

**Design, Build and Commissioning of 7 MLD
Common Effluent Treatment Plant (CETP) and
0.5 MLD Package Sewage Treatment Plant
(STP) at DPIA on EPC basis with 4 years
Operation and Maintenance - Package B**

VOLUME 3

**PART 4 GENERAL CIVIL AND STRUCTURAL
SPECIFICATIONS**

July 2026



**Managing Director
Maharashtra Industrial Township Limited
Udyog Sarathi, MIDC Office, Marol Industrial Area,
Andheri (East), Mumbai, Maharashtra State, India – 400093**

Contents

1. GENERAL AND PRELIMINARY	6
1.1 General.....	6
1.2 Environmental Conditions	6
1.3 Documentation to be Supplied by the Contractor	7
1.4 Programme and Progress	8
1.5 Health and Safety.....	9
1.6 Plant and Methods.....	11
1.7 The Site	20
1.8 Setting Out of the Works	22
1.9 Temporary Facilities.....	23
1.10 Traffic Management	24
1.11 Existing Services and Structures	25
1.12 Records	26
2. MATERIALS AND EQUIPMENT	27
2.1 Quality of Materials	27
2.2 Alternative Materials	27
2.3 Manufacturer's Instructions	27
2.4 Supply of Materials	28
2.5 Stock of Materials	28
2.6 Copies of Orders	28
2.7 Environmental Conditions	28
2.8 Shipping Documents	29
2.9 Receiving Cum Damage Reports	29
2.10 Title to the Plant	30
2.11 Local Agent.....	30
2.12 Spare Parts	30
2.13 Unloading and Storage of Materials	30
2.14 Ownership of Packing Materials	30
2.15 Storage and handling of Materials.....	30
2.16 Water	31
3. EARTHWORKS	31
3.1 Definitions.....	31
3.2 Classification of Soils.....	32
3.3 Antiquities and Useful Materials	33
3.4 Protections.....	33
3.5 Site Clearance	33
3.6 Excavation General	34
3.7 Setting Out and Making Profiles	35
3.8 Excavation in All Kinds of Soils	35
3.9 Excavation in Ordinary/Hard Rock.....	36

3.10	Existing Roads and Services	37
3.11	Borrow Pits.....	37
3.12	Excavation	38
3.13	Filling.....	40
3.14	Controlled Low Strength Fill	44
4.	MATERIAL	44
4.1	Cement.....	44
4.2	Aggregate.....	46
4.3	Sand	49
4.4	Reinforcement	50
4.5	Bricks.....	52
4.6	Stone.....	53
4.7	Admixtures.....	53
4.8	Water Proofing Compounds	55
4.9	Water Bars	55
4.10	Bitumen/Bituminous Materials	56
5.	CONCRETE.....	56
5.1	Plain and Reinforced Cement Concrete.....	56
5.2	Concrete Mix Proportioning	58
5.3	Batching	61
5.4	Concrete Mixing.....	62
5.5	Trial Mixes.....	63
5.6	Quality Control.....	64
5.7	Batching	67
5.8	Placing.....	71
5.9	Formwork.....	75
5.10	Reinforcement	79
5.11	Joints	81
5.12	Curing and Protection	82
5.13	Finishes	84
5.14	Special Concrete	85
5.15	Tolerances.....	87
5.16	Action in the event of Non-compliance	87
5.17	Repairs and Remedial Works	88
5.18	Surface Protection Materials	88
5.19	Application of Concrete Surface Treatment	89
5.20	Vacuum Dewatering	90
5.21	Testing of Water Retaining/Excluding Structures.....	91
5.22	Concrete (Piling work).....	91
5.23	Replacement of Rejected Piles	95
5.24	Open foundations	97
6.	DESIGN REQUIREMENTS	97
6.1	General.....	97
6.2	Standards of Construction Safety	99

6.3	General Arrangement of Plant.....	100
6.4	Orientation.....	100
6.5	Buildings and Structures	100
6.6	Testing of Water Tightness	103
6.7	Roadways, Pathways and Hard Standings	104
6.8	Walkways	105
6.9	Site Drainage	105
6.10	Cable and Pipe Trenches.....	105
6.11	Pipes and Ducts.....	105
6.12	Valve Chambers	106
6.13	Inlet and Interconnection Chambers	106
6.14	Finishes	106
6.15	For Water Retaining Structures	106
7.	PIPEWORK	107
7.1	General.....	107
7.2	Submittals	112
7.3	Materials for Pipework and Ancillaries.....	114
7.4	Trenches.....	119
7.5	Construction of Pipework and Manholes	124
7.6	Testing.....	130
8.	BLOCKWORK	134
8.1	Cement.....	134
8.2	Aggregate	134
8.3	Sand	134
8.4	Lime.....	134
8.5	Water	134
8.6	Mortar Plasticiser.....	134
8.7	Precast Concrete Blocks.....	135
8.8	Testing of Blocks	135
8.9	Special Blocks.....	135
8.10	Concrete Screen Walling Blocks.....	135
8.11	Damp-proof Courses	135
8.12	Reinforcement	136
8.13	Anchor Ties	136
8.14	Movement Joints	136
8.15	Sliding Joints.....	136
8.16	Mortar Mixes	136
8.17	Mortar – General	136
8.18	Laying of Damp-proof Courses	137
8.19	Laying of Blockwork	137
8.20	Fair Faced Blockwork	137
8.21	Load bearing Walls.....	137
8.22	Non-load Bearing Walls	138
8.23	Bearings for Lintels	138
8.24	Cavity Ties and Anchors	138

8.25	Protection of Cavities.....	139
8.26	Cavity Insulation.....	139
8.27	Protection of Finished Walls	139
8.28	External Pointing.....	139
9.	BUILDING FINISHES	139
9.1	Screed and Render.....	139
9.2	Painting.....	143
9.3	Tiling.....	147
9.4	Miscellaneous	149
10.	ROOF COVERINGS.....	149
10.1	Guarantee	149
10.2	Cement.....	149
10.3	Sand	150
10.4	Water	150
10.5	Roof Screed	150
10.6	Waterproofing Materials	150
10.7	Insulation	150
10.8	Solar Slabs	150
10.9	Solar Slabs Support Pads.....	150
10.10	Gravel Borders	150
10.11	Laying of Roof Screed.....	150
10.12	Laying of Waterproofing Materials.....	151
10.13	Fixing of Aluminium Flashings.....	151
10.14	Laying of Roof Insulation	151
10.15	Laying of Roof Solar Slabs	151
10.16	Laying of Gravel Borders.....	151
10.17	Joints in Roof Screed.....	151
10.18	Joints Sealing.....	151
11.	CARPENTRY, JOINERY AND IRONMONGERY	152
11.1	Timber.....	152
11.2	Physical Condition of Timber	152
11.3	Moisture Content of Timber	152
11.4	Plywood and Melamine	153
11.5	Blockboard	153
11.6	Adhesives	153
11.7	Flush Doors	153
11.8	Framed, Ledged and Braced Board.....	154
11.9	Fire-check Doors	154
11.10	Workmanship.....	154
11.11	Built-in Joinery	155
11.12	Fixed-in Joinery	155
11.13	Frames and Linings	155
11.14	Architraves, Door Stops, Skirtings etc.....	155
11.15	Access Panels	155

11.16	Fixings and Jointing	155
11.17	Screw Fixing of Aluminium.....	155
11.18	Protection of Joinery from Damage.....	156
11.19	Ironmongery	156
12.	GLAZING	156
12.1	Glazing Materials	156
12.2	Glazing – General.....	156
12.3	Workmanship.....	157
12.4	Cleaning	157
13.	PLUMBING AND SANITATION	158
13.1	General.....	158
13.2	Buildings Drainage	158
13.3	Sanitary Plumbing.....	159
13.4	Sanitary Fittings	160
14.	METALWORK.....	161
14.1	Minor Steelwork	161
14.2	Bolts	161
14.3	Aluminium.....	161
14.4	Aluminium Flashings and Trims	162
14.5	Expanded Metal Mesh	162
14.6	Aluminium Louvres and Flyscreens	162
14.7	Aluminium Doors and Windows	163
14.8	Window Frame Tolerances	163
14.9	Roller Shutter Doors	164
14.10	Bird Screens	164

1. GENERAL AND PRELIMINARY

1.1 General

1.1.1 Standards

Materials and methods shall comply with the current issue of the standards indicated, generally the relevant Standards and Codes of Practice.

The Contractor shall make available to the Engineer-in-charge, as required, copies of each and any Codes of Practice, International Standards, test methods, etc., relevant to the Works.

If the Contractor proposes the adoption of alternative Standards, he shall provide details and explanations for approval.

1.1.2 NOCs

The Contractor shall be responsible for obtaining all necessary permits, licences, and NOCs from the relevant authorities required for the proper execution of the Works. The permits, licences and no-objection certificates shall also cover all the materials, goods and instruments, etc, which are required to complete the Works. The Contractor shall ensure that all necessary permits, licences and NOCs are obtained prior to starting the work to which they relate. All costs and fees associated with the necessary permits, licences and NOCs shall be borne by the Contractor. The Contractor is also responsible for any costs associated with charges made by the Department for examination, certification or connection.

1.1.3 Tidal Data

The tidal data given are believed to be correct but the Employer accepts no responsibility for any inaccuracies in the information given and claims will not be allowed in respect of any loss, damage or additional work arising therefrom.

1.1.4 Emergency Arrangements

The Contractor shall maintain arrangements whereby he can quickly call out labour outside normal working hours to carry out any work needed for an emergency associated with the Works. The Engineer-in-charge shall be provided at all times with a list of addresses and telephone numbers of the Contractor's staff who are currently responsible for organising emergency work.

The Contractor shall acquaint himself and his employees with any relevant local arrangements which are in existence for dealing with emergencies.

1.2 Environmental Conditions

1.2.1 Climatic Conditions

The following typical climatic conditions prevail in the area of the works;

Peak ambient temperature	-	45°C
--------------------------	---	------

Minimum ambient temperature - 20 °C

Average Relative humidity - 65%

Special hazards include sandstorms and salt-laden atmosphere, and a high chloride level in the soil and up to 30,000 ppm in groundwater.

1.3 Documentation to be Supplied by the Contractor

1.3.1 Submission of Documentation and Drawings

Unless otherwise specified, all documentation and drawing submittals required by the Contract shall be in accordance with the following clauses.

1.3.2 Formats and Quantities

Documentation and drawings shall be submitted in English and in both paper and electronic versions. Three copies of the paper versions shall be provided. For drawings, this shall include one copy at the original sheet size (e.g. A1), unless agreed otherwise with the Engineer-in-charge. The format of the electronic copies shall be agreed with the Engineer-in-charge.

1.3.3 Delivery of Submittals

All submittals shall be made by delivery to the Engineer-in-charge's site office during the Engineer-in-charge's normal working hours.

1.3.4 Contractor's Approval

Documents and drawings submitted for approval shall be signed as approved by the Contractor. In the case of sub-contractor documents and drawings, these shall also be checked by the Contractor prior to issue for approval. The Contractor shall date-stamp, and sign each of the subcontractor's documents and drawings. Any documents or drawings submitted to the Engineer-in-charge for approval that have not been signed as checked and approved by the Contractor will be returned for resubmission.

1.3.5 Deviations

Submissions by the Contractor shall be accompanied by details of any proposed deviations from the requirements of the Contract, or failing which it shall be deemed that the Contractor's proposal is fully compliant vide the requirements of the Contract.

1.3.6 Approval by the Engineer-in-Charge

A response will be given by the Engineer-in-charge within twenty-one days of receipt of the drawings or documents. The Engineer-in-charge will inform the Contractor by letter or by return of a copy of the document, marked with one of the following remarks:

Code 1: Approved

Code 2: Approved Subject to Comments

Code 3: Returned with Comments

Code 4: Examination Not Required

"Approved Subject to Comments" authorises the Contractor to proceed with the appropriate section of the Works subject to the corrections or comments noted on the document and/or accompanying letter or approval sheet. After correction, the document shall be resubmitted to the Engineer-in-charge for approval with all corrections made on the drawing.

"Returned with Comments" indicates that the document must be revised and resubmitted for approval before proceeding with the manufacture.

"Examination Not Required" indicates that the details on the document are not considered to require approval by the Engineer-in-charge due to such details being standard, typical, etc., or not relevant to the acceptability of the proposed works/method.

The approval shall not be taken as constituting an expression of opinion on the part of the Engineer-in-charge as to the strength or efficiency of the plant and equipment or to its correctness or in any way relieving the Contractor from his responsibilities or obligations under the Contract.

1.3.7 Delayed Engineer-in-Charge's Response

The Contractor shall not proceed with any Works that require approval until such approval is given by the Engineer-in-charge. In the event that the twenty-one-day review period elapses and no response is received from the Engineer-in-charge, the Contractor may proceed at his own risk with the affected element of the works, subject to the fulfilment of his contractual obligations.

1.3.8 Late Submittals

Submissions for the Approval of the Engineer-in-charge shall be made at times to suit the Contractor's program and as detailed in the Contractor's program. Should the drawings and documents not be submitted in accordance with the Contractor's program, the periods for review by the Engineer-in-charge shall be extended as necessary without the Contractor having any entitlement to any associated Extension of Time for Completion.

1.4 Programme and progress

1.4.1 Management Plan

Within 21 days of the Commencement Date, the Contractor shall submit a Management Plan. The Management Plan shall be in accordance with the Contractor's Quality Assurance Accreditation, and the contents shall include but not be limited to:

- Site Management Structure;
- Contact Details for Key Staff;
- Programme;
- Document Numbering and Document Control Procedures;
- Pro-forma for Requests for Information, Requests for Inspection etc;

- Checking and Approval Procedures for Design elements under the Control of the Contractor;
- Change Control;
- Control Procedures for key activities, including survey, placement of concrete, pipe laying, testing, and preparation of as-built records;

The Management Plan shall be updated as appropriate throughout the duration of the Contract.

1.4.2 Programme and Progress

Within the period stipulated in the Contract, the Contractor shall submit for approval a programme or programmes for the execution of the Works. The programme(s) shall be presented in Gantt chart format, to the approval of the Engineer-in-charge, with the critical path and float periods clearly shown.

All construction activities, including those by sub-contractors, shall be shown, together with any temporary works construction, services diversions, traffic diversions and the like.

Critical interface dates for the issue of information for construction and for design and materials or equipment ordering by the Contractor shall be included.

If instructed by the Engineer-in-charge, the Contractor shall provide additional detailed tables, bar-charts and critical path(s) networks of the whole or parts of the Works.

The programme(s) shall be updated and/or expanded at such times as the Engineer-in-charge shall direct. Updated programming data in the form of Networks, Tables and Gantt charts showing actual progress in comparison with the Contract programme shall be submitted to the Engineer-in-charge at monthly intervals.

1.4.3 Betterment of Existing Services

The Contractor shall, by his own representations to the relevant controlling authorities, determine the likelihood and extent of betterment works initiated by and executed concurrently with the new Works and shall make allowance for such work in programming his own work.

1.4.4 Photographs

When required, the Contractor shall provide a set of photographs comprising digital copies and four A4 size colour prints of each of five photographs, suitably inscribed in English as directed, of such portions of the Works in progress or completed as may be directed. The negatives of the photographs shall remain the copyright property of the Employer.

1.5 Health and Safety

1.5.1 Health and Safety Plan

Within 21 days of the Commencement Date, the Contractor shall submit a Health and Safety Plan. The Health and Safety Plan shall contain, but not be limited to:

- Construction risk assessment and control measures;
- Organisation and management arrangements for implementation of the plan;
- Lifting schedule and lifting equipment certification;
- Scaffolding and temporary access controls;
- Provisions for First Aid, Welfare and Fire Fighting;
- Temporary Power Supplies;
- Access.

The Health and Safety Plan shall be updated as appropriate throughout the duration of the Contract.

1.5.2 Safety Officer

The Contractor shall appoint a competent safety officer and shall take all reasonable precautions to prevent accidents to the Contractor's workforce and to the public by providing, inter alia, proper ladders for access, adequate temporary covers to manholes, fencing around excavations, hard hats for use in designated areas and notices clearly indicating "hard-hat" areas, warning lights and general illumination of hazardous areas.

1.5.3 Cease Works

In the event that the Contractor's safety arrangements and precautions are not to the satisfaction of the Engineer-in-charge, he shall be instructed to cease work on the Works or particular section of the Works until such time as he improves such arrangements and precautions to satisfy the Engineer-in-charge.

1.5.4 Work near Live Sewers

Care must be exercised when working in or near live sewers, and tests must be made to verify that no low oxygen atmospheres, hydrogen sulphide or other poisonous gases are present, before anyone enters an existing manhole or confined space.

Particular attention is drawn to the dangers of poisoning, asphyxiation or explosion while working in or near, or inspecting, sewers, manholes, chambers, treatment units, pumping stations or any confined space. In this connection, the Contractor shall obtain appropriate safety equipment and acquaint all personnel of the dangers involved and precautions to be taken and shall regularly discuss with the Engineer-in-charge's Representative the sufficiency of safety precautions on the Site.

1.5.5 Tidal Conditions

The Contractor shall take appropriate precautions when working close to the shoreline or making excavations in areas where the groundwater level may be tidal. These precautions shall include, but not be limited to, the following. In highly permeable ground with high groundwater levels, the Contractor shall frequently monitor the stability of excavations, including of ground behind supported excavations. The Contractor shall ensure that the Works are protected against the maximum expected tide levels. The Contractor shall

maintain a plan for securing the works against storm events and shall monitor weather forecasts for advance warning of such events.

1.5.6 Safety of the Public

The need for adequate protection to the general public in the vicinity of all excavations and other potentially dangerous areas of the Works is stressed.

1.5.7 First-Aid

The Contractor shall arrange for the treatment of casualties on the Site in first-aid units and for the removal by ambulance of injured or sick employees to hospitals or to their homes.

1.5.8 Fire Protection

The Contractor shall construct, equip and administer at his cost fire points in such positions and of such size as will provide an adequate service for the protection against fire on the Site. He shall install and maintain a proper warning system to ensure that firefighting equipment can be concentrated on a fire before it has had time to spread.

1.6 Plant and Methods

1.6.1 Contractor Design

Where the Contract requires the Contractor to undertake design, all drawings, calculations and any other information as may be required by the Engineer-in-charge to review and fully evaluate the Contractor's design shall be submitted for approval by the Contractor in accordance with his programme.

1.6.2 Plant and Methods

The Contractor shall submit a comprehensive plant schedule, which shall include the proposed dates of arrival on site of each major item of plant.

Before commencing any section of the Works, the Contractor shall obtain approval of the plant and methods proposed for use.

1.6.3 Contractor's Responsibility

The Contractor shall take upon himself the full and entire responsibility for the sufficiency of plant, centring, scaffolding, timbering, machinery, tools or implements and generally for all means used for the fulfilment of the Contract, whether such means may or may not be approved or recommended by the Engineer-in-charge.

Notwithstanding any minimum requirements included in this Specification regarding quantity, output and adequacy of plant or outline of methods, the attaining of the specified standards of quality of work shall be the sole responsibility of the Contractor.

1.6.4 Abatement of Nuisance from Noise, Dust, etc

The Contractor shall take precautions to minimise nuisance arising from noise, dust, etc. Diesel and petrol engines shall be fitted with efficient silencers, which are not necessarily those supplied by the plant manufacturers and if required plant shall be screened with acoustic materials. The Contractor may be required to operate electrically driven plant if a suitable power supply is available.

Compressed air-operated road breakers, tools, ventilation equipment, etc., shall be effectively muffled or shall be of a design with acceptably low noise frequency.

1.6.5 Coordination between Contractors

The Contractor shall ensure that he cooperates, coordinates and liaises with other Contractors working adjacent to the works and brings to the attention of the Engineer-in-charge any problems or difficulties faced.

1.6.6 Blasting

The Contractor shall obtain the prior written approval of the Engineer-in-charge, the Police and other relevant authorities for the use of explosives, magazine storage arrangements and blasting procedures, and shall provide trained and qualified safety men for the protection of persons and property during blasting operations.

1.6.7 Temporary Works

The Contractor shall submit to the Engineer-in-charge for approval details of Temporary Works not less than 21 days prior to commencement.

The Contractor is responsible for ensuring that Temporary works are not in any way detrimental to existing structures in any way.

The Contractor shall make safe and reinstate all areas affected by Temporary Works.

1.6.8 Geo Technical Investigation

The Contractor shall undertake all geotechnical and soil analysis testing as necessary for use in his works design. These tests are required to be conducted by the contractor at the treatment plant site before commencement of any construction work. This information shall be provided to the Engineer-in-charge for his information with the design calculations. These works shall be deemed to be included in the Contract Price.

A. Soil Investigation

1. Borehole Tests

- a) Boreholes shall be sunk at specified locations (duly approved by the Engineer-in-charge) to obtain information about the sub-surface soil, and to collect soil and rock samples for strata identification and laboratory testing. The minimum diameter of the borehole shall be 150 mm in soil and NX size (75 mm dia.) in rock, and the boring shall be carried out in accordance with the provisions of IS 1892 and as per specification. Bore holes shall be advanced using water or bentonite. No slush should be allowed to flow on the road. If any slush is there, the same should be cleaned during and after completion of boring. Casing may be necessary to maintain the sides of the boreholes

in a stable condition. Rock boring shall be carried out using a double core barrel / triple tube having a diamond bit to get higher core recovery. Necessary barricading with 2.4mx1.8m metallic/wooden boards with necessary fixing/supporting arrangements shall be made around the work area. The barricades shall be provided with wheels for easy shifting and movement. The cost of providing, maintaining, shifting etc. of barricading shall be borne by the contractor.

- b) All boreholes shall extend up to depths of 30 m in soil (up to $N \geq 100$) or 10 m in weathered rock ($RQD \leq 50\%$) or 5 m in hard rock ($RQD > 50\%$) unless otherwise directed by the Engineer-in-charge. However, the maximum depth of bore borehole does not exceed 30m. If strata having a standard Penetration Test value greater than 100 with characteristics of rock is met with earlier, the borehole shall be advanced further by boring with approval of the Engineer-in-charge. When the boreholes are to be terminated in soil strata, the Standard Penetration Test shall be carried out at the termination depth and recorded.
- c) Casing shall be used in the boreholes to support their sides, if required. When casing is used, it shall be ensured that its bottom end is, at all times, less than 150 mm above the bottom of the borehole. In case of cohesion less soil, the advancement of the casing shall be such that it does not disturb the soil to be tested or sampled. The casing shall be advanced by slowly turning the casing pipe and not by driving. Casing can be withdrawn after inspection of bore borehole by the Engineer-in-charge with his approval. No extra payment shall be made for providing the casing.
- d) In-situ tests shall be conducted and undisturbed samples shall be obtained at specified intervals in the boreholes. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water level shall be determined in the boreholes and shall be carefully recorded on the drilling log.
- e) The borehole shall be cleaned, using suitable tools up to the depth of testing or sampling, ensuring that there is minimum disturbance of the soil at the bottom of the borehole. The process of letting through an open tube sample shall not be permitted. In cohesive soils, the borehole may be cleaned by using a bailer with a check valve.

2. Rotary Drilling

The rotary method can be used in all types of soil below the water table. In this method, boring shall be done by rotating the bit fixed at the bottom of the drill rod. Proper care shall be taken to maintain contact between the bit and the bottom of the borehole at all times. Use of percussion tool shall be permitted in hard clays and dense sandy deposits.

3. Water Level Measurement

The water level in the borehole shall be carefully recorded and reported, when first encountered, whilst drilling the water level shall be measured every morning before recommencement of the drilling activities.

4. In-Situ Tests

- a) **Standard Penetration Tests:** SPT tests shall be conducted in all types of deposits at 1.5m intervals or as per direction of Engineer-in-Charge in charge. The tests shall be

carried out by driving a standard split spoon sampler by means of a 63.5kg hammer (140 lbs) having a free fall of 76 cms(30 inches). Detailed procedure for testing, as specified in IS 2131 shall be followed. The samples obtained in this split spoon sampler shall be placed in an airtight jar or equivalent, levelled and preserved for identification tests in the laboratory.

- b) **Water samples:** Samples of groundwater shall be obtained from each borehole when first encountered or unless specified otherwise.
- c) At the specified depth, water shall be pumped out so that fresh groundwater flows into the borehole. Care shall be taken in avoiding any contamination with surface water at any time. Water samples shall be collected in 5 litre polythene or glass container and labelled properly.
- d) **Field Permeability Tests:** Field Permeability Tests shall be conducted, if required to determine the water percolation capacity of overburden soil. The specification of the equipment required for the tests and the procedure of testing shall be in accordance with IS 5529 Part-1.
- e) **Chemical Tests:** Chemical tests shall be conducted on soils and water samples as per relevant BIS (latest revisions) to report the following:
 - i. pH
 - ii. Chlorides in ppm and percentage
 - iii. Sulphates in ppm and percentage and expressed as SO₃ and SO₄.
 - iv. Presentation of Drilling Information and Core Description
 - v. Daily drilling reports confirming to AnnexureA, IS: 4464 shall be prepared and submitted to the Engineer-in-charge.
 - vi. Within 24 hours of completion of each borehole, a field borehole log shall be prepared by a competent Engineering geologist or geotechnical Engineer. The log will include descriptions of the materials encountered and shall include the observations made during drilling, including the samples obtained along with the depth, SPT, N-value and relevant information. The Engineer-in-charge will comment on the log and provide comments to be incorporated for the final report. This shall conform to Annexure - B of IS: 4464 and shall be submitted in triplicate to the Engineer-in-charge. The Contractor must seek the approval of the Engineer-in-charge for the bore log format.
- f) **Rock Investigation**
 - 1. **Drilling:** Rotary core drilling shall be adopted by open drilling through soft materials, or by drilling ahead in soft ground boring which has already been made. The substrata to be cored, may be soft, or may contain a mixture of hard rock and soft weathered rocks. The drilling equipment used shall have an adequate capacity so as to ensure that the required depths are reached and good quality rock core is recovered. The drilling equipment shall be hydraulically operated. The equipment, method and the procedure for drilling shall conform to IS: 1892. Drilling shall be carried out using NX size diamond tipped drill bits, a double core barrel with core catchers shall be used to ensure

continuous and good core recovery. Core barrels and core catchers shall be used for breaking off the core and retaining it when the rods are withdrawn, double tube core barrels shall only be permitted. Water shall be circulated continuously down the hollow rods and the washings at the surface shall be collected. A very high recovery ratio shall be aimed at in order to get a satisfactory undisturbed sample. Core of 1.5m length shall be aimed at. If the Engineer-in-charge determines that poor core recovery is due to the inability of the drilling crew a new borehole will be drilled at no cost to the Employer/ PMC.

2. No drilling run shall exceed 1.5 m in length. If the core recovery is less than 80 % in any run, the Engineer-in-charge shall be informed, and the length of the subsequent run shall be reduced to 0.75 m.
3. Prior to commencement of the drilling operations, the rig shall be properly weighted down, or anchored, so as to minimize vibrations and ensure maximum core recovery.
4. Full observations in respect of the colors and nature of the return drill water, water loss and permeability, speed of drilling, core loss and other relevant details, shall be described as per relevant IS codes.
5. The color of return water at regular intervals, the depth at which any change of color of return water is observed, the depth of occurrence and amount of flow of hot water, if encountered, shall be recorded.
6. The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration or sudden fall of drill rod occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.
7. Any heavy vibration or torque noticed during drilling should be recorded together with the depth of occurrence.
8. Special conditions, like the depth at which grouting was done during drilling, presence of artesian conditions, loss of drilling fluid, observations of gas discharge with return water etc., shall also be observed and reported.

g) Extraction and Storing of Core Samples

Core samples shall be extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores shall be extracted from the barrel directly into a suitable-sized half-round plastic channel section. Core shall be taken to maintain the direction of extrusion of the sample same as while coring.

- a) Immediately after withdrawal from the core barrel, the cores shall be placed in a tray and transferred to boxes specially prepared for the purpose. The boxes with a sturdy cover shall be made from seasoned timber or any other suitable material and shall be indexed on top of the lid as per IS: 4078. The cores shall be numbered serially and arranged in the boxes in a sequential order. The description of the core samples shall be recorded as per IS: 4464 when core is recovered, it shall be recorded as specified in the standard, and the Engineer-in-charge should be informed so that remedial measures can be implemented. Continuous record of core recovery and RQD to be mentioned in the log as per IS: 11315, Part-II. All core boxes shall be transported and handed over to the Engineer-in-charge on completion of each borehole. All core boxes

shall be photographed, and the photos attached to the report. The photographs shall show the rock core box clearly labelled, indicating project name, borehole number, and depth stored in the core box and the serial number of the box for the borehole (e.g. box 2 of n)

- b) All cores/samples shall be kept in the safe custody of the contractor till the completion of the work. The cores/samples shall be disposed of as per the instructions of the Engineer-in-charge. In no case sample shall destroyed without the written permission of the Engineer-in-charge.

h) Laboratory Testing

At the completion of the borehole, the field log should be transmitted to the Engineer-in-charge within 24 hours. The Engineer-in-charge will assign a laboratory test programme for the samples of that borehole within 3 working days after receipt of the field log.

These boreholes are to be conducted for confirmation of the data available and for finding out the depth of the rock profile at certain locations. As such, the testing of samples has to be carried out in a meticulous manner. Availability of testing facilities as directed is a must, and a visit to the laboratory may be made by a representative of Employer/ PMC before accepting any offer submitted by any Tenderer.

Necessary laboratory tests shall be conducted on selected samples in consultation with the Engineer-in-charge. For this purpose, all undisturbed samples shall be entered on the proforma shown in the relevant IS Codes and submitted, in triplicate, to the Engineer-in-charge with records of the field bore logs.

All tests shall be performed as per IS: 2720 (relevant parts) and as per the directions of the Engineer-in-charge as directed.

Testing of Rock Samples: Selected core samples shall be tested in the laboratory for hardness / crushing and shear strength, test samples shall be chosen so as to include joints, fissures etc. as far as possible

Point Load Test on rock Cores Intact samples of minimum 50 mm diameter and length equal to 1.5 times the diameter should be tested on a Point Load Tester, and its point load index shall be determined. The Uniaxial Compressive Strength (UCS) of the sample should be calculated from the point load index. The index as well as the UGS should be reported. Uniaxial Compressive Strength of Intact Rock Samples Intact rock cores of minimum NX size and length 2.5 to 3 times the diameter should be tested for its uniaxial compressive strength. This test should be conducted on perfectly cylindrical samples, which shall be polished and conform to the Indian Standard Code of Practice. The UCS of the sample should be reported along with the diameter and length of the sample.

Laboratory Tests: Tests as indicated in the specification and as called for by the Engineer-in-charge shall be conducted as per the Schedule of Quantity. Direct shear and triaxial tests shall both be conducted at the same depth for the same material obtained from one sampler at least at two locations in each borehole to find out the values of cohesion and the angle of shearing resistance. The tests shall be carried out for all conditions and their specific Engineering significance should be maintained. However, conditions of test, i.e., unconsolidated undrained, consolidated drained etc. shall be as per specific instructions

from the Engineer-in-charge. Type and location of other tests shall be decided by the Engineer-in-charge. It shall be the duty of the contractor to obtain details of locations and the type of tests from the Engineer-in-charge before starting boring for a particular borehole. The Engineer-in-charge shall, however, be free to change these locations if so warranted by site conditions. The analysis of the above data shall include calculations for self-standing height, de-watering requirements including capacity of pumps and number of pumps and shall be included in the report in detail. All soil testing as directed by the Engineer-in-charge shall be conducted by a Laboratory holding a current accreditation under International Standard Organisation / Bureau of Indian Standards.

Sampling

1. General

- a) Sufficient number of soil samples shall be collected. Disturbed soil samples shall be collected for field identification and conducting tests such as sieve analysis, Index properties, i.e. Plastic & Liquid limits chemical analysis etc. Undisturbed samples shall be collected to estimate moisture content, density, the physical strength and settlement properties of the soil.
- b) All accessories required for sampling and the methods of sampling shall conform to IS 2132 and IS 1892
- c) All disturbed and undisturbed samples shall be collected at the site as per IS: 1498/1970.
- d) All samples shall be identified with date, borehole number, depth of sample, etc.
- e) The tube samples shall be properly trimmed at the ends, waxed and suitably capped. Soil samples shall be transported to the laboratory at the end of each working day with proper protection against loss and damage.

2. **Disturbed Soil Samples:** Disturbed soil samples shall be collected in boreholes at regular intervals. Samples, weighing approximately 1 kg shall be collected in boreholes at 1.5m intervals starting from a depth of 0.5m below ground level and at every identifiable change of strata to supplement the boring records. Samples shall be immediately stored in air-tight containers or equivalent, and which shall be filled to capacity as much as possible.

3. **Undisturbed Soil Samples:** In each borehole, undisturbed soil samples shall be collected at every change of strata subject to a minimum of two as follows. Undisturbed samples shall be of 100mm dia and 450 mm length. Samples shall be collected in such a manner that the structure of the soil and the moisture content do not get altered. The specifications for the accessories required for sampling and the sampling procedure shall conform to IS: 1892 and IS: 2132. The undisturbed sample shall be immediately followed by the SPT test, after the borehole has been cleaned.

4. Undisturbed sampling in cohesive soil

- a) Undisturbed samples in soft to stiff cohesive soils shall be obtained using a thin-walled sampler. In order to reduce the wall friction, suitable precautions, such as oiling the surfaces, shall be taken.

- b) Undisturbed samples in very loose saturated sandy and silty soils and very soft clays shall be obtained by using a piston sampler, consisting of a sampling cylinder and piston system. In soft clays and silty clays, with water standing in casing pipe, the piston sampler shall be used to collect undisturbed samples. During this method of sampling, expert supervision is called for. Accurate measurements of the depth of sampling, height of sampler, stroke and length of sample recovered shall be recorded on the field log. After the sampler is pushed to the required depth, both the sampler cylinder and piston system shall be drawn up together, ensuring that there shall not be any disturbance to the sample which shall then be protected from changes in moisture content. The ends of the tubes will be waxed and provided with caps. All samples must be transported to the laboratory at the end of each working day. The tubes shall be clearly marked to indicate the type of sample.

Report

1. On completion of field and laboratory work a draft factual report in triplicate, shall be submitted, incorporating the following:
 - a) A complete description of the soils and rocks encountered, along with in-situ test results and the sample type and depths.
 - b) Procedure of investigation employed.
 - c) Detailed borehole logs, laboratory and field test results, both in tabular as well as in graphical form, and a plot plan showing locations and reduced levels of bore holes and other tests.
 - d) Soil classification curves including Table indicating D-10, D-30, D-60 size, uniformity coefficient etc. These figures should be made on AutoCAD and submitted in suitable media (such as CD or DVD).
 - e) Mohr's circle diagrams drawn on the basis of data obtained from shear strength tests shall be enclosed.
 - f) Aggressiveness of soil and soil water to concrete, steel and other building materials.
 - g) Any other information of special significance encountered during investigations and likely to have a bearing on design and construction.
 - h) Reduced levels and coordinates of bore holes shall be tabulated. The depth of water table with respect to the ground shall also be given.
2. Detailed report giving recommendations for type of foundation, analysis of bore logs and tests results along with SBC values.
3. Final report shall be submitted only after incorporation of comments by the Engineer-in-charge.
4. A report duly representing all the figures shall be given to the Employer/ PMC. CD/DVD for this report and figures shall be submitted by the contractor.
5. All the locations of borehole points shall be marked on the drawing and give horizontal Coordinates and reduced levels. The Reduced Levels of the top of Bore holes shall be

interlinked with the GTS Bench Marks in Coordination with the Agency doing the detailed topographical Survey.

6. CBR values for road design shall be tabulated for soaked and unsoaked conditions.

1.6.9 Safety of Works and Adjacent Structures

The Contractor shall provide and erect approved supports to protect structures or works requiring support as a result of the Works and remove the same on completion.

The Contractor shall monitor any structure in close proximity to any construction activities to ensure that no damage or disturbance is caused to existing structures.

The Contractor shall submit his proposals for monitoring to the Engineer-in-charge for his consent prior to any construction activities on the Site. The proposals shall include an assessment of the structures likely to be affected by the construction activities together with details of the proposed monitoring activities and details of proposed temporary support if necessary to ensure no adverse effect on the structures concerned.

The Engineer-in-charge shall have the right to suspend the Works at no cost to the Employer if in the opinion of the Engineer-in-charge the Works are causing excess or uneven settlement, damage or disturbance to any structure affected by the Works, and the Contractor shall bear the cost of any repairs, reinstatement, temporary supports and the like so occasioned whether by the Contractor's acts or omissions.

1.6.10 Protection of Completed Work

The Contractor shall protect completed work from damage during subsequent operations, from the weather or any other cause, including the naturally aggressive nature of the environment in which the Works are to be constructed and make good any damage so arising.

1.6.11 Extra High Tide

The Contractor shall keep the Works safe during extra high tides and storms and shall make good any damage to the Works that may be attributed to them, and all direct and incidental costs arising therefrom are at the Contractor's risk except as provided for in the Conditions of Contract.

1.6.12 Slips

The Contractor shall make good any damage or defect caused by slips to any cuttings, excavations or embankments and shall do all necessary work to prevent or remedy the same.

1.6.13 Damage to Access Roads

The Contractor shall ensure that damages to any public or private roads, footpaths and tracks used by any vehicles or plant proceeding to or from the Site shall be kept to a minimum, and he shall be responsible for the cost of all repairs necessary to restore such roads, tracks or footpaths to the satisfaction of the Engineer-in-charge.

1.6.14 Keeping Work Free from Water

Except where underwater construction is directed, the Contractor shall execute all works in the dry, and shall construct any temporary drains, water courses, pumping, and other works that may be necessary for the purpose.

1.6.15 Disposal of Groundwater

The Contractor is to comply with the directions of the Employer's Engineer/PMC/Engineer-in-charge regarding the disposal of groundwater.

1.6.16 Approved Sites for Disposal of Materials

The Contractor shall take surplus material for disposal to an approved tip.

1.6.17 Testing

The Contractor shall provide all staff, labour and equipment necessary for the performance of all tests required, or he may employ an approved independent testing laboratory to carry out all or part of the testing.

If the Contractor provides his own testing facilities, the equipment staff and method of operation shall be approved by the Engineer-in-charge, and 10% of all tests conducted by the Contractor shall simultaneously be carried out, on samples of the same material, by an approved independent testing laboratory.

In either case, the Engineer-in-charge shall have access to the laboratory(ies) at all reasonable times.

The Contractor shall obtain approval of his proposed testing arrangements and shall submit all results without delay.

1.7 The Site

1.7.1 Notice Boards

Notice boards shall be in both English and the local language and shall be displayed in suitable positions on the sites to show the Employer's name together with the name of the Project and the names of the Engineer-in-charge and Contractor. The boards shall have a minimum overall size of 5.0m x 2.45m and shall be in a format to be provided by the Engineer-in-charge.

1.7.2 Interference in Land Interests

The Contractor shall confine his constructional operations to within the Site, or such other areas of land as may be negotiated, and shall instruct his employees not to trespass.

Before exercising any right negotiated by him in connection with wayleaves or accommodation outside the Site, the Contractor shall notify the Engineer-in-charge in writing of such arrangements.

1.7.3 Access to Works

The necessary facilities will be provided by the Employer for the access of the Contractor's employees to the Works, and the Contractor shall be responsible for seeing that such employees obey all regulations made by the Employer in regard to the conditions of access to and over such property.

