical stabilization, Ground freezing. There are various shaft construction method alternatives, Liner plates, 2-flange steel liner, horizontal metal sheeting, sloping or battered excavation, trench boxes, slide railing system, soldier piles with timber lagging, soldier piles with steel lagging, steel / concrete / RCC sheet piles, CMP shafts, concrete sinking shafts, precast concrete segments, concrete slurry walls, Pre-cast or cast in- situ caissons, Rock anchorage rods and tensioned rock bolts, metal straps, un-tensioned steel dowels, Wire mesh with guniting and ground freezing. No extra payment shall be claimed by the contractors for carrying out soil improvement / stabilization, or shaft shoring techniques as mentioned above other than BOQ items.

The Contractor shall submit the design and construction details of all Temporary Shafts andtheir proposed locations along the tunnel alignment to the Engineer for acceptance. The submission shall also include details on shoring system, entry and exit arrangement ,thrust wall layout and design details, general layout of guide rail and jacking table arrangement etc. Temporary Shaft drawings are to include but not limited to:

1. Launch/jacking and reception shaft configurations.
2. Design and construction of launch/jacking and reception shaft.
3. Details for excavation and backfilling procedures, ground support systems, and ground stabilisation if required.
4. Special requirements for jacking and receiving shaft penetrations, thrust blocks, backstops or other reactions required for Microtunnelling, casing pipe jacking or any other jacking.
5. Full calculations supporting maximum jacking capacity that jacking shafts will withstand
6. Dewatering and ground water control plans for all temporary and permanent shafts.

The shaft shall be kept dry at all times and shall have a drainage sump to pump out the ingress water. The Contractor is deemed to be fully aware of the serious consequences to the tunnelling equipment and other accessories if the shaft is flooded. He shall take every precaution to avoid flooding in the shaft. The shaft shall be well protected against surface runoff getting into the shaft. The contractor shall be solely responsible for any consequential delays and expenditure arising as a result flooding the shaft.

The shaft floor shall be designed to withstand the tunnel machine and other accessories and shall be designed to withstand uplift forces.

The Contractor shall be solely responsible for providing and subsequent removal of shoring to the shafts or pits and ensuring stability of the sides of such excavations and safety of adjoining structures.

The sizes of the shafts shall be kept as small as possible considering site constraints.

Equipment manufacturer's data on required shaft sizes shall be furnished to the Engineer along with the bid. The sizes of pits shall take due cognizance of available space needed for jacking frame, shoring or feed pumps or other ancillary equipment, thrust wall and entrance ring.

6.13 Construction of Thrust Wall

Thrust wall shall be designed and constructed by the contractor to the approved details. The thrust wall shall be of MS plate, reinforced or unreinforced concrete constructed against the wall of the jacking shaft. The Contractor shall ensure that the thrust wall is constructed as an independent structure and it shall not interfere with the jacking shaft or the floor when jacking force is applied on to it. Contractor shall indicate in his submittals the construction details of the thrust wall showing details on how the wall be made independent of the jacking shaft structure.

The contractor shall ensure that the thrust wall and the soil behind are in complete contact and there is no gap between them. The contractor shall further ensure that the thrust wall shall effectively transfer the jacking force on to the soil behind and that the ground behind is capable of withstanding the jacking force.

In the event that there is gap between the thrust wall and the soil behind, the Contractor shall arrange the gap to be filled with approved cement grout before loading the thrust wall.

6.14 Installation of Guide Rails

The contractor shall design and fabricate the guide rail / Jacking frame in accordance with the microtunneling equipment manufacturer's details and install it firmly onto the floor of the jacking shaft. He shall ensure that the guide rail / Jacking frame is installed to the correct grade, levels and alignment. It shall be also square to the pipeline alignment at all times and not disturbed due to forces arising from the jacking operation. He shall arrange with the Engineer's representative to check the level, alignment etc of the guide rail and obtain the Engineer's endorsement before commencing guide the pipe jacking work.

6.15 Entrance and Exit Arrangement

One of the most critical microtunneling operations is the launching and retrieval (entry and exit) of the microtunneling machine. Often this process takes place well below the water table. In those cases, it is critical that the contractor implement adequate engineering measures including stabilisation of unstable soil by grouting or other means to prevent soil and water inflows into the shaft.

