TATA MEMORIAL CENTRE

ADVANCED CENTRE FOR TREATMENT RESEARCH AND EDUCATION IN CANCER (ACTREC).

A GRANT-IN-AID INSTITUTE UNDER DEPARTMENT OF ATOMIC ENERGY, GOVERNMENT OF INDIA

Website – www.actrec.gov.in

Construction of "Shantilal Shanghvi Pediatric Hematolymphoid Cancer Centre" at ACTREC Kharghar, NAVI MUMBAI

NIT No. TMC/ACTREC/ENGG/SSPCC/PT-14/2020

dated 28/08/2020

TECHNICAL SPECIFICATION

INDEX

VOLUME - I

1.00 EARTH WORK

1.0 GENERAL

1.1 Standards

Work shall be carried out to Indian Standards and Code of Practices. In absence, International Standards shall be followed. These shall be latest issue. List given hereunder is not to be considered as conclusive and is for reference and guidance only. Any discrepancies/conflict noticed shall be directed to the Engineer-in-charge for his direction/approval. However as a general rule more stringent specification shall take precedence. This section covers the works specification of earthwork in excavation in all kinds of soils including murrum, hard murrum, soft rock (without blasting), hard rock (without blasting), earth and sand filling in plinth, rubble soling and brick on edge soling, Anti termite treatment.

(1)	IS 1498	Classification and identification of soils for general engineering purpose
(2)	IS 3764	Safety code for excavation work
(3)	IS 4081	Safety code for blasting and related drilling operation
(4)	IS 6313 Part 1	Code of practice for antitermite measures in buildings : constructional measures
	Part 2	Code of practice for anti termite measures in buildings: Pre constructional chemical treatment measures
(5)		Explosive Rules 1940
(6)	IS 4988 (Part IV)	Glossary of terms and classifications of earth moving machinery (all parts).
(7)	IS 12138	Earth moving Equipment
(8)	IS 3385	Code of practise for measurement of Civil Engineering works.
(9)	IS 2720	Part II Determination of moisture content.
		Part VIII Determination of moisture content dry density relation using light compaction.
		Part XXVIII Determination of Dry density of soils, in place by the sand replacement method.

	Part XXIX Determination of Dry density of soils, in place by the Core cutter method.
(10) IS 783	Code of practise for laying of concrete pipes.
(11) IS 1200	Method of measurement of building and civil engineering works - Part 1.
(12) IS 1490	Portland - Pozzolana cement.
(13) IS 2809	Glossary of terms and symbols relating to soil mechanics.

2.0 DRAWINGS

Engineer in-charge will furnish all necessary drawings/ information showing the areas to be excavated, filled, sequence of priorities etc. Contractor shall follow strictly such drawings.

3.0 GENERAL:

Contractor shall provide all tools, plants, instruments, qualified supervisory personnel, labour, materials, and temporary works, consumables, any and everything necessary, whether or not such items are specifically stated herein, for completion of the Work.

Contractor shall carry out the survey of the site before excavation and set properly lines and establish levels for various works such as earthwork in excavation for levelling, basement, foundations, plinth filling, roads, drains, cable trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to establish reference/grid lines at 5 m intervals or nearer as determined by Engineer based on ground profile. These shall be checked by Engineer and thereafter properly recorded.

The area to be excavated/ filled shall be cleared of fences, trees, plants, logs, slumps, bush, vegetation's, rubbish slush etc. and other objectionable matter. If any roots or stumps of trees are found during excavation, they shall also be removed. The material so removed shall be burnt or disposed off as directed by Engineer. Where earth fill is intended, the area shall be stripped of all loose/soft patches, top soil containing deleterious matter/materials before fill commences.

4.0 RELICS, OBJECTS OF ANTIQUITY, ETC.

All gold, silver, oil minerals archaeological and other findings of importance, all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of owner and Contractor shall dully preserve the same to the satisfaction of Owner and from time to time deliver the same to such person or persons as Owner may from time to time authorise or appoint to receive the same.

5.0 SITE CLEARANCE

5.1 Prior to the start of any activity of earth-work, the area under construction shall be cleared of shrubs, vegetation, grass, brushwood, trees and saplings of girth upto 30 cm measured at a height of 1 metre above ground level. All rubbish must be removed and stacked at a distance of 50 m outside the periphery of the area under clearance or location as decided by the Engineer-in-charge.

5.2 The rate of such clearance is to be included in the rate of other earth-work items and no separate rate shall be paid.

5.3 The trees of girth above 30 cm measured at a height of one meter above ground shall be cut only after permission of the Engineer-in-Charge is obtained in writing. The roots of trees shall also be removed as specified in above item 2.1. Payment for cutting such trees and removing the roots shall be made separately.

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

5.5 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.

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

6.0 SETTING OUT

6.1 The contractor shall prepare detailed setting out drawings based on the layout of Architectural drawings and those shall be submitted to the Engineer-in-charge prior to commencement of work. Bench Marks and Reference Lines shall be established, by the contractor with approval of the Engineer-in-charge.

6.2 The contractor shall do the setting out with the use of Total-station and like instruments at site, based on details given to him. He shall erect timber profiles, masonry pillars, burjis, etc. for his use. All markings on these shall be painted with red colour and they shall be maintained for the entire duration of the project. Setting out shall be approved by the Engineer-in-charge before the commencement of any work.

6.3 The approval of the setting out by the Engineer-in-charge shall not relieve the contractor of any of his responsibilities and obligation to rectify the errors/defects, if any, which may be found at any stage during the progress of the work or after the completion of the work.

6.4 The rate for the earth-work items shall include expenses for site clearance, dewatering, removal of debris, setting out work, profile, establishment of reference bench mark(s), taking spot levels, construction of all safety and protection devices, barriers, temporary access, any work required to complete project all such work including labour, material and equipment/instruments, etc. No additional payment shall be eligible on this account.

7.0 EXCAVATION IN SOILS

7.1 Excavation over area

Excavation exceeding 1 m in width as well as 10 sq m in plan and 30 cm in depth shall be considered as excavation over area.

7.2 Surface dressing

Trimming of natural ground, excavated surfaces, and filled up areas to remove vegetation and/or small inequalities not exceeding 15 cm in depth shall be described as surface dressing.

7.3 Rough excavation

Excavation not requiring dressing of sides and bottom and reduction to exact levels, such as winning earth from borrow pits, hill side cuttings, etc. shall be described as rough excavation.

7.4 Surface excavation

Excavation exceeding 1 m in width as well as 10 sq m on plan but not exceeding 30 cm in depth shall be considered as surface excavation.

7.5 Trenches for pipes/cables

It shall be detailed with nominal dia of pipe/cable. Required bottom width, allowance for concrete foundation for laying pipes, working area, grip required for socketed pipe, return fill, ramming and removal of surplus soil shall be part of this item unless otherwise specified.

7.6 Post holes

Independent post holes (or similar holes) each not exceeding 0.5 cu m shall generally be enumerated. Rate shall include return fill, ramming and removal of surplus soil. However this shall be in cubic meters as part of excavation items.

7.7 General

7.7.1 The excavated earth shall be thrown or disposed off beyond 50 m periphery of the building. Earth suitable for back filling shall be stacked separately. The lead will be as per BOQ.

Subsequent disposal of the surplus and unsuitable material shall be as per the respective items. Foundations, trenches shall be dug out to the exact dimensions as shown in the drawings or as directed by the Engineer-in-charge.

7.7.2 In firm soil, the sides of the trench shall be kept vertical upto a depth of 1.5 m. If the trench is to be deeper, it shall be in the form of steps of 50 cm, at every 1.5 m depth. This shall be suitably increased or decreased as per site conditions and type of soil met with. This shall be to the approval of the Engineer-in-charge. Sloping of sides also may be adopted.

7.7.3 The bed of trenches shall be firmly consolidated and leveled by watering and ramming of the soft soil. Defective spots shall be dug out and filled with concrete of the same mix as of PCC or as directed by the Engineer-in-charge.

If excavation is done to a depth greater than that required, excess depth shall be back filled with the same mix as of PCC or as directed. Cost of such concrete shall be to the contractor's account.

7.7.4 Excavated trenches shall have to be approved by the Engineer-in-charge prior to laying of PCC or any other Permanent Work.

7.7.5 Excavation for drains shall be carried out with extra care to cut the sides and bottom exactly to the required shape, slope and gradient. Filling for excess deeper excavation shall be done at the contractor's cost in consultation with the Engineer-in-charge.

7.7.6 Excavated materials shall not be placed within 1 m of the edge of the trench or half the depth of the trench, whichever is more.

7.7.7 Excavations for column footings shall be carried to depths indicated in the drawings. Safe bearing capacity at such depth shall be verified to comply design requirements. If ordered by the Engineer-in-charge, appropriate tests shall be carried out by the contractor.

7.7.8 To the extent available, selected surplus spoils from excavated materials shall be used as backfill. Fill material shall be free from clods, salts, sulphates, organic & other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill up the voids and the mixture used for filling.

7.7.9 As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches etc. shall be cleared of all debris and filled with earth in layers 15 cm to 20 cm, each layer being watered, rammed and properly consolidated before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of Engineer.

7.8 Protection

7.8.1 Fencing and/or other suitable measures for protection against risk of accidents due to open excavation shall be provided by the contractor at his cost.

7.8.2 Where excavation is to be carried out below the foundation level of an adjacent structure, and to avoid underpinning, precautions such as shoring and strutting, etc. must be taken. No excavation should start till such measures are taken to the satisfaction of the Engineer-in-charge. Payments for such work shall not be made separately unless specified otherwise.

8.0 EXCAVATION IN SOFT ROCK

8.1 This shall include rock, boulders, slag, chalk, slate, hard mica schist, laterite etc. which are to be excavated with or without blasting or could be excavated with jcb, poclain with bucket, picks, hammer, crow bars, wedges etc. This shall also include excavation in macadam and tarred roads and pavements. This shall also include rock boulders not bigger than 1 metre in any dimension and not more than 500 mm in any one of the other two dimensions Rubble masonry to be dismantled will also be measured under this item.

8.2 Other general details same as clause 7.7 and its sub clauses.

9.0 EXCAVATION IN HARD ROCK

9.1 General

9.1.1 On meeting hard rock that requires blasting, the contractor shall inform the Engineer-in-charge. On approval in writing, blasting operation shall start if the contractor feels it necessary and so desires.

9.1.2 The contractor shall obtain the necessary license from the District Authorities for undertaking blasting work and explosive storing as per Explosives Rules 1940, and as updated. Explosives shall only be procured from an authorized dealer. He shall be responsible for the safe custody and proper accounting of explosives. The Engineer-in-charge shall have access to the store.

9.1.3 The contractor shall be responsible for any accident to those working on the site, to the public or to property due to blasting operations.

9.2 Precautions

9.2.1 Safety measures to be adhered to shall be as detailed in IS 4081, Safety Code of Blasting (as amended from time to time, and to related drilling operations). Also digest No.37 of C.R.R.I and I.R.C.A. Road tariff No.18 shall be adhered to.

9.2.2 Blasting operation shall be carried out under the supervision of a responsible authorized agent of the contractor. Timings shall be as approved by the Engineer-in-charge in writing. Lunch break will be preferred. The authorized agent of the contractor should be well conversant with the rules and regulations of blasting operations. Further the contractor shall employ licensed blasters for actual operation.

9.2.3 All proper precautions for safety shall be taken. All persons shall be moved away to a distance not less than 200 m. All entries shall be sealed and red flags displayed at prominent places.

9.2.4 Blasting shall be done only with gunpowder. Dynamite, gelignite, or any other high explosive shall be used only with written permission of the Engineer-in-charge.

9.2.5 The number of charges to be fired and the actual number of shots heard shall be counted and the contractor's agent shall satisfy himself by examining that all charges have exploded. Only then shall workmen be allowed to start work. Unexploded charges shall be flooded with water, a new hole drilled and exploded again.

9.2.6 The Engineer-in-charge shall be informed about all misfires, their causes and the remedial steps taken.

10.0 CLASSIFICATION

10.1 All soils comprising any of the following:

(a) Vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose murrum.

(b) Any mixture of soils in (a).

(c) Mud concrete below ground level.

(d) Generally any material which yields to the ordinary application of a pickax and shovel or to phawra, rake or other ordinary digging implement and not affording resistance to digging greater than mentioned in (a) to (c).

(e) Stiff heavy clay, hard shale, or compacted murrum requiring close application of a grafting tool or pick or both and shovel.

(f) Gravel and cobblestone (cobblestone is a rock fragment), usually rounded, having maximum dia in one direction of 75-300 mm.

10.2 Soft rock comprising any of the following

(a) Soling of roads, paths, etc. and hard core.

(b) Macadam surfaces of any description (water bound, grouted, tarmac, etc.)

(c) Lime concrete, stone masonry, in lime mortar and brick work in lime or cement mortar, below ground level.

(d) Soft conglomerate, where the stones may be detached from the matrix with picks, crow bars, wedges, etc.

(e) Limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with a crowbar.

(f) Unreinforced cement concrete which may be broken up with crowbars or pickaxes and stone masonry in cement mortar, below ground level.

(g) Boulders not requiring blasting, rock fragments usually rounded by weathering, disintegration and exfoliation or abrasion by water or ice, having maximum dia length in any direction of 500 mm, found loose, embedded, etc.

(h) Other varieties of rock which would normally be removed with pick, crowbars, wedges and hammer with only a little difficulty.

10.3 Hard rock comprising any of the following

(a) Any rock or cement concrete in excavation for which the use of mechanical equipment like chisel / ripper / air compressor or blasting is required.

(b) Reinforced cement concrete.

(c) Boulders bigger than 1/2 cubic meter requiring blasting.

(d) Hard rock as in (a) to (c) requiring blasting but prohibited from doing so for any reason and excavation has to be carried out by chiseling, wedging or any other agreed method.

11.0 DEWATERING AND PROTECTION:

Where water is met with in excavation due to stream flow, seepage, springs, rain or other reasons, the Contractor shall take adequate measures such as bailing, pumping, construction of diversion channels, drainage channels, bunds, cofferdams and other necessary works to keep the foundation trenches/pits dry when so required and to keep the green concrete/masonry against damage by erosion or sudden rise of water level. The method to be adopted in this regard and other details thereof shall be left to the choice of the Contractor but subject to the approval of the Engineer. Approval of the Engineer shall, however, not relieve the Contractor of his responsibility for the adequacy of dewatering and protection arrangements and the safety of the works.

Pumping from inside of any foundation enclosure shall be done in such a manner as to preclude the possibility for the movement of water through any freshly placed concrete. No pumping shall be permitted during the placing of concrete or for any period of at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or similar means. At the discretion of the Contractor shall take all precautions in diverting channels and in discharging the drained water so as not to cause damage to the works or to the adjoining property.

12.0 SHORING / EARTHWORK SUPPORT : (ALL TYPES OF SOIL/ ROCKS)

The contractor shall appoint approved geotech consultant for designs of shoring for piles, boundary wall and for earthwork retention. The design will have to be got approved from approved agency / institute, Government Engineering Colleges at Mumbai by the contractor. Contractor to quote the rates taking this requirement in mind.

The contractor shall shore and strut the sides of excavation to the satisfaction of the Engineer-in-charge. If there should be any slips or settlement, not withstanding the shoring, the contractor shall make good the same at his own expense, with concrete or

other approved material, as directed by the Engineer-in-charge. Shoring shall be removed gradually side by side with backfilling to prevent any settlement and under no circumstances, until such time as the foundation concrete has hardened enough, to take any loads brought on by the removal. Under special circumstances, shoring shall be left in place, if so directed by the Engineer-in-charge. The Contractor to quote this as a part of the excavation item only and no Separate payment will be done on this account.

13.0 DISPOSAL OF SURPLUS EARTH

13.1 Surplus earth shall be used to the maximum extent in the compound. Earth useful for filling shall be separately stacked as directed by the Engineer-in-charge from time to time. Approved quality earth shall be used in the filling. It shall be consolidated as detailed and approved by the Engineer-in-charge.

13.2 Rate for excavation shall include sorting out of useful materials.

13.3 All surplus and unusable earth shall be disposed off outside the campus at a location approved by local authority and conforming to their specification. The contractor shall quote his rate for disposing off or carting away the items considering requirements and standards of the local authority with whose permission surplus and unusable earth shall have to be disposed off.

Case 1 : In case the soil is carted outside simultaneously as the excavation is being done, theoretical quantity which is to be paid only for the PCC Dimension as in plan multiplied by height. No reduction to be considered for loose soil. No additional measurement will be in Cum.

Case 2 : In case the soil is already excavated and is heaped up in loose form then the theoretical measurement of the heap to be done and the Quantity to be reduced by 30% on account of compaction. The mode of measurement will be in Cum.

However in all the cases, the numbers of trucks including the truck details, capacity, date, time, etc to be recorded and handed over along the measurement sheet.

14.0 FILLING

14.1 Filling shall be done where required with approved quality of earth. It may be from 11 plinth to have at least one set of proctor density conducted irrespective of plinth area or for every 500sqm of compacted area or part thereof.) The base surface shall be cleared

of vegetation by up-rooting or any organic matter, prior to commencement of filling operation. When filling reaches the finished level, the surface shall be flooded with water, if directed by the Engineer, for 24 hours, allowed to dry and then the surface is again compacted as specified above to avoid settlements at a later stage. The finished level of the filling shall be trimmed to the level/slope specified.

b) Where specified in the item description given in the Schedule of Quantities that the compaction of the plinth fill shall be carried out by means of 10/12 tonnes rollers smooth wheeled or mechanical vibro-roller, as rolling proceeds water sprinkling shall be done to assist consolidation.

Payment for filling in plinth with selected excavated material will be made as specified/directed. Payment for this work will be made based on measurement of plinth/dimensions filled. The plinth/ ground levels shall be surveyed beforehand for this purpose. The lead shall be as specified.

Mode of Measurement: It shall be measured in CuM.

14.2 **Filling in Plinth & Superstructure Under Floors with Earth Brought from Outside:**

a) Filling shall be carried out with approved material as described above, the material and source shall be subject to prior approval of Engineer. The approved area, from where the fill material is to be dug, shall be cleared of all bushes, roots plants, rubbish etc. top soil containing salts, sulphate and other foreign material shall be removed. The materials so removed shall be burnt or disposed off as directed by Engineer. The Contractor shall make necessary access roads to those areas and maintain the same, if the road does not exist, at his cost.

b) The selected fill material shall be approved quality murrum having liquid limit not more than 40 and plasticity index not more than 20 and minimum dry density not less than 1700 kg per cu.m. If any material is rejected by Engineer, Contractor shall remove the same forthwith from the site at no extra cost to the owner. Surplus fill material shall be disposed of by uniform spreading within the site as instructed by the Engineer.

c) The compaction shall be carried out as specified in the Item specified for filling in plinth and as per Item specified for filling in ground for land development. Backfilling, plinth filling etc. with borrowed earth will be paid for under specified items.

The quoted rate shall include all operations such as clearing, excavation, lead and transport, fill, compaction etc. as specified. Quantity of consolidated filling or quantity of excavation in the borrow pits (less such top soil which has been excavated and not used for filling) whichever is less shall be measured as per drawing and paid for in cubic metre. The lead, lift etc. shall be as indicated in the schedule of quantities. Additional quantity of backfilling which is resulted due to additional / unwanted / working space done by the Contractor will not be measured for payment.

Mode of Measurement: It shall be measured in Cum.

14.3 **Sand filling**

At places backfilling shall be carried out with local sand if directed by Engineer. The sand used shall be kept flooded with water for 24 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to Contractor's account. The surface of the consolidated sand shall be dressed to require level or slope, Construction of floors or other structures on sand fill shall not be started until Engineer has inspected and approved the fill.

Mode of measurement: Actual quantity of consolidated sand filling shall be measured and paid in Cum as per drawing. No additional measurement will be paid for additional working space done by the contractor.

14.4 **Rubble soling**

Good quality 150 mm to 230 mm thick rubble soling shall be carried out depending upon the grade of soil. Rubble used shall be at least 100 mm for 150 mm thick soling and 150 mm for 230 mm thick soling. Stone shall be hand packed as close as possible and bedded firmly with the broadest face downwards and the greatest length across, voids filled with chips and small stones. These shall be hammered down to achieve packing and the complete filling of interstices. To achieve the desired levels and slopes, pegs at suitable intervals (about 12 m) shall be fixed.

Soling shall be watered and again packed with sand or murrum to fill interstices created by watering. Then it shall be rolled with 10 ton roller or vibratory compactor. Filling sand or murrum, watering and rolling shall continue till full compactness is achieved to satisfaction of the Engineer-in-charge.

14.5 **Metal packing**

Coarse aggregate used for metal packing shall be crushed or broken stone, hard, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter.

Prepared sub-base surface shall be uniformly spread with well graded metal. The size of the metal shall be 60mm to 80mm. Templates shall be used for leveling. Leveling shall be true and checked with 3 m straight edge. Any raised areas or depressions of more than 12.5 mm shall be corrected. This shall be rolled with power wheel roller of 8 to 10 tons as required or as asked by the Engineer-in-charge for the intended purpose. Rolling shall continue till aggregate is thoroughly keyed and the creeping of the aggregate ahead of the roller is no longer visible. The rolled surface shall be checked and all irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and rerolling until the complete area conforms to the required datum.

After the coarse aggregate has been thoroughly keyed and set by rolling, screening shall be carried out to fill the interstices. This shall be done in 3 to 4 layers. Material shall be dry and no sprinkling of water shall be allowed.

15.0 ANTI-TERMITE TREATMENT

15.1 Indian Standards

Indian Standards to be followed is IS : 6313 Part (II)-2013.

15.2 General

The treatment shall create a chemical barrier /Zone and around the building during the construction.

15.3 Materials

The following chemical which is effective when applied uniformly over the area to be treated – shall be used in water emulsion for the soil treatment with the concentration shown against it.

Chemical	Relevant Indian Standard	Concentration By Weight, Percent	Dosage
Imidacloprid (Bayer)	IS :16131 (Code under printing)	0.075	10.5ml in 5 litre water

15.4 Treatment

The principle of the treatment is to create a continuous chemical barrier/Zone below and around the building. The treatment is designed depending on the type of building is described below:

15.4.1 Treatment of RCC Foundation (Buildings without basement):

A) Treatment to backfill soil along column periphery :

In case of reinforced cement concrete(RCC) foundation, the treatment shall start at a depth of 500 mm below the ground level except when such ground level is raised or lowered by filling or cutting after the foundation have been cast. In such cases, the depth of 500 mm shall be determined from the new soil level resulting from the filing or cutting mentioned above, and soil in immediate contact with the vertical surface of RCC Foundation shall be treated at the rate of 7.5 liters per sq

B) Treatment of top surface of plinth filling :

The top surface of the consolidated earth within the plinth wall shall be treated with chemical emulsion at the rate of 5 liters per square meter of the surface before the sand-bed or sub -grade is laid. If the filled earth has been well rammed and surface does not allow the emulsion to seep through, holes up 50 to 75 mm deep at 150 mm centers both ways may be made with 12 mm diameter mild steel rod on the surface to facilitate the chemical emulsion for absorption.

C) Treatment at junction of the Wall and the floor::

Special care shall be taken to establish continuity of the vertical chemical barrier /zone of inner wall surface from ground level up to the level of filled earth surface .To achieve this a small channel 30 mm x 30 mm shall be made at the junction of wall and columns with the floor (before laying the subgrade) and rod holes made in the channel up to the ground level 150 mm apart and the rod moved backward and forward to break up the earth and chemical emulsion poured along the channel at the rate of 7.5 liters per square meter of the vertical wall or column surface so as to soak the soil right to the bottom. The soil should be tamped back into place after this operation.

D) Treatment of Soil along External Perimeter of Building

After the building is complete , the earth along the external perimeter of the building should be rodded at intervals of 150 mm and to a depth of 300 mm .The rods should be moved backward and forward , parallel to the wall to break up the earth and emulsion poured along the wall at the rate of 7.5 liter per square meter of vertical surfaces. After the treatment, the earth should be tamped back into place. Should the earth outside the building be graded on completion of building , this treatment should be carried out on the completion of such grading .In the event of filling more than 300 mm , the external

perimeter treatment shall extend to the full depth of filling up to the ground level so as to ensure continuity of the chemical barrier /Zone.

