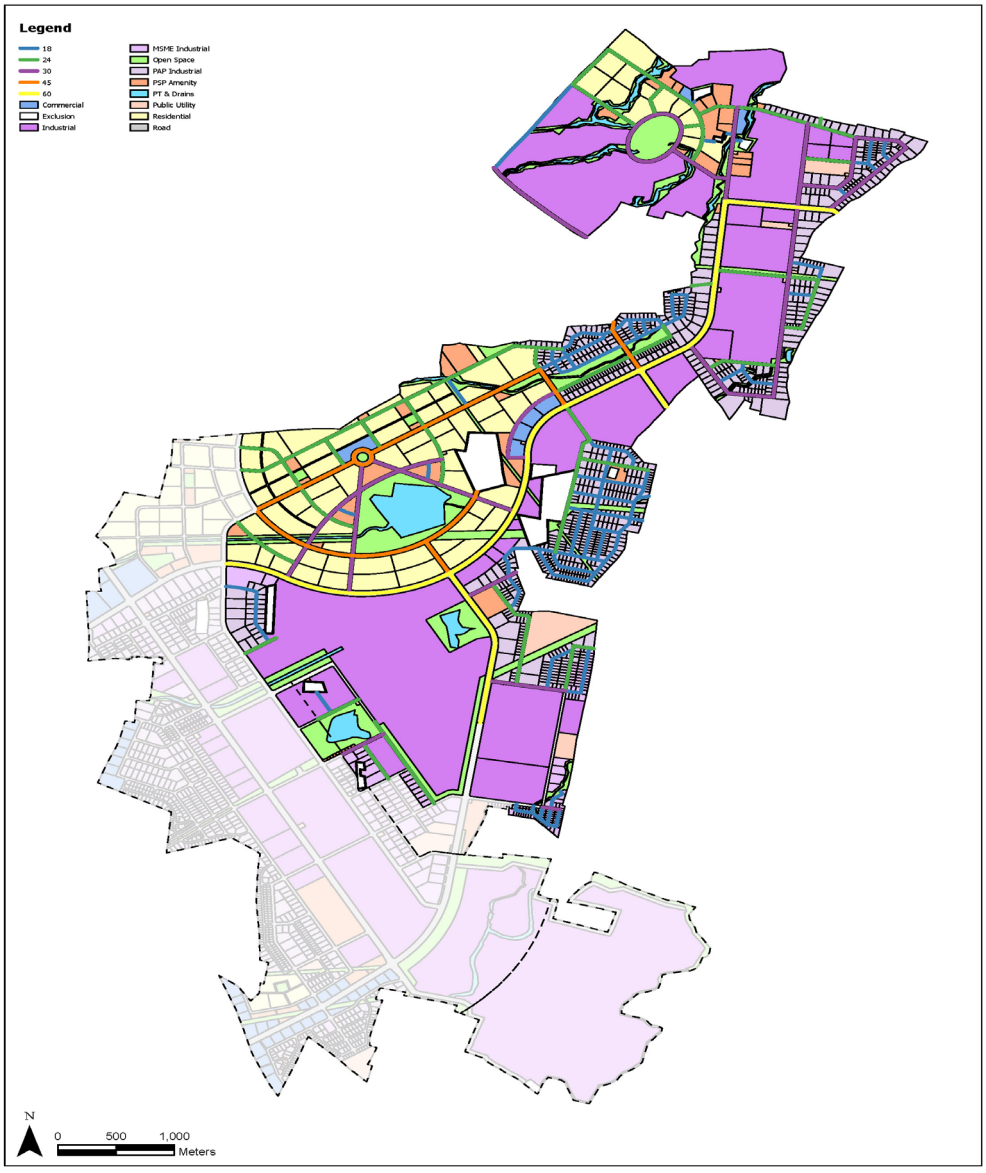
Maharashtra Industrial Township Limited (MITL)

Design, Construction, Testing, Commissioning, Operation and Maintenance of Infrastructure Works at AURIC - Bidkin Industrial Area (BIA), Sector B & C on EPC Basis

Request for Proposal cum Request for Qualification

Volume II: Technical Specifications
Part E - Civil and Structural Specifications

November 2026



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Disclaimer

This Tender is not an Agreement and is neither an offer nor an invitation by the Employer to the prospective Bidders or any other person. The information contained in this tender document or subsequently provided to Bidder(s), whether verbally or in documentary or any other form by or on behalf of the Employer or any of its employees or advisors, is provided to Bidder(s) on the terms and conditions set out in this tender and such other terms and conditions subject to which such information is provided.

The purpose of this tender is to provide interested parties with information that may be useful to them in making their financial offers (BIDs) pursuant to this tender. This tender includes statements, which reflect various assumptions and assessments arrived at by The Employer in relation to the Project. Such assumptions, assessments and statements do not purport to contain all the information that each Bidder may require. This tender may not be appropriate for all persons, and the Employer, its employees or advisors can't consider the objectives, financial situation and particular needs of each party who reads or uses this tender. The assumptions, assessments, statements, and information contained in the Bidding Documents, especially the Preliminary Design details/ information, may not be complete, accurate, adequate, or correct. Therefore, each Bidder should conduct its investigations and analysis and check the accuracy, adequacy, correctness, reliability and completeness of the assumptions, assessments, statements, and information contained in this tender and obtain independent advice from appropriate sources.

Information provided in this tender to the Bidder(s) is on a wide range of matters, some of which may depend upon interpretation of law. The information given is not intended to be an exhaustive account of statutory requirements and should not be regarded as a complete or authoritative statement of law. The Employer accepts no responsibility for the accuracy or otherwise of any interpretation or opinion on law expressed herein.

The Employer, its employees and advisors make no representation or warranty and shall have no liability to any person, including any Applicant or Bidder under any law, statute, rules or regulations or tort, principles of restitution or unjust enrichment or otherwise for any loss, damages, cost or expense which may arise from or be incurred or suffered on account of anything contained in this tender or otherwise, including the accuracy, adequacy, correctness, completeness or reliability of the tender and any assessment, assumption, statement or information contained therein or deemed to form part of this tender or arising in any way for participation in this Bidding Process.

The Employer also accepts no liability of any nature whether resulting from negligence or otherwise howsoever caused arising from reliance of any Bidder upon the statements contained in this tender.

The Employer may in its absolute discretion, but without being under any obligation to do so, update, amend or supplement the information, assessment or assumptions contained in this tender. The issue of this tender does not imply that the Employer is bound to select a Bidder or Contractor, as the case may be, for the Project and The Employer reserves the right to reject all or any of the Bidders or Bids without assigning any reason whatsoever.

The Bidder shall bear all its costs associated with or relating to the preparation and submission of its BID including but not limited to preparation, copying, postage, delivery fees, expenses associated with any demonstrations or presentations which may be required by The Employer, or any other costs incurred in connection with or relating to its BID. All such costs and expenses shall remain with the Bidder and The Employer shall not be liable in any manner whatsoever for

the same or for any other costs or other expenses incurred by a Bidder in preparation or submission of the BID, regardless of the conduct or outcome of the Bidding Process.

Nothing in this tender shall constitute the basis of a contract which may be concluded in relation to the Project, nor shall such documentation/information be used in construing any such contract. Each Bidder must rely on the terms and conditions contained in any contract, when, and if, finally executed, subject to such limitations and restrictions which may be specified in such contract.

The Bidders are prohibited from any form of collusion or arrangement in an attempt to influence the selection and award process of the Bid. Giving or offering of any gift, bribe or inducement or any attempt to any such act on behalf of the Bidder towards any officer/employee of Employer or to any other person in apposition to influence the decision of the Employer for showing any favour in relation to this tender or any other contract, shall render the Bidder to such liability/penalty as the Employer may deem proper, including but not limited to rejection of the Bid of the Bidder and forfeiture of its Bid Security.

Laws of the Republic of India are applicable to this tender.

Each Bidder’s procurement of this tender constitutes its agreement to, and acceptance of, the terms set forth in this Disclaimer. By acceptance of this tender, the recipient agrees that this tender and any information herewith supersedes documents(s) or earlier information, if any, in relation to the subject matter hereto.

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Part E- General Design Specifications

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1 General Civil and Structural Specifications

1.1 Design

a) The following design requirements shall be as per the provisions of IS: 456-2000 and IS: 3370 (Part 1 &2) – 2021 for all reinforced or plain concrete structures:

b) The design of all reinforced concrete structures shall be as per IS:456, and the design of pre-stressed concrete structures as per IS:1343. In general, the structural safety of all foundations on soil shall be based on IS:1904.

c) For calculation purposes "Limit State Design" methods according to IS:456-2000 shall generally be adopted, except for water retaining structures where IS:3370 (Part I-IV) shall be referred.

d) The structures not in contact with liquid or soil shall be designed using Limit State Method provisions of IS 456: 2000 i.e. limit states of strength and serviceability. A deflection check shall be performed for serviceability conditions as per provisions of IS 456:2000.

e) Structures directly in contact with wastewater shall have an allowable crack width of 0.1 mm. Structures which are in direct contact with non-hazardous/ potable water and/or soil shall have an allowable crack width of 0.2 mm.

f) The walls and base slabs of liquid retaining structures shall be designed as per Limit State Method provisions of IS 3370 (Part 2): 2021.

g) Crack Width in liquid retaining structures due to thermal and shrinkage stresses shall be estimated using IS 3370 (Part 2): 2021, whichever is approved by the Employer's Engineer.

h) Minimum reinforcement for liquid retaining structures 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 (x) above. For all liquid retaining structures, a minimum of 10 mm diameter bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.

i) The minimum design life of all Structures and Buildings shall be 50 years.

j) All foundations and concrete structures shall be designed to resist full operating dead and live loads, with an appropriate combination of wind and seismic forces and with due allowance for impact, inertia loading, vibration, unbalanced dynamic loads, etc. as secondary effects of live loads, erection loads, temperature variation etc. While designing structures and foundations either the effect of seismic forces or wind loads, whichever produces the worst effect, shall be considered along with usual load conditions. Apart from the installation and operating loads indicated by the equipment manufacturers, the design of buildings and structures shall be based on dead and imposed loads calculated according to IS:875. All structures shall be designed for seismic load as per IS1893 latest in category one above the stated in the specified code.

k) Concentrated and uniformly distributed live load on floors and platforms shall be considered depending upon the usage and in accordance with the maximum expected process requirements, to be indicated by the equipment manufacturers. When the loads are movable, they shall be so placed as to get the worst effect in moment & shear, axial load etc. for which the elements shall be designed. The effect of concentrated load shall not be reduced. Due allowance shall be made, wherever necessary, for the installation and operation of any equipment as per the equipment manufacturer's data and recommendations. The design shall be based on the maximum loading due to uniform live

load and/or equipment loading including impact, vibration, unbalanced operating forces, etc.

l) Foundations for structures and equipment shall be proportioned to resist the worst combination of loading and shall generally be designed as per the provision of IS:1904 for open foundations on soil and IS:2911 for foundations on piles.

m) All grouting below machine/equipment bases, and pockets shall be non-shrinking grout of adequate thickness and a minimum grade of M35 with 6mm and down aggregates. Grouting below structural column bases shall be a minimum grade of M30 with 6mm and down aggregates.

n) PCC shall be of minimum M15 grade for Plinth protection, screed concrete, foundation below masonry walls, encasing of underground pipes & conduits, ground floor at plinth level, toilet, rest room, etc. The thickness shall not be less than 100 mm.

o) All structural reinforced concrete for non-water retaining structures shall be a minimum M25.

p) The minimum Cement Content in Concrete shall be as per Section 10.5.2.5 / relevant IS code (whichever higher) for all concrete work as per the specified concrete grade.

q) Foundations Conditions:

i) The footing/foundations/piling arrangements shall rest on firm strata and shall be used for designing purposes. The foundation shall be so engineered that short-term and long-term settlement (including differential settlement between adjoining columns/walls) is within permissible limits as per stipulations of IS: 1904-1986 and IS: 456-2000 (Latest Revision).

ii) Soil below the foundation and plinth filling or filling shall be compacted/consolidated or given any suitable treatment so as not to undergo volume changes due to consolidation or proximity of groundwater or surface water.

r) Stability analysis shall be performed on all structures. All water retaining structures shall be watertight and shall be protected from flooding. The total structure shall be designed for uplift and shall have a factor of safety of at least 1.25. The uplift may be resisted by the dead weight of concrete. Alternatively, it can be resisted using 50% dead weight and 50% rock anchor as per design requirements. The factor of safety for sliding and overturning shall be 1.5.

s) Base pressure of the structures shall be within permissible limits for normal conditions. No tension shall be allowed in the base slab/footing under normal conditions.

t) All blinding and levelling concrete shall be a minimum 100 mm thick in concrete M20 grade. The excavation in the hard strata / hard rock is to be done by controlled blasting or mechanical means.

u) The minimum cover to all reinforcement including stirrups and links shall be as specified in Standard Specifications and IS: 456-2000 for respective exposure conditions of structures.

v) All buildings/treatment units shall have a minimum 1.0 m wide, 100 mm thick plinth protection paving in M15 grade concrete. All plinth protection shall be supported on a well-compacted stratum and hand-packed rubble soling 230 mm thick minimum.

l. Any structure or pipeline crossing below roads shall be designed for Class A of IRC loading.

II. 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.

III. All pipes and conduits laid below the structural plinth and road works shall be embedded in the concrete of grade M-20 having a minimum 150 mm thick concrete cover all around.

IV. Approved quality waterproofing compound (chloride-free) shall be added during concreting of liquid retaining structures, in the proportion specified by the Manufacturer or 2% by weight of cement as approved by the Employer's Engineer.

V. All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions which include but are not limited to dead load, live load, wind load, and seismic load. Any other loads deemed relevant by the Design Engineer and Employer's Engineer shall also be considered.

VI. The combination of loads to be considered are as follows:

Preliminary load combinations

i. Normal conditions

ii. Construction condition- all construction complete

iii. Operation condition- Plant running

Emergency conditions

i. Construction conditions + other loads + Earthquake

ii. Construction conditions + other loads + wind load

iii. Operation conditions + other loads + Earthquake

iv. Operation conditions + other loads + wind load

In buildings housing mechanical equipment, pumps and motors the foundation should be designed as a machine foundation. The consideration of machine loads in foundation design shall be limited to the equipment footing or be extended to all foundations, depending on the load transfer mechanism adopted by the Design consultant. A vibration analysis shall be carried out to check the effect of machine vibration on the building.

Detailing of reinforcement for all structures shall be as per IS 13920 (latest revision) considering Zone-III.

A sliding layer or slip layer (1000-micron thickness) shall be provided between the subbase and structural slab (Raft) as per IS 3370: part 1 2021 or the latest.

The maximum length of the 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.

The thickness of various structural members/elements shall be as per relevant IS Codes/contractor's design

Walls for liquid retaining structure	250 mm
Roof Slabs for liquid-retaining structures	200 mm
Bottom slab for liquid retaining	250 mm
Floor slab including roof slab, walkways, canopy slabs	150 mm
Walls of cable/Pipe Trenches, underground pits	150 mm
Column Footing	300 mm
Precast trench cover	100 mm
Launder Wall/Slab	200 mm
Dome	200 mm
Grade Slab	200 mm
Retaining Wall (RCC)	300 mm

1.2 Standards of Construction Safety

a) IS: 3696 - Safety code for scaffolds and ladder (Part 1 & 2)

b) IS: 3764 - Safety code for Excavation Work

c) IS: 7205 - Safety code for erection of structural steel Work

d) IS -7293 - Safety code for working with construction machinery

1.3 Standards' Documents

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

b) The Contractor shall make available to the Employer's Engineer as required copies of each and any Codes of Practice, International Standards, test methods etc. relevant to the Works.

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

1.4 NOCs

The Contractor shall be responsible for obtaining all necessary permits, licenses, and NOCs from the relevant authorities required for the proper execution of the Works. The permits, licenses 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 related. All costs and fees associated with the necessary permits, licenses 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.

1.5 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 Employer's Engineer shall be always provided 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.

2 Plant and Methods

2.1 Contractor Design

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

2.2 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.

2.3 Contractor's Responsibility

The Contractor shall take upon himself the full and entire responsibility for the sufficiency of plant, centering, 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 Employer's Engineer.

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.

2.4 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 an 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.

2.5 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 Employer's Engineer any problems or difficulties faced.

Blasting

The Contractor shall obtain the prior written approval of the Employer's Engineer, 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.

2.6 Temporary Works

The Contractor shall submit to the Employer's Engineer 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.

2.7 Geotechnical Investigation

The contractor shall carry out necessary soil surveys, and field and laboratory investigations for selecting appropriate borrow pits and finalizing structural features and design of the embankments and cut sections. Soil investigations and tests shall be in accordance with the requirements specified in IRC: SP:19-2001.

These tests are required to be conducted by the contractor at the utility building, major roads and bridges site before commencement of any construction work. This information shall be provided to the Employer's Engineer for his information with the design calculations. A report on the soil investigation shall be furnished along with the design.

These works shall be deemed to be included in the Contract Price.

2.7.1 Soil & Rock Investigation

I. Borehole Tests

a) Boreholes shall be sunk at specified locations (duly approved by the Employer's Engineer) 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. Boreholes 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 the completion of the boring. The 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 be extended up to depths of 30 m in soil (up to N>=100) or 10 m in weathered rock (RQD <=50%) or 5 m in hard rock (RQD>50%) unless otherwise directed by the Employer's Engineer. However, the maximum depth of the borehole does not exceed 30m. If strata having a standard Penetration Test value greater than 100 with characteristics of rock are met earlier, the borehole shall be advanced further by boring with the approval of the Employer's Engineer. 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 its 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 the case of cohesionless 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. The casing can be withdrawn after inspection of the borehole by the Employer's Engineer 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.

II. 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.

III. In-situ Tests

a) Standard Penetration Tests: SPT tests shall be conducted in all types of deposits at 1.5m intervals or as per the direction of the Employer's Engineer 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 cm (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 to avoid any contamination with surface water at any time. Water samples shall be collected in a 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 overburdened 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 Annexure – A, IS: 4464 shall be prepared and submitted to the Employer's Engineer.

f) 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 Employer's Engineer 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 Employer's Engineer. The Contractor must seek the approval of the Employer's Engineer for the bore log format.

IV. Drilling

a) 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.

b) 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 always be taken to maintain contact between the bit and the bottom of the borehole. Use of percussion tools shall be permitted in hard clays and dense sandy deposits.

a) The drilling equipment used shall have an adequate capacity to ensure that required depths are reached and good quality rock core is recovered. The drilling equipment shall be hydraulically operated. The equipment, method and 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. The core of 1.5m in length shall be aimed at. If the Employer's Engineer 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.

b) No drilling run shall exceed 1.5 m in length. If the core recovery is less than 80 % in any run, the Employer's Engineer shall be informed, and the length of the subsequent run shall be reduced to 0.75 m.

c) 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.

d) Full observations with respect to the colours 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.

e) The colour of return water at regular intervals, the depth at which any change of colour of return water is observed, the depth of occurrence and the amount of flow of hot water, if encountered, shall be recorded.

f) The depth through which a uniform rate of penetration was maintained, the depth at which marked change in the rate of penetration of sudden fall of drill rod occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.

g) Any heavy vibration or torque noticed during drilling should be recorded together with the depth of occurrence.

h) 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.

V. Extraction and Storing of Core Samples

a) Core samples shall be extracted by the application of 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 suitably sized half-round plastic channel section. Core shall be taken to maintain the direction of extrusion of the sample same as while coring.

b) 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 the core is recovered, it shall be recorded as specified in the standard and the Employer's Engineer 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 Employer's Engineer 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 the 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)

c) 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 Employer's Engineer. In no case sample be destroyed without written permission of the Employer's Engineer.

VI. Laboratory Testing

a) At the completion of the borehole the field log should be transmitted to the Employer's Engineer within 24 hours. The Employer's Engineer will assign a laboratory test programme for the samples of that borehole within 3 working days after receipt of the field log.

b) These boreholes are to be conducted for confirmation of data available and for finding out the depth of rock profile at certain locations. As such the testing of samples must be carried out meticulously. 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.

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

d) All tests shall be performed as per IS: 2720 (relevant parts) and as per the directions of the Employer's Engineer as directed.

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

f) 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 their 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.

g) Laboratory Tests: Tests as indicated in the specification and as called for by the Employer's Engineer, 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 the test i.e., unconsolidated undrained, consolidated drained etc. shall be as per specific instructions from the Employer's Engineer. The type and location of other tests shall be decided by the Employer's Engineer. It shall be the duty of the contractor to obtain details of locations and types of tests from the Employer's Engineer before starting boring for a particular borehole. The Employer's Engineer 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, and de-watering requirements including the capacity of pumps and a number of pumps and shall be included in the report in detail. All soil testing as directed by the Employer's Engineer shall be conducted by a Laboratory holding current accreditation under the Inter-National Standard Organisation / Bureau of Indian Standards.

2.7.2 Sampling for laboratory tests

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, 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.

i. **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.

ii. **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 diameter 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 an SPT test after the borehole has been cleaned.

iii. Undisturbed sampling in cohesive soil

f) 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.

g) 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 the casing pipe, a 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 the sample.

2.7.3 Report

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 boreholes 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 Auto Cad 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 boreholes shall be tabulated. The depth of the water table with respect to the ground shall also be given.

i) Detailed report giving recommendations for type of foundation, analysis of bore logs and test results along with SBC values.

j) Final report shall be submitted only after incorporation of comments by the Employer's Engineer.

k) 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.

l) 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 Boreholes shall be interlinked with the GTS Benchmarks in Co-ordination with the Agency doing the detailed topographical Survey.