It is common practice to install a rubber seal at the entry and exit. The seal is to prevent the flow of ground water or lubricant (used for reducing the frictional resistance) through the shield/pipe entry opening on the shaft wall.

An exit ring must be provided without exception if the strata at the level of exit happens to be loose.

The contractor shall plan this work well in advance and fabricate the fittings and rubber seal as per approved method.

6.16 Soil Stabilization at the Tunnel Entry and Exit.

In addition to the seal, it may be necessary to stabilize the soil behind the entrance wall. This is to prevent any free flow of unstable soils into the pit when opening is made for the shield to enter into the ground. Chemical grouting, cement grouting, jet grouting, piles, ground freezing or temporary shoring are some methods commonly used by the contractors to prevent the soil flow into the shaft.

6.17 Cement Grouting

The Contractor shall be fully responsible for preventing the occurrence of voids outside the pipe and if they occur he shall fill them with cement grout. Immediately following the jacking operation the Contractor shall pressure grout the jacked section to fill all voids existing outside of the pipe. Grouting shall be from the interior of the pipe through grouting holes as specified. The grout mix shall be at least of CM 1:3.

Systems of standard pipe, fittings, hose, and special grouting outlets embedded in the pipe walls shall be provided by the Contractor. Care shall be taken to ensure that all parts of the system are maintained free from dirt. Grout composed of cement, sand and other approved compound and water shall be forced under pressure into the grouting connections at the invert and shall proceed until grout begins to flow from upper connections. Connections shall then be made to these holes and the operation continued to completion.

Apparatus for mixing and placing grout shall be of a type approved by the Engineer and shall be capable of mixing effectively and stirring the grout and then forcing it into the grout connections in a continuous uninterrupted flow.

After grouting is completed, pressure shall be maintained by means of stop cocks, or other suitable devices until the grout has set sufficiently. After the grout is set, grout holes shall be completely filled with dense concrete and finished neatly without evidence of voids or projections.

6.18 Jacking System

The hydraulic jacking system shall be installed against a purpose built thrust wall in the jacking shaft. The substantial force required for jacking pipes and the tunnelling machine shall be provided by high pressure jacks driven by hydraulic power packs. The ram diameter and stroke of the jacks may vary according to individual contractor's technique and to suite site conditions.

The jacks shall be mounted on specially made frames so that the jacks are square to the pipe alignment. The jacking frame shall be firmly supported to the floor so that it does not move during jac

There are jacking systems with multiple strokes or long stroke (3m or 2.43m long), mounted on a specially made jacking frame available to push a full length pipe in a single setting. The system does not require the use of spacers and hence a substantial increase in productivity can be achieved by using multiple stroke jacking system.

6.19 Jacking force.

The Contractor shall calculate the expected jacking load for each microtunnel drive well ahead of designing the jacking pipes. Accurate estimation of the jacking load is necessary to determine the pipe wall thickness, the need for intermediate jacking stations and lubrication requirements, types of jacking system and thrust block design. The overall jacking force depends on the type of surrounding soil, depth of cover, pipe materials, diameter and the overall length of the pipeline. The total jacking force essentially consists of two components, "Frictional force around the pipeline" and the balancing force at the tunnel face called "Face Pressure". The Contractor shall use appropriate geo-mechanics formulae and guidelines for computing the jacking force. The contractor shall calculate the anticipated jacking force for each drive and submit his calculation to the Engineer for approval.

The Contractor shall be solely responsible to ensure that the pipes are not subjected to excessive jacking force or tortional force so as to crush them. If such thing occurs the contractor shall have to remedy the situation at his risk and cost.

6.20 Pipe Lubrication System

The boring machines are commonly designed to overcut about 10mm (in some cases up to 20mm) around the external diameter of the pipeline. The pipeline can, in theory, be jacked freely through a fluid medium by injecting a clay based (bentonite) or polymer based lubricant into this annulus. In practice, however, fluid losses may occur into the surrounding ground. The contractor shall carefully monitor the jacking force and use appropriate lubrication system, to bring down the jacking force within the allowable jacking force for the pipe.