E) Treatment of Soil Surrounding Pipes ,Wastes and Conduits :

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

F) Treatment for Expansion Joints :

Expansion joints at ground floor level are one of the biggest hazards for termite infestation. The soil beneath these joints should receive special attention .This treatment should be supplemented by treating through the expansion joint after the sub – grade has been laid , at the rate of 2 liters per linear meter .

15.4.2 Treatment to RCC Basement Buildings

The treatment starts after the excavation for basement is complete and before laying soling and plain cement concrete (PCC). The treatment shall be carried out in the following stages.

A) Treatment to soil below raft

Before laying the rubble soling and PCC, the compact and levelled soil shall be treated at 5 litres per sq m.

In cases where treatment to soil below floor is difficult due to presence of sub-soil water, as sub soil water may affect on dilution of chemical , in such situations, it is recommend to carry out treatment on PCC surface before starting of waterproofing , In this treatment normal dosage of 5 lit per sq. m. may not be feasible as there may not be absorption like in soil surface. Adequate absorption shall be achieved by maintaining same quantity of termiticide and reducing quantity of water by half to make the emulsion and spray @ 2.5 lit per Sq.M . For better absorption, the prepared emulsion shall be sprayed in two or three rounds with the gap of 30 to 45 minutes or more.

B) Treatment to soil along the retaining wall

The soil retained by the walls (soil coming in contact with retaining wall) shall be

treated at the rate of 7.5 liter per sq m of the vertical surface so as to effect a continuous outer chemical barrier, in continuation with that of the one formed under Treatment to Soil Below Raft. The treatment shall follow the backfilling as backfiling is done in stages of 300 mm but not to exceed a depth of 1 m. Rodding may be carried out to facilitate the treatment.

If the piles are casted on the periphery to retain the soil. The soil is not available for the treatment. So there is a need to create the chemical barrier / zone on diaphragm / skin wall before waterproofing layer.This treatment will be done with the chemical emulsion at the rate of 7.5 liters per square meter of surface area.

C) Treatment of soil along external perimeter of building

After the building is complete , the earth along the external perimeter of the building should be rodded at intervals of 150 mm and to a depth of 300 mm .The rods should be moved backward and forward , parallel to the wall to break up the earth and emulsion poured along the wall at the rate of 7.5 liter per square meter of vertical surfaces. After the treatment , the earth should be tamped back into place . Should the earth outside the building be graded on completion of building , this treatment should be carried out on the completion of such grading .In the event of filling more than 300 mm , the external perimeter treatment shall extend to the full depth of filling up to the ground level so as to ensure continuity of the chemical barrier /Zone.

D) Treatment of Soil Surrounding Pipes ,Wastes and Conduits :

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

E) Treatment to the negative areas / Podiums / upper level gardens :

If the negative area (soil filling for garden etc.) is at the plinth level, then there is no need for additional treatment for such filling. But if such filling is at above level then additional treatment is necessary and the top surface of soil filling is treated at 5 lit per sq.m similar to the treatment mentioned in " Treatment to Soil below raft ". Charges for this treatment will be quoted separately according to the area involved for treatment.

F) Treatment to first residential floor :

Chemical : Water base - Imidacloprid 30.5 SC to be used at 0.075% concentration. (2.1 ml of Imidacloprid 30.5 SC to be mixed with 1 ltr of water to get 0.075% concentration)
Oil base – Mineral oil or Kerosene based solution of Chlorpyrifos 20 EC, 1 percent concentration is used for treatment of wood.

Wall and floor junction treatment - Holes of 12mm dia 30 cms apart will be drilled along the inner junction of wall and floor in the first residence floor levels / premises . Water based chemical emulsion will be injected under pressure into these holes till refusal or max upto 1 ltr per hole, to create a barrier against termites .

Treatment to Door / Windows – Holes of 12 mm dia will be drilled at the bottom corners (both sides) of the door and window frames and chemical emulsion will be injected in these holes till refusal or max upto 1 ltr per hole. The treatment could be modified depending on the site conditions as per the discretion of the Clients Site in charge. All the drilled holes will be sealed and made good using cement.

15.5 Workmanship

15.5.1 Conditions of formation

Barrier shall be complete and continuous under the whole of the structure to be protected. All foundation shall be fully surrounded by and in close contact with the barrier of treated soil. Each part of the area treated shall receive the prescribed dosage of chemical.

15.5.2 Time of application

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

15.5.3 Disturbance

Once formed, treated soil barriers shall not be disturbed. If, by chance, treated soil barriers are disturbed, immediate steps shall be taken to restore the continuity and completeness of the barriers- system at no extra cost.

15.5.4 Spraying Equipment

A pressure pump shall be used to carry out spraying operations to facilitate uniform spraying and penetration of chemical into the earth. The chemicals, concentration and dosage for horizontal and vertical surfaces are based on the IS code of practice for Anti-termite measures in Buildings. IS 6313 (Part-II).

15.5.5 Safety

Work shall be carried out as per safety measures instructions of manufacturer of approved pesticide & direction of Engineer-in-charge. Also IS 4015 part I and II shall be followed.

15.5.6 Free Service Guarantee

The contractor shall note that termite proofing work, is subject to a free service guarantee from the date of completion of the treatment. The contractor shall give an undertaking in writing to the effect that during the guarantee period any infestation of subterranean termites will be eradicated and necessary treatment carried out to prevent re-infestation, free of cost to the employer. The guarantee shall allow a minimum period of - 10 (ten) years for pre-constructional treatment.

Tenderers must ensure that the work will be done through the professional Pest Control operator. They should be members of National Pest Control Association of USA, or Indian Pest Control Association or any other recognized professional body. They should furnish a list of Termite Control jobs carried out by them successfully for Government Department, Statutory bodies or large private organizations to prove that they are capable of handling anti termite work.

16.0 PASSIVE ROCK ANCHORSFOR UPLIFT RESISTANCE

A) Drilling of Anchor Holes

Drilling for anchors will be completed by rotary or pneumatic methods as per installation pattern, sizes and lengths provided in drawings. Drilling will commence from top of PCC level after completion of PCC.

Borehole sides shall be adequately protected against side collapse by use of PVC or MS Casing up to hard rock.

The deviation of the anchor hole entry angle from its verticality shall be no greater than $\pm$ 3 degrees.

B) Anchor Reinforcement

Torsteel bars of diameter as per drawings will be cut to length of complete anchor including that required for development length in raft portion.

The torsteel bars shall be pretreated to remove rust/oil, scaling, grease, etc.

Centralizers or spacers shall be utilized to position the torsteel bar so a minimum cover of 40mm to reinforcement bar is achieved.

C) Primary Grouting of Anchors

The grout shall entirely fill the annular space between the torsteel bar and the borehole wall in the bond length.

Gravity grouting will be done with neat cement grout with non-shrink compound CEBEX 100 or equivalent, or with GP2 compound as per BOQ.

Grout strength of minimum M25 should be achieved prior to casting of raft. Three (3) grout cubes (7.5cm x 7.5cm x 7.5cm) will be cast for each day of grouting. One cube will be tested at 7 days while the remaining cubes will be tested at 14 days.

D) Testing of Anchorage

At least 1.5% of the total rock anchors shall be proof tested to 1.1 times the design load. The load will be held at the final test load for at least 15 minutes.

A jack of adequate capacity should be utilized for testing the anchors. Elongation should be measured at final load. The load will be held at the final test load for at least 10 minutes.

The anchor can be deemed acceptable upon proof testing if the below conditions are satisfied:

i) Total drop in pressure is less than 10% at final load in 10 minutes of holding time.

E) Fixing of Anchorage

Development length of the anchor torsteel bar of 50d will then be fixed with binding wires or with welding to the raft main reinforcement bars, as per structural engineer.

VOLUME - I

2.00 CONCRETE WORK

APPENDIX – A

STANDARDS AND SPECIFICATIONS TOLERANCE

The provisions of the latest revisions with amendments, if any, of the following Indian Standards and other relevant codes shall form part of this specification to the extent they are relevant.

A.1 BUREAU OF INDIAN STANDARDS

IS - 269	Specification for ordinary Rapid Hardening and Low Heat Portland Cement
IS – 383 - 2016	Specification for coarse and fine Aggregate from natural source for concrete.
IS - 455	Specification for Portland blast furnace slag
IS – 456	Plain and reinforced concrete – code of practice
IS – 460	Specification for Test Sieves (Part I, II & III).
IS – 515	Specification for Natural and Manufactured Aggregates for use in Mass Concrete
IS – 516	Methods of Tests for strength of concrete.
IS - 650	Standard Sand for Testing of Cement
IS – 1199	Methods of sampling and Analysis of concrete.
IS - 1200	Method of Measurement of Building Works
IS – 1343	Code of practice for Pre-stressed Concrete
IS - 1489	Specification for Portland-Pozollana cement
IS - 1542	Sand for Plaster
IS – 1727	Methods of test for pozzolanic materials.
IS – 1791	General requirements for batch type concrete mixers
IS – 2386	Methods of Test for Aggregates for concrete. (Part I to VIII)
IS – 2395 Part I & II	Code of practice for concrete, masonry and plastering surfaces

IS - 2396 (I)	Flakiness Index of aggregates
IS – 2430	Methods of sampling of aggregates for concrete.
IS - 2438	Specification for roller pan mixer
IS - 2502	Code of Practice for Bending and fixing of bars for Concrete Reinforcement
IS – 2505	Concrete vibrators – immersion type. -General requirements
IS – 2506	General requirements for concrete vibrators, screed board type.
IS – 2514	Specification for Concrete vibrating Tables.
IS – 2645	Integral Waterproofing Compounds for Cement Mortar and Concrete – Specification.
IS – 2722	Specification for portable swing weighs batcher for concrete. (Single & Double bucket type).
IS - 2911	Code of Practice for Design and Construction of Pile Foundation
IS –3025	Methods of sampling and test (Physical and Chemical) for water and waste water (Part 1 to 56)
IS – 3085	Method of tests for permeability of cement mortar & concrete.
IS - 3366	Pan vibrators
IS - 3385	Code of practice for measurement of civil engineering works
IS - 3414	Code of practice for design and installation of joints in buildings
IS – 3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS - 3696	Safety code for scaffolds and ladders
IS-3812 (Part-I)	Pulverized Fuel Ash – Specification: For use as Pozzolana in Cement, Cement Mortar and Concrete.
IS - 4014	Code of practice for Steel Tubular, (Part I & II) scaffolding
IS – 4031	Methods of physical tests for hydraulic cement (Part 1 to 15).
IS – 4032	Method of chemical analysis of hydraulic cement.
IS – 4082	Recommendations on stacking and storage of construction materials and components at Site.

IS – 4634	Methods of testing performance of batch type concrete mixers.
IS - 4656	Specification for form vibrators for concrete
IS – 4845	Definitions and terminology relating to hydraulic cement.
IS – 4925	Concrete batching and mixing plant: specification
IS - 5640	Method of test for determining Aggregate Impact Value of soft, coarse aggregates
IS – 5816	Split Tensile Strength of Concrete – Method of Test.
IS – 5892	Concrete transit mixers and agitators: specification
IS – 6461	Glossary of terms relating to cement concrete (Part-1 to 12)
IS – 7320	Specification for Concrete slump test apparatus.
IS – 7325	Specification for Apparatus for determining constituents of fresh concrete.
IS – 7861	Code of practice for Extreme weather concreting.
IS - 8043/E	Emergency specifications for Hydrophobic Cement
IS – 8112	Specification for 43-grade ordinary Portland cement.
IS – 8142	Method of test for determining setting time of concrete by penetration resistance.
IS -9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS – 9103	Concrete Admixtures – Specification
IS – 10262	Recommended Guideline for Concrete mix Design
IS – 12089	Specification for granulated slag for manufacture of Portland slag cement.
IS – 12269	Specification for 53-grade ordinary Portland cement.
IS – 12600	Specification for low heat Portland cement.
IS – 14687	Code of practice for mix design
IS –14959 (Part-I)	Determination of Water Soluble and Acid Soluble Chlorides in Mortar and Concrete.

IS - 16700	Criteria for Structural Safety of Tall Buildings (you may take appropriate clauses from attached annexure B of the code)
SP-23	Handbook on Concrete Mixes.
IS-15388	Silica fume-Specification

A-2 ASTM STANDARDS

ASTM C-33	Specification for Concrete Aggregates.
ASTM C-94	Specification for Ready Mixed Concrete
ASTM C-156	
ASTM C-295	Guide for Petrographic Examination of Aggregates for Concrete
ASTM C-309	
ASTM C-469	
ASTM C-494	Specification for chemical admixtures for concrete.
ASTM C–1202	Test method for electrical indication of concrete ability to resist chloride ion penetration.
ASTM C-1240	Specification for use of silica fumes as a Mineral Admixture in Hydraulic-Cement concrete, Mortar and Grout.
ASTM C–1260	Standard test method for Potential Alkali Reactivity of Aggregate (Mortar Bar Method)
ASTM D–75	Sampling of Aggregates
ASTM D–1411	Test methods for Water Soluble chlorides present as admixtures in graded aggregate road mixes.

A-3 ACI / ASME CODES AND SPECIFICATIONS

ACI 211.1	Standard Practice for selecting proportions for normal, Heavy Weight and mass concrete.

ACI 304.1R.	Guide for the use of Preplaced Aggregate Concrete for Structural and Mass concrete Applications.
ACI 304.2R	Placing Concrete by Pumping Methods.
ACI 318	Building code requirements for structural concrete and commentary.
ACI 381-05	Structural use of concrete.
ACI 224-R	Control of cracking in concrete structures.
ACI 301	Specification for structural concrete.
ACI 350	Environmental Engineering concrete structures.
ACI 350 2R	Concrete structures for of Hazardous materials.
BS 8110 : 1997	Code of practice for concrete structures.

A-4 BS STANDARDS

BS EN 206-9	
BS EN 12390-8	
BS 1881 - 122	
BS 1881 - 208	

A-5 OTHER STANDARDS

a) Railway Specifications – Tests for chloride and sulphate content of aggregates.

b) The European guidelines for Self Compacting Concrete – Specification, Production and Use (EFNARC Publication).

c) DIN-1048 Specification for water permeability of concrete.

d) Concrete library of JSCE No. 36 – Recommendations for construction of concrete containing ash as a mineral admixture

e) JSCE Concrete engineering series 31-Recommendation for self-compacting concrete

f) IS - 16714 - 2018 - Specifications for Ground Granulated Blast Furnace Slag for use with Portland cement

General

This specification covers all the aspects of mix design or proportioning, required properties test, Normal / High Performance / Self-compacting concrete for plain, RCC, pre-stressed and precast concrete work and repair and replacement of unsatisfactory concrete This specification for general works should be referred to for items such as concrete production like procurement of ingredients, storing, mixing, placing, vibrating, etc. and reinforcement.

(IA) Materials.

The ingredients to be used in the manufacture of standard concrete shall consist solely of standard type Portland cement, clean sand, natural coarse aggregate, clean water and admixtures.

1) Cement

a) the Contractor is responsible to supply cement, and the following points shall be applicable:

i) All cement used for the work shall be 53 grade Portland cement. Portland cement shall comply with the requirements of the latest issue of the IS-269-2015

ii) The Contractor shall make arrangements to the satisfaction of the Engineer for the storage of cement to prevent deterioration due to moisture and/or intrusion of foreign matter. Bulk cement shall be stored in approved waterproof bin or silo. Bagged cement shall be stored in suitable weather-tight warehouse in a manner to provide easy access for identification and inspection of each consignment. Stored cement shall meet the test requirements as per IS-269 at any time after storage, when a retest is ordered by the Engineer. Each consignment shall be stacked separately with the date of receipt flagged on it, not more than 12 bags stacked in height, the bags being arranged with headers and stretchers. Normally consignments shall be used in the order of receipt at site unless otherwise directed. In the case of large concrete pours, the Engineer will decide on the batch of cement to be used taking into consideration the quantity of cement with particular reference to the concerned concrete pours. Any additional work in handling and storage of cement contingent upon this requirement shall be to the contractor's account and no extra claim will be entertained. Cement shall be protected from exposure to moisture in transit, in storage at the works and until it enters the concrete mixers. The contractor shall keep accurate records of the deliveries of the cement and of its use in the work. The frequency and the type of test on cement to be as per relevant IS code.

2) Aggregates

a) Aggregate in general designates both fine and coarse inert materials used in the manufacture of concrete. Fine aggregate is aggregate all of which passes through 4.75 mm IS sieve. Coarse aggregate is aggregate most of which is retained on 4.75 mm sieve

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

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

d) **Sampling and testing**

Samples of the aggregates for mix design and determination of suitability shall be taken under the supervision of Engineer and delivered to the laboratory, well in advance of the scheduled placing of concrete. Records of tests, which have been made on proposed aggregates and on concrete made from this source of aggregates, shall be furnished to Engineer in advance of the work for use in determining aggregate suitability. The costs of all such tests, sampling etc. shall be borne by contractor. The frequency and the type of test on aggregate to be as per relevant IS code.

e) **Storage of Aggregates**

All coarse and fine aggregates shall be stacked in stock separately in stock piles in the material yard near the work site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign materials and with earth during storage and while heaping the materials shall be avoided. The aggregate must be of specified

quality not only at the time of receiving at site but more so at the time of loading into mixer. Loaders / Rackers of appropriate capacity shall be used for lifting the coarse aggregates from bins. or stockpiles. Coarse aggregate shall be piled in layers not exceeding 1.20 meters in height to prevent coning or segregation. Each layer shall cover the entire area of the stockpile before succeeding layers are started. Aggregates that have become segregated shall be rejected. For RMC operations, aggregates will be stored as mentioned in relevant section.

f) **Specific Gravity**

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

3) Crushed stone Sand

Crushed stone sand should be from Vertical Shaft Impactor (VSI). The process should meet the requirement of IS-383-2016.

a) **Screening and Washing**

Either natural or manufactured sand shall be prepared for use by such screening or washing or both as necessary, to remove all objectionable foreign matter while separating the sand grains to the required size fractions. Natural sand shall be washed, unless specific written authority is given by the Engineer to use sand that meets specification and standards of cleanliness without washing. The sand shall be washed in screw type mechanical washers in potable water to remove excess silt, clay and chlorides. The screening and washing of sand shall be completed at least one day before using it in concrete. The cost of screening and washing must be borne by the Contractor. The fine aggregate shall be taken from a source approved by the Engineer.

b) **Foreign Material Limitations**

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

		Uncrushed	**Crushed**
i)	Material finer than 75Micron IS sieve	3.00	15.0
ii)	Shale	1.00	-
iii)	Coal and lignite	1.00	1.00
iv)	Coal and lignite	1.00	1.00
v)	Total of all above substances including items (i) to (iv) for uncrushed sand and items iii) and (iv) for crushed sand	5.00	2.00

c) **Gradation**

Unless otherwise directed or approved, the grading of sand shall be within the limits indicated hereunder:

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

Where the grading falls outside the limits of any particular grading zone of sieves other than 600 micron IS sieve, by total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron IS sieve or to percentage passing any other sieve on the coarser limit of grading zone I or the finer limit of grading zone IV.

d) **Fineness Modulus**

The sand shall have a fineness modulus of not less than 2.2 or more than 3.2. The fineness modulus is determined by adding the Cumulative percentages retained on the following IS

sieves sizes 4.75mm, 2.36 mm, 1.18 mm 600 micron, 300 micron and 150 micron and dividing the sum by 100.

4) Coarse Aggregate

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

b) **Screening and Washing**

Natural gravel and crushed rock shall be screened and/or washed for the removal of dirt or dust coating, if so demanded by Engineer.

c) **Grading**

Coarse aggregate shall be graded in both cases the grading shall be within the following limits.

IS Sieve Designation	% passing for single sized aggregate of nominal size (mm)					% passing for graded aggregate of nominal size (mm)			
	40	20	16	12.5	10	40	20	16	12.5
63mm	100	-	-	-	-	100	-	-	-
40mm	85 - 100	100	-	-	-	95 100	100	-	-
20mm	0-20	85-100	100	-	-	30-70	95-100	100	-
16mm	-	-	85-100	100	-	-	-	90-100	-
12.5mm	-	-	-	85-100	100	-	-	-	90-100
10mm	0.5	0-20	0-30	0-45	85-100	10-35	25-55	30-70	40-85
4.75mm	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36mm	-	-	-	-	0-5	-	-	-	-

Size of coarse aggregates:

Following shall be the maximum nominal size of coarse aggregate for the different items of works :

Size of coarse aggregates in different types of works

Item of construction	Maximum nominal size of coarse aggregate
1. RCC well staining concrete, RCC well curb and RCC piles and plum concrete	63 mm
2. Well cap or pile cap, solid piers, and abutments and wing walls, pier caps and general item of work in bridge and building construction	40 mm
3. RCC works in cross girders, deck slab, wearing course, kerb, light posts, ballast walls, approach slab etc. and hollow type piers, abutments, wing walls and pier caps	20 mm
4. RCC bearings, shells and other thin walled members and in zones of congestion	10 mm

For any other item of construction not covered by items above as specified in drawings or as desired by the Engineer.

d) **Foreign Materials Limitations**

The percentages of deleterious substance in the coarse aggregate delivered to the mixer shall not exceed the following: Please refer Table 2 of IS 383-2016

	Percent by Weight	
	Uncrushed	Crushed
i) Material finer than 75 micron IS sieve	3.0	3.0
ii) Coal and lignite	1.0	1.0
iii) Clay lumps	1.0	1.0
iv) Soft fragments	3.0	-
v) Total of all the above substances	5.0	5.0

5) **Fly Ash** (pulverized fuel ash) :

Fly ash conforming to Grade 1 of IS3812 may be used as part of replacement of Ordinary Portland Cement provided uniform blending with cement is ensured. Each LOT / Bulker should be tested for retaintion on 45 microns seive by wet seiving and it should not be more than 15%.

6) **Microfine materials :**

Microfine materials like ultrafine slag as per IS 16715 – 2018 silica fume, processed fly ash, processed limestone, approved by the concrete technologist appointed by the Owner may be used as part replacement of cement provided uniform blending with the cement is ensured. These are very fine materials and can be used normally in a proportion of 5 to 10% of the cementitious content of a mix, depending on the requirement of the performance of the concrete.

The Contractor shall provide the services of a manufacturer's technical representative, experienced in mixture proportioning, placement procedures, and curing of concrete containing silica fume or microfine materials as and when required.

7) **Ground Granulated Blast Furnace Slag :**

Ground Granulated Blast Furnace Slab obtained by grinding granulated blast furnace slag conforming to IS 16714-2018 may be used as part replacement of ordinary Portland Cement provided uniform blending with cement is ensured .Each LOT / Bulker should be

tested for retention on 45 microns sieve by wet sieving and it should not be more than 10% .

8) **Admixtures :**

It is essential to use approved Melamine, Naphthalene or PC based admixtures for imparting special characteristics to the concrete, on satisfactory evidence that its use does not in any way adversely affect the properties of concrete, particularly its strength, volume changes, durability and has no deleterious effect on the reinforcement. They should not impair durability of concrete nor combine with the constituent to form harmful compounds. The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before the use of the admixtures. Minimum cement quantity shall not be reduced on account of use of admixtures.

The admixtures shall also have the property of set retarding. Before approval of super plasticizer, the Contractor will submit test reports as specified in IS-9103 from an approved laboratory as approved by the Engineer in Charge. Subsequent batches will be tested for IR analysis, UV analysis, chloride content, PH, ASH content and solid content or any other tests as directed by Engineer in charge. Every Lot should be tested by a third party LAB for the above parameters

If two or more admixtures are used simultaneously in the same concrete mix, data should be obtained to assess their interaction and to ensure their compatibility.