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

2.8 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 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 Employer's Engineer 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 Employer's Engineer shall have the right to suspend the Works at no cost to the Employer if in the opinion of the Employer's Engineer 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.

2.9 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.

2.10 High-Intensity Rainfall

The Contractor shall keep the Works safe during high-intensity rainfall 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.

2.11 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.

2.12 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 Employer's Engineer.

2.13 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.

2.14 Disposal of Ground Water

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

2.15 Approved Sites for Disposal of Materials

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

2.16 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. Concrete testing should be done on-site

If the Contractor provides his own testing facilities, the equipment staff and method of operation shall be approved by the Employer's Engineer, 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 Employer's Engineer 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.

3 The Site

3.1 Notice Boards

Notice boards shall be in both English and 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 Employer's Engineer 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 Employer's Engineer.

3.2 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 Employer's Engineer in writing of such arrangements.

3.3 Access to Works

The necessary facilities will be given 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 regarding the conditions of access to and over such property.

3.4 Safety Barricading

Safety Barricading shall be erected around the Contractor's working area shall meet the requirements of MITL and shall be to the satisfaction of the Employer's Engineer.

3.5 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. If the contractor intends to use such material obtained from excavations within the project area he shall compensate the employer as per the market rate of the material. Any unauthorised or unapproved excavations shall be refilled by the contractor at his own cost. Any excess material from the excavations if not used by the contractor shall be disposed off by the contractor without any additional cost as directed by the Employer's Engineer.

3.6 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 Employer's Engineer.

3.7 Final Clearing 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 Employer's Engineer:

a) Remove temporary labels, stains and foreign substances.

b) Polish transparent and glossy surfaces.

c) Clean roofs, gutters, downspouts and drainage systems.

d) Remove debris and surface dust from limited access surfaces.

e) Broom clean concrete floors and unoccupied spaces.

f) Clean light fixtures and lamps so they operate at maximum efficiency.

g) Other cleaning tasks as directed by the Employer's Engineer.

The Contractor shall clean the Site and shall undertake the following to the satisfaction of the Employer's Engineer:

a) Sweep paved areas and rake all other surfaces.

b) Remove litter and foreign substances.

c) Remove stains, chemical spills and other foreign deposits

d) Other cleaning tasks as specified by the Employer's Engineer

3.8 Setting Out of the Works

3.8.1 Datum

The Employer's Engineer will indicate the position and value of a benchmark near the Works.

3.8.2 Temporary Benchmarks

The Contractor shall establish, construct, and protect temporary benchmarks during the period of construction and such benchmarks shall be jointly checked periodically and the value agreed with the Employer's Engineer.

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.

3.8.3 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 Employer's Engineer.

3.8.4 Site Reconnaissance

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

3.8.5 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 upon by the Employer's Engineer.

The Contractor shall provide the Employer's Engineer with all coordinates and level data in an ASCII format.

Setting out of the Works at Site

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.

3.9 Temporary Facilities

3.9.1 Transport

The Contractor shall arrange for the transport of his staff and workmen to and fro from the Site of the Works including movement on the site.

3.9.2 Site Offices for the Employer's Engineer

The Contractor shall provide air-conditioned site office and equipment including stationery items like paper, pens, pencils, markers, stickers, files, covers, printer cartridges etc for the exclusive use of the Employer's Engineer, client and their teams for the whole duration of the Contract Period. The contractor shall maintain and clean the site offices throughout the contract period. Contractor to maintain supply of drinking water, water for cleaning and washing and electrical power supply to the site offices round the clock.

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

Broadband facilities shall be provided separately for the Employer's Engineer, client and their teams round the clock.

3.9.3 Assistance to the Employer's Engineer

The Contractor shall provide for the exclusive use of the Employer's Engineer 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 Employer's Engineer. A schedule of basic equipment requirements is given in Volume 1 of the RFQ cum RFP Document.

3.9.4 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 Employer's Engineer 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 Employer's Engineer and the authority concerned for as long as they may be required.

3.9.5 Accommodation for Contractor

Land for building a labour camp will be provided by the client as per the approved plan for the labour camp. The Contractor shall house his workforce at a location and to a standard compliant with the current legislative requirements. The land shall be handed over back to the Engineer after removing & clearing the temporary or permanent structures, debris etc. if any. However, the cost of construction of sleeping quarters and/or camp accommodation, equipment including furniture etc. and its running cost should have been deemed to be included in the price bid with no additional implication to the Employer.

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

3.9.6 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.

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 Employer's Engineer.

3.9.7 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 Employer's Engineer before any work commences.

3.10 Traffic Management

3.10.1 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 Employer's Engineer 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 always be reflectorised or adequately illuminated at night in an approved manner and kept clean and legible. The Contractor shall reposition, cover or remove signs as required during the progress of the Works.

3.10.2 Flow of Traffic

The flow of traffic on the existing roads and access to properties shall always be maintained during the Contract. The flow of traffic shall always take place 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 Employer's Engineer 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 cooperate closely with the Employer's Engineer and the appropriate controlling authority.

3.10.3 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 Employer's Engineer 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 Employer's Engineer 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 Employer's Engineer 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 Employer's Engineer for as long as required.

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

3.11 Existing Services and Structures

3.11.1 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 made available to the Employer's Engineer.

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 Employer's Engineer 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. Any existing services which need to be relocated to carry out permanent works shall be taken up by the contractor . The actual cost of such shifting as approved and communicated by the entity owning the utility, shall be paid by the contractor and reimbursed by the employer to the contractor.

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 appropriate controlling authority as laid down in "Safe Working in the vicinity of natural gas pipeline", in addition to the requirements of the Directorate of Natural Gas Distribution and any other appropriate controlling authority.

3.11.2 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 Employer's Engineer for approval and to Employer/PMNC for agreement. Such method statements shall take note of known constraints.

Drains Streams etc.

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

3.12 Records

3.12.1 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. Contractor shall keep all records updated on client's PMIS.

The Contractor shall maintain a continuous record of all field deviations from the drawings, if any, as approved by the Employer's Engineer 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 Employer's Engineer a set of the latest revisions of all drawings and specifications marked to show the Works or relevant sections of the Works as constructed.

3.12.2 '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 co-coordinates and the representation of services as 3-dimensional entities.

The Contractor's 'As Constructed' drawings and 3D models shall be submitted as follows.

a) Bound sets of A3 size drawings. These must be stamped and signed by the Contractor's Representative.

b) External hard drive with all models and 3D drawings shall be submitted in native file formats for e.g. SewerGEMS, WaterGEMS, 3Ds Max, Autodesk Civil 3D format etc

The 'As Constructed' drawings shall:

c) Display the Contractor's name and logo.

d) Be bound using a suitable spiral binder.

e) Have a front cover of approved quality and colour.

f) Have a plastic transparent sheet above the cover.

g) Have a backing sheet of the required thickness.

h) Be clearly legible.

4 Materials and Equipment

4.1 Quality of Materials

a) 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.

b) 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 another approved standard.

c) 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 Employer’s Engineer.

d) 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.

e) Contractor shall submit all the materials to be used in permanent works in submittal form accompanied by the material datasheet, relevant standards and sample for the engineer’s approval.

4.2 Alternative Materials

The Contractor may offer alternative materials or equipment than those specified in the contract. If alternatives are proposed, the Contractor shall submit for the Employer’s Engineer's approval details including technical descriptions, drawings and specifications to demonstrate that the alternatives are equal to the previously specified material quality. No alternative material shall be submitted without any cost savings to the client.

4.3 Manufacturer’s Instructions

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

b) 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.

c) Contractor to submit the procurement schedule for engineer’s review with unambiguous dates for order and delivery for all the materials in line with the approved primavera programme of works. Any material supplied out of turn will be paid only as per the approved programme.

4.4 Supply of Materials

a) 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 to the Employer’s Engineer.

b) 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.

4.5 Stock of Materials

c) 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.

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

4.6 Copies of Orders

The Contractor shall, if required, submit to the Employer's Engineer copies of orders for materials and equipment to be incorporated into the Works.

4.7 Shipping Documents

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

4.8 Receiving Cum Damage Reports

a) The Contractor shall submit receiving reports to the Employer's Engineer 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 Employer's Engineer 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.

b) In all cases of irreparable damages, the Contractor shall immediately notify the relevant manufacturer(s). He shall also immediately notify the Employer's Engineer 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 Employer's Engineer.

4.9 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 the issue of the last Initial Taking Over Certificate.

4.10 Local Agent

All materials and equipment shall be supplied by manufacturers or their agents who are to be approved by the Employer's Engineer.

4.11 Spare Parts

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

4.12 Unloading and Storage of Materials

The Contractor shall unload all imported equipment and material at the Site from trucks, trailers or delivery vehicles. Items of permanent installation shall be properly and neatly stored in areas designated by the Employer's Engineer 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 Employer's Engineer.

4.13 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. The contractor shall promptly arrange to dispose off the unwanted packaging material as directed by the Employer's Engineer.

4.14 Storage and handling of Materials

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

b) 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.

4.15 Water

a) Contractor to arrange water for the works from a suitable source.

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 be not less than 6. Potable water shall be considered satisfactory. Underground water can also be used with the prior approval of the Employer's Engineer if it meets all the requirements of clause 5.4 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 Employer's Engineer may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall have an average 28 days compressive strength not lower than 90% of the strength of concrete prepared with distilled water.

e) The Employer's Engineer 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 Employer's Engineer 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 cement and 4 parts 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 or creek water shall not be used for the preparation of cement mortar, and concrete as well as for curing of plain/reinforced concrete and masonry works. Sea or creek water shall not be used for hydro testing and checking the leakage of liquid retaining structures.

5 Earthworks

5.1 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 taken. Route other than the shortest practical route may be considered in cases of unavoidable circumstances and approved by The Employer's Engineer 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 an 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 earthwork. 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.

5.2 Classification of Soils

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

All kinds of soils: Generally, any strata, such as sand, gravel, loam, clay, mud, black cotton murrum, shingle, river or nallah bed boulders, siding of roads, paths etc. and hardcore, 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, scarifiers, ripper and other manual digging implements.

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 lime stone, sand stone, hard laterite, hard conglomerate and un-reinforced cement concrete below ground level.

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'.

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.

Hard rock (blasting prohibited): Hard rock requiring blasting as described above, but where the blasting is prohibited for a reason and excavation has to be carried out by chiselling, wedging, use of rock hammers and cutters, or any other method agreed with Employer's Engineer.

5.3 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 Employer's Engineer and shall be the property of the Government.

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

5.4 Protections

Excavation where directed by the Employer's Engineer 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 engineer in charge during the night to avoid accidents.

The Contractor shall take adequate protective measures to see 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 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 Employer's Engineer.

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 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.

5.5 Site Clearance

Before the earthwork is started, the area coming undercutting 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 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 sub-grade 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 Employer's Engineer 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 Employer's Engineer.

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 Employer's Engineer and protect the same properly during the execution of works.

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 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 Employer's Engineer. The contractor has to take written permission about the place of disposal of the earth before the earth is disposed of, from Employer's Engineer.

5.6 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 them 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.

5.7 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 Employer's Engineer. Necessary profiles with strings stretched on pegs, bamboos or 'Burjis' shall be made to indicate the correct formation levels before the work is started. The contractor shall supply labour and materials for constructing the benchmark, setting out and making profiles and connecting the 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 Employer's Engineer) 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 Employer's Engineer. The north direction line and position of the benchmark shall invariably be shown on the plans. These plans shall be signed by the contractor and the Employer's Engineer or their authorized representatives before the earthwork is started. The labour required for taking levels shall be supplied by the contractor at his own cost.

5.8 Excavation in All Kinds of Soils

All excavation operations manually 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, clear 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 cm 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 the sides sloped or the soil shored up as directed by the Employer's Engineer. It shall be the responsibility of the contractor to take complete instructions in writing from the Employer's Engineer 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 Employer's Engineer.

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 the foundation is done to a depth greater than that shown in the drawings or as required by the Employer's Engineer, 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 Employer's Engineer.

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 Employer's Engineer, 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 stormwater 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 Employer's Engineer, 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 Employer's Engineer considering feasibility, urgency of work, availability of labour /mechanical equipment and other factors involved. The contractor shall ensure every safety measure for the workers. Neither any deduction will be made nor any extra payment will be made on this account.

5.9 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 or 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 met with and blasting operations are considered necessary, the contractor shall obtain the approval of the Employer's Engineer in writing for resorting to the blasting operations. Blasting operations shall be done as specified in 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 Employer's Engineer 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 Employer's Engineer 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 Employer's Engineer. 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 Employer's Engineer and nothing extra shall be payable.

5.10 Excavation- Additional

5.10.1 Excavation for Structures

The type of foundation whether Pile Foundation or Open Foundation shall depend on the recommendations of the Geotechnical Consultant subject to the approval of the Employer's Engineer. 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.

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.

All excavation surfaces on which the foundations are to be laid should be compacted to a minimum of 95% of Maximum Dry Density (MDD).

5.11 Excavation and Preparation for Trench

Excavation shall be done using adequate number of excavators and hard rock cutting machines. The trench shall be so dug that the pipe may be laid to the required gradient and at the required depth. A minimum cover of 1.0 m shall be taken into consideration. The width of the trench at bottom shall provide not less than 300 mm clearance on both sides of the pipe. Additional width shall be provided at positions of sockets and flanges for joint. Depths of pits at such places shall also be sufficient to permit finishing of joints

When excavating to specified or required levels for the foundation of any structure or to specified or required limits for the face of any structure required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing the constructional work, except where the Employer's Engineer shall permit otherwise. Should the Contractor have excavated to within 150mm above these specified levels or to within 150 mm of these specified limits before he is ready or able to commence the constructional work he shall, where required by the Employer's Engineer, excavate further so as to remove not less than 150mm of material immediately before commencing the constructional work. Before commencement of any constructional work all shattered and loose material shall be removed from the excavations by hand so as to ensure that the work rest on a solid and perfectly clean foundation or abuts against solid ground.

5.12 Excess Excavation (Excluding Overcuts / Depressions) as in to be made good

In case of excess excavation by the Contractor (beyond that specified in drawings), the contractor shall, at his own expense, if directed, remove from the pits all material resulting from excess excavation and shall make good the same with such kind of fill material or in such class of concrete as may be reasonably required by Employer's Representative having regard to the circumstances.

The Contractor shall backfill such excess excavation with concrete, rubble, stone or rock fill as directed by the Employer's Engineer / PMNC Consultant. Filling other than concrete shall be placed in layers not exceeding 300 mm in thickness, shall be thoroughly compacted and have adequate fines content to fill the voids.

5.13 Existing Roads and Services

The Contractor shall survey existing services and make suitable arrangements to shift the existing services as directed by the Engineer in charge. The shifting of utilities may involve rerouting, laying new services to replace old services to ensure uninterrupted service to the existing users. The Contractor shall take all precautions which, in the opinion of the Employer’s Engineer, 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 Employer’s Engineer, 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 Employer’s Engineer.

5.14 Crossing of Watercourses

Where the pipeline crosses rivers, culverts and other water courses, the Contractor shall be deemed to have allowed for all the additional measures as necessary and approved by the Employer's Engineer for the proper construction of the pipeline and trenches at these crossings including maintaining the full flow of water across the trench or pipeline.

5.15 Borrow Pits

The Contractor shall obtain the permission of the persons or authorities concerned for the citing 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 and safety.

It shall be the Contractor's responsibility to locate suitable borrow areas for borrowing fill material. Such areas will be inspected by the Employer's Engineer and approved before the Contractor makes arrangements to borrow the fill material. The topsoil which may contain vegetation, rubbish, slush etc. shall not be used. If requested by the Employer's Engineer, the Contractor shall arrange to have trial pits of specified dimensions and numbers dug at locations specified, for the Employer's Engineer to examine and nature and type of material likely to be obtained from the borrow areas.

The borrowed soil shall be generally granular, and non-cohesive. It shall consist of sand, silty and murrum, ordinary soil, gravel and shingle. Dredged material, free from clayey deposits, may be accepted. Fill material shall also be free from sulphate, salts, organic, foreign and other harmful or objectionable materials. Any material rejected by the Employer's Engineer shall be removed from the site immediately.

Roads, of a temporary nature, are required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material, etc. to or over-borrow areas and/or to or over areas on which fill has to be deposited shall be constructed by the Contractor. Such access roads shall be maintained in good condition during all seasons to ensure completion of the work according to the time schedule.

All fill material whether such material is brought from outside borrow areas or excavation within the site, will be subject to Employer's Engineer's approval. Notwithstanding any approval given to the fill material or borrow areas from which fill materials are proposed to be brought, the Employer's Engineer reserves the right to reject such material which in his opinion either does not meet the specification requirements or is unsuitable for the purpose for which it is intended.

5.16 General Site Grading

Site grading shall be carried out as directed by the Employer's Engineer. Excavation shall be carried out as specified in the specification. Filling and compaction shall, be carried out as specified under (ii) of this Clause unless otherwise indicated below:

The approved material shall be placed in layers not exceeding 225 mm in depth before compaction and shall be compacted to a dry density not less than 95 per cent of the maximum dry density obtained by the test in Part 7 of IS 2720.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor. Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed. This shall hold good for embankments as well.

The Contractor shall protect the earth fill from being washed away by rain or damaged in any other way. Should any slip occur, the Contractor shall remove the affected materials and make good the slip.

The fill shall be carried out to such dimensions and levels as directed by the Employer's Engineer, after the stipulated compaction. The fill will be considered as inoculate if the desired compaction has not been obtained.

If specifically permitted by the Employer's Engineer, compaction can be obtained by allowing loaded trucks conveying fill or other material to ply over the fill area. Even if such a method is permitted, it will be for the Contractor to demonstrate that the desired/specified compaction has been achieved. In order that the fill may be reasonably uniform layers. Traffic over the fill shall then be so routed to contact the area uniformly throughout.

If so specified, the rock as obtained from the excavation may be used for filling and leveling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cm approximately. After rock filling to the approximate level indicated above has been carried out, the void in the rockfill shall be filled with finer materials such as earth, broken stone etc. and the area flooded so that the finer fill material does not get washed out. Over the layer, so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12-ton roller. Not less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up

5.17 Embankments

5.17.1 Earthwork in Embankment

1 Stripping

The entire area to be occupied by the embankment shall be stripped to a sufficient depth, as determined by the Employer's Engineer to remove all materials unsuitable and objectionable for incorporation in the embankment.

All excavations below the ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly all as specified for the embankment fill material, so as to make the surface at these points conform to the surrounding area.

2 Setting Out

After the site has been cleared the limit of embankments shall be set out true to lines as shown on the drawings.

3 Embankment Construction

The material used in the embankment shall be earth, approved by the Employer’s Engineer. The size of the coarse material in the earth shall not exceed 50mm. Such material shall be free of logs, brush, stumps, roots rubbish, organic matter, humus, or any other unsuitable material likely to deteriorate or affect the stability of the embankment.

The limits of embankments shall be marked by, fixing batten pegs at regular intervals as guides before, commencing the earthwork. It is desirable to fix the pegs about 0.5metre back from the actual limits of the fill and to paint them in a distinctive colour.

In all cases, the original ground under the embankments shall be prepared by scarifying, by ploughing, or by harrows or rakes or by any suitable method, all clods broken and, then moistening in the range of+1 to -2 % of optimum moisture content and rolling, as directed by the Employer's Engineer.

The embankment material shall be spread uniformly over the entire width of the embankment in horizontal layers not exceeding 230 mm and 150 mm in loose thickness when sheep foot rollers and smooth wheeled rollers respectively are used for compaction.

Successive layers of embankment shall not be placed until the layer under construction has been thoroughly compacted to the requirements set down hereunder:

Moisture content of the material shall be checked at the source of supply and -if- found less than that specified for compaction, the same shall be made good either at the source or after spreading the soil in loose thickness for compaction, in the latter case, water shall be sprinkled directly from a hose line or from a track-mounted water tank, and flooding shall not be permitted under any circumstances. Moisture content shall be distributed uniformly throughout each layer of the material.

If the material is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction.

Moisture content of each layer of soil shall be so adjusted (making due allowance for evaporation losses) that at the time of compaction, it is in the range of 1 per cent above to 2 per cent below the optimum moisture content determined in accordance with IS: 2720 (Part 7).

After adding the required amount of water, the soil shall be processed by means of harrows, or as otherwise approved by the Employer's Engineer until the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have a maximum size of 50mm when being placed in the lower layers of the embankment and a maximum size of 25 mm when being placed in the top 0.5-meter portion of the embankment.

Only compaction equipment approved by the Employer's Engineer shall be employed. If directed by the Employer's Engineer, the Contractor shall demonstrate the efficacy of the plant he intends to use by carrying out compaction trials.

Each layer of the material shall be thoroughly compacted to a field dry density of not less than 95% of the maximum laboratory dry density as per IS: 2720 (Part 7). Frequent laboratory tests to determine optimum moisture content and maximum laboratory dry density for different soil samples being used for embankment construction shall be made. Subsequent layers shall be placed only after the finished layer has been tested, as specified hereinafter, and accepted by the Employer's Engineer. If in the opinion of the Employer's Engineer, the surface of the prepared foundation or the compacted surface of any layer of earth fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it shall be moistened properly with the layer of material to be placed thereon, it shall be moistened and/or worked with harrow, scarifies, or other suitable equipment, "in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer of earth fill material is placed. If in the opinion of the Employer's Engineer the compacted surface of any layer of the earth fill in place is too wet for proper compaction of the layer of earth fill material to be placed thereon, it "shall be removed; allowed to dry or be worked with harrow, scarifies or other suitable equipment to reduce the moisture content to the required amount and then it shall be re-compacted before the next succeeding layer of earth fill material is placed.