1.7.4 Temporary Fences

Temporary fencing erected around the Contractor's working area shall meet the requirements of Aurangabad Municipality and shall be to the satisfaction of the Engineer-in-charge.

1.7.5 Materials on and under the Site of Works

Materials arising from Site clearance, soil stripping and excavations shall belong to the Employer and shall not be removed from the Site without consent. The Contractor shall use such materials obtained as the Engineer-in-charge may approve for use in the construction of the Works or shall dispose of the materials as directed.

1.7.6 Billposting and Advertising

The Contractor shall not undertake or allow billposting or advertising of any kind upon the Works without the written consent of the Engineer-in-charge.

1.7.7 Clearance of Site

Final clearing shall be done before the final inspection.

The Contractor shall clean all interior and external surfaces exposed to view. The Contractor shall undertake the following to the satisfaction of the Engineer-in-charge:

1. Remove temporary labels, stains and foreign substances;
2. Polish transparent and glossy surfaces;
3. Clean roofs, gutters, downspouts and drainage systems;
4. Remove debris and surface dust from limited access surfaces;
5. Broom clean concrete floors and unoccupied spaces;
6. Clean light fixtures and lamps so they operate at maximum efficiency;
7. Other cleaning tasks as specified by the Engineer-in-charge.

The Contractor shall clean the Site and shall undertake the following to the satisfaction of the Engineer-in-charge:

1. Sweep paved areas and rake all other surfaces;
2. Remove litter and foreign substances;
3. Remove stains, chemical spills and other foreign deposits
4. Other cleaning tasks as specified by the Engineer-in-charge.

1.8 Setting Out of the Works

1.8.1 Datum

Levels on the drawings are to the MSL (Mean Sea Level) Datum. Natural Ground level/Altitude of the site is adopted at 577m above MSL. The Engineer-in-charge will indicate the position and value of a benchmark near the Works.

1.8.2 Temporary Bench Marks

The Contractor shall establish, construct and protect temporary bench marks during the period of construction, and such bench marks shall be jointly checked periodically and the value agreed with the Engineer-in-charge.

The number and location of temporary benchmarks shall be such that the maximum distance from a temporary benchmark to any construction activity shall not exceed 150 metres. Temporary benchmarks shall be formed by concreting steel pins into the ground and shall be of sturdy construction and protected from displacement or damage.

1.8.3 Locations and Levels of Benchmarks

The Contractor shall plot all permanent and temporary benchmarks on a suitably scaled plan drawing, including details of their coordinates and reduced levels. A copy of the plan shall be issued to the Engineer-in-charge.

1.8.4 Site Reconnaissance

Prior to commencement, the Contractor shall carry out a full photographic reconnaissance of the Site with the Engineer-in-charge. Two colour prints of each negative, with descriptions of locations, shall be handed over to the Engineer-in-charge within two weeks and shall form a record of the Site before commencement of construction.

In addition to the still photographs, a video reconnaissance of the Site shall be made. Two copies of the video shall be made and handed over to the Engineer-in-charge.

1.8.5 Surface or Sea-bed Levels

Before commencing any section of the works, the Contractor shall check the levels shown as existing on the drawings by accurately surveying the whole of the Site. No work shall be commenced until the levels so measured have been checked and agreed by the Engineer-in-charge.

The Contractor shall provide the Engineer-in-charge with all coordinates and level data in an ASCII format.

1.8.6 Setting out of the Works

The Contractor shall clearly set out the works on the Site in advance of the permanent works to enable the trial holes and the positions of the existing services to be identified in actual relation to the permanent Works.

1.9 Temporary Facilities

1.9.1 Transport

The Contractor shall arrange for the transport, if necessary, of his staff and workmen to and from the Site of the Works.

1.9.2 Site Offices for the Engineer-in-Charge

The Contractor shall provide, equipment, maintain and clean site offices for the exclusive use of the Engineer-in-charge for the whole of the Contract Period.

Where a septic tank has to be provided, the Contractor shall be responsible for arranging for its installation, regular emptying, etc.

Telephone facilities for the Engineer-in-charge shall have separate connections direct to a public telephone exchange with privacy of conversation for the Engineer-in-charge.

1.9.3 Assistance to the Engineer-in-Charge

The Contractor shall provide for the exclusive use of the Engineer-in-charge all necessary instruments, which shall be new or in proven good condition, appliances, protective clothing, safety boots, and labour required for checking the setting out of the Works, testing, inspection and for any other attendance on the Engineer-in-charge. A schedule of basic equipment requirements is given in Appendix B.

1.9.4 Sanitary Conveniences

Sanitary conveniences for the use of persons employed on the Works shall be provided and maintained by the Contractor to the extent and in such manner and at such places as shall be approved by the Engineer-in-charge and the authority concerned. All persons connected with the Works shall be obliged to use them. The Contractor shall make temporary arrangements for the proper discharge of sewage and drainage from or in connection with the work and shall maintain the same to the satisfaction of the Engineer-in-charge and the authority concerned for as long as they may be required.

1.9.5 Accommodation for Contractor

No temporary sleeping quarters and/or camp accommodation shall be permitted on the Site. The Contractor shall house his workforce at a location and to a standard compliant with the current legislative requirements.

1.9.6 Services

The Contractor shall arrange the supply of fresh water, electricity, telephone, compressed air and other services to his Site establishment and shall provide, maintain for the duration of the Contract and remove on completion all pipes, cables and fittings to carry such services to his operations.

1.9.7 Electricity Distribution on site

All electrical installations forming part of the Temporary Works shall comply and be tested in accordance with Central Electrical Authority/IE Rules/Employer's specific Requirements for Electrical Installations.

1.9.8 Drinking Water

The Contractor shall provide an adequate supply of drinking water, with all necessary drainage, on the Site for the use of his staff and workpeople and shall make all the necessary arrangements with the relevant authorities. The number, capacity and location of the installations shall be to the satisfaction of the Engineer-in-charge.

1.9.9 Lighting

The Contractor shall install and maintain at his own cost a system of lighting to provide a reasonable degree of illumination over the area of the Works. He shall submit details of this scheme for the approval of the Engineer-in-charge before any work commences.

1.10 Traffic Management

1.10.1 Traffic Control

Traffic management is the responsibility of the Contractor. The Contractor shall provide, erect and maintain on the Site and at such positions on the approaches to the Site as may be required by the Engineer-in-charge or by the relevant authority all traffic signs and traffic control signals necessary for the direction and control of traffic. Control of traffic shall include vehicle speed and exclusion of vehicles as appropriate. Approval of the size of all such signs and the lettering and wording thereon shall be obtained before erection. The signs shall be reflectorised or adequately illuminated at night in an approved manner and kept clean and legible at all times. The Contractor shall reposition, cover or remove signs as required during the progress of the Works.

1.10.2 Flow of Traffic

The flow of traffic on the existing roads and access to properties shall be maintained at all times during the Contract. The flow of traffic shall take place at all times over a reasonable surface, which shall be segregated as far as possible from areas where work is in progress. Flagmen and signalling equipment shall be provided as necessary to control the traffic to the satisfaction of the Engineer-in-charge and the appropriate controlling authority. In the planning and execution of any temporary or permanent works which may affect the traffic flow and/or access to properties, the Contractor shall co-operate closely with the Engineer-in-charge and the appropriate controlling authority.

1.10.3 Temporary Diversion of Traffic

The diversion of traffic is the responsibility of the Contractor. The Contractor shall construct temporary diversion ways wherever the Works shall interfere with existing public or private roads or other ways over which there is a public or private right of way for any traffic.

The standard of construction shall be suitable in all respects for the class or classes of traffic using the existing way, irrespective of the condition of the existing way. The details of such diversions shall be to the approval of the Engineer-in-charge and the appropriate controlling authority. The Contractor shall obtain the approval of such authority before constructing the diversion.

The Contractor shall prepare plans showing any proposed traffic diversions. The plans shall fully detail the diversion in all respects and shall include construction details if necessary. The plans shall show the position of ramps, traffic signs, cones, barriers, demarcation posts and tape, flashing lights and any other traffic control devices. The plans shall be submitted to the Engineer-in-charge for review and shall be approved by the controlling authority. Traffic diversion apparatus shall not be erected until prior approval has been given by the Engineer-in-charge and approving authority.

Diversion ways shall be constructed in advance of any interference with the existing ways and shall be maintained in a condition satisfactory to the Engineer-in-charge for as long as required.

The provisions of this Clause shall not apply to any temporary access or accommodation works which the Contractor may construct for his sole use in the execution of the Works.

1.11 Existing Services and Structures

1.11.1 Boundaries Cut Through

Fences, walls, etc., crossed by the Works and forming boundaries of plots outside the area occupied by the Works shall not be cut through or destroyed for more than the distance necessary to permit the erection of new fencing, etc. and the Contractor shall make the ends of the cut fences reasonably secure. Where fences or walls are damaged or destroyed, the whole shall be restored and reinstated with like materials to the satisfaction of the owners or occupiers and the Engineer-in-charge.

1.11.2 Existing Services

The Contractor shall by his own representations to the relevant controlling authorities, determine the extent and location of existing services. All such service information shall be recorded on the General Arrangement drawings, and a copy shall be made available to the Engineer-in-charge.

The Contractor shall execute the Works in such a manner that he does not damage or interfere with existing services on or near the Site, except as shown by the Contract drawings. If damage or interference is so caused, the Contractor shall make repairs to the approval of the Engineer-in-charge and relevant authority, or the authority may carry out the repairs at the cost of the Contractor. Additionally, the Contractor may be charged the Statutory Penalties enforced by the authorities.

Prior to backfilling, if any existing services shall have been exposed during the progress of the Works, the Contractor shall arrange for a representative of the relevant service authority to be present during backfilling operations, if such authority so requires.

When working adjacent to natural gas pipelines, the Contractor shall comply with the requirements of the appropriate controlling authority as laid down in "Safe Working in the vicinity of natural gas pipeline", in addition to the requirements of the Maharashtra Electricity and Water Authority, Directorate of Natural Gas Distribution and any other appropriate controlling authority.

1.11.3 Modifications to Existing Manholes and Inspection Chambers, etc.

When required, the Contractor shall raise or lower the cover levels of manholes, inspection chambers and the like for existing water, drainage, sewerage, electricity and telephone services. Details of the modifications required will be shown on the relevant drawings. Any damage, including ingress of sand, road construction materials and rubbish, shall be attended to as it occurs and in a manner approved by the Engineer-in-charge and the appropriate controlling authority.

1.11.4 Temporary Over Pumping

Where installation works involve the diversion or over-pumping of sewage or drainage flows, detailed methods of working shall be drawn up and submitted to the Engineer-in-charge for approval and to the Employer/PMC for agreement. Such method statements shall take note of known constraints.

1.11.5 Drains Streams, etc.

Drains, pipes, channels, watercourses or streams affected by the Contractor's operations shall be reinstated to their original condition.

1.12 Records

1.12.1 Field Records

During the progress of the work, the Contractor shall maintain an up-to-date copy of all drawings, specifications, supplementary data and latest revisions.

The Contractor shall maintain a continuous record of all field deviations from the drawings, if any, as approved by the Engineer-in-charge and, within one month of the issue of the Certificate of Completion for the Works or parts of the Works, he shall submit to the Engineer-in-charge a set of the latest revisions of all drawings and specifications marked to show the Works or relevant sections of the Works as constructed.

1.12.2 'As Constructed' Drawings

On completion of the Works, the Contractor shall bring all the construction drawings up to 'As Constructed' status, incorporating all modifications, additions, alterations, etc., which may have been made during the construction. The 'As Constructed' drawings shall be to the same standard and format as the construction drawings, including the provision of 3-Dimensional coordinates and the representation of services as 3-Dimensional entities.

The Contractor's 'As Constructed' drawings shall be submitted as follows;

- 1 set of A1 size negatives on polyester film (gauge 110/115 gms);

- Bound sets of A3 size drawings. These must be stamped and signed by the Contractor's Representative.
- 1 digital disk in Autodesk Civil 3D format;
- 1 digital disk in Autodesk AutoCAD format;
- 1 digital disk in Microstation format.

The 'As Constructed' drawings shall:

- Display the Contractor's name and logo;
- Be bound using a suitable spiral binder;
- Have a front cover of approved quality and colour;
- Have a transparent plastic sheet above the cover;
- Have a backing sheet of required thickness;
- Be clearly legible.

2. MATERIALS AND EQUIPMENT

2.1 Quality of Materials

The term "materials" shall mean all materials, goods and articles of every kind, whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

Materials and equipment used in the Works shall be of the best quality of their respective kinds and shall comply with the current issue of the appropriate standard published by the Bureau of Indian Standards or other approved standard.

A copy of the relevant parts of the standards of the recognised national standards body shall be provided by the Contractor in English where required by the Contract, and be to the satisfaction of the Engineer-in-charge.

All materials shall be specifically designed for use in all climates. The Contractor shall provide full details of all materials proposed, including evidence that they have proved successful in use in conditions equal to those prevailing in India.

2.2 Alternative Materials

The Contractor may offer alternative materials or equipment to those specified, provided they are of at least equal quality. If alternatives are proposed, the Contractor shall submit for the Engineer-in-charge's approval details, including technical descriptions, drawings and specifications to demonstrate that the alternatives are equal to the original.

2.3 Manufacturer's Instructions

Materials and equipment shall be used or installed in accordance with the instructions of the manufacturer unless otherwise required.

Materials and components shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination, failing which such damaged materials will be rejected and shall not be used on any part of the Works under this contract

2.4 Supply of Materials

As soon as possible after the Contract has been awarded, the Contractor shall submit a list of suppliers from whom he proposes to purchase the materials and equipment required for the Works. This shall be at least 28 days prior to use. Samples shall also be submitted at the request of the Engineer-in-charge.

Samples shall be taken and tested in accordance with the relevant Indian Standards where applicable. Materials and equipment subsequently supplied shall not be changed without prior written approval.

2.5 Stock of Materials

The contractor shall inspect the Site and prepare a memorandum containing an inventory of the Site, including the vacant and unencumbered land, buildings, structures, road works, trees and any other immovable property on or attached to the Site.

Contractor shall maintain a proper system of records to identify all inventories related to the required materials, facilities and preparing and provide to the Employer a complete accounting of such inventory for every fiscal quarter and shall be accessible at all times by the Engineer-in-charge for routine inspection.

2.6 Copies of Orders

The Contractor shall, if required, submit to the Engineer-in-charge copies of orders for materials and equipment to be incorporated in the Works.

2.7 Environmental Conditions

In supplying the materials for use in this Contract, the Contractor must consider the conditions to which these materials will be subjected at the various stages in the treatment process. The Contractor should note that materials in contact with sewage and its atmosphere will be subjected to a corrosive environment.

The following conditions are typical:

- Maximum normal temperature of the sewage or effluent 40 deg C;
- Normal operating temperature of the sewage or effluent 20-35 deg C;
- Acidic conditions with a pH as low as 1.0 in slime deposits;
- Presence of hydrogen sulphide gas in pipelines, chambers, and other confined spaces;
- Presence of hydrogen sulphide dissolved in the sewage.

In addition, groundwater may contain chloride levels of 100,000 mg/l and sulphate levels of 1000 parts per 100,000.

2.8 Shipping Documents

The Contractor shall submit complete shipping documents as soon as possible after shipping, in order to reach the Engineer-in-charge before the arrival of the shipment. Responsibility for delays, loss or damage to shipping documents shall rest with the Contractor.

The shipping documents shall be distributed as follows:

Documents	Employer	Engineer-in-Charge's Site Office
Shipping Invoice for the Consignments		
Original	1	-
Copy	1	1
Packing List	1	1
Bill of Lading		
Original	1	-
Copy	1	1
Certification of Origin		
Original	1	-
Copy	1	1
Manufacturer's Certificate		
Original	1	-
Copy	1	1
Confirmation of Declaration of Insurance	1	1
Certificate of Inspection Authority	1	1

Should the Work or any part thereof, the manufacture and/or supply of any material, equipment or plant component as well as any equipment or tool required for the Work, be delayed with respect to the relevant time schedules, the Contractor shall transport the part or component delayed by air at no extra cost to the Employer.

All imported freight consignments to be incorporated into the Works shall be imported directly.

2.9 Receiving Cum Damage Reports

The Contractor shall submit receiving reports to the Engineer-in-charge to cover each individual shipment received and checked at the job site. Each shipment on arrival at the

job site shall be unloaded, opened and carefully checked for any damage in transit, and the Contractor shall immediately submit a damage report, countersigned by the Engineer-in-charge, to the Insurance Company with copies to the Employer and to the Engineer. Where damage has occurred in Marine Transportation, a copy of the damage report shall also be sent to the registered/appointed surveyor.

In all cases of irreparable damages, the Contractor shall immediately notify the relevant manufacturer(s). He shall also immediately notify the Engineer-in-charge of the actions he will be initiating and undertaking in order to repair or replace the damaged part(s) and of the consequences this damage will have on the completion date of the Works. Any repairs proposed by the Contractor will be subject to the approval of the Engineer-in-charge.

2.10 Title to the Plant

Title to the Plant shall pass to the Employer upon delivery ex-factory, but the Contractor shall maintain total and exclusive care, custody and control, including all risk or loss until issue of the last Initial Taking Over Certificate.

2.11 Local Agent

All materials and equipment shall be supplied by manufacturers or their agents who are to be approved by the Engineer-in-charge.

2.12 Spare Parts

Wherever possible, there should be a local dealer or Agent within India for imported equipment.

2.13 Unloading and Storage of Materials

The Contractor shall unload all imported equipment and material at the Site from trucks and trailers, and delivery vehicles as the case may be. Items of permanent installation shall be properly and neatly stored in areas designated by the Engineer-in-charge and shall be protected to prevent damage or deterioration of any type. Storage methods shall be such as to cause minimum inconvenience to others and shall be arranged to facilitate inspection and withdrawal from stores. All equipment and material storage shall be subject to the approval of the Engineer-in-charge.

2.14 Ownership of Packing Materials

All packing boxes (excluding shipping containers belonging to shipping lines or other agencies but used by Contractors in bringing material to Site), planking, covering, etc., shall become the property of the Employer as soon as the equipment and material which is contained therein arrives at Site. The Employer, on application from the Contractor, may permit the Contractor to use some of the boxes, containers, etc., for equipment and material storage purposes until the items are installed or erected by the Contractor.

2.15 Storage and handling of Materials

Materials and components shall be stored in such a manner as to preserve their quality and condition to the standards required by the Contract.

Unless otherwise described in the Contract, the installation, application or fixing of materials and components shall be in accordance with the recommendations of the manufacturer. Where appropriate, the Contractor shall make use of any technical advisory services offered by manufacturers.

2.16 Water

- a) Water shall be obtained from a public utility undertaking supply, and be of a potable quality.
- b) Water used in construction for all civil & structural works shall be clean and free from injurious amounts of oil, acids, alkalis, organic matters or other harmful substances which may be deleterious to concrete, masonry or steel. The pH value of the water sample shall not be less than 6. Potable water shall be considered satisfactory. Underground water can also be used with the prior approval of the Engineer-in-Charge, if it meets all the requirements of IS:456.
- c) Tests on water samples shall be carried out in accordance with IS:3025, and they shall fulfil all the guidelines and requirements given in IS:456.
- d) The Engineer-in-Charge may require the Contractor to prove that the concrete prepared with water, proposed to be used, shall have an average 28-day compressive strength not lower than 90% of the strength of concrete prepared with distilled water.
- e) The Engineer-in-Charge may require the Contractor to get the water tested from an approved laboratory before starting the construction work, and in case the water contains any oil/organic matter or an excess of acid, alkalis or any injurious amount of salts, etc., beyond the permissible maximum limits given in IS:456, the Engineer-in-Charge may refuse to permit its use. In case the water is supplied by the owner, the contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense. In case there is any change in the source of water, water samples shall be tested again to meet the specified requirements.
- f) Water shall be stored in tin barrels, steel tanks or water-tight reservoirs made with bricks/stone or reinforced concrete. Brick/stone masonry reservoirs shall have an RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirement at any stage of construction.
- g) Water for curing shall be of the same quality as used for concreting and masonry works. Sea water shall not be used for the preparation of cement mortar, concrete, as well as for the curing of plain/reinforced concrete and masonry works. Sea water shall not be used for hydro testing and checking the leakage of liquid retaining structures, also.

3. EARTHWORKS

3.1 Definitions

- **Deadmen or Tell Tales:** Mounds of earth left undisturbed in pits dug out for borrowing earth

- **Burjis:** Short pillars of brick/ stone having a top surface finished with cement plaster for marking, etc.
- **Formation or Profile:** Final shape of the ground after excavation or filling up.
- **Foul condition:** Filthy and unhygienic conditions where physical movements are hampered, such as soil mixed with sewage or night soil.
- **Lead:** All distances shall be measured over the shortest practical route and not necessarily the route actually taken. A route other than the shortest practical route may be considered in cases of unavoidable circumstances and approved by the Engineer-in-charge, along with reasons in writing.
- Carriage by manual labour shall be reckoned in units of 50 metres or part thereof.
- Carriage by animal and mechanical transport shall be reckoned in one km. unit. Distances of 0.5 km or more shall be taken as 1 km. and a distance of less than 0.5 km. shall be ignored. However, when the total lead is less than 0.5 km, it will not be ignored but paid for separately in successive stages of 50 metres, subject to the condition that the rate worked on this basis does not exceed the rate for the initial lead of 1 km by mechanical/animal transport.
- **Lift:** The vertical distance for removal with reference to the ground level. The excavation up to 1.5 metres depth below the ground level and depositing the excavated materials up to 1.5 metres above the ground level are included in the rate of earth work. Lifts inherent in the lead due to ground slope shall not be paid for.
- **Safety rules:** Safety rules as laid down by the statutory authority and as provided in the National Building Code (NBC) shall be followed.

3.2 Classification of Soils

The earthwork shall be classified under the following categories and measured separately for each category:

- a) **All kind of soils:** Generally, any strata, such as sand, gravel, loam, clay, mud, black cotton moorum, shingle, river or nallah bed boulders, siding of roads, paths etc. and hard core, macadam surface of any description (water bound, grouted tarmac etc.), lime concrete mud concrete and their mixtures which for excavation yields to application of picks, shovels, jumper, sacrifiers, ripper and other manual digging implements.
- i) **Ordinary rock:** Generally, any rock which can be excavated by splitting with crow bars or picks and does not require blasting, wedging or similar means for excavation, such as limestone, sandstone, hard laterite, hard conglomerate and unreinforced cement concrete below ground level.
- j) If required, light blasting may be resorted to for loosening the materials, but this will not in any way entitle the material to be classified as 'Hard rock'.
- k) **Hard rock:** Generally, any rock or boulder for the excavation of which blasting is required, such as quartzite, granite, basalt, reinforced cement concrete

(reinforcement to be cut through but not separated from concrete) below ground level and the like.

- l) **Hard rock (blasting prohibited):** Hard rock requiring blasting as described under (c), but where the blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging, the use of rock hammers and cutters or any other agreed method.

3.3 Antiquities and Useful Materials

Any finds of archaeological interest, such as relics of antiquity, coins, fossils or other articles of value, shall be delivered to the Engineer-in-Charge and shall be the property of the Government.

Any material obtained from the excavation which, in the opinion of the Engineer-in-Charge, is useful shall be stacked separately in regular stacks as directed by the Engineer-in-Charge and shall be the property of the Government.

3.4 Protections

Excavation, where directed by the Engineer-in-Charge, shall be securely barricaded and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with red lights and/or written using fluorescent reflective paint as directed by the Engineer-in-Charge during the night to avoid accidents.

The Contractor shall take adequate protective measures to ensure that the excavation operations do not damage the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes and chambers, communication cables, power supply cables, etc., met within the course of excavation shall be properly supported and adequately protected, so that these services remain functional. However, if any service is damaged during excavation shall be restored in a reasonable time.

Excavation shall not be carried out below the foundation level of the adjacent buildings until underpinning, shoring, etc., is done as per the directions of the Engineer-in-Charge.

Any damages done by the contractor to any existing work shall be made good by him at his own cost. Existing drain pipes, culverts, overhead wires, water supply lines and similar services encountered during the course of execution shall be protected against damage by the contractor. The contractor shall not store material or otherwise occupy any part of the site in a manner likely to hinder the operations of such services.

3.5 Site Clearance

Before the earth work is started, the area coming under cutting and filling shall be cleared of shrubs, rank vegetation, grass, brushwood, trees and saplings of girth up to 30cm measured at a height of one metre above ground level and rubbish removed up to a distance of 50 metres outside the periphery of the area under clearance. The roots of trees and saplings shall be removed to a depth of 60cm below ground level or 30 cm below formation level or 15 cm below subgrade level, whichever is lower, and the holes or hollows filled up with the earth, rammed and levelled.

The trees of girth above 30 cm measured at a height of one metre above ground shall be cut only after permission of the Engineer-in-Charge is obtained in writing. The roots of trees shall also be removed.

Existing structures and services such as old buildings, culverts, fencing, water supply pipe lines, sewers, power cables, communication cables, drainage pipes, etc., within or adjacent to the area, if required to be diverted/removed, shall be diverted/dismantled as per directions of the Engineer-in-Charge.

In case of archaeological monuments within or adjacent to the area, the contractor shall provide necessary fencing around such monuments as per the directions of the Engineer-in-Charge and protect the same properly during execution of works.

The lead of 50 m mentioned in the 'Schedule of Quantities' is the average lead for the disposal of excavated earth within the site of work. The actual lead for the disposal of earth may be more or less than the 50 m for which no cost adjustment shall be made in the rates.

Disposal of Earth shall be disposed of at the specified location or as decided by the Engineer-in-Charge. The contractor has to obtain written permission about the place of disposal of earth before the earth is disposed of, from the Engineer-in-Charge.

3.6 Excavation General

The Contractor shall, before commencing any earthworks, survey and level the whole of the Site, and prepare plans and sections accordingly. The plans and sections shall, when finally and mutually agreed, be signed by the Engineer and Contractor as representing the levels at the commencement of the earthworks.

The Contractor shall inform himself about the nature of the strata, materials, and the likely volume of water in excavations, open cuttings, and trenches.

The Contractor shall remove the whole of the turf, topsoil, concrete, flagging, paving, kerbing, road-metalling and other materials from the site of any excavation and shall keep separately and preserve the same for re-use afterwards. The ground shall be excavated for the permanent and temporary works to the required depths, widths and levels so that the dimensions of the permanent work shall not be less than is shown on the drawings, or as may be directed. All rubbish and matter of an offensive nature taken out of any excavation shall be disposed of at once and not left on the surface.

No authorisation, approval or direction of the Engineer with regard to excavation, or any matter or thing connected therewith, shall in any way relieve the Contractor of his responsibility and liability therefore, and for the effects thereof, as provided in the Contract and in this Specification. The Contractor shall carry out all excavations required for the Permanent Works in whatever materials may be met with. All excavations shall be carried out to suitable lengths, widths, depths and profiles required for the safe construction of the Works shown on the drawings, or to such other dimensions as may be ordered by the Engineer in writing.

When instructed by the Engineer, the Contractor shall produce the calculations for the structural stability of any temporary works, but approval shall not relieve the Contractor of his responsibility for adequately supporting any excavation.

Excavation shall be carried out so as to avoid disturbance to the surrounding ground, particularly when working close to existing installations, and where necessary or instructed by the Engineer the Contractor shall maintain vertical sides to the excavations and provide all necessary side supports to achieve this.

Soft or unsound areas uncovered during excavation shall be notified immediately to the Engineer.

Excavations shall be kept dry by the use of approved dewatering equipment, pumps, sumps and sub-drains as necessary.

3.7 Setting Out and Making Profiles

A masonry pillar to serve as a benchmark will be erected at a suitable point in the area, which is visible from the largest area. This benchmark shall be constructed and connected with the standard benchmark as approved by the Engineer-in-Charge. Necessary profiles with strings stretched on pegs, bamboo or 'Burjis' shall be made to indicate the correct formation levels before the work is started. The contractor shall supply labour and material for constructing benchmark, setting out and making profiles and connecting benchmark with the standard benchmark at his own cost. The pegs, bamboos or 'Burjis' and the benchmark shall be maintained by the contractor at his own cost during the excavation to check the profiles.

The ground levels shall be taken at 5 to 15 metres intervals (as directed by the Engineer-in-Charge) in uniformly sloping ground and at closer intervals where local mounds, pits or undulations are met with. The ground levels shall be recorded in field books and plotted on plans. The plans shall be drawn to a scale of 5 metres to one cm or any other suitable scale decided by the Engineer-in-Charge. The north direction line and position of benchmark shall invariably be shown on the plans. These plans shall be signed by the contractor and the Engineer-in-Charge or their authorised representatives before the earthwork is started. The labour required for taking levels shall be supplied by the contractor at his own cost.

3.8 Excavation in All Kinds of Soils

All excavation operations manual or by mechanical means, shall include excavation and 'getting out' the excavated materials. In case of excavation for trenches, basements, water tanks, etc., 'getting out' shall include throwing the excavated materials at a distance of at least one metre or half the depth of excavation, whichever is more, and clearing off the edge of excavation. In all other cases, 'getting out' shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the items of excavation, stating lead.

During the excavation, the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.

In firm soils, the sides of the trenches shall be kept vertical up to a depth of 2 metres from the bottom. For greater depths, the excavation profiles shall be widened by allowing steps of 50 cms on either side after every 2 metres from the bottom. Alternatively, the excavation can be done so as to give a slope of 1:4 (1 horizontal: 4 vertical). Where the soil is soft, loose, or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer-in-Charge. It shall be the responsibility of the contractor to take complete instructions in writing from the Engineer-in-Charge regarding the stepping, sloping or shoring to be done for excavation deeper than 2 metres.

The excavation shall be done true to levels, slope, shape and pattern indicated by the Engineer-in-Charge.

In case of excavation for foundation in trenches or over areas, the bed of excavation shall be to the correct level or slope and consolidated by watering and ramming. If the excavation for foundation is done to a depth greater than that shown in the drawings or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for levelling/ bed concrete for foundations. Soft/defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

While carrying out the excavation for drain work, care shall be taken to cut the side and bottom to the required shape, slope and gradient. The surface shall then be properly dressed. If the excavation is done to a depth greater than that shown on the drawing or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with stiff clay puddle at places where the drains are required to be pitched and with ordinary earth, properly watered and rammed, where the drains are not required to be pitched. In case the drain is required to be pitched, the backfilling with clay puddle, if required, shall be done simultaneously as the pitching work proceeds. The brick-pitched storm water drains should be avoided as far as possible in filled-up areas and loose soils.

In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling in with earth duly watered, consolidated and rammed.

In case the excavation is done wider than that shown on the drawings or as required by the Engineer-in-Charge, additional filling, wherever required on the account, shall be done by the contractor at his own cost.

The excavation shall be done manually or by mechanical means as directed by the Engineer-in-charge, considering feasibility, urgency of work, availability of labour /mechanical equipment and other factors involved. Contractor shall ensure all safety measures for the workers. Neither any deduction will be made nor any extra payment will be made on this account.

3.9 Excavation in Ordinary/Hard Rock

All excavation operations shall include excavation and 'getting out' the excavated matter. In case of excavation for trenches, basements, water tanks, etc., getting out shall include throwing the excavated materials at a distance of at least one metre or half the depth of excavation, whichever is more, clear off the edge of the excavation. In all other cases,

'getting out' shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the item of excavation stating lead.

During the excavation, the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.

Where hard rock is encountered and blasting operations are considered necessary, the contractor shall obtain the approval of the Engineer-in-Charge in writing for resorting to the blasting operations. Blasting operations shall be done as specified in the clause 0 and chiselling shall be done to obtain correct levels, slopes, shape and pattern of excavation as per the drawings or as required by the Engineer-in-Charge, and nothing extra shall be payable for chiselling.

Where blasting operations are prohibited or are not practicable, excavation in hard rock shall be done by chiselling.

In ordinary rock excavation shall be carried out by crowbars, pick axes or pneumatic drills and blasting operations shall not be generally adopted. Where blasting operations are not prohibited and it is practicable to resort to blasting for excavation in ordinary rock, the contractor may do so with the permission of the Engineer-in-Charge in writing, but nothing extra shall be paid for this blasting.

If the excavation for foundations or drains is done to a depth greater than that shown in the drawings or as required by the Engineer-in-Charge. The excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for levelling/ bed concrete for foundations. Soft/ defective spots at the bed of foundations shall be dug out and filled with concrete as directed by the Engineer-in-Charge, and nothing extra shall be payable.

3.10 Existing Roads and Services

The Contractor shall take all precautions which, in the opinion of the Engineer-in-charge, are necessary to protect from damage, and ensure the uninterrupted operation of, all existing roads and services which are on the line of or adjacent to the work, and shall maintain these until, in the opinion of the Engineer-in-charge, the general progress of the work renders further protection unnecessary. All damage occasioned by the Contractor to these roads and services shall be repaired without delay at the Contractor's cost, to the specification and instruction of the controlling authority and to the satisfaction of the Engineer-in-charge.

3.11 Borrow Pits

The Contractor shall obtain permission from the persons or authorities concerned for the siting of approved borrow pits. The Contractor shall leave borrow pits in a tidy state and ensure that they are self-draining and do not constitute a danger to health.

3.12 Excavation

3.12.1 Excavation for Structures

The bottom of all excavations for the foundations of structures shall be carefully levelled and compacted and, if necessary, stepped or benched horizontally. Any pockets of soft or unsuitable material or loose rock in the bottom of excavations shall be removed and refilled with concrete or other suitable material, as directed.

If, due to excessive exposure after excavation, or for any other reason, the surfaces of excavations deteriorate, the unsuitable material shall be removed or recompacted as directed by the Engineer at the Contractor's expense.

No excavation shall be filled or covered with concrete until it has been inspected and approval given by the Engineer to proceed. Immediately after approval, foundations shall be blinded with concrete as detailed.

3.12.2 Breaking Out of Existing Road Pavement

If pavement layers have to be broken out from existing roads, underlying layers of material shall not be disturbed. Damage shall be made good by the Contractor.

3.12.3 Blasting

All blasting shall be carried out by an approved specialist. Prior to the commencement of blasting on site, the Contractor shall submit for approval the proposed blasting patterns, charges and safety procedures.

3.12.4 Excavations beyond the True Line and Level

If excavations other than for concrete work are carried out beyond the true line and level the Contractor shall fill to the required line and level with approved material using approved methods.

If excavations for concrete works are carried out beyond the true line and level, the Contractor shall fill to the required line and level with concrete similar in grade to that intended to be used in the concrete works.

3.12.5 Spoil Disposal

Excavated material from the Works, which is approved for re-use, shall be placed directly in its final position or stockpiled on Site. Surplus materials shall be removed.

The Contractor shall ensure that the angle at which any fill is stockpiled is less than the natural angle of repose of the fill and shall take such measures as are necessary to prevent slip or collapse of stockpiles. Fences or walls shall be provided around the perimeters of stockpiles to prevent danger to the public.

The Contractor shall trim and regulate stockpiles and tips to profiles and levels as directed and maintain the flow of water courses affected by them, and shall observe the requirements of the owner or relevant authority.

3.12.6 Removal of Water

At locations where the excavation extends below the groundwater table, a dewatering system is to be provided, which will lower ambient groundwater levels. The resulting groundwater level shall be at a depth which is sufficiently below the excavation level so as to allow the safe and proper execution of the work. The resulting foundation level shall be a stable, dry sub-grade which is suitable for the execution of subsequent operations.

The Contractor is to design the dewatering methods and settling basins so that no critical amounts of soil, sand or silt are removed during either the dewatering operations.

Complete working drawings showing the type of dewatering and groundwater control system proposed shall be submitted to the Engineer-in-Charge for his review. The Contractor's submittal shall include drawings that show the arrangement, location and depths of the proposed dewatering system. A complete description of the equipment and materials to be used and the procedures to be followed is to be given, together with details of required standby equipment and standby power supply. The Contractor shall also indicate their proposed location(s) for the discharge of extracted groundwater.

The dewatering system design should also include the details of measures required to prevent damage due to settlement of roads, pavements, utilities, sewers, buildings and other structures outside the excavation but within the area affected by the dewatering.

3.12.7 Removal of Unsuitable Material

3.12.8 The Engineer may order the excavation and removal of any material deemed unsuitable for supporting the fill, pipelines, or structures to be placed thereon, and its replacement by suitable approved material. Unsuitable material shall be removed from the site as soon as practicable after excavation. Storage of unsuitable material will not be permitted.

3.12.9 Formation Tolerance

The finished surface at the formation level resulting from excavation or breaking out of road pavement shall be trimmed and compacted to the levels shown on the Drawings within a tolerance of $\pm 25\text{mm}$.

3.12.10 Testing at the Formation Level

Tests shall be carried out at the formation level to establish that the top 150mm of subgrade has achieved a relative compaction of at least 95% of the laboratory maximum dry density, determined in accordance with IS: 2720 (Part 8). Where the formation is at or below original ground level, laboratory CBR tests (IS: 2720 (Part 16)) shall be carried out, as directed, and the minimum acceptable CBR value shall be 15%. Testing shall be at the rate of one density test for each 500m² and one CBR test for each 2500m². CBR tests shall not be required at the formation level for structures. CBR tests shall be undertaken on the formation for road works only.

If this compaction cannot be achieved or if the material below the formation level is unsuitable, then the material shall be removed to the extent directed and disposed of by the Contractor. The resulting void shall be backfilled with suitable material compacted in

layers not exceeding 150mm thick to achieve the above requirement, or other higher CBR value required by succeeding construction layers. CBR tests shall not be required at the formation level for structures. CBR tests shall be undertaken on the formation for road works only.

Special methods of compaction shall be used over areas which are inaccessible to rollers or other heavy plant. The Contractor shall avoid damage to pipes, cables, structures and the like when compacting fill around and over them.

3.12.11 Inspection of Excavations

The Contractor shall obtain approval of excavations prior to placing pavement layers, fill, pipes or pipe bedding material, concrete or any other covering. The Contractor shall maintain open excavations in an approved condition and shall rectify the effects of deterioration due to weather.

3.12.12 Preparation of Surfaces to Receive Concrete

A blinding layer of concrete or the first pour of concrete, according to the detail on the Drawings, shall be placed immediately after the required level has been achieved and the excavated surface approved.

3.13 Filling

3.13.1 Test Standards

Unless stated otherwise, testing of fill materials and workmanship shall be carried out in accordance with BS812 and IS: 2720 (Part 8). Laboratory Maximum Dry Density tests shall be in accordance with IS: 2720 (Part 8); Liquid Limit shall be determined in accordance with Test 2A or 2B of BS 1377. In situ CBR testing shall be carried out in accordance with ASTM D4429. CBR tests shall be undertaken to fill for road works only.

3.13.2 Backfill – General

Except around structures, excavations shall be backfilled with approved material compacted in layers of 200mm maximum thickness to achieve a density of at least 95% of the laboratory maximum dry density. On-site dry density testing shall be in accordance with Test 15 of BS 1377/relevant IS Code.

3.13.3 Backfilling to Structures

The Contractor shall not backfill around structures until the structural elements have attained adequate strength and the approval of the Engineer to proceed has been obtained. Unless otherwise directed, the backfill material shall be selected excavated material, thoroughly compacted in layers not exceeding 200mm thick to achieve a density of at least 95% of the laboratory maximum dry density.