6.21 Programme and Progress Chart

Within one week of the Date of Acceptance of the Bid, the Contractor shall submit a Construction Programme showing the time within which the various significant activities of the work will be executed and completed. External dependencies such as provision of access, drawing approvals and material and equipment supplied by others shall be identified in the programme. The programme shall make due allowance for public holidays etc.

The Construction Programmes shall be in the form of a critical path network set out to a time scale of working days and critical path of the Works as well as the interdependencies of the activities and available float shall be clearly indicated

The Construction Programme submitted to the Engineer shall be a construction programme under clause of the “General Conditions of Contract for civil works” of the corporation. The Contractor shall also supply a soft copy of the work plan in MS Project format to the Engineer.

A section of the overall work plan shall also be displayed at the site offices for each individual site packages and shall be updated every day at the beginning of the office hours.

Any departure from the works procedure as programmed shall first be discussed with and agreed to by the Engineer before implementation.

When required by the Engineer, and/or deemed necessary by the Contractor, an updated Construction Programme shall be prepared by the Contractor to incorporate any changes in the methods, times or sequence of activities, and to show the Contractor’s planned progress towards the Date of practical Completion. The level of detail required for the updated programme shall be as specified for the original Construction Programme.

Should the Contractor fail to comply with the provisions of this clause, notwithstanding the provisions of the conditions of the contract, the Engineer may withhold the issue of payment certificate next due and any subsequent payment certificates, until such time as the Contractor complies with the provisions of this clause.

6.22 Special Traffic Precautions

The Contractor’s attention is specially drawn to the requirements by the traffic police and road authorities and Specifications regarding Traffic Control, Access and the Reinstatement of road surfaces etc. It shall be the responsibility of the contractor to obtain permissions from traffic police and other authorities well in advance of the commencement of the works.

The Contractor shall obtain separate permission for each Works Package from the respective Senior Inspector of Police (traffic).

The Contractor’s progress/programme and road opening schedule must be arranged in details for discussion with the Engineer and the Traffic Police. The laying of pipelines must be broken into appropriate sections and where necessary special traffic diversions arranged.

Whenever carriageways are affected, the Contractor must arrange to contain the works within the narrowest possible area. Excavated material must be removed as the work proceeds or contained within the areas designated by the Engineer/ Traffic Police.

The Contractor shall carry out the work in such a manner as to cause minimum interference with the public use of highways, footpath and other thorough fares.

All workmen working on roads are required to wear approved retro-reflective vests at all times.

The Contractor shall include in his rates for compliance with all the conditions stipulated above.

6.23 Road Opening

Where manholes have to be constructed on existing metalled road, the Contractor is required to submit a detailed road opening schedule to the Engineer for approval. In case of works requiring breaking of concrete roads for shafts the Contractors shall provide for reinstatement of concrete road as per MORTH &Municipal specifications and guidelines in vogue for this purpose and the cost of same shall be deemed to be included in the rate of tunnelling. The contractor shall also provide for additional time for getting the necessary permission from C.C. Roads department in this regards.

The Contractor shall contain the works within the narrowest possible area when laying pipelines along metalled road. The Contractor shall keep the Site and all working areas in a tidy and workmanlike condition and free from debris, muck, rubbish and waste materials. Any Temporary Works, construction equipment, materials or other things which are not at that time required for use by the Contractor may, with the consent of the Engineer, be removed from the Site at Contractor's risk and cost or kept in the available stacking area in orderly manner. Stacking of pipes or liners outside the defined site areas for shafts shall not be permitted. The Contractor shall plan the logistics of pipes and liners with due consideration for the availability of stacking space.

Traffic flow must be maintained at all times along the roads affected by the work. Sufficient lighting, road signs, barricades and traffic diversion signs must be established along the sites of the works in accordance with the Traffic Police requirements and to the entire satisfaction of the Engineer.

The Contractor shall also comply with the conditions imposed by Traffic Police and Roads Opening Conditions and Requirements stipulated by Roads Department, MCGM or any other Authority.

Upon the completion of the pipeline or manholes, the Contractor shall backfill and make good all disturbances to the road, side table, road kerb and storm water drains to the satisfaction of the Authorities and the Engineer.