When field density measurements reveal any soft areas in the embankment, further compaction shall be carried out as directed by the Employer's Engineer. If in spite of that, the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material compacted to the density requirements. The Contractor shall be entitled to no additional allowance above the prices bid in the schedule by reason of any work required due to the above conditions.

Contractor shall maintain the embankment in an approved manner till the end of the Defects Liability Period

5.17.2 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. A proper method statement for repairs shall be submitted by the contractor for approval by the Engineer in charge.

5.17.3 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.

1 Excavations Beyond 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 material and methods approved by the Employer's Engineer.

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.

2 Soil 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 maintain the flow of water courses affected by them and observe the requirements of the owner or relevant authority.

3 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 Employer's Engineer 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 are given, together with details of required standby equipment and standby power supply. The Contractor shall also indicate his 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 the settlement of roads, pavements, utilities, sewers, buildings and other structures outside the excavation but within the area affected by the dewatering.

Removal of Unsuitable Material

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.

Formation Tolerance

The finished surface at 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 ±25mm.

4 Testing at Formation Level

Tests shall be carried out at 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 the 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 to the formation level for structures. CBR tests shall be undertaken to the formation for road works only.

If this compaction cannot be achieved or if the material below 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 to the formation level for structures. CBR tests shall be undertaken to 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.

5 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.

6 Preparation of Surfaces to Receive Concrete

A blinding layer of concrete (minimum 75 mm) shall be laid immediately after the required level has been achieved and the excavated surface has been approved by the Engineer. Subsequently, the first pour of concrete shall be placed according to the details on the Drawings.

7 Filling

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.

8 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.

9 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 submit the method statement, Inspection and Test Plan prior to the start of each activity for review and approval by the Employer's Engineer.

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

Vibratory roller having a mass per metre width of the roll, not exceeding 1,300kg with a total mass not exceeding 1,000kg

Vibrating plate compactor having a mass not exceeding 1,000kg

Vibro-tamper having a mass not exceeding 75kg.

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

Below grade slab, minimum 500 mm topsoil 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 a minimum 95% modified proctor density.

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.

10 General Filling

Filling 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 always be maintained with a sufficient camber and cross fall and a surface sufficiently even to enable surface water to drain readily from it.

11 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.

12 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	100 mm 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:

at 90% of laboratory MDD	10% minimum
at 95% of laboratory MDD	15% minimum
Chloride content (BS EN 1744-1)	3.3% maximum (top 150mm only)
Sulphate content (BS EN 1744-1)	2.0% maximum (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 (AASHO 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 the Site, or daily, whichever is the less frequent.

13 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.

14 Formation Tolerance for Fill

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

15 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 AASHO T 191, together with ASTM D1556, as directed.

16 Testing of Top Layer of Fill

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

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	1000m²

Test	**Frequency of Test (not less than one test per)**
Optimum moisture Content	1000m^2
Grading	3500m²
Plasticity Index	3500m²
Linear Shrinkage	3500m²
CBR	3500m²
Sulphate content	3500m²
Chloride content	3500m²
In-situ tests to confirm that the required degree of compaction is being achieved during construction:	
Dry Density	500m²
CBR	2500m²

In situ CBR shall be applicable to road works only.

17 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 the settlement of the fill.

Such fill shall be Dara Fill (as manufactured by GRACE Construction Products/Emirates Chemicals LLC), or a 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.

6 Technical Specifications for Material

6.1 Bricks

6.1.1 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 requirement 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 comers 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.

6.1.2 Tests after Delivery

The Contractor shall take samples of each type of brick as directed by the Employer's Engineer 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 Employer's Engineer. All subsequent deliveries shall be upto the standards of the approved samples.

6.1.3 Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS:4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to 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 site at any time. Bricks, of different class, shall be stacked separately

6.1.4 Local Bricks / Class 3.5 Bricks

Where shown on drawings, locally available bricks of non-modular size (230mm x 115mm 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. The minimum compressive strength of these bricks shall not be less than 3.5N/mm2

6.1.5 Stone

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 the dressing of natural building stones.	IS: 1129

6.1.6 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, considering the appropriate crushing strength of the stone and type of the 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. The width of the stone on the base shall not be less than 150mm and in no case exceed the 314th thickness of the wall. The height of the stone shall not be more than 300mm.

6.1.7 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near to the place of work as defined in IS:4082 and shall be stacked on 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 stones are available at the site at any time.

6.1.8 Concrete Mixing- Site Aspect

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. Percent 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 Employer's Engineer.

6.1.9 Mixer

Mechanical Mixers shall comply with IS:1791 and IS: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.

6.1.10 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 Employer's Engineer may, however, direct a change in the mixing time, if he considers such a change necessary.

Capacity of mixer	Minimum Mixing time
2 m3 or less	2 minutes
Above 2 m3	3 minutes or as recommended by the mixer manufacturer

59.1.2 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 far away isolated places, this may be permitted by the Employer's Engineer as a special case. Ten percent (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.

6.1.11 Additives

Additive in concrete shall be used only with the prior approval of the Employer's Engineer 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.

6.1.12 Trial Mixes on Site

1 Laboratory Trial Mixes

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

Preliminary laboratory tests shall be carried out in dedicated laboratory established at site with all-time access of Employer's Engineer 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:

i. Bleeding (non- vibrating) Nil/negligible;

ii. Air content if applicable;

iii. Free water/cement ratio;

iv. Consistence (workability);

v. Fresh and hardened concrete densities.

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

vii. Absorption. The upper target limit for absorption after 30 mins shall be 2% for reinforced concrete and 2.3% for unreinforced concrete;

viii. Initial surface absorption tests (ISAT).

ix. The target limits shall be:

x. Time after starting test 10 min 30 min 1 hour

xi. ISAT results ml/m2/s 0.25 0.17 0.10

xii. For Reinforced Concrete only:

xiii. Penetration of water. The target limit for penetration at 4 days shall be 30mm;

xiv. 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.

6.1.13 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 Employer's Engineer 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 meet the limits given in IS code. In addition, the consistency of the trial mix shall be to the satisfaction of the Employer's Engineer and within tolerance limits given in relevant IS code and approved by the Employer's Engineer.

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 Employer's Engineer, 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 Employer's Engineer, 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 Employer's Engineer 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.

6.2 Cement

6.2.1 Cement General

Unless otherwise specified in the Specification or called for by the Employer's Engineer, cement shall be ordinary Portland cement (OPC-43 grade) Bags. The use of bulk cement will be permitted only with the approval of the Employer's Engineer. Changing brands or the type of cement within the same structure should be avoided as far as possible and may be done with due consent of the Employer's Engineer. The cement to be used throughout the Works shall be obtained from manufacturers approved in writing. Specific requirements 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 Employer's Engineer and shall meet specifications as under:

i. Specification for Portland slag cement IS:455
ii. Specification for Portland pozzolana cement (fly ash-based) IS: 1489 Pt. 1
iii. Specification for Portland pozzolana cement (calcined clay-based) IS: 1489 Pt.2
iv. Specification for Masonry Cement IS:3466
v. Specification for high alumina cement for structural use IS:6452
vi. Specification for rapid hardening Portland cement IS:8041
vii. Specification for 43-grade ordinary Portland cement IS:8112
viii. Specification for 53-grade ordinary Portland cement IS: 12269
ix. 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.

Where chloride and sulphates are encountered in soil and groundwater, ordinary Portland cement with C3A content from 5 to 8 per cent shall be desirable to be used in concrete instead of sulphate-resisting cement.

6.2.2 Type of Cement

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

i. 43 Grade Ordinary Portland Cement conforming to IS: 8112.

ii. Portland Slag Cement conforming to IS: 455.

iii. Portland Pozzolana Cement conforming to IS: 1489.

iv. 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. Where chloride is encountered along with sulphates in soil or groundwater, ordinary Portland cement with C3A content from 5 to 8 per cent shall be desirable instead of sulphate resisting cement.

The minimum cement content as mentioned in the table above shall be adjusted for aggregates other than 20 mm 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 ‘very severe’ exposure and only Sulphate-resisting Portland Cement shall be used . Underground structures not in direct contact with sewage or effluent will be under “severe” exposure. The Structural Components shall be designed as per IS: 3370 & IS: 456-2000 and other relevant Codes with the latest revisions. The nominal maximum size of aggregate for RCC and PCC shall be 20 mm and 40 mm, respectively. The minimum cement content for liquid retaining structure, above-ground structure and PCC are 350 kg/m3, 330 kg/m3 and 250 kg/m3 respectively.

6.2.3 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/m3 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

6.2.4 Storage at Site

i. The Contractor will have to make his own arrangements for the supply and storage of an adequate quantity of cement. Employer will not supply cement. It will be the responsibility of the Contractor to ensure adequate and proper storage and complete protection from dampness, and contamination and minimize caking and false set.

ii. Cement bags shall be stored in a dry enclosed shed (storage under tarpaulins will not be permitted), well away from the outer walls, and insulated from the floor to avoid contact with moisture from the ground and so arranged as to provide ready access. The storage of cement (lifted from the Owner's godown or procured by the Contractor himself) at the site of work shall be at the 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 also 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. The storage arrangement shall be such that there is no dead storage.

iii. 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 Employer’s Engineer for verification.

iv. Damaged or reclaimed or partly set cement will not be permitted to be used and shall be removed from the site. The Employer's Engineer shall approve the storage arrangement. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery.

v. The sample shall be tested at the approved Laboratory or at the contractor's site lab at the Contractor's cost from each lot of cement delivered at site. Cement held in storage for a period of ninety (90) days or longer shall be tested. Should at any time the Employer's Engineer have reasons to consider that any cement is defective, then irrespective of it origin, date of manufacture and/or manufacturer's test certificate, such cement shall be tested immediately at the Contractor's cost at the approved laboratory and until the results of such tests are found satisfactory, it shall not be used in any work. The Contractor shall not be entitled to any claim of any nature on this account.

6.2.5 Cement Testing

i. 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 Employer's Engineer for analysis before the source is approved.

ii. 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 also 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:

iii. Properties to be tested

Strength;
Fineness;
Setting Time;
Soundness;
Reactive Alkali Level as Na2 O Equivalent;
Chloride Content;
Loss on Ignition;
Insoluble Residue;
Tricalcium Aluminate Content;
SiO2, MgO, Al2O3, Fe2O3, CaO contents;
SO3

6.2.6 Approved Cement Manufacturer

The contractor shall use cement from any of the following manufacturers

i. Ultratech

ii. ACC

iii. Ambuja

iv. JK Cement

v. Shree Cement

vi. Ramco

6.2.7 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.

Silica Fume Powder	
SiO2	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 Na2O equivalent	Max 2%
Relative density	2.2
Silica Fume Slurry	
pH	5.5±1
Water content	50% ±2%
Relative density	1.3-1.4

6.2.8 Rejection

The Employer's Engineer 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.

6.3 Aggregate

i. 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 amounts of alkalis, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, seashells etc.

ii. Source and type of aggregates shall be approved by the Employer's Engineer before procurement. Change in source and type of aggregates, at a later stage, shall not be generally permitted; but under specific circumstances, the Employer's Engineer can allow a change in source and type of aggregate. The contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit a fresh mix design for approval of the Employer's Engineer. Any such change, if permitted by the Employer's Engineer, shall be without any time and cost implication to the owner.

iii. Aggregates which may chemically react with the alkalis of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Employer's Engineer, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.

iv. 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 the case of newly developed quarry sites, the contractor shall submit necessary test results as per IS:383 and IS:2386 to the Employer's Engineer prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.

v. Under no circumstances shall the use of porous aggregates, such as slag, crushed over burnt brick or tile, bloated clay aggregates and sintered fly ash aggregates, be allowed for parts of the structure either in contact with liquid on any face or enclosing the space above liquid.

vi. Coarse and fine aggregates shall be batched separately. All-in-aggregate shall be used only where specifically permitted by the Employer's Engineer.

vii. 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 Employer's Engineer, whenever asked for, to ensure conformity with those submitted along with the mix design.

viii. Whenever required by the Employer's Engineer, 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.

ix. Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

6.3.1 Coarse Aggregates

i. Coarse aggregates are the aggregates, which are retained on a 4.75mm BIS Sieve. It shall have a specific gravity of not less than 2.6 (saturated surface dry basis).

ii. 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 the densest possible concrete. For this purpose, the contractor shall submit to the Employer's Engineer at least three sets of mix design and test results, each with a different grading of coarse aggregates, proposed to be used. The Employer's Engineer may allow "All-in-aggregates" to be used provided they satisfy the requirements of IS:383.

6.3.2 Fine Aggregates

i. Fine aggregates are the aggregates which pass through a 4.75mm BIS sieve but not more than ten per cent (10%) pass through a 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.

ii. 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 river banks affected by tides, shall not be used for filling or concrete works.

6.3.3 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 Employer's Engineer. 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 Employer's Engineer. The method of sampling shall be in accordance with the requirements given in IS:2430.

6.3.4 Alkali – Reactivity Potential

i. 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.

ii. 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.

6.3.5 Storage of Aggregates

i. 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.

ii. 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.

iii. 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 Employer's Engineer 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.

6.4 Sand

6.4.1 Sand for Masonry Mortars

i. 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.

ii. 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.

iii. Unless found satisfactory as a result of further tests as may be specified by the Employer's Engineer, 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.

6.4.2 Grading of Sand

i. 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	

ii. 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 Employer's Engineer. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

6.4.3 Sampling and Testing

i. The method of sampling shall be in accordance with IS:2430. The amount of material required for each test shall be as specified in relevant parts of 1S:2386. Any test which the Employer's Engineer may require in connection with this, shall be carried out in accordance with the relevant parts of IS:2386.

ii. 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.

6.4.4 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 Employer's Engineer. Sand obtained from seashores, 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 grading zone-111 as per IS:383 shall be allowed for filling.

6.4.5 Reinforcement

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 respective Indian standard codes.

All reinforcement will be CRS TMT steel of grade Fe 500D and not more than Fe 550D. CRS steel. The contractor shall obtain the Employer's Engineer's approval for the selection of the steel grade for each structure.

The contractor shall use the steel of any following makes

i. Tata Steel

ii. JSW

iii. SAIL

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

2 Supply

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

ii. Each delivery of reinforcement steel shall be accompanied by the manufacturer's material test certificate which essentially shall include batch number, heat number etc.

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

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

v. Yield load;

vi. Yield/Proof stress;

vii. Ultimate load;

viii. Mode of failure and where occurring;

ix. Other pertinent data

x. Fixing

xi. 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.

xii. 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 Employer’s Engineer.

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

xiv. In addition to supports 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.

xv. 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.

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

3 Bending Schedules

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

ii. Restrictions on bending steel shall be as follows:

iii. Re-bending including minor adjustments: Obtain instructions.

iv. Temperatures below 5°C: Obtain instructions;

v. Temperatures greater than 100°C: Prohibited.

vi. Cutting shall be carried out with an approved cropping machine.

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

viii. Grade 550/500 bars must not be re-bent or straightened without approval from the Employer's Engineer.

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

4 Welding

No welding shall be allowed for joining the reinforcement bars at the site. Only approved couplers may be used for joining the bars.

5 Cover to Reinforcement

i. Where required to support and retain the reinforcement in its correct position, the 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.

ii. 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.

iii. Plastic spacers of the required diameter shall be used for the vertical elements to maintain the cover.

iv. 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.

v. 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.

vi. 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 for 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 Employer's Engineer for approval prior to any covering up.

6 Reinforcement Bars

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

ii. Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement (grade I) IS:432

iii. Specification for hard-drawn steel wire fabric for concrete reinforcement IS:1566

iv. Specification for plain hand-drawn steel wire for prestressed concrete IS: 1785

v. Specification for High strength deformed steel bars and wires for concrete reinforcement IS: 1786

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

vii. Specification for indented wire for prestressed concrete IS:6003

7 Structural Steel

Structural steel to be used for general structural purposes shall be galvanised for corrosion resistance. Structural steel columns, beams, girders and bracings to be encased in concrete shall be unpainted. The encasing shall be done in concrete with 10 mm maximum size aggregate and works cube strength not less than 15 N/mm2 at 28 days unless otherwise specified. The steel member shall be wrapped with galvanised wire mesh of adequate size. All steel members in the floor level in tanks in contact with water shall be embedded in concrete for min. 450 mm above the fished floor level. The galvanised wire mesh shall be at 20 mm from the edge or surface of the steel member and shall be held in position securely. The steel, member will have a minimum cover of 50 mm unless otherwise indicated on the drawings. Where the clear cover to steel is more than 75mm, mild steel bar and concrete with 20 mm coarse aggregate can be used.

i. Structural steel sections shall conform to the following BIS Codes.

ii. Steel tubes for structural purposes. IS:1161

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

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

v. Hollow steel sections for structural use. IS:4923

Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following BIS Codes.

i. Steel wire ropes for general engineering purposes IS:2266

ii. Thimbles for wire ropes. IS: 2315

iii. Bulldog grips. IS:2361

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

6.4.6 Anchor Bolts

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

6.4.7 Insert Plates & Anchor Fasteners

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

b) Anchor Fasteners shall be Hilti type or equivalent as per standards

6.4.8 Storage of Reinforcement

i. 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 prevented.

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

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

iv. 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.

v. 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.

vi. Suitable anticorrosive treatment shall be provided to the reinforcement bars as approved by the Employer’s Engineer`12q

6.5 Concrete

Plain and Reinforced Cement Concrete

6.5.1 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 over-ground structures, floors, pavements etc. Any special requirements as shown or noted by the Employer’s Engineer on the drawings shall supersede the provisions of these specifications. All concrete in the works shall be "controlled concrete" as defined in IS 456.

Reference Codes and Specifications

i. 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, “Concrete Structures for Storage of Liquids” IS:3370 (Part 1 & 2) and other relevant codes mentioned therein.

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

6.5.2 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/mm2)**
M 20	20
M 25	25
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 material below which not more than five (5) percent of the test results are expected to fall.

6.5.3 Minimum Strength of Concrete

The minimum compressive strength of 15 CM. cubes at 7 and 28 days after mixing conducted in accordance with IS: 516

Class	**Preliminary test N/mm2**		**Works test N/mm2**		**Maximum size of aggregate**	**Locations for use**
	At 7 days	At 28 days	At 7 days	At 28 days		
M40	33.5	50.0	27.0	40.0	20	As indicated in the specifications or as required.
M35	30.0	44.0	23.5	35.0	20	-do-
M20	17.5	26.0	13.5	20.0	40 or 20	-do-

Notes: It shall be very clearly understood that whenever the concrete such as M20, etc. is specified it shall be the Contractor's responsibility to ensure that the minimum crushing strength stipulated for the respective grade of concrete is obtained at works.

The minimum cement content in the concrete used for liquid/ water retaining structure shall be 350 kg/m3 for 20 mm downgraded aggregate.

6.5.4 Type of Concrete Mix

Unless otherwise noted on drawings, all lean/plain concrete shall be of M20 grade

Reinforced Cement Concrete shall be of the following grade conforming to the requirements of IS 456:2000.

Structure	**Grade of Concrete**
All the structures, including but not limited to water retaining structures, overground structures, underground structures, buildings, retaining walls, etc	M25 for all structure & Water retaining structure M35.

6.5.5 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
M 20 (1:1.5:3)	34

Note: The proportions of the fine to coarse aggregates should be adjusted from upper limit to 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.

6.5.6 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values as per IS 456:2000. The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times the standard deviation. So far 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 Employer's Engineer 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.

6.5.7 Concrete Mix Proportioning- Technical Aspect

Determination of mix proportions shall be carried out according to "Recommended Guidelines for Concrete Mix Design' conforming to IS: 10262. Whenever there is a change either in the required strength of concrete, or water-cement ratio or workability or the source of aggregates and/or cement, preliminary tests shall be repeated to determine the revised proportions of the mix to suit the altered conditions.

While designing mix proportions, over-wet mixes shall always be avoided. While fixing the value for the water/cement ratio for preliminary mixes, assistance may be derived from IS: 456.

i. 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 design of the concrete mix:
    i. Grade designation.
    ii. Type of cement.
    iii. Maximum nominal size of aggregate.
    iv. Minimum cement content.
    v. Maximum free water cement ratio
    vi. Workability requirements.

ii. The Employer's Engineer shall verify the strength of the concrete mix, before giving his sanction of 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 Employer's Engineer shall order fresh trial mixes to be made by the Contractor.

iii. 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.

6.5.8 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 Employer's Engineer at least three sets of mix design and corresponding test results after varying the mix proportions and/or grading of aggregate to establish the maximum density of any particular grade of concrete.

6.5.9 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 to maintain the approved free-water cement ratio.

6.5.10 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.

Workability

i. The concrete mix proportion shall be such that the concrete has 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.

ii. 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 be approved by the Employer's Engineer.

6.5.11 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. 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. For the nominal maximum aggregate size of 20 mm, the parameters are listed in following table.

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	260	0.45	M 35	340	0.45	M 35
Moderate	260	0.45	M 35	340	0.45	M 35

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
Severe	260	0.45	M 35	340	0.45	M 35
Very Severe	260	0.45	M 20	340	0.45	M 35
Extreme	310	0.40	M 20	360	0.40	M 40

6.5.12 Testing for Mix Design

Site Testing

Test specimens shall be prepared with at least two different water/cement ratios for each class of concrete, consistent with the workability required for the nature of the work.

The materials and proportions used in making preliminary tests shall be similar in all respects to those to be actually employed in the works as the object of these tests is to determine the proportions of cement, aggregates and water necessary to produce concrete of required consistency and to give the specified strength. It will be the Contractor's sole responsibility to carry out these tests and he shall therefore furnish to the Employer's Engineer a statement of proportions proposed to be used for the various concrete mixes. For preliminary tests, the following procedure shall be followed:

Materials shall be brought to room temperature and all materials shall be in a dry condition. The quantities of water, cement and aggregates for each batch shall be determined by weight to an accuracy of 1 part in 1000 parts.