The Contractor shall restrict the compaction plant used on fill to structures, within 1m of a structure, to the following items:

1. Vibratory roller having a mass per metre width of roll, not exceeding 1,300kg, with a total mass not exceeding 1,000kg;
2. Vibrating plate compactor having a mass not exceeding 1,000kg;
3. Vibro-tamper having a mass not exceeding 75kg.

The masses of plant listed above shall be determined in accordance with Series 600 of the UK Department of Transport Specification for Highway Works.

The compacted level of the fill within this zone shall not differ during construction from the compacted level of the remainder of the adjoining fill to structures by more than 250mm.

3.13.4 General Filling

Filling of areas which have no specific load-bearing or structural role shall be as follows. Embankments and other areas of fill shall be formed of suitable materials capable of normal compaction to form a stable fill, deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used.

The filling shall, where practicable, be built up and compacted evenly, and shall be maintained at all times with a sufficient camber and cross fall and a surface sufficiently even to enable surface water to drain readily from it.

3.13.5 Compaction of Subgrade

Prior to placing fill, the top 150mm of subgrade under structures and road pavement layers shall be compacted to a density of not less than 95% of the laboratory maximum dry density.

3.13.6 Fill Material

Fill material shall be approved evenly-graded granular material obtained from excavations or borrow pits. The material shall be free from organic matter and shall have the following properties:

Particle size : 100mm maximum

Percentage retained on 75mm sieve : 10% maximum

Percentage passing 75 microns sieve : 20% maximum

Liquid Limit : 35% maximum

Plasticity Index : 6% maximum

CBR values after 96 hours soaking:

a) at 90% of laboratory MDD	10% minimum
	15% minimum

b) at 95% of laboratory
MDD

Chloride content : 3.3% maximum
(BS EN 1744-1) (top 150mm only)

Sulphate content : 2.0% maximum
(BS EN 1744-1) (top 150mm only)

CBR tests shall be undertaken on the fill material for road works only.

Fill for use behind earth-retaining structures shall additionally be tested by means of shear box tests (AASHTO T234 or T236, as appropriate) to prove that it will achieve, in its placed condition, a minimum internal angle of friction of 33 degrees when compacted to 95% of the laboratory maximum dry density.

The Contractor shall carry out the following initial tests on material proposed for use as fill:

- Grading;
- Dry density/moisture content relationship;
- Shear tests;
- Plasticity Index;
- Tests for chloride and sulphate contents.

CBR tests at optimum moisture content and after 96 hours soaking, at both 90% and 95% of laboratory MDD CBR tests shall be undertaken on the fill material for roadworks only.

Thereafter, one set of tests shall be carried out for each 200m³ of fill delivered to Site, or daily, whichever is the less frequent.

3.13.7 Placing of Fill

Granular material shall be placed and compacted in layers not exceeding 200mm thick to achieve a density of 95% of the laboratory maximum dry density.

Special methods of compaction shall be used over areas which are inaccessible to rollers or other heavy plant. The Contractor shall avoid damage to pipes, cables, structures and the like when compacting fill around and over them.

3.13.8 Formation Tolerance for Fill

The finished surface at formation level resulting from filling operations shall be within 25mm of the levels shown on the Drawings.

3.13.9 Testing of Fill - General

Tests shall be carried out on fill to determine the degree of compaction achieved, at the rate of one test for each 500m² of each layer. Compacted layers shall not be covered without approval.

The density of individual compacted layers shall be determined by an appropriate method detailed in Test 15 of BS 1377/ IS 2720 (Part 16), or AASHTO T 191 together with ASTM D1556, as directed.

3.13.10 Testing of Top Layer of Fill

Tests shall be carried out on the top layer of fill as follows:

1. Laboratory tests to monitor the consistency of the approved material during construction:

Test	Frequency of Test (not less than one test per.....)
Maximum dry density	1500m ²
Optimum moisture Content	
Grading	
Plasticity Index	
Linear Shrinkage	
CBR	
Sulphate content	3500m ²
Chloride content	

2. In-situ tests to confirm that the required degree of compaction is being achieved during construction:

Test	Frequency of Test (not less than one test per.....)
Dry Density	500m ²
CBR	2500m ²

In situ CBR shall be applicable to road works only.

3.14 Controlled Low Strength Fill

Areas of over-excavation on which structures are to be founded shall be filled with controlled low flow able strength fill. The purpose of this material is to ensure that movement in the structure is not induced by settlement of the fill.

Such fill shall be Dara Fill (as manufactured by GRACE Construction Products/Emirates Chemicals LLC), or similar approved stabilised fill mix. A typical mix design is:

100 kg/m³ OPC; 1400kg/m³ sand; 135 kg/m³ water; 90 ml Dara Fill admixture.

The fill shall: be cement bound; have air content of nom 20 – 35%; achieve nom crushing strength of 7.5N/mm²; be flow able; be impermeable once set to limit the potential for migration of fines into the fill; have a wet density of nom 1600 – 2000 kg/m³.

4. MATERIAL

4.1 Cement

4.1.1 Cement General

The cement to be used throughout the Works shall be obtained from manufacturers approved in writing. Specific requirement for the type of cement to be used shall be as shown in the drawings or as specified in the contract or as directed by the Engineer-in-Charge and shall be meeting specifications as under:

Specification for 33 grade ordinary portland cement	IS:269
Specification for portland slag cement	IS:455
Specification for Portland pozzolana cement (fly ash based)	IS: 1489 Pt. 1
Specification for Portland pozzolana cement (calcined clay based)	IS: 1489 Pt.2
Specification for Masonry Cement	IS:3466
Specification for high alumina cement for structural use	IS:6452
Specification for rapid hardening portland cement	IS:8041
Specification for 43 grade ordinary portland cement	IS:8112
Specification for 53 grade ordinary portland cement	IS: 12269
Specification for Sulphate Resisting Portland cement	IS: 12330

The temperature of the cement shall not exceed 65°C at the time of incorporation into a concrete mix.

4.1.2 Storage at Site

- a) The storage of cement (lifted from the Owner's godown or procured by the Contractor himself) at the site of work shall be at contractor's expense and risk and shall meet the requirements of IS:4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner as to permit easy access for proper inspection and to prevent deterioration due to moisture. In the event of any damage occurring to the quality of cement due to faulty storage or on account of negligence on the part of the contractor, such damages shall be borne by the contractor himself.
- b) All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufactured owner. The contractor shall maintain a register, on day-to-day basis, giving the details of the receipt/consumption, source of supply and type of cement etc. The register shall always be accessible to the Engineer-in-Charge for verification.

4.1.3 Cement Testing

Cement shall be certified by the manufacturer as complying with the requirements of the appropriate specification. Before ordering cement, the Contractor shall submit details of the proposed supplier and information on the proposed methods of transport, storage and certification for approval and show that the quantity and quality required can be attained and maintained throughout the construction period. Representative samples of the proposed cement are to be taken and forwarded to an independent laboratory approved by the Engineer-in-charge for analysis before the source is approved.

Having obtained approval, the Contractor shall not change the agreed arrangements without permission. Each consignment of cement shall be accompanied by a certificate showing the place of manufacture and the results of standard tests carried out on each day's bulk production included in the consignment. Additionally, tests shall be carried out on each consignment of cement on arrival, and at monthly intervals during storage. The Contractor shall store the cement so that separate consignments can be identified until the results of the testing are available. Tests should be carried out for the properties listed in the following table with test methods and limits to the relevant parts of relevant Indian standard codes as appropriate:

Properties to be tested

- Strength;
- Fineness;
- Setting Time;
- Soundness;
- Reactive Alkali Level as Na_2O Equivalent;
- Chloride Content;
- Loss on Ignition;

- Insoluble Residue;
- Tricalcium Aluminate Content;
- SiO₂, MgO, Al₂O₃, Fe₂O₃, CaO contents;
- SO₃

4.1.4 Silica Fume

Silica fume shall not contain more than 0.2% silica metal by mass or any deleterious materials, such as carbon, quartz, rust and cellulose fibres. The materials must originate from silicon plants producing silicon or ferrosilicon with silicon contents higher than 85%. The suitability of the silica fume shall be ascertained by testing to confirm that its properties are within the following limits.

Parameter	Requirement
Silica Fume Powder	
SiO ₂	Min 85%
Loss on Ignition	Max 5%
Fineness	Min 15000m ² /kg
Activity index	>95% after 28 days
Carbon content	Max 2%
Alkali level as Na ₂ O equivalent	Max 2%
Relative density	2.2
Silica Fume Slurry	
pH	5.5±1
Water content	50% ±2%
Relative density	1.3-1.4

4.1.5 Rejection

The Engineer-in-Charge may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant Indian standard codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective, shall not be used and shall be promptly removed from the site by the contractor.

4.2 Aggregate

- Coarse and fine aggregates for Civil and Structural Works shall conform in all respects to IS:383 (Specification for coarse and fine aggregates from natural sources for concrete). Aggregates shall be obtained from an approved source known to produce the same satisfactorily. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof. These shall be

chemically inert, hard, strong, dense durable, clean and free from veins, adherent coatings, injurious amount of alkalis, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, seashells etc.

- b) Source and type of aggregates shall be got approved by the Engineer-in-Charge prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, Engineer-in-Charge can allow a change in source and type of aggregate. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Engineer-in-Charge. Any such change, if permitted by the Engineer-in-Charge, shall be without any time and cost implication to the owner.
- c) Aggregates which may chemically react with alkalis of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Engineer-in-Charge, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.
- d) The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS:2386 - Part -II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS:383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the contractor shall submit necessary test results as per IS:383 and IS:2386 to the Engineer-in-Charge prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.
- e) Coarse and fine aggregates shall be batched separately. All-in-aggregate shall be used only where specifically permitted by the Engineer-in-Charge.
- f) Separate sieve analysis and grading curves shall be prepared by the Contractor for Any/all batches of coarse and fine aggregates, and submitted to the Engineer-in-Charge, whenever asked for, to ensure conformity with those submitted along with the mix design.
- g) Whenever required by Engineer-in-Charge, the aggregates (coarse/fine) shall be washed and/or sieved by the contractor before use in the works to obtain clean and graded aggregate at no extra cost to the owner.
- h) Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

4.2.1

Coarse Aggregates

- a) Coarse aggregates are the aggregates, which are retained on 4.75mm BIS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).
- b) These may be obtained from crushed or uncrushed gravel or stone as per clause 3.1 and may be supplied as single sized or graded. The grading of the aggregates shall be as per IS1383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the contractor shall submit to the Engineer-in-Charge at least three

sets of mix design and test results, each with different grading of coarse aggregates, proposed to be used. The Engineer-in-Charge may allow "All-in-aggregates" to be used provided they satisfy the requirements of IS:383.

4.2.2 Fine Aggregates

- a) Fine aggregates are the aggregates which pass through 4.75mm BIS sieve but not more than ten percent (10%) pass through 150-micron BIS sieve. These shall comply with the requirements of grading zones I, II and III of IS:383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.
- b) Fine aggregates shall consist of material resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or gravel sand. Sand from sea shores, creeks or riverbanks affected by tides, shall not be used for filling or concrete works.

4.2.3 Sampling and Testing

The Contractor shall carry out all tests including mix designs of concrete, at his own expense, at the start of work as well as during any stage of construction as required by the Engineer-in-Charge. Test shall be carried out in accordance with IS:516- Methods of test for strength of concrete and IS:2386-Methods of test for aggregates for concrete. Testing shall be carried out from laboratories approved by the Engineer-in-Charge. The method of sampling shall be in accordance with the requirements given in IS:2430.

4.2.4 Alkali – Reactivity Potential

Aggregate shall not contain any matter which is likely to undergo disruptive expansive reactions with alkalis in the mix or otherwise affect the long-term durability of the concrete.

The Contractor shall initially assess an aggregate source by petrographic examination in accordance with relevant Indian standards if potential reactivity is indicated, then accelerated mortar bar tests in shall be carried out.

4.2.5 Storage of Aggregates

- a) Storage of all types of aggregates at site of work shall be at contractor's expense and risk and shall be stored as specified in IS:4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.
- b) The Contractor shall maintain sufficient quantities of aggregates, near to the place of work, required for the continuity of the work. Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.
- c) Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for at least 24 hours. The Contractor shall obtain prior approval of the Engineer-in-charge for the use of such aggregates and shall adjust the water content in accordance with IS:2386 to achieve the desired mix. In the absence of test results, and to allow variation in mass of aggregates and water content on

account of moisture content, the Contractor can make suitable adjustment in the masses as per IS:456, for preparation of nominal mix concrete only.

4.3 Sand

4.3.1 Sand for Masonry Mortars

- a) The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS:2116.
- b) The sand shall not contain any harmful impurities such as iron pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, seashells in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.
- c) Unless found satisfactory as a result of further tests as may be specified by the Engineer-in-Charge, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS:2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS:2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS:2386.

4.3.2 Grading of Sand

- a) The particle size grading of sand for use in mortars shall be within the limits as specified below:

IS Sieve Designation IS: 460 (PART I)	Percentage passing by mass	Ref. To method of
4.75 mm	100	IS 2385 (Part I)
2.36 mm	90 to 100	
1.18 mm	70 to 100	
600 microns	40 to 100	
300 microns	5 to 70	
150 microns	0 to 15	

- m) In case of a sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles, this shall be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of natural sand particles or crushed stone screenings which are by themselves unsuitable. Based on test results and in the light of practical experience with the use of local materials, deviation in grading of sand may be

considered by the Engineer-in-Charge. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

4.3.3 Sampling and Testing

- a) The method of sampling shall be in accordance with IS:2430. The amount of material required for each test shall be as specified in the relevant parts of IS:2386. Any test which the engineer-in-charge may require in connection with this shall be carried out in accordance with the relevant parts of IS:2386.
- b) If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (1:6) may be made in accordance with IS:2250 using the supplied material in place of standard sand, and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality

4.3.4 Sand for Filling

Sand for filling shall meet the requirements of IS:383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling shall be used only after it is approved by the Engineer-in-Charge. Sand obtained from sea shores, creeks or river banks affected by tides shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below the grading zone-111 as per IS:383 shall be allowed for filling.

4.4 Reinforcement

4.4.1 General

All steel bars, sections, plates, and other miscellaneous steel materials, etc, shall be free from loose mill scales, rust, as well as oil, mud, paint or other coatings. The materials, construction specifications such as dimensions, shape, weight, tolerances, testing, etc, for all materials covered under this section, shall conform to the respective Indian standard codes.

4.4.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works, shall be one of the following or in combination thereof.

Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement (grade I).	IS:432
Specification for hard-drawn steel wire fabric for concrete reinforcement.	IS:1566
Specification for plain hand-drawn steel wire for prestressed concrete.	IS: 1785
Specification for high-strength deformed steel bars and wires for concrete reinforcement.	IS: 1786

Steel for general structural purposes (Grade A). IS:2062

Specification for indented wire for prestressed concrete IS:6003

4.4.3 Structural Steel

- a) Structural steel to be used for general structural purposes shall be one of the following or in combination thereof. Structural steel sections shall conform to the following BIS Codes.

Steel tubes for structural purposes. IS:1161

Mild Steel Tubes, tubulars and other wrought steel fittings. IS: 1239

Steel for general structural purposes (Grade A). IS:2062

Hollow steel sections for structural use. IS:4923

n) Miscellaneous Steel Materials

Miscellaneous steel materials shall conform to the following BIS Codes.

Steel wire ropes for general engineering purposes IS:2266

Thimbles for wire ropes. IS: 2315

Bulldog grips. IS:2361

Mild Steel Tubes, tubulars and other wrought steel fillings. (For handrail tubular sections). IS: 1239

4.4.4 Anchor Bolts

Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates, etc., shall be as per the relevant BIS Codes mentioned above.

4.4.5 Insert Plates & Anchor Fasteners

Material for the Insert plates shall be as per the relevant BIS Codes mentioned above

Anchor Fasteners shall be Hilti type or equivalent as per standards

4.4.6 Storage of Reinforcement

Reinforcement shall be stored on racks with sufficient supports to avoid permanent deformation of the bars, with a waterproof overhead cover to screen stocks from

contamination from windblown dust. Delivery and storage shall be organised in such a manner as to make identification easy. Supports shall be such that distortion of bars is avoided and contamination and corrosion are prevented.

Individual bundles of reinforcing bars shall be durably marked to identify source, batch number, type and diameter.

Reinforcement must not be roughly handled, dropped from a height, or subjected to shock loading or mechanical damage.

Any reinforcement which becomes contaminated shall be abrasive blasted with an approved blasting media, and washed if necessary, not earlier than 3 days before its incorporation in the Works.

Reinforcement shall be stored clear of the ground and protected from contamination by other materials. At the time of placing concrete, reinforcement to be clean and free of corrosive pitting, loose mill scale, loose rust, ice, oil and other substances which may adversely affect the reinforcement, concrete, or bond between the two.

4.5 Bricks

4.5.1 General

Bricks for masonry works shall conform to IS: 1077 - Specification for common burnt clay building bricks and shall be of class 5.0. Specific requirements for any other class of bricks shall be as shown in drawings or as described in the contract for a particular site or type of work. Physical requirements, quality, dimensions, tolerances, etc., of common burnt clay building bricks shall conform to the requirements of IS:1077. Bricks shall be hand-moulded or machine-moulded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp corners and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

4.5.2 Tests after Delivery

The Contractor shall take samples of each type of brick as directed by the Engineer-in-Charge as per the requirements of IS:5454, and tests shall be carried out as per IS:3495. The cost for carrying out any or all the tests shall be borne by the Contractor. The bricks, when tested, as per IS:3495, shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight when soaked in cold water for 24 hours.

Brick samples so approved shall be deposited with the Engineer-in-Charge. All subsequent deliveries shall be up to the standards of the approved samples.

Stacking of Bricks

Bricks shall be stored at the site as per the requirements given in IS:4082 and shall not be dumped at the site. They shall be unloaded from trucks to a place on a levelled surface near the work site. They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged

that as far as possible, at least two days' requirements of bricks are available at the site at any time. Bricks, of different classes, shall be stacked separately

4.5.3 Local Bricks / Class 3.5 Bricks

Where shown on drawings, locally available bricks of non-modular size (230mm x 115 mm x 75mm) in place of bricks of modular size (190mm x 90mm x 90mm) can be used in case the bricks satisfy the other requirements of IS: 1077. Minimum compressive strength of these bricks shall not be less than 3.5N/mm²

4.6 Stone

4.6.1 General

All Stones used for masonry works shall conform to the requirements of the following BIS Codes.

Method of identification of natural building stones.	IS : 1123
--	-----------

Recommendations for dimensions and workmanship of natural building stones for masonry work.	IS: 1127
---	----------

Recommendations for dressing of natural building stones.	IS: 1129
--	----------

4.6.2 Quality of Stones

Stones shall be of approved quality, hard, dense, strong, sound, durable, clean and uniform in colour. They shall also be free from veins, adherent coatings, injurious amounts of alkalies, vegetable matters and other deleterious substances such as iron pyrites, coal, lignite, mica, sea shells, etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS:1905, taking into account the appropriate crushing strength of stone and the type of mortar used. The percentage of water absorption, when tested in accordance with IS: 1124, shall not exceed 5 per cent.

Stones normally used shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150mm and in no case exceed 3/4th thickness of the wall. The height of the stone shall not be more than 300mm.

4.6.3 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near the place of work as defined in IS:4082 and shall be stacked on a firm ground having adequate slope for drainage. The supply of stones shall be so arranged that, as far as possible, at least two days' requirements of stone are available at the site at any time.

4.7 Admixtures

All concrete admixtures shall in general, comply with the following BIS Codes unless otherwise stipulated in this specification.

- Specification for integral cement waterproofing compounds. IS:2645
- Specification for other admixtures for concrete: IS:9103

Generally, admixtures shall have IS1 certification marks. However, even in the case of BIS-certified admixtures, the Engineer-in-Charge may require the Contractor to carry out and submit any or all the tests (as specified in relevant BIS Codes), from approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.

In case admixtures certified by BIS are not available, the contractor shall submit to the Engineer-in-Charge the type and/or proprietary brand of the admixture from only reputed manufacturers, along with necessary test certificates from recognised and approved laboratories or any other document directed by the Engineer-in-Charge for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Engineer-in-Charge for his selection. In case both names are rejected, the contractor shall submit a fresh list of two manufacturers for approval by the Engineer-in-Charge.

The Engineer-in-Charge may direct the contractor to submit test results as required by IS: 2645 or IS: 9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any BIS code for testing and acceptability criteria, the relevant American, British or German Code shall be applicable.

Prior approval of the Engineer-in-Charge shall be obtained while using water-reducing admixtures in the concrete (PCC/RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless specified on the design drawings or prior approval is taken from the design approving authority. Once approved, utmost care shall be exercised at the site by the Contractor to maintain the consistency in the quality of admixture and the concrete/mortar so produced.

The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates, together with any other materials to be actually used in the works as per the direction of the Engineer-in-Charge. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests specified in BIS Codes shall be carried out only with the type of material and mix design to be actually used in the work site.

No admixture shall impair the durability of the concrete, nor combine with the ingredients to form harmful compounds, nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has been established, strict checks shall be maintained not to alter the proportions of ingredients and water-cement ratio of the Design Mix during execution.

The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.

Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

4.7.1 Corrosion inhibitors

Corrosion inhibitors shall be calcium nitrite-based and be in a liquid form suitable for addition to concrete during batching. The corrosion inhibitor shall contain $30 \pm 2\%$ calcium nitrite by mass and have a minimum of 10 years of field history in similar products. The suitability of the inhibitor, compatibility with other products in the concrete and dosage shall be confirmed in writing by the manufacturer. This shall include detailed long-term independent test data that conclusively substantiates the product's ability. This should include, as a minimum test data to relevant Indian standards.

Upon request, the Contractor shall submit test method(s) which determine the plastic and hardened concentration of the active component in the corrosion inhibitor.

4.7.2 Polypropylene Fibres

Polypropylene fibre reinforcement shall be 100% virgin polypropylene fibres specifically manufactured for use as a concrete reinforcement and so certified by the manufacturer. It shall contain no reprocessed olefin materials. The fibre dosage shall provide a minimum surface area of 200m^2 of fibres per cubic metre of concrete. The length of each fibre shall be between 10mm and 50mm. Fibres may be monofilament or fibrillated.

4.8 Water Proofing Compounds

Waterproofing compounds shall be mixed with only ordinary portland cement of grade 33, conforming to IS:269.

The permeability of the specimen with the admixture shall be less than half of the permeability of a similar specimen without the use of these compounds. These compounds shall be used in such proportion as recommended by the manufacturer, but in no case shall they exceed 3% by weight of cement.

The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes, and the final setting time shall not be more than 10 hours. The test shall be carried out in accordance with IS:4031. Compressive strength of the specimen at 3 days shall not be less than 160kg/sq.cm nor 80% of the 3-day compressive strength of mortar cubes prepared with the same cement and sand only, whichever is higher. Similarly, compressive strength at 7 days shall not be less than 220 kg/sq.cm nor less than 80% of the 7-day compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS: 4031.

4.9 Water Bars

PVC water bars shall be used in reinforced concrete construction of liquid retaining structures or any other structure to safeguard them from hydrostatic pressure and water leakage, and any relative movement between two parts of the structure due to thermal

loading, shrinkage or differential movement of foundations. Wherever desired or shown in the drawings, they shall be used at expansion/contraction/construction joints. These shall be pre-formed and shall provide a permanent water-tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. The minimum thickness of the water bar shall be as shown on drawings or described in the schedule of rates, and unless otherwise mentioned, these shall be able to withstand a water head of at least 12 meters.

Performance requirements of PVC water bars shall meet the requirements of IS: 12200. These shall be of approved make and of ribbed/serrated/plane type with a bulb at the centre. The thickness and width of water bars shall be as per the schedule of rates/drawings, but in no case shall the thickness be less than 5mm and the width less than 150mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

4.10 Bitumen/Bituminous Materials

Bitumen to be used for various types of work shall meet all the requirements of the relevant BIS Codes as given below:

Specification of Paving Bitumen.	IS: 73
Specification for bitumen mastic for flooring.	IS: 1195
Specification for Bitumen felts for waterproofing and damp proofing.	IS: 1322
Specification for Bituminous compounds for waterproofing and caulking purposes.	IS: 1834
Specification for preformed fillers for expansion joint in concrete pavements and structures.	IS: 1838
Specification for bitumen mastic for use in waterproofing of roofs.	IS:3037
Specification for bitumen primer for use in waterproofing and damp proofing.	IS:3384
Specification for Bitumen Mastic for Tanking and Damp Proofing.	IS:5871

5. CONCRETE

5.1 Plain and Reinforced Cement Concrete

5.1.1 Scope

This specification establishes the requirements of materials, mix proportioning, placing, curing, etc. of all types of cast-in-situ and precast concrete used in foundations, underground and overground structures, floors, pavements, etc. Any special requirements as shown or noted on the drawings shall supersede over the provisions of these specifications.

5.1.2 Reference Codes and Specifications

Apart from this specification, construction of plain and reinforced concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS:456 and other relevant codes mentioned therein.

In case of conflict between the clauses mentioned in this specification and those in the Bureau of Indian Standards (BIS), this specification shall govern.

5.1.3 Grades of Concrete

Unless otherwise noted on the drawings or called for in the schedule of rates, the grades of concrete shall generally be as per the details below:

Grades of Concrete	
Grade designation	Specified Characteristic Comprehensive Strength of 150 mm cube at 28 days (N/mm ²)
M 15	15
M 20	20
M 25	25
M 30	30
M 35	35
M 40	40
M 45	45
M 50	50
M 55	55

Notes: The characteristic strength is defined as the strength of the material below which not more than five (5) per cent of the test results are expected to fall.

Plain and reinforced cement concrete work shall conform to the Indian Standard for plain and concrete- Code of practice, fourth revision IS 456:2000.

5.1.4 Type of Concrete Mix

Unless otherwise noted on drawings, all lean/plain and reinforced concrete shall be of M20 grade suitable for severe exposure conditions and Reinforcement Cement Concrete shall be of grade M30/M35 suitable for very severe exposure conditions, conforming to IS 456:2000.

5.1.5 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting a nominal concrete mix with proportions of materials as specified in the table below:

Nominal mix of concrete (by mass)	Quantity of water per 50 kg of cement (Max) litres
1:5:10	60
1:3:6	34
M 15 (1:2:4)	32
M 20 (1:1.5:3)	34

Note:

1. The proportions of the fine to coarse aggregates should be adjusted from the upper limit to the lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger graded coarse aggregates shall be used.

5.1.6 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than the appropriate values. The target mean strength of the concrete mix shall be equal to the characteristic strength plus 1.65 times the standard deviation. As long as the quality of materials does not change, a mix design done earlier may be considered adequate for later work. However, in case the quality of materials changes or there is a break in the continuity of construction and the same work is allocated to a new contractor, the Engineer-in-Charge shall ask for a new design mix.

Irrespective of the grade of concrete required to be produced as per characteristic strength criteria, the minimum cement content and maximum free water cement ratio in the design concrete shall be strictly maintained for the corresponding grade of concrete.

5.2 Concrete Mix Proportioning

Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required workability when fresh green and strength, durability and surface finish, when hardened. The following information shall be collected prior to the design of the concrete mix :

- Grade designation.
- Type of cement.
- Maximum nominal size of aggregate.
- Minimum cement content.
- Maximum free water cement ratio

- Workability requirements.

The Engineer-in-Charge shall verify the strength of the concrete mix before giving his sanction for its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If, during the execution of the work, cube tests show lower strengths than required, the Engineer-in-Charge shall order fresh trial mixes to be made by the Contractor.

No claim to alter the rates of concrete work shall be entertained due to such changes in mix variations. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of the start of work.

5.2.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for each grade of concrete shall be selected to give as nearly as practicable the maximum density. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation. The contractor shall submit to the Engineer-in-Charge at least three sets of mix design and corresponding test results after varying the mix proportions and/or grading of aggregate so as to establish the maximum density of any particular grade of concrete.

5.2.2 Free Water Cement Ratio

Once a mix, including its free water cement ratio, has been determined and approved for use by the Engineer-in-Charge, that free water cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved free water cement ratio.

5.2.3 Consistency

The concrete shall have a consistency such that it shall be workable in the required position, and when properly vibrated, it flows around reinforcing steel, all embedded fixtures, etc.

5.2.4 Workability

The concrete mix proportion shall be such that the concrete is of adequate workability for the placing condition and can be properly compacted with the means available. Use of additives of approved make shall be taken recourse to where required for attaining proper workability as specified under clause 4.7.

The ranges of values of workability of concrete shall be in accordance with IS: 1199. However, the actual values to be followed shall be established depending on aggregate sizing, mix proportions, placing conditions, etc and shall be approved by the Engineer-in-Charge.

5.2.5 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, a low water-cement ratio, and adequate cement content shall always be used. Workability of concrete shall be such that the concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as shown on drawings. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum free water cement ratio and minimum grade of concrete conforming to the exposure conditions as given in the Table below.

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum cement concrete ratio (kg/m ³)	Maximum free water content ratio	Minimum grade of concrete	Minimum cement concrete ratio (kg/m ³)	Maximum free water content ratio	Minimum grade of concrete
Mild	240	0.60	M 15	330	0.55	M 20
Moderate	265	0.60	M 15	330	0.50	M 25
Severe	275	0.50	M 20	350	0.45	M 30
Very Severe	280	0.45	M 20	400	0.45	M 35
Extreme	310	0.40	M 20	400	0.40	M 40

Generally, the following types of cement shall be used for Plain and reinforced concrete works:

- 33 Grade Ordinary Portland Cement conforming to IS: 269.
- 43 Grade Ordinary Portland Cement conforming to IS: 8112.
- Portland Slag Cement conforming to IS: 455.
- Portland Pozzolana Cement conforming to IS: 1489.
- Sulphate Resisting Portland Cement conforming to IS: 12330

Sulphate Resisting Portland Cement shall be used only for specific requirements, depending on environmental and process exposure conditions to which the structures may be subjected to like high sulphate concentrations, processes involving sulphur handling, etc.

The minimum cement content, as mentioned in the table above, shall be adjusted for aggregates other than 20mm nominal maximum size. The minimum cement content in the concrete mix shall be increased by 40kg/m³ and decreased by 30 kg/m³ for 10 mm and 40 mm nominal maximum size aggregates, respectively.

Structures in contact with sewage or effluent shall be under 'extreme'. Structures not in direct contact with sewage or effluent will be "very severe". The Structural Components shall be designed as per IS: 3370 & IS: 456-2000 and other relevant Codes with latest revisions.

5.2.6 Limits to Deleterious Constituents

Careful selection of the mix and the constituent materials shall be made to limit the presence of deleterious constituents in concrete. The total acid-soluble chloride content calculated from the mix proportion and the measured chloride content of each of the constituents shall not exceed 0.6 kg/m^3 at the time of placing of concrete. The total water-soluble sulphate content of the concrete mix shall not exceed 4 per cent by mass of the cement in the mix

5.3 Batching

In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass. Where the mass of cement is determined on the basis of the mass of cement per bag, a reasonable number of bags shall be weighed periodically to check the net mass. Where the cement is weighed at site and not in bags, it shall be weighed separately from the aggregates. Water shall be either measured by volume in calibrated tanks or weighed. Any solid admixtures that are to be added shall be measured by mass; liquid and paste admixtures shall be measured by volume or mass. The batching plant shall conform to IS:4925. All measuring equipment shall be maintained in a clean serviceable condition, and their accuracy shall be within +2% and +3% for the measurement of cement and aggregates/water/admixtures, respectively.

Except where it can be shown to the satisfaction of the Engineer-in-Charge that the 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 when required, different sizes being stacked in separate stockpiles. The grading of coarse and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Engineer-in-Charge to ensure that the approved grading is maintained.

Under very special circumstances change from weigh batching to appropriate volume batching may be permitted by the Engineer-in-Charge. However, in such cases, all conversions from mass of ingredients to volume shall be based on actual and appropriate bulk densities physically measured at the site and approved by the Engineer-in-Charge.

The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in both fine and coarse aggregates. For the determination of moisture content in the aggregates, IS:2386 (Part-3) may be referred to. To allow for the variation in mass of aggregates due to variation in their moisture content, suitable adjustments in the mass of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in the Table below:

Aggregate	Approximate quantity of surface water
-----------	---------------------------------------

	Surface by mass	Litres/m ³
Very wet sand	7.5	120
Moderate wet sand	5.0	80
Moist sand	2.5	40
Moist gravel or crushed rock	1.25-2.5	20-40

No substitutions in materials used on the work or alterations in the established proportions, except as permitted in specifications, shall be made without additional tests to show that the quality and strength of concrete are satisfactory. In case the Contractor proposes any change in the already approved mix design, a fresh mix design with supportive laboratory tests shall be submitted to the Engineer-in-Charge, and his approval has to be obtained prior to using the revised mix proportion in the works. However, such proposals for revision shall only be entertained in case of successive failure of test cubes to achieve the required strength

5.4 Concrete Mixing

The mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixer shall be fitted with water measuring devices. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency.

If there is segregation after unloading from the mixer, the concrete shall be remixed. Per cent by mass. Use of Ready Mixed Concrete supplied by Ready Mixed Concrete Plants or from on/off-site batching plants (IS:4926) shall be preferred for structural concrete. All records and charts for the batching and mixing operations shall be prepared and maintained by the contractor as per the instructions of the Engineer-in-Charge.

5.4.1 Mixer

Mechanical Mixers shall comply with IS:1791 and 12119 and shall be maintained in satisfactory operating condition. These shall be used only for producing lean/ plain concrete and/ or nominal mix concrete wherever permitted.

5.4.2 Mixing Time

Mixing time shall be as indicated in the following table. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Engineer-in-Charge may, however, direct a change in the mixing time if he considers such a change necessary.

Capacity of mixer	Minimum Mixing Time
2 m ³ or less	2 minutes

Above 2 m ³	3 minutes or as recommended by the mixer manufacturer
------------------------	---

5.4.3 Hand Mixing

Hand mixing of concrete shall not be permitted. However, for non-critical applications, namely foundations for crossovers, isolated operating platforms, etc., using concrete of maximum grade M20 and located at faraway isolated places, this may be permitted by the Engineer-in-charge as a special case. Ten per cent (10%) extra cement shall be added to the design proportion. Mixing shall be carried out on a water-tight platform, and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. No extra payment shall be made to the Contractor for mixing by hand or for using extra cement due to hand mixing.

5.4.4 Additives

Additive in concrete shall be used only with the prior approval of the Engineer-in-Charge and shall comply with IS:456. Any additive used for obtaining proper workability or leak-proofness of concrete or repairing works of concrete due to non-conformance to the specifications shall not be measured and paid for. All costs relating to such usage shall be borne by the Contractor.

5.5 Trial Mixes

5.5.1 Laboratory Trial Mixes

Preliminary laboratory tests shall be carried out in a dedicated laboratory established at the site with all-time access of the Engineer-in-charge to determine the mixes to satisfy the specification with the available materials.

Trial mixes shall be tested with relevant Indian standards to determine the following properties of mixes proposed for initial field tests:

1. Bleeding (non- vibrating) Nil/negligible;
2. Air content if applicable;
3. Free water/cement ratio;
4. Consistency (workability);
5. Fresh and hardened concrete densities.

The following tests should commence when the concrete specimens are 28 days old:

1. Absorption. The upper target limit for absorption after 30 minutes shall be 2% for reinforced concrete and 2.3% for unreinforced concrete;
2. Initial surface absorption tests (ISAT).

The target limits shall be:

Time after starting the test	10 min	30 min	1 hour
------------------------------	--------	--------	--------

ISAT results ml/m ² /s	0.25	0.17	0.10
--------------------------------------	------	------	------

For Reinforced Concrete only:

1. Penetration of water. The target limit for penetration at 4 days shall be 30mm;
2. Chloride permeability. The target limit shall be 1000 Coulombs.

If any of the values obtained for properties mentioned above for unreinforced concrete or for reinforced concrete are unacceptable, the mixes shall be re-designed.

5.5.2 Initial Field Tests

Full-scale trial mixes shall be prepared for each proposed mix using the batching plant proposed for use in the works and shall be undertaken at least 35 days before the commencement of concreting. Six cylinders/cubes shall be taken from each mix, three for compressive testing at 7 days and three for testing at 28 days.

The remainder of the mix shall be cast in a wooden mould and compacted. After 24 hours, the sides of the mould shall be struck and the surface examined in order to satisfy the Engineer-in-charge that an acceptable surface can be obtained with the mix.

The strength requirements shall be considered to be satisfied if the strength of the cubes tested after 28 days meets the limits given in the IS code. In addition, the consistency of the trial mix shall be to the satisfaction of the Engineer-in-charge and within the tolerance limits given in the relevant IS code, to approval of the Engineer-in-charge.

When a proposed mix has been approved, no variations shall be made in the mix proportions, or in the type size, grading zone or source of any of the constituents except with the approval of the Engineer-in-charge, who may require further trial mixes to be made before any such variations are approved.

Until the results of trial mixes for a particular class have been approved by the Engineer-in-charge, no concrete of the relevant class shall be placed in the Works.

When the Contractor intends to purchase factory-made precast concrete units, trial mixes may be dispensed with, provided that evidence is given to satisfy the Engineer-in-charge that the factory regularly produces concrete which complies with this Specification. The evidence shall include details of mix proportions, water-cement ratios, slumps and strengths obtained at 28 days.

5.6 Quality Control

5.6.1 Quality and Testing

Concrete, mixing, sampling, and curing all shall comply with relevant Indian standards where specifications specified herein differ.

Concrete for water-retaining structures shall be watertight and shall comply with the recommendations of the relevant Indian standard code.

Mass concrete for paving shall be tested and shall have a characteristic flexural strength of 4.5N/mm² at 28 days. Characteristic flexural strengths are for concrete which has been

cured at a temperature of $20^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and are values below which no more than 5% of the test results fall.

Before placing concrete, the Contractor shall obtain approval of the mixes proposed for each class of concrete and the average target strengths. The mixes shall be designed to achieve the minimum workability for the Contractor to place and compact the concrete with the equipment proposed for use.

The mean strength shall exceed the Characteristic Strength by a margin of at least 1.65 times the standard deviation expected from the concreting plant, except that no standard deviation less than 3.5 N/mm^2 shall be used as a basis for designing a mix.

5.6.2 Test Specimens

Complete, correlated records for sampling and testing shall be maintained to include, as a minimum:

- Sampling, site tests, and identification numbers of specimens tested in the laboratory;
- Location of the parts of the structure represented by each sample;
- Location in the structure of the batch from which each sample is taken.

A visual examination of each batch of concrete delivered to the site shall be undertaken by suitably experienced and qualified personnel. Water-cement ratio for each batch delivered shall be checked from complete and accurate autographic records, showing aggregate moisture corrections.

Slump, flow table, or slump flow consistency tests shall be carried out at the site of the pour on each truck load of concrete delivered. The consistency shall be as per the mix design with the permitted tolerances given in the relevant standard.

Temperature measurements of the concrete shall be carried out on each batch of concrete if the ambient temperature at the time of placing lies outside the range $10\text{-}25^{\circ}\text{C}$.

One sample shall be taken from concrete delivered to the site, at the frequency given in the Table of Mixes, and whenever doubts are raised regarding the quality of the concrete. The sampling shall be in accordance with the relevant IS code and tested for placement temperature, consistency (workability), plastic density, water-cement ratio and compressive strength.

From each sample, three cubes/cylinders shall be made for testing at 28 days and one for testing at 7 days for control purposes. The 28-day results shall be the mean of three cubes.