Admixture Approvals

Descriptive literature of the grout, air-entraining admixtures, accelerating admixtures, Retarding Admixture, bonding agents, expansive admixtures, surface retarders, water reducing and High Range Water Reducing admixtures, membrane forming curing agents, curing sheets etc. proposed for use containing certified laboratory test results showing that they meet the approved standards shall be submitted 30 days prior to their use together with a certificate from the manufacturer stating that the products are suitable for the application or exposure for which they are being considered. In addition, a detailed plan shall be submitted for review, showing equipment and procedures for use in mixing and placing the admixtures and agents. All chemical admixtures furnished as liquids shall be

in a solution of suitable viscosity for field use as determined by the Engineer in charge. The admixtures shall not be paid for separately.

9) **Concrete Cover Blocks : The Grade of concrete of cover blocks should be one grade higher than the structural grade of concrete and it should meet the requirements as given in BS 7973. The cover blocks to be factory made as per BS 7973. Alternatively PVC cover blocks as per relevant IS standards can also be used with the permission of Site-in-charge. Appropriate spacing should be maintained based on element size**

10) **Materials for Repair Work :**

The use of approved construction chemicals for bonding between old and fresh concrete and pressure grouting with polymer additives used for repairs shall be must. The selection of the bonding agents and polymer grouts shall be made on written approval of the Engineer. These bonding agents and polymer grouts shall be applied and used in accordance with the instructions of the Manufacturer. The cost of such repair shall be borne by the Contractor. However, it is the Engineer in charge's sole discretion whether the unsatisfactory portion of concreting is to be allowed to be repaired or to order the portion to be demolished to be reconstructed. The cost of the reconstruction will also be borne by the Contractor.

11) **Water**

a) Water used for both mixing and curing shall meet the requirements of IS 456 and be free from injurious amounts of deleterious .Potable water is generally satisfactory for mixing and curing concrete.

b) In case of doubt, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time test specified in IS-456 -2000. The sample of water taken for testing shall be typical of the water proposed to be used for concreting, due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water. The frequency and the type of test on water to be as per relevant IS code.

c) Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water.

d) The initial setting time or test block made with the appropriate set cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by more than plus minus 30 seconds form the initial setting time of control test block prepared with the appropriate test cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of IS 4031.

e) Where water can be shown to contain an excess of acid, alkali sugar or salt, engineer may refuse to permit its use. As a guide, the following concentrations represent the maximum permissible values:

i) To neutralize 100 ml sample of water, using phenolphthalein as indicator, it should not require more than 5 ml of 0.2 normal NaOH. The details of test shall be as given in IS 3025 (part 22).

ii) To neutralise 100 ml sample of water using Mix Indicator as an indicator, it should not require more than 25 ml of 0.02 normal H_2SO_4. The details of test shall be given in IS 3025 (part 23).

iii) Percentage of solids when tested in accordance with the method indicated below shall not exceed the following:

	Percent	Test as per
Organic	200 mg/L	IS 3025-1964 (part 18)
Inorganic	3000mg/L	- Do -
Sulphate (as SO4 Alkali)	400 mg/L	IS 3025-1964 (part 24)
Chlorides (as Cl)	2000 mg/L	IS 3025-1964 (part 32)
Suspended matter	2000 mg/L	IS 3025-1964 (part 17)

(IB) Characteristics and Proportioning of Concrete Mix

- **Concrete Classification**

Unless otherwise specifically stated as Nominal Mix, all concrete, contemplated under this specification, shall be taken to mean as "**Controlled Concrete**".

Controlled concrete is a concrete where the mix proportions are determined by mix design, preliminary mix proportioning and laboratory tests. These shall be carried out at specified intervals and also whenever the Engineer has reasons to believe that there has been a change in the quality, properties, or grading etc of any of the constituents of concrete, which, in his opinion, would impair the strength and /or durability.

Each class of concrete shall be identified by designation consisting of a prefix and two numbers like N/25/40. Prefix 'N' signifies normal density or normal concrete. Next two numbers e.g. 25 and 40 would denote the Uniaxial characteristic compressive strength at 28 days in MPa (25 MPa and maximum size of coarse aggregate in mm (40 mm) respectively. Normal concrete shall have a net unit weight of not less than 2400 Kg/cu.m.

Concrete grade shall be specified for 28 days Compressive strength for all work other than for raft for which reference to IS-16700 (2017) be made and 90 days strength may be specified. If strength at an age later than 28 day is specified, correlation between 28 day strength and later age specified shall be established to ensure construction continuity. It shall be ensured that the concrete develops the Requisite strength at specified days before predominant loads are imposed on it.

Class designation of concrete shall be as specified on the drawing. Maximum size of aggregate shall be 20 mm unless specified otherwise. However, when concreting has to be carried out in congested areas or for self-compacting concrete, maximum size of aggregate may be suitably reduced, with the approval of the Engineer. Unless otherwise specified on drawings or called for in the schedule of Quantities, the class designation of normal concrete to be used shall, generally, be selected from Table - 1.

TABLE - 1 GRADES OF NORMAL CONCRETE

Class	**Characteristic Compressive Strength of 15 cm cubes at 28 days in MPa**	**Maximum size of aggregate in mm**
N/10/20	10	20
N/20/20	20	20
N/30/20	30	20
N/35/20	35	20
N/40/20	40	20
N/45/20	45	20
N/50/20	50	20
N/60/20	60	20
N/70/20	70	20
N/80/20	80	20

Note : The Maximum size of aggregate has to be 10 mm wherever there is a congestion of reinforcement clear spacing less then 80 mm or as decided by the client.

Note 2 : The following compressive strength should be acquired for the concrete cubes

When 100% of characteristic strength should be achieved as per IS-516	No of days	Type of material	Percentage of characteristic strength to be achieved as per IS-516
28 days	3 day	Fly ash	45%
28 days	3 day	GGBS	45%
28 days	7 day	Fly ash	70%
28 days	7 day	GGBS	66%
90 days	7 day	Fly ash	55%
90 days	7 day	GGBS	50%

Grade of Concrete **Compressive works test strength in N/sq.mm on 150 mm cubes after tests conducted in accordance with relevant IS code.**

- **Durability of Concrete**

To meet the requirement of durability, the water content as well as water to binder ratio shall be as low as practicable. In addition, there shall be adequate compaction and immediate curing as well as curing for longer period is necessary.

- **Exposure Conditions**

Various conditions for which the concrete will be exposed during its service life are given in the Table-2.

TABLE - 2 ENVIRONMENTAL EXPOSURE CONDITIONS

Sr. No	Environment	Exposure Condition
1	Mild	Concrete surface protected against weather or aggressive conditions except those situated in coastal area.
2	Moderate	Concrete surface sheltered from severe rain or freezing whilst wet Concrete exposed to condensation and rain. Concrete continuously under water. Concrete in contact or buried under non-aggressive soil / ground water. Concrete surfaces sheltered from saturated salt air in coastal area.
3	Severe	Concrete surface exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation. Concrete completely immersed in seawater. Concrete exposed to coastal environment.
4	Very Severe	Concrete surface exposed to seawater spray, corrosive fumes or severe freezing conditions whist wet. Concrete in contact with or buried under aggressive subsoil / ground water.

5	Extreme	Surface of members in tidal zone Members in direct contact with liquid/solid aggressive chemicals

- **Exposure to Sulphate Attack**

Requirements for concrete exposed to sulphate attack shall be as per relevant provisions of IS 456. All the recommendations for the type of cement, maximum free water/cement ratio and minimum cement content, which are required at different sulphate concentrations in near-neutral ground water having pH 6 to 9, given in the Table -3, shall be followed.

For the very high sulphate concentrations in Class 5 conditions, some form of lining such as polyethylene or polychloroprene sheet; or surface coating based on asphalt, chlorinated rubber, epoxy, or polyurethane materials should also be used to prevent access by the sulphate solution. The decision of Engineer shall be followed in this regard. Such liner shall be measured and paid separately.

TABLE - 3 REQUIREMENTS FOR CONCRETE EXPOSED TO SULPHATE ATTACK

Notes:

- **Use of Super sulphated cement is generally restricted where the prevailing temperature is above 40 ^{o}C.**
- **The cement content given in above table is the minimum recommended. acceptable life provided that the concrete is dense and prepared with a W/C ratio of 0.4 or less in mineral acids, down to pH3.5. For SO3 contents near the upper limit of any class, cement content above these minimums are advised.**
- **For severe conditions, such as thin sections under hydrostatic pressure on one side only and sections partly immersed, consideration should be given to a further reduction of W/C ratio.**
- **Portland Slag Cement conforming to IS: 455 with slag content more than 50% exhibits better sulphate resisting properties.**
- **Where chloride is encountered along with sulphate in soil or ground water, ordinary Portland cement with C3A content from 5 to 8% shall be desirable to be used in concrete, instead of sulphate resisting cement. Alternatively, Portland slag cement conforming to IS: 455 having more than 50% slag or a blend of ordinary Portland**

cement and slag may be used provided sufficient information is available on performance of such blended cements in these conditions.

- ***Minimum Cement Content, Maximum W/C***

Unless specified otherwise, the value for minimum *binder* content and maximum free water-cement ratio given in the Table 4 for different exposure conditions and for 20 mm maximum size aggregate may be used in the mix design.

TABLE– 4 MINIMUM CEMENT CONTENT, MAXIMUM WATER-CEMENT RATIO AND MINIMUM GRADE OF CONCRETE FOR DIFFERENT EXPOSURES WITH NORMAL WEIGHT AGGREGATE OF 20MM NOMINAL MAXIMUM SIZE

Exposure	Plain Concrete			Reinforced Concrete		
	Minimum Cement Content kg/m3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m3	Maximum Free water-Cement Ratio	Minimum Grade of Concrete
Mild	220	0.60	-	300	0.55	M 20
Moderate	240	0.60	M 15	300	0.50	M 25
Severe	250	0.50	M 20	320	0.45	M 30
Very Severe	260	0.45	M 20	340	0.45	M 35
Extreme	280	0.40	M 25	360	0.40	M 40

Notes:

It is most important to keep the specified water-cement ratio constant and at its correct value. To this end, moisture content in both fine and coarse aggregates shall be determined by the Engineer according to the weather conditions. The amount of mixing water shall then be adjusted to compensate for variations in the moisture content. For the determination of moisture content in the aggregates, IS-2386 (Part

III) shall be referred to. Suitable adjustments shall also be made in the weights of aggregates to allow for the variation in weight of aggregates due to variation in their moisture content.

Minimum cementitious content : Durability considerations
(REFER TABLE NO 5 of IS 456 - latest revision)

Exposure condition	Minimum Cementitious content (kg/m3)	Minimum grade of concrete	Maximum Free Water-Cement ratio	Cover to concrete
1. PCC (Moderate)	240	M-15	0.6	Cover as per drawing
2. RCC (Moderate)	300	M-25	0.5	Cover as per drawing

Cement content prescribed in the above table is inclusive of additions of fly ash, micro fine material or GGBS. However, the proportions of the individual additional ingredient shall not exceed the limits prescribed for each one in the respective IS code.

For concretes of all grades, the proportions of cement, aggregates, admixtures etc. shall be strictly on the basis of experimentation carried out well in advance of commencing the construction. All such experimentation must be recorded in approved formats and will be circulated to structural consultant, site engineers, project managers and engineer in charge representing the Owner.

a) Cement content prescribed in this table is irrespective of grade of cement and is inclusive of mineral admixture like fly ash, microfine materials, GGBS etc

b) Maximum quantity of fly ash that shall be taken into account in the concrete composition for minimum cement content computation specified above shall be is in line with IS 1489 requirements.

c) Maximum quantity of GGBS that shall be taken into account in the concrete composition with respect to minimum cement content requirement specified above shall

be in line with IS 455 requirements.

d) Minimum cement content shall be increased by 40 kg/m^3 for 10 mm maximum size of aggregate and shall be reduced by 30 kg/m^3 for 40 mm maximum aggregate size

e) The quantity of water shall be just sufficient to produce dense concrete of required workability and strength for the job. An accurate and strict control shall be kept on the quantity of mixing water.

In the case of reinforced concrete work, workability shall be such that the concrete surrounds and properly grips all reinforcement. The degrees of consistency, which shall depend upon the nature of work and methods of vibration of concrete shall be determined by regular slump tests. A guideline for workability to be adopted for different types of works is given in IS 456.

f) Free flow concrete workability will be specified in terms of flow as per IS 9103, depending on the job For thin sections and sections with congested reinforcement where vibration is not possible, Self-Compacting Concrete of appropriate clause as per IS 1199 Part 6 2018 at no extra cost

Plasticizers and/or retarders shall be used wherever necessary to control the water cement ratio and to achieve the required slump at no extra cost.

- **Concrete Mix Proportioning**

- **Mixing Proportioning Criteria**

The mix proportioning, in case of OPC concrete shall be based on 28-day characteristic strength. For concrete containing fly ash, GGBS or any other mineral admixture, the concrete acceptance criteria shall be based on 28-day strength except wherever specified. Any other specific requirement, if any, will be as indicated on the construction drawings.

Concrete shall be proportioned to obtain workable mixes for intended purpose and to meet the strength and finish requirements.

Preliminary mix proportioning shall be established by conducting trials by the contractor, well in advance, so as to meet the time schedule. Mix proportion adopted shall meet the specified properties of green as well as hardened concrete.

While conducting trials, contractor shall use the ingredients that are qualified for actual work. All efforts shall be made to carry out the trials in laboratory and after the mix is finalized, final trials shall be done at batching plant for final qualification of the mix proportion.

- **Mix Proportioning Method**

Concrete mix proportioning may be done by methods given in IS 10262, SP-23, ACI 211.1, or by any other suitable method so that the final product meets the specified requirements for green as well as hardened concrete. Efforts shall be made to keep cement content as well as unit water content as minimum as possible, with the use of suitable quality of chemical admixture.

- **Target Mean Strength**

The target mean strength of concrete mix shall be equal to the characteristic strength plus 1.65 times standard deviation. The standard deviation for each grade of concrete shall be calculated separately. When sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in **IS - 10262 2019** may be assumed for mix proportioning in the first instance. As soon as the test results on sufficient number of samples are available, actual standard deviation shall be calculated and used in mix proportioning. However, when adequate past record for a similar grade exists the same may be used for deciding target mean strength.

(III) PROPERTIES OF CONCRETE

DEFINITIONS:

REGULAR AREAS : means all areas like Utility area, workshops area, loading /unloading area, all staircases, OHWT, RCC walls in these areas, Service floor roof slab , foundations, columns, beams, walls, slabs, etc..

Acceptable Properties for concrete for REGULAR area

- Workability and slump

The workability measured in terms of tests as per IS 1199 Part 2 2018. As majority of concrete is desired to be placed using pumps, the workability of concrete shall be such that mix is pumpable. **As a general guideline, flow of 500±50 mm at placement point is**

suitable for pumping of concrete. The requirement of workability for various pours, based on the placement methods and reinforcement congestion shall be decided at site with the concurrence of the Engineer.

- Unit weight

Normal concrete should have a net dry theoretical unit weight of 2400 kg/m^3, when tested as per IS 1199. The unit weight of concrete of any grade shall not be lower than 2375 kg/m^3. For heavy concrete, the net dry unit weight shall not be less than 3600 kg/m^3 and for special heavy concrete, the net dry unit weight shall be 4100 kg/m^3.

- Air content

While designing mix proportioning, air content for different aggregate sizes shall be as per Table-7 of IS 10262 2019

- Setting time

Setting time of concrete shall be determined as per IS 1199 Part 7 2018 As the setting time depends on the temperature of concrete at the time of production as well as ambient conditions, it is required to check the setting time of concrete under same temperature and ambient conditions, as envisaged in the work.

- Bleeding

Bleeding of concrete shall not be excessive, when tested as per IS 9103.

- Chloride content in concrete

The total acid soluble chloride in fresh concrete determined as per IS 14959 Part-1 shall not exceed 0.6 kg/m^3 and 0.4 kg/m^3 as per IS 456 (2000) reinforced and pre stressed concrete respectively.

- Cube compressive strength

Uniaxial Compressive cube strength shall be determined on 150 mm size cubes, as per IS 516.

- Cylinder compressive strength

Uniaxial Compressive cylinder strength shall also be determined on 150 mm diameter 300

mm long size cylinder, as per IS 516. Uniaxial characteristic compressive cylinder strength shall not be less than 80% of characteristic compressive cube strength.

- Flexural strength

Flexural strength of concrete shall be determined as per IS 516. Flexural strength shall not be less than 0.7√fck MPa where fck is the characteristic compressive cube strength of concrete in MPa.

- Static Modulus of elasticity

The modulus of elasticity of concrete shall be determined as per ASTM-C469. The static modulus of elasticity shall not be less than 5000√fck MPa, where fck is the characteristic compressive cube strength of concrete in MPa. This is applicable up to 50 MPa.If the actual measured value differs by more than ± 20% from the value obtained from the above expression then it shall be reported to the Engineer.

- Chloride Permeability shall be determined by conducting Rapid Chloride Penetration Test (RCPT) as per ASTM C-1202.

- Concrete used in tall building construction shall be durable. For ensuring long term durability, concrete shall satisfy the following

Test criteria;

1. Rapid chloride ion permeability test (ASTM C 1202)

I) Foundations– Not more than 1000 coulomb.

II) Superstructure- Not More than 1000 coulomb.

2. Water Penetration test (BSEN 12390 part 8 / ~~Din 1048)~~ IS 516 Part 2 2018

I) Foundations- 15mm Max.

II) Superstructure-20 mm Max.

(IV) Trial Mix at Laboratory

Based on the guidelines given above concrete mix design and proportioning shall be carried out so that it meets the requirements of strength, workability and durability. The test to be carried out in Pan Mixers only.

To qualify a mix proportion, at least 4 trials shall be carried out in the 3rd Party laboratory (NABL accredited Lab) using the preliminary mix design. Trials shall be carried out to optimize the quantity of cement, pozzolonic materials and other ingredients of concrete subsequently and on continuous basis.

A. Test for Compressive strength of Trial mix Concrete:

Trial mix concrete shall consist of three trials on three different days with aggregate samples collected each day for each grade and for each trial compressive strength tests shall be conducted on six specimens. Of the six specimens in each set, three shall be tested at seven days and the remaining three at 28 days. The preliminary tests at 7 days are intended only to indicate the strength likely to be attained at 28 days.

The contractor is entirely responsible for the design of the concrete mixes. The design is however to be approved by the Engineer. At least 12 weeks before commencing any concreting in the works, the contractor shall make trial mixes using samples of coarse aggregates, sand, water, plasticizers and cement, typical of those to be used in the works and which have been tested in an approved laboratory. A clean dry mixer shall be used and the first batch discarded. The use of plasticizers cum retarders of approved quality at Contractor's own cost is mandatory.

If the average strength of the concrete cubes falls below the required target mean strength, fresh preliminary mixes for that grade shall be made as before, until the trial mixes yield cubes of compressive strength at 28 days greater than the required average target mean strength at that age.

Whenever there is a significant change in the quality of any of the ingredients for concrete, the Engineer may at his discretion order the carrying out of fresh trial mixes. All costs for trial mixes and tests shall be to the Contractor's account and held to be included in the Contract Rates.

Before commencing the works, the Contractor shall submit to the Engineer, the full details of all preliminary trial mixes and tests for his approval.

The Contractor shall carry out trial casting of a mock-up of at least one meter length of an RCC member to establish the correctness of grading aggregates, suitability of mould oil

proposed to be used on formwork to prevent surface blemishes etc.. All costs of such trial casting shall be included in the Contract Rates.

Whenever the quality or brand or source of ingredients used in the approved trial mix changes on any account, fresh preliminary tests conforming to all the above requirements shall be carried out and the mix shall be approved by the Engineer before carrying out concreting with the new mix.

Following tests shall be carried out on these mixes. Trials to be witnessed by the Client.

- Flow (as per IS 1199) at 0 min, 30 min and 60 min, 120 min, 180 mm (400 +/- 50 @ placing point without any bleeding and segregation.)
- Unit weight :
- Air content
- Temperature
- Initial and final setting time (IS 1199)
- Bleeding
- Compressive cube strength at 1, 3, 7, 28 and 56 and 90days
- Split tensile strength at 28 days (on 150x 300mm cylinder)
- RCPT at 56 days
- Static Modulus of elasticity at 28 days (ASTM-C469 on 150 x 300mm cylinder)
- Water penetration test - 28 days

The concrete shall meet the specified values for all the above properties. The mean of 28 or 90 days (as the case may be), cube compressive strength of all the four sets shall be more than or equal to target strength.

(V) Acceptance Test At Batching Plant

To ensure that laboratory proportioned concrete mix meets all the requirements when

produced using the actual batching plant and other equipment, at least 4 trials shall be conducted at batching plant. It has to be ensured that all the requirements specified in above clause are met with. At least one test shall be conducted to check the yield of the concrete. In case of significant difference from the theoretical yield and the observed yield, it shall be investigated and rectification measures shall be taken.

Contractor shall submit a detailed report on the concrete mix proportioning to the Engineer for his approval. This report shall include the test results on concrete ingredients, laboratory trial results and batching plant trial results.

(VI) Tests on Concrete

Samples from fresh concrete shall be taken as per IS 1199 at the **placement point or pumping point**. Frequency of testing shall be as given in Table-8

. Works Strength Tests for Controlled and Ordinary Concrete:

Work strength tests shall be made in accordance with IS:516. Each test shall be conducted on six specimens, three of which shall be tested at 7 days and the remaining three at 28 days. The samples of concrete shall be taken on each day as per IS - 4926. The client reserve right to increase the frequency as per site condition s at no extra cost.

Similar works test shall be carried out whenever the quality and grading of materials is changed irrespective of the quantity of concrete poured. The number of specimens may be suitably increased as deemed necessary by the Engineer, when procedure of tests given above reveals a poor quality of concrete and in other special cases.

All work shall be carried out under the supervision of qualified and competent Engineer appointed by and working on behalf of the Contractor (not the Engineer-in-charge) who will supervise proportioning, placing and compacting of concrete at all stages.

If concrete is batched at more than one point simultaneously, the above frequency of making cubes shall be followed at each point of batching.

All necessary labour, materials, equipment, etc. for sampling preparing test cubes, curing, etc. shall be provided by the Contractor. Testing of the materials and concrete may be arranged by the Engineer in an approved laboratory at the cost of the Contractor.

TABLE - 8 FREQUENCY FOR DETERMINATION OF PROPERTIES OF FRESH AND HARDENED CONCRETE

Sl. No.	Description of test	Frequency of testing
1	Slump / flow	Every Transit Mixer
2	Temperature	Every Transit Mixer
3	Unit weight	At the time of casting of cubes one sample per day for each grade
4	Air content	One sample per month for each grade or as per site requirement
5	Initial and final setting time	One sample per month for each grade or as per site requirement
6	Bleeding	One sample per month for each grade or as per site requirement
7	Cube compressive strength 3,7, 28,56 and 90 days	As per IS 4926 The client reserve right to increase the frequency as per site condition s at no extra cost. At least one sample on each day of concreting for each grade.
8	RCPT	One sample per month for each grade
9	Chlorides and sulphate content test	One sample per month for each grade
10	Static Modulus of elasticity	One sample per month for each grade
12	Split tensile	One sample per month for each grade

Note:

- As per the requirement of Engineer in-charge.
- One sample for strength test means sufficient number of cubes to determine average of at least 3 cubes at specified time . One set for each grade is 15 Nos of cubes for 3,7,28,56,90 days. The frequency of sampling will be as per IS 4926 or as mentioned in specification, whichever is more stringent.

- For all materials required for concrete construction including cement, aggregate, water, reinforcing and prestressing steel the original copies of test certificates, test results etc. either carried out by the manufacturer or any other agency, the mix design recommendations etc. shall be submitted to the Engineer for his approval and record. It shall remain the property of the Engineer.

- In case the Contractor has set up his in-house Laboratory, 5% of the testing needs to be done at the External Laboratory (NABL accreditated Lab) for which no extra charges will be paid.

- **NDT as a Tool for Assuring in-situ Quality of Concrete in New Structures (at clients cost)**

NDT techniques are to be used to assess quality of concrete in to assess the in-situ quality of concrete as a structure is built as an assurance.

In this case, NDT sturdy has to be included at the planning stage. In consultation with the structural consultant / Clients Site In charge ,minimum 3% percentage of structural elements at selected locations will be marked for the study. The type of test to be conducted are Rebound Hammer test, Ultrasonic pulse velocity, core test.