6.5.13 Mixing Concrete

It shall be done by hand or in a small batch mixer as per I.S. 516 in such a manner as to avoid loss of water. The cement and fine aggregate shall first be mixed dry until the mixture is uniform in colour. The coarse aggregate shall then be added, mixed and water added and the whole batch mixed thoroughly for a period of not less than two minutes until the resulting concrete is uniform in appearance. Each batch of, concrete shall be of such a size as to leave about 10% excess concrete, after moulding the desired number of test specimens.

6.5.14 Consistency

The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test in accordance with I.S.1199. If in the slump test, care is taken to ensure that no water or other material is lost, the material used for the slump test may be remixed with the remainder of the concrete for making the specimen test cubes. The period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

6.5.15 Size of Test Cubes

Compression tests of concrete cubes shall be made as per I.S.516 on 15 cm. cubes. Each mould shall be provided with a metal base plate having a plain surface so as to support the mould during filling without leakage.

The base plate shall be preferably attached to the mould when assembled shall be positively and rigidly held together. Before placing concrete, the mould and base plate shall be cleaned and oiled. The dimensions and internal faces of the mould shall be accurate within the following limits:

Height and distance between the opposite faces of the mould shall be of specified size +0.2 mm. The angle between the adjacent internal faces and between the internal faces and top and bottom faces of the mould shall be 90 +_ 0.5°. The interior faces of the mould shall be plain surface with a permissible variation of 0.03 mm.

6.5.16 Compacting

Concrete test cubes shall be moulded by placing fresh concrete in the mould and compacted as specified in I.S. 516.

6.5.17 Curing

Curing shall be as specified in I.S.516. The cubes shall be kept in moist air of at least 90% relative humidity at a temperature of 27° ±_2° C for 24 hours ±1/2 hour from the time of adding water to the dry ingredients. Thereafter they shall be removed from the moulds and kept immersed in clean, fresh water and kept at 27° ± 2° C temperature "until required for test. Curing water shall be renewed every seven days. A record of maximum temperatures at the place of storage of the cubes shall be maintained during the period they remain in storage.

6.5.18 Testing of Specimens

The strength shall be determined based on not less than five cube test specimens for each age and each water-cement ratio. All these laboratory test results shall be tabulated and furnished to the Employer's Engineer. The test results shall be accepted by the Employer's Engineer if the average compressive strength of the specimens tested is not less than the compressive strength specified for the age at which specimens are tested subject to the condition that only one out of the five consecutive tests may give a value less than the specified strength for that age. The Employer's Engineer may direct the Contractor to repeat the tests if the results are not satisfactory and also make such changes as he considers necessary to meet the requirement specified. All their preliminary tests shall be conducted by the Contractor at his own cost in an approved laboratory.

6.5.19 Concrete Mixing- Site Aspect

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. Percent 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 Employer’s Engineer.

6.5.20 Mixer

Mechanical Mixers shall comply with IS:1791 and IS: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.

1 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 Employer’s Engineer 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

6.5.21 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 far away isolated places, this may be permitted by the Employer's Engineer as a special case. Ten per cent (10%) of 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.

6.5.22 Additives

Additive in concrete shall be used only with the prior approval of the Employer's Engineer 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. Trial Mixes on Site Batching Plant

6.5.23 Laboratory Trial Mixes

Preliminary laboratory tests shall be carried out in a dedicated laboratory established at the site with all-time access of the Employer's Engineer 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:

Bleeding (non-vibrating) Nil/negligible;

Air content if applicable.

Free water/cement ratio;

Consistency (workability);

Fresh and hardened concrete densities.

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

Absorption. The upper target limit for absorption after 30 mins shall be 2% for reinforced concrete and 2.3% for unreinforced concrete;

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:

i. Penetration of water. The target limit for penetration at 4 days shall be 30mm;

ii. 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.

6.5.24 Initial Field Tests

i. 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.

ii. 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 Employer's Engineer that an acceptable surface can be obtained with the mix.

iii. The strength requirements shall be considered to be satisfied if the strength of the cubes tested after 28 days meets the limits given in IS code. In addition, the consistency of the trial mix shall be to the satisfaction of the Employer's Engineer and within tolerance limits given in the relevant IS code and approved by the Employer's Engineer.

iv. 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 Employer's Engineer, who may require further trial mixes to be made before any such variations are approved.

v. Until the results of trial mix for a particular class have been approved by the Employer's Engineer, no concrete of the relevant class shall be placed in the Works.

vi. 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 Employer's Engineer 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.

6.5.25 Admixtures

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

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

ii. Generally, admixtures shall have ISI certification marks. However, even in the case of BIS certified admixtures, the Employer's Engineer 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.

iii. In case, admixtures certified by BIS are not available, the contractor shall submit to the Employer's Engineer 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 Employer's Engineer for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Employer's Engineer for his selection. In case, both the names are rejected, the contractor shall submit a fresh list of two manufacturers for approval by the Employer's Engineer.

iv. The Employer's Engineer 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.

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

vi. Prior approval of the Employer's Engineer 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 taken from the design approving authority. Once approved, utmost care shall be exercised at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/ mortar so produced.

vii. 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 Employer's Engineer. 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.

viii. 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. The 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 the water-cement ratio of the Design Mix during execution.

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

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

6.5.26 Corrosion inhibitors

a) 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±2% calcium nitrite by mass and have a minimum of 10 year 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.

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

6.5.27 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 200m2 of fibres per cubic metre of concrete. The length of each fibre shall be between 10mm and 50mm. Fibres may be monofilament or fibrillated.

6.5.28 Water Proofing Compounds

i. Waterproofing compounds shall be mixed with only ordinary Portland cement of grade 43, conforming to IS:269.

ii. 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, it shall exceed 3% by weight of cement.

iii. 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. The compressive strength of the specimen at 3 days shall not be less than 160kg/sq.cm nor 80% of the 3 days 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 days 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.

6.5.29 Water Bars

i. 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 variations 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.

ii. 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 the thickness shall be less than 5mm and the width less than 150mm. The joining of the water bars shall be carried out by vulcanizing strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

6.5.30 Bitumen/Bituminous Materials

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

i. Specification of Paving Bitumen. IS: 73

ii. Specification for bitumen mastic for flooring. IS: 1195

iii. Specification for Bitumen felts for waterproofing and damp proofing. IS: 1322

iv. Specification for Bituminous compounds for waterproofing and caulking purposes. IS: 1834

v. Specification for preformed fillers for expansion joints in concrete pavements and structures. IS: 1838

vi. Specification for bitumen mastic for use in waterproofing of roofs. IS:3037

vii. Specification for bitumen primer for use in waterproofing and damp proofing. IS:3384

viii. Specification for Bitumen Mastic for Tanking and Damp proofing. IS:5871

6.6 Quality Control

6.6.1 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 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 °C ±2 °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/mm2 shall be used as a basis for designing a mix.

Testing of Concrete

i. The contractor shall provide an elaborate concrete testing plan for concrete testing and covering all the structures for review and approval by the Employer's Engineer. In addition to the conventional cube test, the contractor should use the Concrete Maturity Meter System (CMMS) for bulk concreting exceeding 20 cu. m. The CMMS shall provide direct real-time measurement of in-situ concrete performance (Concrete Temperature, Compressive Strength) in short-term (curing phase), as per IS 456 (Cl 17.8.1) / ASTM C1074. This Quality 4.0 system shall deploy reusable wireless battery powered (minimum IP65 rated) CMMs having detachable and retrievable sensors. It should include analytical software functional mode of data communication (wifi-router/dongle/hotspot etc) for the maturity meters and provide test results in the form of ready-to-print reports. The system should display above mentioned performance parameters in numerical/info-graphical format on connected PC/Laptop/Smart-phone devices in real time.

Test Specimens

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

ii. Sampling, site tests, and identification numbers of specimens tested in the laboratory;

iii. Location of the parts of the structure represented by each sample;

iv. Location in the structure of the batch from which each sample is taken.

v. A visual examination of each batch of concrete delivered to 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.

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

vii. 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 10-25°C.

viii. One sample shall be taken from concrete delivered to 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 relevant IS code and tested for placement temperature, consistence (workability), plastic density, water-cement ratio and compressive strength.

ix. 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.

x. Procedures for testing conformity shall be carried out in accordance with relevant Indian standards to the approval of the Employer's Engineer.

xi. Water shall not be added on site to re-temper concrete prior to concrete placement.

xii. Superplasticiser may be added to the concrete, but the addition of admixtures shall only be carried out by authorised personnel with approval from Engineer in charge and shall be recorded and signed on site placement records to show amount incorporated.

xiii. Tests for consistence shall be repeated after addition of super plasticising 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 consistence testing, the concrete shall be rejected from the Works.

6.6.2 Test Certification

i. 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.

ii. The name and Certifying Body reference number of the laboratories shall be submitted for the approval of the Employer's Engineer well in advance of making trial mixes or concrete for use in the works.

6.6.3 Test Results

i. Reports of the identity testing results shall be submitted for the approval of the Employer's Engineer within one day of the completion of each test.

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

6.6.4 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

6.6.5 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

6.6.6 Failures

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

- Changing the 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;
- Cutting out and replacing defective concrete.

b) 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 Employer's Engineer.

c) The Employer's Engineer 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.

d) 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 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.

e) 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.

6.6.7 Batching

a) In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass. Where the mass of cement is determined based on 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.

b) Except where it can be shown to the satisfaction of the Employer's Engineer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, different sizes being stacked in separate stock piles. The grading of coarse and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Employer's Engineer to ensure that the approved grading is maintained.

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

d) 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 the 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:

e)	Aggregate	Approx. Quantity of surface water	
f)	Surface by mass	Litres/m3	
g)	Very wet sand	7.5	120
h)	Moderate wet sand	5.0	80
i)	Moist sand	2.5	40
j)	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, fresh mix design with supportive laboratory tests shall be submitted to the Employer's Engineer 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

6.6.8 Machinery

a) Batching plant shall conform to IS:4925. Batching shall be by weigh batching machines equipped with accuracy checks for the weighing mechanism unless approved otherwise for special circumstances. The machines shall be cleaned, checked and adjusted regularly as approved. All measuring equipment shall be maintained in a clean serviceable condition.

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

6.6.9 Accuracy of Batching

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

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

f) The batched quantities shall be adjusted to compensate for variations in the moisture content of the aggregates with the approval of the Employer's Engineer.

6.6.10 Batching and Mixing

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

b) 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.

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

d) If concreting is not started within 24 hours of consent being given, consent shall again be obtained from the Employer's Engineer. Concreting shall then proceed continuously over the area to be completed.

6.6.11 Pre-production Site Check

a) 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.

b) 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.

c) 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 Employer's Engineer, joints between panels of formwork shall be filled with an acceptable material.

6.6.12 Other Production Site Checks

a) 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 Employer's Engineer.

b) Volume batching of constituent proportions shall not be permitted unless approved for special circumstances.

c) 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 Employer's Engineer. 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 □3% of the masses per batch derived from trial mixes and agreed by the Employer's Engineer.

d) Dispensing equipment for admixtures shall be to the approval of the Employer's Engineer and shall be accurate to within □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.

e) 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.

f) 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.

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

h) Contract name;

i) Concrete Strength Class;

j) Nominal workability (consistency);

k) Masses of constituents;

l) Time at which water was added

6.6.13 Production Checks

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

b) Workability of each truckload of concrete shall be determined at 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.

c) Temperature of concrete at 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.

d) 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.

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

f) Registration number of truck, name of concrete supplier and location of batching plant;

g) Time of introduction of cement and water to the mix;

h) Time of arrival of truck at the concrete pour location and times when concrete discharge and compaction were completed;

i) Strength Class of concrete and actual mix proportions including admixtures;

j) Position in which concrete batch is to be placed;

k) Whether test cylinders/cubes were taken from the load and sample reference numbers;

l) Workability test results;

m) Concrete temperature at time of start and completion of discharge.

n) A daily concrete batching report shall be prepared and submitted to 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, the batched aggregate and water weights per cubic metre.

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

6.6.14 Hot Weather Concreting

a) 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.

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

c) Protecting all aggregate stockpiles, water lines and tanks as well as the mixer from the direct rays of the sun;

d) Mixing water cooled by the addition of ice to the storage tanks;

e) Concreting carried out during the cooler parts of the day or during the night;

f) 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

g) Providing wind shields during periods of drying winds.

h) 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 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.

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

6.7 Placing

6.7.1 Employer's Engineer Approval for Equipment & Methods

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

6.7.2 Construction Sequence/ Timing Requirements

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

b) The Contractor shall submit a detailed method statement to the Employer’s Engineer for approval defining his 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.

c) 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 Employer’s Engineer. All concrete showing signs of excessive cracking due to early thermal and drying shrinkage effects shall be removed at the Contractor’s expense.

d) The maximum temperature of the concrete during hydration shall not exceed 70 °C so that the difference between peak hydration temperature and ambient temperature is maintained at 30 °C.

6.7.3 Thick sections

a) 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 10x10-6/°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.

b) Details of the trial shall be submitted to the Employer's Engineer for approval prior to the production of concrete.

6.7.4 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 saturate surface dry condition immediately prior to concrete placement.

6.7.5 Inspection of Surfaces

Notice shall be given to the Employer's Engineer 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.

6.7.6 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 metre 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.

6.7.7 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.

6.7.8 Pumps

a) 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.

b) 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.

c) 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.

6.7.9 Placing

a) Concrete shall be placed and compacted without delay and in accordance with the recommendations of relevant Indian standards such that dense homogenous concrete is obtained within the Works.

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

c) 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.

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

e) Concrete shall generally be placed without segregation.

f) 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 Employer's Engineer 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.

g) Placing in each section of work shall be continuous between construction joints. A suitable placing boom along with concrete pump shall be used for placement of concrete. The rate of concreting shall vary between 10 cu. m per hour to 40 cu. M per hour per pump depending upon the type of element and compaction equipment deployed at site. The delivery of concrete should be well coordinated so as to place the concrete within the specified time as approved in the method statement. The Contractor shall make provision for standby equipment. If the placing of concrete is delayed due to 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 Employer's Engineer.

h) 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.

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

j) The returns shall give for each location in the work:

k) The position of the pour (e.g. bay or lift reference number);

l) The Strength Class of the concrete placed;

m) The total volume of concrete placed and the number of batches used.

n) 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.

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

6.7.10 Compaction

a) Concrete shall be thoroughly compacted in its final position, whichever is lesser: within two hour 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.

b) Honey combing of structure shall be avoided by proper use of needle vibrators. If honey combing is found, then the structural section shall be suitably replaced/treated with epoxy concrete as per directions of Engineer in Charge. Bleeding of concrete if encountered then direction of Engineer in Charge should be followed.

c) 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.

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

e) 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.

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

g) The formation of cold joints shall not be permitted.

h) No-fines concrete shall be lightly tamped only.

6.7.11 Vibrators

a) 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.

b) External vibrators shall be used only on approval from the Employer’s Engineer.

6.7.12 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 placing of concrete is delayed due to 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.

6.7.13 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.

6.7.14 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.

6.7.15 Placing under Water

a) 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.

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

c) Placing shall be commenced in approved sections and continued to completion.

d) 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.

6.8 Bonding of New And Old Concrete

6.8.1 General

Epoxy resins may be used to bond fresh concrete to concrete that is fully cured, to give a monolithic bond capable of transmitting high stresses when traditional bonding agents such as cement slurry cannot always be relied upon to provide good adhesion which is particularly the case when large areas are involved.

The formulation shall be applied to a suitably prepared concrete substrata and the fresh concrete poured as soon as possible, but always during the 'open time' of the adhesive. Material used shall be of best quality and approved by .the Employer's Engineer. Manufacturer's instruction shall be followed in all respects.

Preferably an Acrylic emulsion cement modifier shall be used.

6.8.2 Application

a) Preparation of the Substrata

b) To obtain good adhesion it is necessary to have a clean and sound substrata. Preparation can be carried out using a variety of techniques including chemical treatment and mechanical methods such as grinding, milling abrading, planning and sand blasting. Dust and loose particles resulting from the pre-treatment should be removed by vacuum cleaning or an oil-free air blast.

c) Mixing

d) The resin and hardener should be thoroughly mixed before mixing in the dry filler. The mixed, ready to use adhesive should not contain lumps of unwetted filler and should be of a uniform colour. For a total weight of 1 kilogram or less, hand mixing should be sufficient. For quantities in excess of 1 kilogram, the use of a mechanical mixer is recommended.

e) Pot life and 'Open Time'

f) The pot life is the period during which the ready to use Araldite based formulation must be applied. After this period the mix can no longer be worked and will have begun to set in its container. The table below indicates the pot life at different temperatures :

g) The 'open time' is the maximum period of time allowable between application of the ARALDITE adhesive and pouring the fresh concrete. Exceeding the 'open time' would result in considerably reduced adhesion.

h) The adhesive should be applied to the pre-treated substrata as soon as the components have been mixed and fresh concrete poured immediately afterwards.

i) Accurate knowledge of the 'open time' is essential in case the work in interrupted.

Table 1.9

Substrate temperature ^{0}C	Open Time
35	30 Minutes
30	1 Hour
25	1.75 Hours
23	**3 Hours**

j) Table 1.9 gives the 'open time' of ARALDITE base formulations as a function of substrata temperature. In all cases, the adhesives shall be applied immediately after mixing. Any delay between mixing and application will reduce the 'open time'. Fresh concrete must be poured before the adhesive begins to gel. New to old concrete bonding is not recommended at temperatures below 5°C as adequate curing cannot be assured under these circumstances.

k) Methods of Application

l) The shape and size of the concrete structure will determine the method of application used. The ARALDITE-based adhesive may be applied by hand using brushes, brooms or any other suitable applicator.

m) Suitability of the Fresh Concrete

n) The best results are obtained when the water/cement ratio of the new concrete is as low as is practicable.

o) Coverage

p) One kilogram of the mixed ARALDITE adhesive including hardeners and thinner covers an area of 2.3 sq. metres when applied with a stiff nylon bristle brush. However, the coverage is very much dependent on the finish of the concrete.

6.8.3 Handling Precautions

Epoxy resins can cause irritation of the skin of the person if incorrectly handled. Certain safety precautions must therefore be observed and those handling the resins and hardeners should be given suitable instructions. Those working with epoxy resins should, above all, be instructed that personal cleanliness at the place of work is essential. The resin and hardener should not be allowed to come into direct contact with the skin. The most effective protection is achieved by wearing rubber or polythene gloves, the latter having the advantage that they can be replaced when dirty. They are most pleasant to wear if cotton gloves are worn underneath. Parts of the skin which have come into contact with the resin or hardener should be washed with lukewarm water and a mild soap. Special cleaning creams have also proved to be highly suitable.

6.8.4 WATER STOPS AND JOINT FILLERS

At all vertical construction joints in walls of water retaining structures and all expansion joints in the water retaining structures and wherever specified or directed by the Employer's Engineer, water stops shall be provided. The water stops shall be of synthetic grade rubber and shall be as follows:

Tensile strength not less than	20 N per sq.mm
Elongation at break not less than	500%
Modulus at 300% elongation	5.1 N per sq.mm
Specific gravity	1.12
Compression set / constant deflection percent of original deflection at 700C for 22 hrs.	24% max.
Change in weight water immersion (2 days at 700C)	1.6% max.
Tensile strength and elongation at break as % of original, after oxygen pressure test 48 hours, 700C, 21.1 kgf per sq.cm before ageing	
Tensile strength	85% min.
Elongation at break	83% min.

Water stops shall not be exposed to direct sunlight for long periods. Before being concreted, water stops shall be cleaned of all foreign materials. Wherever provided, water stops shall be placed in such a manner that they are embedded in the adjacent sections of the panels for equal width.

The storage, fixing in position, splicing of water stops shall be as per the manufacturer's instructions.

Water stops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place concrete so that water stops do not bend or distort

The different type of water stops to be used in liquid retaining structures shall be as follows:

Table 1.10

S. No.	Type of Joint	Type of Water Stops
1.	Partial/complete contraction joint in walls and slabs	150 mm wide, ribbed with hollow center bulb and 5 mm minimum thickness
2.	Expansion joints in walls and slabs	225 ram wide, ribbed with hollow center bulb and 9 mm minimum thickness
3.	Construction joint in a raft	225 mm wide, ribbed with hollow center bulb and 5 mm minimum thickness
4.	Construction joint in wall	150 mm wide, ribbed with a hollow center bulb and 5 mm minimum thickness
5.	Partial/ complete contraction joint in a raft	225 mm wide, ribbed with hollow center bulb and 5 mm minimum thickness
6.	Expansion joint in a raft	225 mm wide, ribbed with a hollow center bulb and 5 mm minimum thickness

6.8.5 Joint Fillers

Joint fillers shall be of durable, compressible, and non-extruding material. The joint filler shall be Thermocol TF quality of thickness 25 mm. The side face of the reinforced concrete member shall be thoroughly cleaned with a wire brush and 85/25 industrial-grade hot bitumen, conforming to IS: 702 shall be applied uniformly over the surface at the rate of 1.5 kg/sq. m.

Thermocol boards (TF quality) of 25 mm thickness shall be stuck means of the same grade of hot bitumen. The joints of the boards shall be sealed with bitumen. Holes in joint filler to accommodate the dowel bars shall be accurately done to produce a sliding fit on the dowel bars.