Procedures for testing conformity shall be carried out in accordance with relevant Indian standards, with the approval of the Engineer-in-charge.

Water shall not be added on site to retemper concrete prior to concrete placement.

Superplasticiser may be added to the concrete, but the addition of admixtures shall only be carried out by authorised personnel and shall be recorded and signed on-site placement records to show the amount incorporated.

Tests for consistence shall be repeated after the addition of superplasticising admixtures, and after the concrete has been remixed in the truck for at least 2 minutes at maximum

revolutions. If the concrete subsequently fails the consistency testing, the concrete shall be rejected from the Works.

5.6.3 Test Certification

All testing equipment and procedures shall have a valid testing certificate or equivalent international standard. Personnel undertaking sampling and testing of concrete shall be suitably qualified and experienced.

The name and Certifying Body reference number of the laboratories shall be submitted for the approval of the Engineer-in-charge, well in advance of making trial mixes or concrete for use in the works.

5.6.4 Test Results

Reports of the identity testing results shall be submitted for the approval of the Engineer-in-charge within one day of the completion of each test.

A complete set of test results will be retained on site for inspection at any time or as appropriate.

5.6.5 Broken Samples from Failed Tests

The pieces of each cube/cylinder which fail to meet the conformity requirements for individual results shall be kept separately for a period of three months

5.6.6 Early Age Strength Testing

A regime of accelerated or normal curing and early testing, which is capable of predicting the 28-day strength of designed mixes, may be used for determining compliance, subject to prior approval. If such a regime is adopted, two additional cubes must be made from each sample and cured normally so that, in the event of non-compliance, they can be tested at 28 days to provide information which will help in deciding the action to be taken

5.6.7 Failures

In the event of non-conformity, the concrete supplier shall be informed and the supplier's compliance with conformity criteria requirements of relevant standards shall be examined. Following this investigation, one or more of the following actions will be instructed:

1. Changing the mix;
2. Improving quality control;
3. Cutting and testing specimens from the placed concrete;
4. Durability testing of placed concrete;
5. Load-testing relevant structural units;
6. Non-destructive testing of placed concrete;
7. Cutting-out and replacing defective concrete.

In the event of (iii), the Contractor shall cut specimens from approved locations. Cores shall be tested, and the method of interpretation of the results shall be subject to the approval of the Engineer-in-charge.

The Engineer-in-charge may issue instructions for the work to be stopped or delayed until reasons for the failure have been established possible consequences assessed and appropriate preventative and remedial measures taken.

Wherever the specified sampling, testing and compliance procedures show that a concrete mix is not in accordance with the specification (even if the work is eventually accepted), and measures are taken to help in establishing whether or not the work is acceptable, such measures:

- will be at the expense of the Contractor, and
- will not be considered as grounds for extension of time.

5.6.8 Other Tests

The air content of air-entrained concrete shall be determined for each batch produced until consistency has been achieved, when fewer batches may be tested.

Random monitoring of the plastic density of the concrete shall be carried out weekly, using a calibrated container.

5.7 Batching

5.7.1 Machinery

Batching shall be by weigh-batching machines equipped with accuracy checks for the weighing mechanism. The machines shall be cleaned, checked and adjusted regularly as approved.

The water supply to the concrete mixers shall have a metering system to control and record the amount

5.7.2 Accuracy of Batching

Batched materials shall be measured out within the following tolerances and discharged into the mixer without loss:

Cement	± 2% of the weight of the cement in the batch.
Aggregate	± 2% of the weight of each aggregate in the batch.
Water	± 3% of the weight of water added to the batch.
Admixture	± 5% of the amount to be added to the batch.

The batched quantities shall be adjusted to compensate for variation in the moisture content of the aggregates with the approval of the Engineer-in-charge.

5.7.3 Batching and Mixing

The batching and mixing of concrete shall comply with the relevant sections of the Indian standards. The concrete batching plant shall be capable of providing concrete at the rate necessary to comply with the approved construction schedule.

All mixers shall be properly maintained in good working order in every respect. For each mixer proposed, the Contractor shall provide a copy of the manufacturer's specification and statement of performance capability. The amount of concrete mixed in any one batch shall not exceed the rated capacity of the mixer.

No concreting shall commence in any portion of the Works until the preparations have been accepted and permission given by the Engineer-in-charge. Adequate notice must be given to the Engineer-in-charge that areas are ready for concreting to enable the Engineer-in-charge to attend and make necessary tests, inspections and checks.

If concreting is not started within 24 hours of consent being given, consent shall again be obtained from the Engineer-in-charge. Concreting shall then proceed continuously over the area to be completed.

5.7.4 Pre-production Site Check

Before concreting is commenced, the reinforcement and other embedded items shall be thoroughly cleaned of all deleterious matter, including concrete splash from previous concreting operations.

The Contractor shall take every precaution to ensure that contamination due to windborne dust, organic or chemical products from ongoing operations surrounding the works does not occur.

All forms and falsework shall be carefully examined for access and safety, and the space to be occupied by the concrete thoroughly cleaned out. Where considered necessary by the Engineer-in-charge, joints between panels of formwork shall be filled with an acceptable material.

5.7.5 Other Production Site Checks

No concrete shall be placed in the works until the batching plant, transit vehicles, concrete ingredients, mix batch quantities, quality procedures and results of laboratory and works trial mixes have been approved by the Engineer-in-charge.

Volume batching of constituent proportions shall not be permitted.

Accuracy of weighing and water dispensing mechanisms in batching plants shall be maintained within the tolerances. Accuracy shall be checked against accurate masses and volumes every four weeks or more frequently if required by the Engineer-in-charge. The masses of cement and each size of aggregate in each batch of concrete shall be recorded at the batching plant. The masses shall be within $\pm 3\%$ of the masses per batch derived from trial mixes and agreed by the Engineer-in-charge.

Dispensing equipment for admixtures shall be to the approval of the Engineer-in-charge and shall be accurate to within $\pm 5\%$ of the quantity of admixture being used. Admixture

dispensers shall be checked for accuracy at the same frequency as the weighing and water dispensing mechanisms.

The batch masses of fine and coarse aggregate shall be adjusted to allow for the free water contained in them. The quantity of water added to each batch shall be adjusted by the quantity of free water contained in the fine and coarse aggregate and the liquid content of any admixture.

The times at which cement and water are introduced to each batch shall be recorded. Concrete shall be transported in mixer trucks, which shall be operated in accordance with the manufacturer's recommendations.

Each load of concrete shall be accompanied by a delivery note that states:

- Contract name;
- Concrete Strength Class;
- Nominal workability (consistency);
- Masses of constituents;
- Time at which water was added

5.7.6 Production Checks

Concrete shall be completely discharged within 60 minutes of water being added to the mix.

Workability of each truckload of concrete shall be determined at the Site using relevant Indian Standards appropriate to the consistency of the concrete (i.e., slump or flow tests). Workability shall be within the tolerances permitted.

The temperature of concrete at the time of discharge shall not exceed 30°C. Temperature measurements of the concrete at placing shall be carried out on each batch of concrete if the ambient temperature lies outside the range 10-25°C.

Concrete mixed as above shall not be modified by the addition of water or otherwise in order to facilitate handling or for any other purpose.

Autographic records and a record book shall be kept at the Site by the Contractor and be available for inspection by the Engineer-in-charge at all times. The records shall contain the following information relating to each delivery of concrete to the Site:

- Registration number of truck, name of concrete supplier and location of batching plant;
- Time of introduction of cement and water to the mix;
- Time of arrival of truck at the concrete pour location and times when concrete discharge and compaction were completed;
- Strength Class of concrete and actual mix proportions including admixtures;
- Position in which the concrete batch is to be placed;

- Whether test cylinders/cubes were taken from the load and sample reference numbers;
- Workability test results;
- Concrete temperature at time of start and completion of discharge.

A daily concrete batching report shall be prepared and submitted to the Employer detailing the type and source of cement used, the quantities of any admixture used, the required aggregate and water weights per cubic metre, the amount of free moisture in each size of aggregate, and the batched aggregate and water weights per cubic metre.

On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed out with clean water.

5.7.7 Hot Weather Concreting

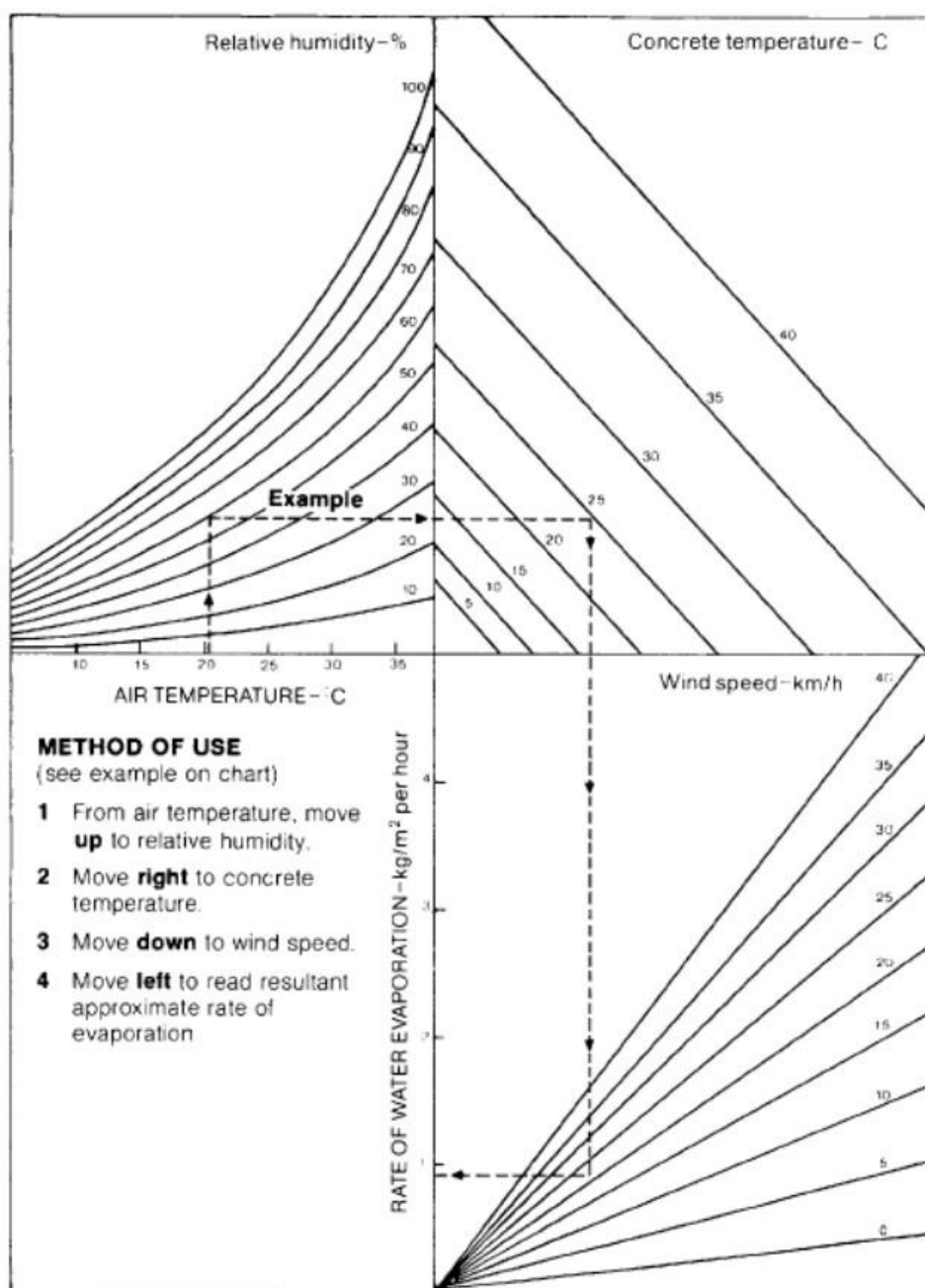
When the temperature of fresh design mix concrete exceeds 30°C, with the consequence that workability is adversely affected, mixing and placing of the concrete in question shall be terminated.

Special precautions shall be taken to ensure the concrete temperature at placing is maintained below 30°C. These precautions may include:

- Protecting all aggregate stockpiles, water lines and tanks as well as the mixer from the direct rays of the sun;
- Mixing water cooled by the addition of ice to the storage tanks;
- Concreting carried out during the cooler parts of the day or during the night;
- Cooling all chutes, formwork and reinforcement by watering when possible, or otherwise protecting the site of placing from the direct rays of the sun. Any water so used shall be removed before placing the concrete in the formwork
- Providing wind shields during periods of drying winds.

To minimise the possibility of plastic shrinkage of the fresh concrete, the rate of evaporation of water from the surface of the concrete shall be measured according to the relevant Indian standard and if this exceeds 1.0 kilogram per square metre per hour, the concrete shall be protected immediately after placing, which may be required directly after placement but before surface finishing for a large pour.

Evaporation shall be determined using the following nomogram (Concrete Society Report 22).



5.8 Placing

5.8.1 Construction Sequence/ Timing Requirements

The Contractor's attention is drawn to the need to address the risk of Delayed Ettringite Formation.

The Contractor shall submit a detailed method statement to the Engineer-in-charge for approval, defining their proposed arrangement to avoid the effects of thermal cracking and temperature differentials. The method statement shall include, but not be limited to, the size and sequence of pours, concrete temperature-monitoring system of pours, formwork type and removal time, and calculations for temperature and strain

development at internal and surface locations, taking into account heat of hydration, ambient radiation and temperature, and physical restraints.

The Contractor shall assess the weather conditions immediately prior to pouring concrete in watertight concrete structures and shall, if necessary, either suspend placing of watertight concrete or carry out placing during the late afternoon or evening if the weather is considered to be too hot and/or sunny. Other methods of keeping the concrete within an acceptable maximum temperature may be used with the agreement of the Engineer-in-charge. All concrete showing signs of excessive cracking due to early thermal and drying shrinkage effects shall be removed at the Contractor's expense.

The maximum temperature of the concrete during hydration shall not exceed 70°C.

5.8.2 Thick sections

The temperature differentials in elements greater than 0.5-metre-thick shall be limited to a maximum permissible between the core and the surface of 20°C (or 30°C for aggregate having a coefficient of thermal expansion not exceeding $10 \times 10^{-6}/^{\circ}\text{C}$). The Contractor shall undertake a trial pour under conditions representative of those anticipated during the works. Thermocouples shall be used to monitor the ambient, core and surface temperature values in the trial pour and in the works.

Details of the trial shall be submitted to the Engineer-in-charge for approval prior to the production of concrete.

5.8.3 Surfaces to Receive Concrete

Surfaces to receive concrete shall be cleaned immediately before placing concrete. Surfaces shall be clean with no debris, tying wire clippings, fastenings or free water. Absorbent surfaces where concrete is to be laid shall be wetted to a saturated surface dry condition immediately prior to concrete placement.

5.8.4 Inspection of Surfaces

Notice shall be given to the Engineer-in-charge to allow inspections of reinforcement and surfaces before each pour of concrete. The period of notice shall be at least 24 hours. Process control sheets shall be developed to administer the procedures for inspection and approval.

5.8.5 Chutes and Drop Pipes

Concrete may be placed directly from a truck mixer or other transporting equipment. The chutes attached to this equipment may be used provided that the clear free fall from the end of the chute is no greater than 2 metres and that the slope of the chute does not exceed 1 vertical to 1 horizontal. When transferring concrete vertically from higher to lower elevations, drop pipes (trunking) shall be used.

5.8.6 Buckets and Skips

Concrete buckets and skips may be used provided that the equipment is designed to discharge concrete of the slump required, the discharge gates are tight against escaping grout when closed and that any free fall of concrete does not exceed 1 metre.

5.8.7 Pumps

The delivery pipe shall be steel or heavy-duty flexible hose, and the concrete shall be supplied continuously to the pump. The pump shall be of adequate capacity and power to ensure delivery of a continuous supply of concrete.

Whenever the supply of concrete to the pump is interrupted for more than 1 hour, the chutes, pumps, pipes and any other means of distribution shall be thoroughly flushed out with water and cleaned, and shall be flushed with water immediately prior to the resumption of concreting.

All wash water used shall be discharged outside the formwork and clear of any freshly placed concrete. When pumping is complete, the concrete remaining in the pipeline shall be ejected without contaminating the concrete in place. At all times when pumping concrete Contractor shall provide adequate alternative arrangements for placing the concrete in case of a breakdown of the pumping equipment.

5.8.8 Placing

Concrete shall be placed and compacted without delay and in accordance with the recommendations of ACI 304R and ACI 309, such that dense homogeneous concrete is obtained within the Works.

Concrete shall be placed directly in its final position without segregation or displacement of the reinforcement, embedded items and formwork.

The Contractor shall take suitable precautions when placing concrete in the tidal zone or in the open during heavy rain to protect the concrete from the adverse effects of tidal variation and the weather.

Concrete placement temperature shall be limited to a maximum of 30°C and to a minimum of 5°C.

Concrete shall generally be placed without segregation.

The size of each lift of concrete shall be limited to 600mm to ensure full compacting of concrete between layers. Greater or lesser lift heights shall be proposed by the Contractor for the approval of the Engineer-in-charge to suit concrete type and shall achieve efficient amalgamation during compaction. Where spreading of concrete in the forms is necessary, it shall be carried out by approved means and not by the use of vibrators. Concrete shall not be allowed to fall freely more than 2 metres.

Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to the breakdown of equipment or other cause then the Contractor shall erect vertical stop-ends and form a construction joint, or remove the concrete already placed and restart after repair of the equipment, as agreed with the Engineer-in-charge.

Placing shall not take place in the open during high winds, storms or heavy rains. If such conditions are likely to occur, the Contractor may provide protection for the materials, plant and formwork so that work may proceed.

Contractor shall submit daily returns in respect of all concrete placed during the previous day.

The returns shall be given for each location in the work:

- The position of the pour (e.g. bay or lift reference number);
- The Strength Class of the concrete placed;
- The total volume of concrete placed and the number of batches used.

In addition, Contractor shall maintain an accurate and up-to-date record showing dates, times, weather and temperature conditions when each part of the work was concreted.

Results of all tests on concrete shall be recorded and identified with the parts of the work to which they relate.

5.8.9 Compaction

Concrete shall be thoroughly compacted in its final position, whichever is lesser: within two hours of water being added to the cement at the batcher or loss of workability of concrete does not allow satisfactory placement of concrete. Partially-set concrete shall not be used in the works.

Poker vibrators shall be operated such that each layer of concrete is well compacted and is thoroughly intermixed with the previously placed layer at the joint line, and shall be withdrawn from the concrete in a manner that does not form voids. Vibration shall be applied continuously during the placing of each batch of concrete until the expulsion of air has practically ceased and in a manner that does not promote segregation of the ingredients.

Vibration shall not be applied directly or indirectly to concrete after the initial set has taken place, where a construction joint shall be created.

Poker vibrators shall not be used to make concrete flow horizontally into position, except where necessary to achieve full compaction under void formers and cast-in accessories and at vertical joints. Compaction shall continue until the expulsion of air has virtually ceased, and in a manner which does not promote segregation of the ingredients.

Slabs 100 millimetres thick or less shall be compacted by vibrating beams or other approved techniques and not by internal vibrators.

The formation of cold joints shall not be permitted.

No-fines concrete shall be lightly tamped only.

5.8.10 Vibrators

Sufficient numbers and types of vibrators, including back-up, shall be maintained on site to suit the rate of pouring, consistency and location of concrete. Concrete placing shall cease in the event of a total breakdown of the vibration equipment and shall be reduced

with partial failure of the equipment. Concrete that has not been properly compacted shall be rejected.

External vibrators shall be used only with the approval from the Engineer-in-charge.

5.8.11 Continuity of Placing

Placing in each section of work shall be continuous between construction joints. The Contractor shall make provision for standby equipment. If the placement of concrete is delayed due to a breakdown, then the Contractor shall erect vertical stop-ends and form a construction joint or remove the concrete already placed and restart after repair of the breakdown, as directed.

5.8.12 Placing in Inclement Weather

Placing shall not take place in the open during storms or heavy rains. If such conditions are likely to occur, the Contractor shall provide protection for the materials, plant and formwork so that work may proceed. If strong winds are prevalent, protection from driving rain and dust shall be provided.

5.8.13 Placing at Night

If approval has been given for placing at night or in dark interiors, adequate lighting shall be provided where mixing, transportation, and placing are in progress.

5.8.14 Placing under Water

5.8.15 Underwater concrete shall be placed with minimum disturbance of the water. Running water and wave wash shall be controlled. The specified concrete grade shall be used and the mix design shall provide for good flowing ability.

Tremie pipes, bottom-dump skips or other approved placing equipment shall be used. Segregation shall be avoided.

Placing shall commence in approved sections and continue to completion.

The tremie pipe shall be buried in the concrete, and the pipe must not be emptied until the pour is complete. If a bottom-dump skip is used, the contents shall be covered by canvas or similar before lowering into the water. The doors shall be opened when the skip is resting on the bottom with no tension in the support cable, and the skip shall be lifted gradually so that the concrete flows out steadily.

5.9 Formwork

5.9.1 General

Formwork shall be designed and constructed in accordance with the recommendations of the relevant Indian standard or similar approved standard and shall ensure that the finished concrete members conform accurately to the dimensions, lines and elevations shown on the drawings and to the specified tolerances.

The Contractor shall submit details of formwork to the Engineer-in-charge for review and approval in advance of concreting.

Details of formwork for special finishes shall be approved before materials are ordered.

Formwork shall be designed and constructed to withstand the worst combination of the following without producing deformation of the finished concrete in excess of the specified tolerances:

Total weight of formwork, reinforcement and concrete.

- Construction loads including dynamic effects of placing, compacting and construction traffic;
- Wind loads.

The faces of formwork shall be clean, free from protrusions, adhering grout and other imperfections or defects and shall be removable without disturbing the concrete.

Top formwork shall be provided to slopes of 30 degrees or more from horizontal.

Formwork panels shall have true edges for accurate alignment and shall be fixed with either vertical or horizontal joints. Joints shall be close-fitting and shall not permit leakage of grout, nor steps and ridges in exposed surfaces.

Rough formwork shall be butt-jointed, seasoned, and sawn timber

Fine finish formwork shall be used for all concrete surfaces unless detailed otherwise on the Drawings. This finish shall be obtained from forms designed to produce a hard, smooth surface with true, clean arises.

Concrete shall not be placed prior to inspection and approval of the formwork for each individual pour. Not less than four working hours' notice shall be given for the inspection and approval of the formwork and reinforcement.

5.9.2 Form Ties

Form ties shall be factory-fabricated, removable or snap-off metal ties which will neither allow formwork deflection nor spall the concrete when removed. The ties shall be provided with backing plates to distribute loads evenly to the formwork.

Bolt or tie systems which, when removed, leave a hole through the member shall not be permitted in liquid retaining structures. Ties shall be fitted with devices that will leave holes in the concrete surface not less than 6 millimetres nor more than 25 millimetres in diameter. Bolts and rods that are to be completely withdrawn from the finished concrete shall be coated with an approved non-staining bond breaker prior to concreting.

Tie cavities shall be roughened and filled with approved non-shrink concrete or epoxy mortar.

Removable ties shall be located so that the specified cover to reinforcement is maintained to all surfaces, including that of the tie-holes. If ties are left in, the cover to the part of the tie which remains in the concrete shall be as specified for the reinforcement or as approved by the Engineer-in-charge.

5.9.3 Boxouts

Boxes for forming holes shall be constructed to be easily removable without damaging the concrete during removal. They shall be properly vented to permit the escape of entrapped air and shall be capable of being sealed subsequently to prevent the loss of grout. The use of polystyrene blocks for forming holes shall not be allowed unless used purely as a void filler within otherwise rigidly constructed boxes.

5.9.4 Inspection Holes

Openings in formwork for inspection and cleaning-out shall be formed so that they can be completely sealed before the placing of concrete.

5.9.5 Formwork Props

The Contractor shall submit a method statement for proposals for prop bearings and sequence of propping / repropping and backpropping at least 14 days before commencement of concreting.

Formwork props shall prevent deflection and damage to the structure. Carry down props to bearings strong enough to provide adequate support throughout concreting operations.

All props shall be supported on adequate sole plates and shall not bear directly on or against previous concrete. They shall be capable of being released gently without shock to the supported formwork. No appliance for supporting the formwork shall be built into the permanent structure.

5.9.6 Chamfers

Where chamfers are required, the fillets shall be cut to provide an even line.

All outward projecting 90-degree corners shall have a 25 millimetre x 25 millimetre chamfer unless shown otherwise on the drawings.

5.9.7 Treatment of Formwork

Forms, other than retained-in-place metal forms, shall be coated with form oil (mould oil) or form release agent before the concrete is placed. The coatings shall be approved commercial formulations of satisfactory and proven performance.

Release agents which are suitable for use with the type(s) of formwork, formed finishes, and specified applied finishes shall be used. The same type and make of release agent shall be used throughout the entire area of any one finish and shall be applied evenly to form faces, from top downwards, and to horizontal surfaces last. The minimum amount necessary shall be used to obtain a clean release and prevent excessive local collection.

Release agents shall not bond with, stain or adversely affect the concrete surfaces and shall not impair subsequent treatment of concrete surfaces, depending upon the bond or adhesion, nor impede the wetting of surfaces to be cured with water or curing agent. Forms for unexposed surfaces that are to be treated with a waterproof membrane shall be moistened with water immediately before placing concrete. Surplus oil on form

surfaces, reinforcing steel and construction joints shall be removed before placing the concrete.

Release agent shall be prevented from touching the reinforcement, hardened concrete, other materials not part of the form face, and permanent forms.

Surface retarders shall not be used for formed faces unless as part of any construction joint details, or otherwise, for the approval of the Engineer.

5.9.8 Removal of Formwork

The consent of the Engineer-in-charge shall be obtained in all cases before any formwork is removed, but any permission given or indicated in these documents shall in no case relieve the Contractor of his responsibility in respect of any injury or of any damage to the concrete work arising from the removal of the forms.

Formwork shall be removed in a manner not to damage the concrete, and at times to suit the requirements for its curing and to prevent restraint that may arise from elastic shortening, shrinkage or creep. Formwork shall not be removed until the concrete has sufficient strength to support itself.

Side forms shall not be removed until the concrete has sufficient strength to support itself. Soffit forms, centres and props may be removed when the member has sufficient strength and stiffness to carry itself and any loading without unacceptable stresses or deflections. Load shall not be applied to a member until it can be demonstrated that it has sufficient strength and stiffness.

Where waterproofing membrane is applied to remove formwork, it shall be ensured that a minimum concrete compressive strength of 10N/mm^2 is reached before the formwork is stripped.

Where it is intended to re-use formwork, it shall be thoroughly cleaned and made good by the Contractor to the satisfaction of the Engineer-in-charge.

No remedial work or covering up shall be undertaken until the struck concrete face has been inspected and approved by the Engineer.

External loading shall not be applied until the concrete has reached the 28-day characteristic strength.

Formwork striking times shall be determined in accordance with relevant Indian standards.

Proposals by the Contractor for the striking of formwork shall be submitted to the Engineer-in-charge for approval prior to the commencement of concrete production for the main works.

5.9.9 Permanent Formwork

Permanent formers of GRP pipe are to be used where indicated on the drawings. The min. wall thickness of the GRP shall be 5mm.

5.9.10 Controlled Permeability Formwork

Controlled permeability formwork may be used to reduce the incidence of blow holes on surfaces to receive coatings. It shall be a proprietary system designed for (and with a track record in) concrete construction, shall be generally robust and fit for purpose, and shall be the subject of a submission for approval, in accordance with Concrete Society Technical Report 52.

5.10 Reinforcement

5.10.1 Reinforcement General

All reinforcing steel shall be supplied by an approved reinforcement manufacturer. Site records shall be kept of delivery documents and labels.

The Contractor shall check the schedules against the drawings and be responsible for their accuracy and fit.

The Contractor shall maintain a record of test results for Qualification, Performance and Results to include the following:

- Yield load;
- Yield/Proof stress;
- Ultimate load;
- Mode of failure and where occurring;
- Other pertinent data

5.10.2 Fixing

Reinforcement shall be fabricated to the shapes and dimensions shown and shall be fixed in strict accordance with the owner-approved drawings as prepared by the Contractor. However, minor adjustments may be made to keep reinforcement clear of pipes, openings, water bars, built-in items, etc.

Reinforcement shall be fixed into cages or mats by binding the intersections and laps with tying wire or approved fixing clips. The fixings shall be of sufficient quantity to ensure that the reinforcement is held securely in place during construction and concreting. Use of additional steel for support of temporary works shall be permitted subject to the approval of the Engineer-in-charge.

Tack welding shall not be carried out unless authorised by the Engineer-in-charge and recommended by the reinforcement manufacturer, and then only to the manufacturer's recommendations.

In addition to support shown on drawings or schedules, the Contractor shall provide chairs and spacers as necessary to support reinforcement in position and maintain the specified cover. Bar reinforcement must be fixed in position before the concrete is placed.

Suitable precautions shall be taken by the Contractor to prevent displacement of the reinforcement during the placing and compaction of the concrete and maintain the specified cover. The placement of reinforcement with kinks or bends shall not be permitted.

Contact between ordinary carbon steel and stainless or galvanised reinforcement shall be prevented.

5.10.3 Bending Schedules

Cutting and bending of reinforcement shall be carried out in accordance with approved schedules and relevant Indian standards.

Restrictions on bending steel shall be as follows:

- Rebending, including minor adjustments: Obtain instructions;
- Temperatures below 5°C: Obtain instructions;
- Temperatures greater than 100°C: Prohibited.

Cutting shall be carried out with an approved cropping machine.

On-site facilities shall be provided for bending reinforcement to deal with approved minor adjustments.

Grade 250 bars shall be bent to radii not less than BS 8666: Table 1. Grade 460/425 bars must not be re-bent or straightened without approval from the Engineer-in-charge.

Any bars showing signs of cracking or brittleness, after bending or re-bending, shall be rejected.

5.10.4 Welding

Electric arc welding may be used, if approved, for joining bars. Covered-alloy or shielded-arc electrodes and workmanship shall conform to relevant standards. Joints shall be butt-welded with standard double-V or double-U welds.

Electric arc welding of any reinforcement is prohibited on all bridge works.

5.10.5 Cover to Reinforcement

Where required to support and retain the reinforcement in its correct position, Contractor shall provide templates, stools or other supports. Target or nominal cover to reinforcement shall be in accordance with the Drawings and this Specification. Cover shall be maintained over ties, stirrups and lap splices.

Approved type(s) of cover spacers shall be used, which will adequately support the reinforcement, adequately resist displacement, not cause indentation of the formwork and be made from: Plastics (perforated to at least 25% of their area), or Concrete (strength and durability to match surrounding concrete). Spacers and chairs shall be in accordance with Indian Standards. Cover spacers shall not be closer than 300 mm centre to centre and staggered on adjacent parallel bars.

Where precast concrete support blocks are used, they shall be wedge-shaped, not larger than 90 millimetres by 90 millimetres, of a thickness necessary to provide the required cover and with an embedded hooked stainless steel tie wire for anchorage.

If the formed surface is exposed to view, the precast concrete support block shall be the same quality, texture and colour as the finished surface.

Following concreting checks shall be carried out using a cover meter in accordance with Indian standards over at least 10% of accessible surfaces at a 1m spacing prior to covering up. The measured cover values to all steel shall not be less than the minimum cover value given in the Table of Mixes. The results of the survey shall be submitted to the Engineer-in-charge for approval prior to any covering up.

5.11 Joints

5.11.1 Construction Joints

Construction joints shall be located and the sequence of placing arranged as approved, or as shown on the Drawings, to minimise shrinkage and thermal strains in the concrete.

Concrete placing shall not be interrupted except where joints occur, and shall continue after normal hours if necessary to achieve this.

Joints shall be formed square to the work with keyways included.

Horizontal joints shall be generally at least 500mm above ground level (relevant Indian standard shall apply), and 500mm above high water level in marine locations, or as shown on the Drawings.

Upon removal of the formwork, the joint face shall be inspected, and if the soundness of the concrete is not approved, the Contractor shall investigate and remedy defects.

Before placing is resumed at a joint, the set surface shall be roughened to remove laitance and expose the aggregate; the concrete shall have gained sufficient strength to ensure that the aggregate is not in any way damaged or loosened within the matrix. If damaging materials have come into contact with the surface of the joint, the concrete shall be cut back and the roughened surface cleaned by compressed air or water jets, and brushed and watered immediately before placing.

Chemical surface-retarders shall not be used.

Construction joints shall be sealed with an approved sealant on debonding tape at external and liquid-contact faces.

Construction joints in water-retaining structures shall incorporate an approved water bar, and construction joint details shall be submitted to the Engineer-in-charge for approval.

5.11.2 Design Joints

Expansion and contraction joints shall be as shown on the Drawings.

A contraction joint in a non-water-retaining structure shall form a plane of discontinuity in the member. The concrete face first cast shall be painted with two coats of approved rubberised bitumen paint before the adjacent concrete is placed. The adjacent concrete shall include a groove against the joint for sealant. The exposed edges shall be sealed with an approved sealant on debonding tape.

If a contraction joint is likely to be contaminated, the joint shall be sealed immediately with an approved free-flowing sealing fluid as soon as the formwork has been removed.

An expansion joint in a non-water-retaining structure shall be formed as for a contraction joint, but non-absorbent closed-cell polyethylene joint filler shall be included so that the adjacent concrete members can expand.

A design joint in a water-retaining structure shall include a continuous water stop strip of copper, rubber, rubber and steel or PVC fixed across the joint as shown on the Drawings. The concrete shall be free from honeycombing, and the work shall work against the embedded part of the strip. Projecting portions of the strip shall be protected from damage during operations and, in the case of rubber and plastic, from light and heat.

Bituminous paint shall be applied to the lips of the loop of copper water stop, and the loop filled with bituminous compound before embedding in the concrete.

The method of joining water stops shall be in accordance with the manufacturer's instructions.

5.12 Curing and Protection

5.12.1 Curing

Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete in normal weather, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers, etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain, disfigure or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing. Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete.

The Contractor shall have all equipment and materials required for curing on hand and ready to use before concrete is placed.

For curing the concrete in pavements, floors, flat roofs or other level surfaces, the ponding method of curing shall be used. For the first 24 hours after concreting, the concrete shall be cured by the use of wet sacking, canvas, hessian, etc. The minimum water depth of 25mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Engineer-in-Charge. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by the ponding method shall be cleared of all debris and foreign materials after curing period is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set

Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency of 90% as specified by BS-8110. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Engineer-in-Charge may not allow curing by curing compounds for those surfaces where use of curing compound may be detrimental to application of future finishes over the concrete. Impermeable membranes such as polyethylene sheeting closely covering the concrete surface may also be used.

For concretes containing Portland pozzolana cement or Portland slag cement, the curing period as given above shall be doubled. Curing by ponding shall, however, commence after the first 24 hours of concreting.

5.12.2 Curing and Protection

Concrete shall be protected from sunshine and drying winds by approved shading and wind-breaks, and from cold, rain or running water, for a period of 14 days after placing. During this period, the following measures shall be taken to prevent the loss of moisture and to minimise thermal stresses caused by the difference in temperature between the surface of the concrete and the core of the concrete mass:

1. Horizontal surfaces.

- Polythene sheeting shall be placed immediately after finishing.
- After the final set has taken place, the polythene shall be replaced by wet hessian covered with polythene; the hessian shall be kept permanently damp.
- After 14 days, the hessian and polythene shall be removed and an approved aluminised or white resin-based curing compound applied. The rate of application shall be as recommended by the manufacturer.
- Alternative methods of curing must be approved before use where special finishes are required.

2. Vertical surfaces.

- Polythene over wet hessian shall be secured to the surfaces immediately after removal of the formwork. The hessian shall be kept permanently damp.
- After 14 days, the hessian and polythene shall be removed and an approved aluminised or white resin-based curing compound applied.
- Water used during curing operations shall be potable water. Curing membranes shall be compatible with waterproofing or other materials that may subsequently be applied to the surface of the concrete.

5.12.3 Contamination

Concrete shall be protected from contamination by sea or brackish water, oil, fuel and other deleterious materials for a minimum period of 30 days after placing.

5.12.4 Insulating Formwork

Insulating formwork shall be left in place for 72 hours after placing or until the temperature peak of the concrete is reached. The initial curing period in as mentioned above, may then be reduced in proportion.

5.12.5 Protection of Joints

Rebates formed to receive sealant, and the surfaces of construction joints shall be protected from curing compound by wet hessian to ensure proper curing of the joint surface and adjacent concrete. The protection shall remain in place until the joint surface is sealed.

5.13 Finishes

5.13.1 Finishes General

The finished faces of concrete shall be sound, even coloured, even-textured and free from defects. Arises shall have a 20 x 20mm chamfer unless detailed otherwise on the Drawings. A fine finish shall be provided unless detailed otherwise on the Drawings.

5.13.2 Concrete Surfaces without Formwork

On upward-facing surfaces which do not require formwork or special finish, the finish shall be produced by proper placing and compacting operations alone.

For a fair finish, screeding shall be used, carried out by sliding and tamping a screed board running on the top edges of the formwork, or on screeding guides, to give a dense concrete skin.

For a fine finish, screeding shall be used as described, then left until the concrete has stiffened and the film of moisture has disappeared. A steel or wooden float shall then be used for a glossy or sandpaper surface as required. Working shall be the minimum compatible with a good finish. The surface shall be protected from water drops.

5.13.3 Wire-Brushed Finish

After removal of the formwork, the surface of the concrete shall be abraded by stiff wire brushes and water to remove the cement laitance and expose the aggregate.

5.13.4 Bush-Hammered Finish (Roughened surface)

The surface shall be abraded by carborundum stones to remove irregularities. Within 3 weeks, the surface shall be bush-hammered to remove the cement laitance and expose the aggregate. Approved bush hammers shall be worked to within 12mm of corners and arrases; the remaining 12mm shall be hand-chiselled to match. Bush hammers shall be operated perpendicularly to the surface, and the remaining exposed aggregates shall not

be loose or fractured. The treated surface shall be washed with water and stiffly brushed. The exposed aggregate shall be clean and free from film.

5.13.5 Chemical Retarders

Chemical surface retarders, if approved, may be used to produce an exposed aggregate finish, and the Contractor shall demonstrate that the durability of the concrete surface is not reduced.

5.13.6 Carborundum Finish

Carborundum finish shall be achieved by sprinkling carborundum grit on the unset surface and working-in with a wooden float. The grit shall vary in size between BS 1.18mm mesh and BS 0.60mm mesh and shall be distributed from a BS 1.18mm hand-screen at the rate of 2.15 kg per m².

5.13.7 Specimen Panels of Concrete

The Contractor shall produce specimen panels of finished concrete for approval. The approved panels shall be retained by the Engineer-in-charge and used to determine the acceptability of concrete finishes in the Works.

5.14 Special Concrete

5.14.1 Precast Concrete

The Contractor shall submit for approval details of arrangements for casting, handling and placing precast units.

The Contractor shall cast sample panels for approval, and approved panels shall be retained on site as the control standard for subsequent panel production.

Precast concrete units shall be cast on manufactured beds. The beds shall not be liable to settlement and shall have smooth, hard and level surfaces. Each unit shall be marked with a serial number and the date of casting. Steel bars shall not be embedded in the concrete for lifting.