If required the pits shall be covered with decking plates with appropriate support so that all traffic shall be allowed to run over the decking. No extra payment shall be admissible for such arrangements and the contractor's rates shall be deemed to cover such requirement. If directed by the authorities or the Engineer, the Contractor shall construct temporary diversion roads at his own cost to allow the traffic to flow through during the construction.

6.24 Partial Covering up of Road in Busy Areas

Where it is unavoidable to locate manhole shafts or working shafts for tunnels in busy roads, the top of the openings shall be covered by decking, leaving only the minimum required area open at the top to carry out work within the shaft. Vehicles shall be permitted to travel over such covers provided. The Contractor shall submit to the Engineer details of the partial covering. He shall allow for compliance of this requirement in his rates.

6.25 Reinstatement of Road and affected Surfaces

The Contractor shall carry out the reinstatement of road foundation and road surface in accordance with the Specifications and requirements of the MORTH / Roads Department, MCGM. This shall include machine-paving as and when directed by the Engineer. Where road markings are affected, the Contractor shall reinstate with thermoplastic paintings to the satisfaction of Roads Department, MCGM. The Contractor shall include in his rates for compliance with all the conditions stipulated above.

The Contractor will be required to maintain in a clean, safe and tidy state the temporary reinstatement of trench and other damage surfaces in roads as specified previously until such time as the permanent reinstatement is carried out.

Permanent reinstatement must only be carried out on receipt of an instruction from the Engineer and the reinstatement will then be commenced within 3 days and completed as soon as possible. The Engineer may instruct the Contractor to reinstate the road intersections as the work proceeds.

The reinstatement must comply with all the requirements of the MORTH, PWD or MCGM. Any work not conforming in standard or meet the requirements of the Engineer or the concerned authorities must be immediately removed and replaced.

Should the Contractor fail to carry out all the required reinstatement works within 7 days of his being instructed to do so, the Engineer may arrange for the execution of the work at the expense of the Contractor.

On completion of the reinstatement the Contractor will be required to maintain all the road surfaces etc., affected for the full period of the Contract and Maintenance Period. All faults, settlement etc., developing within this period must be made good immediately upon receipt of an instruction form the Engineer.

The Contractor attention is also drawn to the fact that he will be liable for all claims for injury or damage arising from any defect in the reinstated road surface during the Contract and Maintenance Periods.

The Contractor shall allow for carrying out this reinstatement work in one or more stages; the maintenance of the reinstatement to the satisfaction of the Engineer; the provision of temporary surfacing, maintenance and subsequent breaking out and removal in the event of this being required for the reinstatement of carriageways; reinstating whatever widths shall have been taken out and any additional width the Engineer considers require reinstating due to the Contractor’s operations or to subsidence or traffic; any expense incurred in carrying out the work in short lengths or in stages.

The Contractor shall also allow for the complete reinstatement of all surfaces damaged in side-tables, and all Private or Government’s or Corporation’s Lands to approval of the Engineer and generally to a condition at least equal to the original ground surface before the Works commenced.

In the event of the Contractor failing to carry out maintenance work and this work being done by others, on the others of the Engineer as set out in the Specification, then the cost so incurred shall be borne by the Contractor and deducted from money due or to become due to the Contractor.

The Contractor shall also allow for matching paving in all reinstatement of road surfaces.

6.26 Ventilation

The Contractor shall provide adequate ventilation and efficient apparatus to keep all excavations, tunnels and pipelines free from all dangerous gases, whether generated in the soil strata or otherwise, and he shall take precaution to ascertain that they are in a safe condition before allowing his workmen to descend.

While working in existing pipeline or manhole, the Contractor shall provide air blowers to ventilate the place as sewage gas usually contains a high proportion of hydrogen sulphide, methane and other toxic gasses which in combination with oxygen is explosive. Approved gas monitors/detectors and oxygen meters shall be used to ensure that the place is free from all dangerous gases. The Contractor is required to appoint a Supervisor/ Safety

Officer to ascertain that the pipeline or manhole is in a safe condition before allowing his workmen to descend and work. No smoking or naked flame shall be allowed in the pipeline or manhole. Monitoring of the air quality shall also be carried out regularly by the Contractor's supervisor while work is in progress and work shall be immediately suspended should unsafe conditions develop.