6.8.6 Bitumen Paint

The material shall be of the best quality unpigmented bituminous base paint of such a composition as to satisfy the requirements of IS: 9862 where total volatile matter contained in the paint shall not exceed 55% by weight.

At least 95% of the solid materials shall be soluble, in carbon di-sulphide or in benzene, and the closed flash point as determined in Abel's apparatus shall not be less than (86°F)30°C. The paint shall remain liquid and retain its consistency at the ordinary atmospheric temperature when packed in suitable containers. The drying time shall not be less than 2 hours and not more than 8 hours and after drying, the paint shall not show any surface cracks, tendency to powder or discoloration due to weathering action or expansion and contraction, It shall also be able to resist the action of acids and alkalis. It shall soften under the action of mineral turpentine.

The film resulting from brushing the material on a strip of tinned iron, 30 standard wire gauge after being allowed to dry at room temperature not below (65°F) 18.3°C for 48 hours shall not when bent do1.lble over a (quarter inch) 6 mm dia rod, shown any signs of flaking or cracking. The time occupied for the actual bending shall not exceed" one second. When the paint has dried hard, a 4 H pencil should not be capable of scratching it. The weight of the paint shall be from 0.83 to 1.25 kg per litre, and the component of the paint shall be such as not to react with the water chlorinated or otherwise and develop poisonous or harmful elements thereto.

The paint shall be of Indian manufacture of approved make and quality.

6.8.7 Bitumen Kraft Paper

The Bitumen Kraft paper shall comprise of two plies or kraft paper laminated with bitumen. It shall conform to type 1 of IS: 1398. It shall be free of cracks. The adhesion between the plies shall be such that they cannot be separated by pulling apart with hands after conditioning as per Clause 2.1 of IS: 1060 Part I without damaging the paper. Its minimum bursting strength should be 2.3 kgs / sq / cms. Its tensile strength shall be as per IS: 1398.

6.8.8 Sealing Compound

The sealing compound shall satisfy the following requirements.

a) To seal the joints against the passage of water.

b) To prevent ingress of grit or other foreign matters and

c) To provide protection to the joint filler where necessary.

The various characteristic properties of the sealing compound that require consideration are adhesion, good extensibility, resistance to flow, resistance to ingress of foreign matter, resistance to weathering and resistance to oil, fuel and fat.

For application of, the sealing compounds the concrete shall be in dry condition. The subsequent climatic conditions after construction shall also be considered in the selection of proper sealing compounds and its application so that the sealing compound is able to withstand the stress and maintain its adhesive bond with the concrete. After allowing the concrete to dry, the sealing cavity shall be cleaned and exposed to the atmosphere for some time till it is dry.

While applying compounds, the manufacturer's advice may be followed with regard to the application of primer, if necessary. The application of primer shall be such as to cover the sealing cavity to the full depth. No excess primer shall be applied. Sufficient time shall be allowed after the application of primer so that it dries completely before the application of the sealing compound.

6.8.9 Tolerances in Concrete Surfaces

Concrete surfaces for the various classes of unformed and formed finished specified in various Clauses shall comply with the tolerances shown in Table 1.11 hereunder, except where different tolerances are expressly required by the specification.

In Table 9.11 'line and level' and 'dimension' shall mean the lines, levels and cross-sectional dimensions as specified and required.

Surface irregularities shall be classified as 'abrupt' or 'gradual'. Abrupt irregularities include but shall not be limited to, offsets and fins caused by displaced or misplaced formwork, loose knots and other defects in formwork materials, and shall be tested by direct measurement. Gradual irregularities shall be tested by means of a straight template for plain surfaces or its suitable equivalent for curved surfaces, the template being 3 m long for unformed surfaces and 1.5 m long for formed surfaces.

Table 1.11

Class of Finish	Maximum tolerances 9mm) in :			
	Line and Level	Abrupt irregularity	Gradual irregularity	Dimension
U1	±12	6	±6	---
U2	±6	3	±3	---
U3	±6	3	±3	---
F1	±12	6	±6	+12 - 6
F2	±6	6	±6	+12 - 6
F3	±3	3	±6	+6

6.8.10 Unformed Surfaces - Class of Finish

Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, 'spaded" or 'bonded concrete'. Where the class of finish is not specified the concrete shall be finished to Class U1.

Where a bonded concrete surface is specified, the laitance shall be removed from the Class U1 finished surface and the aggregate exposed while the concrete is still green.

A spaded finish shall be a surface free from voids and brought to a reasonably uniform appearance by the use of shovels as it is placed in the works.

Class U2 finish shall be a wood float finish. Floating shall be done after the initial set of the concrete has taken place and the surface has hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform surface free from screed marks.

Class U3 finish shall be a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked into the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

The addition of dry cement, mortar or water shall not be permitted during any of the above operations,

6.9 Formwork

6.9.1 General

a) All the formwork surfaces shall be plywwod where concrete is to be placed at site. The plywood should be in condition without any peel offs of surface film, free of undulations and warping.

b) Formwork shall be designed and constructed in accordance with the recommendations of relevant Indian standards or similar approved standards 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.

c) The Contractor shall submit details of formwork to the Employer's Engineer for review and approval in advance of concreting.

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

e) 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:

f) Total weight of formwork, reinforcement and concrete.

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

ii. Wind loads.

g) 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.

h) 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.

i) 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.

j) 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.

6.9.2 Form Ties

a) 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.

b) Bolt or tie systems which, when removed, leave a hole through the member, shall not be permitted in liquid retaining structures. Galvanized water stops with provision for tie rods fixing at both ends shall be used for water retaining structures. Tie rods shall be fixed with PVC sleeves 25 mm diameter and fish plate along with tie bolts. The PVC sleeve should be removed after de-shuttering and filled with non-shrink grout material of strength not lesser than the concrete.. 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.

6.9.3 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 void filler within otherwise rigidly constructed boxes.

6.9.4 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.

6.9.5 Formwork Props

a) Contractor shall use only metal props or cuplock system for slab formwork.

b) The Contractor shall submit formwork design along with calculations and a method statement for proposed prop bearings and sequence of propping / re-propping and back propping at least 14 days before commencement of concreting.

c) All props shall be supported on an adequate solid surface and shall not be placed directly on the ground. 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. Chamfers

d) PVC chamfers shall be used wherever fillets are required.

e) All external 90 degree corners in vertical concrete elements shall have a 25 millimetre x 25 millimetre chamfer unless shown otherwise on the drawings.

6.9.6 Treatment of Formwork

a) All formwork surface to be in contact with concrete shall be coated with an approved form release agent before the concrete is placed. The coatings shall be approved commercial formulations of satisfactory and proven performance.

b) 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.

c) 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.

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

6.9.7 Removal of Formwork

a) The consent of the Employer's Engineer 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. The formwork striking period shall be determined by the compressive strength of the concrete for slabs and beams and shall not be disturbed until the concrete has reached 75% of the design strength. The vertical formwork can be removed after a minimum 24 hours of concrete pouring but in any case, should not be removed until the initial setting is complete.

b) 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.

c) Where it is intended to re-use formwork, it shall be thoroughly cleaned and made good by the Contractor to the satisfaction of the Employer's Engineer.

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

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

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

g) Proposals by the Contractor for the striking of formwork shall be submitted to the Employer's Engineer for approval prior to the commencement of concrete production for the main works.

6.10 Joints

6.10.1 Construction Joints

a) The location of Construction joints shall be identified and the sequence of placing executed as approved construction joint locations and as shown in the Drawings.

b) Additional reinforcement for shear shall be well-planned and placed at the construction joints.

c) Concrete placing shall not be interrupted except where joints occur and shall continue after normal hours if necessary.

d) Horizontal joints shall be generally at least 500mm above ground level (relevant Indian standards shall apply), or as shown on the Drawings.

e) Upon removal of the formwork the joint face shall be chipped off and made suitable for bonding with the next pour..

f) 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 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. The joint surface should be cleaned and applied with suitable bonding agent mixed with cement prior to placing new concrete.

g) Construction joints in water retaining structures shall incorporate an approved water bar and construction joint details shall be submitted to the Employer's Engineer for approval.

6.10.2 Design Joints

a) Expansion and contraction joints shall be as per the approved drawings.

b) A contraction joints 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.

c) 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.

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

e) Design joint (contraction, expansion and sliding joint) shall not be provided for water retaining structures.

f) The method of joining water stops shall be in accordance with the manufacturer's instructions. Lapped joints shall not be allowed under any circumstances.

6.10.3 Movement Joints

Movement joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The Contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Employer's Engineer, demonstrate that the jointing materials can be applied satisfactorily.

The Contractor shall show locations of all movement joints and details thereof on drawings submitted for the Employer's Engineer approval.

The surface of set concrete in a movement joint shall, as shown on the Drawings, be painted with two coats of bituminous paint and new concrete shall be placed against it only when the paint is dry. Expansion joints shall be formed by a separating strip of approved performed joint filler. Caulking grooves shall be provided. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried, it shall be primed and caulked with approved sealing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and a 50 mm width of concrete on either side shall be painted with two coats of paint having the same base as the sealing compound.

6.11 Curing and Protection

6.11.1 Curing

a) 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 of concrete. See section 10.2.16.

b) 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.

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

d) 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 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 Employer’s Engineer. The ponded areas shall be kept continuously filled

with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing period is over.

e) Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Employer's Engineer. 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

f) Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer so as to obtain an efficiency as specified by relevant Indian Standards. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Employer's Engineer 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.

g) 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.

6.11.2 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:

a) Horizontal surfaces.

b) Polythene sheeting shall be placed immediately after finishing.

c) 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.

d) 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.

e) Alternative methods of curing must be approved before use where special finishes are required.

f) Vertical surfaces.

g) Polythene over wet hessian shall be secured to the surfaces immediately after removal of the formwork. The hessian shall be kept permanently damp.

h) After 14 days the hessian and polythene shall be removed and an approved aluminised or white resin based curing compound applied.

i) 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.

6.11.3 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.

6.11.4 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.

6.11.5 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.

6.12 Concrete Surface Finish

6.12.1 General

a) 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.

b) The internal faces of the tank shall be protected by an epoxy resin coating except where a GRP liner is provided. The total internal surface of water and sewage containers, walkways, steps, slabs, and soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

6.12.2 Concrete Surfaces without Formwork

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

b) 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.

c) 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.

6.12.3 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.

6.12.4 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.

6.12.5 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. It shall not be used at construction joints (see 10.5.10.1)

6.12.6 Carborundum Finish

Carborundum finish shall be achieved by sprinkling carborundum grit on the unset surface and working in by 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.

6.12.7 Specimen Panels of Concrete

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

6.13 Other types of Concrete

6.13.1 Precast Concrete

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

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

c) 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 date of casting. Steel bars shall not be embedded in the concrete for lifting.

d) 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.

6.13.2 Cement Mortar, Grout, and Rendering

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

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

c) 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.

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

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

6.14 Tolerances

6.14.1 Tolerances of Concrete Surfaces

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

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

6.14.2 Action in the Event of Non-compliance

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

b) Work should stop;

c) Investigation of the non-compliance;

d) Redesign of the concrete mix;

e) Improving quality control;

f) Cutting and testing specimens from placed concrete;

g) Durability testing of placed concrete;

h) Load testing relevant structural units;

i) Non-destructive testing of placed concrete;

j) Breaking out and replacing concrete.

k) In the event that the Contractor shall cut specimens from approved locations. Cores shall be tested in accordance with relevant Indian standards. 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.

l) The Engineer in charge 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.

6.14.3 Repairs and Remedial Works

a) 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.

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

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

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

6.15 Surface Protection Materials

6.15.1 External Sheet Tanking Membrane

External sheet tanking membrane to concrete substructures shall be an impervious, cold-applied flexible laminated sheet, consisting of multi-layer 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 be not 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/mm² Trans. 48 N/mm²
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	ASTM D1000/Equivalent	1.8 N/mm
Puncture Resistance	ASTM E154/Equivalent	290 N 65 mm
Water Resistance	ASTM D570/Equivalent	After 24 hours 0.14% After 35 days 0.95%
Environmental Resistance	ASTM D543/Equivalent	Conforms
Moisture Vapour Transmission Rate	ASTM E96/Equivalent	0.3 g/m²/24 hrs
Adhesive Softening Point	ASTM D36/Equivalent	Not lower than 103°C

6.15.2 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.

6.15.3 Internal Face of Liquid Retaining Structures

The internal faces of all liquid retaining tanks shall be protected by an epoxy resin coating except where a GRP liner is provided. The total internal surface, walkways, steps, slabs, and soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

6.15.4 Above-Ground Concrete Coatings

a) 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.

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

c) Coatings shall be applied by a specialist applicator approved by the manufacturer and the Employer's Engineer and shall have at least five years of proven successful experience.

d) A method statement for 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.

e) 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.

f) 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.

6.15.5 Surface Preparation

a) 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.

b) 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 application of coatings.

6.15.6 Testing of Water Retaining Structures

On completion of a structure 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 Employer's Engineer that this structure is structurally stable if filled for testing purposes and obtain the written approval of the Employer's Engineer 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 Employer's Engineer. 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 as described below.

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:

a) For the water tightness test, before the filling operations are started, the reservoirs shall be jointly inspected by the Employer's Engineer representative and the representative of the Contractor and the condition of surfaces of the 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 floodlights, circulators etc. for carrying out proper inspection of surfaces and internal conditions if so desired by the Employer's Engineer representative.

b) The water retaining structures shall be filled with water gradually at a rate not exceeding a 30 cm rise in water level per hour and shall not be filled more than one-fourth of capacity in one day. Records of leakages starting at different levels of water in the reservoirs, if any, shall be kept.

c) 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 after allowing for evaporation and rainfall, shall not exceed 1/500 of the average water depth of the full tank or 20mm, whichever is less. It shall be considered as an indication of the water tightness of the reservoir, conforming with IS: 3370 (Part 1)-2021. Also, there should not be any indication of leakage around the puddle collars or on the wall and bottom of the reservoir.

d) If the structure does not satisfy the test requirements and the daily drop in water level is decreasing, the period of the test may be extended for a further seven days and if the specified limit is not exceeded, the structure may be considered satisfactory.

e) In case the drop in water level exceeds the permissible limit within the stipulated period of the test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Employer's Engineer 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.

f) 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.

g) During testing and during the defect liability period the impression marks created due to seepage shall be rectified and made good by grouting.

h) All testing arrangements shall be subject to the approval of the Employer's Engineer.

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

j) Reinforced concrete liquid retaining structures shall be tested prior to the application of any 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.

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

6.15.7 General Arrangement of Utility Buildings/ Structures

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.

a) The general arrangements of all the treatment units of utility buildings and other structures like pump rooms, reservoirs, tanks etc shall be approved by the EMPLOYER/ PMNC. Changes if any suggested will be incorporated into the final layout at no extra cost to EMPLOYER/ PMNC.

b) Suitable passages, lifting eyes or other means shall be provided to permit the removal of equipment that may be required during its normal operational life for maintenance or any other purpose.

c) Areas where the leakage is likely to occur whether under normal use or during maintenance shall be provided with covered drainage channels, which shall direct spilled 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.

6.15.8 Orientation

a) The Layout of the proposed utility buildings/ structures shall be suitably prepared and fit within the space allotted to interface conveniently with the existing infrastructure of roadways as well as inlet and outlet pipe work.

b) 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's Engineer representative.

6.15.9 Buildings and Structures

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

a) The buildings shall have an aesthetically pleasant elevation with roof design suitable for the local climatic conditions.

b) All building works shall be in reinforced concrete framed structures.

c) All external walls shall be in 230 mm thick brick masonry built in cement mortar in (1:4) or AAC blocks with suitable adhesive.

d) All internal partition walls shall be in 230 mm thick brick masonry built in cement mortar (1:4) . The ceiling shall have 6 mm thick plaster in CM 1:3. The RCC stiffener columns and beams shall be provided in the masonry walls as per codal requirements.

e) 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.

f) All external masonry surfaces shall be plastered in two coats with sand-faced cement plaster in cement mortar (1:4) & shall have a 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 the use of PVC chicken mesh wherever applicable.

g) A parapet wall of 500 mm high with 230 mm thick brickwork shall be provided for Non Accessible roof and 1200 mm high with 230 thick brick wall/200 thick RCC wall shall be provided for the accessible roof.

h) All external surfaces above ground level shall be painted.

i) The type of flooring of various units shall be as specified in the Schedule of Finishes.

j) The minimum clear height of the floor shall be a minimum of 3.3m.

k) RCC Staircase shall be provided to permit access to the accessible roof of the building and platforms of treatment units. All non-accessible rooftops of the building shall be provided with a cat ladder made of stainless steel.

l) All staircases shall be provided with SS-304 hand railing. The top railing and vertical of the SS-304 railing shall be 32 mm dia. The lower railing shall be in SS-304 with a minimum 25 mm diameter.

m) All floor cutouts and cable ducts, etc. shall be covered with pre-cast concrete covers in outdoor areas and GRP chequered plates of adequate thickness in indoor areas. All uncovered openings shall be protected with an SS-304 hand railing fixed with two rails.

n) All doors, windows, and rolling shutters shall have chajjas above in order to prevent rainwater from splashing into the building. The minimum width i.e., projection from the building wall of chajja / lintels for doors, windows and rolling shutters shall be 750 mm, 600 mm & 900 mm respectively.

o) Stainless steel (SS 304) footrests shall be provided to access to the tank, pits, sumps, manholes etc.

p) The Ground Floor of all the building of utilities shall have 200 thick RCC (M25) Grade slab over 100 thick PCC. Grade slab shall be provided with 10 mm reinforcement bar at 200 mm c/c both ways alternatively.

q) 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.

r) The separate toilet facilities for ladies and gents shall be provided. The facilities for men shall include at least 1 WC, 1 Washbasin and 2 Urinals whereas facilities for women shall include at least 1 WC, 1 Washbasin. Bathroom accessories like shataf/ hand-held jet spray, soap bottle and holder, waste bin, mirror etc shall be provided.

s) All WCs shall be of approved make European type with a concealed flush tank and flushing mechanism.

t) 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. 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.

u) 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.

w) SS soap bottle and holder.

x) All stopcocks, valves and pillar cocks shall be of chromium-plated brass, heavy duty.

y) All fittings such as ‘P’ or ‘S’ traps, floor traps, pipes, down take pipes etc. in PVC Heavy Duty.

z) The wastewater from toilet blocks, laboratory, pantry etc. shall be connected to the sewer system.

aa) The washroom walls & floor tiles shall be Porcelain tiles of approved make at least 8 mm thick. The floor tiles shall be non-slippery and the walls shall be fixed for full wall height. The layouts for floor and wall tiles should be approved by PMNC before fixing. The size of the tiles shall be 300 x 300 for the floors and 300 x 600 for the walls. The joints of floor and wall tiles should be aligned.

bb) All steps shall have 20 mm nosing. The width of the staircase and passage shall be a minimum of 1.2 m.

cc) 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/ PMNC’s representative to access areas not frequently visited. Steel ladders are to be provided for access to chemical dosing tanks, if any.

dd) Electrical fittings, plumbing and bathroom fittings shall be in the bidder’s scope.

ee) Fire safety equipment shall be provided in this building.

ff) All floor cutouts 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.

gg) Hand railing/ protection shall be provided as follows:

hh) Parapet walls of min 1.2m height for outdoor RCC Platforms or bridges

ii) Buffed stainless steel grade 304 handrail/ protection (three rails viz. top, bottom and middle) of 1.2m height fixed to steel balustrades to be provided along access platforms and around sumps/ tanks.

jj) The reinforced concrete roofs shall be with Liquid bituminous waterproof coating followed by brick bat coba guaranteed for 10 years. Cement concrete cornice shall be provided for upstand joint. The finished roof surface shall have adequate slope/grading in cement concrete 1:2:4 to drain rainwater to RW down take points.

kk) For roofing drainage, UPVC pipes confirming 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.

ll) Top surfaces of eaves and canopies shall be made waterproof using polymer modified flexible cementitious membrane sloped to drain the rainwater.

mm) Plinth shall be a minimum of 450 mm above finished ground level around the building.

nn) All concrete channels and ducts used for conveying water shall have a smooth finish from the inside. The width of concrete channels shall not be less than 500 mm.

oo) Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of the Factory Act.

pp) All rooms in the utility buildings shall be provided with appropriate signboards indicating the function of the rooms involved.

qq) Wherever equipment & machinery are required to be moved for inspection, servicing, replacement etc. suitable moveable gantry/monorail of required capacity shall be provided.

rr) 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.

ss) Drinking tap water shall be provided in the utility buildings. The water purifier shall be fixed for drinking water purposes.

tt) Toilet blocks in utility building shall be provided with a sink/wash basin

uu) All plumbing Work shall be carried out in "C" class GI pipes both outside and inside the building and below ground including plumbing connection from the main water supply line of EMPLOYER/ PMNC.

vv) All chequered plates shall be GI and min 4 mm thick with proper fitting in place and arrangement for lifting.

ww) All doors and windows shall be as specified below

xx) Opening of the windows shall be a minimum 25% of the wall area.

yy) 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.

zz) A fire safety board and 'No Smoking' signboard shall be installed in the area prone to flame to prevent any accident and/or as per the D.C. rules.

aaa) Furniture shall be supplied as per details mentioned in the document elsewhere.

6.15.10 Roadways, Pathways and Hard Standings

a) A comprehensive RCC road network shall be provided around the utility buildings to link with the main road and the existing road network to permit vehicular access to each unit of the utility building for necessary maintenance, delivery of consumables and personnel

access. Road of min 7 m width with storm water drain shall be provided for the utility building.

b) Roads shall be designed as per provisions of IRC codes. The proposed roads shall have the following crust.

c) compacted subgrade of minimum 95% P.D.

d) granular sub-base (GSB).

e) wet mix macadam

f) Concrete pavement.

g) External lighting as per approved design and lux levels shall be provided for all utility buildings to ensure visibility at night.