Units shall not be removed from the beds until the representative flexure-test beams reach adequate strength for handling, and shall not be placed until the cubes representing them reach the appropriate 28-day Characteristic Strength.

5.14.2 No-fines Concrete

The aggregate for no-fines concrete shall be coarse graded from 10mm to 20mm. A small percentage of fines from 10mm to 5mm may be added to improve the strength if approved. Cement shall be mixed with the aggregate in the proportion of 1 to 8 by volume. Segregation of the cement grout shall be prevented.

5.14.3 Granolithic Concrete

Granolithic concrete shall consist of one part by weight of cement to three parts of combined coarse and fine aggregate. The combined aggregate grading shall be as follows:

BS Sieve	Percentage Passing
14 mm	100
10 mm	95 - 100
5 mm	30 - 45
2.36 mm	30 - 35
1.18 mm	15 - 25
0.60 mm	10 - 20
0.30 mm	5 - 10
0.15 mm	0 - 5

Granolithic concrete shall be laid on top of the unset base concrete, and compacted and worked to the correct levels. The surface shall be floated with a steel float after hardening until the water sheen has disappeared. Cement or cement-sand shall not be sprinkled onto the surface. The layer shall be 12 to 18mm thick.

If a granolithic layer is required to be placed on set concrete, the latter shall be scabbled and cleaned to expose the aggregate, and an approved bonding agent shall be applied. The layer shall not be less than 50mm thick.

If required, compounds shall be added or applied to give a concrete with improved dust-proof and oil-proof qualities. The compounds shall be used in accordance with the manufacturer's instructions.

Granolithic concrete paving shall be placed in panels not exceeding 3m square. Approved contraction joints shall be provided around the perimeter of each panel.

5.14.4 Cement- Mortar, Grout, and Rendering

Cement-mortar shall consist of one part cement and four parts fine sand by volume, with just enough water to achieve workability.

Grout shall consist of cement mixed with water in approved proportions. Fine sand may be included in approved quantities.

Rendering shall consist of three parts fine, sharp sand to one part cement applied in two 10 mm coats and one 5 mm finishing coat. The colour of the finishing coat shall be as approved.

Acid-resistant epoxy mortar shall be obtained from an approved manufacturer and shall be applied in accordance with the manufacturer's instructions.

Mortar, render, and grout shall be used freshly mixed.

5.14.5 White Concrete

White concrete shall comply in all respects with the requirements of this Specification, and with the additional requirements of this clause.

Fine and coarse aggregate shall be white and shall be obtained from approved sources.

Cement shall be white PC and shall be obtained from an approved source.

Trial mixes shall be produced and trial units cast to demonstrate the suitability/consistency of the mix. As detailed on the Drawings, units shall be sand or grit blasted to achieve the required exposed aggregate finish. Bulk orders for materials shall not be placed until the mix and the exposed aggregate finish have been approved. Thereafter, all units shall achieve the quality of the approved trial unit(s).

Sufficient material shall be obtained in one order to satisfy the entire contract requirement, to ensure consistency through the Works.

5.15 Tolerances

5.15.1 Tolerances of Concrete Surfaces

The tolerances of concrete surfaces shall be in accordance with the relevant Indian standards.

The Contractor shall manage the tolerances between his purchased metalwork and cast-in-situ concrete.

5.16 Action in the event of Non-compliance

In the event of a failure to comply with the specification, then any of the following actions may be instructed:

- Work should stop;
- Investigation of the non-compliance;
- Redesign of the concrete mix;
- Improving quality control;
- Cutting and testing specimens from placed concrete;
- Durability testing of placed concrete;
- Load-testing relevant structural units;
- Non-destructive testing of placed concrete;
- Breaking-out and replacing concrete.

In the event that the Contractor shall cut specimens from approved locations. Cores shall be tested in accordance with the relevant Indian standard. If the estimated in situ cube strength is less than 80% of the characteristic strength of the concrete mix, then the concrete represented by the cores shall be treated as non-compliant.

The Company may issue instructions for the work to be stopped until reasons for the failure have been established, possible consequences assessed and appropriate preventative and remedial measures taken. Wherever a non-compliance has been identified (even if the work is eventually accepted), the corrective actions arising will be at the expense of the Contractor, and will not be considered as grounds for extension of time.

5.17 Repairs and Remedial Works

Methods and details for carrying out remedial work to damage and defects shall be submitted in the form of a detailed method statement for approval.

In general, repairs and remedial methods shall be based on the use of proprietary polymer-modified cementitious materials.

No remedial work or covering up shall be undertaken until the struck concrete face has been inspected and approved.

The location and nature of all repairs and remedial works shall be recorded, and a copy of the records shall be handed over at completion.

5.18 Surface Protection Materials

5.18.1 External Sheet Tanking Membrane

External sheet tanking membrane to concrete substructures shall be an impervious, cold-applied applied flexible laminated sheet, consisting of multi-layer high-density high-density cross-laminated polyethylene film with a backing of self-adhesive rubber bitumen compound to give a combined thickness of 1.5 mm and protected with silicone-coated release paper. The mass of the membrane shall not be less than 1.6 kg/m² gross. A special grade of compound formulated for hot climates shall be used, which has in excess of 10 years of successful usage in India. The laminate shall withstand cracking of the substrate up to a crack width of 0.6 mm. Minimum test performance data shall be as follows:

Property	Test Method	Results
Tape Strength	ASTM D638/Equivalent	Long. 4.2 N/mm Trans. 4.8N/mm
Tensile Strength	ASTM D638/Equivalent	Long. 42 N/mm ² Trans. 48 N/mm ²
Elongation Film	ASTM D638/Equivalent	Long. 210% Trans. 160%
Tear Resistance	ASTM D1004/Equivalent	Long. 270 N/mm Trans. 270 N/mm
Adhesion to Primed Concrete	ASTM D1000/Equivalent	1.8 N/mm
Adhesion to Self		1.8 N/mm

Puncture Resistance	ASTM D1000/Equivalent	290 N 65 mm
Water Resistance	ASTM E154/Equivalent	After 24 hours 0.14%
		After 35 days 0.95%
Environmental Resistance	ASTM D570/Equivalent	Conforms
	ASTM D543/Equivalent	
Moisture Vapour Transmission Rate		0.3 g/m ² /24 hrs
	ASTM E96/Equivalent	
Adhesive Softening Point		Not lower than 103°C
	ASTM D36/Equivalent	

5.18.2 External Brush-Applied Tanking Membrane

Coatings shall be solvent-based bituminous compounds complying with relevant Indian standards. They shall be applied in two coats and the second coat shall incorporate non-asbestos fibre reinforcement and shall be applied to a minimum thickness of 1.5 mm.

5.19 Application of Concrete Surface Treatment

5.19.1 Above-Ground Concrete Coatings General

All exposed surfaces of reinforced concrete elements shall be protected by a water repellent, chloride-resistant coating. Coatings for specific applications are to be as shown on the Drawings. All other surfaces shall receive the protective and decorative coating specified for bridges.

The complete coating system, including primers, shall be applied in accordance with the manufacturer's instructions.

Coatings shall be applied by a specialist applicator approved by the manufacturer and the Engineer-in-charge, and shall have at least five years' proven successful experience.

A method statement for the application shall be submitted giving full details of all equipment and application methods proposed, and safe access provisions. The method statement shall include wet and dry film thickness tests, pull-off tests and any other quality control tests appropriate to the coating performance.

Sample panels of each coating type shall be prepared, before approval of material and applicator, on L-shaped panels comprising vertical and horizontal surfaces of at least 1 m² each.

Full records of areas coated, quantity of material applied, ambient and substrate temperature, and humidity shall be kept on a daily basis and submitted to the Engineer.

5.19.2 Surface Preparation

Surfaces shall be lightly grit blasted to remove all contamination such as oil, grease, loose particles, decayed matter, laitance, mould release oils and curing compounds.

Any surface defects and blow holes shall be filled to produce a fine finish using a proprietary product such as an acrylic modified cementitious repair fairing coat (or mortar for larger defects). The repair shall be completed at least 48 hours before the application of coatings.

5.19.3 Coating of Exposed Concrete Surfaces

Exposed concrete surfaces shall be coated in accordance with the relevant Section of this Specification. The general and surface preparation requirements of this Section shall be followed.

5.20 Vacuum Dewatering

5.20.1 Vacuum Dewatering General

Vacuum dewatering, where specified, shall be in accordance with the requirements of this Specification, and shall be carried out by a specialist contractor with at least five years' experience of application of the process in the Middle East.

Vacuum dewatering shall be achieved by the use of a specialist system incorporating a filter mat and vacuum extraction of water at a suction pressure of between 0.6 and 0.8 atmospheres.

Concrete with micro silica shall not be used in areas subject to vacuum dewatering. Where blast furnace slag or pulverised fuel ash is used, the test results of fineness of the cement and cement substitute material shall be submitted to the specialist contractor, and written acceptance of suitability obtained.

For all mixes, the details of mix design shall be submitted to the specialist contractor, and written acceptance of suitability shall be obtained.

Following submittal of the contractor's method statement and initial approval, a trial area of vacuum dewatering shall be carried out. The trial area of slab shall be at least 100 m² and shall not be part of the permanent Works, and shall be laid using the mix, equipment and personnel proposed. Finishes and joints within the trial area shall match the requirements of the final slab.

Vacuum dewatering shall be carried out on each part of the slab for a period of one minute for each centimetre of slab thickness, or as otherwise established by trial or during the progress of the Works and agreed by the Engineer.

5.21 Testing of Water Retaining/Excluding Structures

Testing shall be done in accordance with the requirements of the relevant Indian standard and this section of the specifications.

On completion of structures designed to retain/exclude an aqueous liquid shall be cleaned thoroughly in such a way as to remove all oil, grit and other deleterious matter. Prior to testing, the Contractor shall satisfy the Engineer-in-charge that this structure is structurally stable if filled for testing purposes, and obtain the written approval of the Engineer-in-charge to proceed with testing. Filling shall not take place earlier than 28 days after casting of the final section of the structure unless otherwise agreed by the Engineer-in-charge. In case the structure is subdivided into individual tanks and each tank can work in complete isolation, then each tank shall be tested separately. All concrete tanks, channels and conduits shall then be tested for leakage in the following manner.

As far as practicable before any earth, sand or other filling is placed against the outside wall faces, concrete structures designed to retain an aqueous liquid shall be filled to maximum operational level with water at a uniform rate of not greater than 2m in twenty-four hours. A period of twenty-one days shall be allowed for stabilisation. After stabilisation, two shallow water tight trays 200mm x 200mm x 150mm deep trays shall be filled with 75mm of water and placed to float in the structure. These trays shall be positioned away from the sides of the structure and any overhead member that may shade or shield them. Water level shall be recorded by a hook gauge with Vernier attachment or by approved means at twenty-four-hour intervals for a test period of seven days. During the test period, the total permissible drop, after allowing for evaporation and rainfall, shall not exceed 1/500 of the average water depth of the full tank or 10mm, whichever is the lesser.

Notwithstanding the satisfactory completion of the above test, any leakage visible on the outside faces of the structure shall be stopped. Any caulking or making good of cracks in the wall section shall, where practicable, be carried out from the inside face.

All testing arrangements shall be subject to the approval of the Engineer and should be performed in accordance with BS 8007 Clause 9.2.

Should any leakage or loss of pressure appear on any test, the Contractor shall take such measures as are necessary to remedy the faults to the satisfaction of the Engineer-in-charge, and shall re-test to prove the effectiveness of the remedial work. All tests and remedial work shall be at the Contractor's expense.

Potable water supplied by the Contractor shall be used for testing purposes.

Reinforced concrete liquid retaining structures shall be tested prior to the application of protective coatings. The Contractor shall be deemed to have allowed within his rates for the provision of any associated temporary plugs or blank flanges to effect the testing.

5.22 Concrete (Piling work)

5.22.1 General

1. Unless otherwise stated herein, all aspects of the concrete work, including materials, specifications, preliminary mix designs, workmanship and inspection testing stipulated in specifications of “plain and reinforced concrete” shall apply.
2. Cement:
 - f) Cement shall be used for any of the following, and the type selected shall be appropriate for internal use.
 - g) Portland slag cement (PSC): Chemical requirements as per IS 455-1989 and physical requirements as per IS 8112-1989 as directed by the Engineer-in-charge.
 - h) GGBS: GGBS conforming to IS 12089 will be permitted to mix in an appropriate proportion in OPC 43, provided the concrete is produced in a batching plant as directed by the Engineer.
 - i) 43 Grade ordinary Portland cement conforming to IS 8112-1989 is generally acceptable.
 - j) Portland Pozzolano Cement (PPC): PPC Cement shall be permitted conforming to IS 1489 & applicability as per relevant IS codes / as directed by the Engineer.
3. The maximum size of aggregates shall be 20mm.
4. Unless otherwise called for on the drawings or in the bills of quantities, the concrete shall be of Grade M35. Concrete for pile in an aggressive environment like alkali soils / alkaline water shall have a minimum cement content of 400 Kg / cum.
5. Concrete, for piles cast-in-situ, shall have sufficient slump (125 to 175 mm) to give it a self-compacting consistency. The water-cement ratio, including the water contained in the aggregates, shall be limited to 0.45 unless otherwise stipulated. Plasticising agents may be used by the Contractor to improve the workability, but the Engineer shall be furnished with proof that the proposed plasticising agent has no adverse effects on the hardened concrete or reinforcement.
6. At least one load test shall be made for every 100 piles cast, and not less than six cubes shall be cast on each day of concreting of piles. Three of the six cubes constituting one test shall be tested on the 7th day from casting the cubes, and the remaining cubes shall be tested on the 28th day after casting. Records of all cube tests shall be communicated to the Engineer-in-Charge.
7. The Engineer-in-charge reserves the right to reject any pile of deficient concrete strength.
8. Such rejected piles shall be replaced by the Contractor at his own cost, who shall also bear the additional costs of widening pile caps resulting from the grouping of the piles as a result of the replacement of piles.
9. The engineer also reserves the right to order a change in the mix design and/or water-cement ratio to obtain the specified strength or workability.

10. All reinforcement for use in the pile shafts shall be as per drawings and be assembled and tied, and/or welded together and made up into cages sufficiently rigid to withstand handling without damage and distortion.
11. Joints in longitudinal reinforcement bars, if unavoidable, shall be made by lapping, and the laps shall be tack-welded to prevent distortions of the reinforcement cage.
12. The projecting length of longitudinal bars beyond the pile cut-off level shall be equal to 40 times the diameter or such other length as shown on the drawings.
13. As specified in the drawings, the lateral reinforcement shall consist of a helix made as shown on the drawings.
14. The minimum of longitudinal bars shall be six (6).

Concrete cover over all reinforcement, including lateral helical reinforcement, shall be 50 mm, unless otherwise specified or shown on the drawings. Care shall be taken to preserve the correct cover and alignment of reinforcement free from any twist, throughout the whole operation of placing the reinforcement in the bore hole and placing the concrete, the inside diameter of the reinforcement cage shall be adequate for the operation of the tremie pipe when used.

5.22.2 Drilling mud (bentonite)

The drilling mud shall have such properties as to permit the formation of filter cake on the sides of the bore holes, the thickness of which would depend on the nature of the subsoil deposit. Sodium-based bentonites have ideal properties suitable for use as drilling mud.

During the boring operation, the fresh suspension gets contaminated with bored spoil and gradually becomes heavy. This contaminated bentonite may be reused depending upon the manner of boring, type of strata encountered and the specific gravity of the contaminated bentonite. It is essential to check the specific gravity of the bentonite in the borehole before concreting. The contaminated bentonite may be collected in a suitable receptacle and allowed the heavier particles to settle, and the slurry washed out before reuse. The drilling muds shall be suitably disposed of without causing any nuisance to the surrounding area in a manner approved by the Engineer-in-charge.

5.22.3 Boring for lined bored piles or pressure piles

1. Boring shall be done to the minimum elevation specified on the drawings or as modified in writing by the Engineer-in-charge during the progress of boring.
2. Permanent 6.0mm thick liner up to hard strata shall be used to line the bore hole as the depth increases to prevent the sides of the bore hole from collapsing. If firm strata are not met with, such as stiff clay or soft rock, the casing shall be tapped down into these strata to prevent the ingress of the groundwater water and the boring may then proceed without casing, if approved by the Engineer-in-charge.
3. The bottom of the lining shall be kept for enough in advance of the boring to prevent the entry of soil into the lining and formation of cavities and settlement of soil surrounding the lining.

4. Bailing out of muck from the borehole shall be done by a flap value bailer or any other method approved by the Engineer-in-charge.
5. After the bore hole has gone down to the final depth, clean water should be pumped through a pipe resting at the base of the bore hole, to remove completely all muck and other loose material from the bottom of the bore hole. Sufficient pressure of the water shall be maintained during these flushing operations, which shall normally continue for 10 to 15 minutes.
6. Boring may be done by direct mud circulation, reverse mud circulation or by a bailer using drilling mud to stabilise the borehole from collapsing.
7. A protective steel casing of suitable length both above the ground and below it shall be installed for the protection of personnel and to prevent caving and displacement of the earth, and for retention of the surface water.

5.22.4 Inspection of Bored Piles

The boring, immediately before placing the reinforcement and depositing the concrete, shall be thoroughly inspected visually by means of an electric lamp attached to a drop of chord of sufficient length to reach the bottom of the boring.

The diameter of the hole may be checked in the case of bentonite slurry bored piles by lowering a guide ring through the depth of the hole. The depth of the borehole shall be measured by means of a chain to which a plump bob weighing not less than 250 gm is attached.

The Contractor shall provide all the equipment required for the above inspection, and he shall coordinate this work with the Engineer-in-charge.

5.22.5 Concreting

1. The concrete shall be freshly mixed and in sufficient quantities in the casing to ensure that during the withdrawal, a sufficient head of concrete is maintained to prevent the inflow of soil and subsoil water.
2. The entire depth of the pile shall be concreted in one operation without stoppage.
3. All concreting operations for piles shall be carried out during daytime only.
4. Exposed proportion of piles shall be cured for at least 10 days from the date of casing.
5. When installing the piles in groups, sufficient time shall be allowed for freshly poured concrete in the pile to set before installing adjacent piles. The Engineer, in consultation with the Contractor, shall determine the installation sequence and time schedule to ensure that freshly concreted piles are not damaged due to the installation of adjacent piles. Consecutive piles in a group within 0.5 m of each other shall, however, not be constructed before a lapse of 2 days after the installation of the previous pile.
6. All care shall be taken to prevent the formation of voids in the piles by pockets of air trapped within. Particular attention shall be paid to this during the withdrawal of casing. The Volume of concrete placed in the pile shall be checked with the theoretical

Volume of the pile, and any shortfall in the actual Volume concreted shall be reported to the Engineer-in-charge.

7. After the boring has been flushed and approved, and with the reinforcement in place, the pile shaft shall be concreted by the tremie process, as described above for lined bored piles. Before concreting, the bore shall be flushed once again with bentonite slurry through the tremie pipe to ensure that the bottom is cleaned after placing the reinforcement. The tremie pipe shall always be maintained at a minimum of 2 to 2.5 m inside the concrete.

5.22.6 Testing of Piles

1.5% of the total number or a minimum of two piles shall be subjected to non-destructive load tests to 1.50 times to design load. (i. e. estimated load carrying capacity of pile).

The test shall be carried out by applying a series of loads on a pile unaided by any other support. The load shall preferably be applied by means of a hydraulic jack reacting against a loaded platform, which shall be preloaded to not less than $2 \frac{1}{2}$ times the estimated safe load-bearing capacity of the pile.

The test load shall be applied in equal increments of one-fifth of the estimated safe load or as directed by the Engineer-in-charge. Alternate loading and unloading at each load increment shall be performed, and the elastic and plastic settlements recorded.

Each stage of loading or unloading shall be maintained till the rate of movement of the pile top is not more than 0.02 mm per hour

Piles shall satisfy the following requirements:

- vii. The total settlement for the test load shall not exceed 12 mm.
- viii. The net (residual) settlement after the test load is removed shall not exceed 6 mm.
- ix. The general behaviour of the pile during the test shall be proper and uniform.

The pile which fails to satisfy the above requirements shall be rejected, and another pile shall be tested in lieu. The rejected pile shall be replaced or rectified with prior approval of the Engineer-in-charge at the Contractor's risk and cost.

If the second pile tested also fails, the rejection of part or the entire lot and rectification measures to be done at Contractor's risk and cost, shall be at the discretion of the Engineer-in-charge.

Any pile / piles to be installed in replacement of the rejected piles as directed by the Engineer-in-charge shall be done by the Contractor at their own cost. The Contractor shall also not be paid for expenses incurred by him in extracting the rejected piles / casings provisions of extra piles, enlargement of pile caps necessitated as a result of defective or workmanship of the Contractor.

5.23 Replacement of Rejected Piles

Piles / boring / casing that are defective or exceed the tolerances as specified above shall be left in place or pulled out as directed by the Engineer-in-charge without adversely

affecting the performance of the adjacent piles. In case the piles/casing cannot be removed, they shall be cut out as directed by the Engineer-in-charge. Voids resulting from rejected borings or the extraction of the piles or casings shall be filled with gravel or sand unless other piles are installed in such voids.

- a) Pumping and bailing out of water, shoring, shuttering, etc., if found necessary for successful and speedy operation of work, shall be carried out by the Contractor, and the cost of such works shall be included in his rates. No extra claims whatsoever on all subsidiary works pertaining to piling work will be entertained.
- b) All the excavated materials, including debris, loose earth, etc., shall be carted away and disposed of as directed by the Engineer-in-charge.
- c) The Contractor shall provide all the equipment, tools and plants required for the works, and the rates shall include the cost of bringing the equipment, etc. to the site proper maintenance and removal of the same after completion of work.
- d) The piles shall be driven as accurately as possible to the vertical or to the specified batter. The permissible positioned deviation for piles shall not be greater than 7.5 cm and shall not exceed 2% (about 1 deg.) from the specified inclination. Piles not conforming to the above requirements may be rejected. The Contractor at his own cost, shall rectify any remedial measures required due to errors in piling. Prior to carrying out the rectification work, approval for such remedial measures should be obtained by the Contractor from the Engineer-in-charge.
- e) Piles that are defective shall be pulled out or left in place as directed by the Engineer-in-charge, and additional piles shall be driven to replace them.
- f) The piles should penetrate into hard, load-bearing strata. The founding stratum of each pile shall be approved by the Engineer. The pile should penetrate a minimum of 15 cm into the founding strata. The founding strata shall be as follows:
 - i. For piles up to and including 45 cm dia that the strata in which penetration by chiselling with a $\frac{3}{4}$ Tonne chisel continuously for half an hour does not exceed 15 cm.
 - ii. For piles above 45 cm dia – Same as above, but with 2 Tonne chisel.
- g) Samples of the hard strata be taken and appropriately marked. SPT tests shall be performed on the pile to determine the founding strata (clay stone) with $N > 50$.
- h) Chipping of concrete piles above the given cut-off level or building up piles up to the given cut-off levels, if any, for casting pile caps and plinth beams with the specified concrete mix and as per drawings shall be included in the cost of piling and no extra payment shall be considered on this account.
- i) Adequate length of bars to be left over the cut-off level of the pile to develop anchorage in the pile caps, and also dowels to be kept of adequate lengths.
- j) Built-up portion of piles/pile caps and beams shall be thoroughly cured as per instructions of Engineer-in-charge for a period of two weeks at least or as directed.

- k) A sample of the hard strata shall be taken, appropriately marked and preserved. All openings, etc. if required in beams and walls shall be provided by the Contractor, free of cost, if intimated to the Contractor before pouring concrete.
- l) Rig register and weekly report as per the format, approved by the Engineer-in-charge, shall be submitted to the Employer of the project.
- m) During the period of establishing the mix design, no nominal mix for piling work will be followed. In no case Contractor will be allowed to cast a pile with a nominal mix.

The length of the pile shall be measured from the tip of the pile to the bottom of the pile cap. The eight cm. length of the pile tip projecting into the cap shall not be measured for the payment, and also shall not be deducted from the quantity of pile cap concrete. Empty boring will not be considered for any type of payment.

5.24 Open foundations

- 5.24.1
- 1. Foundation depth shall be as per the Soil Investigation Report. Minimum foundation depth shall be as per IS: 1904 and/or as per the foundation requirement for the proposed facility/structure.
 - 2. The wall strip footing shall rest on firm strata with the desired safe bearing capacity and satisfying allowable settlement criteria and the minimum founding level conditions as per soil conditions. However, below-grade slab, minimum 500 mm top soil or as recommended by Geotechnical Consultant, shall be removed and replaced with good filling earth, preferably a CNS (cohesive non-swelling) soil, in compacted layers of 200 mm up to 95% modified proctor density or 80% relative density as the case may be.
 - 3. The type of foundation, whether Pile Foundation or Open Foundation, will depend on the recommendations of the Geo-Technical Consultant, subject to approval of Employer/ PMC. The decision of the Employer/ PMC whether the Pile Foundation or Open Foundation to be adopted will be final, and the agency will have to design and execute the work accordingly without any additional cost.

6. DESIGN REQUIREMENTS

6.1 General

The following design requirements shall be as per the provisions of IS: 456- 2000 for all reinforced or plain concrete structures:

- i. All binding concrete shall be a minimum 100 mm thick in concrete M20 grade, and all levelling concrete shall be a minimum 100 mm thick in concrete M10 grade.
- ii. All structural reinforced concrete for liquid water retaining structures shall be at least of M35.
- iii. The minimum Cement Content in Concrete shall be as per Cl 5.2.5/latest relevant IS code (whichever higher) for all concrete work as per the specified concrete grade.

- iv. The minimum grade of concrete for sewage retaining structures shall be a M35 design mix having a minimum cement content shall be as per CI 5.2.5/latest relevant IS code (whichever higher). The quantity of the admixture shall be as per the mix design.
- v. The minimum cover to all reinforcement, including stirrups and links, shall be as specified in Standard Specifications and IS: 456-2000. However, the minimum clear cover shall not be less than the following:

Location	Minimum Clear Cover (in mm)
Slabs (floor & roof), Canopy Cantilevers, Waist Slabs, Chhajjas	25mm
Beams (floor, roof and tie), Lintel and Plinth	30mm
Columns	50 mm
Column Pedestals	75 mm
Foundation Slabs	75 mm
<i>Retaining Walls, Basements and Pit Walls</i>	
• Face in contact with earth	-50 mm
• Free Face	50 mm
Liquid Retaining Structures	
• Face in contact with liquid	-50 mm
• Face away from liquid but in contact with earth	50 mm
• Free Face	
Raft slab, Bottom, Sides & Top	75 mm
Piles	75 mm
Pile Caps	75 mm

- vi. All buildings shall have a minimum 1.0 m wide, 100 mm thick plinth protection paving in M20 grade concrete. All plinth protection shall be supported on a well-compacted stratum and hand-packed rubble soling 230 mm thick minimum.
- vii. Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.
- viii. The bridges and supporting structure shall be designed to safely withstand the loadings, such as loads and torque transmitted through scrapper blades, motor, etc. Depending on the arrangement offered, besides other loads.

Necessary camber shall be provided in the bridges/pipe supports to account for deflection.

- ix. All pipes and conduits laid below the structural plinth and road works shall be embedded in concrete of grade M-20 having a minimum 150 mm thick concrete cover all around.
- x. Approved quality waterproofing compound (chloride-free) shall be added during concreting of all liquid retaining structures, in the proportion specified by the Manufacturer or 2 % by weight of cement, whichever is higher.
- xi. For walls and base slabs of liquid retaining structures, the following shall be considered.
- xii. Minimum reinforcement shall be as per the latest IS 3370, part II. This reinforcement shall be placed closer to the concrete faces and the minimum specified clear cover as per IS: 3370 and Clause (f) above.
- xiii. The maximum length of Panel to be concreted, sequential of pouring, and height of pour shall be as per Standard Specifications, IS 456-2000 and IS 3370-part I, latest revision as applicable.
- xiv. The minimum thickness of all RCC works for various structural members/elements shall be as follows:

i)	Walls for liquid retaining structures	200 mm
ii)	Roof slabs for liquid retaining structures	200 mm
iii)	Bottom slabs for liquid retaining	200 mm
iv)	Floor slabs, including roof slabs, walkways, and canopy slabs	150mm
v)	Walls of cables/pipe trenches, underground pits etc	175mm
vi)	Column footings	300 mm
vii)	Parapets, chajjas	100 mm
Viii)	Precast trench covers	100 mm
ix)	Pile caps	500 mm

Ordinary Portland cement shall be used in the design and construction.

6.2 Standards of Construction Safety

- i. IS: 3696 - Safety Code for scaffolds and ladder (Part 1 & 2)
- ii. IS: 3764 - Safety Code for Excavation Work
- iii. IS: 7205 - Safety code for the erection of structural steel Work

6.3 General Arrangement of Plant

- i. The following general guidelines shall be considered while preparing the general arrangement of the proposed plant, besides the process requirements, as specified in these documents.
- ii. The general arrangements of all the treatment units of STP/CETP, buildings and other structures shall be approved by the EMPLOYER/ PMC. Changes if any, suggested will be incorporated in the final layout at no extra cost to EMPLOYER/ PMC.
- iii. Suitable passages, lifting eyes or other means shall be provided to permit the removal of equipment that may be required during the course of its normal operational life for maintenance or any other purpose.
- iv. Areas where leakage is likely to occur, whether under normal use or during maintenance, shall be provided with covered drainage channels, which shall direct spilt liquid either to a suitable plant drain or to a sump from where it can be pumped out to an external drain in the plant area.

6.4 Orientation

- i. The Layout of the proposed plant shall be suitably prepared and to fit it within the space allotted in order to interface conveniently with the existing infrastructure of roadways, as well as inlet and outlet Pipe-Work.
- ii. Underground services, requiring to be relocated in order to accommodate the proposed site layout, shall be relocated by the Contractor with the approval of the Employer/ PMC's representative.

6.5 Buildings and Structures

Unless otherwise specified, all the buildings and structural works shall generally comply with the following EMPLOYER/ PMC's requirements:

The buildings shall have an aesthetically good elevation.

- a) All building works shall be in a reinforced concrete framework.
- b) All external walls shall be in 230 mm thick brick masonry built in cement mortar in (1:5).
- c) All internal partition walls shall be in 115 mm thick brick masonry built in cement mortar (1:4) with two 8 mm dia. MS bar in every fourth course laid horizontally. Transoms and mullions shall be of size 115 mm x 230 mm and shall form Panels not exceeding 3500 mm x 3500 mm in size.
- d) All internal masonry surfaces shall be finished with 12 mm thick cement plaster in cement mortar (1:4) with plaster of Paris (POP). The walls shall be finished with painting, and the type of painting shall be in accordance with the specifications as specified.
- e) All external masonry surfaces shall be plastered in two coats with sand-faced cement plaster in cement mortar (1:4) & shall have total thickness of 23 mm. Waterproofing

compound of approved make and quality shall be added to the cement mortar in proportions specified by the Manufacturer only with use of PVC chicken mesh wherever applicable.

- f) All external surfaces above ground level shall be painted.
- g) Type of flooring of various units shall be as specified.
- h) Bathroom / W.C. floor slab shall be sunk and filled with brickbat coba (broken bricks set in cement mortar) and provided with waterproofing as per the specifications of an approved specialist waterproofing company. The finished floor level in the Bathroom, W.C. areas shall be 25 mm below the finished floor level on the outer side.
 - i. The toilet facilities shall include at least: a Bathroom of size 1.2 x 1.2 m.
 - ii. WC of size 0.9 x 1.2m with Water closets of approved ISI make with white porcelain Orissa pan minimum 580 mm long with PVC flushing cistern of 10 litres capacity.
 - iii. 2 Urinals of approved ISI make of size 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a granite partition of size 1200 mm x 600 mm.
 - iv. Washbasin of approved ISI make of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
 - v. Mirror of size 400 mm x 600 mm wall-mounted type fitted over washbasins.
 - vi. SS soap trays.
 - vii. Chromium plated brass towel rails minimum 750mm long.
 - viii. All stopcocks, valves and pillar cocks shall be of chromium plated brass, heavy duty.
 - ix. All fittings such as 'P' or 'S' traps, floor traps, pipes, down take pipes etc. in PVC Heavy Duty.
 - x. The wastewater from toilet blocks, laboratory, pantry etc. shall be led to the inlet chamber of sewage pump house.
 - xi. Wherever specified, staircases shall be finished with 25 mm thick grey Granite Treads in single piece and 12 mm thick grey Granite Riser and Skirting. The rise of stairs shall not exceed 170 mm and minimum width of the tread shall not be less than 275mm.
 - xii. The walls & floors of W.C. shall be glazed with white or coloured glazed tiles of approved ISI make. The tiles on walls shall be fixed for full floor height. The corner pieces shall be prefabricated. The cut pieces with machine cut suit to size. The tiles shall be of 1st quality.
 - xiii. The back & side walls, along with channels in urinals shall be glazed with white / coloured glazed tiles of approved ISI make and for full floor height.
 - xiv. The wash basin, mirrors shall be properly backed with glazed tiles as above.

- i) All steps shall have 20 mm nosing.
- j) RCC stairways shall be provided to permit access between different levels within buildings. All roof tops and tops of overhead tanks shall be made accessible with the staircases. Vertical ladders in stainless steel fitted with landing point extensions will be permitted where considered appropriate by the EMPLOYER/ PMC's representative to access areas not frequently visited.
- k) All floor cut outs and cable ducts, etc. shall be covered with pre-cast concrete covers in outdoor areas and Stainless Steel 304 chequered plates of adequate thickness in indoor areas.

The cables shall be supported on Aluminum / stainless steel cable bays and firmly secured.

- a) Hand railing shall be provided as follows:
 - i. Outdoor RCC Platform
 - ii. Outdoor Steel Bridge
 - iii. Inside Building Buffed stainless-steel grade 304 handrail (three rails viz. top, bottom and middle) fixed to steel balustrades to be provided along access platforms Around process units
- b) The reinforced concrete roofs shall be made waterproof by application of approved cement water proofing treatment by India Waterproofing, guaranteed for 10 years. Cement concrete vatta shall be provided for upstand surface. The finished roof surface shall have adequate slope to drain rainwater to RW down take points.
- c) For roofing drainage, UPVC pipes conforming to IS: 13592 shall be provided. For roof areas up to 40 sq.m minimum two numbers 110 mm diameter pipes shall be provided. For every additional area of 40 m² or part thereof, at least one no. 110 mm diameter pipe shall be provided.
- d) Top surfaces of chajjas and canopies shall be made waterproof by providing a brick-bat waterproofing treatment and sloped to drain the rainwater or as above.
- e) Plinth shall be minimum 600 mm above finished ground level around building.
- f) All concrete channels and ducts used for conveying liquid shall have smooth finish from inside. The width of concrete channels shall not be less than 500 mm.
- g) Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of the Factory Act.
- h) All rooms in the treatment plant buildings shall be provided with appropriate signboards indicating the function of the rooms involved.
- i) Wherever equipment & machinery is required to be moved for inspection, servicing, replacement, etc. suitable moveable gantry/monorail of required capacity shall be provided.
- j) Emergency exit doorways shall be provided in buildings to comply with local and international regulations. Stairways and paved areas shall be provided at exit points.

- k) Water purifier shall be fixed for drinking water purposes.
- l) Drinking water shall be supplied from an overhead tank provided on top of the Blower/MCC building. All plumbing Work shall be carried out in “C” class GI pipes both outside and inside the building and below ground, including plumbing connections from the main water supply line of EMPLOYER/ PMC with a water meter.
- m) All chequered plates shall be Stainless Steel 304 with proper fitting in place and arrangement for lifting.
- n) All doors and windows shall be as specified in Table A of this subsection.
 - i. Opening of the windows shall be a minimum 25% of the wall area.
 - ii. Minimum sizes of various structures shall be as given in the layout drawing or as obtained from the Parameters for sizing or as specified for carpet areas of utility buildings elsewhere in the document.
 - iii. Fire safety board and ‘No Smoking’ sign board shall be installed in the area prone to flame to prevent any accident and/or as per the D.C. rules.
 - iv. Furniture shall be supplied as per the details mentioned in the document elsewhere.

6.6 Testing of Water Tightness

The Contractor shall carry out a water-tightness test for the maximum head condition in liquid retaining structures, i.e. with the liquid standing at full supply level. All costs of testing, including the cost of water, shall be borne by the Contractor. This test shall be carried out in accordance with the procedure given below:

- i. For the water tightness test, before the filling operations are started, the reservoirs shall be jointly inspected by the EMPLOYER/ PMC’s representative and the representative of the Contractor and condition of surfaces of wall, construction joints etc shall be inspected and noted and it shall be ensured that jointing material filled in the joints is in position and all openings are closed. The Contractor shall make necessary arrangements for ventilation and lighting of the reservoir by way of flood lights, circulators etc., for carrying out proper inspection of surfaces and internal conditions if so desired by the EMPLOYER/ PMC’s representative.
- ii. The water retaining structures shall be filled with water gradually at a rate not exceeding 30 cm rise in water level per hour and shall not be filled more than one fourth capacity in one day. Records of leakages starting at different levels of water in the reservoirs, if any, shall be kept.
- iii. The reservoirs once filled shall be allowed to remain filled for a period of 7 days before any readings or drop in water level is recorded. The top level shall be maintained for 7 days. Then drop in water level for 7 days shall be observed. The total drop in surface level over a period of 7 days shall be taken as an indication of the water tightness of the reservoir, which shall conform to IS:

3370 (Part 1)-2009. Also, there shall be no indication of leakage around the puddle collars or on the wall and bottom of the reservoir.

- iv. If the structure does not satisfy the test requirements and the daily drop in water level is decreasing, the period of test may be extended for a further seven days, and if the specified limit is not exceeded, the structure may be considered as satisfactory.
- v. In case the drop in water level exceeds the permissible limit with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the EMPLOYER/ PMC's representative to reduce the leakage to the permissible limit. The entire rectification Work that shall be carried out in this connection shall be at the Contractor's cost.
- vi. If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water tightness test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure will be condemned,, and the Contractor will dismantle and reconstruct the structure to the original specification, at his own cost.
- vii. During testing and during the defect liability period, the impression marks created due to seepage shall be rectified and made good by grouting.

6.7 Roadways, Pathways and Hard Standings

- a) A comprehensive road network shall be provided around the proposed treatment plant units i.e. main entrance, administrative block and all adjacent buildings, Centrifuge building, grit chambers, digesters, aeration tank and clarifiers etc. to link with the main road and the existing road network to permit vehicular access to each unit of the plant for necessary maintenance, delivery of consumables and personnel access.
- b) Roads shall be designed as per the provisions of IRC codes. The proposed roads shall have the following crust.
 - i. 500 mm compacted subgrade of minimum 95% P.D.
 - ii. 200 mm granular sub-base (GSB).
 - iii. wet mix macadam in 2 layers of 100 & 75 mm.
 - iv. 75 mm bituminous bound macadam (BBM).
 - v. 50 mm dense bituminous macadam (DBM).
 - vi. 25 mm bituminous concrete (BC/AC).
 - vii. The use of sand drains or removal of marshy soil shall be ascertained by the bidder before proceeding for sub-grade.
- c) Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking all plant areas. Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Employer/ PMC's representative.

- d) Hard-standing areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the plant area and leave again without going in reverse or carrying out complicated manoeuvres in order to exit the plant.
- e) Parking facility to park a minimum 10 nos. of four-wheelers at a time with precast paver block of approved make 60/80mm thick. With precast kerb stones along the edges.