After the selected element has been built, at a time beyond 28 days, the test or test will be conducted and the data analyzed. To improve the reliability of data, before starting constructions, the calibration of the instruments will be carried out using concrete mixes designed for the project. This is required, in NDT parameters measured are not the one that specify the quality of concrete. They are related to the required parameters and calibration with the designed mix using raw materials to be used for the project greatly improve the reliability of the NDT measurements. This exercise will help in assuring the quality of as built structure to all involved viz. the client, the consultants, and contractor and more importantly to the ultimate buyer /owner of a unit.

The testing is to be done by the CLIENT and this is not a cost to the contractor.

(VII) Acceptance Criteria

1. **The strength requirement of any particular grade of concrete will be considered satisfactory if the 28 days compressive strengths of individual sets (each set consists of 3 cubes) and of individual cubes satisfy the following requirements of IS 456 clause 15, 16, 17 except wherever specified.**

NOTE:

- In the absence of established value of standard deviation, the value given in Table-9 may be assumed, and attempt should be made to obtain result of 30 samples as early as possible to establish the value of standard deviation.
- Concrete is liable for rejection, if criteria mentioned in Table -9 is not met with.
- If the concrete, after opening the shutter, is found to be porous or honeycombed, or concrete placing is interrupted without providing a proper construction joint or the reinforcement has been displaced beyond the tolerances specified, or construction tolerances have not been met with, it is liable to be rejected.
- However, the same may be accepted if remedial measures as approved by the structural consultant is adopted and if the same are carried out to the satisfaction of the Engineer-in-charge.

(VIII) Use of 3,7,28,56 and 90 Days Tests

For any mix, a correlation between 3 day, 7 day, 28 day, 56 day and 90 day strengths may be established in the laboratory. Soon after a job starts, a similar correlation shall be established during actual progress of the work. After the correlation has been established, the results of the 7 day test may be used as the precursor for the expected compressive strength at 28-days. If 7-day test indicates low compressive strength, corrective measures shall be taken without waiting for 28-day strength results. Similarly for concrete with fly ash, GGBS and micro silica, co-relation shall be established between 3, 7, 28, 56 and 90 day compressive strength.

(IX) Failure to Meet Strength Requirement

In the event of concrete, tested in accordance with the relevant standards, fails to meet the acceptance criteria above with the approval of Engineer, the following measures shall be taken by the contractor, in the order as below with no extra cost to the owner.

- Extended curing of the concrete represented by the specimen
- Non -destructive test on structure.
- Taking cores from the structural element, where the test has failed, (IS:456).
- Load tests on part of structures as per IS: 456.
- Replacement of affected part / parts of the structure.

(X) Non Destructive Tests

In case of doubts about the quality of concrete in the construction, non -destructive tests shall be conducted as directed by the Engineer. The tests shall be carried out by a NABL accredited Laboratory as per the provisions of relevant IS standards. Based on the NDT evaluation, decision on acceptance of structure or otherwise shall be taken by the Engineer.

(XI) Core Test

Three cores shall be extracted from the structure for determination of compressive strength represented by that structural element. The diameters of core shall be at least 3 times the maximum size of aggregate used in the concrete and height to diameter ratio shall be 2.0. Core shall be tested as per IS 516. Concrete in the member, represented by a core, shall be considered acceptable, if the average equivalent cube strength of the core (computed as 80% of the core cylinder strength) is equal to at least 85 percent of the specified characteristic strength and no individual average equivalent cube strength of core has strength less than 75% of the specified characteristic strength.

If the strength of concrete in any portion of the structure is lower than the required strength, but is considered nevertheless adequate by the Engineer so that demolition is not necessary, the Contractor shall be paid lower rate for such lower strength concrete as determined by the Engineer.

(XII) Placing Concrete by Pumping

A. MIXING CONCRETE :

a.1 Mixing with Mechanical Mixers :

a.1.1 Stationery Mixers

For all work, concrete, with the permission of Client, can be mixed in a mechanical mixer which along with other accessories shall be kept in first class working condition and so maintained throughout the construction. Mixing shall be continued till materials are uniformly distributed and uniform colour of the entire mass is obtained and each individual particle of the coarse aggregate show complete coating of mortar containing its proportionate amount of cement. In no case shall the mixing be done for less than two minutes after all ingredients have been put into mixer. Hand mixing will not be permitted under any circumstances. Mixers that have been out of use for more than 30 minutes shall be thoroughly cleaned before putting in a new batch. Unless otherwise agreed to by the Engineer, the first batch of concrete from the mixer shall contain only two thirds of the normal quantity of coarse aggregate. Mixer shall be thoroughly cleaned before changing from one type of cement to another.

Each mix shall combine the materials into a uniform mixture and discharge this mixture without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer on the nameplate. Excessive over-mixing requiring introduction of additional water will not be permitted. The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired or replaced.

a.1.2 Weigh Batching

All structural concrete shall be weigh batched. All concrete ingredients shall be batched by weight using a weigh batcher of an approved make. (IS : 2722 - Portable Swing Weigh Batchers for Concrete.) Batching shall be to an accuracy of not less than 1/2 kg and the batcher shall be tested for accuracy of calibration before commencement of the works and at least once a week thereafter or more frequently if so required by the Engineer. Weigh batching can be permitted depending upon space on the site and with the permission of client only.

a.2 Mixing with Batching Plants :

Concrete to be produced only in the Batching plant irrespective of the Quantity. Such batching plants may be erected within or outside the project site provided the client gives permission to set up the plant within the premises. If the permission to set up the plant is given by the client as per the terms and conditions of the tender than , Post Captive plant is set up, in case the additional quantity is required or due to Batching plant failure, the concrete shall be procured from prior approved RMC vendor but with one grade higher at the cost of contractor and no extra cost will be paid.

a.2.1 Capacity

The batching, mixing, conveying, and placing systems shall have a capacity of at least sixty cubic meters per hour or as directed by the Engineer in charge.

a.2.2 Batch Plant

Batch plant shall meet the following requirements.

a.2.2.1 Location

The concrete plant may be located at the site of the work in the general area indicated on the drawings, or may be located offsite.

a.2.2.2 Bins and Silos

Separate bins, compartments, or silos shall be provided for each size or classification of aggregate and for each of the cementitious materials. The compartments shall be of ample size and so constructed that the various materials will be maintained separately under all working conditions. All compartments containing bulk cement, pozzolan, ground granulated blast-furnace slag, or silica fume shall be separated from each other by a free-draining air space. All filling ports shall be clearly marked with a permanent sign stating the contents.

a.2.2.3 Batching Equipment

a. Batchers

Aggregate shall be weighed in separate weigh batchers with individual scales. Bulk cement and/or other cementitious materials shall each be weighed on a separate scale in a separate weigh batcher. Water shall be measured by weight or by volume. If measured by weight, it shall not be weighed cumulatively with another ingredient. Ice shall be measured separately by weight. Admixtures shall be batched separately and shall be batched by weight or by volume in accordance with the manufacturer's recommendations.

b. Water Batcher

A suitable water-measuring and batching device shall be provided that will be capable of measuring and batching the mixing water within the specified tolerances for each batch. The mechanism for delivering water to the mixers shall be free from leakage when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, a suitable strainer shall be provided ahead of the metering device.

c. Admixture Dispensers

A separate batcher or dispenser shall be provided for each admixture. Each plant shall be equipped with the necessary calibration devices that will permit convenient checking of the accuracy of the dispensed volume of the particular admixture. The batching or dispensing devices shall be capable of repetitively controlling the batching of the admixtures to the accuracy specified. Piping for liquid admixtures shall be free from leaks and properly valved to prevent backflow or siphoning. The dispensing system shall include a device or devices that will detect and indicate the presence or absence of the admixture or provide a convenient means of visually observing the admixture in the process of being batched or discharged.

Each system shall be capable of ready adjustment to permit varying the quantity of admixture to be batched. Each dispenser shall be interlocked with the batching and

discharge operations so that each admixture is added separately to the batch in solution in a separate portion of the mixing water or in fine aggregate in a manner to ensure uniform distribution of the admixtures throughout the batch during the required mixing period. Storage and handling of admixtures shall be in accordance with the manufacturers recommendations.

d. Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched. A moisture meter shall be provided for measurement of moisture in the fine aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher.

e. Scales

Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete. The weighing equipment and controls shall have an accuracy within 0.2 percent of the scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Tests shall be made at the frequency set by the Engineer in charge and in the presence of a representative of the Engineer in charge or a quality assurance representative. Each weighing unit shall include a visible indicator that shall indicate the scale load at all stages of the weighing operation and shall show the scale in balance at zero load. The weighing equipment shall be arranged so that the concrete plant operator can conveniently observe the indicators.

f. Operation and Accuracy

The weighing operation of each material shall start automatically when actuated by a single starter switch and shall end automatically when the designated amount of each material has been reached. These requirements can be met by providing an automatic batching system. There shall be equipment to permit the selection of four preset mixes each by the movement of not more than two switches or other control devices. Cumulative weighing will not be permitted. The weigh batchers shall be so constructed and arranged that the sequence and timing of batcher discharge gates can be controlled

to produce a ribboning and mixing of the aggregates, water, admixtures,and cementitious materials as the materials pass through the charging hopper into the mixer. The plant shall include provisions to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy as per IS 4962.

g. Interlocks

Batchers and mixers shall be interlocked so that:

The charging device of each batcher cannot be actuated until all scales have returned to zero balance within ± 0.2 percent of the scale capacity and each volumetric device has reset to start or has signaled empty.

The charging device of each batcher cannot be actuated if the discharge device is open.

The discharge device of each batcher cannot be actuated if the charging device is open.

The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.

One admixture is batched automatically with the water.

Each additional admixture is batched automatically with a separate portion of the water or with the fine aggregate.

The mixers cannot be discharged until the required mixing time has elapsed.

g. Recorder

An accurate recorder or recorders shall be provided and shall conform to the following detailed requirements:

(1) The recorder shall produce a graphical or digital record on a single visible chart or tape of the weight or volume of each material in the batchers at the conclusion of the batching cycle. The record shall be produced prior to delivery of the materials to the mixer. After the batchers have been discharged, the recorder shall show the return to empty condition.

(2) A graphical recording or digital printout unit shall be completely housed in a single cabinet that shall be capable of being locked.

(3) The chart or tape shall be so marked that each batch may be permanently identified and so that variations in batch weights of each type of batch can be readily observed. The chart or tape shall be easily interpreted in increments not exceeding 0.5 percent of each batch weight.

(4) The chart or tape shall show time of day at intervals of not more than 15 minutes.

(5) The recorder chart or tape shall become the property of the Owner.

(6) The recorder shall be placed in a position convenient for observation by the concrete plant operator and the Owner's inspector or Engineer in charge.

The recorded weights or volumes when compared to the weights or volumes actually batched shall be accurate within ± 2 percent.

i. Batch Counters

The plant shall include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

j.Rescreening Plant

A rescreening plant shall be located, arranged, and operated in a manner that all coarse aggregate will be routed through the plant and that its operation will ensure delivery to the mixers of graded coarse aggregate free from excessive variation and conforming to the size groups and grading of aggregates and with moisture content of the aggregates. Coarse aggregate may be rescreened and delivered to the batch plant bins one size group at a time or two or more adjacent size groups at a time. Simultaneous rescreening of nonadjacent size groups is not permitted. All material passing the bottom screen of the smallest size of coarse aggregate being screened shall be wasted.

k. Washing Plant

All coarse aggregates shall be washed immediately prior to entering the rescreening plant. The rewashing plant shall contain adequate water nozzles and vibrating screens to remove foreign materials and coatings from aggregate particles.

l. Trial Operation

Not less than 7 days prior to commencement of concrete placing, a test of the batching and mixing plant shall be made in the presence of the Engineer in charge to check operational adequacy. The number of full-scale concrete batches required to be produced in trial runs shall be as directed, will not exceed 20, and shall be proportioned as directed. All concrete produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected prior to the start of concrete placing operations. No separate payment will be made to the Contractor for labour or materials required by provisions of this paragraph. The Contractor shall notify the Engineer in charge of the trial operation not less than 7 days prior to the start of the trial operation.

m. Protection

The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

The entire Batching plant / Bin / Silo / Storage yard of aggregate etc shall also be covered for dust control. Water fogging system to control dust generation will be installed by the Contractor at no extra cost. Incase monsoon shed is required over the concrete placing area, the same to be done by the Contractor at no extra cost.
If the temperature of the concrete is required to be lowered at the time of manufacture, chilled water plant or ice storage facilities may have to be provided.

a.3 Water and Super Plasticizers :

Water and super plasticizers shall be batched by weight or by volume measures as approved by the Engineer. The method of batching shall be such as will ensure an accuracy to 0.2 liters or better for water and 20 ml more better for plasticizers.

The contractor shall provide the mixer operator with standard measures for dispensing water and plasticizers in accurate quantities as per design. Concrete mix containing water in excess of that specified in the mix design summary shall be rejected and shall not be allowed for use in works.

a.4 General Approval to the batching plant layout

Drawings, in triplicate, showing the layout of the plant the Contractor proposes to use on the work shall be submitted by the Contractor for review. The drawings shall show the locations of the principal components of the construction plant; offices; shop and storage building; housing facilities, if any; and storage areas and yards which the Contractor proposes to construct at the site of the work and elsewhere. The Contractor shall also furnish for review drawings, in triplicate, showing the general features of his aggregate processing plant; aggregate transporting; storage and reclaiming facilities; aggregate rinsing and dewatering plant, if required; coarse aggregate rescreening plant, if required; concrete batching and mixing plant; concrete conveying and placing plant; and when pre-cooling of concrete is required, the cooling plant. The drawing shall appropriately show the capacity of each major feature of the plant including the rated capacity of the aggregate production plant in tons per hour of fine and coarse aggregates; rated capacity of the aggregate transporting, storage and reclaiming facilities; volume of aggregate storage; capacity of cement and pozzolan storage; rated capacity of the concrete batching and mixing plant in cubic meters per hour; rated capacity of the concrete transporting and placing plant in cubic meters per hour; and when used rated capacity of plant for pre-cooling of concrete. Drawings in triplicate showing any changes in plant made during design and erection or after the plant is in operation shall be submitted for review. Two sets of the drawings will be retained and one set will be returned to the Contractor with comments.

B. TRANSPORT, PLACING AND COMPACTION OF CONCRETE:

b.1 General :

The method of transporting and placing concrete shall be approved by the Engineer. Concrete shall be so transported and placed that no contamination, segregation or loss of its constituent materials takes place. Transporting, placing, compacting and curing shall be done as per IS:456. Use of truck mixers, concrete pumps, placer booms, trolleys, rails, hoists, cranes and buckets etc. shall be adopted wherever possible and as per the requirement. The method statement of the transportation and placing of the concrete shall be submitted to the Engineer in Charge. In case any of the concrete transporting equipment is likely to impose loads and forces of any magnitude, on the partly or wholly completed structure or a part thereof, the structural consultant should be informed well in advance about the same. The structural consultant may have to take into account the forces arising out of operations and self weights of these equipments in the structural design of the building elements including its foundations. Failure to do so may result in denial to adopt certain transporting, placing and compacting methods on account of progress of the work already carried out at the site with a structural design no accounting for the same.

b.2 Transporting Equipment

Transporting equipment shall be designed, operated, and maintained so that it does not cause or permit segregation or loss of material.

b.2.1 Buckets

Bottom-dump buckets shall conform to the following requirements: the interior hopper slope shall be not less than 70 degrees from the horizontal; the minimum dimension of the clear gate opening shall be at least five times the nominal maximum size of the aggregate, and the area of the gate opening shall not be less than 0.2 square meters; the bucket gates shall be grout-tight when closed, shall be of the double clamshell type, and shall be manually, pneumatically, or hydraulically operated; and the gate-opening mechanism shall be designed to close the gates automatically when the control is released or when the air or hydraulic line is broken. If gate actuation is dependent on integral air or hydraulic reservoirs, the capacity of the reservoirs shall be sufficient to open and close the gates three times without recharging the reservoir.

b.2.2 Trucks

Truck mixers shall not be used to transport concrete with larger than 37.5 mm nominal maximum-size aggregate or 50 mm or lower slump. Non-agitating trucks may be used for transporting central-mixed concrete over a smooth road when the hauling time is less than 15 minutes and the slump is less than 75 mm as per the discretion of site incharge. Bodies of non-agitating trucks shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

b.2.3 Chutes

When concrete can be placed directly from a truck mixer, agitator, or Non-agitating truck, the chutes supplied by the truck manufacturer as standard equipment may be used. A discharge deflector shall be used when required by the Engineer in charge. Separate chutes and other similar equipment shall not be permitted for conveying concrete except when specifically approved and in no case shall slump be increased to accommodate their use.

b.2.4 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer or delivery truck to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete or loss of mortar at the transfer point(s) and the point of placing. The idler spacing shall not exceed 900 mm. Belt speed shall be a minimum of 90 m per minute and a maximum of 230 m per minute. Belt width shall be a minimum of 600 mm.

b.2.5 Pump Placement

Concrete may be conveyed by positive-displacement pump when approved. The pumping equipment shall be piston or squeeze-pressure type. The pipeline shall be rigid-steel pipe or heavy-duty flexible hose. Aluminium pipe shall not be used. The inside diameter of the pipe shall be at least 3 times the nominal maximum size of the coarse aggregate in the concrete to be pumped but not less than 100 mm. The pump capacity to be sufficient enough to supply concrete at the required height and location of the pour.

b.3 Formwork and embedments :

All formwork and reinforcement contained in it shall be cleaned and made free from standing water, or dust, immediately before placing of concrete. Formwork, reinforcement, all embedments shown on all drawings, i.e. architectural, plumbing, electrical, air-conditioning, structural reinforcement, structural steel inserts, etc. shall be properly placed and secured tightly to the formwork or reinforcement as the case may be and Engineer's approval shall be taken in writing as regards their accuracy in terms of dimensions, locations, numbers, spacing, quality, adherence to specifications etc. before placing concrete in any part of the structure.

b.4 Approval from Engineer :

No concrete shall be placed in any part of the structure until the approval of the Engineer has been obtained in writing.

If concreting is not started within 24 hours of the approval being given, it shall have to be obtained again from the Engineer. Concreting then shall proceed continuously over the area between pre-determined construction joints. Fresh concrete shall not be placed against concrete that has been in position for more than 30 minutes unless a proper construction joint is formed.

b.5 Temperature during concreting :

Fine and coarse aggregates for concreting shall be kept shaded and the concrete aggregates sprinkled with water for a sufficient time before concreting in order to ensure that the temperature of these ingredients is as low as possible prior to batching. The mixer and the batching equipment shall be also shaded and if necessary painted white in order to keep their temperatures as low as possible.

Concrete when deposited shall have a temperature of not less than 4.5 degree centigrade and not more than 30 degrees centigrade unless otherwise specified.

Care shall be taken to protect freshly placed concrete from overheating by sunlight in the first few hours of laying. The time of day selected for concreting shall also be chosen so as to minimize placing temperatures. In case of concreting in exceptionally hot weather the Engineer may in his discretion specify the use of chloride free ice either flaked and used directly in the mix or blocks used for chilling the mixing water. In either case, the Contractor shall NOT be paid the cost of such ice delivered on site and nothing extra for additional labour involved in weighing and mixing.

b.6 Time lag between mixing and placing :

It shall be compacted in its final position within 30 minutes of its discharge from the mixer unless carried in properly designed agitators, operating continuously, when this time shall be within 3 hours of the addition of water to the mix subject to required workability without adding additional admixture or water. The decision of the Engineer in-charge will be final.

b.7 Placing :

Except where otherwise agreed to by the Engineer concrete shall be deposited in horizontal layers to a compacted depth of not more than 0.45 meter when internal vibrators are used and not exceeding 0.30 meter in all other cases.

When trunks or chutes are used they shall be kept clean and used in such a way as to avoid segregation. When concrete is conveyed by chute, the plant shall be of such size and design as to ensure practically continuous flow. Slope of the chute shall be so adjusted that the concrete flows without the use of an excessive quantity of water and without any segregation of its ingredients. The delivery end of the chute shall be as close as possible to the point of deposit. The chute shall be thoroughly flushed with water before and after each working period and the water used for this purpose shall be discharged outside the formwork.

b.8 Compaction :

Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete. All vibrators to be electrically operated. Use of diesel vibrator will be permitted at the discretion of the Client.

Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses, arch sections etc. For sections such as slabs, the concrete shall be compacted by surface type vibrators. Depending on the thickness of layer to be compacted, 25 mm, 40 mm and 60 mm dia internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until :

i. air bubbles cease to come to surface

ii. resumption of steady frequency of vibrator after the initial short period of drop in the frequency when the vibrator is first inserted.

iii. the tone of vibrator becomes uniform

iv. flattened, glistening surface with coarse aggregate particles blended into it appear on the surface.

After the compaction is completed, the vibrator should be withdrawn slowly from the concrete so that concrete can flow in to the space previously occupied by the vibrator. To avoid segregation during vibration the vibrator shall not be dragged through the concrete nor used to spread the concrete. The vibrator shall be made to penetrate into the layer of fresh concrete below if any for a depth of about 150 mm. The vibrator shall be made to operate at a regular pattern of spacing. The effective radii of action will overlap approximately half a radius to ensure complete compaction.

To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.

A sufficient number of spare vibrators shall be kept readily accessible to the lace of deposition of concrete to assure adequate vibration in case of breakdown of those in use.

25 mm diameter immersion vibrators shall be used in thin sections. 40 mm diameter immersion vibrators in fairly wide sections and 60 mm diameter vibratos in foundations and arch abutments. Screed vibrators shall be used for precast deck elements and in the in-situ deck slab concreting where the thickness of the slab is 50 mm.

Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete shall be vibrated to achieve full compaction, using needle or screed vibrators as necessary.

Direct contact between vibrator and reinforcement or inserts and embedments should avoided.

b.9 WORKING IN EXTREME WEATHER:

When depositing concrete in very hot weather, precautions shall be taken so that the temperature of wet concrete does not exceed 30 degrees centigrade while placing. This shall be achieved by stacking aggregate under the shade and keeping them moist, using cold water or crushed or flaked chloride free ice if specified and permitted by the Engineer, reducing the time between mixing and placing to the minimum, cooling formwork by sprinkling water, starting curing before concrete dries out and restricting concreting, as far as possible, to mornings and evenings. During hot weather and rains the concrete shall be covered with tarpaulins and transported in as short a time as possible and placed in the forms and consolidated to final state.

Commencement of concrete pours shall be avoided during heavy rains, storms and high winds.

b.10 DISPOSAL OF WASTE CONCRETE:

In case the concrete is left over or rejected for any reason whatsoever the same to be disposed off of the premises at no extra cost. In case the concrete dries off, it will be the Contractor's responsibility to break the same and dispose it at any lead at no extra cost. All statutory permissions like royalty, transport etc will not be paid for and the contractor has to consider the same in their costing.

(XIII) Protecting Fresh Concrete

Newly placed concrete shall be protected from rain, sun and wind. Concrete placed below the ground level shall be protected from falling earth during and after placing. Concrete placed in ground, containing deleterious substances, shall be kept free from contact with such ground or with water percolating from such ground during placing of concrete and for a period of at least 3 days. The ground water around newly poured concrete shall be maintained to a level lower than the fresh concrete layer by pumping or other means of drainage. Adequate steps shall be taken to prevent flooding. Fresh concrete shall be protected by, leaving the forms in place, prevention of disturbing shocks and vibrations and avoiding premature stressing until the concrete attains sufficient strength to sustain such loads or shocks. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, abrasion, vibrations, and deleterious ground water, mixing with earth or other concrete.