6.15.11 Utility Building 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 stormwater drains shall be in precast concrete.

c) The stormwater drainage system shall also take into consideration the run-off from the existing Sewage Treatment Plant area and structures as necessary. The stormwater shall be directly discharged into the rainwater harvesting pit.

d) The design norms for stormwater drains shall be followed as per CPHEEO Manual.

6.15.12 Cable and Pipe Trenches

a) All external cables are to be laid in DWC pipe casing buried underground.

b) All the instruments such as measuring Meters, 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.

6.15.13 Pipes and Ducts

a) Precast concrete ducts for drainage shall have a minimum of 1m thick of soil overburden while running across a road.

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

6.15.14 Valve Chambers

a) Valve Chambers shall be of adequate size to facilitate ease in maintenance and operation. Valve chamber shall be in RCC construction. Valve chambers sizes shall be as per CPHEEO manual.

b) Inlet and Interconnection Chambers - These chambers shall be constructed in RCC. Each chamber shall be provided with platform at top as necessary. Suitable provision shall be made to access the bottom of the Chambers.

6.15.15 Manholes

Precast Concrete Manholes for sewer line shall be built for every change in alignment, gradient or diameter, at the head of all sewers and branches, at every junction of two or more sewers. The spacing and design of manholes shall be based on IS:4111 (Part 1) and other relevant codes, subject to approval of design consultant and Employer's Engineer.

a) Manholes shall be sufficiently spacious to accommodate a man to clean the same.

b) The manhole shall be circular and shall be construction in concrete only of required grade.

c) Where a pipe enters and leaves a manhole, on edge must be cut to proper form and laid around the upper half of pipe so as to form an arch. Where the depth of invert exceeds 1 meter below the surface of the ground, PVC encapsuled steps of approved pattern shall be built in at every four courses with additional hand irons.

d) The covers shall then be placed in position and the whole work shall be left neat and dry.

e) Covers and frames shall be circular in pattern of ductile iron conforming to IS: 1726 coated with Dr. Angus Smith's composition or precast conforming to IS 12592:2002. They shall be airtight, heavy pattern only, weighing about 150 kg to 180 kg

6.15.16 Finishes

a) Interior Wall (other than water retaining structure):

b) All interior walls should be finished with sand-cement plaster, POPand Emulsion paint system.

c) Exterior Wall (other than water retaining structure):

d) 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.

e) The structure shall be sand faced cement plastered followed by exterior type two coats of approved quality and colour of acrylic exterior emulsion wall finishing paint over one coat of primer.

f) This shall be of approved shade and brand to give an even shade on the Work in 2 or more coats.

g) All the structures above ground shall be painted with 2 coats of acrylic emulsion paint over a coat of primer.

h) Liquid Retaining Structure: the inside surface shall be made water proof using minimum 4mm thick GRP lining whereas the outside surface of the water retaining structures shall be painted by water repellent epoxy paint in three coats including primer of the following approved make.

   i. Berger Paints

   ii. Mc-Bauchemie

   iii. Fosroc

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

j) technology buildings/chambers/tanks - 2 coats of epoxy paint or acrylic paint over epoxy primer over 2 coats of an approved brand of wall putty shall be applied from outside for a pleasant aesthetic appearance as per the Manufacturer’s specification and approved by Engineer in charge

k) All elevated RCC platforms, walkways around and across all units of WTP/STP/CETP including along the channels shall have flooring of chequered tiles of minimum 22 mm thick.

l) Wherever specified, staircases shall be finished with 25 mm thick grey/black granite treads in single piece and 12 mm thick grey Granite Riser and Skirting. The rise of stairs shall not exceed 170 mm and the minimum width of the tread shall not be less than 275mm.

m) Flooring for various building shall be as follows:

Administrative Building/SCADA Building/ Laboratory	Vitrified glazed tiles 600 x 600 mm or any suitable size.
Pump houses/other process buildings, etc.	Polished Kota stone flooring.
Toilet	Matt finish ceramic tiles

6.15.17 References & Standards

a) Except where otherwise specified the works under this project shall comply with the requirements of relevant Indian Standards (IS), CPWD specifications and manufacturer's instruction manual. If required reference is not available, for any of the work(s) mentioned in the specifications and tender, in IS code(s) then relevant clauses of either British Standards (BS), American Standards (AWWA) or ISO Standards shall be followed. The following standards and the amendments made thereto till date and any other IS code provisions found to be applicable to this work shall be binding on the bidders (bidding and executing the work). All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions and amendments of the standards.

b) The bidders are therefore advised to refer to and follow all relevant IS codes and amendments along with relevant ISO codes till date regarding supplying, testing, and commissioning of DI/HDPE pipes and fittings, their testing, dimensions and measurement, composition of raw material, physical properties, mechanical characteristics, laying, jointing and their performance requirements, sampling and conformity criteria, marking and certification, etc.

c) If there are varying or conflicting provisions made in any one document forming part of the contract, the Accepting Authority shall be the deciding authority with regard to the intention of the document and his decision shall be final and binding on the contractor.

d) Following actions shall be taken where no Specifications are specified:

e) In the case of any class of work for which there is no such specification, such work shall be carried out in accordance with the Bureau of Indian Standards Specifications. In case there is no such specification in the Bureau of India Standards, the work shall be carried out as per the manufacturer's specifications. In case there are no such specifications as required above, the work shall be carried out in all respects in accordance with the instructions and requirements of the Employer's Engineer.

f) All materials and workmanship not fully specified herein or not covered by an approved relevant standard shall be of such kind as is used in first-class work and suitable to the climate in the project area.

6.15.18 Site Preparation

Before commencing the works and also during progress the bidder shall give due notice to the concerned authorities as may be required to the effect that the work is being taken up in a particular location and that necessary diversion of traffic may be arranged for. The contractor shall cooperate with other contractors and government agencies and provide for necessary barricading of roads, protections to existing underground mains, cables etc.

a) Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey, record existing ground elevations and stake the location of trenches to be excavated.

b) The Contractor shall obtain relevant excavation and road cutting permits as required for commencing the work at the site.

c) The Contractor shall perform the clearing and grubbing (if any), of topsoil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300 mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and offloaded, spread and levelled to approved dumps as directed by the Engineer.

d) The Contractor shall include for grading the route to provide access for his equipment and personnel, executing all cuttings to remove the high point of rises in terrain and in all respects prepare the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.

6.16 Removal, Restoration & Maintenance of Surface

6.16.1 Removal of Pavement

The existing pavements may be required to be removed as per the design requirement and the existing services like Water, Power etc to the adjoining villages may also be affected due to construction works. The contractor to ensure the continuity of services and access for the villagers all the time. Any damages to the villagers property, roads or services due to contractor's construction activities shall be made good by the contractor without any additional cost.

The Contractor shall remove pavement and road surfaces as a part of the trench excavation, and the volume removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures. The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the top width of the trench specified by more than 200 mm on each side of the trench. The widths and lengths of the area of pavement removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 300 mm on each side. Wherever, in the opinion of the Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the Engineer but shall receive no extra compensation therefore. The Contractor shall use such methods, either drilling or chipping, as will assure the breaking of the pavement along straight lines. The cut must be sharp and approximately vertical. The Engineer's representative may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

6.16.2 Supporting Excavation

The Contractor shall be well and effectually support the sides and ends of all excavations to prevent fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation. Any excavation necessary to provide space for such support or other working space shall be carried out. If, for any reason, any portion of the bottoms, sides or ends of any excavations shall give way, the Contractor shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby distributed. Where the Contractor elects and is permitted by the Employer's Engineer / PMNC Consultant to perform excavations with sloping faces (other than sloping excavations shown on the drawings or required as permanent features of the works) and without shoring, the

excavated faces shall be to stable slopes and heights. No extra cost shall be paid for any additional excavation and backfilling.

6.16.3 Shoring

The shoring shall be designed adequately to prevent caving in of the trench walls by subsidence of soil adjacent to the trench. Contractor to allow for shoring wherever required.

6.16.4 Dewatering

Trenches shall be dewatered for laying of pipes or any brick or concrete work and kept dewatered until the pipe joints or brick work or concrete have cured. The pumped-out water from the trenches shall be disposed of in existing storm water drainage arrangement nearby. Precautions are to be taken to arrest potential floating of the laid pipelines, arising out of induced buoyancy during rainy season.

6.16.5 Backfilling of Trench Excavations

Trench excavations shall be refilled using suitable materials selected from excavations carried out at site or borrow areas as directed by the Employer's Engineer / PMNC Consultant.

Soft material (free from stones greater than 25 mm in size shall be deposited in 150 mm layers and thoroughly compacted with plate/ roller compactor under and around the pipe working alternately on either side of the pipe (particular care being taken to avoid damage to the pipe and any sheathing) until the trench has been refilled upto the swell of the pipe, thereafter until the soft filling has been carried up at least 300mm above the top of the pipe.

The remainder of the refilling may consist of coarse material (including broken rock from excavation in hard rock) free from boulders and clods of earth larger than 150 mm in size provided that the compacted backfill is, in the opinion of the Employer's Engineer sufficiently dense to prevent material from the superimposed layers being washed into the voids in such backfill. This coarse material shall be spread in layers of not greater depth than 225 mm and be thoroughly rammed by an approved mechanical rammer. The coarse filling is to be carried up to the level at which (in roads and footpaths) surface reinstatement is to commence or (elsewhere) to such level as with the surface reinstatement of the whole of the topsoil will leave the finished work sufficiently "proud" to allow for future settlement to the original ground level.

Hard material such as broken rock and original road metalling shall normally be used only for the surface reinstatement of roads as. Specified but where it is suitable and available in sufficient quantity it may be used in place of or as well as the aforesaid coarse material.

Where necessary the Contractor shall adjust the moisture content of the refill material either by drying out or by adding water to assist the compaction of the material.

Should the material being placed as refilling, while acceptable at the time when approved, become unacceptable to the Employer's Engineer due to exposure to weather conditions or due to flooding or have become puddle, soft or segregated during the progress of the works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material. Where directed by the Employer's Engineer / PMNC Consultant trench excavations shall be refilled with concrete.

Any excavation required for thrust block for pipes shall be carried out by the contractor without any additional cost.

6.17 Brickwork/Blockwork

Brickwork shall be built in accordance with the requirements of IS: 2212. Every brick shall be wetted and laid on a full and close joint of mortar on its bedside and end in one operation, joints being fully flushed up as the work proceeds. The previous course shall be wetted if it has dried

and the walls shall be brought up evenly with no portion racked up (and not toothed) more than one metre higher than another. All brickwork shall be properly bonded together. Joints shall not exceed 10mm in thickness and shall be raked out to a depth of 7.5mm as a key for rendering or plastering. All courses shall be truly horizontal and all perpendiculars shall be strictly plumb and square.

In the cavity walls, the two leaves of brickwork shall be bonded with galvanized wall ties 150 mm to 250 mm long as required. The ties shall be built into the horizontal joints as the work proceeds and the space between successive ties shall not exceed 750 mm horizontally nor 250 mm vertically. Ties shall be staggered and shall be laid sloping down towards the outer leaf of the cavity. Cavities shall be kept free from mortar droppings by the use of suspended battens and temporary openings at the bottom of the wall. Every fourth vertical joint in the external face in the course immediately above the horizontal damp-proof courses shall be raked out and left open to form a weep hole. Completed brickwork shall be kept wet for a minimum period of 14 days.

Precast Concrete Blocks

Factory-made precast concrete blocks of a minimum 10 N/mm2 from an approved manufacturer shall be used for construction. No blocks shall be casted or produced at the site.

Testing of Blocks

The Contractor shall submit 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.

6.17.1 Concrete Screen Walling Blocks

a) 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.

b) Damp proof Course shall conform to relevant IS code.

c) Felt for damp proof courses shall be bituminous 3-ply felt to relevant IS code.

6.17.2 Uncoursed Stone Masonry

Uncoursed stone masonry shall be built in layers not exceeding 450 mm in height. No stone shall be less in breadth than 14 times its height and less in length than twice in height. Every stone whether large or small shall be laid in its natural bed and set flush in mortar, and the small stones used for wedging or filling being carefully selected to fit the interstices between the large stones. Care shall be taken to see that no dry work or hollow space is left in the masonry. The stones shall be so arranged as to break joints at least every 80mm and long vertical joints of joints shall be avoided. The joints at the face shall be finished off neatly, being struck and smoothed with a trowel, while the mortar is fresh. The upper surface of the work shall be brought to a uniform level at the height of each course. The faces of masonry walls shall be kept in perfect plumb and where the batter has to be given it shall be uniform. The stones at all comers and junctions of wall shall be of large sizes and hammer dressed to the concrete angle.

Each stone shall be thoroughly wetted before being used in the work. The masonry shall be kept thoroughly wet during the progress of the work, (care being taken to water it even on Sundays and Holidays, special labour being employed if so required for this purpose) until it becomes hard. As far as practicable, the whole of the masonry shall be raised in one uniform level and no part of the masonry shall be allowed to rise more than 1 metre above the rest to avoid unequal settlement. If raising one part of wall before the other becomes unavoidable the end of the raised portion shall be racked back in steps to prevent cracks developing at the junction of the old and new work. Care shall be taken to see that the sides of the wall are not built separately from the hearting, the faces and internal filling being done simultaneously. The stones shall overlap and

cross each other as much as possible. No course shall be laid unless the previous close is perfectly set.

At least one header or through stone per square metre of wall face shall be built into the work. The headers or through stones shall be at least 0.05 m2 in area at face and shall have at least 0.025m2 area at the back face. Where the thickness of the wall is more than 600 mm a series of through stones shall be laid through the work so as to form front to back, breaking joints or overlapping each other for at least 150 mm. No stone whose length is less than 600 mm shall be used in such work as a header.

All the through stones shall be marked inside and outside and the marks shall be retained until ordered by the Employer's Engineer to be removed. Sufficient number of headers shall be collected on site before commencing any masonry work. Where adequate sized through stones are not available in required quantities, the use of pre- cast plain concrete headers in M-20 mix may be permitted at the discretion of the Employer's Engineer. No extra payment will be made for the provision of substitute headers in concrete.

Quoins shall be 150 mm high and formed of header stones at least 300 mm long. They shall be laid lengthwise alternately along each face and square on their beds, which shall be dressed to a depth of at least 80 mm.

Weep holes 80 mm wide and 150 mm in height shall be provided in retaining walls at the rate of one square metre as specified or directed. They shall be pointed with 1 : 2 cement sand mortar after raking the joints to a minimum depth of 25 mm.

Completed masonry shall be kept wet for a minimum period of 14 days, hi wet weather newly laid masonry shall be protected from the effects of heavy rainfall by tarpaulins or other approved material.

6.17.3 Pointing of Uncoursed Masonry

Joints in exposed masonry faces shall be formed while the mortar is still green and shall be finished as flush joints, weathered joints, round-recessed joints or square-recessed joints as directed by the Employer's Engineer. Masonry which is to be rendered or plastered shall have the joints raked out to a depth of 1 5 mm to form a key.

6.17.4 Stone Pitching

Stone pitching to slopes shall be carried out where specified or as directed by the Employer's Engineer. Stone for pitching shall be obtained from an approved source and shall be hard, sound, durable, clean and generally as specified. The minimum dimension of any stone shall be at least equal to the specified thickness of the pitching.

After excavation and trimming, slopes to be pitched shall be spread with a 75 mm thick layer of crusher run rock or graded coarse aggregate ranging from 75 mm particle size to fines. The slope shall then be hand packed with hard broken rock to a total thickness of 150 mm, each stone being individually placed and rammed home, with smaller stones edged into the cracks. 50 mm diameter weep holes shall be provided where specified at intervals not exceeding two metres in both directions. Joints in stone pitching shall be flushed up with sand/cement mortar on completion.

6.17.5 Rubble Stone Packing

Rubble used for packing under floors, foundations, etc., shall be hard and durable rock, free from veins, flaws and other defects. The quality and size of the rubble shall be subject to the approval of the Employer's Engineer.

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

The bed on which rubble soling is to be laid shall be cleared of all loose materials, levelled, watered compacted and approved by the Employer's Engineer.

Small interstices shall be filled with hard clean sand and well watered and rammed. Cable or pipe trenches if shown in the drawing and as required by the Consultant shall be done before the soling is started. Over the prepared surface, the stone shall be set as closely as possible and well-packed and firmly set. The stones shall be of full height and shall be laid so as to have their bases of the largest area resting on the subgrade. Soling shall be laid in one layer of 230mm or 150mm or other specified thickness and no stones shall be less than 230mm or 150mm depth or specified thickness of soling with a tolerance of 25mm. After packing the stones properly in position, the interstices between them shall be carefully filled with quarry spoils of stone chips of larger size possible to obtain a hard, compact surface. Spreading of loose spoils or stone chips is prohibited.

All interstices shall be filled with approved murrum. Excess murrum if any over the surfaces shall be removed. Unless otherwise specified, the murrum shall be supplied by the Tenderer at his own cost from the selected areas. The surfaces shall then be watered and consolidated with mechanical or sufficiently heavy wooden tampers and log-rammers as approved by the Consultant to give the required slope or level and dense sub-base. After compaction, the surface shall present a clean look. Adequate care shall be taken by the Tenderer while laying and compacting the rubble soling to see that concrete surfaces in contact with soling are not damaged.

6.17.6 Rubble Soling

Rubble soling for road work including footpaths, culverts, side drains etc. shall be carried out as specified herein as above for rubble stone soling, as far as they are applicable, with the following additions.

Subgrade for soling shall be prepared by cleaning of all foreign substances including rank vegetation, if any. Any ruts or soft yielding places that appear due to improper drainage conditions, traffic, hauling or from any other cause shall be corrected by filling/cutting up to 150 mm and compacted and the Subgrade dressed off parallel to the finished profile and the same shall be approved by the Consultant, before laying of soling. Soling shall be laid in regular lines and staggered joints. The stones shall be laid as closely as possible and packed well. The stones shall be so laid as to have their bases and the target area resting on the Subgrade and in contact with each other.

Soling shall be laid to proper gradient and chamber, which shall be checked frequently to ensure accuracy. Rolling shall then be carried out by an 8 to 10 T power roller and soling consolidated properly shall be lightly sprinkled during rolling, if ordered by the employer's Engineer. The surface thus prepared shall first be passed by the Consultant, after which 40mm to 50mm thick layer of selected hard murrum available from excavation shall be spread over the soling as directed by the Consultant, and rolled again such that the hard murrum gets into the interstices, It shall, however, be ensured that a thin layer of murrum/grit shall remain on the finished surface of soling. The area of soling actually done of specified consolidated thickness limiting to the dimensions as per drawing. Shall be measured in square metre upto two decimal places.

6.17.7 Finishes in General

The Contractor shall demonstrate his ability to apply finishes to the standards required under the Contract. If in the opinion of the Employer's Engineer, the demonstrations do not satisfy the

standards required, the Employer's Engineer may order the Contractor to employ a specialist firm of subcontractors approved by the Employer's Engineer to carry out all or part of this work.

6.17.8 Reinforcement for Finishes

Reinforcement for all external walls shall be stainless steel (grade 316) expanded metal mesh strip supplied by an approved manufacturer. Galvanised mesh shall be used for all internal walls. The mesh shall be placed on every alternate course.

Fe 516 reinforcement bars shall be used for concrete infill and lintels as per the approved design.

6.17.9 Anchor Ties

Slots and anchors for bonding to concrete shall be of 18-gauge galvanised steel (supplied by an approved manufacturer) fixed on an alternate course.

6.17.10 Movement Joints

a) Sealant for movement joints shall be gun grade quality and shall conform to Indian standards.

b) Movement joints shall be primed with an appropriate primer and backed with debonding tape or foam prior to sealing.

c) Sealant, debonding tape or foam, and primer for sealant shall be obtained from the same manufacturer unless otherwise approved.

6.17.11 Mortar Mixes

a) Mortar for blockwork shall be a mix measured by volume of one part of Ordinary Portland Cement, and four parts of sand. The minimum compressive strength at 28 days shall be 5.5 N/mm2.

b) Plasticiser may be used. However, the quantity of plasticiser used shall be strictly in accordance with the manufacturer's recommendations.

c) Mortar shall be tested in accordance with Indian standards at the rate of one sample per 25m² of blockwork.

6.17.12 Mortar – Specifications

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.

6.17.13 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.

6.17.14 Laying of Blockwork

a) Blockwork shall be laid in accordance with the recommendations of Indian standards.

b) Blocks shall be wetted by sprinkling with fresh water before being laid.

c) 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.

d) 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.

e) 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. Perpends, quoins and the like shall be kept strictly true and square and the whole properly bonded together and levelled.

f) 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.

g) Wall faces which are to receive an applied finish shall be hacked and the joints shall be raked out to form a key.

6.17.15 Non load Bearing Walls

a) All structural work shall be framed concrete structure and all walls shall be non-loadbearing walls.

b) 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 or the ties can be fixed mechanically through anchors to concrete members.

c) 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.

Bearings for Lintels

All the blocks below the bearing for the lintel shall be essentially solid blocks.

6.17.16 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

Utility Building Finishes

130.1.2 Screed and Render

Cement and Water

Cement and water shall be as specified for Concrete.

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.

6.17.17 Laying of Floor Screed

a) 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 of 1% falls to floor drains.

b) 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 the 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.

c) 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.

d) A minimum of 24 hours shall elapse between the placing of adjacent bays.

e) Finished bays shall be continuously wet-cured for 7 days.