6.8 Walkways

Walkways should connect at the operating level to all components of the plant. The width of the walkway shall not be less than 1.2 m and with hand railings.

All Elevated RCC walkways 1.2m wide shall be of RCC with M-25 grade concrete. The floor of the walkway shall be finished smooth with 40 mm thick cement concrete and finished with suitable cement (coloured) chequered tiles. It shall be provided with Buffed stainless steel grade 304 handrail (three rails, viz. top, bottom and middle) fixed to steel balustrades to be provided on both sides of the walkway with connecting platforms.

All pathways and footpath over ground connecting individual units to bituminous road shall be 0.75 m wide and be 100 mm thick cement concrete (1:3:6) finished with 40 mm thick (including base mortar 1:4) chequered cement concrete tiles. The base concrete to be laid on 150 mm thick hard core with 50 mm down stone ballast and moorum rammed and consolidated properly as per the direction of the Engineer-in-charge.

6.9 Site Drainage

- a) Storm water drains running along the roads (to be provided under this Contract) shall be sized suitably, allowing for 100% run-off.
- b) All storm water drains shall be in RCC/PCC.
- c) The storm water drainage system shall also take into consideration the run-off from the existing Sewage Treatment Plant area and structures as necessary. The storm water may be directly discharged into the nearby storm water channel.
- d) The design norms for storm water drain shall be followed as per CPHEEO Manual.

6.10 Cable and Pipe Trenches

- a) All cables to be laid in HDPE pipes.
- b) All the instruments, such as measuring Meter, Panels etc., shall be well protected from heavy rainfall and corrosion with stainless steel sheeting covers and/or plastic, fibrous material having a minimum life of 15 years.

6.11 Pipes and Ducts

- a) RCC ducts for drainage shall have a minimum 1m thick of soil overburden while running across a road. Access shafts of size not less than 600 mm x 1000 mm shall be provided.

- b) All drains (except storm water drains running along the periphery of the compound wall) shall be covered and designed structurally for appropriate loads.

6.12 Valve Chambers

Valve Chambers shall be of adequate size to facilitate ease in maintenance and operation. Valve chamber 1.5m deep below ground shall be brick masonry, and valve chamber having depth greater than 1.5m shall be in RCC construction. Valve chambers sizes shall be as per CPHEEO manual.

6.13 Inlet and Interconnection Chambers

These chambers shall be constructed in RCC. Each chamber shall be provided with a platform at the top as necessary. Suitable provision shall be made to access the bottom of the Chambers.

6.14 Finishes

- a) Interior Wall (other than water retaining structure):
- b) All interior walls should be painted with two coats of approved quality and color of oil-based distemper over one coat of primer as directed by the Engineer.
- c) Exterior Wall (other than water retaining structure):
 - i. The colour scheme of the external surfaces of the building will have to be decided according to the designed elevation after approval of the Engineer.
 - ii. In case the structure is plastered, then the plastering will be sand-faced cement plaster in CM (1:4) 23 mm thick, followed by exterior type two coats of approved quality and colour of acrylic exterior emulsion wall finishing paint over one coat of primer.
 - iii. This shall be of approved shade and brand to give an even shade on the Work in 2 or more coats.
- d) All the structures above ground shall be painted with 2 coats of acrylic emulsion paint over a coat of primer.

6.15 For Water Retaining Structures

Inside and outside surfaces of the water retaining structures shall be painted by water-repellent epoxy paint in three coats, including primer of the makes given below following manufacturer's specification:

- a) Berger Paints
- b) Mc-Bauchemie
- c) Fosroc

Coal tar epoxy in two coats is to be applied on the external surface of all the structures in contact with soil.

2 coats of epoxy paint or acrylic paint over epoxy primer, over 2 coats of approved brand of wall putty shall be applied from outside the technology buildings/chambers/tanks for a

pleasant aesthetic appearance as per the Manufacturer's specification and approved by the Engineer in charge.

7. PIPEWORK

7.1 General

7.1.1 Existing Underground Services

When working in the vicinity of existing underground services, all trial holes/trenches and subsequent excavation shall be carried out by hand. Before digging, the Contractor shall notify the relevant Authorities and shall comply with all the requirements, specifications and restrictions imposed by them.

The Contractor shall take all practical steps to avoid damage to existing underground services. These steps shall include:

The Contractor shall take all practical steps to avoid damage to existing underground services. These steps shall include:

- Making contact with all relevant authorities to establish location records of existing services;
- All services indicated as being within 5m of the works (including from the extents of the temporary works) shall be located by tracing or other means.

All traced services which are within 1m of the edge of an excavation shall be identified by hand excavation of trial holes/trenches.

Extreme care and caution shall be exercised when working in the proximity of HV electric cables or coaxial telephone cables carrying national or international circuits.

All exposed existing cables, pipes, ducts, etc, shall be adequately supported and protected to the satisfaction of the Engineer and the relevant Authority.

7.1.2 Water Supply Hygiene

Before any person is engaged in work involving contact by direct or indirect means with potable water, he shall be notified of the need for personal hygiene and the dangers of contamination. He shall complete a medical questionnaire. The Contractor shall notify the Engineer-in-charge of any person who has been certified by a doctor as suffering from an illness associated with looseness of bowels or other stomach illnesses. Such persons shall not be permitted to work in the vicinity of potable water until an approved doctor has certified that it is safe for them to be so employed. Where necessary, he shall be tested for waterborne diseases.

7.1.3 Compliance with Existing Statutory Authority Requirements

The Contractor shall take due account of any specifications issued by and/or specific requirements pertaining to the respective adopting Statutory Authority. Should an instance arise where the Authority's specified requirements conflict with this project

specification, and unless instructed to the contrary by the Engineer, the Authority's specified requirements shall prevail.

7.1.4 Definitions

"RTR" - Reinforced Thermosetting Resin to include Fibre Reinforced Plastic (FRP), Glass Reinforced Plastic (GRP) and Reinforced Plastic Mortar or matrix (RPM).

Structured-Wall Pipes and Fittings - Products which have an optimised design with regard to material usage to achieve the relevant performance requirements.

Profile wall - a pipe wall construction that presents a smooth surface in the waterway but includes ribs or other shapes, which can be either solid or hollow that help brace the pipe against deformation.

7.1.4.1 Pressure Pipes and Pressure Ratings

Pressure pipelines shall be those pipelines through which fluid is pumped or which at any point operate under an internal pressure in excess of 3.0 metres head of water.

The pressure ratings for all pipes and fittings shall be those calculated to give a minimum service life of 50 years at an ambient temperature of higher than 40° centigrade.

Pressure ratings for valves shall be those calculated for maximum working pressure at an ambient temperature of 20° centigrade.

The system test pressure shall be calculated from the design pressure by:

If the surge is calculated:

System Test Pressure = (Design Pressure + Surge) + 1 bar

If surge is not calculated:

System Test Pressure = Design Pressure x 1.5

Or System Test Pressure = Design Pressure + 5 bar whichever is the least

7.1.4.2 Dimensional

Apart from specials, rocker pipes and cut to suit lengths, pipes shall be supplied in any standard lengths allowed under the specification. Unless otherwise specified the tolerance on all pipe dimensions shall be $\pm 5\text{mm}$.

7.1.4.3 Marking of pipes and fittings

Each pipe, special and fitting shall be clearly and indelibly marked at the place of manufacture with:

- The name or distinctive mark of the manufacturer;
- The country of manufacture;
- The date of manufacture;
- The class or pressure rating;

- The nominal diameter;
- The manufacturing standard to which it has been produced;
- For rigid pipes, crushing strength (in kN/m) or class;
- For flexible pipes, stiffness (in N/sq. m).

7.1.5 Quality Assurance

Unless otherwise indicated on the drawings, or specifically permitted by the Engineer, all pipes and RTR fittings shall be furnished by a single manufacturer who is experienced in the manufacture of the items to be furnished in conjunction with specified valves and fittings. However, it shall not be a requirement that the same manufacturer manufacture the pipe and fittings, provided the pipe, valve and fittings are compatible in both compounding and size. The pipes, valves and fittings shall be designed, manufactured and constructed in accordance with the best practice-applying manufacturer's standard installation guidance deemed suitable for the intended service.

Any manufacturers design and engineering shall be performed by personnel regularly employed by the manufacturers who are experienced in the design of pipes similar to those specified.

All pipes, valves and fittings shall be inspected and tested at the foundry and/or factory as required by the standard specifications to which the material is manufactured. The sworn certificates of such tests and their results shall be issued in duplicate to the Engineer-in-charge prior to the shipment.

Prior to dispatch from the factory, the Contractor shall notify the Engineer-in-charge in sufficient time to allow the Engineer, or his representative, to carry out a visual inspection and dimensional checks of the pipes, valves and fittings, if so desired.

7.1.6 Inspections at Site

Inspection of the pipe, valve or fitting will be made by the Engineer-in-charge or other representatives of the Employer after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the requirements specified herein, even though pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall immediately be removed from the job or where permitted by the Engineer-in-charge repaired to his satisfaction.

All pipes, valves and fittings shall be subject to visual inspection at any time and shall meet with the specified requirements. Any damage shall be notified to the Engineer-in-charge for a decision as to the acceptability, with or without repairs or remedial work. The criteria set out below will be used for guidance, but are not to be regarded as representing necessarily all grounds for rejection. The final decision will be taken by the Engineer-in-charge based on his judgment of the suitability of the items for the purpose intended.

All notification shall be made by written Inspection Request. An advance copy may be sent electronically to the Engineer's office, but the original must arrive or be submitted before the scheduled day of inspection.

Minimum notification times must be as follows:

1. 24 hours on site;
2. 72 hours for areas within MIDC area;
3. 3 weeks outside of MIDC area.

The Contractor shall store pipes under shade in a properly prepared and maintained storage area demarcated in respect of pipe sizes, pressure ratings, stiffnesses/strengths and manufacturers.

7.1.6.1 Flexible pipes – Visual Inspections at Site

Condition	Requirements	
	Unplasticised Polyvinyl Chloride/Polyethylene	Reinforced Thermosetting Resin
Ellipticity	± 1% on mean diameter	As per specifications
Length	± 25mm	As per specifications
Wall thickness	Pipe wall thickness measured at any point must be such that the Standard Dimension Ratio calculated on that thickness is within the stipulated range.	As per specifications
End Squareness / End Planeness	N/A	As per specifications
Surface finish	There shall be no flaking or indication of disintegration. There shall be no evidence of extrusion dye-marks or 'spider-lines'.	There shall be no crazing of internal or external gel-coats or resin rich layers. Resin dry areas not exceeding 6mm dia. Internally or 60mm dia. Externally may be accepted if made good.
Scratches	No internal scratches. External surfaces shall be free from longitudinal scratches and circumferential scratches longer than 100mm or deeper than 5% of the pipe wall thickness.	Scratches not exceeding 0.3 mm deep may be accepted without repair. Scratches exceeding 0.3 mm deep may be accepted if satisfactorily made good.
Cracks	All pipes shall be free from cracks.	<u>Longitudinal cracks:</u> There shall be none on internal surfaces. External cracks may be

		accepted after repair if less than 200mm long. <u>Circumferential cracks:</u> No cracks shall be of sufficient depth to expose glass fibres. Cracks not exceeding 200mm length may be accepted after repair. <u>"Star Cracks"</u> may be accepted after repair if all cracks are contained within a circle of 100mm diameter.
Voids	No visible voids will be accepted	Voids (or blisters) may be accepted after repair if not greater than 2mm diameter and 1mm depth provided that not more than 0.5% of surface area is affected.
Protuberances	There shall be no protruding aggregates. There shall be no protuberances of any sort extending more than 2mm from the normal surface.	There shall be no protruding fibres from the internal surface of the pipe. Wrinkles and undulations shall not exceed 3mm in height.
Inclusions	There shall be no visible inclusions or extraneous matter	There shall be no visible inclusions or extraneous matter, other than permitted fillers of aggregates.
Delamination	Not applicable	There shall be no visible delamination.

7.1.6.2 Fabricated items (other than pipes)

Condition	Requirements
	Reinforced Thermosetting Resin
Surface finish	There shall be no crazing of gel coats or resin rich layers. Resin dry areas not exceeding 6mm dia. on moulded and corrosion resistant surfaces may be accepted if made good. Not more than 0.5% of the surface area shall be so affected. There shall be no resin dry areas on other surface after repair.

Scratches	Scratches not exceeding 0.2 mm deep to moulded and corrosion resistant surfaces may be accepted without repair provided that no glass fibres are exposed. Scratches exceeding 0.2mm deep but not exceeding 0.5mm deep may be accepted if satisfactorily made good. The total extent of scratching shall not exceed 200mm length per 1 sq. meter surface area. Alternatively, where small scratches are grouped together, the affected area shall not exceed 1% of the surface area. Scratches to other surfaces may be repaired provided that the structural integrity of the laminate is not impaired.
Cracks	For moulded and corrosion resistant surfaces there shall be no cracks of depth greater than 0.5mm or of sufficient depth to expose glass fibres. Cracks up to 0.5mm depth not exposing glass fibres and not exceeding 200mm in length may be accepted after repair but such cracks shall not present to an extent greater than 1 crack per 5 sq. metres of surface area. Cracks not exceeding 200mm in length to other surfaces may be repaired provided that the structural integrity of the laminate is not impaired. “Star Cracks” may be accepted after repair if all cracks are contained within a circle of 100mm diameter and a maximum of 0.2% of the area of any one moulding is affected.
Voids	Voids (or blisters) at moulded and corrosion resistant surfaces may be repaired if not greater than 2mm diameter and 1mm depth provided that the voids occur in discrete areas of discrete clusters and the sum of the areas does not exceed 0.5% of the total moulded area. Voids to other surfaces may be repaired if they do not extend to more than 20% of the laminate thickness and not more than 3% of the surface area is affected.
Protuberances	There shall be no protruding fibres from the internal surface of laminates. Wrinkles and undulations shall be gradual and the internal surface shall be continuous at such locations. Such defects shall not appear extensively on single mouldings and shall not be repeated through a production run.
Inclusions	There shall be no visible inclusions or extraneous matter, other than permitted fillers of aggregates.
Delamination	There shall be no visible delamination.

7.2 Submittals

Prior to the placement of purchase orders for pipes, valves and fittings, the Contractor shall submit documentation to the Engineer to establish compliance, and shall obtain the Engineer-in-charge's approval. The documentation to be submitted shall include at least the following:

1. Documentation of manufacturer's qualifications and experience, with systems similar to those specified;
2. Manufacturer's installation instructions, recommended field quality control procedures and specific field handling and storage requirements;
3. Shop drawings including piping layouts and schedules shall be submitted to the Engineer and shall include dimensioning, fittings, locations of valves and appurtenances, joint details, methods and locations of supports and all other pertinent technical specifications to be furnished;
4. Shop drawing submittals for piping under this section shall include all data and information required for the complete piping systems. All dimensions shall be based on the actual equipment to be furnished. Types and locations of pipe hangers and/or supports shall be shown on the piping layout for each piping submittal.
5. Test certificates confirming compliance with the relevant specification;
6. Confirmation of compliance with the specifications, with details of any deviations.

In addition, for RTR pipe and fittings, submit the following:

1. The work size of each diameter of pipe, defined as the internal diameter, declared by the manufacturer;
2. Design calculations (including checks against positive and negative internal pressure, external soil and traffic loads, handling, and the effects of the environmental conditions);
3. For filament wound pipes, a method statement describing how structural reinforcement shall be prevented from penetrating the barrier layers;
4. Resin manufacturer's corrosion service data for the proposed resin systems. Corrosion service data shall show satisfactory long term service in similar physical and chemical environments to those specified herein;
5. Sample coupons of each different laminate not less than 300 x 300 mm square. Provide sample laminate coupons for each method of manufacture;
6. Details of the proposed laminate construction for RTR fittings.
7. Samples of liquid and cast resin together with reinforcements and surfacing veils (or fabrics) required to manufacture the samples indicated above.

In addition, for valves submit the following:

1. The total weight of each item;
2. Materials of construction and coating details;
3. Certified hydrostatic test data, per manufacturer's standard procedure;
4. For each valve specified to be manufactured, tested and/or installed, submit an affidavit of compliance with the appropriate standards, including certified results of required tests and certification of proper installation;
5. Draft Operation and Maintenance Manual.

In addition, for HDPE pipes, submit the following:

1. Calculations covering the soil pressure on the buried pipe and restraint of expansion or contraction. Restraint anchors shall be provided if required. Manholes may be regarded as such restraint blocks, provided that they can be shown to provide the necessary resistance;
2. The manufacturer shall provide proof of successful past use of the HDPE pipes and fittings on work of a similar environment and scope to that for this project;
3. Method Statement: shall include details on connection of pipe to manhole lining materials to ensure protection of connection on lined concrete manhole;
4. Detailed shop drawings shall be submitted to the Engineer-in-charge for approval. These shall show all relevant details including:
 - Connections to manholes;
 - Jointing to existing mains;
 - Joints detail;
 - The contractor shall furnish the Engineer with samples of the proposed connections between the pipe and manhole lining when used with lined concrete manholes and provide testing as required by the Engineer.
5. Representative samples of each type shall be submitted to the Engineer-in-charge for approval;
6. Different sizes and types of pipes and fittings, even if from the same manufacturer, shall be placed in separate submittals

7.3 Materials for Pipework and Ancillaries

7.3.1 PVC-U Pipes

All PVC-U pipes shall comply with ISO 161/1 as applicable or other approved standard. Unless a higher class is noted elsewhere in the Contract Documents, PVC-U pipes for pressure applications shall be PN 10 at 20°C. The permitted pressure will be de rated by a third for 40°C. If the working pressure of the system is greater than 4.5 bar, the pressure class of the pipe shall be at least 2.2 times greater than the working pressure.

The material shall have a minimum extrapolated hoop tensile strength of 17.5MN/m² at 50 years and at a temperature of 35°C.

Where PVC-U pipes are used for drainage purposes a standard dimension ratio (SDR) of 41 is required or Type SN4 in accordance with Indian standards.

Joints for gravity pipe shall be made by means of rubber ring seal connections.

Slotted PVC-U pipes for land and storm water/land drains shall be of an approved design giving infiltration rates at least equal to those specified in Indian standards for porous concrete pipes and they shall comply with them.

Any pipe or part pipe with discoloration, scratching, abrasion, pit marks or otherwise considered unsuitable by the Engineer-in-charge shall be rejected.

7.3.2 Precast Concrete Pipes and Fittings

Precast concrete pipes and fittings of circular cross-section used for the conveyance of sewage or surface water, Concrete Manholes and inspection chambers shall comply with the appropriate Indian standards. All precast concrete products shall be made using sulphate resisting cement.

Concrete jacking pipes shall comply with the relevant provisions of Indian standards. The Contractor shall ensure that the pipes can withstand the jacking loads without damage.

All pipes and fittings shall have gasket spigot and socket type joints unless noted otherwise. Strength class is to be Class 120 unless noted elsewhere in the Contract. Strength class is minimum crushing load in KN/m divided by one thousandth of nominal diameter in mm.

7.3.3 Pipe Joints General

Unless specified elsewhere, rubber joint rings for water mains and drainage purposes shall be types W and D respectively complying with the relevant standards and shall generally be obtained from the pipe manufacturers. The elastomer used for the manufacturer of the rings shall be first grade plantation rubber, styrene butadiene or ethylene propylene rubber complying with Indian standards.

7.3.4 Step Irons

Step irons for manholes shall be in accordance with Indian standards.

7.3.5 CI Covers and Frames

Cast ductile iron covers and frames shall be of the size, type and grade shown on the Drawings and shall comply with Indian standards. They shall be lockable unless noted otherwise. If specified elsewhere to be airtight, they shall be capable of resisting an internal pressure of 100kN/m². All covers shall be obtained from approved manufacturers to the sizes, grades and pattern numbers as detailed. Where no grade is detailed, Class D400 shall be used in paved areas and Class C250 in areas where there is no vehicular access.

Covers shall be supplied complete with 5 sets of lifting keys obtained from the cover manufacturer. Frames and covers for sewers shall have a removable self-sealing GRP or similar corrosion-resistant plate that fits securely between cover and frame such that the minimum surface area of the frame is exposed to the atmosphere within the manhole. The design of the frame, cover and plate shall be to the approval of the Engineer. Covers and frames to air valve chambers shall be of ventilated type unless the chamber is separately ventilated.

All manhole covers shall be coated with 400 micron spray epoxy.

7.3.6 CI Surface Boxes, Gully Gratings and Frames

Cast ductile iron surface boxes, gully gratings and frames shall be heavy duty complying with Indian standards for Class D400 loading except for kerb gullies which shall be Class C250 loading. Kerb gullies shall have reversible covers capable of preventing the ingress

of sand and shall suit the kerb profile. Kerb gully frames shall include an internal GRP grating and road retaining bar. The weir entrance to the road gully shall be barred vertically to prevent the ingress of objects larger than 75mm.

7.3.7 Gullies

Road gullies shall be polypropylene or GRP in accordance with Indian standards, 450mm internal diameter by 900 or 1,050mm deep with 150mm outlet and without trap for soakaways but with trap for a positive drainage system. They shall be complete with GRP perforated basket and incorporate a 100mm diameter opening in the base, unless otherwise directed by the Engineer-in-charge.

7.3.8 Protection to CI Manhole Covers etc

Gratings, covers and frames shall be prepared in accordance with the relevant clause for preparation of steelwork prior to protective treatment and shall be coated with heavy duty abrasion resistant epoxy paint to a minimum DFT of 375 microns prior to installation.

Contact surfaces of covers and frames (other than machined covers) shall be coated with approved heavy duty grease immediately prior to final fitting of covers. Surfaces of machined covers and frames shall be coated with approved graphite grease immediately prior to final fitting of covers.

7.3.9 Manhole Linings

Manhole linings shall effectively resist the corrosive effects of septic sewage or effluent with a normal maximum temperature of up to 40 degree Centigrade.

The lining shall be subjected to the following test. The lining shall be fully resistant to 10% W/V sulphuric acid at 50 degrees C when subjected to an immersion test which shall last a minimum of 100 days. The laboratory and method of testing shall be to the approval of the Engineer.

Manhole linings shall have a resin rich lining having a nominal thickness of 1.5mm consisting of an inner most 0.3mm layer reinforced with 'C' glass. The remainder of the lining shall consist of acid resistant chopped 'ECR' glass strand or mat and having a glass content between 25 and 30% by weight. Manhole linings shall be provided with a resin rich outer layer reinforced with 'C' glass veil.

The resin to be used for the resin rich lining of the manhole lining shall be an epoxy based Vinylester resin. For the structural wall of the manhole lining high grade Isophthalic polyester resin shall be used. No dark pigments shall be used. Fine silica sand containing no impurities and complying with requirements of Indian standards – may be added to the structural layer to achieve adequate stiffness.

All glass reinforcement except for the inner and outer surfaces of the manhole lining shall be of the acid resistant 'ECR' type.

The internal surface of the liner material shall be smooth and both the internal and external surfaces shall be clean and free from defects such as protruding fibre, voids, pits,

bubbles, cracks, blisters or foreign matter which would impair their performance in service.

The external surface of the lining shall have suitable GRP lugs moulded on the surface at appropriate spacings to allow adequate bonding to the concrete.

The manufacturing tolerances shall be $\pm 0.5\%$. All deviations from roundness, with the exception of deformation due to self-weight, shall be contained within this tolerance.

At no position shall the thickness of the manhole liner material be less than 7mm.

Circular lining material shall be able to withstand an external hydrostatic head of concrete of 7 metres without deforming.

The lining material shall have adequate strength to withstand loading, off-loading and site handling. It shall not buckle or distort so as to affect circularity, water-tightness or continuity of laminate when a concrete surround is being placed. Internal bracing whilst pouring concrete shall be adopted if required.

Joints, where permitted, shall be as detailed and shall be made using an external purpose-made sleeve or plate bonded by an approved solvent to the liner and shall be equal or superior in performance to the lining, in both the circumferential and longitudinal directions. Overbonding shall extend for a minimum of 150mm on each side of the joint.

A representative sample of the liner material shall be submitted to the Engineer for testing and for comparison with the product as delivered to Site, together with full details of the chemical properties of the resins.

7.3.10 Ladders

Aluminium alloy ladders shall be of approved design and obtained from an approved manufacturer. The dimension of ladder widths, rung spacing etc. shall comply with Indian standards.

GRP ladders shall be of approved design and obtained from an approved manufacturer. They shall comply with Indian standards.

7.3.11 Safety Chains

Mild steel safety chains shall be 8 mm nominal size Grade M(4) non-calibrated chain, Type 1, complying with relevant Indian standards. After manufacture, mild steel safety chains shall be hot dip galvanized as per standards.

Chain links shall be welded and have an internal length not exceeding 45mm and an internal width of between 12mm and 18mm. The fins caused by welding shall be removed and the weld shall be smoothly finished all round. When tested in accordance with standards, each chain shall withstand a breaking force of 30kN and a proof force of 15kN.

7.3.12 Water stops

Plasticized PVC water stops shall comply with the relevant provisions of WIS 4-31-02.

7.3.13 Filter Fabric

Filter fabric surround to soakaways and land drains shall be suitable for subsurface filtration. Geotextile is to have a minimum tear resistance of 225N. A minimum permeability of 90 l/m².s and a mean O₉₀ size of 0.18mm is required. The Contractor is to demonstrate the suitability of the geotextile for the particular application including submission of calculations together with soil grading curves to the approval of the Engineer. Geotextile shall be laid with 500mm overlaps at joints unless indicated elsewhere in the Contract.

7.3.14 Marker Tape

Marker tape shall be provided where directed and shall be approved high quality, acid and alkali-resistant polyethylene film 250mm wide, with a minimum thickness of 150 microns. Tape shall have minimum tensile strength of 125kg/cm² longitudinally and 105kg/cm² laterally with an elongation factor of 350%. Where the service is of a non-magnetically detectable nature, approved metal-backed tape shall be used.

Tape shall be printed with 50mm high black lettering, alternately in Arabic and English. The complete wordings shall be repeated every 2m along the tape. The colours shall be vivid, glossy and permanent with a life expectancy of 40 years.

Warning tapes shall be coloured and inscribed for identification as follows:

Service	Colour	Inscription
Electricity Ducts/ Cables	Red	'CAUTION-BURIED ELECTRIC CABLE'
Telephone Ducts/ Cables	Green	'CAUTION-BURIED TELEPHONE CABLE'
Potable Water	Blue	'CAUTION-BURIED WATERMAIN'
Foul/Surface Water Rising Main	Yellow	'CAUTION-BURIED RISING MAIN SEWER'
Foul/Surface Water Sewer	Yellow	'CAUTION-BURIED GRAVITY SEWER'

7.3.15 Oil Separators

The design of oil separators is to conform to the pollution prevention guidelines of UK Environmental Agency "Use and Design of Oil Separators in Surface Water Drainage Systems: PPG3" or to similar requirements by other regulatory agencies where approved by the Engineer-in-charge.

Unless shown otherwise in the drawings, oil separators shall be of the Class I as per Indian standards.

An oil level alarm shall be provided to indicate both a visual and audible warning when the level reaches 80% of its maximum capacity. The sensor shall be rated to IP68 or higher.

7.4 Trenches

7.4.1 Trench Excavation

Prior to commencing any excavation, the Contractor shall submit to the Engineer-in-charge for approval of his proposals for the provision of any necessary traffic control measures and the erection of safety barriers and night-time lighting. This shall not relieve the Contractor of any responsibility for complying with the requirements of the Police Department, local Municipality or any other Authority, and the Contractor shall make himself fully aware of these requirements prior to his submission to the Engineer-in-charge.

Before opening a section of trench the Contractor shall satisfy himself that the line of the trench is clear of underground obstructions, by taking out trial holes on the line of the trench.

Trenches shall be excavated to the lines shown on the Drawings and to levels that will allow for the pipe wall thickness and bedding thickness, if any. civil

Sight rails shall be set up and fixed securely into the ground and maintained at intervals not exceeding 25 metres. A minimum of three sight rails shall be maintained for every length of trench being excavated to one grade.

The widths of trenches shall be such as to provide at least 150mm clearance between the barrel of the pipe and the side of the excavation or timber or other sheeting, but the width measured between undisturbed faces of the trench sides at a level of 300mm above the crown of the pipe shall not, unless approved or required by the Engineer-in-charge, exceed the outside diameter of the pipe being laid plus 550mm for pipes up to and including 800mm diameter, and plus 750mm for pipes over 800mm in diameter. If the width of the trench exceeds the specified dimension or the trench supports move so as to disturb the ground in the trench side at or below crown level, the Contractor shall, at his own expense, extend the bedding to the full width of the trench. The Contractor shall be responsible for the disposal of surplus excavated material off site to an approved area.

If any loose, soft or bad ground is encountered, the Contractor shall report this to the Engineer and, where directed, shall excavate the same to a solid foundation and replace this with concrete or Class I fill material or other approved fill, as directed.

The Contractor shall ensure that all excavation and trench side support is carried out in a careful manner, that it is rendered secure and safe, and that all necessary measures are taken to prevent the removal or falling-in of material beyond the trench dimensions detailed. The Contractor shall maintain all trench side support until the completion of the work to the satisfaction of the Engineer and shall promptly remove any material which has collapsed into the excavation. Except where described in the Contract or approved by the Engineer-in-charge, excavations shall not be battered.

The Contractor shall protect his excavation with suitable supports where such support is necessary to ensure the safety of the workmen, the integrity of adjoining structures and work generally. Where ordered, the Contractor shall leave steel sheet piling, plain or interlocking steel sheeting or timbering in excavations, trenches or headings.

A clear space of a minimum of 2m or greater if instructed by the engineer shall be left between the edges of excavations and the inner toes of spoil banks. No vehicles or other heavy machinery is permitted may operate within this clear space.

When a void occurs between the sides of the excavation and the trench supports, this shall be filled with Class III fill material well-compacted in 200mm layers up to ground level immediately after the final positioning of the trench supports. A clear space shall be left between the edges of excavations and the inner toes of spoil banks, to the approval of the Engineer-in-charge. Back-throwing shall not be allowed and all materials shall be brought to the surface and formed in heaps clear of the excavation.

Where two pipes are to be laid side by side in the same trench, but at different levels, the excavation shall first be taken down to a level 200mm above formation level for the upper pipe; the excavation for the lower pipe shall then be carried out and the lower pipe laid, jointed and completed; backfilling shall then be carried out up to formation level of the upper pipe, the remainder of the excavation for the upper pipe completed, and the laying of the pipe completed. Unless otherwise approved by the Engineer-in-charge, sewers shall be laid from the downstream end.

Except where indicated elsewhere in the Contract, the minimum depth to the top of pipes shall be 1200mm under roads and other trafficked and hard standing areas and 900mm elsewhere.

All flexible pipelines will be subjected to in-situ deflection measurements, firstly after placing and compaction of the surrounds and secondly not less than four weeks following completion of backfill. Any section of pipe failing to meet the deflection criteria shall have its surround material re-compacted, such procedure being repeated until the in-situ pipe is found to satisfactory. Pipes will be regarded as damaged and shall be removed from the trench and condemned if their in-situ deflection at any time exceeds the values stated in the table below. Such pipe shall be removed from site and shall not be used in any part of the Works.

Deflections in pipes smaller than 600mm diameter shall be measured by pulling through approved cylindrical plug dimensioned to suit the minimum deflected diameter of the pipe. For pipes 600mm and larger internal measurements are to be made in the vertical plane, with readings at both ends and one in the midpoint of each pipe. All measurements to be taken no sooner than 4 weeks after backfilling, except in pipelines where access points are more than 100 metres apart, in which case they may be taken progressively with the backfilling.

7.4.2 Road Crossings

The Contractor shall close sheet and adequately support all trenches across existing roads. Care shall be taken by the Contractor to ensure that existing roads and services are not damaged by road crossing operations and that the safety of the workforce and general public is maintained.

7.4.3 Pumping and Dewatering

Excavations shall be kept free from water at all times and adequate pumping plant, including special dewatering equipment, shall be provided together with means of conveying away the pumped water and all water from excavations. Sumps, when used, shall be formed clear of excavations for permanent works. Silt traps shall be provided unless directed otherwise by the Engineer.

The Contractor shall submit details of his proposed dewatering methods to the Engineer for approval. All dewatering will be subject to relevant discharge approvals

7.4.4 Sub-Drains

If necessary for the construction of the Works, the Contractor shall lay sub-drains, where directed, to convey the water to pumping sumps or soakaways. Sub-drains shall be laid unjointed with the invert not less than 300mm below the formation level of the permanent works, and shall be covered with gravel to formation level. The Contractor shall ensure that these drains are kept free from silt. The pipe materials for sub drains shall be to the approval of the Engineer.

7.4.5 Trenches under Roads

All trenches for services, drains and the like cut in to or adjacent to the roads or surfaced area formation shall, where possible, be compacted, backfilled and consolidated before the sub-base and pavement are laid. The Contractor shall satisfy the Engineer-in-charge as to the proper consolidation of all backfilling in trenches. Any subsidence shall be made good and the trench thoroughly tested by rolling to the Engineer's satisfaction. Damage to the road or surfaced area foundation or surface due to subsidence of trench filling shall be made good at the Contractor's expense.

Backfill materials more than 300mm above the tops of ducts and pipes and all materials around and over manholes, soakaways, etc. shall be well compacted in approved layers by mechanical compactors so that a minimum 95% relative compaction is achieved throughout.

Where trenches have been cut through existing paved roads the trench backfill shall be brought up to formation level whereupon the pavement layers shall be reinstated and rolled to the Engineer-in-charge's satisfaction using similar approved materials.

7.4.6 Material for Pipe Bedding and Trench Filling

Material to be used for pipe bedding and trench backfill (divided into Classes I, II and III) shall be free from vegetable and perishable matter and shall be obtained from sources approved by the Engineer-in-charge. They shall comply with the following particular requirements:

Class I Trench Fill shall be free-draining, rounded, granular material consisting of natural gravel or similar material.

For pipes up to and including 300mm, the nominal size shall be 10mm; for pipes exceeding 300mm but not exceeding 900mm diameter, the nominal size shall be 14mm; above

900mm diameter, the nominal size shall be 20mm. The overall grading shall be such that the material shall have a Compaction Fraction of 0.10 or less.

Class II Trench Fill shall consist of approved granular material obtained from excavations or borrow pits and shall exclude stones larger than 25mm in size. The material shall be capable of being compacted to a stable mass and shall achieve a laboratory CBR of 20% after 96 hours soaking, when compacted to 95% of the laboratory maximum dry density tested in accordance with relevant Indian standards.

Class III Trench Fill shall consist of approved granular material obtained from excavations or borrow pits, shall be capable of being compacted to a stable mass and shall achieve a laboratory CBR of 20% after 96 hours soaking when compacted to 95% of the laboratory maximum dry density.

Where separate bedding material is required for pressure pipes up to and including 300mm diameter, it shall consist of Class I Trench Fill.

7.4.7

Bedding for Pipes

Unless directed otherwise by the Engineer-in-charge, should any trench invert be over-dug, it shall be made good with the class of material specified for the layer immediately overlaying it.

If any bedding material is damaged by water, sewage, collapse of trench sides or in another way, it shall be removed from the trench and replaced with new material before any pipes are laid or re-laid.

The required bedding and surround for rigid pipes shall conform to one of the following three categories:

Class B bedding shall comprise a Class I Trench Fill bed at the base of the pipe with a Class II Trench Fill surround to the sides and the crown.

Class G bedding shall comprise a full Class I Trench Fill surround to the pipe. The minimum thickness of fill material shall be 150mm.

Class Z bedding shall comprise a full mass concrete bed and surround.

The category of bedding used in the Works shall be as noted on the Drawings or instructed by the Engineer-in-charge.

Where Class Z bedding is required, the backfill shall not be commenced until at least twenty-four hours after the placing of the concrete has been completed. Heavy rammers shall not be used nor shall traffic loads be imposed until at least seventy-two hours after concreting, or as directed by the Engineer-in-charge.

Where Class B or Class G bedding is required, the bedding material shall be hollowed out to receive the sockets and allow proper jointing and wrapping. The bedding shall be completed to the required level and compacted such that the pipes are evenly supported over their entire lengths.

Bedding for pipes shall be constructed by spreading and compacting material over the full width of the trench.

7.4.8 Backfilling to Pipes

During placing or compaction of backfill, the Contractor shall take all precautions necessary to prevent movement or flotation of pipes.

The side fill shall be placed and compacted as soon as possible after pipe-laying and testing, or as soon as it is safe to do so without damaging concrete beddings or surrounds.

Timbering or sheeting shall be withdrawn progressively as filling proceeds where practicable to ensure that no voids are left in the filling.

Initial backfill shall be placed over the pipe as soon as possible to provide a protective layer of material, hand-compacted to a level 300mm above the crown of the pipe. Remaining backfill shall then be placed and thoroughly compacted in layers not exceeding 200mm thick.

Material shall not be dropped from an excessive height. Where required water may be added to assist compaction.

Power operated rammers or other mechanical compaction equipment shall not be used within 300mm of the top of the pipe.

Heavy mechanical equipment shall not be allowed to cross any pipeline until the trench has been completely backfilled and compacted.

7.4.9 Standards of Compaction

The standards of compaction of trench fill materials shall be as follows:

- **Well-compacted:** The material shall be compacted by mechanical means in layers not exceeding 200mm compacted thickness. The density obtained in each layer shall not be less than 95% of the maximum dry density determined as per Indian standards or as directed by the Engineer-in-charge. Tests shall be carried out as instructed by the Engineer-in-charge, up to a maximum of two tests per layer per 100 metres of trench.
- **Hand-compacted:** The material shall be thoroughly compacted by hand in layers not exceeding 100mm compacted thickness, using an iron rammer weighing not less than 4.5kg. The density obtained in each layer shall not be less than 95% of the maximum dry density determined using relevant Indian standards or as directed by the Engineer-in-charge. Tests shall be carried out as instructed by the Engineer-in-charge, up to a maximum of two tests per layer per 100 metres of trench.

7.4.10 Concrete Surround

Concrete provided as a protective surround to pipes shall comply with the requirements for mass concrete as detailed elsewhere in the Specification. Where pipes with flexible joints are used, concrete protection shall be interrupted over its full cross section at each joint by a shaped compressible filler consisting of 20mm thick bitumen impregnated filler unless specified otherwise in the Contract. Such joint filler shall be provided at each pipe joint as indicated on the drawings unless directed otherwise by the Engineer-in-charge.

Concrete surround will normally be required under roads where the cover to the pipe crown is less than 900mm and in gardens and areas not subject to traffic loading where the cover is less than 600mm. Additionally, the Engineer may direct the Contractor to lay pipes in concrete surround where in his opinion the pipes are vulnerable to corrosion by adverse ground conditions or exposed to damage by other Contractors.

RTR pipe shall be protected from direct contact with the concrete in accordance with the pipe manufacturer's recommendations.

Concrete shall be Grade 30/20/S unless otherwise shown on the drawings. The minimum thickness of concrete between the bottom of the pipe and the trench shall be 0.25x nominal pipe diameter, subject to 150mm minimum, with a minimum 100mm beneath sockets. Additional concrete cover maybe needed to prevent floatation during the placing or the pipe may need anchoring at the Engineers discretion to secure during concrete placement.

Flexible pipes with concrete surround shall have a maximum pipe length of 3 metres. The pipes shall be set to correct alignment allowing for deflection with appropriate isolation joints where detailed in the standard drawings.