(XIV) Repair and Replacement of Unsatisfactory Concrete

A procedure shall be prepared by the contractor for carrying out inspection, repair and replacement of unsatisfactory concrete. Repair of unsatisfactory concrete shall be carried out by means of removing the unsatisfactory portion and replacing it with new concrete. Suitable keys, dovetail slots etc. may be provided to get proper bond between new concrete and old concrete. Prepared surface shall be kept wet for 24 hours immediately before the patching material is placed. However, surface shall be dry. Repair of concrete shall be carried out using skilled workmen. Repairs shall be undertaken as soon as practicable, after removal of forms, so as to meet the requirements of finish in that particular location. The portion of the concrete to be repaired may be reinforced with steel mesh, if directed by the Engineer. The contractor shall carry out all such repair with no extra cost to the owner. Repairing leakages in liquid retaining structures which become apparent during leak-testing will also have to be repaired by the Contractor at his own cost following methods and specifications as directed by the Engineer.

The complete methodology for the repair shall be submitted by the Contractor which shall cover the type of system used, type of material used, the curing method etc and shall have the approval of the Client / RCC Consultant before undertaking such repair job. The sample repair if required to be done by the Contractor at no extra cost before the Final approval from the Client.

(XV) Self-Compacting Concrete (SCC)

Self-Compacting Concrete shall conform to European specification (EFNARC Publication) for Self-Compacting Concrete – Specification, Production and Use. All the ingredients of SCC are same as that of normal concrete, except Viscosity Modifying Agent (VMA) , Shrinkage Reducing Admixture , etc …as additional ingredient Quality of all the ingredients shall be the same as that for normal concrete. VMA shall be added to increase shear resistance of the concrete. All the test equipment as well as desired parameters for fresh concrete shall be as detailed in European specification. After the mix proportion is finalized, adequate Material of Construction-ups shall be done, to ensure consistent quality of self-compaction. SCC may be used for casting all the structural elements of buildings. It shall be kept in mind that formwork design shall be carefully done for SCC, as the SCC remains in liquid form for a longer period. As far as possible, pumping shall be resorted to. All other requirements for testing shall be the same as that of normal concrete, specified elsewhere in these specifications.

Properties of the fresh concrete are to be checked as per the provisions in the European specification. The desired parameters are given in Table-10. Testing methods and testing equipment's like flow table, V-funnel, L-box, U-box, fill box and segregation resistance test shall be as per European specification. The tests to be carried out to establish various properties are given in Table-10. Once it is established that the mix proportion is meeting the desired parameters and after establishing the consistency of the results, the flow table test and V-funnel test are to be conducted at production point and placement point as a quality control measures. For hardened concrete, the tests specified in Table-8 are to be carried out. These Two (2) tests shall be conducted for first 3 transit mixers and subsequently one for every set of 5 transit mixers.

TABLE - 10 PARAMETERS FOR SCC

Sl. No.	Test	Unit	Minimum	Maximum
01	Slump flow	mm	650	800
02	T50 cm slump flow	Sec	2	5
03	"V" funnel	Sec	5	20
04	'L' box	h2 / h1	0.8	1.0
05	'U' box	(h2 -h1) mm	0	30
06	Fill box	%	90	100
07	Segregation Resistance test	%	-	20

TABLE - 11 PROPERTIES TO BE ESTABLISHED BY TESTS

Slump flow test	Stability of mix (Cohesiveness)
T-50 cm time slump flow test	-do
V-funnel test	Flow ability
L-Box test	Passing ability
U-Box test	-do
Fill box test	Filling ability
Segregation Resistance test	Segregation

(XVI) MASS CONCRETING

Mass concrete is defined in ACI 116R as “any volume of concrete with dimensions large enough to require that measures be taken to cope with generation of heat from hydration of the cement and attendant volume change to minimize cracking. The one characteristic that distinguishes mass concrete from other concrete work is thermal behavior. Significant tensile stresses and strains may result from the restrained volume change associated with a decline in temperature as heat of hydration is dissipated. Measures should be taken where cracking due to thermal behavior may cause a loss of structural integrity and monolithic action, excessive seepage and shortening of the service life of the structure.

For lack of a standard definition, as a thumb rule it is considered that mass concrete to be any element with a minimum dimension equal to or greater than 3 ft (0.9 m) .

Some of the typical construction practices used to control temperature changes within concrete structures and resulting damage include:

1. Optimizing the mix proportions to keep cementitious materials content as low as possible and use of high percentage of fly ash /GGBS
2. Cooling batch water
3. Replacing a portion of the batch water with ice
4. Shading aggregates in storage
5. Cooling aggregates with natural or manufactured chilled air
6. Shading aggregate conveyors
7. Spraying aggregate stockpiles for evaporative cooling;
8. Scheduling placements when ambient temperatures are lower, such as at night or during cooler times of the year
9. Controlling surface cooling of the concrete with insulation.
10. Avoiding thermal shock during form and insulation removal
11. Protecting exposed edges and corners from excessive heat loss
12. Better monitoring of ambient and material temperatures**.**

The guidelines given for mass concreting in this project are as follows. Temperature differential shall not be greater than 20°C.
The peak temperature in any part of the concrete shall not be greater than 70°C.

Insulation shall be maintained until the temperature differential has been reduced to 10°C

Fresh concrete temperature at the point of placing to be maintained below 30°C. This is to be achieved by

1. While using ice flakes it is to be ensured that the ice melts prior to placing. Keeping minimum mixing time without sacrificing homogeneity of concrete.
2. Dosage of admixture has to be adjusted for the low temperature of concrete, as otherwise this will result in segregation.
3. Insulated transit mixers
4. Depending on the volume and rate of placement, deploy adequate number of batching. plants with minimum lead.
5. Placing in layers of 400-450 mm thickness as given in the guidelines for good compacting ability, ensuring that the next layer is placed before initial setting time of the concrete mix.
6. For relatively slender vertical structures, a lift height of 3 meters may be considered appropriate.
7. Appropriate vibrators are to be available.
8. For very large pours, where the time gap required for the placement of the subsequent layer would be long, the setting time last pour a layer to be delayed appropriately by use of additional retarder to prevent cold joints.
9. The time elapsed between two subsequent pours in layers is be kept minimum to avoid heating up of the already placed layer

Concrete workability to be maintained at 130±20mm at the point of placement. Optimal vibration of concrete to be ensured.

It is necessary to conduct a mock up size at least 2m x 2m 2m with the mix developed and monitor the concrete temperature with sensors at core as well as side and top and bottom to determine the maximum temperature, attained as well as the maximum gradient reached to ensure they are within the limits specified in IS 16700 2017 i.e. Maximum temperature of 70°C and a maximum gradient of 20°C. Otherwise mix needs to be redesigned.

Broad guidelines / Notes on Temperature Monitoring of Concrete (in the contractors scope)

Monitoring temperature of mass concrete involves, placing temperature sensors at the core of concrete at the centre as well as top and I access is available the bottom also. Temperature sensors are also placed near the form work about an inch away.

Temperature sensors are fixed to the nearby reinforcement bar, care being taken to see that the sensing probe is not in contact with the steel. Leads from all the thermocouples are connected to Data Logger.

After placement of concrete begins, temperature is sensed and data transmitted periodically to the logger. Peak temperature is attained normally between 36 hrs and 72 hrs. This may further vary depending on concrete mix proportion, concrete element dimensions, formwork an ambient conditions. Normally temperature is monitored for a period of at least seven days or as advised the consultant. Subsequently the data is downloaded and analysed for maximum temperature and maximum gradient and the time at which these have occurred after commencement of concreting.

The number of sensors and location of the same would be decided based on the dimensions of the raft /structural element. It is necessary to conduct a mockup of size a least 2 x2 x 2 meter with the selected mix and get the maximum temperature and maximum temperature gradient before actual construction.

THE CONTRACTOR TO SUBMIT DETAILED METHOD STATEMENT FOR APPROVAL BEFORE EXECUTION OF THE WORK.

(XVII) CURING

(a) General

Exposed surface of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least 10 days from the date of placing concrete in case of OPC Concrete and at least 10 days (14 days for hot weather condition) where mineral admixture or blended cement is used. The Quality of curing water shall be the same as that used for mixing concrete. Water Curing on slab to be covered with Plastic sheet. Any type of the covering that would stain or damage the concrete during or after the curing period shall not be permitted. Covering shall be kept continuously wet during the curing period.

The structural elements with concrete having low water binder ratio (w/b < 0.4) and also when cement is partially replaced by pozzolanic material, the curing shall be done in two stages viz., initial curing and final curing. Otherwise, curing can be done in one stage, i.e. final or water curing.

Where water curing is not possible, use of curing membranes meeting the requirements of ASTM C 309 may be adopted and tested as per ASTM C156.

The curing tank capable of holding 500 Nos of cubes to be made at No extra cost. The water within the curing tank to be cleaned once a week and the Water tank to be cleaned once a month.

(b) Initial Curing:

The initial curing shall start immediately after work on fresh concrete surface is over.

- The trowelled/finished concrete surface exposed to environment shall be kept covered by 250 micron plastic sheet or other type of impermeable covers immediately after finishing (approx 60 to 90min from placing). The wet curing shall start immediately after the final set. This shall be carried out with the help of placing wet burlaps over the concrete surfaces.
- Exposed surface of construction joint should be covered with opaque color PVC sheet after spraying of surface retarder for subsequent green cutting after the final setting of concrete. Surface retarder may be mixed with a dye in order to ensure uniform spraying by visual inspection. In hot and dry ambient conditions fog spray may be used. Treatment of construction joints may be referred to for specification of green cutting,

(c) Final curing:

The final curing shall be done with water. It shall commence about an hour after the initial curing and continue upto a minimum period specified above. Hessian cloth can be wrapped on to columns and on vertical surfaces and the same shall be kept wet all the time by a suitable arrangement.

(d) Water for Curing

Contractor shall make suitable arrangement for continuous water supply, along with necessary equipment for getting a nozzle pressure of not less than 7 kg/cm^2, even at the highest elevation, for convenient and effective jetting on concrete surfaces for green cutting, for cooling aggregate, for curing and for other requirements. All necessary appliances such as hose, sprinklers, spraying devices etc. may be made available.

For curing of concrete in floors, flat roof or other level surfaces, the ponding method of curing is preferred. Special attention shall be given to edges and corners of the slab to ensure proper protection. The ponded area shall be kept continuously filled with water throughout the curing period.

(e) Curing of Patch Work

Immediately after any patchwork is completed, the area shall be covered with non-staining, water-saturated material and the same shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the area shall be kept continuously wet by a fine spray or sprinkling of water. The layers of patch may be reinforced with steel wire mesh, if directed so by the Engineer at no extra cost to the owner. Curing compound with adequate protection can be used for the same.

(f) Curing works with curing compound

If mentioned in the boq , Fresh concrete shall be covered with plastic sheet of not less than 500 micron thickness immediately after finishing .After 3 days of water curing, curing compound shall be used on the slab. and the same to be covered with plastic sheet 500 microns or any protective boards to protect the curing compound while carrying out the construction related works. No additional cost will be given for the same. Incase the contractor is not able to arrange for the water, than he will do curing using curing compound.

Surface coating type compounds shall be used only by special permission of Engineer; curing compounds shall be liquid type white pigmented. Other curing compounds shall be used on surfaces where future blending with concrete, water or acid proof membrane or painting is specified.

(XVII) CONSTRUCTION JOINTS AND KEYS

A General

When the work is to be interrupted, horizontal and vertical construction joints and bonding keys shall be located and shall conform to the details given on the drawings. In case of water retaining structure, and other structures, water stops as specified on the drawing shall be provided.

In case of columns, beams and slabs etc, the location of the joints shall be as indicated in the drawing or as directed by the Engineer. Concrete in a beam shall be placed throughout, without a horizontal joint. Before fresh concrete is placed, cement skin or any loose or porous material of partially hardened concrete shall be thoroughly removed and cut back

until the solid face is exposed and surface made rough by hacking, or any other method. Rough surface shall be thoroughly wetted for about two hours and shall be in surface dry condition before new layer of concrete is placed over it.

B Sequence of Casting and Construction Joints

- The sequence of concreting, locations of construction joints etc. will be as shown on the drawing. However, any adjustment during execution will be only with specific approval of the Engineer. Some factors influencing final joint locations are:
  - Embedded parts and local thickenings
  - Locations of prestressing cables or reinforcements
- The general lift height will be maximum 3m for wall. The thickened portion of the wall at raft-wall junction shall be cast in two lifts as specified in construction drawings. In general, each of the lift of the wall will be cast in single pour.
- Placement interval between two subsequent or adjacent pours shall be as specified in the drawing
- Flat roof slab should be cast in one pour. The base raft will also be preferably cast in one pour. Appropriate concrete mix (e.g. self-compacting concrete) should be developed for this purpose. Contractor should develop and got approved by the engineer in-charge suitable procedure and adequate planning prior to commencement of large pour in order to avoid cold joints.
- Meridional joints are not permitted except for emergency stoppage of work with the specific approval of the Engineer. The concreting will start for the first pour at the crown and subsequent pours from crown downwards will be taken up for casting. Casting in any particular pour will, however start from the lower most elevation and proceed upwards as sown in the drawings and instructed by the Engineer.
- The treatment of the construction joints of the structure to render them leak tight by grouting. Re-injectable grouting hose of approved quality shall be laid along the construction joints. The grouting material to be used and grouting operation shall be as approved by the manufacturer

C Treatment on Suspension of Work

Whenever work is suspended on any section for more than two hours, the horizontal

edges of the concrete next to the forms on surfaces that will be exposed shall be brought to a horizontal plane perpendicular to the plane of the forms and treated, so that the finished work will show smooth straight lines.

D Construction Joint Treatment

D.1 CONSTRUCTION JOINTS:

Concreting shall be carried out continuously joints, the position and details of which shall be as shown on approved drawings or as directed by the Engineer. Such joints shall, however, be kept to the minimum.

For a vertical construction joint, a stopping board HiRib or equivalent shall be fixed previously at the pre-determined position and shall be properly stayed for sufficient lateral rigidity to prevent its displacement or bulging when concrete is compacted against it. Concreting shall be continued right up to the board. The board shall not be removed and the construction will be continued.

D.2 Joint Preparation

Concrete surfaces to which other concrete is to be bonded shall be prepared for receiving the next lift or pour or adjacent concrete by cleaning by sandblasting, high-pressure water jet, or air-water cutting. Surface cutting by air-water jets will not be permitted for concrete surfaces congested with reinforcing steel or if they are relatively inaccessible. If, for any other reason, it is considered undesirable to disturb the surface of a lift or pour before it has hardened, the use of sandblasting or high-pressure water jet after hardening will be required. Regardless of the method used, the resulting surface shall be free from all laitance and inferior concrete so that clean, well-bonded coarse aggregate particles are exposed uniformly over the lift or pour surface. Application of the joint treatment method shall be such that the edges of the larger particles or aggregate are not undercut. Where joint preparation occurs more than 2 days prior to placing the next lift or pour or where the work in the area subsequent to the joint preparation causes dirt or debris to be deposited on the surface, the surface shall be cleaned as the last operation prior to placing the next lift or pour. The surface of the construction joint shall be kept continuously wet for the first 12 hours of the 24 hours prior to placing concrete, except that the surface shall be damp with no free water at the time of placement. Spray surface retarder after the concrete pour and clean the same with water jet after 18 to 24 hours.

D.2.1 Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time, generally between 4 and 12 hours after placement and only on horizontal construction joints. This period may be modified if a retarder is used to prolong the setting of the cement at surface of the concrete.

The air pressure used in the jet shall be 620 to 760 kPa, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved a surface retarder It shall be solvent free poly-hydroxyl compound and shall have a distinctive colour, which could be easily identifiable on its application over concrete may be applied to the surface of the lift or pour to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, the Contractor shall furnish samples of the material to be used and shall demonstrate the method to be used in its application. After cutting, the surface shall be washed and rinsed until the wash water is no longer cloudy. The water from the air water jet, used for green cutting of the concrete surface, shall be properly drained so as not to harm the quality of the concrete already placed. It shall also be ensured that this water does not get stagnated on the surface of concrete, depositing washed cement particles. As a pre-qualification, field Material of Construction-ups shall be conducted to check the adequacy of the material and method to be deployed on the job, before adopting in the field. In case of change in material source / type or methodology of green cutting, pre-qualification shall be redone. If air-water cutting does not produce acceptable results, the surface shall be prepared by high-pressure water jet or sandblasting at no extra cost.

D.2.2 High-Pressure Water Jet

A stream of water under a pressure of not less than 21 MPa may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the high-pressure water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting at no extra cost.

D.2.3 Wet Sandblasting

This method of joint preparation may be used when the concrete has reached sufficient strength to prevent undercutting of coarse aggregate particles.

The operation shall be continued until all accumulated laitance, coatings, stains, debris, and foreign materials are removed. The surface of the concrete shall then be washed thoroughly to remove all loose material.

This method may be used on both horizontal and vertical surfaces.

When work has to be resumed on a surface, which has hardened, it shall be thoroughly hacked, swept clean, wetted and covered with a layer of neat cement grout. The neat cement grout shall be followed by a 15 mm thick layer of mortar mixed in the same proportion as in concrete and concreting resumed immediately thereafter. The first batch of concrete shall be rammed against the old work to avoid formation of any stone pockets, particular attention being paid to corners and close spots.

In all cases, the position and detailed arrangement of all construction joints shall be predetermined and got approved by the Engineer.

No separate payment shall be allowed to the contractor for forming joints or chipping and cleaning them. When a horizontal construction joint is formed, provision shall be made for interlocking with the succeeding layer by the embedment of saturated wooden blocks or strips beveled on four sides to facilitate their removal. Prior to the next pour, the wooden pieces shall be loosened and removed in such a manner as to avoid injury to the concrete.

E Wash Water

Wash water shall be removed in a manner to prevent running down and staining of concrete surfaces, exposed on completion of the job. Should unsightly wash-water streaks develop on the exposed surface, the same shall be removed to get a uniform colour and texture.

(XVIII) QUALITY CONTROL QA/QC:

High strength concretes are quite sensitive to changes in properties of ingredients, variations in mix proportions and testing procedures. Hence, special efforts shall be taken to enforce strict quality assurance (QA) and quality control (QC) during production and testing such concrete. The contractor/RMC producer supplying concrete shall provide a detailed QA and QC Plan. The owner or its representatives shall approve it and devise measures to monitor the Strict implementation of the QA and QC Plan. Concrete obtained from the plant certified Under Ready-Mixed Concrete Plant Certification Scheme shall be preferred (See IS 4926).

If Concrete is procured from RMC plant, it should be from the plant accredited from QCI (Quality Council of India)

Contractor shall ensure good workmanship and also the plant shall be maintained to meet peak demand. Degree of control on all the concrete operation, right from selection of the ingredients to the final testing of specimen, shall be in line with the approved Quality Assurance Plan.

The Contractor shall engage experienced supervision at all levels. Complete crew, engaged in each of the concreting activity, shall be duly qualified for a particular activity and shall demonstrate their skills and capabilities to produce the final product meeting specified parameters.

The contractor shall take the services of a reputed concrete consultant to assist / verify and approve concrete mix designs to ensure they are adequate to meet the specifications for concrete in fresh state and durability of structure, suggest section materials for suitability, assist in ensuring consistency quality of concrete at the time of production and investigate defects in concrete that may arise during construction and suggest remedial / repair methods.

The consultant agency be a specialist consultant for concrete, with experience in designing high performance and high strength concrete for highrise pumping / infrastructure projects of high durability, well versed with various tests and the interpretation of the test results for durability. They should be capable of interacting with the structural consultant for the

projects and address their concerns regarding various aspects of concrete . It Is desirable that they have the following capabilities also.

1. Research work in Concrete
2. Training in concrete technology for civil engineers / RMC personnel/ admixture manufactures
3. Auditing and certification of ready-mix concrete facilities as per QCI guidelines
4. Presentation of technical papers in National & International seminar / workshops
5. Testing of concrete durability as per Indian & International standards
6. Evaluation of supplementary cementitious materials.

The charges/ fee payable for rendering the service of Concrete technologist till the completion structural work shall be borne by the Contractor and no additional payment will be paid on any account.

(XIX) USE OF PLUMS IN ORDINARY CONCRETE:

Stone plums shall not be used unless specified on the drawings, when used the size of stone plums may be from 150 to 300 mm. The maximum dimension of these stones or plums shall not exceed 1/3rd the least dimension of the members.

All plums shall be hard, durable, clean and free from soft materials or loose pieces or deleterious substance in them and shall not have sharp corners.

During concreting the first layer of concrete of the specified mix shall be laid to a thickness of at least two and a half times the thickness of the maximum size of plums to be used. The plums shall then be laid while the top portion of this concrete is still green but sufficiently stiff to prevent complete submergence of the plums under their own weight. These plums shall be about half embedded in the concrete and the remaining part exposed so as to form a key with the next layer of concrete. No plums shall be used for concrete laid under water.

While placing the plums, care shall be taken to see that the clear distance between any two plums is not less than either the width of thickness of either of the plums. The distance from plums to the outer surface or from any steel reinforcement shall be equal to greatest width of the plum.

If plums of stratified stones are used, they shall be laid on their natural bed. Stones with concave faces shall be laid with the concave upwards.

The thickness of the next and successive layers of concrete shall be at least twice that of the largest plums.

The total volume of plums shall not exceed 20 percent of the volume of the finished concrete.

(XX) MEASUREMENT FOR PAYMENT:

i) The cement concrete shall be measured in cubic meters. In reinforced concrete the volume occupied by reinforcement shall not be deducted.

ii) Any concrete used in excess of the theoretical dimensions as shown on the drawings will not be paid.

iii) Unacceptable Work:

All defective concreting work, including but not limited to defects arising out of honeycombing, undersizing, etc. are liable to be demolished and rebuilt by the Contractor at his own cost. In the event of such works being accepted by carrying out repairs etc. as specified by the Engineer, the cost of repair will be borne by the contractor. In the event of the works being accepted by giving a design concession' arising out of but not limited to undersizing, understrength, by accepting high design stresses in members, or accepting materials not fully meeting the specifications etc. The Contractor will be paid for the work actually carried out by him at the reduced rate of the tendered rate for portion of the work thus accepted. The percentage of reduction to be decided by the client.

(XXI) TOLERANCES :

A.1 Tolerances in Reinforced Concrete Work :

Description	Permissible Departure
Departure from established	

alignment of all elements		30 mm.
Departure from established grades		10 mm.
Variation from plumb or specified) batter in lines and surface) columns, piers, walls and in rises)		12 mm in 3 m. if exposed 25 m in 3 m. if backfilled
Variation from level or indicated) grade in slabs, beams, horizontal) and railing offsets.		12 mm in 3 m. if exposed 25 mm in 3 m. if backfilled
Variation in cross sectional dimensions of columns, piers, slabs, walls and beams.	:	-6 mm to +12 mm
Variation in slab thickness:		-3 mm to + 6 mm
Footings: plan dimensions	:	-15 mm to + 30 mm
Misplacement or eccentricity	:	2% of footing width in the direction of misplacement and not exceeding 30 mm.
Reduction in thickness:		5% of specified thickness
Variations in size and location: of slabs, wall openings.		12 mm

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Notwithstanding the above allowances, it is presumed that all works will be carried out true to the lines, levels and grades shown on the drawings and within the tolerances specified below. The contractor shall establish, erect and maintain in an undisturbed condition, until final completion and acceptance of the project, control points and bench marks necessary and adequate to establish these tolerances.

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VOLUME - I

3. FORM WORK

1.0 GENERAL

1.1 Standards

Work shall be carried out to Indian Standards and Code of Practices. In absence International Standards shall be followed. These shall be latest issue. List given hereunder is not to be considered as conclusive and is for reference and guidance only. Any discrepancies/conflict noticed shall be directed to the Engineer-in-charge for his direction/approval. However as a general rule more stringent specification shall take precedence.

IS 303	Specification for plywood for general purpose.
IS 456	Code of practice for construction and design of reinforced concrete.
IS 2751	Code of practice for welding of M.S bars used for RCC
IS 3696	Safety Code of scaffolds and ladders :
Part 1	Scaffolds
Part 2	Ladders
IS 4014	Code of practice for steel (part 1 & 2) tubular scaffolding
IS 4082	Recommendation on stacking and storage of construction materials
IS 8989	Safety code of erection of concrete formed structures

Notes : It is essential that shuttering/formwork is well constructed and does not move during concreting. All joints should be leak tight to prevent leakages and honeycombing. Care should be taken during placement and compaction to ensure that the concrete remains homogeneous. Before starting to place Concrete, the formwork shall be inspected by the Contractor to ascertain that the same is sturdy, water-tight, non-absorbent and capable of imparting the desired form and finish to the cured concrete. Formwork shall be designed to withstand a pressure equivalent to the static hydraulic pressure. Calculation of the stability of the formwork should be submitted by the contractor for client's approval. Methodology of formwork erection should be submitted by the contractor and approved by the client.