6.17.18 Indian Patent Stone Flooring

a) The Indian Patent Stone Flooring shall be 50mm in thickness and shall consist of cement concrete mixed in the proportion of 1: 2: 3 (with 12.5 mm chips only) with an admixture of the approved water-proofing compound. The least amount of mixing water that will produce a workable mix and will allow finishing without excessive trowelling shall be used. Generally, a water cement ratio of 0.5 should suffice.

b) It shall be laid, after applying to the surface neat cement slurry, in bays of suitable sizes but not exceeding 6 sq.m. each, and required slope in a chess board alternate panel fashion and neatly finished smooth in red colour where directed with lines drawn as directed. The concrete shall be cast against teakwood stop-off boards, which shall be removed only after the concrete is set.

c) No dry cement shall be allowed to be used for finishing the surface. Mechanical mixing may be resorted to.

d) The surface shall be kept well watered after it is dry, for period of 8 days.

e) Construction joints shall be formed in between the sequential panels cast, with straight edges, 20 mm deep and 12 mm wide in groove form. These joints on completion of work, shall be cleaned and washed free of dust with the help of brush and shall be treated with hot bitumen poured in the gap, over which fine sand shall be spread to arrest the flow of bitumen.

6.17.19 Shahabad/ Tandur/ Kota Stone Flooring

a) Stones shall be of approved quality, hard, sound, durable and of uniform thickness. Edges shall be chisel dressed and the top surface shall be machine polished with joints running true and parallel from, side to side. Stones shall be laid on a bed cement mortar or proportion 1: 4. Thickness of mortar bedding shall not be less than 12 mm and not more than 25 mm. Before laying, the stone slabs shall be thoroughly wetted with clean water. Thick cement slurry shall be spread over the mortar bed over as much area as could be covered with the stone slabs within half an hours. The slabs shall then be laid and gently tapped with mallet till they are firmly and properly bedded. There shall be no hollows left. The joints shall not be more than 2mm wide and shall be struck smooth. The floor shall be kept covered with damp sand or water for a week. Slabs shall be of standard sizes and shapes and shall meet all the required properties and test requirements as stipulated in IS: 1124.

b) Stones in skirting shall be laid against bedding of cement mortar 1: 4 20mm thick to the full height of skirting, to a true plane, level and plumb,. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. The continuous horizontal grooves at the top of the skirting shall be provided if required. The

skirting surfaces shall be repolished with hand to the satisfaction of the Employer's Engineer. The skirting shall be cured for 7 days. The top of exposed skirting shall be machine-cut and polished. The used at projecting corners shall be suitably levelled to present as a neat corner.

6.17.20 Tile Flooring and Dado

a) Glazed tiles including angles, corners, borders and specials shall be of the approved make and quality, Johnson or equivalent with mat finish.

b) The tiles before laying shall be soaked in water for at least 2 hours and shall be set in concrete mortar of one part of cement, and two parts of lime for dado to walls. Tiles which are fixed in the floor adjoining the wall shall be so arranged that the surface of the round edge tiles shall correspond to the skirting or dado. Neat cement grout of honey-like consistency shall be spread over the bedding mortar just to cover so much area as can be toiled within half an hour. The edges of the tiles shall be smeared with neat white cement slurry and fixed in this grout one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. There shall be no hollows in the bed or joints. The joints shall be kept as close as possible and in straight lines. The joints between the tiles hall not exceed 1.5 mm in width.

6.17.21 Heavy Duty Abrasion Flooring

The type, quality, size, thickness, colour, etc., of the tile for flooring and skirting work shall be of the best quality approved by the Employer's Engineer. For this purpose, the Contractor shall provide the Employer's Engineer with necessary samples for his selection. Tiles shall be hardwearing, resistant to impact, resistant to abrasion, free from slipperiness and also resistant to attack by water, oils and greases. The tiles shall be laid on cement concrete mortar bedding of about 30 mm thick to give an overall thickness of 50mm.

6.17.22 Integral Cement Finish On Concrete Floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded, off to the proper level and tamped with tamper having conical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface.

6.17.23 Dividing Strips

a) 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.

b) 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 Employer’s Engineer/Employer for selection of a colour.

6.17.24 Self-levelling Floor Compound

a) 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 Level top 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 deg C.

b) 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 is one layer, strictly in accordance with the manufacturer's printed instructions.

6.17.25 Concrete Surface Hardener

Where required by design consultant, 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.

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.

Render

Render shall be a pre-mixed of approved make either dry or wet. No site mixed mortar shall be allowed.

Render shall be mixed with clean water in mechanical mixer with Water to Cement ratio as per the manufacturer's recommendations.

6.17.26 Application of Render

a) Blockwork walls shall be left for at least 14 days before the application of render.

b) As far as is practicable, rendering shall not be commenced until all mechanical and electrical services, conduits, pipes, and fixtures have been installed.

c) 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.

d) Surface to be rendered shall be clean and free from dust, loose mortar and all traces of salts.

e) Surfaces shall be thoroughly sprayed and soaked with fresh water, and surface water allowed to disappear before render is applied.

f) 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.

g) Wet curing of finished render shall be undertaken for a minimum of 4 days, but as long as is necessary to prevent cracking.

h) 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.

6.17.27 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.

6.17.28 Textured Protective Paint Finish

a) Textured protective paint finish to render and concrete shall be anti- algal and water resistant paint system as approved. The paint finish shall be applied as one coat sealer coat followed by one coat of texture and two coat of finish paint, all strictly in accordance with the manufacturer's recommendations. A sample board showing different layers of paint should be submitted to engineer for approval. A sample board showing different layers of paint should be submitted to engineer for material approval.

b) 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.

c) Sample panel of 1 sq. m size four numbers shall be installed on site for colour approval by client/ Employer’s Engineer.

d) The applicator for the paint system shall be empanelled with the approved paint manufacturer.

6.17.29 Smooth Protective Paint Finish

a) Smooth protective paint finish to render and concrete shall be of approved make. The paint finish shall be applied as one coat of primer, followed by two coats of paint all strictly in accordance with the manufacturer's recommendations. A sample board showing different layers of paint should be submitted to engineer for material approval.

b) 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.

c) Sample panel of 1 sq. m size four numbers shall be installed on site for colour approval by client/ Employer’s Engineer

d) The applicator for the paint system shall be empanelled with the approved paint manufacturer.

6.18 Painting

6.18.1 Stopping

Stopping of surfaces prior to painting shall be carried out using the following materials:

a) For render it shall be cement based filler.

b) For concrete or blockwork, it shall be of similar materials to the background and shall be finished with a similar texture.

c) 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.

d) 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.

6.18.2 Surface Preparation

a) 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.

b) 2 coats of approved brand of wall putty to be applied to exterior walls prior to application of epoxy primer and painting on buildings as per Manufacturer's instruction.

c) The internal faces of tank and chemical buildings shall be protected by an epoxy resin coating except where a GRP liner is provided.

d) Concrete surfaces shall be clean, dry and free from loose material before painting.

e) 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.

f) Surfaces shall be cleaned and rubbed down between each coat.

6.18.3 Painting and Decorating

a) Painting and decorating shall be executed in accordance with the recommendations of relevant Indian standards.

b) Every possible precaution shall be taken to keep down dust before and during the painting process. 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.

c) 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.

d) 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.

e) 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.

f) 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.

g) 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.

h) Dilution of painting materials shall not be allowed except as recommended by the manufacturer and as approved.

i) The total internal surface of water and sewage containers, chemical buildings, walkways, steps, slabs, soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

j) The inside wall of the laboratory, if any, shall be provided with two coats of oil-bound distemper of approved quality of colour over a coat of primer; for the outside walls, two coats of waterproof cement paint of approved quality and colour shall be provided. All steel surfaces in a lab are to be painted with approved anticorrosive paint.

k) The total internal surface of water and sewage containers, chemical buildings, walkways, steps, slabs, soffits shall be painted with 2 coats of epoxy paint or acrylic paint over epoxy primer.

l) The inside wall of the laboratory, if any, shall be provided with two coats of oil bound distemper of approved quality of colour over a coat of primer; for the outside walls, two coats of waterproof cement paint of approved quality and colour shall be provided. All steel surfaces in a lab are to be painted with approved anticorrosive paint.

6.18.4 Decorating Materials

a) Paint shall be supplied in sealed branded containers, by one of the following manufacturers, or equal and approved:

b) Asian Paints

c) Berger Paints

d) Nerolac Paints

e) Dulux

f) Nippon paints

g) Indigo paints

h) 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.

i) White spirit, size, knotting all shall comply with Indian standards.

6.18.5 Care of Materials

i. 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.

ii. Decorating materials shall be used within six months of delivery.

iii. 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.

iv. 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.

6.18.6 Colour Scheme

a) Colours of building finishes shall be as detailed in the specifications.

b) Colours shall not be mixed on-site.

6.18.7 Workmanship

a) 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.

b) 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.

c) The tint of each coat shall vary from the previous one and each coat shall be approved before the next is applied.

d) All the finishing tints shall be approved.

e) Each coat of paint and the like shall be thoroughly dry before the application of a further coat.

f) Not less than 24 hours shall be allowed between each coat, but the maximum intervals shall not exceed 21 days.

g) 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.

6.18.8 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.

6.18.9 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.

6.18.10 Painting of Woodwork

a) 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.

b) 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.

c) After erection on site a further coat of primer shall be applied to all accessible faces.

d) 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.

e) Joinery shall then be given two coats of undercoating paint followed by one or more coats of alkyd resin enamel paint.

6.18.11 Painting of Exposed uPVC Pipework

Exposed uPVC pipework, fittings and brackets shall be abraded and painted with three coats of exterior quality emulsion paint.

6.18.12 External protective coating for visible structures

a) 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 Employer's Engineer, in advance of the permanent coating works.

b) 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.

6.19 Tiling

6.19.1 Tiles - General

a) The Contractor shall not place an order for any tiles unless a sample has been submitted to,and approved in writing by the Employer's Engineer. Tiles delivered to site shall be of the same standard and quality as the approved sample.

b) Porcelain tiles shall be supplied by one of the following manufacturers, or equal and approved:

c) H&R Johnson Tiles Ltd

d) Kajaria Ceramics Ltd.

e) Bajaj Tiles.

f) Nitco Ltd.

g) Orient Bell Ltd.

h) Regent Granito India Ltd.

i) Somany Ceramics Ltd.

j) Asian Granito India Ltd.

k) The flooring for laboratory and battery rooms shall be in acid-resistant vitrified tiles and the make, quality and colour shall be got approved by the Engineer in Charge.

l) Dewatering building, washrooms and staircases shall be provided with antiskid tiles.

6.19.2 Porcelain Floor Tiles

Porcelain tiles of a minimum 8mm thick shall be used for the flooring and a minimum of 6 mm thick should be used for the walls. The tiles should be full body porcelain of approved make and size complying with IS 13712 : 2006. 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 1. A minimum of 10 samples of the proposed tile should be submitted for selection by client and to agree on variation in colour and size.

6.19.3 Porcelain Skirting Tiles

Porcelain 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.

6.19.4 Laying and Grouting of Floor and Skirting Tiles

a) Porcelain floor and skirting tiles shall be fixed and grouted in accordance with the manufacturer's requirements Grout shall be coloured as directed using a proprietary colour mix.

b) 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.

c) Where tiles abut sanitary fittings, gullies, pipes etc., joints shall be sealed with an approved silicone sealant.

d) 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.

6.19.5 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.

6.19.6 Acid Resistant Tiles

Chemical Buildings, Laboratories, Battery Room etc. shall be provided with acid-resistant tiles of suitable grade as approved by the Employer’s Engineer

6.19.7 Fixing and Grouting of Wall Tiles

a) Fixing and grouting of wall tiles shall be executed in accordance with the manufacturer's recommendations.

b) 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.

c) Particular care shall be taken to keep all courses perfectly horizontal, all perpends truly vertical and joint widths consistent.

d) 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.

6.20 Miscellaneous

6.20.1 False Flooring

Modular false 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.

6.20.2 Roller Shutter Doors

Roller shutter access doors shall be facing mounted, rotating handle operated units of approved make. 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 counterbalance 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.

6.20.3 Roof Coverings

Guarantee

The Contractor still provides a ten-year guarantee for the roof waterproofing, and shall effect any necessary remedial work within 30 days of formal notification.

Cement

Cement shall be Ordinary Portland Cement or as specified in the tender document.

Sand

Sand shall be wadi sand and shall comply with relevant Indian standards.

Water

Potable water shall be used for roof cover.

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.

Waterproofing Materials

Waterproofing materials shall be MasterSeal, Krytonite, Dr Fixit LEC, Newcoat, Bridge Deck waterproofing or equal and approved by the Engineer in Charge.

Insulation

Roof insulation shall be 50mm thick extruded "Roofmate" or similar approved polystyrene foam board with rebated edges.

Solar Slabs

Roof solar slabs shall be 600 x 600 x 50mm natural coloured precast concrete complying generally with relevant Indian Standards.

Solar Slabs Support Pads

Solar slab support and spacer pads shall be 5mm thick x 120mm diameter PVC pads.

Gravel Borders

Gravel borders shall be 20mm single-size crushed limestone from an approved source.

6.20.4 Laying of Roof Screed

a) Screed shall be laid in bays of area not exceeding 16m2 and length not exceeding 5m.

b) 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.

c) A minimum of 24 hours shall elapse between the placing of adjacent bays.

d) Finished bays shall be continuously wet cured for 7 days.

6.20.5 Laying of Waterproofing Materials

a) Waterproofing materials shall be laid or applied in accordance with the manufacturer's instructions. The waterproofing membrane shall be debonded for 75mm on each side of screed bay joints by a layer of Visqueen or equal and approved.

b) 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 a minimum depth of 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.

6.20.6 Fixing of Aluminium Flashings

Aluminium flashings and the like for in-situ 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 Raw plugs or equal and approved.

6.20.7 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.

6.20.8 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.

6.20.9 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.

6.20.10 Joints in Roof Screed

Joints in the roof screed shall be provided to correspond with any joints in the structural concrete.

6.20.11 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.

7 Carpentry, Joinery and Ironmongery

7.1 Timber

The following timbers shall be used for carpentry and joinery work:

a) 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.

b) Concealed surfaces of softwood joinery shall be primed.

c) 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.

7.2 Physical Condition of Timber

a) Timber shall be thoroughly seasoned and matured, sound, straight, free from wrap, sapwood, signs of rot, shakes, large and loose knots, wormholes, 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.

b) 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 know nowhere occupies more than one-sixth of the width of the surface.

c) 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.

d) 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 standards 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.

7.3 Moisture Content of Timber

a) Moisture content of timber shall comply with the requirements of relevant Indian standards

b) Softwood shall have a maximum moisture content of 15%.

c) Hardwood shall have a maximum moisture content of 12% and shall have been kiln-dried or properly seasoned by other approved means.

d) The Contractor shall supply a copy of the timber supplier's certificate specifying the moisture content of the timber on delivery.

e) 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.

7.4 Plywood and Melamine

a) 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.

b) Plywood for internal applications shall comply with relevant standards and be equal in quality to Grade 2, Type MR.

c) Face veneer shall be hard and durable and capable of being finished to smooth surface and be equal to an approved sample.

d) Melamine shall be not less than 1.5mm thick and shall comply with relevant standards, and of an approved colour and pattern.

e) 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.

f) 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.

7.5 Blockboard

The blockboard shall comply with relevant Indian standards.

7.5.1 Adhesives

a) Adhesives for woodwork shall have proportions at least equal to values as specified in the relevant standard.

b) Adhesives for fixing laminated plastic sheets to wood surfaces shall be petroleum based contact adhesives of approved type.

c) PVA types of adhesives will not be accepted.

7.5.2 Flush Doors

a) Flush doors shall comply with the requirements of Indian standards.

b) 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.

c) Flush doors shall have 10mm hardwood lipping tongues into all edges. In the case of hardwood-faced flush doors to receive a clear finish, the lipping shall match the facing veneer.

d) 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.

e) Metal air transfer grilles shall be of approved aluminium design.

f) 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.

7.5.3 Framed, Ledged and Braced Board

Ends of match boarding 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 standards.

7.5.4 Fire check Doors.

a) Fire-resisting flush doors shall be constructed in accordance with the requirements of relevant Indian standards and shall have a half-hour fire check rating in accordance with

standards. Frames to fire-resisting doors shall have a 25mm deep continuous rebate or applied stop, the latter fixed in accordance with the standard.

b) Where air transfer grilles occur in half-hour fire doors, approved intumescent honeycomb fire dampers shall be fitted.

7.5.5 Workmanship

a) 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.

b) 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.

c) 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 on the top edge of the timber as far from the centre of the span as possible.

d) Carpentry work which does not form an essential part of the structural fabric shall not be executed nor brought onto the site until required unless the Contractor can show that such materials will be adequately stored and protected.

e) Timber for joinery work shall be cut to size and shape, properly jointed and put together, including framing, glueing, dowelling, screwing and mortising etc.

f) 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.

g) Joints and quality of workmanship shall be in accordance with relevant standards.

h) Timber required to be wrought shall have the faces brought to a smooth finish (not machine planed only) with all arises pencil rounded.

i) Dimensions of joinery items to be fitted into structural openings shall be obtained in situ and not from the Drawings.

j) Faces of timber in contact with the structure or other non-wood surfaces shall be treated with preservatives and primed before fixing.

k) Cover beads, architraves etc. abutting any irregular surface shall be accurately scribed to fit.

7.5.6 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.

7.5.7 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.

7.5.8 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 of 600mm centres.

7.5.9 Architraves, Doorstops, Skirtings etc.

Architraves, door stops, cover beads etc. shall be mitred at external angles and scribed at internal angles.

7.5.10 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 hardwood.

7.5.11 Fixings and Jointing

a) 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.

b) Fixing of hardwood joinery shall be by means of brass wood screws to relevant standard.

c) 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.

7.5.12 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.

7.5.13 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.

7.5.14 Ironmongery

a) Ironmongery, including latches, knobs, handles, closures, kick plates, indicator bolts, barrel bolts and cupboard door pulls and latches etc. shall be supplied by an 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.

b) 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.

c) Locks shall be provided with two sets of keys and door closures shall be provided with adjusters.

d) All ironmongery shall be fixed with matching screws.

e) 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.

7.6 Glazing

7.6.1 Glazing Materials

a) Clear glass for internal partitions shall be float plate glass complying with Indian standards.

b) Solar glass for external windows shall comply with Indian standards.

c) Non-reflective, toughened glass shall be at least 5mm thick complying with Indian Standards. The Contractor shall be required to obtain samples for the Employer's Engineer's approval.

7.6.2 Glazing – General

a) Glass shall be to the thicknesses recommended by the manufacturer calculated according to wind loading, pane size, etc. and as per relevant Indian standards.

b) Types of glazing (single or double, etc.) shall be as indicated on the Drawings.

c) 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.

d) Glass in timber doors, partitions etc. shall rest on glazing blocks supporting the bottom edge and shall be completely bedded on the front, back and edges with approved glazing compound. The surplus compound shall be neatly trimmed off.

7.6.3 Workmanship

a) 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 mattered 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.

b) Rebates to receive glass shall be cleaned and primed before glazing.

c) Surface preparation and painting adjacent to window frames shall be completed before window frame installation.

7.6.4 Cleaning

On completion, the glass shall be cleaned and polished on both sides before handing over of the works.

7.7 Plumbing and Sanitation

7.7.1 General

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.

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:

a) Local water and health authorities;

b) Insurance companies;

c) Indian Standards;

d) PWD Guide Books;

e) Fire Regulations;

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.

7.8 Buildings Drainage

7.8.1 General

The building's drainage shall comply with relevant Indian standards.

7.8.2 Materials

a) 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.

b) Underground drainage pipes of 110mm size and above shall be uPVC satisfying relevant Indian standard as water main manufactured by Hepworths Plastics or equal and approved with rubber ring seal joints, subject to approval by Employer's Engineer. Underground drainage pipes below 110mm size shall be as specified for soil and ventilation pipes, unless detailed otherwise on the Drawings, subject to approval by Employer's Engineer.

c) 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.

7.8.3 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 the roof solar slab level.

The cavity between brick masonry and the pipes etc. shall be made good in cement mortar, neatly after the fixing of the pipe.

In case of terraced roof, the cast iron grating shall be fixed at the inlet end of the pipes, properly secured in the wall to receive the rain water. The cast iron grating shall be recessed at a slightly lower level than the adjacent terrace floor level.

The pipes shall be fixed with nails driven through the holder battens fixed in the walls with the sockets facing up. Pipes and fittings shall be kept 12mm from the walls to facilitate cleaning, paintings etc. The joints shall be sealed with a few turns of spun yard soaked in bitumen or tar, which shall be pressed home with a caulking tool for 1/3" the depth of joints. More spun yams

shall then be wound around the joint with cement mortar (1:3). At the ground level, they shall be supported on M-10 concrete blocks 300mmx300mm of sufficient height.

Pipes fittings and joints shall be tested for leaks as specified and defects, if any shall be rectified.

7.8.4 Access pipes

Access pipes shall be provided at the foot of soil vent stacks 300mm above floor level and at bends above this level.

7.8.5 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 bend floor slabs shall have a 1000mm radius.

7.8.6 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.

7.8.7 Fixing of above slab pipework

Pipes shall be fixed to the structure at 2m centres for vertical runs and 1m centres for horizontal runs. Brackets shall be painted galvanized mild steel and fixings shall be stainless steel screws into raw plugs.

7.8.8 Expansion

Provision shall be made for expansion by ensuring that the spigot and socket joints are put together with the recommended 10mm gaps.

7.8.9 Testing of drains

Drains shall be tested in accordance with the IS codes.