The Contractor is warned that besides performing any work in existing pipeline or manhole, connecting to or breaking into existing pipeline or manhole also poses potentially hazardous conditions. The existing pipeline or manhole to which connection is to be made should therefore be thoroughly ventilated and certified as safe by the Supervisor/ Safety officer before workmen are allowed to execute the connection.

The Contractor and his Supervisor/ Safety officer shall be solely responsible for safety of persons entering in to the pipelines or confined spaces like manholes/ pits.

6.27 Continuous working

If, in the opinion of the Engineer it is necessary, by reason of the safety of the works, or the restoration of interrupted services or for any other reason whatever, the Contractor shall, when so ordered carry out the works or any portion thereof continuously by day and by night without extra charge and allow for such a contingency in his Bid price.

It shall be clearly and definitely understood by the Contractor that no claims in respect of any of the above shall be allowed in the settlement of the Final Account.

6.28 Trial holes

The Engineer may order the Contractor to make trial excavations/ trial bores and to submit a report and/or drawing of the date obtained from each such excavation.

.6.29 RCC / Steel sheet trenching works

Wherever the sub-soil conditions are expected to be of a soft and unstable character, the normal methods of timbering may prove insufficient to prevent subsidence of the adjoining road surfaces, drains and canal and other services or adjoining buildings and structures, in such circumstances the Contractor will be required to use RCC / steel trench sheeting or RCC / steel sheet piling adequately supported by timber or steel struts, walling, etc.

Steel sheet piles shall conform to the provision of I. S 2314 or B.S. 4360 and shall be driven where required as directed by the Engineer.

The Contractor will be required to design the layout of the piling and the overall dimensions of the excavation to suit the sheets and corners available and to give sufficient working space for the proper construction of the work.

The Contractor will be expected to supply, pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Specification and the terms "timber" or "timbering" shall also apply to RCC / steel trench sheeting or RCC / steel sheet piling throughout. The Contractors shall be solely responsible for design of any shoring or timbering or sheeting system and their adequacy and safety. The rates quoted by the Contractors shall be inclusive of such measures of providing steel sheeting or sheet piling.

6.30 Sewage in the connecting sewers

The pipelines installed under this Contract are meant to connect some of the existing functioning upstream and downstream functioning sewers. It is considered that these pipelines are carrying sewage and may also be in surcharged conditions at times.

6.31 Connection to existing sewers

The Contractor shall note that in connecting pipelines to existing sewers, every care shall be taken to ensure that the connections are watertight and the existing pipelines are not damaged. Special precautionary measures shall be taken to ensure the stability of the pipelines connected to them.

The Contractor shall ensure that there is no interruption to existing flows during the dry connection works. No debris shall be allowed to fall or be discharged into the existing pipelines or manholes. Any debris which falls into the existing pipeline/ manholes and any obstructions thereby caused shall be removed at the Contractor’s expense immediately.

All connection to existing pipelines shall be subject to water tightness test and must meet the requirement for the same.

It shall be noted that during connecting the newly laid sewer line to the existing sewer, or for connecting cross sewers to the newly laid sewer, or to repair existing sewer, the contractors shall make necessary arrangement at his own cost, to procure Pneumatic plug / Inflatable plug / mechanical plug / Pillow plug for plugging existing sewer line. Plugging existing sewer by using mud / sand filled gunny bags will not be permitted. Plugging shall be done in co-ordination with & as directed by concerned staff of Main Sewer Dept.

Safety measures for use of Sewer Plugs -

Contractors need to ensure that the sewer plug is inspected prior to each use. The plug shall be partially inflated and inspected under low pressure for any obvious wear, tear, cuts, abrasions or damage. Also, examine the accessories with which the PLUG is to be inflated.

Inflation pressures as in the Manufacturer’s instruction manual and on the plug, must be adhered to when inflating the plug, but never exceed the max. working pressure. Check the internal pressure in the PLUG regularly.

Utilizing an air line extension plugs can be inflated from a distance, away from the danger zone or outside.

The PLUGS shall only be used by persons who have been properly instructed and who are trained for the use.

When using the PLUGS, the safety of the user and any bystanders must always be borne in mind, as wrong use can cause life threatening situations.