The Contractor may use wooden folding wedges on precast concrete blocks cast at least 7 days in advance to support the pipe before concreting. The wedges should be the same length as the blocks and the blocks shall be founded on the trench bottom to support the pipe adequately without settlement. The wedges shall be removed during placing concrete. Blocks may have thin tie wires cast in to assist in holding down the pipe during concrete pouring. Gaps of 450mm long shall be left at the ends of each pipe for expansion/movement joint as shown on the drawings.

No traffic load shall be placed on the concrete surround within 72 hours of the concrete surround.

7.4.11 Marker Tapes

The Contractor shall install approved marker tape during backfilling work over buried pipes, cables, conduits and ducts, as required. The tape shall be compliant with Indian standards.

Where required by the relevant utility or authority, tiles shall be provided to their approval.

7.5 Construction of Pipework and Manholes

7.5.1 Pipework and Manholes—General

The Contractor shall construct pipelines, manholes and chambers to the lines and levels shown on the drawings and provide the materials in accordance with the Specification.

All pipes, half-pipes, junctions, bends, fittings, etc. shall be of first class quality and obtained from an approved manufacturer

7.5.2 Concrete Stools, Anchor and Thrust Blocks

Except where welded, laminated or self-anchoring joints are used, thrusts from bends and branches in pressure pipes shall be resisted by concrete thrust blocks cast in contact with undisturbed ground. Concrete stools, anchor and thrust blocks, and other supports for pipes shall be cast in situ or fixed after the installation has been finally positioned to the lines and levels shown on the drawings but before loading or charging the installation.

Unless otherwise directed by the Engineer-in-charge, concrete shall be cast directly against the undisturbed face of the trench excavation. The Contractor shall maintain correct clearances in order that bolts, nuts and joints may be tightened or removed after supports have been installed. The Contractor shall provide temporary supports pending the casting of fixing of permanent supports, fixings, fittings, anchors and stools. Any additional excavation required to accommodate thrust blocks shall be carried out after the bend or branch is in position and the thrust face shall be trimmed back immediately prior to concreting.

Where thrust blocks are cast against flexible pipes the pipe shall, prior to concreting, be wrapped with 2 layers of an approved tape of minimum thickness 1.15mm applied with 50% overlap.

All bends and stop-ends on pressure mains shall be securely anchored by concrete placed between the bend or stop-end and the solid undisturbed vertical face of the trench. The concrete shall be as detailed on the drawings.

If directed by the Engineer-in-charge, the Contractor shall provide detailed drawings and calculations of his proposed supports and thrust blocks for approval.

Unless otherwise directed, thrust blocks shall be allowed to develop adequate strength with a minimum setting time after casting of 24 hours before any pressure is applied to the pipeline.

7.5.3 Unloading and Laying out Pipes

Pipes and specials shall be unloaded with great care to avoid breakages and allow inspection of their state on arrival. If they are shipped in packs or pallets, each pack or pallet shall be lifted individually with suitable lifting equipment. If the pipes have to be unloaded singly and by hand, this shall be done by means of skids and check ropes and no pipes shall be dropped or allowed to roll unchecked. Pipes shall not be allowed to roll together and shall be wedged to prevent further movement. The Contractor shall submit the manufacturer's proposals for unloading, stacking and laying out pipes.

PVC-U pipes shall be uniformly stacked along the pipe length and shall be given side support. Stacks shall be limited to 1 metre in height or 4 layers; whichever is the lesser. PVC-U, PE and RTR pipes and fittings shall be stored completely under shade at all times.

Pipes or specials shall not be laid out in such a manner as to impede traffic, or obstruct paths or accesses to properties. Pipes or specials shall not be laid out in beds of ditches; every precaution shall be taken to preserve their cleanliness before laying.

All pipes and specials shall be carefully examined before laying and any damage to the pipe coating or lining shall be made good to the approval of the Engineer-in-charge.

Before the trench is backfilled, the pipes shall again be examined and any further damage caused to the coating during laying shall be made good.

7.5.4 Laying and Jointing Pipes

All pipe systems shall be laid to true and even falls and to the lines and levels shown on the drawings. The Contractor shall supply and fix all necessary bends, tees, tapers, valves and other specials, and shall carry out all necessary cutting, coring, drilling holes, jointing and connecting to new and existing work.

Pipes shall be kept free from mud, debris and other obstruction during laying and until handed over, and suitably sized stoppers shall be used to block up the ends of all pipes, junctions, etc., while preparing the trench for the next pipe or after working hours. The excavation shall in all cases be carefully completed at least 6 metres but not more than 50 metres in advance of the laying of the pipes, unless agreed otherwise by the Engineer-in-charge.

Where ground water is encountered, it shall be kept below the formation level of the trench.

Before laying, each pipe shall be brushed out and examined and each spun iron pipe shall be tested for soundness by being tapped with a hammer while the pipe is suspended clear of the ground.

Each pipe shall be carefully lowered onto the prepared bed by means of the necessary slings and tackle. If the prepared bed is damaged and if stones are dislodged into the trench, the pipe shall be raised and the bed made good and stones removed before pipe laying is continued.

Pipes shall not be jointed before being lowered into the trench without the permission of the Engineer-in-charge.

Joint lubricants for sliding joints shall have no deleterious effect on either the joint rings or pipes, and be unaffected by the liquid to be conveyed. Joint lubricant for potable water pipes must be approved for use with potable water.

No pipe or pipeline may be used for trench drainage purposes without the permission of the Engineer-in-charge.

Where pipes with flexible joints are required to be laid to curves, the deflection at any laid joint shall not exceed two thirds of the maximum deflection recommended by the manufacturer.

Between adjacent manholes, the total length of pipeline shall remain uncovered until it has been inspected and satisfactorily tested. Such inspection shall not relieve the Contractor of his responsibility for delivering the whole of the Works in a watertight, correct and perfect condition.

No pipe shall be covered up until it has been inspected and satisfactorily tested as specified.

Unless otherwise approved by the Engineer-in-charge, sewers shall be laid from the downstream end with the pipe sockets facing upstream.

Where pipes are built into manholes, pits, chambers, thrust blocks and other firmly-founded structures, at changes in class of pipe bedding and at other locations where differential settlement can be expected, a flexible joint shall be provided as close as is feasible to the outside face of the structure and a second pipe (rocker pipe) provided as set out below:

Diameter, D mm	First (maximum projecting) mm	Pipe length	Second (rocker mm	Pipe pipe)
150 to 400	400		600	
Larger than 400	D/2		1.5D	

7.5.5 Cutting Pipes

Pipes shall be cut by a method which provides a clean square profile, without splitting or fracturing the pipe wall, and which minimises 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 and any protective coatings shall be made good. Spigot ends shall be prepared for reuse in accordance with the manufacturer's instructions.

Where GRP or ductile iron pipes are to be cut to form non-standard lengths, the Contractor shall comply with the manufacturer's recommendations in respect of ovality correction and tolerances to the cut spigot end. Where concrete pipes are cut, any exposed reinforcement shall be sealed with an epoxy resin mortar.

7.5.6 Junctions

The Contractor shall install junctions where directed. Before the trench is refilled, he shall make accurate measurements of the distance from each junction to the centres of the nearest manholes upstream and downstream, and record the invert level of the branch and shall furnish this information to the Engineer-in-charge, with details of the size and direction of the branch.

7.5.7 Constructing Manholes and Chambers

The Contractor shall build in pipes and form grades as directed. Short pipes, as specified elsewhere, with flexible joints shall be used immediately adjacent to manholes and chambers. Benching shall include a surface layer of acid resistant epoxy mortar at least 25mm thick. Benching shall be left completely smooth.

The concrete in walls and surrounds shall be formed using properly constructed formwork. Manholes and chambers shall be constructed concurrently with the adjacent pipe lengths. Where flexible pipes are to be cast into concrete, the Contractor shall submit his proposals for ensuring flexibility.

After the concrete has hardened sufficiently and the protective tanking has been completed, selected material shall be carefully filled and rammed behind the concrete and compacted in accordance with the requirements of the specifications.

All manholes and chambers shall be watertight to the satisfaction of the Engineer-in-charge. The Contractor shall thoroughly clean out and flush manholes with clean water.

Sulphate resisting brickwork, where detailed under manhole covers and frames, shall be solid concrete bricks generally in accordance with BS 6073. The standard block shall be 190 x 90 x 65mm high with a minimum compressive strength of 40N/mm², unless shown otherwise.

Manholes shall be constructed concurrently with the laying of the adjacent pipelines. RTR Manhole linings shall be stored completely in the shade at all times.

7.5.8 External Protection of Manholes and Chambers

The external faces of manholes and chambers shall be protected in accordance with the relevant clauses of the Concrete Specification for external sheet tanking membrane for reinforced structures or brush applied for mass concrete structures.

7.5.9 Internal Protection of Manholes and Chambers

Unless described elsewhere in the Contract, the internal faces of manholes and chambers shall be protected by an epoxy resin coating except where a GRP liner is provided.

The Solvent Free pitch extended Epoxy Resin coating shall be a two component 100% solids material. The material shall be applied in at least two coats to give a total of dry film thickness of at least 400 microns.

The surface preparation fillers and coating shall only be applied on shaded surfaces.

Surface preparation shall include an epoxy resin fairing coat applied in accordance with manufacturer's instructions.

The coating shall be heavy duty, waterproof, and flexible. It shall be abrasion resistant and have demonstrated resistance to sulphuric acid and chemicals present in the sewage treatment environment.

The final surface shall be smooth and pinhole free.

Material Test requirements are:

Bond Strength	2.4 N/sq mm
Reduction in chloride ion penetration (diffusion cell method)	More than 98%
Able to bridge crack of at least	0.25 mm
Water absorption (ASTM D570)	Less than 0.01%

7.5.10 Puddle/Anchor Flanges

Where pipes are built through concrete walls, puddle/ anchor flanges shall be provided. Cast-on or welded flanges shall be provided. This requirement shall apply to all concrete structures and chambers except manholes.

7.5.11 New Manholes on Existing Sewers

Where directed, the Contractor shall excavate down to and around existing sewers. Concrete foundations shall be formed under the existing pipe. A manhole shall be constructed on this foundation in accordance with the Specification and a new pipe laid from there to the new sewer.

The section of the existing pipe inside the new manhole shall then be carefully removed and new benching formed as specified. The ends of any disused pipes shall be sealed off with a concrete plug rendered over with acid resistant epoxy mortar 25mm thick.

Care shall be taken to ensure that no materials from the excavation, or debris of any kind, enters the sewers during the construction of manholes.

The Contractor shall comply with the safety standards of the Employer and relevant authorities.

7.5.12 Sealing Future Connections

Vitrified clay or polypropylene stoppers of approved pattern with flexible joints shall be used to seal off the ends of all vitrified clay, GRP or PVC-U pipes left for future connections. Cast iron caps shall be used to seal off the ends of all iron pipes and asbestos cement pipes for future connections

7.5.13 Connections to Sewers

No sewage shall be discharged to new sewers until the whole of the Works are completed to the satisfaction of the Engineer-in-charge except that where a substantial part of the scheme has been completed to his satisfaction, the Engineer-in-charge may permit connections to such part of the scheme.

Care shall be taken to ensure that no materials from the excavation or debris of any kind enters the existing or new sewers whilst connections are being made.

The alignments and elevation of the connection pipes and chambers of manholes shall be determined by the Engineer-in-charge.

7.5.14 Abandonment of Pipeline

Sewers or pipelines to be abandoned shall be filled by grouting. The lowest point of the length to be abandoned shall be suitably sealed, and the grouting operation shall commence from that point and continue progressively so as to completely fill all voids.

Grout shall be compliant with the Concrete Works specification.

Where manholes or chambers are to be abandoned, the shafts or walls shall be broken down to a level 1m below ground level and the remaining void filled with well compacted Class III fill.

7.6 Testing

7.6.1 Testing General

The Contractor shall ensure that all pipes, fittings, specials etc. are watertight to the satisfaction of the Engineer-in-charge.

The Contractor shall supply all the necessary labour, blank flanges, anchors, air-valves, test pumps, gauges, clips, stoppers etc. for testing. Prior to use, the pressure gauge shall be tested at an approved independent testing laboratory and test certificates provided to the Engineer-in-charge.

Water required for testing shall be obtained from an approved source. The pipeline shall be filled in such a way that the pipework is not damaged in any way. The Contractor shall supply and dispose of the water for testing.

The Contractor shall give the Engineer-in-charge adequate notice in writing of his intention to test any pipeline (at least 24 hours for pressure pipelines). Testing shall not proceed until permission to do so has been received from the Engineer-in-charge. Permission to test shall not imply approval of the method nor relieve the Contractor in any way of his responsibilities in connection with the Works.

All pipes shall be cleaned and tested as the work proceeds. If 3 (three) months or more shall elapse between the final test and the pipeline being taken over, the Engineer-in-charge may require the pipeline to be retested as specified for the final test.

Pipes, fixtures and fittings which fail under test, or are broken by or found to be broken under test, or considered by the Engineer-in-charge as a result of the test to be unserviceable shall be rejected and removed from the site forthwith and shall be replaced. Replacement shall be at the Contractor's expense if, in the opinion of the Engineer-in-charge, failure is due to the Contractor's treatment, faulty installation of the component or inadequate inspection. After replacement the testing shall be repeated.

In the event of failure of a section of pipeline causing damage to any adjacent road, pavement, structure or existing service, the Contractor shall be liable for all remedial work necessary to restore the damaged item to its original condition.

On completion and prior to disinfection, if so required, pipes and specials shall be cleaned out and flushed with water, all silt, mortar, concrete debris and other obstructions being removed.

Such testing or inspection of any of the Works shall not be held to relieve the Contractor from his responsibility to deliver the whole of the Works in a sound and clean state, free from leakage and other defects under the maximum test or operating pressure, whichever is the greatest.

Upon satisfactory testing of a pipeline or section of a pipeline the Contractor shall submit a test acceptance form in a format to be mutually agreed, for signature by the Engineer-in-charge. This form shall be the true record of all acceptable tests. The Contractor shall retain one copy on site at all times.

7.6.2 Testing of Foul Sewers and Laterals

All sewers, junctions, risers, laterals, feed, washout and sludge pipes etc. up to and including 600mm diameter shall be tested with air at the completion of each working day or when 20 metres of pipe have been laid.

A gauge in the form of a glass U-tube shall be provided and air shall be blow or pumped into the length of pipes until a pressure equal to 125mm of water is indicated on the gauge.

Without further blowing or pumping the pressure shall not have fallen below 100mm after a period of 5 minutes. The pipes shall continue to withstand this pressure without further loss and without blowing or pumping for a further period of 5 minutes.

When a section of pipeline between manholes or such other sections as may be agreed by the Engineer-in-charge or his representative has been completed, and whilst uncovered, the pipeline shall be tested with water at a minimum pressure equal to 3.0m head of water or such pressures as the Engineer-in-charge may determine both before and after backfilling.

When testing pipes with water or final effluent, the test pressure shall be applied at the upstream end of the test length, but in no case shall the resultant pressure at the downstream end exceed 6.0m head, including the 3.0m test head.

The test pressure shall be applied for a sufficient period to allow for initial absorption etc. The test shall then be carried out over a period of one hour, and the pressure restored to the test pressure by the addition of water at 10 minute intervals. On each test length the acceptance criteria shall be the addition of no more than 0.042 litres of water per hour per linear metre per metre of pipe diameter of the pipe under test, to maintain the test head.

The test head or pressure shall be maintained while the refilling of the trenches proceeds until there is a consolidation depth of 1200mm over the barrel of the pipes. Should the loss of head or pressure then exceed the maximum permitted, the Contractor shall excavate to the pipes and make good any defects to the Engineer-in-charge's approval, after which the test shall be repeated.

On completion of testing, in the case of pipes up to and including 450mm diameter where a visual inspection is not possible, a wooden ball 25mm less in diameter than the diameter of the pipe shall be passed through each length, or the pipeline proved to be clean and unblocked in another approved manner.

In addition to the above, all pipelines shall be inspected on completion to ensure that there is no infiltration of ground water, where the pipeline is below the water table.

Where directed, pipelines shall be re-tested by means of the air test or water test, as previously specified, at the time of final inspection before commissioning the pipelines, the type of test to be instructed by the Engineer-in-charge.

7.6.3 Testing of PVC-U Pipelines

In addition to the other tests as described in the Contract, immediately after backfilling, a wooden ball 3% smaller than the pipe bore shall be passed through PVC-U pipelines. A further test using a wooden ball 5% smaller than pipe bore shall be carried out prior to the pipeline being put into service.

7.6.4 Testing of Gravity Surface Water Systems

Pipes up to and including 600mm diameter shall be air-tested in lengths from manhole to manhole before, during and after backfilling. Pipes greater than 600mm in diameter shall be visually inspected internally.

In addition to the above, all pipelines shall be inspected on completion to ensure that there is no infiltration of ground water, where the pipeline is below the water table. Manholes shall be visually inspected to ensure that there is no discernible infiltration.

Manholes and chambers shall be water-tight. Water testing of surface and land drains will not generally be required unless specifically ordered by the Engineer-in-charge.

Remedial work shall be carried out as necessary to obtain satisfactory air-tests and acceptable exclusion of ground water.

7.6.5 Testing of Pressure Pipelines

Before backfilling, pressure pipework shall be hydrostatically tested in accordance with relevant Indian standards for a continuous period of 4 hours. Cement lined pipes shall be kept at working pressure for a continuous period of 24 hours prior to carrying out of the test.

Sections for testing shall be in lengths approved by the Engineer-in-charge. The Contractor shall submit his proposals for pressure testing prior to commencement of pipe laying. Road crossings and other short sections of pipe installed independently of main runs shall be tested separately. Testing shall follow immediately upon pipe laying and, upon satisfactory completion of the test, shall be backfilled so that tested lines are not left exposed.

Test pressure measurements shall be made at the lowest point of the pipeline section under test.

The system test pressure shall be calculated from the design pressure by:

If the surge is calculated:

System Test Pressure = (Design Pressure + Surge) + 1 bar

If surge is not calculated:

System Test Pressure = Design Pressure x 1.5

Or System Test Pressure = Design Pressure + 5 bar whichever is the least

The Contractor shall completely fill the section of pipeline under test with potable water or where approved final effluent or raw water, expelling air from the pipe. Before applying the test pressure, air valves shall be isolated from the main to avoid damage to the floats. Testing against valves is not permitted unless directed by the Engineer-in-charge.

During the test, water shall be added if the pressure drops, the test pressure restored, and the amount added shall be recorded. On each test length the acceptance criteria shall be that the amount of water added does not exceed 0.1 litre/mm of diameter/km of length/24 hours/30 metres of head. Where pumping is required to maintain the pressure it shall be done at 30 minute intervals.

Following successful testing of all sections, the pipeline in its entirety shall be re-tested to the same test pressure as for the individual sections.

Before the pressure testing of the pipeline is carried out, the trench shall be sufficiently refilled to ensure that the requisite anchorage is provided for each pipe as this will prevent movement during the testing period.

7.6.6 Test Pressure for Valves

Gate and check valves shall be tested to the test pressure of the main in which they are situated or to the maximum pressure rating of the valve, whichever is the greater. The test shall be sustained for 30 minutes. Valves shall be works tested and independently certified. Air release valves shall withstand a test pressure of 16 bar. They shall be works tested and independently certified. Test pressures may be lower where specified by the Engineer-in-charge.

7.6.7 Flushing of Pipelines

Before the pipeline is put into service it shall be flushed at washouts and valves etc., to ensure complete freedom from obstructions and debris. Unless directed otherwise by the Engineer-in-charge, the Contractor shall provide the water for flushing which shall be of potable quality.

7.6.8 Disinfection of Potable Water Pipelines

Mains and services for potable water shall be disinfected prior to commissioning. The Contractor shall submit a method statement indicating means of testing and obtaining test results. The Engineer-in-charge may direct the Contractor to use particular testing laboratories.

7.6.9 Testing RTR Fittings

Tests on RTR fitting fabrication will be in accordance with relevant Indian standard and in particular;

1. The laminate shall be fully cured and shall show full resistance to a commercial acetone sensitivity test.
2. The laminate shall give Barcol Hardness of at least 90% of the resin manufacturer's recommendations. The measurement of hardness by means of a Barcol Impressor shall be carried out in accordance with relevant standards.
3. Resin burn off tests shall be performed on cut-outs for man-ways or other apertures. Where no such cut-out exists the Engineer-in-charge reserves the right to have 50mm diameter cut-outs for checks to be made local glass reinforcement content; the laminate shall then be repaired by the manufacturer. The tests shall be conducted in accordance with the relevant Indian standards, except that the result shall define glass content.
4. Where directed by the Engineer-in-charge the following strengths of the laminate shall be determined as per relevant Indian standards as follows:

- Ultimate tensile unit strength, lap shear strength and extensibility
- Flexural strength.
- Where a laminate has been designed to take bolts in the make up of the structure, tests for bolt bearing strength shall be performed.
- Where a laminate is to be used in conjunction with electrical control equipment, electrical strength and insulation resistance tests in accordance with Indian standards may be called for.

5. Additional tests may be called for at the discretion of the Engineer-in-charge.

All the tests reference above shall be witnessed unless waived in writing by the Engineer.

Test Certificates shall be obtained as follows:

From the resin supplier for the following properties of the resin when cured as proposed for the laminate manufacturing procedure:

1. Heat distortion temperature.
2. Barcol hardness.
3. Extension to failure of fully cured unreinforced resin.

From the glass reinforcement manufacturer for all the different grades and types of glass employed in the fabrication of the laminate

8. BLOCKWORK

8.1 Cement

Cement shall be Ordinary Portland Cement or any other cement as specified complying Indian standards.

8.2 Aggregate

Aggregate shall be natural aggregate complying with Indian standards.

8.3 Sand

Sand for mortar shall comply with specifications as specified.

8.4 Lime

Lime for mortar shall be hydrated semi-hydraulic lime complying with Indian standards.

8.5 Water

Water for mortar shall be as specified for Concrete.

8.6 Mortar Plasticiser

Mortar plasticiser shall be of an approved proprietary air-entraining type complying with Indian standards.

8.7 Precast Concrete Blocks

Precast concrete blocks shall be manufactured and tested in accordance with relevant standards and shall comply with Local Orders. Unless detailed otherwise, blocks shall be of the following types:

1. Minimum compressive strength of 7.5 N/mm² for non-load-bearing blockwork and 12.5 N/mm² for load-bearing blockwork, using Sulphate Resisting Cement and suitably graded fine and coarse aggregate, for use below damp-proof course level.
2. Minimum compressive strength of 7.5 N/mm² for non-load-bearing blockwork and 12.5 N/mm² for load-bearing blockwork, using Ordinary Portland Cement and suitably graded fine and coarse aggregate, for use above damp-proof course level.

The constituents of the concrete mix shall comply with the criteria laid down for constituents in the Concrete Specification. Blocks shall have a density (calculated by dividing the mass of the block by the overall volume) in the range 1500 kg/m³ to 2160 kg/m³.

Each block shall be clearly and permanently marked indicating the date of casting and its use whether for below or above damp-proof course level.

Blocks shall be of work size 200mm high, 400mm long and 200mm or 100mm thick, and shall be solid unless detailed otherwise.

Where hollow blockwork is specified for work above damp-proof course level, the blocks shall have two voids running vertically; the minimum thickness of outside skin shall be 30mm and of diaphragms 25mm; the maximum longitudinal dimension of any one void shall be 150mm.

Blocks shall be protected from the sun and cured for not less than 10 days.

8.8 Testing of Blocks

The Contractor shall supply certificates of tests carried out on representative samples of each batch of blocks.

The general procedure for sampling and testing shall be as per Indian standards

8.9 Special Blocks

Special shaped blocks, required to form proper bonding, which cannot be made in a standard block-making machine may be made in approved wooden moulds.

8.10 Concrete Screen Walling Blocks

Ornamental precast concrete screen walling blocks shall be to the sizes and shapes shown on the Drawings or as directed.

Blocks shall be obtained from an approved supplier.

8.11 Damp-proof Courses

Felt for damp-proof courses shall be bituminous 3-ply felt to relevant Indian standards.

8.12 Reinforcement

Reinforcement for walls shall be stainless steel (grade 316) expanded metal mesh strip supplied by an approved manufacturer. Unless detailed otherwise on the Drawings, galvanised mesh shall be used.

Rod reinforcement for concrete infill and lintels shall be as specified for Concrete.

8.13 Anchor Ties

Slots and anchors for bonding to concrete shall be of 18-gauge galvanised steel supplied by an approved manufacturer, and fixed on an alternate course.

8.14 Movement Joints

Sealant for movement joints shall be gun grade quality and shall conform to Indian standards.

Movement joints shall be primed with an appropriate primer and backed with debonding tape or foam prior to sealing.

Sealant, debonding tape or foam, and primer for sealant shall be obtained from the same manufacturer unless otherwise approved.

8.15 Sliding Joints

Sliding joint materials shall be supplied by an approved manufacturer and shall comprise a layer of self-adhesive

PTFE strip followed by a layer of uncoated PTFE strip applied strictly in accordance with the manufacturer's instructions.

8.16 Mortar Mixes

Mortar for blockwork below ground floor slab level and in contact with the ground shall be a mix measured by volume of one part of Sulphate Resisting Cement, one quarter of a part of lime and three parts of sand. The minimum compressive strength at 28 days shall be 11 N/mm².

Mortar for blockwork above ground floor slab level shall be a mix measured by volume of one part of Ordinary Portland Cement, one half of a part of lime, and four and a half parts of sand. The minimum compressive strength at 28 days shall be 5.5 N/mm².

Plasticiser may be used in lieu of lime; the quantity of plasticiser used shall be strictly in accordance with the manufacturer's recommendations.

Mortar shall be tested in accordance with Indian standards at the rate of one sample per 25m² of blockwork.

8.17 Mortar – General

Mortar shall be mixed dry and then with the minimum practicable quantity of water added until the correct consistency is obtained. Mortar shall be thoroughly mixed on a clean

platform and shall be used as mixed. Mortar shall be used within one hour of the addition of water. No mortar which has been allowed to set prior to use shall be used in the work.

8.18 Laying of Damp-proof Courses

Bituminous felt damp-proof courses shall be laid on an even bed of mortar in accordance with relevant standards and shall be lapped 150mm at joints.

8.19 Laying of Blockwork

Blockwork shall be laid in accordance with the recommendations of Indian standards.

Blocks shall not be set in place within 28 days of casting.

Blocks shall be wetted by sprinkling with fresh water before being laid.

Blocks shall be laid in stretcher bond, solidly bedded, jointed and flushed up in mortar. Joints shall have a nominal thickness of 10mm and extreme thicknesses of 5mm and 15mm.

Blockwork shall be set out and built to the respective dimensions, thicknesses and heights required and the Contractor shall set out courses, openings and the like with approved setting out rods.

Blocks shall be well buttered with mortar before being laid and joints shall be thoroughly filled and flushed up from the top as the work proceeds. Blockwork shall be carried up in a uniform manner, no portion being raised more than one metre above another. Perpend, quoins and the like shall be kept strictly true and square and the whole properly bonded together and levelled.

Where a horizontal or vertical joint is not solidly filled or where it is found that the Contractor has used blocks other than the blocks specified the whole panel of wall shall be considered suspect and shall be removed and rebuilt.

Wall faces which are to receive an applied finish shall be hacked and the joints shall be raked out to form a key.

8.20 Fair Faced Blockwork

Wall faces required to be finished fair face shall be built with blocks having unblemished surfaces, with good clean arrises to all exposed edges and shall be pointed with a neat flush joint as the work proceeds.

Before any fair faced block walls are commenced the Contractor shall provide for approval a specimen panel of minimum size 2 metres square. Thereafter all fair faced blockwork shall conform to this approved standard.

Holes through fair faced blockwork shall be saw-cut, drilled or formed with original faces of saw-cut blocks to give a neat fair faced appearance without mortar rendering.

8.21 Load bearing Walls

Load bearing walls required to support a concrete floor or roof shall have a separating joint consisting of two layers of PTFE slip material at the top of the wall to provide a slip surface.

The corners and intersections of loadbearing walls shall be constructed with hollow blocks and shall have the voids filled with concrete reinforced with one 16mm high yield steel bar for the full height of each void. Bars shall be lapped with starter bars from footings. At L-shaped corners three voids shall be filled and at T-shaped intersections four voids shall be filled. To allow the removal of excess mortar prior to concreting, clean-out openings shall be formed at the base of reinforced sections of wall by the use of 190 x 190 x 90mm solid block supports laid with the 90mm dimension at centres to coincide with second course perpend.

The top course of walls shall be constructed of U-shaped blocks filled with concrete reinforced with two 16mm high yield steel bars to provide a continuous tie at the top of the wall and trowelled smooth to receive the slip materials.

The concrete mix for filling to hollow blocks, U-shaped blocks and lintels shall be grade 30/10/M as specified for Concrete.

8.22 Non-load Bearing Walls

Non load-bearing walls shall not be constructed at the same time as load-bearing walls but shall be built at least two weeks after the concrete slab formwork has been struck.

Non load bearing walls shall be tied to load bearing walls by 400mm long expanded metal strips, 50mm narrower than the former, built into alternate courses. Strips shall be built into load bearing walls and later embedded in the mortar joints of the non load bearing walls. Tothing into load bearing walls shall not be permitted.

Non load bearing walls shall be tied to concrete members by anchor ties at alternate courses. The slots of such ties shall be cast in at the time of concreting.

Joints between non load-bearing walls and load-bearing walls or concrete members shall be sealed both sides with 10mm wide sealant. For fair faced walls the joint shall be raked out each side to the required depth and for rendered or tiled walls the render or tiling shall be stopped 10mm short of the load-bearing element. Sealant shall be 10mm deep.

Where the top of a non-load-bearing wall abuts a load bearing structure a separating layer of an approved compressible filler material, of not less than 10mm thickness shall be inserted, and sealed both sides to a depth of 10mm.

8.23 Bearings for Lintels

Bearings for lintels shall be 150mm or the depth of the lintel, whichever is greater. Voids in hollow blockwork immediately below bearings shall be filled solid with concrete grade 30/10/M.

8.24 Cavity Ties and Anchors

Where both skins of cavity walls are built in blockwork, the skins shall be tied together with galvanised mild steel butterfly pattern wall ties to relevant Indian standard, spaced at the rate of one every 800mm horizontally and 400mm vertically, staggered, and every 400mm vertically at ends, jambs and quoins.

Where cavities of cavity walls are formed between blockwork and concrete, the blockwork skin shall be tied to the concrete by means of approved anchor ties.

8.25 Protection of Cavities

The Contractor shall ensure that cavities are suitably protected from any mortar, concrete or other material falling into them. He shall submit for approval details of the methods that he proposes to use.

8.26 Cavity Insulation

Cavity walls shall be insulated with 50mm rock wool batts supplied by an approved manufacturer.

8.27 Protection of Finished Walls

The Contractor shall ensure that finished walling is not damaged by subsequent operations. Newly or partially built walling shall be cured by covering with hessian or other approved material kept wet for three days

8.28 External Pointing

External joinery or metalwork bedded against blockwork or concrete shall be pointed with an approved silicone sealant.

9. BUILDING FINISHES

9.1 Screed and Render

9.1.1 Cement and Water

Cement and water shall be as specified for Concrete.

9.1.2 Lime and Sand

Lime for rendering shall comply with relevant Indian standard.

Sand for rendering shall comply with relevant Indian standard. Sand for screeding shall comply with Indian standards.

9.1.3 Floor Screed

Floor screed shall consist of a mix of four parts sand to one part of cement mixed with the minimum practicable amount of water. The water/cement ratio shall not exceed 0.42.

9.1.4 Laying of Floor Screed

Screed shall be laid in bays of area not exceeding 16m² and length not exceeding 5m. Screed in wet areas shall be laid to minimum 1% falls to floor drains.

Concrete floor slabs shall be sweep-blasted to remove laitance and shall have all loose material removed by brushing. Where electrical conduits and the like are to be buried in screeds they shall be rigidly fixed to the concrete floor and the screed continuously reinforced along the length of the conduit with a 150mm wide strip of galvanised

expanded metal mesh. The mesh shall be positioned midway between the crown of the conduit and finished screed level and shall be fixed to the concrete floor at 300mm centres on both sides of the conduit by shot-fired masonry nails or other approved means.

Floor slabs shall be soaked for 12 hours with fresh water. Standing water shall then be removed by brushing or compressed air, neat cement grout scrubbed into the damp concrete surface and screed material laid immediately. Screed material shall be compacted and finished by wooden floats to the required levels and falls. The maximum permissible surface deviation shall be a 3mm gap under a 3m straight edge.

A minimum of 24 hours shall elapse between the placing of adjacent bays.

Finished bays shall be continuously wet cured for 7 days.

9.1.5 Dividing Strips

Dividing strips between different floor finishes, other than at entrance doors to toilets, kitchens and wet areas, shall be of approved heavy duty polished aluminium section, fixed to the substrate by stainless steel or aluminium alloy screws at 200mm centres on both sides of the strip. Dividers shall have a nominal exposed width of 6mm.

At entrance doors to toilets, kitchens and wet areas, the dividing strip shall comprise a 150mm wide x 50mm thick threshold of best quality Carrara polished marble fixed rigidly between jambs, 10mm proud of adjacent finishes. Marble shall be fixed down using 8mm diameter stainless steel pins at 250mm centres, epoxy grouted into both the concrete substrate and the underside of the marble. The gap below the marble threshold shall also be filled with epoxy grout. Through-drilling of marble will not be permitted. Samples of marble shall be submitted to the Engineer-in-charge/Employer for selection of a colour.

9.1.6 Self-levelling Floor Compound

Self-levelling floor compound shall be an approved proprietary cementitious free-flowing compound capable of being laid to any thickness in the range 1mm to 20mm, Nitoflor Leveltop GP, or equal and approved. For thicknesses greater than 10mm a clean sharp sand filler complying with relevant Indian standard, may be incorporated into the mix. The material shall have a minimum 28-day compressive strength of 30 N/mm² when tested as 50mm cubes cured at 35°C.

Prior to laying floor compound, the concrete substrate, which shall be at least 14 days old, shall be sweep-blasted to remove laitance. The blast-cleaned surface shall then be prepared and primed in accordance with the floor compound manufacturer's requirements. Floor compound shall be laid and finished in one layer, strictly in accordance with the manufacturer's printed instructions.

9.1.7 Concrete Surface Hardener

Where detailed, concrete floors shall be treated with an approved concrete surface hardening and dust proofing compound, applied strictly in accordance with the manufacturer's instructions. The hardener shall be of the penetrating type that reacts

chemically with lime and other soluble particles in the concrete to form hard crystals permanently bound into the concrete matrix, as Nitoflor Lithurin, or equal and approved.

9.1.8 Protection of Finished Flooring

Floor finishes shall be covered up and protected during the course of the works, and cleaned off and left sound, true and level upon completion.

9.1.9 Render

Render shall be a mix measured by volume of one part of cement, one quarter of a part of lime and four parts of sand.

Render shall be mixed dry in a clean container or on a clean board and then with the minimum practicable quantity of water added. The water/cement ratio shall not exceed 0.42.

9.1.10 Application of Render

Blockwork walls shall be left for at least 14 days before the application of render.

As far as is practicable, rendering shall not be commenced until all mechanical and electrical services, conduits, pipes, and fixtures have been installed.

Irregularities in surfaces to be rendered shall be filled with mortar, without lime, 24 hours before rendering is commenced. Joints in blockwork shall be raked out before rendering to form a good key. Concrete surfaces to be rendered shall be sweep-blasted to expose aggregate and provide an adequate mechanical key for the render.

Surface to be rendered shall be clean and free from dust, loose mortar and all traces of salts.

Surfaces shall be thoroughly sprayed and soaked with fresh water, and surface water allowed to disappear before render is applied.

After preparation of surfaces, a coat of cement slurry shall be applied to the damp surface to be rendered by means of a tyrolean machine, and wet cured for 24 hours. The render coat shall then be applied to the damp slurry coat by means of trowels, between screeds laid, ruled and plumbed as necessary. This coat, which shall be to the required thickness, shall be allowed to set hard and then wet cured. Surfaces shall be finished with a sponge or with a wood or steel float to smooth flat surfaces free from all marks.

Wet curing of finished render shall be undertaken for a minimum of 4 days, but as long as is necessary to prevent cracking.

The Contractor shall ensure that the work is protected from direct sunlight during execution and curing, and that the surrounding building work and paving is protected from cement or tyrolean splashes.

9.1.11 Edges of Render

Bevelled or struck edges shall be worked where the render finishes against joinery work, fair faced concrete etc., as indicated on the Drawings, or as directed. Expanded metal

render stops and angle beads, rigidly fixed to the substrate, shall be provided at all other edges and corners. Render stops shall be galvanised steel in dry air-conditioned areas internally, and stainless steel grade 316 externally and in internal wet and/or un-air conditioned areas.

9.1.12 Textured Protective Paint Finish

Textured protective paint finish to render and concrete shall be Arpax M50, as manufactured by W&J Leigh & Co, or equal and approved. The paint finish shall be applied as one coat of Arpax E318 sealer coat followed by one coat of Arpax M50 and one coat of Arpax M20, all strictly in accordance with the manufacturer's recommendations.

Alternative protective systems will only be considered if they provide equivalent protection to the specified system in terms of carbon dioxide diffusion, water vapour permeability, and salt spray/chloride permeability.

Up to four sample panels, each 1m², shall be prepared and submitted to the Engineer/Employer for selection of a preferred colour.

9.1.13 Smooth Protective Paint Finish

Smooth protective paint finish to render and concrete shall be Arpax M20, as manufactured by W&J Leigh & Co, or equal and approved. The paint finish shall be applied as one coat of Arpax M20, thinned 15%, followed by two coats of Arpax M20, unthinned, all strictly in accordance with the manufacturer's recommendations.

Alternative protective systems will only be considered if they provide equivalent protection to the specified system in terms of carbon dioxide diffusion, water vapour permeability, and salt spray/chloride permeability.

Up to four sample panels, each 1m², shall be prepared and submitted to the Engineer-in-Charge/Employer for selection of a preferred colour.

9.1.14 Tyrolean Finish

Tyrolean render shall be Cullamix ready mixed decorative wall finish, as manufactured by the Cement Marketing Company Ltd., or equal and approved, applied in accordance with the manufacturer's instructions.

All external rendering shown on the Drawings shall have a tyrolean finish unless detailed otherwise. The rendering shall consist of three coat work as CX4 Cullamix tyrolean finish specification D.

The finish shall be built up in layers to give the required honeycombed texture.

The interval between the application of successive layers shall depend on the suction of the surface. If the surface is sufficiently absorbent, the process shall be practically continuous. Where possible, an area shall be completed to an architectural feature at the end of a day's work but, where this is not possible, the operator shall feather out the tyrolean application in order that the next day's work will marry. The mixture shall be flicked on using an approved tyrolean machine.

Curing of tyrolean finish shall commence as soon as a water spray can be applied to the surface without causing damage and shall be continued for as long as is necessary to prevent cracks appearing.

9.2 Painting

9.2.1 Stopping

Stopping of surfaces prior to painting shall be carried out using the following materials:

1. For render it shall be cement-based filler.
2. For concrete or blockwork, it shall be of similar materials to the background and shall be finished with a similar texture.
3. For internal woodwork, hardboard, fibreboard and plywood to be painted it shall be putty complying with relevant Indian standard which shall be tinted to match the colour of the undercoat.
4. For clear finished woodwork it shall be a putty complying with Indian standards tinted to match the surrounding woodwork. This shall only be applied to small holes and minor blemishes. Large holes shall be repaired with graving pieces or grain pins.