General

The work covered under this section shall include the providing, erection and removal of formwork for all normal, heavy, pre-stressed and pre-cast concrete in walls, columns, foundations, slabs, beams, walls and slabs including its supporting members.

The formwork shall consist of but not limited to shores, bracings, sides of beams, columns, walls, rafts and bottom of slabs including ties, anchors, inserts, hangers, false work, wedges, etc. complete which shall be properly planned for the work. For the floors, supports can be taken from the floor down below with prior permission of the Engineer. Wherever required provision shall be made to support the floor shuttering by means of trusses, which shall be spanned from the nearby walls/columns.

The Contractor shall prepare, before commencement of actual shuttering work, design and drawing for formwork and centering and get them approved by the Engineer well in advance before fabrication and erection of formwork. Formwork shall be designed to fulfill the following requirements.

- Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.
- Made of suitable materials.
- Capable of providing concrete of the correct shape (linear as well as curved shape) and surface finish within the specified tolerance limits.
- Capable of withstanding without deflection the worst combination of self weight, reinforcement and concrete weight, all loads including lateral pressure on vertical surfaces and dynamic effects arising from construction and compacting activities, wind and weather forces.
- Capable of easy striking without shock, disturbance or damage to the concrete.
- Soffit forms capable of imparting a camber if required.
- Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete, design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

Forms shall conform to the shapes, lines, grades and dimensions including camber of the concrete as called for on the drawings. Ample struts, walers, braces, etc. shall be used to hold the forms in proper position without any distortion whatsoever until the concrete has set sufficiently to permit removal of forms. Unless otherwise specified all forms in contact with concrete having F-3 finish shall be plywood panel formworks. Forms will be firmly bolted to previous pour of concrete. No through bolts embedded in concrete will be permitted in structures. Threaded mild steel sleeves designed for holding in concrete and standard coil nuts/cone anchors shall be embedded in preceding concrete pours to anchor tie rods on lower end, while on the other end tie rods shall be provided beyond the lift under construction. Tie arrangement with baffle plate within the concrete may also be used as substitute for through tie with prior approval of the Engineer. The Contractor should finish all the coil nuts by dry packing. The recesses, if any, formed by removable timber wedges shall be filled with caulking compound or epoxy mortar or cementitious grout if depth is less at the Contractor's own cost. Formwork for removable hatchways and plugs shall be installed in place wherever possible. Back form for sloping concrete surfaces shall be provided as decided by the Engineer at no extra cost.

1.2 Classes of Finishing :

The surface finish for formed and unformed surface are classified and defined as below: Surface irregularities permitted for the various classes of finishes are termed either "abrupt" or " gradual". Fins or offsets caused by displaced or misplaced form sheathing, lining or form sections, by loose knots in form lumber or by otherwise defective form lumber are considered abrupt irregularities. All other cases are described as gradual irregularities. Gradual irregularities will be measured with a template consisting of a straight edge for plane surface or its equivalent for curved surfaces. The length of metal template for testing gradual irregularities on formed surfaces shall be 1.5 m in length, the permissible gradual irregularities being measured over this length of the template.

Special surfaces, finishes and treatment falling outside of these classes but defined elsewhere by the Engineer shall also form part of these specifications.

Finish F1,F2 and F3 shall describe formed surfaces.

Finish U1,U2 and U3 shall describe unformed surfaces.

Class F1 Finish : This class of finish shall apply to all formed surfaces for which class F2 and F3 is not specified. It shall generally be formed by sawn timber formwork so constructed that there shall be no loss of material from the concrete during placement and compaction. After hardening, the concrete shall be in the positions required and shall have the shape and dimensions called for in the drawings. Any abrupt irregularities shall not exceed 8 mm and gradual irregularities shall not exceed 16 mm. All fins and drifts in excess of the above limits shall be made good by chipping and grinding if required by the Engineer. Small blemishes caused by entrapped air or water may be expected but the surface shall be free from voids, honeycombing or other large blemishes. Class F1 finish shall be generally specified for all surfaces buried in ground or not visible during service or for surfaces that are to receive further rendering treatment such as plastering etc. Unless otherwise specified in the item of Bill of Quantity the surface finish shall be understood to be Class F1.

Class F2 Finish : Class F2 shall be obtained by the use of properly designed forms with closely jointed wrought timber forms or with forms having plywood or steel sheet lining. The abrupt irregularities shall not exceed 5 mm and gradual irregularities shall be less than 8 mm. Small blemishes caused by entrapped air or water may be permitted but the surface shall be generally free from honeycombing, void and large blemishes. Surface irregularities in excess of those stipulated shall be removed by chipping or rubbing with abrasive stone.

Class F3 Finish : Class F3 finish shall be formed by specially designed close jointed rigid forms having lining of high quality form plywood in which the surface irregularities shall be limited to nil for abrupt irregularities and upto 3 mm for gradual irregularities. Class F3 finish may be obtained from Class F2 finish by carefully removing all fins, projections, abrupt irregularities by rubbing/grinding. If steel forms are used, they shall be subject to Engineer's approval.

In addition, finish F3 shall include filling air holes with mortar and treatment of the entire surface with sack rubbed finish. It shall also include clean up of loose and adhering debris. Where a sack rubbed finish is specified, the surfaces shall be prepared within two days after removal of the forms.

The surfaces shall be wetted and allowed to dry slightly before mortar is applied by sack rubbing. The mortar used shall consist of one part cement to one and half parts by volume of fine (I.S. no. 16 mesh) sand. Only sufficient mixing water to give the mortar a workable consistency shall be used. The mortar shall then be rubbed over the surface with a fine burlap or lines cloth so as to fill all the surface voids. The mortar in the voids shall be allowed to stiffen and solidify after which the whole surface shall be wiped clean with clean burlap such that all air holes etc. are filled and the entire surface presents a uniform appearance without air holes, irregularities etc.

Class U1 finish : This is the screeded finish used on the surface over which other finish such as wearing coat etc. are to be placed. It is also the first step in the formation of U2 To U3 finishes. The finishing operation consists of leveling and screeding the concrete to produce an even uniform surface so that gradual irregularities are not greater than 6 mm. Surplus concrete should be removed immediately after consolidation by striking it off with a sawing motion of straight edge or template across a wooden or metal strip[that has been set as guide. Unless the drawing specifies a horizontal surface or shows the slope required, the tops of narrow surface, such as stair treads, walls, curbs and parapets shall be sloped approximately 10 mm per 300 mm width. Surfaces to be covered with concrete topping, terrazzo, and similar surfaces shall be smooth screeded and leveled to produce even surface, irregularities not exceeding 6mm.

Class U2 Finish: This is a floated finish used on all outdoor-unformed surfaces not prominently exposed to view such as top of piers etc. Floating may be done by hand or power driven equipment. It should not however be started until some stiffening has taken place in the surface concrete and the moisture film or "shine" has disappeared. The floating should work the concrete no more than is necessary to produce a surface that is free from screed marks. All joints and edges should be finished with edging tools. It shall include the repair or abrupt irregularities unless a roughened texture is specified and the repair of gradual irregularities exceeding 6 mm.

Class U3 Finish : This is troweled finish used on all surfaces exposed to view at close quarters such as tops of parapets and kerbs etc. steel troweling should not be started until after the moisture film and "shine" have completely disappeared from the floated surface and until the concrete has hardened enough to prevent an

excess of fine material and water from being worked to the surface. Excessive troweling especially if started too soon tends to produce crazing and lack of durability. Too long a delay will result in a surface too hard for proper finishing. Steel troweling should be performed with a firm pressure that will flatten and smooth the sandy surface left by floating. Troweling should produce a dense, uniform surface free of blemishes, rippler and travel marks. It shall include the repair of abrupt irregularities and the repair of gradual irregularities exceeding 6 mm, finishing joints and edges of concrete with edging tools.

1.3 Design and Fixing of Formwork

The formwork shall be designed and fixed to meet the tolerance in various areas as specified elsewhere in this specification. All floors and beam centering shall be crowned not less than 8 mm in all directions for every 5-meter span. Forms in contact with concrete shall be free from adhering grouts, projecting nails, splits or other defects. Formwork shall be so designed and erected with the forms for slab so that the sides of beams, columns and walls may be removed first, leaving the formwork to the soffits of beams and their supports in position. Where formwork for column is erected for its full height, one side shall be left open and built up in sections as placing of concrete proceeds, if so directed by the Engineer.

Not withstanding the approval given to the design criteria and loading and the general scheme for the centering, the entire responsibility for the satisfactory execution of the centering and all temporary works shall rest with the contractor and he shall be liable to pay all claims and compensations arising from any loss or damage to life and property due to any deficiency, failure or malfunctioning of the centering or all the temporary works.

- Design Loads

Unless prior approval in writing has been received from the Engineer all vertical wall forms shall be constructed for the minimum pressure as per CIRIA recommendations. The Contractor shall ensure that the constructions of the forms are adequate for all concrete placing condition and all the applicable CIRIA recommendations are followed. However, in case of self compacting concrete, the entire height of the pour shall be considered to be in fluid state and the lateral pressure shall be w x h, where “w” is the unit weight of green concrete and “h” is the height of pour.

All horizontal forms shall be constructed for pressures from the dead load of concrete including embedment and a minimum live load of 200 Kg/sq.m.

Forms constructed for retaining heavy concrete shall be built for pressures which have been increased by the ratio of the unit weight of heavy concrete to normal concrete.

Further, the formwork shall be designed to withstand all pressures arising out of placement of concrete using pumps, incidental loads if any and live load on the working platforms.

- Temporary Openings

Temporary openings, which can be conveniently closed, shall be provided at the base of the columns and wall forms and other places necessary to facilitate cleaning, inspection and vibration of concrete. Immediately before concrete is placed the forms shall be made sufficiently rigid and tight, thoroughly cleaned properly treated and free from foreign material. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected. Reinforced temporary openings shall be provided as directed by Engineer to facilitate removal of formwork which otherwise may be inaccessible.

- Materials

Materials for the formwork shall be of plywood, timber form covered, oil tempered hard board. The supporting system shall be either adjustable props made of mild steel pipes for heights up to 7 meter or composite columns fabricated using M.S. Structural steel members.

Shuttering arrangement for concreting shall be of 12mm /16mm /18 mm (as mentioned in BOQ) thick plywood backed with **STEEL** framework and supports of horizontal and vertical walers connected to turn buckles. Supports shall be rigid and strong enough to withstand effect of vibration without any deflection, bulging, distortion or loosening of its supports and shall be so as to prevent loss of slurry from the concrete. Plywood used shall be waterproof plywood conforming to IS: 4990. Test certificates from the manufacturers will be obtained and verified. Form strips or any other suitable sealing tapes will be used to prevent loss of slurry through the joints of formwork.

Suitable working platform should be provided for execution/ inspection of reinforcement, embedded parts and concreting.

1.4 Centering Requirements

Centering using steel tubular props, H frames, built-up sections, with provisions to adjust heights of props shall be used and they shall be to true levels and rigid. They shall be adequately braced horizontally and vertically. For faster construction, quick strike **decking system/ Acro/Doka/PERI or approved equivalent** systems shall also be used for shuttering supported on floors below, vertical props shall be so supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the shuttering. Bamboos or wooden poles shall not be used as props or cross bearers. Centering supported on structural steelwork shall also be designed for the conditions mentioned above.

1.5 Tie Rods

Tie rods shall have provisions for removal of a section of each rod at surface of the concrete to a depth of approximately 50 mm. All holes left by the removal of conical nuts or other removable fixtures embedded in the face of the concrete should be filled and finished with epoxy mortar or cementitious grout (as mentioned in BOQ) in a manner specified in the finishing specification. Threaded inserts embedded on each face of the wall be cut for attaching the forms to previously placed concrete and when permitted shall be out off flush with the face of concrete or countersunk, filled and finished as required by the Engineer in the manner specified in the finishing specification. Measures shall be taken to prevent rust stains on concrete. Use of internal through ties shall not be permitted.

1.6 Form Oil

The form-releasing agent shall cover the forms fully and evenly without excess overdrip. Care shall be taken to prevent form-releasing agents from getting on the surface of the construction joints and on reinforcement bars. Special care shall be taken to cover thoroughly the form strips for narrow grooves, so as to prevent swelling of the forms and the consequent damage to concrete prior to or during removal of forms. A non-staining mineral oil or other approved oil **(CEMOL- 35 of HPCL or approved equivalent)** may be used provided it is applied before placing reinforcing steel and embedded parts. Such form oil

shall be insoluble in water and not injurious to concrete and shall not become flaky or be removed by rain or wash water. Form oils that retard the setting of concrete shall not be used.

All excess oil on the form surface and any oil on metal or other parts to be embedded in the concrete shall be carefully removed. Before treatment with oil, forms shall be thoroughly cleaned of dried splatter of concrete from placement of previous lift.

The Contractor shall clean the concrete surfaces from any leftover form oil at his own cost if form oils are used.

1.7 Suspended Formwork

In certain areas, as identified by the Engineer, metal decking/conventional form ply and supported on structural steel framework shall be used as self supporting shuttering as an alternative to the conventional shuttering in places where the area below has to kept free of scaffolding and centering works. The fixing of metal sheets to structural steel members shall be by bolting or welding as advised and nothing extra shall be payable for such bolting and/or bolting.

Plate inserts may be embedded in the sidewalls during concreting, from which bracket supports can be obtained. Structural steel built-up sections or trusses shall be used for supporting the formwork. The Contractor shall submit the design and detailed drawings for the above scheme for the approval of the Engineer. The scope of work shall include design, fabrication, erection and dismantling of the supporting structure.

1.8 Joints

Joints in forms shall be truly horizontal or vertical unless otherwise specified and shall be sufficiently tight to prevent any leakage of cement slurry to avoid formation of fine or blemish. Where forms for continuous surfaces are placed in successive units, the forms shall lap and fit tightly over the completed surface so as to prevent leakage of cement slurry from the fresh concrete and to maintain accurate alignment of the surface. Faulty joints shall be sealed as directed by the Engineer. Suitable devices shall be used to hold adjacent edges together in accurate alignment. The Contractor shall use sealing tapes to avoid leakage of slurry through the formwork joints. On removal of forms the Contractor shall

finish marks left by sealing tapes so as to merge with other concrete surface. The Contractor shall take care to maintain symmetry in formwork in slabs, walls, columns etc. so as to give a pleasant appearance to finished concrete surface. All forms shall be so made that they can be removed without hammering or prying against the concrete.

1.9 Reuse of Forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired or re-oiled before resetting. Formwork shall not be used/reused, if declared unfit or unserviceable by the Engineer.

1.10 Opening/inserts

All required openings and pockets shall be provided as detailed in the drawing. They may be enumerated or paid on area basis as detailed in the BOQ. The contractor shall provide for the required material, labour, for fixing and supporting during concreting, in his quoted price. It is imperative that all openings and pockets shall be deshuttered with care and all corners of openings shall be preserved. All openings/pockets shall be in a correct line and level. After concreting, the openings shall be secured against any accident by proper covering and guard rail and warning notice, if any.

The contractor shall clean and grout the pocket at a later date with a non-shrinking compound added to the grout mix or non-shrinking cement shall be used. It shall be well-cured and protected to correct line and level till handing over.

1.11 Cleanout Provisions

Forms with limited working space within, shall be provided with temporary clean-out doors or openings for cleaning, washing, blowing and removal of water, wood chips, trash etc.

1.11 Working platform

The Contractor shall provide safe working platform for workmen, when working above ground level. Safe method of approach shall be provided to reach locations above ground level. Handrails shall be provided for all working platforms. Hanging platforms shall have safety net provisions. All ladders shall have handrails and shall

not be kept vertical. All platforms, ladders, handrails etc. Shall be firmly secured to ground or on supports. No loosely supported ladders or platforms shall be used in the work. All ladders and platforms shall have a kick plate 150 mm high in MS for safety of personnel. Ladders and platforms shall be periodically cleaned of loose debris etc.

1.12 Removal of Forms

In the determination of time for removal of forms, consideration shall be given to the location and character of the structure, the weather and other conditions including the setting and curing of the concrete and materials used in the mix.

Forms and their supports shall not be removed without approval of the Engineer. Improper methods of removal of formwork likely to cause overstressing or damage to the concrete shall not be used. Supports shall be removed in such a manner so as to permit the concrete to uniformly and gradually take the stress due to its own weight.

The supports can be reinstated in anticipation of abnormal conditions. Repropping of beams shall not be done except with the approval of the Engineer.

The minimum period for removal of forms shall be as mentioned below. However, the seven-day test results shall be as per IS: 456 (latest revision). If the strength requirements are not met with, the formwork shall be removed as per the instructions of the Engineer.

Note : 1) Time shall be measured from last batch concreted in respect to the structural member under consideration.

2) In no case shall forms be removed until there is an assurance that removal can be accomplished without damaging the concrete surface. Heavy loads shall not be permitted until after the concrete has reached its design strength. The forms shall be removed with great caution and without jerking the structure.

TABLE - A MINIMUM PERIOD FOR REMOVAL OF FORMWORK

Sr.	Class of Structures	Earliest Concrete age at stripping for placing Temperature above 20 deg. C

No.		Where ordinary Portland cement is used	Where mineral admixture is used
1.	Walls, Columns & Vertical sides of Beams	24 to 48 hrs. as decided by the Engineer	48 to 96 hours
2.	Slabs (props left under)	3 days	7 days
3.	Beam soffits (props left under)	7 days	14 days
4.	Removal of props to slabs		
	For thickness above 300mm		
	a) Spanning upto 4.5M	14 days	21 days
	b) Spanning over 4.5M	21 days	28 days
	For thickness upto 300mm		
	a) Spanning upto 4.5M	7 days	14 days
	b) Spanning over 4.5M	14 days	21 days
5.	Removal of props to beams and arches		
	a) Spanning upto 6M	14 days	21 days
	b) Spanning over 6M	21 days	28 days
6.	Cantilever construction	Not until adequate fix-ity is developed	Not until adequate fix-ity is

		subject to a min. of 10 days	developed subject to a min. of 21days

For rapid hardening Cement Concrete 3/7 th of the period specified for ordinary Portland Cement will be sufficient subject to the minimum period of 24 hours.

Striking shall be done with utmost care to avoid any damage to concrete surfaces or any projections on it and without shock and vibrations, by gently easing the wedges/jacks. If after removing the formwork, it is found that timber has been embedded in the concrete, it shall be removed and made good as approved.

Tie rods, clamps, form bolts etc. which must be entirely removed from walls or similar structures shall be loosened not sooner than neither 24 hours nor later than 40 hrs. after the concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled towards the inside face cutting ties back from the faces of walls and grade beams will not be permitted.

Works damaged due to premature or careless removal/withdrawal/ loosening/striking of forms shall be reconstructed at Contractor's cost.

For liquid retaining structures no sleeves for through bolts shall be used nor shall through bolts be removed as indicated above. The bolts, in this case, shall be cut at 25 mm depth from the surface and then the hole shall be made good by epoxy mortar or cementitious grout (as mentioned in BOQ) as the concrete just after striking the formwork.

Necessary approach / staging for ease of the access of workmen, inspection and supervision staff, in accordance with safety requirements and as per the instructions of the Engineer to be provided for all types of framework, for all the elements at all the depth / heights the cost of such arrangements detailed here above shall be deemed to be included in the quoted unit price of the item. The rate shall include providing and erecting formwork in position as per drawings, applying oil, removal of form after the specified period.

1.13 Settlement of Formwork and Camber :

Due to various reasons such as closure of form, joints, shrinkage of timber, dead load, deflections, elastic shortening of form members formwork deflections or settlement may occur.

The members of the formwork must be rigid enough to prevent excessive deflections, the usual acceptable limit being 1/500 of the formwork.

In the absence of any specified camber on the drawings, soffit of all beams more than 5 m. in span and other than prestressed concrete beams shall be laid to a camber, the amount of which at midspan shall be not less than 1/500 of the span of the structure. The profile of soffit shall be parabolic.

1.14 Mock-ups:

The method for pouring concrete into difficult zones will be pre studied on mockups. Mock-ups will be particularly necessary for the following :

i) Zones around penetrations and openings

ii) Behind anchorages of prestressed members

iii) Dome and shell in general requiring single and double forms

iv) Various zones of large thickness for studying placement temperatures in relation to internal temperature build-ups.

Work involved in mock-ups pours will NOT be paid for at the rates entered under relevant items of work. Sampling and testing of all samples will be done by the contractor. Unsuccessful mock-ups may have to be repeated in full or in part as required by the Engineer.

1.15 Requirement of Formwork for Special Purpose

- **Stopper Formwork**

Stopper formwork (Bulkhead) Hy-rib sheets to size 500 W x 1220 L x 0.60 mm T manufactured from branded sheet from Jindal / Essar as per approved drawing having 4 " V "shaped knotches each of size 15 mm x 15 mm (V shaped) x 1220 mm long ,

with perforation in 48 rows x 24 perforations in each row = 1152 perforations shall be provided at all vertical construction joints. Such formwork shall be leak-tight and shall not allow leakage of cement slurry. Wherever specified in the drawings, gas barrier/water stopper shall be provided in the stopper shutter. In addition to the erected stopper, emergency stopper formwork shall be kept ready before starting large concrete pours, with provision for gas barrier/water stopper if required. **All stopper formwork shall not be measured separately and is included in the item of formwork only.**

- **Sloping Formwork**

  The bottom formwork shall be made out of plywood with wooden backing members. For slope above 15 Degree with the horizontal it is recommended to have plywood formwork for the top surface and supported on steel or wooden truss. These shall be divided into panels, which shall be fabricated in the shop to the required profile. The bottom of truss will be closed by plywood formwork at the time of concreting. Subsequently further closer formwork for the top surface will be extended after concreting and compaction of the lower portion The entire formwork shall be supported on structural steel/scaffolding supported on a firm base.

- **Pockets For Foundation Bolts**

  Pockets for foundation bolts shall be made out of plywood or timber. These shall be made slightly tapered for ease of removal. The bottom of such formwork shall be necessarily closed so as not to allow entry of concrete from bottom. The timber pocket may have to be broken to withdraw after concreting. Templates shall be provided wherever required or as directed by the Engineer.

- **Curved Formwork**

  This shall cover all such formwork, which is curved in plan. The formwork shall be fabricated to the required curvature at shop before use. Mismatch if any at site, shall be rectified by cutting or replacing the panel/members.

  The contractor shall interpolate intermediate sections as necessary and shall construct the forms so that the curvature will be continuous between sections.