7.8.10 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.

7.9 Sanitary Plumbing

7.9.1 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.

7.9.2 Waste traps

Sanitary fittings shall be fitted with white polypropylene traps on waste outlets in accordance with the following:

a) Washbasins: 32mm anti-syphon traps with 76mm seal

b) Sinks: 38mm anti-syphon traps with 76mm seal

c) Showers: 38mm tubular 'S' traps with 76mm seal

d) Traps shall comply with BS 3943.

7.9.3 Waste pipe gradients

Horizontal waste pipes below basins, sinks, urinals and the like shall fall at a uniform gradient of 1 in 45.

7.9.4 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.

7.9.5 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.

7.9.6 Testing of waste and vent pipes

a) An air test shall be applied to all waste and vent pipes as follows:

b) A gauge in the form of a glass U tube shall be connected to the drain plug in the section of the 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 of 5 minutes.

c) The Contractor shall locate and remedy any defects found whilst carrying out the test, and the test repeated until found to be satisfactory.

7.9.7 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.

7.10 Sanitary Fittings

7.10.1 General

Sanitary fittings shall be obtained from the proposed/preferred vendor or shall be of a quality equal to that provided by the following manufacturers:

a) Kohler

b) Roca

c) Duravit

d) Jaquar

All fittings shall be obtained from one manufacturer and shall be complete with all necessary plugs, chains, screws, washers, grommets etc.

7.10.2 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.

7.11 Metalwork

7.11.1 Door Frames

a) Material: Galvanized steel sheet conforming to IS 277 standards.

b) Thickness: Minimum 1.6 mm (16 gauge) for the frame and 1.2 mm (18 gauge) for the door leaf.

c) Profile: Single rebate grooved profile, typically sized 125 x 55 mm.

d) Construction:

e) Frames are mitred and field assembled with self-tabs.

f) Built-in grooved sealing system with fire-rated EPDM gasket

g) Frames should be provided with back plate brackets and anchor fasteners for installation on a finished plastered masonry wall opening1.

h) Coating: Zinc coating with a weight designation of G40 or G60.

i) Sealing: Includes a built-in grooved sealing system and is fitted with a PVC seal as standard

j) Fire Rating: Should comply with IS 3614 for fire doors, tested for 120 minutes of stability and integrity.

k) Finish: Factory prepped for receiving appropriate hardware and provided with necessary reinforcement for hinges, locks, and door closers.

7.11.2 Minor Steelwork

Minor steelwork items shall comply with the section of the Specification covering Structural Steelwork.

7.11.3 Bolts

Expanding steel fixing bolts shall be stainless steel. When expanding bolts are used externally, fixing holes shall be sealed with approved resin grout.

7.11.4 Aluminium

a) Extruded aluminium shall be of IS alloy 738 or equivalent; sheet aluminium shall be IS alloy 738 or 1285 or equivalent, and all other aluminium shall be of alloys which possess such properties that they will be durable in the climate that exists on Site.

b) 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.

c) Aluminium for angles and channels shall be IS alloy 738 or equivalent together with bolts, screws etc, shall comply with the relevant requirements of IS 738,1285, IS 6477 for windows, screens and doors, form of construction, finishes and performance shall generally be in accordance with the relevant Indian standard.

d) 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.

e) Fixings to timber shall be made with aluminium alloy screws.

f) The Contractor shall ensure that no aluminium is allowed to have contact with unset cement.

7.11.5 Aluminium Flashings and Trims

a) 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 standards, appropriate to its thickness and composition. Fixing shall be with aluminium clips secured with aluminium alloy screws.

b) 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.

c) Care shall be taken to avoid contact of aluminium with dissimilar metals, and materials containing alkalis, etc.

7.11.6 Expanded Metal Mesh

For general purposes, expanded metal mesh shall comply with BS 405 and shall be galvanised and of approved shape and size.

7.11.7 Aluminium Louvres and Flyscreens

a) All aluminium parts shall be finished in stoved polyester powder paint or as recommended in Indian standards.

b) 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 done by means of stainless-steel bolts through mullion shoes with isolating grommets and washers. Gaps between louvre frames and structural openings shall be sealed on both sides with the manufacturer’s recommended mastic sealant.

c) 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.

d) Sand trap louvres shall be installed whenever shown on the drawings as per the following specifications:

e) The frame and blades are of high-quality extruded aluminium profiled construction with the advantages of corrosion resistance and rigidity.

f) Composed two sets of inverted U - U-channels mounted vertically on two opposite rows.

g) Drain holes of diameter 20 mm are provided in two rows at the bottom of the louvre for emptying filtered sand and dust.

h) Designed to separate dust from the air stream.

7.11.8 Aluminium Doors and Windows

a) 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 coordination of dimensions and details, in accordance with the door schedule.

b) 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 subframes shall be of nonferrous metal. Sealants shall be approved silicone sealants complying with relevant Indian standards.

c) 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.

d) 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 the inner faces. The weather performance of windows and doors shall be in accordance with relevant standards.

e) 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.

f) Aluminium windows shall be complete with glazing gaskets, gear for the 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.

g) Fixed glazing units shall be fabricated from extruded sections, and glazing shall be set in neoprene gaskets and secured with aluminium beads.

h) The Contractor shall store and fix, including assembling component parts, aluminium doors and windows in accordance with the manufacturer's printed instructions.

i) 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.

j) Exposed frames shall be protected against alkali or acid washes, abrasion or impact damage which may be caused by negligence or following trades.

k) The Contractor shall ease and adjust all aluminium doors and windows and leave them in perfect working condition on completion.

7.11.9 uPVC extruded sections

All profiles shall be made from uPVC (Unplasticised Polyvinyl Chloride) Type A material & only those additives used that are essential in producing sound extrusions in accordance with BIS 7413:1991. No reworked material shall be used. The profile shall be a hollow 3-chamber (across depth) profile with a nominal 2.3 mm wall thickness, +/- 0.3mm of tolerance. The profile shall be uniform and free from foreign bodies, cracks or marks. The profiles shall be multi-chambered, with a min. of three chambers. The central chamber, being for reinforcement, shall be fully sealed when main profiles are welded at joints. The colour of the profiles shall be decided by the Employer’s Engineer.

All reinforcements for profiles shall be Galvanized Mild Steel. The reinforcement is secured to the profile so that it does not move or rattle and it maintains the structural integrity of the frame and satisfactory thermal separation. The structural frame assemblies must be capable of withstanding and accommodating satisfactorily wind loads and pressures in accordance with the requirements of relevant national/international codes.

The door/window/ventilator units shall be designed with all corner joints, transom joints and mullion joints being mitred and fusion welded. The joints must be completely moisture resistant and not permit any penetration into the profiles either externally or internally. All excess material is to be neatly trimmed and neatly feature grooved to corner, transom and mullion joints. No

polishing of any joints are permitted. There is to be no mechanical jointing of the profile unless the profile section is less than 350 mm long. The units shall be designed so that the route of drainage is prevented from passing through the reinforcement chamber. The dimensional tolerances on the finished outer frame height and width is +/–3mm.

All screws, nuts, bolts, rivets and other fastenings shall be of corrosion-resistant or treated material, like stainless steel or ferritic steel, bi-chromate treated steel and be compatible with other metallic fixings used in the manufacture of the window, in accordance with relevant national/international codes. Fastenings be made from stainless steel 304 which has been finished by one of the following methods:-

a) Zinc plated and passivated.

b) Hot dip galvanised

c) Sprayed with metal coating.

Hardware and ironmongery fittings and fixings are to penetrate at least two thicknesses of the uPVC profile and/or penetrate the reinforcement by at least 2mm. The locking mechanism is to be a Shoot Bolt Locking System operated by a single handle. The gearbox is to be sealed to stop the ingress of the swarf during manufacture and use.

Glazing shall be with clear (obscure in bathrooms/WC) float glass panes. The glass shall be free from bubbles, scratches and other flaws. The glass shall be retained by suitable UPVC snap-on beads matching the existing frame. All glazing gaskets & weather strips shall be of EPDM rubber.

All windows and ventilators shall have float glass panes of 5.50 mm thickness.

The uPVC door shutters shall be 30 mm thick shall be made of styles and rails of a uPVC hollow section of size 60x30 mm and wall thickness 2 mm (± 0.2 mm), with inbuilt decorative moulding edging on one side. The styles and rails are mitred and joint at the corners by means of M.S. galvanised/ plastic brackets of size 75x220 mm having wall thickness 1.0 mm and stainless-steel screws. The styles of the shutter reinforced by inserting galvanised M.S. tube of size 25x20 mm and 1 mm (± 0.1 mm) wall thickness. The lock rail is made up of an 'H' section, a uPVC hollow section of size 100x30 mm and 2 mm (± 0.2 mm) wall thickness fixed to the shutter styles by means of plastic/ galvanised M.S. 'U' cleats. The shutter frame filled with a uPVC multi-chambered single panel of size not less than 620 mm, having an overall thickness of 20 mm and 1 mm (± 0.1 mm) wall thickness. The panels filled vertically and tie bar at two places by inserting horizontally 6 mm galvanised M.S. rod and fastened with nuts and washers, complete as per the manufacturer's specification and the direction of the Empolyer’s Engineer.

7.11.10 uPVC sections of rigid PVC foam sheet

The door frame shall be of size 50x47 mm with a wall thick

ness of 5 mm, made out of extruded 5mm rigid PVC foam sheet, mitred at corners and joined with 2 Nos of 150 mm long brackets of 15x15 mm M.S. square tube, the vertical door frame profiles to be reinforced with 19x19 mm M.S. square tube of 19 gauge, EPDM rubber gasket weather seal to be provided throughout the frame. The door frame is to be fixed to the wall using M.S. screws of 65/100 mm size, complete as per the manufacturer’s specification and the direction of the Engineer.

The door shall be made of 30 mm thick pre-laminated PVC door shutters consisting of the frame made out of M.S. tubes of 19 gauge thickness and size of 19 mm x 19 mm for styles and 15x15 mm for top & bottom rails. M.S. frame shall have a coat of steel primers of approved make and manufacture. M.S. frame covered with 5 mm thick heat moulded PVC 'C' channel of size 30 mm thickness, 70 mm width out of which 50 mm shall be flat and 20 mm shall be tapered in 45-degree angle on both side forming styles and 5 mm thick, 95 mm wide PVC sheet out of which 75 mm shall be flat and 20 mm shall be tapered in 45 degree on the inner side to form top and bottom

rail and 115 mm wide PVC sheet out of which 75 mm shall be flat and 20 mm shall be tapered on both sides to form lock rail. Top, bottom and lock rails shall be provided on both sides of the panel. 10 mm (5 mm x 2) thick, 20 mm wide cross PVC sheet be provided as gap inserts for top rail & bottom rail, panelling of 5 mm thick on both sides PVC sheet to be fitted in the M.S. frame welded/ sealed to the styles & rails with 7 mm (5 mm+2 mm) thick x 15 mm wide PVC sheet beading on the inner side, and joined together with solvent cement adhesive. An additional 5 mm thick PVC strip of 20 mm width is to be stuck on the interior side of the 'C' Channel using PVC solvent adhesive etc. complete as per the direction of the Employer's Engineer, manufacturer's specification & drawing.

The manufacturer shall be as per the approved vendor list.

7.11.11 Galvanized Steel Rolling Shutters

Rolling shutter shall be provided in workshop & other such buildings as directed by Engineer. GI Sheets and Plates used for manufacturing the guide channels, brackets and lock plate should be of hot rolled steel of thickness not less than 18 gauge conforming to IS5986. All components of the rolling shutter are to be hot dip galvanized with a zinc coating containing not less than 97.5% pure zinc. The galvanization of members shall conform to the requirements of IS 4759, IS 209, IS 2629, IS 2633 and IS 6745.

Rolling shutters shall conform to IS: 6248 and shall be suitable for fixing in position as specified i.e. outside or inside on or below the lintel or between jambs of the opening. Shutters up to 10 sqm shall be on push and pull type and shutters with an area of over 10 sqm shall generally be provided with reduction gear operated by a mechanical device with a chain or handle. The crank handle shall be removable.

Alternatively, these can be power operated with the help of a push button station conveniently located beside the shutter or as shown on drawings. One emergency hand chain/ crank operation shall also be provided for use in case of failure of the electric system.

The manufacturer shall be as per the approved vendor list.

7.11.12 Window Frame Tolerances

Window frame tolerances shall be as required by the window manufacturer and as set out in IS 4021,

7.11.13 Bird Screens

Bird screens are 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 Employer's Engineer

8 Precast Concrete

The precast element/component shall be factory-made (wet cast) of Width x Height as per the Contractor's design in accordance with the tender specifications and made up of high-strength precast reinforced cement concrete duly steam cured in a controlled environment and manufactured by using high-performance self-compacting concrete of M40/M50 grade using Fe 500D/550D grade TMT steel reinforcement bar.

Design should confirm to IS 15916: 2020, IS 11447: 1985 and other latest relevant BIS standards / Guidelines/ Codes furthermore taking into consideration expected handling and erection stresses etc. Relevant ASTM codes shall be used for any design parameter not available in BIS codes.

The structural designs for custom-made precast concrete units shall be submitted along with the shop drawings furnished by the precast concrete producer for approval by the Employer's Engineer. These drawings shall show complete design, installation, and construction information in such detail as to enable the Employer's Engineer to determine the adequacy of the proposed units for the intended purpose. Details of steel reinforcement size and placement as well as supporting design calculations, if appropriate, shall be included. The drawings shall include a schedule, which will list the size and type of precast concrete units at each location where they are to be used. The precast concrete units shall be produced in accordance with the approved drawings.

Cages of reinforcement shall be fabricated either by tying the bars, wires or welded wire fabric into rigid assemblies or by welding where permissible in accordance with relevant IS/ASTM codes. Reinforcing shall be positioned as specified by the design so that the concrete cover conforms to requirements. Positive measures shall be taken to ensure that the reinforcement does not move significantly during the casting operations

Concrete shall be deposited into forms as near to its final location as practical. The free fall of the concrete shall be kept to a minimum. Concrete shall be consolidated in such a manner that segregation of the concrete is minimized and honeycombed areas are kept to a minimum. Vibrators used to consolidate concrete (as applicable) shall have frequencies and amplitudes sufficient to produce well-consolidated concrete.

The precast component shall not be removed from the forms until the concrete reaches the compressive strength for stripping required by the approved design and as ascertained from the digital/online concrete maturity meter. Precast components shall not be shipped until they are at least 5 days old unless it can be shown that the concrete strength has reached at least 75% of the specified 28-day strength, or that damage will not be caused which will impair the performance of the product.

The precast elements shall comply with the following loading requirements

Sl	Name of Precast Element/Component	Design Load Requirement
1	U Shape Drain/Box drain (Pedestrian load)	Minimum Wheel load of 2.4 Tonnes for light movement and earth pressure.
2	U Shape Drain/Box drain (Vehicular load)	Minimum 10 T Axle Load - 5 T Wheel Load and as per the contractor's design and IRC guidelines
3	Flume Drain	Minimum 1.8 T wheel loading on top and 25 T uniformly distributed loading on its side wall.
4	Box Culvert/Minor Bridges	As per the contractor's design and IRC guidelines

Sl	Name of Precast Element/Component	Design Load Requirement
5	Retaining Wall	As per the contractor's design and IRC guidelines
6	Kerb stones	As per the contractor's design and IRC guidelines
7	Electrical Duct - FT Flume (Pedestrian load)	Wheel load of 2.4 Tonnes for light movement and earth pressure.
8	Electrical Duct (Vehicular load)	Minimum 10 T Axle Load - 5 T Wheel Load.
10	Sewer Manholes with Covers	Minimum Wheel load of 2.4 Tonnes for light movement and earth pressure and as per the contractor's design and IRC guidelines
11	Textured Concrete for Cycle Track & Pathway	As per the contractor's design and IRC guidelines
12	Bollard	As per the contractor's design and IRC guidelines

The Precast component shall have a fair finish with an embossed MITL logo.

Laying and jointing: Unloading of precast concrete drains shall be done as per the standard guideline. Laying trench shall be prepared with PCC of appropriate thickness. Dry levelling cement mortar of 5 - 15 mm thickness shall be placed on the PCC Course to level the surface.

The product should be handled mechanically at the site. The product shall have in-built inserts at optimized locations for handling/transportation. The precast component shall be lifted with suitable lifting devices for placing. The product shall have a tie-shaped groove of 10-20 mm width and 25 mm depth on both sides for joining two precast units. The groove joint shall be filled with ready-mix mortar.

Quality Assurance and Quality Control Requirements: The product shall be manufactured from standard and tested raw materials including cement, fine aggregate, coarse aggregate, concrete and reinforcement. Adequate records shall be maintained by the manufacturer/contractor and submitted to the Employer/Employer's Engineer every month.

The water used for manufacturing concrete should be potable and have a TDS value of no more than 300 ppm.

The product must have reinforcement as per design drawings.

The product shall be steam cured in a controlled environment for better quality control, with a temperature control of 45 ±2 Degrees centigrade.

Necessary facilities should be mandatory for existing In-house or Pre-cast Manufacturing units/ Factories. A list of these criteria is listed below.

a) The precast factory shall have ISO 9001, ISO 14001 and ISO 45001 for design, manufacture and dispatch of products.

b) The product shall be manufactured using RO water for durability criteria. RO water plant with capacity details and photos to support automated concrete batching plant of a minimum of 200 tonnes per day.

c) Steam Curing boiler system with automated steam control system for this production quantity.

d) QA-QC set up with NABL-approved in-house laboratory with all equipment to test all raw materials & fresh concrete. Affidavit stating association with outside laboratory is not permitted.

e) Reinforcement cage shall be fabricated with in-house automated cage making unit having necessary machines like cutting and bending for getting consistent rebar production. It shall be duly certified by the manufacturer.

f) Valid legal registration in India of manufacturing plant to manufacture factory made precast products.

g) Automated steam curing plant details with capacity and photos duly certified by manufacturer to get consistent steam to get the required compressive strength in each product.

The factory-made precast products shall adhere to quality assurance and quality control processes approved by the Employer's Engineer including but not limited to the following. These work tasks shall be carried out as per the ASTM C1074, ACI 228.1R, IS 456 (Cl.17.8), IS 16700, IRC 112 and others, as applicable.

i. The QA/QC of the precast element/product/component manufactured shall be ascertained in real-time using a Concrete Maturity Meter (CMM).

ii. The CMM shall provide compressive strength, temperature, maturity and other related and specified performance parameters of placed concrete during its transition from fresh to hardened state, in real-time, automatically and continuously, from placement till completion.

iii. This Quality 4.0 system shall deploy reusable wireless battery-powered (minimum IP65 rated) CMMs having detachable and retrievable sensors. It should include analytical software functional mode of data communication (wifi-router/dongle/hotspot etc) for the maturity meters and provide data in the form of ready-to-print reports. The system should display above mentioned performance parameters in numerical/info-graphical format on connected PC/Laptop/Smartphone devices in real-time.

iv. The maturity meter shall have a suitable range of measuring temperatures (-55 to +125 degrees Celsius) typically with a user-defined readout frequency range from 1 reading/minute to 1 reading/1 hour.

v. Regular Calibration of each concrete mix needs to be established before deploying the system in concrete elements, as per ASTM C1074 guidelines. Validation of the Calibrated Mix can be performed based upon the discretion of the in-charge QC Engineer. The necessary training in using the maturity meters shall be made available to the QC Team.

vi. The typical monitoring periods can range from 1 to 60 days, depending on the case. Generally, 1 sensor every 10 to 120 cum of placed concrete is typically used, depending on the use case. The location and number of - sensors and meters are to be based on various considerations such as – pour volume, pour schedule, batches, structural and material factors, type of element, curing type and regime, etc.

vii. Sensors shall be installed in the concrete body and shall not be in touch with the steel reinforcements/ other embedments. Select sensors can be used to monitor ambient (air) temperature based upon the discretion of the in-charge QC Engineer.

9 General Building Specifications

The minimum specifications of finishing materials required for different buildings within the project area shall be as per the table below. These building specifications will be applicable for Electrical Substation, Pump Houses and other utility structures. These specifications is a minimum requirement and have to be read in conjunction with the detailed specifications provided elsewhere within the tender document.

Sl	Component	Specification
1.	Flooring	Polished Kota stone flooring, MS galvanised chequered plate over all trenches within and outside the substation.
2.	Wall Finish	Internal Wall - Sand-cement plaster, POP, Emulsion paint system External wall - Sand-cement plaster, weatherproof painting system
3.	Ceiling	Internal - Sand-cement plaster, POP, Emulsion paint system
4.	Roof/Terrace	Liquid bituminous waterproof coating followed by brick bat coba
5.	Doors	Fire-rated metal doors with metal frame, epoxy paint finish
6.	Window	Two-track sliding UPVC window with frame.
7.	Rolling shutter	Manually operated GI
8.	Compound Wall	Cement Concrete Solid blocks are to be placed on the ground beam, and stiffener columns are to be provided at every 4m interval with a capping beam on top. The masonry height shall be 1.2m with an MS grill of height 0.6m above the masonry wall. The masonry shall be plastered on both sides with finished with a weatherproof external paint system.
9.	Gate	MS sliding gate of approved design and make
10.	Lighting	External – All lights are to be LED IP 65 rated as per the required lux level for external visibility of the building. Internal – LED lights as per the required lux level.
11.	Internal Roads	RCC Road of minimum 7 m width with storm water drain shall be provided for the utility building.
12.	Toilet Block	Porcelain tiles, full-height wall tiling and antiskid floor tiling. Wall mounted/hanging type W/C with an inbuilt flush tank, Wash basin with water supply, CP fittings and accessories.