Contractors shall consider measures to brace for and absorb the impact of plug failures and to prevent the PLUG from sliding out. This may include anchored ropes/cables in upstream manholes, bracing in the chase of the plugged manhole, or a combination of methods, all with associated risk assessments and controls in place.

Ensure only the use of approved and calibrated pressure gauges. And also ensure pressures are monitored and controlled during plug inflation / deflation with calibrated gauges.

The Contractor shall allow for all the above in his rates and no extra payment on this part is permissible.

6.32 Supply and delivery of pipes

The Contractor is required to schedule his own requisition for pipes and he shall ensure consistency in the delivery of the pipes as demanded by the work schedule.

Any delay in the delivery of pipes which affect the progress of the work shall be solely the responsibility of the Contractor.

6.33 Laying pipelines in well established residential areas

The Contractor shall note that certain section of the pipeline will be laid in close proximity to existing premises. He shall take all necessary precautions, including the provision of RCC / steel sheet piling cut-off walls where necessary, to prevent any damage to the existing premises and shall be responsible for the damage and complete repairs of the same.

The Contractor shall be responsible for obtaining permissions from the owners of private premises if needed by him for his work. He shall be responsible for restricting his workmen to the site of the work while working in private premises. If the Contractor considers it essential to have additional working space he may obtain the same from private property owners entirely at his risk and cost. The Engineer is not bound to arrange for such facilities from private property owners.

Temporary fencing shall be erected as directed by the engineer to separate the worksite from the rest of the private premises at the Contractor's own expense for all execution.

Turf, walls, slopes, fencing, shed or any other structures whether directly or otherwise disturbed or damaged by the construction work shall be reinstated to the original conditions by the Contractor at his own expense.

The Contractor shall allow in his rates for complying with these requirements as no claim to the contrary will be entertained by the Employer/ Engineer.

6.34 Co-operation with other contractors

Where there are other contractors employed by the Employer or any other agency working in the same area, the Contractor must programme/plan his works to be contained within his working space to avoid any interference to and by the other contractors, and shall schedule the work in co-ordination with them. No claim on account of this clause will be entertained by the Corporation and his prices are to include for such contingency.

6.35 Interaction/liaison with utility personnel

The contractor shall note that it is the responsibility of the Contractor to co-ordinate and arrange meetings with Utility Companies or the Government or Municipal Departments and obtain necessary permissions or get the utilities diverted. The Corporation would arrange to give authority letters to the Contractor for arranging such meetings. The Engineer's representative may be present in such meetings. The Corporation is not contractually bound to accept what transpired in any meetings or discussions in which the Engineer or the Corporation was not represented.

6.36 Hydraulic testing of Sewer line & Handing over of completed works.

Upon completion of works the sewer lines including rising mains shall be hydraulically tested as per the required pressure. After successful testing, the contractors must clean the site as per the satisfaction of the Engineer and the same shall be handed over by the contractor to the user department (Sewerage Operations department) under proper acknowledgement and certificate to this effect.

Hydraulic testing and cleaning up the site on completion is to be done by the contractors at his own cost and no extra payment shall be admissible for this requirement.

6.37 Remedial Measures to be adopted by the Contractor

The Contractor shall take each and every precaution to ensure that the tunnelling or drilling equipment will successfully excavate along the chosen pipeline alignment before he commences the operation. In the event of inability to complete the drive, due to break down or any other reasons, the Contractor shall be fully responsible to recover the equipment safely from the ground and restore the incomplete work to the original condition at his risk and cost by a method agreed with the Engineer and the concerned authorities within the time stipulated by the Engineer or the concerned authority.

The Contractor shall in his Submission clearly state the measures that he would implement to retrieve the shield without causing interruptions to traffic and public life and without causing any damage to the property belonging to the MCGM/ MMRDA or any other third party etc.

The cost for such retrieval measures or any consequential expenditure or delays arising from thereof shall be entirely borne by the Contractor. Any failure of remedial measures shall be entirely at the risk and cost of the Contractor. Any abandoned hole or tunnel must be backfilled to the top of the hard strata with concrete or gravel with grouting to provide a solid infill, or other method agreed with the Engineer completely at the Contractor's cost so as to prevent subsequent settlement.