  After the forms have been constructed, all surface imperfections shall be corrected and all surface irregularities at matching faces of form material shall be dressed to the specified curvature. (Note: Only curved portion will be measured

where curved shuttering is done)

Formwork for Exposed Concrete Surfaces:

i) Where it is desired, directed or shown on the drawings to have original fair face finish of concrete surface without any rendering or plastering, formwork shall be carried out by using wood planks, plywood or steel plates of approved quality and as per direction of the Engineer.

ii) The contractor shall use one type of material for all such exposed concrete faces and the forms shall be constructed so as to produce uniform and consistent texture and pattern on the face of the concrete. Patches or forms for these surfaces will not be permitted. The formwork shall be placed so that all horizontal formworks are continuous across the entire surface.

iii) To achieve a finish which shall be free of board marks, the formwork shall be faced with plywood or equivalent material in large sheets. The sheets shall be arranged in an approved pattern. Wherever possible, joints between sheets shall be arranged to coincide with architectural features, sills, window heads or change in direction of the surface.

iv) All joints between shuttering plates or panels shall be vertical or horizontal unless otherwise directed. Suitable joints shall be provided between sheets. The joints shall be arranged and fitted so that no blemish or mark is imparted to the finished surfaces.

v) To achieve a finish which shall give the rough appearance of concrete cast against sawn boards, formwork boards unless otherwise stated shall be of 150 mm wide, securely jointed with tongue and grooved joints if required to prevent grout loss with tie rod positions and direction of boards carefully controlled. Sawn boards shall be set horizontally, vertically or at an inclination shown in the drawings. All bolt holes shall be accurately aligned horizontal and vertically and shall be filled with matching mortar recessed 5mm back from the surrounding concrete face.

vi) Forms for exposed concrete surfaces shall be constructed with grade strips (the underside of which indicated top of pour) at horizontal construction joints, unless the use of groove strips is specified on the drawings. Such forms shall be removed and reset from lift to lift; they shall not be continuous from lift to lift. Sheeting of reset forms shall be tightened against the concrete so that the forms will not be spread and permit abruption irregularities or loss of mortar. Supplementary form ties shall be used as necessary to hold the reset forms tight against the concrete.

vii) For fair faced concrete, the position of through bolts will be restricted and generally indicated on the drawings.

viii) Chamfer strips shall be placed in the corners of forms for exposed exterior corners so as to produce 20 mm levelled edges except where otherwise shown in the drawings. Interior corners and edges at formed joints shall not be levelled unless shown on the drawings. Moulding for grooves, drip courses and bands shall be made in the form itself.

ix) The wood planks, plywood and steel plates used in formwork for obtaining exposed surfaces shall not be used for more than 3 times in case of wood planks, 6 times for plywood and 10 times for steel plates respectively. However, no forms will be allowed for reuse, if in the opinion of the Engineer it is doubtful to produce desired texture of exposed concrete.

x) In order to obtain exposed concrete work of uniform colour it shall be necessary to ensure that the sand used for all exposed concrete work shall be of approved uniform colour. Moreover the cement used in the concrete for any complete element shall be from single consignment.

xi) No exposed concrete surface shall be rendered or painted with cement or otherwise. Plastering of defective concrete as a means of achieving the required finish shall not be permitted, except in the case of minor porosity on the surface, the Engineer may allow a surface treatment by rubbing down with cement and sand mortar of the same richness and colour as for the

concrete. This treatment shall be made immediately after removing the formwork.

xi) The contractor shall also take all precautionary measures to prevent breaking and chipping of corners and edges of completed work until the building is handed over.

1.16 Construction Joints & Groove For Caulking

A trapezoidal groove tapering from the face of the wall to inside will have to be provided on walls at all construction joints. For construction joints in thin sections a steel cover plate exposed from one side of the surface will be provided replacing the water stop within the thickness and concrete will be cast against the plate. Suitable grooves will be provided at the junction of the plate and the concrete. Also embedded parts passing through the wall will be provided with grooves around its periphery on the walls. All such grooves shall be caulked by epoxy mortar or cementitious grout (as mentioned in BOQ) as directed by the Engineer.

The grout to be used for sealing should be a non-shrink grout of compressive strength higher than the parent concrete. The sealing material would be used, as available or may be used along with 10 mm aggregate, depending on the size of the opening. Non shrink property is required to ensure separation between parent concrete and grout with time.

The grout should be used with the recommended quantity of water as given by the manufacturer, either as a travelable or pourable concrete. For shuttering tie rod holes, stiff consistency may be used. For construction joints, with formwork in place, flowbale consistency may be used and if size permitting, along with 10 mm aggregate.

While selecting the grout, it is preferable to get the same tested by a third party for flow, strength and dimension change.

1.17 Tolerances

- The following tolerances are permitted unless otherwise mentioned in the relevant drawings. The tolerances shall be taken as the departure from the true position at any point after completion of the structure.

- Sectional dimensions :(±) 5 mm for cast-in-situ concrete.
- Plumb: 5 mm in 5 m but not cumulative. Tolerance in various sections should be compensatory and not cumulative
- Levels: 2 mm before any deflection has taken place for both cast-in-situ and pre-cast works.
- Prestressed concrete form work:
- The inside surface: within 12 mm of the dimension shown on the drawing.
- Thickness of the wall and slab: within (+/-) 10 mm.
- Sudden dips or bulges relative to the curved : 6 mm over a distance of 1.50 M (measured in surface any direction)

Latest computerized survey instruments shall be used for checking the vertically and alignment of the formworks at all floor levels.

1.18 Submission of Contractor's Scheme

Bidder shall submit along with his tender the scheme for shuttering, centering, scaffolding for important elements. These should be supported by preliminary drawing and design calculations. Final drawing shall be submitted before start of work.

The scheme submitted by the Contractor should be for all the different type of centering and shuttering schemes proposed and should be so elaborate keeping in mind the entire cross-section of the respective structures in general. The scheme should be such that the construction of one part of any building should not hinder the work on the other parts and keeping in mind the construction schedule.

For centering and shuttering of walls, columns, beams & slabs all the working drawings, details of erection methods calculation of stress and of deflections shall be supplied to the Engineer for approval at least Three (3) months in advance of erection.

1.19 Alterations and Maintenance

Any modification that the Engineer may require shall be made by the Contractor. Notwithstanding the approval of or alteration suggested by the Engineer in the submitted design for any of the temporary work etc., the

Contractor shall remain wholly and entirely responsible until the final acceptance of works, for the efficiency, security, safety and maintenance and for all obligations and risks in regard to such work specified or implied in the contract. The Contractor shall reinstate the same at their own cost, should any mishap or accident occur causing damage or injury thereto, subject however to such provisions of the conditions of contract as may be applicable in the case of such damage or injury.

Mode of Measurement: The mode of measurement will be paid in Sqm which will include the cost of shear keys, cutouts, pockets, formation of chamfer/ fillets. Only the area of shuttering in contact with concrete will be measured for payment.

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4.00 REINFORCEMENT WORK

1.0 GENERAL

1.1 **Standards**

Work shall be carried out to Indian Standards and Code of Practices. In absence International Standards shall be followed. These shall be latest issue. List given here under is not to be considered as conclusive and is for reference and guidance only. Any discrepancies /conflict noticed shall be directed to the Engineer-in-charge for his direction/approval. However as a general rule more stringent specification shall take precedence.

1.	IS 226	Specification for steel standard quality
2.	IS 228	Methods for chemical analysis of steels
3.	IS 280	Specification for mild steel wire for general engineering purpose.
4.	IS 432	Specification for mild steel and medium tensile steel burn and hard drawn steel wires for concrete requirement.
	Part 1	Mild steel and Medium tensile steel bars.
	Part 2	Hard drawn steel wire.
5.	IS 456	Code of practice for construction and design of reinforced concrete.
6.	IS 816	Code of practice for use of metal arc welding for general construction in mild steel
7.	IS 961	Specification for structural steel : high tensile steel bars
8.	IS 1566	Hard drawn steel wire fabric for concrete reinforcement.
9.	IS 1599	Method of Bend test
10.	IS 1642	General requirements for fire protection.
11.	IS 1785	Cold drawn stress relieved wire (part I)
12.	IS 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.

13.	IS 2751	Code of practice for welding of MS bars.
14.	IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
15.	IS 2751	Code of practice for welding of Bars
16.	IS 3696	Safety Code of scaffolds and ladders :
	Part 1	Scaffolds
	Part 2	Ladders
17.	IS 4014	Code of practice for steel (Part 1 & 2) tubular scaffolding
18.	IS 4082	Recommendation on stacking and storage of construction materials at site
19.	IS 5525	Recommendation for detailing of reinforcement in RCC work.
20.	IS 9417	Recommendation for welding cold worked steel bars for reinforced concrete construction
21.	IS 10790	Method of sampling of steel for prestressed and reinforced concrete

1.2 Quality Assurance

1.2.1 The Contractor shall procure and provide reinforcing steel bars conforming to IS specified and shall comply with all physical, chemical and mechanical test.

1.2.2 Steel used on site shall be from leading manufacturers as mentioned in make list.

1.2.3 Steel manufacturers shall conform steel produced conforms IS requirements for reinforced cement concrete works.

Steel shall not react chemically with ingredient of reinforced cement concrete which are harmful to strength, durability of reinforced cement concrete.

1.2.4 Unit weights and diameter of rolled steel bars shall conform to IS.

1.2.5 Provide supervision and work force to ensure workmanship of specified quality.

1.2.6 Contractor to undertake documenting of

- Test reports for steel brought at site for each lot
  a) Chemical composition from factory
  b) Mechanical
  c) Physical
- Barbending schedule for cutting and bending
- Record of laps and anchors / development length

1.2.7 Work shall not be subjected to harmful, dangerous and damaging exposures.

1.3 Submittals

1.3.1 Submit for approval of the Engineer-in-charge all details of Material / Product which conforms the specification laid down in documents.

1.3.2 Submittals shall include

- Product data sheet
- Manufacturers certificates
- Test report of laboratories
- Alternative product if any with tabulation for conformation that alternatives proposed meets / exceeds specification.

1.3.3 Samples for Third Party Testing

Samples of type of materials to be used. Further during construction samples shall be taken and tested by the Contractor as per specification and as directed / instructed by the Engineer-in-charge. The cost of samples and test shall be borne by the Contractor within quoted prices. The frequency and the type of test on steel to be as per relevant IS code.

1.3.4 Shop drawings

Contractor shall prepare and submit bar bending schedule based on structural detailed drawing prior to fabrication for approval of the Engineer-in-charge.

1.4 Examination of Conditions

Contractor shall inspect and examine sub stratas and confirm prior to start that.

- Substrate is acceptable and approved by Engineer-in-charge
- Conditions are satisfactory
- Setting out/Layout is verified
- Corrective measures needed if any are within reach and contractor proceeds with full responsibility for work.

2.0 MATERIAL

2.1.0 Reinforcing Bars

2.1.1 Reinforcement bars used in construction shall be mild steel or medium tensile steel round bars and high strength deformed bars. Steel shall be fresh and new. It shall be free of defects and free of rust, oil, paints, grease, loose mill scale or any other deleterious material undesirable for RCC or prevent adhesion of concrete with reinforcement.

Steel should be from the original iron ore producers (like TATA, SAIL). If other steel

is to be used then billets should be approved from TATA, SAIL. Other steel can be used only after prior approval of the Engineer-in-charge.

2.1.2 M S Plain

Rolled mild steel and medium tensile steel plain round bars used in concrete shall conform to IS 432 Part I. Steel received shall conform to the following IS with regard to manufacturing and chemical composition.

1. M.S. bar Grade I Steel designation Fe 410-S of IS 226
2. M.S. bar Grade II Steel designation Fe 410-O of IS 1977
3. Medium Tensile Steel designation Fe 540 Steel bars W-HT IS 961

2.1.3 Nominal sizes and tolerances shall be as specified in IS 432 Part I. Physical requirements shall be determined in accordance with IS 1608, read in conjunction with IS 226. For reference of minimum requirements, properties are tabulated in IS 432 Table 1 “Mechanical properties of bars mild steel & tensile steel bars”.

2.1.4 Tor Steel

High-strength deformed bars for use as reinforcement in concrete shall be of grade Fe 415, Fe 500, Fe 500D, Fe 550 and Fe 600 conforming to IS 1786.

2.1.5 Chemical composition shall conform to IS 1786 when made as a relevant part of IS 228.

2.1.6 Welding of cold work steel bars in reinforcement shall be permitted as per IS 2751 and 9417. (Recommendation for welding cold worked steel bars for RCC).

2.1.7 Nominal sizes, cross sectional areas and their mass shall be as specified in IS 1786, allowing due consideration for tolerances specified therein.

2.1.8 Physical properties

a) It shall satisfy IS 1599 test for bend and rebend test in conjunction with IS 226.
b) Bond requirements shall be deemed to have been satisfied if it meets clause 4.0 of IS 1786.
c) Tensile, proof stress and percent elongation shall be as per table 3 of IS 1786.

2.1.9 Material received at site shall have ISI certification mark. Each bundle or coil containing the bars shall be suitably marked with ISI certification mark. Also bars shall be marked to identify categories. This shall be done as per IS 1387.

In case bars are without ISI certification mark, the manufacturer shall give a certificate stating process of manufacture, chemical composition and mechanical properties. Each certificate shall indicate the number or identification mark of the batch production/ cast to which it applies. Corresponding number or identification mark should be found on the material.

2.1.10 All reinforcement material shall be free from loose mill scale, excessive rust, loose rust, pitting, oil, grease, paint, mud or any foreign deleterious material present on the surface. Cleaning shall be done to the satisfaction of the Engineer-in-charge.

2.1.11 Each batch brought at site shall be tested prior to use for respective specification / physical properties. Cost of all such tests shall be borne by the contractor. Material acceptable as per IS shall be allowed into the works. All rejected material shall be removed from site by the contractor within 3 days of rejection. If the same is not done, the Engineer-in-charge shall impose a penalty of Rs.5000/- per metric ton per day. This will be without any appeal and shall not be subjected to arbitration.

2.2.0 Cover block

Cover blocks shall be of non-corrosive material such as plastic but not wooden or broken bricks or stone. Designed purpose made PVC cover spacers shall be used in the Works. Concrete cover spacers may be permitted by the Engineer-in-charge. Such concrete spacers shall be cast from concrete and not cement-mortar. Strength of these blocks shall be one grade higher to the strength of concrete in use. These should be fully cured prior to use in works.

2.3.0 Binding Wire

Binding wire shall be 16 or 18 gauge annealed aluminium wire conforming to IS 280. It shall be free from rust, oil, paint, grease, loose mill scale or any other deleterious material undesirable for the reinforcement and concrete or which may prevent adhesion of concrete with reinforcement.

2.4.0 Mechanical Splices

1. **Introduction**

Only cold-forged, parallel threaded mechanical coupler system are recommended. All mechanical couplers shall be of as per TYPE 2 as per ACI and should be simple to install; which can be confirmed by quick visual inspection to have been correctly installed and to have achieved the required full strength connection.

The couplers shall be of standard parallel thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging/upsetting, threaded in such a way that root thread diameter is not lesser than the parent bar to be joined. The coupler shall be in compliance with IS code 16172:2014, ACI 318, ASME, Section III, and Div.2, Caltrans.

Couplers installed shall be strictly in accordance with the manufacturer's

recommendations.

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. **Each coupler shall be clearly stamped indicating batch number and diameter (no coupler delivery shall be accepted without traceability marking)**. This number shall be traceable to the original raw-material. The relevant Certificate of Compliance shall be submitted with supply of each coupler lot. The certificate shall give salient material properties. **The coupler manufacturer shall possess at least an ISO 9000 approved quality assurance programme or equivalent for the manufacture of couplers**.**The mechanical splice providing company must have its own in-house manufacturing capability and none of the couplers supplied to site should not be out-sourced manufactured.**

2. Threading of ends of the reinforcing bars:

The splice system provider shall mobilize the number of equipment set to site as per requirement. Each equipment set will strictly consist of a cutting machine, a forging machine and a threading machine. The threading activity shall preferably be done at Site. The various stages involved in threading are as given below:

a) Cutting (Rebar End Préparation):

The ends of reinforcement bars shall be square cut by the cutting machine at threading yard with machine from threading equipment set; to get a perfect plain and surface perpendicular to the axis of the bar.**No shear or saw cut should be accepted as these give uneven surface leading to improper forging**.

b) Cold forging& threading:

After cutting the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed thread length as per manufacturer's design. Threading shall be done preferably on threading machine. The threads shall be square parallel type to suit the couplers. The thread length and depth shall be as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic end caps before taking the

bars out of the shop.

3. Quality control in making of threads:

Double forging of bars is not permitted. In case of improper cold forging the forged portion of the rebar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and “no go' gauges for the correctness of the thread profile on the rebar.

4. Qualification tests

The coupler shall be qualified as per IS code 16172:2014, ACI 318, ASME - Section III, and Div.2, Caltrans and must have conducted & qualified for the following tests :

a) Static Tensile Test

Mechanical connections shall be tested for all reinforcing rebar sizes. For each rebar size, a minimum of three connections (3 joints + 1 Parent bar) in each load direction shall be tested in accordance with ASTM A370 test method to meet code requirement. A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength. **The tensile strength of an individual splice system shall not be less than 1.25 times the specified yield strength of rebar**.

b) Cyclic tension and Compression test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for cyclic tension & compression test. Each specimen shall withstand cycles of stress variation of the specified minimum yield strength of the reinforcing bar. **Past certificates for low cycle fatigue test shall be accepted, however these should not be more than 3 years old**. The test should be carried out as per the table mentioned below:

Loading Stages and Cycles per stage for cyclic load test

Stage	Tension	Compression	Cycles
1	0.95 fy	0.5 fy	20cycles
2	2 εy	0.5 fy	4cycles
3	5 εy	0.5 fy	4cycles

Note:

fy is specified yield strength of the reinforcing bar.

εy is the strength of reinforcing bar at actual yield stress

c) Cyclic tensile test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength (fy) of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return.**Past certificates for low cycle fatigue test shall be accepted, however these should not be more than 3 years old.**

d) Low cycle fatigue test (for 10,000 cycles)

Fatigue test shall be conducted on splice sample from +173 Mpa to -173 Mpa for 10,000 cycles. A sine wave form @ 0.5 Hz shall be followed for bar dia 36 mm & above and 0.35 Hz shall be followed for bar dia less than 36 mm. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. **Past certificates for low cycle fatigue test shall be accepted, however these should not be more than 3 years old**.

e) High cycle fatigue test (for 2,000,000 cycles) (if applicable)

In high cycle fatigue test, the test specimen is subjected to an axial tensile load which

varies cyclically according to the sinusoidal wave form of constant frequency in the elastic range, as accordance with IS-16172. **Past certificates for high cycle fatigue test shall be accepted, however these should not be more than 3 years old**.

f) Slip test

Slip Test Shall be performed on each diameter coupler specimen as per ASTM A 370 section 10. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. **Past certificates for low cycle fatigue test shall be accepted, however these should not be more than 3 years old**. Total slip shall not exceed the max value of 0.1 mm. Refer table below for more details:

Bar diameter	**TOTAL Slip (µ m)**
8 mm to 20 mm	250
25 mm to 28 mm	350
32 mm to 40 mm	450
45 mm	600
56 mm	750

2.5.0 Delivery and Storage

Reinforcing steel bars each batch should accompany manufacturers' certificate. Reinforcement bars received at site shall be loaded and unloaded at site and stored with care such that it does not get bent or damaged. Steel received shall be as far as possible in straight length of 12 M. Steel shall be weighed in presence of representative of the contractor prior to delivery being received by him. Empty and loaded truck loads shall indicate correct quantity.

Reinforcement bars to be cut and bend outside the premises and to be brought to site properly tagged. Only a few tones of UNCUT steel of different diameters in straight lengths of 12 M will be allowed at site for emergency use only. The decision of the quantum of steel will be decided by the Clients site in charge as per site conditions.

Reinforcement bars received at site shall be stored on hard concrete platform and clear of the ground with the use of timber sleeper, concrete sleeper or any other means. Reinforcement material shall be kept covered by tarpaulins or plastic to avoid excessive corrosion and other contamination. Each dia of bars shall be stacked separately. Bars without "ISI' / Tor marking shall not be brought to site.

3.0 SCOPE OF WORK

The contractor shall be responsible for

3.1 Material Procurement

a) The contractor will submit the Schedule of Procurement of steel in consultation with Engineer-in-charge as specified and conforming to specifications detailed in drawings and bills of quantities.

The steel may be free supply by the client to be delivered to site as per approved indent of the contractor to agreed schedule. However further all balance work to complete the reinforcement bar item shall be same as materials are supplied by the Client.

b) Receive steel and stack with covering on firm platform free of contamination.

c) Collect samples of each type for every batch received and test as per IS for

- Unit weight per running meter
- Cross section area
- Bend / Rebend Test
- Ultimate tensile strength
- Yield stress
- Elongation

d) Procure binding wire, cover blocks splices etc.

3.2 Prepare bar bending / cutting schedule detailing schedule covering as under and obtain approval of Engineer-in-charge.

- Cutting lengths
- Laps
- Rings for various locations and items
- Chairs

3.3 Transport, cut, bend and shift to site reinforcing bars.

3.4 Place in position and tie as detailed in drawing reinforcement with specified cover.

3.5 Provide attendance to keep reinforcement in position during concreting.

3.6 Disposal/stacking of surplus reinforcement steel as per approval of the Engineer-in-charge in scrap yard diameter wise. The scrap will be the property of the Client.

3.7 Provide anticorrosive treatment to reinforcement bars including required handling, application, touch up and maintenance till concreting by either, if specifically noted for in BOQ

a) CECRI System : Cement polymer composite coating system

b) Fusion bonded epoxy coating.

3.8 Providing required tools, plants, equipments such as

- Material cutting and bending tools
- Bending platform Bar cutting machine
- Bar bending machine
- Hydraulic clipping machines.

4.0 WORKMANSHIP

4.1 Fabrication of reinforcement

Reinforcement shall be fabricated as per the drawing and approved barbending schedule. Bending shall be done mechanically or with hand but to the correct radius, with proper tools and platform and shall conform to IS 2502. Bending of material shall be cold bending only. Material shall be inspected for visible defects such as cracks, brittle, excessive rust, loose mill scale, etc. Cracked ends of bars shall not be used in Works. Also the bars should be free from any deleterious material and hence the best practice shall be to hose down reinforcement just prior to concreting.

It is important that bending, straightening, cutting, etc. shall be carried out in a manner not injurious to the material and the safety of the persons working should be ensured.

4.2 Anchoring

Anchoring of bars and stirrup shall be provided exactly as detailed in the structural drawing or as directed by the Engineer-in-charge.

4.3 Lapping of bar

Laps shall be strictly as per the drawing or as directed by the Engineer-in-charge. For general guidance, the following principles shall be followed as given in IS 456.

a) Splices shall be provided as far as possible away from sections of maximum stress and be staggered.

b) Not more than half of the total bars shall be spliced at a section.

c) Where more than one half of the bars are spliced at a section or where splices are made at points of maximum stress, special precautions shall be taken, such as increasing the length of lap and/or using spirals or closely spaced stirrups around the length of the splice.

d) Lap splices shall not be used for bars larger than 36 mm diameter: For larger diameters, bars may be welded. In cases where welding is not practical, lapping of bars larger than 36 mm diameter may be permitted and additional spirals should be provided around the lapped bars.

e) Lap length including anchorage value of hooks in flexural tension shall be Ld (as defined in 25.2.1 of IS 456) or 50 dia or as specified in the Drawing whichever is greater.

f) When splicing of welded wire fabric is to be carried out, lap splices of wires shall be made so that the overlap measured between the extreme cross wires shall be not less than the spacing of cross wires plus 10 cm.

4.4 Spacing of bars

Bars shall be placed in position as shown in the drawing. Following guidelines as given in IS 456 shall be followed in case of difficulties or shall be carried out as directed by the Engineer-in-charge.

a) Horizontal distance between two parallel main reinforcing bars shall usually not be less than the greatest of the following:

1. The diameter of the bar, if the diameters are equal.
2. The diameter of larger bar, if the diameters are unequal, and
3. 5 mm more than the nominal maximum size of coarse aggregate (By using reduced size of aggregate in congested reinforced area, conditions given hereof should be overcome).

b) Greater horizontal distance should be provided. But when needle vibrators are used, distance between bars of a group may be reduced to two-thirds of the nominal maximum size of the coarse aggregate, provided sufficient space is left between groups of bars to enable the vibrator to be immersed.

c) Where there are two or more rows of bars, the bars shall be vertically in line and the minimum vertical distance between the bars shall be 15 mm, two-thirds the nominal maximum size of the aggregate or the maximum size of bar, whichever is more.

4.5 Cover to reinforcement

Reinforcement shall have concrete cover and the thickness of such cover (exclusive of plaster or other decorative finish) shall be as specified in drawing or as directed by the Engineer-in-charge. The following guidelines are to be observed in the absence of the above.

a) At each end of the reinforcing bar, not less than 25 mm, nor less than twice the diameter of such bar;

b) For a longitudinal bar in a column, not less than 40 mm, nor less than the diameter of such bar. In the case of columns of minimum dimension of 200mm or under, whose reinforcing bars do not exceed 12 mm, a cover of 25 mm.

c) For longitudinal reinforcing bar in beam, not less than 25 mm, nor less than the diameter of such bar.

d) For tensile, compressive, shear or other reinforcement in slab, not less than 15 mm, nor less than the diameter of such bar; and

e) For any other reinforcement, not less than 15 mm, nor less than the diameter of such bar.

f) Increased thickness shall be provided in case the concrete members are in the surrounding of harmful chemicals, saline atmosphere, etc. and the cover shall be 50 mm or more as directed by the Engineer-in-charge.

g) For concrete members totally immersed in sea water, the cover shall be 40 mm more than specified above (a) to (f).