9.2.2 Surface Preparation

Painting shall not be carried out on render which has not thoroughly dried out. The rendered surface shall be lightly rubbed down with fine sandpaper and all loose particles removed.

2 coats of approved brand of wall putty to be applied to exterior walls prior to application of epoxy primer and painting on chambers/tanks/buildings as per Manufacturer's instruction.

Concrete surfaces shall be clean, dry and free from loose material before painting.

Woodwork shall be brought to an even silky finish by the use of fine sandpaper. All woodwork for painting shall be knotted, stopped and primed.

Surfaces shall be cleaned and rubbed down between each coat.

9.2.3 Painting and Decorating - General

Painting and decorating shall be executed in accordance with the recommendations of relevant Indian standards.

Every possible precaution shall be taken to keep down dust before and during painting processes. No paint shall be applied to surfaces structurally or superficially damp and all surfaces shall be ascertained to be free from condensation, efflorescence etc before the application of each coat.

Primed or undercoated woodwork and metalwork shall not be left in an exposed or unsuitable situation for an undue period before completing the painting process. No exterior or exposed painting shall be carried out under adverse weather conditions, such as rain, extreme humidity (greater than 80%), dust storms etc.

Metal fittings such as ironmongery etc, not required to be painted, shall first be fitted and then removed before the preparatory processes are commenced. When all painting is completed, the fittings shall be cleaned and refixed in position. Electrical switches and other wall fittings shall be removed during painting.

The Contractor shall be responsible for protecting from damage paintwork and all other work during and after painting operations including the provision of all necessary dust sheets, covers etc.

Brushes, pails, kettles etc used in carrying out the work shall be clean and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of material.

The Contractor shall provide suitable movable receptacles into which shall be placed all waste liquids, slop washings etc which shall on no account be thrown down any gullies, manholes, sinks, WCs or any other sanitary fittings. Solid refuse or inflammable residues shall be removed from the site and disposed of in accordance with Municipality regulations.

Dilution of painting materials shall not be allowed except as recommended by the manufacturer and as approved.

9.2.4 Decorating Materials

Paint shall be supplied in sealed branded containers, by one of the following manufacturers, or equal and approved:

- Jotun Paints
- Oasis Paints (W & J Leigh)
- Hempel Paints
- National paints

Paints listed in Finishes Schedules are as manufactured by Jotun Paints; however, no preference for Jotun Paints is inferred or implied.

Paints, emulsions, varnishes etc shall be of the particular nature or chemical composition specified. Undercoats shall be supplied by the same manufacturer as top coats.

White spirit, size, knotting all shall comply with Indian standards.

9.2.5 Care of Materials

Paint and the like shall be brought to the Works in unopened and sealed tins; paint shall be not taken from one site to another.

Decorating materials shall be used within six months of delivery.

Paint and the like shall be kept well stirred and shall not be used when a thick sediment has settled. Any paint or the like which develops a skin on the contents within the tin shall be removed from the Works. Any residue left in one tin shall not under any circumstances be added to the contents of another tin.

The Contractor shall provide a suitable store in an approved position where paint and the like shall be stored without risk of deterioration from sunlight or weather.

9.2.6 Colour Scheme

Colours of building finishes shall be as detailed in specifications.

Colours shall not be mixed on site.

9.2.7 Workmanship

All grit and shot blasting, scraping, cleaning, stopping and painting shall be done by skilled operatives. Paint shall be applied by brushing or spraying in accordance with the manufacturer's instructions. Thinners shall only be added to paints in strict accordance with the manufacturer's permitted percentages and viscosity tests shall be carried out on random samples of mixed paints as directed. Brushes stored in thinners shall be thoroughly worked out to remove all thinner before re-use. Except as herein specified, no paint shall be applied to any surface when it is in the slightest degree damp; any paint applied to such damp surfaces shall be removed, re-prepared and the surface re-painted. The Contractor shall take all precautions necessary to prevent dust and dirt coming into contact with freshly painted surfaces or with surfaces being coated. Full coatings shall be applied in accordance with the rates of coverage recommended by the manufacturers, having regard to the surface texture and the conditions of application. Sample plates shall be prepared for approval and, when approved, shall be adopted as the standard to be achieved in the finished work.

The Contractor shall take particular care to instruct his workmen to use brushes of appropriate size in the application of paint. All cutting-in shall be executed with brushes not wider than 20mm. The use of masking tape shall be obligatory where directed.

The tint of each coat shall vary from the previous one and each coat shall be approved before the next is applied.

All the finishing tints shall be approved.

Each coat of paint and the like shall be thoroughly dry before the application of a further coat.

Not less than 24 hours shall be allowed between each coat, but the maximum intervals shall not exceed 21 days.

Before buildings are handed over the paintwork shall be free of all imperfections, chips etc. Floors, windows, fittings etc shall be thoroughly cleaned of splashes, drips etc upon completion.

9.2.8 Emulsion Paint

Emulsion paint shall be acrylic copolymer based paint applied in three coats in accordance with the manufacturer's instructions. The finished surface shall present a satin finish. Where used externally, emulsion paint shall be of external quality.

9.2.9 Gloss Paint

Gloss paint shall be alkyd based paint applied to primed surfaces in two undercoats and one or more top coats as required to produce a surface which is consistent and unstreaked in finish and colour.

9.2.10 Painting – General

Painting of buildings shall comply with the recommendations of Indian standard.

9.2.11 Painting of Woodwork

The moisture content of joinery timber at the time of painting shall not be more than 14%. All wrought woodwork to receive a clear varnish finish shall be rubbed down to a smooth surface. Wrought woodwork for painting shall be prepared and primed in the joiner's shop. Large or loose knots shall be cut out and plugged and filled. Nail holes, cracks or other defects shall be filled and levelled up with hard stopping. Small knots and pitch streaks shall then be given two coats of knotting. Joints shall be thoroughly primed before assembly.

As soon as knotting is thoroughly dry the whole of the joinery shall be given a coat of priming paint, care being taken to work the primer into all corners and crevices. End grain and surfaces which will be concealed upon erection shall be given two coats of primer. Spraying will not be permitted.

After erection on site a further coat of primer shall be applied to all accessible faces.

When the primer is dry, and before applying the undercoats, all cracks, nail holes etc shall be stopped. Woodwork which has been primed for some time shall be wiped down and rubbed with damp abrasive, leathered off and allowed to dry before applying undercoat.

Joinery shall then be given two coats of undercoating paint followed by one or more coats of alkyd resin enamel paint.

9.2.12 Clear Varnish

Clear varnish shall be polyurethane varnish obtained from an approved manufacturer.

Hardwood described as being polyurethane 'clear' or 'bright' varnished shall be filled, rubbed down and painted with one priming coat and three finishing coats of polyurethane clear high gloss wood finish, all in accordance with the manufacturer's instructions. Woodwork shall be lightly rubbed down between coats and care shall be taken to avoid the presence of dust by wiping the work with a 'tack' rag immediately before application of the varnish.

9.2.13 Stained Woodwork

Woodwork to have a stained natural finish shall be rubbed down and prepared to a smooth finish. It shall then be treated with two coats of an approved proprietary brand of stain/wood preservative which will impart a natural timber finish or approved shade to the

woodwork. The stain shall be applied in accordance with the manufacturer's instructions to give an even-toned finish.

9.2.14 Polishing

Where woodwork is described as polished it shall first be stained with an approved wood stain. First quality button polish shall then be applied; the first two applications may be by brush but subsequent applications shall be by means of a polisher's rubber and shall be continued until the wood grain is completely filled.

9.2.15 Cement Paint

Cement paint shall be an approved cement-based textured decorative surface coating applied strictly in accordance with the manufacturer's instructions.

Sample panels of different colours shall be prepared, up to a maximum of four. Panels shall be 1.0m² and shall be removed prior to application of the approved paint.

9.2.16 Painting of Exposed uPVC Pipework

Exposed uPVC pipework, fittings and brackets shall be abraded and painted with three coats of exterior quality emulsion paint.

9.2.17 External protective coating for visible structures

Protective coating shall be applied to the external visible faces of the concrete structures which are normally exposed to sunlight. The coating shall be an elastomeric coating based on acrylic co-polymers. It shall be waterproof and UV stable. The surface preparation shall comply with the manufacturer's recommendations including the priming. Two coats of the coating shall be applied in accordance with the manufacturer's recommendations. Colour to be grey and a sample panel will be completed by the Contractor to the satisfaction of the Engineer-in-charge, in advance of the permanent coating works.

2 coats of epoxy paint or acrylic paint over epoxy primer over 2 coats of approved brand of wall putty shall be applied from outside the technology buildings/chambers/tanks for a pleasant aesthetic appearance as per Manufacturer's specification and approved by Engineer in charge.

9.3 Tiling

9.3.1 Tiles - General

The Contractor shall not place an order for any tiles unless a sample has been submitted to, and approved in writing by the Engineer-in-charge. Tiles delivered to site shall be of the same standard and quality as the approved sample.

Ceramic tiles shall be supplied by one of the following manufacturers, or equal and approved:

- H&R Johnson Tiles Ltd
- Gail Inax AG

- Buchtal GmbH

Tiles listed in Finishes Schedules are as manufactured by H&R Johnson Tiles Ltd; however, alternatives of similar colours to those scheduled may be submitted for approval.

9.3.2 Ceramic Floor Tiles

Ceramic floor tiles shall be glazed or unglazed, as detailed on the Drawings, and shall comply with BS 6431. Spacer tiles shall generally be used, but round edge tiles shall be used on step nosings. Tiles shall be of the low water absorption type, i.e Group A1 or Group B1.

9.3.3 Ceramic Skirting Tiles

Ceramic skirting tiles shall be of the same type and from the same manufacturer as the floor tiles. Metric cove tiles with round tops shall be fixed where the wall finish is other than tiling, and square top cove tiles shall be fixed to meet wall tiling. Internal and external corners of skirting shall have proprietary corner tiles.

9.3.4 Laying and Grouting of Floor and Skirting Tiles

Ceramic floor and skirting tiles shall be fixed and grouted in accordance with the manufacturer's requirements. Grout shall be coloured as directed using proprietary colour mix.

Tiling in wet areas such as kitchens, pantries, toilets and the like shall be bedded on and infilled with approved proprietary waterproof epoxy tiling grout, incorporating an anti-fungicide additive.

Where tiles abut sanitary fittings, gullies, pipes etc., joints shall be sealed with an approved silicone sealant.

Finished tiling shall be true to level or shall fall smoothly to gullies without any discernible irregularity, and joint lines shall be true to line without discernible deviations.

9.3.5 Expansion Joints in Floor and Wall Finishes

Expansion joints in floor and wall finishes shall be as detailed on the Drawings. Joint components shall be neatly and accurately aligned to ensure that joints can expand and contract freely without damaging adjacent finishes.

9.3.6 Glazed Ceramic Wall Tiles

Glazed ceramic wall tiles shall comply with the relevant Indian standard; spacer tiles shall be used. Tiles shall be of the low water absorption type, i.e Group A1 or B1.

Edges and external angles shall have appropriate round edge tiles.

9.3.7 Fixing and Grouting of Wall Tiles

Fixing and grouting of wall tiles shall be executed in accordance with the manufacturer's recommendations.

Tiling in wet areas such as kitchens, pantries, toilets and the like shall be bedded on and infilled with approved proprietary waterproof epoxy tiling grout, incorporating an anti-fungicide additive.

Particular care shall be taken to keep all courses perfectly horizontal, all perpend truly vertical and joint widths consistent.

Where tiling abuts wood or metal frames, or other tiling at angles, and around pipes etc., it shall be carefully cut, ground smooth and fitted to form a close neat joint. Tiling shall be continuous behind sanitary fittings. Where pipes pass through walls, or sanitary fittings, cupboards, kitchen units and the like abut tiling, the joints shall be sealed with an approved silicone sealant.

9.4 Miscellaneous

9.4.1 Building Finishes

All building finishes shall be in accordance with specifications specified.

9.4.2 Computer Flooring

Modular Computer type flooring shall consist of easily removed flooring panels supported on galvanised mild steel pedestals and be capable supporting distributed load of 2500 kg/m² and a concentrated load of 400 kg. Flooring panels shall be easily cleaned with a non-slip, grey coloured, anti-static surface. Pedestals and stringers shall be galvanised as per standard. The flooring shall incorporate ventilation outlets to assist with heat dissipation from the underside of the floor and be fire retardant in accordance with class F30 of relevant standard. Spare tiles and any specialist tools required for access and maintenance shall be supplied to the Employer.

9.4.3 Roller Shutter Doors

Roller shutter access doors shall be face mounted, hand-chain operated units. Doors shall be lockable when in the closed position. The curtain shall consist of interlocking galvanised mild steel contour slats, primed and painted brown in accordance with relevant Indian standard. The curtain shall be fitted with a sprung counter balance to ease operation and prevent the door free-falling during closing. Door guides shall be galvanised mild steel. A hood shall be provided to cover the operating mechanism, this shall be galvanised mild steel, primed and painted to match the curtain.

10. ROOF COVERINGS

10.1 Guarantee

The Contractor still provide a ten year guarantee for the roof waterproofing, and shall effect any necessary remedial work within 30 days of formal notification.

10.2 Cement

Cement shall be Ordinary Portland Cement or as specified in tender document.

10.3 Sand

Sand shall be wadi sand and shall comply with relevant Indian standard.

10.4 Water

Water shall be as specified.

10.5 Roof Screed

Roof screed shall consist of a mix of four parts of sand to one part of cement mixed with the minimum practicable amount of screed water. The water/cement ratio shall not exceed 0.45.

10.6 Waterproofing Materials

Water-proofing materials shall be Bituthene Primer HC, Bituthene Mastic HC, Bituthene 1000 HC, Bitushield HC and ServiJoint HC as manufactured by Servicised Ltd. or equal and approved by Engineer-in charge.

10.7 Insulation

Roof insulation shall be 50mm thick extruded "Roofmate" or similar approved polystyrene foam board with rebated edges.

10.8 Solar Slabs

Roof solar slabs shall be 600 x 600 x 50mm natural coloured precast concrete complying generally with BS 368.

10.9 Solar Slabs Support Pads

Solar slab support and spacer pads shall be 5mm thick x 120mm diameter PVC pads.

10.10 Gravel Borders

Gravel borders shall be 20mm single size crushed limestone from an approved source.

10.11 Laying of Roof Screed

Screed shall be laid in bays of area not exceeding 16m² and length not exceeding 5m.

Concrete roof slabs shall be sweep-blasted to remove laitance, shall have all loose material removed by brushing and shall be soaked for 12 hours with fresh water. Standing water shall then be removed by brushing or compressed air, neat cement grout scrubbed into the damp concrete surface and screed material laid immediately. Screed material shall be compacted and finished by wooden floats to the required falls. The maximum permissible surface deviation shall be a 5mm gap under a 3m straight edge.

A minimum of 24 hours shall elapse between the placing of adjacent bays.

Finished bays shall be continuously wet cured for 7 days.

10.12 Laying of Waterproofing Materials

Waterproofing materials shall be laid or applied in accordance with manufacturer's instructions. The waterproofing membrane shall be debonded for 75mm each side of screed bay joints by a layer of Visqueen or equal and approved.

On completion of waterproofing operations and prior to the laying of roof insulation, roofs shall be tested for water-tightness by ponding with freshwater of minimum depth 25mm for a period of 24 hours. Any leaks shall be repaired and the roof re-tested for water-tightness before subsequent operations are commenced.

10.13 Fixing of Aluminium Flashings

Aluminium flashings and the like for insitu work shall be cut from coils and kept free from contact with lime and all other corrosive agents before fixing. Aluminium surfaces in contact with concrete or mortar shall be painted with two coats of bituminous paint, prior to installation. Fixing shall be round head aluminium alloy screws to Indian standard, into Rawplugs or equal and approved.

10.14 Laying of Roof Insulation

Insulation boards shall be laid loose with staggered joints and shall be cut as necessary to fit tightly around protruding elements and against parapets.

10.15 Laying of Roof Solar Slabs

Solar slabs shall be laid loose to a square pattern on 5mm PVC support and spacer pads and shall be cut as necessary to allow a 150mm wide gravel border around protruding elements and Slabs shall be laid so that cutting is kept to a minimum and cut tiles are next to parapets; cut edges shall be rubbed smooth.

10.16 Laying of Gravel Borders

Gravel borders shall be 50mm thick and 150mm wide, laid loose over roof insulation between the edge of precast concrete solar slabs and protruding elements and parapets. Gravel borders shall incorporate stainless steel mesh cages to prevent the gravel border from falling through gargoyles.

10.17 Joints in Roof Screed

Joints in the roof screed shall be provided to correspond with any joints in the structural concrete.

10.18 Joints Sealing

Joint sealing compounds shall be impermeable ductile material of a type suitable for the conditions of exposure in which they are to be placed, and capable of providing a durable, flexible and watertight seal by adhesion to the concrete throughout the range of joint movement.

11. CARPENTRY, JOINERY AND IRONMONGERY

11.1 Timber

The following timbers shall be used for carpentry and joinery work:

Timber for concealed work: Softwood used in the Works shall be approved European white wood and shall be treated before fixing with two coats of clear wood preservative.

Concealed surfaces of softwood joinery shall be primed.

Timber for exposed joinery: Timber for exposed joinery, and where referred to as hardwood, shall be approved selected Red Meranti or other approved species, unless specifically described otherwise, and shall conform to the relevant requirements of Indian standards.

11.2 Physical Condition of Timber

Timber shall be thoroughly seasoned and matured, sound, straight, free from warp, sapwood, signs of rot, shakes, large and loose knots, worm holes, wanes, cracks and other defects, and shall be sawn wrought die square and true on all four sides, or circular, to the scantlings and shapes on the Drawings.

Such timber may contain sound or tight knots on any surface provided that the mean diameter of any one knot does not exceed 20mm and the knot nowhere occupies more than one sixth of the width of the surface.

Samples of each of the approved hardwoods shall be kept on Site, stored in such a manner that the colour shall not be affected by sunlight. All hardwood subsequently used in the Works shall be of the same quality and colour as the approved samples.

Joinery shall be of sufficient size and strength for its specific function. All work whether hardwood or softwood shall comply with the requirements of relevant standard and no imperfection in the timber shall exceed that permitted of that standard for work to receive a clear finish and Class I for work to be painted with an opaque finish.

11.3 Moisture Content of Timber

Moisture content of timber shall comply with the requirements of relevant Indian standards

Softwood shall have a maximum moisture content of 15%.

Hardwood shall have a maximum moisture content of 12% and shall have been kiln dried or properly seasoned by other approved means.

The Contractor shall supply a copy of the timber supplier's certificate specifying the moisture content of the timber on delivery.

Timber for joinery work shall be properly stacked and protected from the weather and ground moisture and stored in such a way that the moisture content is not affected.

11.4 Plywood and Melamine

Plywood for external applications or in contact with external surfaces, shall comply with BS 1455, and be equal in quality to Grade 2, Type WRP.

Plywood for internal applications shall comply with relevant standards and be equal in quality to Grade 2, Type MR.

Face veneer shall be hard and durable and capable of being finished to smooth surface and be equal to an approved sample.

Melamine shall be not less than 1.5mm thick and shall comply with relevant standard, and of an approved colour and pattern.

Joinery finished with a decorative laminated sheet shall have a suitable balancing laminated sheet on the reverse side. The laminates shall be bevelled off with a plane along all arrises.

Where laminate is fixed to doors or shelves etc., without a laminate to the outer edge, a raised hardwood lipping shall be provided and the laminate finished flush against the lipping.

11.5 Blockboard

Blockboard shall comply with relevant standard.

11.6 Adhesives

Adhesives for woodwork shall have proportions at least equal to values as specified in relevant standard.

Adhesives for fixing laminated plastic sheets to wood surfaces shall be petroleum based contact adhesives of approved type.

PVA types of adhesives will not be accepted.

11.7 Flush Doors

Flush doors shall comply with the requirements of Indian standards.

The core of solid core flush doors shall be constructed of longitudinal laminations of precision planed timber, butt-jointed and glued with resin based adhesive under hydraulic pressure, the whole forming a rigid fire-resistant raft. Both sides shall be covered with an external grade plywood not less than 6mm thick and in accordance with the general requirements of Indian standards.

Flush doors shall have 10mm hardwood lipping tongues in to all edges. In the case of hardwood faced flush doors to receive a clear finish, the lipping shall match the facing veneer.

Hardwood face veneers shall be Group 1 Burma Teak, striped Sapele or other approved and shall be sliced out and matched as directed. For doors to receive a painted finish, rotary cut veneers may be used.

Metal air-transfer grilles shall be of approved aluminium design.

The Contractor shall store flush doors in a weatherproof shed and they shall be stacked in a flat position so that their true shape is preserved until required for use.

11.8 Framed, Ledged and Braced Board

Ends of matchboarding shall be tongues and grooved into rails and stiles except at the bottom rail where a bevelled rebate shall receive the ends of the boards on the outside. Stiles and rails shall be morticed and tenoned together. Construction shall comply with relevant standard.

11.9 Fire-check Doors

Fire-resisting flush doors shall be constructed in accordance with the requirements of relevant Indian standard and shall have a half-hour fire-check rating in accordance with standard. Frames to fire-resisting doors shall have a 25mm deep continuous rebate or applied stop, the latter fixed in accordance with the standard.

Where air-transfer grilles occur in half-hour fire doors, approved intumescent honeycomb fire dampers shall be fitted.

11.10 Workmanship

The Contractor shall provide temporary doors where necessary during the progress of the work. Structural timbers shall extend in one piece between their supports or fixings or be jointed in an approved manner.

Where structural timbers are notched over supports, the depth of the notch shall not be more than two-fifths of the depth of the timber.

Where structural timbers are to be cut for the passage of pipes and the like, cuts shall be made as near to the neutral axis as possible and shall not exceed one third of the depth of the timber. Alternatively, they shall be made in the top edge of the timber as far from the centre of the span as possible.

Carpentry work which does not form an essential part of the structural fabric shall not be executed nor brought onto site until required, unless the Contractor can show that such materials will be adequately stored and protected.

Timber for joinery work shall be cut to size and shape, properly jointed and put together, including framing, gluing, dowelling, screwing and mortising etc.

Joinery shall be prepared and framed up and put together at least four weeks before being installed, but shall not be glued or wedged up until immediately before installation. Should any shrinkage or other defects appear in the work, the defective parts or units shall be replaced.

Joints and quality of workmanship shall be in accordance with relevant standard.

Timber required to be wrought shall have the faces brought to a smooth finish (not machine planed only) with all arrises pencil-rounded.

Dimensions of joinery items to be fitted into structural openings shall be obtained in-situ and not from the Drawings.

Faces of timber in contact with the structure or other non-wood surfaces shall be treated with preservative and primed before fixing.

Cover beads, architraves etc. abutting any irregular surface shall be accurately scribed to fit.

11.11 Built-in Joinery

Where joinery works are to be built-in before the surrounding building carcass is completed, the Contractor shall ensure that the joinery works are set plumb and true and shall not be damaged or displaced by subsequent building operations.

11.12 Fixed-in Joinery

Where joinery works are to be fixed-in after the surrounding building carcass is completed, the Contractor shall ensure that the necessary fixings are incorporated in the carcass. The work shall be fixed in plumb and true and in accordance with the Drawings with all necessary wedges and shims as detailed or as may be directed. Overhead clearances and levels shall be maintained where applicable.

11.13 Frames and Linings

Frame and linings shall be secured at jambs by screwing to sawn softwood grounds, blockings or packing pieces. The latter shall be secured to the structure at jambs by screws and plugs at maximum 600mm centres.

11.14 Architraves, Door Stops, Skirtings etc.

Architraves, door stops, cover beads etc. shall be mitred at external angles and scribed at internal angles.

11.15 Access Panels

Access panels shall be easily removable, held in position with domed cups and screws, and be formed with 25mm block board, painted and with edges lipped with 15mm hard wood.

11.16 Fixings and Jointing

Softwood in carpentry work shall be put together with steel nails except where described as framed when it shall be properly jointed and held together with glue and steel screws. Fixings shall be steel screws.

Fixing of hardwood joinery shall be by means of brass wood screws to relevant standard.

Screws heads in work to be painted shall be properly countersunk and stopped. Screw heads in polished work shall be counter-bored and fitted with glued pellets (grain pins) produced with an appropriate tool and matching drill bit. The grain of the pellet shall be in the same direction as the grain of the member.

11.17 Screw Fixing of Aluminium

Where aluminium components are fixed to joinery work, aluminium or cadmium plated screws and washers shall be used.

Brass screws shall not be used in conjunction with aluminium.

11.18 Protection of Joinery from Damage

Joinery shall be protected from damage during the course of the Works. The Contractor shall ensure that doors, drawers etc., work easily and shall make all necessary adjustments before from damage handing over and during the maintenance period.

11.19 Ironmongery

Ironmongery, including latches, knobs, handles, closures, kick plates, indicator bolts, barrel bolts and cupboard door pulls and latches etc. shall be supplied by approved supplier. Names and reference numbers in the schedule shall be taken from the manufacturer's catalogue. The door locks should match the existing locks at the Sewage Treatment Works in order that the existing master key system can be retained. The locks are 'Union' Locks and the master key is ref. CHYC.

The fitting and fixing of ironmongery shall be in accordance with the manufacturer's instructions. Ironmongery shall be fitted prior to any finishing, removed for finishing and fixed on completion of all applied surfacings. Hinges shall be stainless steel or brass butt hinges countersunk-screwed to door and frame; generally three 150mm hinges for framed doors (including panelled units of this type) and solid core doors and two 150mm hinges for flush plywood hollow core doors. Cupboards shall have 25mm wide brass continuous strip hinges for the full length of doors. Doors shall be properly and accurately hung to fit neatly into mortices in frames.

Locks shall be provided with two sets of keys and door closures shall be provided with adjusters.

All ironmongery shall be fixed with matching screws.

Ironmongery shall be kept carefully wrapped and protected until required and when fixed shall be carefully protected against defacement by mortar and plaster droppings, paint splashes, smudges etc.

12. GLAZING

12.1 Glazing Materials

Clear glass for internal partitions shall be float plate glass complying with Indian standard.

Solar glass for external windows shall comply with Indian standards.

Non-reflective, toughened glass shall be at least 5mm thick complying with Indian Standards. The Contractor shall be required to obtain samples for the Engineer-in-charge's approval.

12.2 Glazing – General

Glass shall be to the thicknesses recommended by the manufacturer calculated according to wind loading, pane size, etc. and as per relevant Indian standard.

Types of glazing (single or double, etc.) shall be as indicated on the Drawings.

Glass shall be cut to allow a minimum gap of 2mm all around. Glass in aluminium windows shall be set in neoprene or PVC gaskets and shall be secured with aluminium beads, all as appropriate to the aluminium profiles employed.

Glass in timber doors, partitions etc. shall rest on glazing blocks supporting the bottom edge and shall be completely bedded on front, back and edges with approved glazing compound. Surplus compound shall be neatly trimmed off.

12.3 Workmanship

Glazing shall generally comply with relevant standard. Glass shall be inserted into window frames by competent and experienced tradesmen. Neoprene or PVC insert glazing beads, where used, shall be accurately cut to length and matted at corners. Setting blocks shall be used to locate glass in the correct position. Tolerances required by the manufacturer of the windows shall be maintained.

Rebates to receive glass shall be cleaned and primed before glazing.

Surface preparation and painting adjacent to window frames shall be completed before window frame installation.

12.4 Cleaning

On completion, glass shall be cleaned and polished on both sides before handing over of the works.

13. PLUMBING AND SANITATION

13.1 General

13.1.1 Regulations

The water services and sanitation services installations shall be carried out in accordance with the regulations of the local water and health authorities and to their complete satisfaction.

13.1.2 Basis of Design

The Contractor shall design and execute the Works for the plumbing and sanitation system. The works shall comply with the requirements of all competent bodies including the following or local equivalents:

1. Local water and health authorities;
2. Insurance companies;
3. British Standards;
4. IHVE/CIBS Guide Books;
5. Fire Regulations;
6. Institute of Plumbing Data Book.

13.1.3 Working drawings

Large scale detailed isometric layout drawings shall be prepared by the Contractor and submitted for approval. The drawings shall show the size, positions, levels and falls of all pipes and ducts and the type and position of all fittings. In addition, the details of any builder's work required shall be shown together with pipe fixing positions and details of fixings. No materials shall be ordered until working drawings are approved in writing.

13.2 Buildings Drainage

13.2.1 General

Building's drainage shall comply with relevant standards.

13.2.2 Materials

Soil and ventilation pipes shall be of the captive ring seal type to relevant standard manufactured in uPVC by Bartol Plastics Ltd., or equal and approved.

Underground drainage pipes of 110mm size and above shall be uPVC to BS 3505 as water main manufactured by Hepworths Plastics or equal and approved with rubber ring seal joints. Underground drainage pipes below 110mm size shall be as specified for soil and ventilation pipes, unless detailed otherwise on the Drawings.

Trapped floor gullies shall be uPVC as manufactured by Hepworth Plastics, or equal and approved complying with relevant standard. Gully tiles and grids shall be stainless steel. uPVC extension pieces shall be fitted to suit the levels detailed on the Drawings.

13.2.3 Roof terminals to vent pipes

Ventilation pipes shall be provided with a uPVC balloon grating at the roof termination. Gratings shall be fixed 600mm above roof solar slab level.

13.2.4 Access pipes

Access pipes shall be provided at the foot of soil vent stacks 300mm above floor level, and at bends above this level.

13.2.5 Long radius bends

A long radius bend shall be fitted at the base of all soil, waste and rainwater stacks. Horizontal bends in pipes below floor slabs shall have a 1000mm radius.

13.2.6 Rainwater Stacks

Rainwater stacks shall terminate at roof level with Rainwater purpose made inlets to allow an efficient water entry but with inlets some provision to discourage the ingress of sand. Proprietary ferrous inlets shall be plastic powder coated and fitted with appropriate adaptors to uPVC rainwater stacks.

13.2.7 Fixing of above-slab pipework

Pipes shall be fixed to the structure at 2m centres for vertical runs and 1m centers for horizontal runs. Brackets shall be painted galvanized mild steel and fixings shall be stainless steel screws into raw plugs.

13.2.8 Expansion

Provision shall be made for expansion by ensuring that spigot and socket joints are put together with the recommended 10mm gaps.

13.2.9 Testing of drains

Drains shall be tested in accordance with the IS codes.

13.2.10 Cleaning drains on completion

The Contractor shall, on completion of the work and immediately before handover, cleanse the whole of the drains with rods and accessories, cleanse all traps and gullies, bolt down all access covers etc., and shall leave the whole of the drainage system complete, in sound condition and efficient working order.

13.3 Sanitary Plumbing

13.3.1 Materials

Waste and overflow pipework shall be of the push-fit ring seal type to IS code manufactured in polypropylene. Connections of overflow pipework to tanks and cisterns shall be by compression nut joints.

13.3.2 Waste traps

Sanitary fittings shall be fitted with white polypropylene traps on waste outlets in accordance with the following:

Washbasins : 32mm anti-syphon traps with 76mm seal

Sinks : 38mm anti-syphon traps with 76mm seal

Showers : 38mm tubular 'S' traps with 76mm seal

Traps shall comply with BS 3943.

13.3.3 Waste pipe gradients

Horizontal waste pipes below basins, sinks, urinals and the like shall fall at a uniform gradient of 1 in 45.

13.3.4 Access to waste pipes

Ends of horizontal runs of waste pipes shall be provided with access plugs. Blank ends shall have plugs to allow horizontal rodding; 40° bends, where wastes drop vertically, shall have swept tees or crosses with plugs on the top leg to allow vertical rodding.

13.3.5 Fixing of waste pipes

Waste pipes shall be fixed to the structure at 1m centres with polypropylene pipe clips, stainless steel screws and raw plugs.

13.3.6 Testing of waste and vent pipes

An air test shall be applied to all waste and vent pipes as follows:

A gauge in the form of a glass U tube shall be connected to the drain plug in the section of pipe under test. Air shall be blown into the section of the pipe until a pressure equivalent to 100mm of water is indicated on the gauge. Without further blowing or pumping, the pressure shall not have fallen below 75mm after a period 5 minutes.

The Contractor shall locate and remedy any defects found whilst carrying out the test, and the test repeated until found to be satisfactory.

13.3.7 Cleaning of sanitary Plumbing installation on completion

The Contractor shall, on completion of the installation and immediately prior to handover, thoroughly cleanse and leave the system in sound condition and efficient working order.

13.4 Sanitary Fittings

13.4.1 General

Sanitary fittings shall be obtained from approved vendor or shall be of a quality equal to that provided by the following manufacturers:

1. Armitage Shanks Ltd.
2. Ideal Standard Ltd.
3. Royal Doulton.

All fittings shall be obtained from one manufacturer, and shall be complete with all necessary plugs, chains, screws, washers, grommets etc.

13.4.2 Installation of fittings

The Contractor shall fix all sanitary fittings, including connections to waste pipes and water services, strictly in accordance with the manufacturer's recommendations. Concealed fixing screws shall be stainless steel and exposed screws chrome plated steel.

14. METALWORK

14.1 Minor Steelwork

- 14.1.1 Minor steelwork items shall comply with the section of the Specification covering Structural Steelwork.

14.2 Bolts

Expanding steel fixing bolts shall be stainless steel. When expanding bolts are used externally, fixing holes shall be sealed with approved resin grout.

14.3 Aluminium

Extruded aluminium shall be of BS alloy 6082 or equivalent; sheet aluminium shall be BS alloy 3103 or 5251 or equivalent, and all other of aluminium shall be of alloys which possess such properties that they will be durable in the climate that exists on Site.

Where practicable, all screws and bolt heads shall be concealed. Where this is impracticable on exterior faces, they shall be countersunk. Jointed work shall be closely fitted and finished smoothly and evenly.

Aluminium for angles and channels shall be BS alloy 6082 or equivalent together with bolts, screws etc, shall comply with the relevant requirements of BS 1161, BS 1473, and BS 1494, Part 1 and/or Code of practice for use of Aluminum alloys in Structures IS 8147-1976(R2005) Materials for windows, screens and doors, form of construction, finishes and performance shall generally be in accordance with the relevant Indian standard.

Where aluminium is in contact with any dissimilar metal or galvanised metal, the Contractor shall preclude the possibility of electrolytic action by applying a petroleum impregnated tape or similar protection, or by painting the contracting aluminium with bitumen, or by use of nylon washers and grommets to ensure a minimum separation of 2mm.

Fixings to timber shall be made with aluminium alloy screws.

The Contractor shall ensure that no aluminium is allowed to have contact with unset cement.

14.4 Aluminium Flashings and Trims

Aluminium sheet or strip shall not be less than 0.9mm in thickness with a degree of hardness corresponding to the recommendations in relevant Indian standard, appropriate to its thickness and composition. Fixing shall be with aluminium clips secured with aluminium alloy screws.

Aluminium sheet turned up against walls and upstands shall be welted to an aluminium flashing or apron strip. Flashings and apron strips shall be folded and tucked into blockwork joints to a minimum depth of 25mm, secured by folded aluminium sheet wedges, and pointed with sealant. Vertical joints in aprons and flashings shall be welted.

Care shall be taken to avoid contact of aluminium with dissimilar metals, and materials containing alkalis, etc.

14.5 Expanded Metal Mesh

For general purposes, expanded metal mesh shall comply with BS 405 and shall be galvanised and of approved shape and size.

14.6 Aluminium Louvres and Flyscreens

All aluminium parts shall be finished in stoved polyester powder paint or as recommended in Indian standards.

Louvres shall be continuous horizontal static single banks comprising cold roll formed louvres mounted at 50mm or 100mm pitch on concealed mullions and incorporating head, jamb and Sill sections with mullion shoes. Fixing shall be by means of stainless steel bolts through mullion shoes with isolating grommets and washers. Gaps between louver frames and structural openings shall be sealed both sides with the manufacturer's recommended mastic sealant.

The Contractor shall store, assemble and fix aluminium louvres and flyscreens in accordance with the manufacturer's instructions and shall leave them clean and in perfect working order on completion.

Sand trap louvers shall be installed whenever shown on the drawings as per the following specifications:

- The frame and blades are of high quality extruded aluminium profiled construction with the advantages of corrosion resistance and rigidity.
- Composed two sets of inverted U - channels mounted vertically on two opposite rows.
- Drain holes of diameter 20 mm are provided in two rows at the bottom of the louver for emptying filtered sand and dust.

Designed to separate and dust from the air stream.

14.7 Aluminium Doors and Windows

The Contractor shall arrange for the manufacture of bronze anodised aluminium windows and doors by an approved manufacturer. The manufacturer shall be required to submit for approval, prior to the commencement of fabrication, detailed drawings of windows and doors. The Contractor shall be responsible for the co-ordination of dimensions and details, in accordance with the door schedule.

The Contractor shall describe and indicate on the detailed drawings the relation and method of fixing to, and sealing between, adjacent parts of the structure. Fixings of doors and windows to sub-frames shall be of non-ferrous metal. Sealants shall be approved silicone sealants complying with relevant Indian standards.

There shall be no variation in shape, texture, colour, hue or chroma of the aluminium sections or components. The manufacturer shall submit for approval a range of anodised finishes which shall be in accordance with relevant Indian standards.

When closed, windows and doors shall be sealed so that no air movement in excess of 0.25 m/s shall be perceived at 1 metre from inner faces. The weather performance of windows and doors shall be in accordance with relevant standards.

The Contractor shall demonstrate that the prevailing climatic conditions will not adversely affect the expected or implied performance of windows and doors and that they will, when closed, exclude rain.

Aluminium windows shall be complete with glazing gaskets, gear for operation of moving parts, cylinder locks, catches and fly screens. Locking devices shall be provided to all opening parts, details of which shall be submitted for approval.

Fixed glazing units shall be fabricated from extruded section, and glazing shall be set in neoprene gaskets and secured with aluminium beads.

The Contractor shall store and fix, including assembling component parts, aluminium doors and windows in accordance with the manufacturer's printed instructions.

The backs of all aluminium frames shall be painted with two coats of bituminous paint or protected by other approved means before fixing. Aluminium framings shall be protected against damage from rendering, plaster etc. during building works, by covering with masking tape or by other approved means.

Exposed frames shall be protected against alkali or acid washes, abrasion or impact damage which may be caused by negligence or following trades.

The Contractor shall ease and adjust all aluminium doors and windows and leave in perfect working condition on completion.

14.8 Window Frame Tolerances

Window frame tolerances shall be as required by the window manufacturer and as set out in IS 4021,

14.9 Roller Shutter Doors

Roller shutter access doors shall be face mounted, handed-chain operated units. Doors shall be lockable when in the closed position. The curtain shall consist of interlocking galvanised mild steel contour slats, primed and painted brown in accordance with relevant standard and colour 06 C 39. The curtain shall be fitted with a sprung counter balance to ease operation and prevent the door free-falling during closing. Door guides shall be galvanised mild steel. A hood shall be provided to cover the operating mechanism, this shall be galvanised mild steel, primed and painted to match the curtain.

14.10 Bird Screens

Bird screens to be installed on the outside of the claustra blocks. The bird screens shall comprise 2.5mm electro galvanized welded wire mesh and frame (25mm x 2.5mm), all coated with primer and polyurethane topcoat, fixings shall be stainless steel. All to the satisfaction of the Engineer-in-charge.