This shall be 50 mm more for periodical immersion in sea water.

h) Concrete cover should not exceed 75 mm in any case. Cover to reinforcement shall be as specified in the drawing or as directed by the Engineer-in-charge.

Details given in sub para (a) to (h) are for guidance and shall be followed in absence of any specific direction.

i) The final cover to various concrete members will be mentioned in the drawings. In case there is a variation in Specifications and drawings, the drawings will supercede the Specifications.

4.6 Welded joints or mechanical connections

A) Welded joints or mechanical connections in reinforcement may be used but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of the connected bars. Welding of reinforcement shall be done in accordance with IS recommendation. Welded joints shall preferably be located at points where steel will not be subject to more than 75 percent of the maximum

permissible stresses and welds so staggered that, at any one section, not more than 33 percent of the rods are welded.

B) Welding rods used shall conform to IS 814 : covered electrodes for metal arc welding of structural steel. Work shall be carried out by a competent welder. Samples from work site shall be taken at regular intervals and tested. Frequency and number of samples shall be as directed by the Engineer-in-charge.

4.7 Fixing in position

4.7.1 Correctly cut and bent bars shall be accurately placed in position as detailed in the drawing. Unless otherwise specified by the Engineer-in-charge, reinforcement shall be positioned within the tolerance as under :

a) for effective depth 200 mm or less, + 10 mm

b) for effective depth more than 200 mm, + 15 mm

4.7.2 But in no case shall the cover be reduced by more than 5 mm of that specified. There shall be no compromise on cover for foundation work.

4.7.3 Reinforcing bars shall be held in position during the placing of concrete by use of PVC covers (on special permission from the client)or concrete cover blocks (made of one grade higher strength of well-cured concrete in use) , steel chair spacers, steel hangers, supporting wires, etc. and secured by tying with an annealed binding wire of 16 to 18 gauge as approved by the Engineer-in-charge. Spacing of the cover blocks shall not exceed 1.0m in each direction.

4.7.4 Layer of bars shall be separated by precast concrete spacer blocks or spacer bars. Reinforcement shall be in correct position prior to start of concreting. No reinforcing bar shall be placed on freshly laid concrete for adjusting bar spacing. Care shall be taken to maintain reinforcement in position and keep it clean, throughout the period till it is embedded in the concrete. For maintaining cover, pieces of broken stone or brick or wooden blocks shall not be used at any stage. Chairs used to separate the two layers of reinforcement in slabs shall not exceed 1.2m clear in all four directions. The Diameter of the chairs will be minimum one diameter above the diameter of the slab reinforcement. The final spacing of the chairs can be reduced by the Client / Site –in-charge as per their discretion. Spacer bars in beams to sepeate the two layers will be minimum 25mm diameter and will be at a maximum spacing of 1.0m.

4.7.5 Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is the radius of the bend less than 4 bar diameters in case of plain mild steel

or 6 bar diameters for deformed bars. Care shall be taken when bending back bars to ensure that the concrete around is not damaged/disturbed.

4.8 Inspection - Erected and secured reinforcement shall be inspected, jointly measured and recorded and approved by Engineer prior to placement of concrete.

4.9 Mode of Measurement - Lengths of reinforcement steel including spacers & chairs shall be measured to the nearest centimetre and converted to weight using IS coefficients. The actual quantity of steel embedded in concrete as calculated and approved by Engineer, irrespective of the level or the height at which the work is done shall be taken. The unit rate for reinforcement shall include all wastages, pins, spacers, chairs, rolling margin, binding wire, cover blocks etc. for which no separate payment shall be made. Laps as shown in drawings or as approved by Engineer shall be paid for. In case couplers are used in place of laps, the equivalent length of the lap will be measured and paid for. No extra payment will be made for coupler.

When steel is supplied by the owner, the cost of this quantity of steel plus wastage as specified in the BOQ shall be recovered at issue rate from the Contractor. In that case Rolling margin shall be paid as per BOQ.

It shall be measured in Kgs/MT.

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5.00 PT SLAB WORK

13.0 Special Notes to vendors for Post-Tensioned Slabs and Beams

Identification and design brief

1. All post tensioning design, materials, workmanship, inspection and testing shall be carried out in accordance with IS:1343

2. Recourse to ACI 318-77, BS 8110 : part 1 and AS 1481 may also be allowed upon submitting relevant backup references.

3. Recommended method for pre-stressing slabs is bonded post- tensioning.

4. Post tensioned slabs are indicated in the drawings as “post tensioned slab” or “P.T.slab”.

5. Slabs marked thus shall be post tensioned slabs designed by the approved post tensioning agency, hereinafter referred to as P.T.agency.

6. Slabs marked as s1, s2, s3, s…… shall not be designed as P.T.slabs

7. Minimum Concrete grade for all P.T.slabs and drop panels shall be M:35

8. Reinforcement shall be high yield strength deformed bars with yield strength fy = 500D n / sq.mm

9. However, at the time of stressing, the concrete may have achieved a strength of only M:25 to M:28 .

10. Architect and structural consultant will provide the floor plans, general arrangement drawings and imposed loads to the P.T.agency.

Responsibility

11. Post tensioning agency shall be appointed by the main contractor.

12. P.T. agency will design the P.T.slabs on the basis of the imposed loads mentioned on this drawing for various areas.

13. P.T.agency will be responsible for the structural design of the P.T.slab and for preparation of the shop drawings, obtaining approval from architects and structural engineer, providing and laying the tendons in conjunction with the reinforcement laying (reinforcement is in the scope of the main contractor) , placing anchorages, stressing after concreting (concreting is in scope of the main contractor), grouting and generally ensuring safety at all times by providing proper information on the sequence of staging, propping, deshuttering, re-propping, barricading sensitive areas etc. To the main contractor.

14. The sequence of execution of post tensioning shall ensure that at no time, any of the slabs already stressed, slabs yet to be stressed, any other structural members directly or indirectly affected by the post tensioning activity, any other structural member including slabs which are not connected with the post-tensioned areas – at upper or lower levels to the level under consideration, are completely safe and stable.

15. In case P.T. agency feels that certain areas need to be temporarily supported or work platforms and/or staging is required for carrying out any P.T.activity, the same shall be clearly mentioned in the methodology and the main contractor is bound to follow the recommendations of the P.T.agency and fulfil the requirements in these regards. No extra claim shall be entertained on account of such provisions and support to the P.T.agency.

P.T.design and P.T.drawings

16. The thickness of P.T.slabs and drop panels mentioned on the drawings are indicative. P.T.agency may approach the structural consultant if any change is required in the dimensions of the drop panels and thicknesses of the slabs if the calculations of the P.T.slab design demand so. P.T. agency shall not change the dimensions and thicknesses of slabs and drop panels without the consent of the structural consultant.

17. P.T.designer will take into account but not limited to the following during the design of the P.T.slabs :

- Increase in strength with age
- Tensile strength of concrete
- Elastic deformation
- Shrinkage
- Creep
- Thermal expansion
- Losses due to friction with sheaths
- Relaxation of steel
- Slip in anchorage

18. P.T.agency will inform the structural consultant about the software that is being used in the design of the P.T.slabs, and/or method of calculations to arrive at the capacIty of tendons, spacIng and numbers, P.T.force in the tendons, overall layout and profile elevations.

19. P.T.slab designer shall ensure that sheaths / tendons in orthogonal directions do not clash on account of the same elevation.

20. P.T.slab designer shall ensure that no tendons pass through columns, which will require cutting or bending of the column bars. The tendons in the column strips shall be splayed on the two sides of the column.

21. P.T.slab designer shall account for the moments and shear values at in the P.T.slabs provided by the structural consultant arising out of his overall structural analysis of the building for dead, live, wind, earthquake, temperature and any other load cases.

22. P.T.slab designer shall inform the structural consultant of secondary stresses on structural members such as beams, columns, shear walls and r.c.areas surrounding the P.T.areas so that structural engineer can incorporate the effect of such forces in his R.C.design.

23. P.T.agency will prepare the shop drawings for the P.T.slabs based on the architectural drawings and structural general arrangement drawings, the values of the imposed loads provided by the structural consultant.

24. The framing drawings shall be submitted to the architect and structural consultant for their approval and comments. If any deviation from the architectural intent and structural scheme is proposed due to requirements of P.T.methodology or design constraints, the same shall be brought to the notice of the concerned agencies and approval shall be obtained before proceeding to design, prepare drawings and execution of the work.

25. Upon approval to the framing drawings, the P.T.agency will prepare the working drawings showing :

a. General arrangement of middle strips, column strips, beams, columns, cutouts
b. Tendon layout with unique identification mark for each tendon
c. Tendon profile elevation – dimension from the soffit of the slab to the bottom of the sheath.
d. Dead end anchors : large scale dimensioned detail
e. Stressing block positions and large scale dimensioned detail
f. Tension values for the tendons
g. The quantities of P.T. material used in the area depicted on the drawing
h. The sequence of stressing
i. Loads considered for the design
j. Precautions to be taken to ensure safety and stability at all times.
k. Deshuttering sequence
l. Locations and widths of pour strips
m. Reinforcement layout in plans and sections
n. Bursting reinforcement

26. Locations and widths of the pour strips shall be clearly indicated and approval shall be obtained from the structural consultant before finalizing the design of the P.T.slab.

27. Appropriate notes shall be incorporated in the shop drawing regarding the time after which the pour strips shall be cast and requirement of not disturbing the staging / props under the area in the vicinity of the pour strips.

28. Top and bottom reinforcing bars in the P.T.slabs other than P.T. tendons shall be extended into the surrounding R.C.construction areas for minimum 1000 mm wherever applicable.

29. In case, the stressing of the cables is to be carried out in multiple stages, the supports under the slab shall not be removed until all stages are completed. Props under the slab shall be tightened to provide effective support to the slab after each stressing stage so that the slab is completely supported and the load is not transferred to the tendons partially stressed.

30. If an already stressed slab (say at level ln) is supporting the staging for upper slab (say at level ln+1) being concreted / already concreted but not stressed, then the slab at the current level (level ln) shall be fully propped underneath from lower level (level ln-1) to ensure that the slab at the current level (level ln) does not deflect, causing disturbance to the staging/formwork supporting slab being concreted / already concreted but not stressed at the upper level (level ln+1).

31. De-shuttering of the P.T.slabs after stressing shall be carried out only after written approval from the P.T.agency.

32. Surface preparation at the construction joints and the pour strip locations shall be to the complete satisfaction of the P.T.agency and the project manager. A method statement shall be submitted to structural constultant and project manager by the main contractor in this respect.

P.T. beams

33. P.T.beams are marked in the beam legend / schedule / plan as “P.T.beam”

34. All the above notes are applicable to P.T.beams also.

Testing of structures

35. In case of testing of structures, clause “17. Inspection and testing of structures” in IS : 1343 shall be applicable.

13.01 PRESTRESSING WORK

13.01.01 Anchorages for High Tensile Strands

- Anchorage shall be suitable for simultaneous tensioning and anchoring pre-stressing system of 100T capacity, using 7 ply low relaxation strands conforming to class II of IS:14268. The anchorages and wedges shall be of steel as per relevant clause in the specification.
- The anchorage shall transfer and evenly distribute the entire force from prestressing anchorages to concrete without inducing unacceptable cracking of the concrete or inducing unacceptable level of stresses in it. The test for the efficiency of the anchorage in transferring load to concrete shall be done in accordance with the recommendations of FIB for such tests.
- Unavoidable tolerance in dimensions and material qualities of the anchorage components and the prestressing steel shall not reduce the reliability of an anchorage. The contractor shall submit all the manufacturing drawings of the anchorage system for approval.
- On receipt of each batch of components of anchorages, a copy of the corresponding manufacturer's certificate shall be supplied to the Engineer. The various batches should be stored separately for ease of subsequent identification.

13.01.02 Anchorage Tube Unit

- **Material**

  Material used for casting the Anchorage tube unit shall conform to IS: 210 with minimum tensile strength of 220 N/mm2.

- **Batch Testing of Anchorage Tube Units**

  - Dimensional check: 100% gauge inspection key dimensions and surface defects shall be carried out by the manufacturer. Dimensional check tolerance shall be as per manufacturer's approved drawings Each batch shall carry MTC along with the delivery.
  - Surface hardness:2% of the lot shall be tested by third party agency for surface

hardness and the hardness shall be 160 to 220 BHN.

- **Placing of Anchorage Tube Units**

The anchorage tube units shall be placed accurately in accordance with the drawings and firmly fixed by suitable arrangement specified by the manufacturer to resist displacement during vibration of the concrete. The anchorage tube units shall be fixed so as to be perfectly collinear with the axis of the cable and to remain so, throughout the casting of the concrete.

Fixing anchorage tube units with flexible tying wires and nails shall not be permitted. The connection between the anchorage, sheathing and shuttering shallbe leak-tight. Approved quality of adhesive tapes shall be used for leak tightness.

13.01.03 Bearing Plate

- **Materials**

The material of the bearing plate shall be SG Casting Gr. 220 / EN 8/ EN 9 conforming to BS: 970.

- **Batch Testing of Bearing Plate**

  - Chemical test: Ladle analysis has to be conducted at the beginning of a heat and at the middle of each heat.
  - Mechanical test: three test bars from each heat of 10 tonnes shall be tested for tensile test. the ultimate tensile strength shall be not less than 500 N/mm^2 and elongation more than 7%.
  - Dimensional check:100% final gauge inspection of all key dimensions shall be carried out by the manufacturer and 2% of the tests will be witnessed by the representative of Client on all key dimensions. Before drilling holes, 100% visual inspection and 100% gauge inspection on cutting length, face flatness and parallelism of faces shall be done after drilling holes.
  - Hardness: One out of every 100 pieces shall be checked by the third party for hardness and the same shall be within 150 to 200 BHN.

13.01.04 Wedges

- **Materials**

The material of the bearing plate shall be EN 1A conforming to BS:970 or FG-260 of IS:3896.

- **Testing of Wedges**

- Physical properties: 100% visual inspection, dimensional check and thread profile of all key dimensions shall be carried out by the manufacturer/contractor. 10% of the tests will be witnessed by the representative of the client on all key dimensions
- Hardness test: Hardness test shall be conducted as per IS:210. 1% of every lot shall be inspected for surface hardness. Hardness of the raw material shall be between 88 to 194 in 15 N scale. Hardness after heat treatment shall be 58 HRC

13.01.05 Additional Concrete Cubes For Testing

Where the time of prestressing is decided by the strength of concrete before reaching the 28-day strength the actual strength achieved by the concrete shall be verified by cube tests. Additional cubes over and above the requirement of the quality control shall be cast for this purpose as desired by the Engineer.

13.01.06 Breakage of Strands

The breakage of wires during stressing or after anchoring shall be immediately reported to the Engineer and investigated to establish and correct the causes leading to breakages. The loss of prestress resulting from the breakages shall be made good by using altogether a new cable with prior permission of Engineer.
Under exceptional cases, when such replacement is not possible, appropriate action need to be taken in consultation with the Engineer/Designer.

13.01.07 High Tensile Steel

High tensile 7 ply low relaxation strands having an equivalent capacity of 18.3T and conforming to IS: 14268 shall be delivered at site in the form of coils.

The base metal shall be carbon steel of such quality that when drawn to wire, fabricated into strand and then thermally treated, shall have the properties and characteristic as prescribed in IS: 14268.

The wire used in the manufacture of the strand shall be well and cleanly drawn to the specified dimensions and shall be sound and free from splits, surface flaws, piping and any other defects likely to impair its use in the manufacture of the strand and the performance of the strand in prestressed concrete.

13.01.08 Qualification and Testing

The pre-.stressing strands shall be 7-ply class II low relaxation strands conforming to IS: 14268 for nominal dimensions, mass, mechanical requirements elongation and relaxation properties.

- **Chemical Tests**

The element wire used for the strand shall be tested in accordance with IS:228 for chemical composition shall conform to the following chemical properties.

Chemical	Minimum	Maximum
Carbon	0.6%	0.9%
Silicon	0.1%	0.35%
Manganese	0.5%	0.9%
Sulphur	-	0.05%
Phosphorous	-	0.05%

- **Load Extension Curves and Modules of Elasticity**

The manufacturer shall carry out and supply test results for load elongation curves tested upto the failure in the first loading cycle, tested as per IS:1521. The curves shall indicate

- Breaking load which shall not be less than 1862 N/mm^2.
- 0.2% proof load which shall not be less than 90% of the breaking load and
- E' value for the straight portion of the curve.

The variation in `E' value for the entire supply of material shall be within 3.5% of the average `E' value.

▪ **Proof Load Test**

- 0.2% Proof Load The test procedure to estimate the 0.2% proof load shall be in accordance with IS: 1608 and the minimum value shall be as per IS: 14268 Load at 1.0% Extension The load at 1.0% extension shall be determined as per IS: 1608 and the value shall not be less than the minimum 0.2% proof load.
- 0.1% Proof Load The 0.1% proof load shall be determined in accordance with IS: 1608 and the value shall be mentioned.

▪ **Elongation Test**

The elongation test shall be conducted in accordance with IS:14268 / IS: 1608 and the total elongation shall not be less than 3.5% prior to fracture of any of the component wire at 600 mm gauge length. MTC shall carry this results.

▪ **Relaxation Test**

Relaxation test shall be carried out as per clause 6.4 of IS:14268. Relaxation test shall be carried out at least upto 1000 hours after stressing. The low relaxation strand, when initially loaded to 70% of specified minimum breaking strength of the strand shall have relaxation losses of not more that 1.8% after 100 hrs and not more than 2.5% after 1000 hrs. Required test reports shall be submitted by the manufacturer

13.01.09 Dimensions and Tolerances

The nominal diameter, tolerance, nominal cross sectional area and nominal mass per unit length of the strand shall conform in general to table 2 of IS:14268.

The mean diameters of the constituent wires forming strand may be such as to

produce strand with tolerance to nominal diameter of (+) 0.66mm and (-) 0.15mm. The manufacturer, however, shall use the wires of the same specifications and tolerance for the entire supply and keep the variations in the mean diameter and cross section areas of the strand to a minimum acceptable limit. The mean diameter of the strand together with the tolerance shall be mutually agreed between the supplier and purchaser. This shall be chosen with reference to requirement of the modules of elasticity as specified in in this specification.

13.01.10 Manufacturer's Certificate and Identification Etc.

The manufacturer shall supply the data required as per 'qualification and testing' and 'dimensions and tolerances' of this specification along with the manufacturer's certificate and identifications marks as required by IS: 14268.

13.01.11 Packing

The packing of prestressing cables will be as per cl. 8.0 of IS 14268 with additional requirements as stated here.

The low relaxation strands have superior mechanical properties and the material is stressed and kept almost near to its yield strength. Hence, best possible care shall be taken at all stages of packing, transportation, handling and storage. The coils shall be supplied in oiled condition using Dromos-B oil or equivalent which shall be easily removable with water before stressing and grouting. The strands shall be free of rust and the coils shall be provided with proper rust-preventing packing, which shall be mutually agreed between the Engineer and the contractor. The packing shall be such as to inhibit corrosion or the formation of rust even when the cables are stored outdoors. The coils of prestressing strands supplied shall be marked in such a way that all finished strands can be traced to cast from which they were made. Every facility shall be given to the Engineer or his authorized representative for tracing the strands to the cast from which they were made. Each coil shall carry a label giving the following: a) Indication of the source of manufacture, b) Coil number, c) Nominal diameter of the strand and d) Class where applicable.

Each reel or reelless pack shall have two strong tags securely fastened to it indicating length, size, type, grade name and mark of manufacturer. One tag shall be positioned such that it is not lost in the transit viz., may be placed in the core of rellless pack. The other may be outside where it will be accessible for easy

identification.

Each coil containing the strands may also be suitably marked with ISI certification mark in which case the concerned test certificate shall also contain the ISI certification mark.

The storage shall not be dispatched before the shipping release is issued by Client or their authorized representative.

13.01.12 Storage

- Prestressing strands shall be in single coils made in such a way that a strand should pay off straight without twisting when unrolled or strand pulled off from the stationary coil by the strand-threading machine. The coil shall be securely tied and fully wrapped with strong waterproof protective covering with the dia. and the length of strands indicated on the outside. The coils shall be stored flat on a floor raised off the ground and shall be under full cover from the weather. They shall be protected from damage, oil, corrosion or any deleterious matter and inspected by the Engineer for approval. Strands, which show signs of pitting or has any surface defects such as splits, roughness or necking is not to be used. Any length of strands so affected shall be taken out of the coil and rejected.
- Water-soluble oil such as "Dromos" or equivalent may be used for inhibiting corrosion.
- The storage facilities and procedure for transporting materials in and out of store and the process of fabrication of cable should be such that no mechanical damage can take place. Building operations, flame cutting or similar operations shall not be carried out on or adjacent to tendon materials under any circumstances. The storage facility shall have sufficient ventilation to minimize condensation.

13.01.13 HDPE SHEATHING AND COUPLERS

- **GENERAL**

The Sheathing should be strong and corrosion resistant. HDPE sheathing as per specification shall be used. HDPE sheath material shall conform to IS: 4685. The sheath shall be tested for the acceptance criteria mentioned in specification. If any one of the samples fails to satisfy the acceptance criteria then the retesting shall be

done for six additional numbers of samples. If any one of the retested samples fails to satisfy the acceptance criteria the whole lot shall be rejected.

The HDPE sheath shall be joined as per manufacturer's recommendations. Taping and plugging of all joints or puncture shall be checked and approved by the Engineer before commencement of concreting. In special cases the Engineer may specify water test, which shall be carried out without extra cost.

- **Materials and Shape**

The Corrugated HDPE ducts shall be procured in helical or circular shape. The corrugations are continuous or intermittent forming three shapes such as circular, intermittent circular and helical. The cross section of the ducts shall be circular in general.

Table-1 MATERIAL PROPERTIES FOR HDPE SHEATHING

Property	Applicable Standard	Temp	Acceptance Values (Min)	Acceptance Values (Max)	Attestation of Conformity
Melt Flow Index	IS:2530 ASTM D-1238	190 Deg C		1.2gms/min	(1)
Tensile Strength at Yield	BS:2782 ASTM D-638		20 Mpa	28 Mpa	(1)
Elongation at Yield	BS:2782 ASTM D-638		7%	10%	(1)
Carbon Content			2%	-	(1)
Environmental Stress Crack Resistance	ASTM D-1693	70 Deg C	192 hrs	-	(1)

Shore – D Hardness	DIN 5305		55	65	(1)
Density	IS:2530 ASTM D-1505	23 Deg C	0.94 gms/cc	0.96 gms/cc	(1), (2)
Diameter I.D. O.D.			105mm 122mm	107mm 124mm	(1), (2)
* Wall Thickness			3mm		(1), (2)
Depth of Corrugation			4mm		(1), (2)

LEGEND :

(1) Indicates factory production control or guaranteed values by the manufacturer.

(2) Indicates client control (*)The wall thickness of the duct shall not be less than 1.0 mm after tensioning. This is to be ascertained by conducting wear resistance test.

- **Supply, Packing, Etc.**

  The sheathing shall be supplied in straight lengths or coils and shall be suitable for handling. The packing should be rust/corrosion preventive type and be mutually agreed to between the supplier and the purchaser.

- **Handling**

  Sheathed cables will be handled and tied into place with care to prevent kinks, ovalisations, punctures or opening out of couplings. No welding shall be done in the vicinity of sheaths unless permitted and supervised by the Engineer. If welding is unavoidable the sheathing shall be suitably protected before welding is done.

- **Fixation**

  - Sheaths will be held rigidly in position with a view to preventing movement during concreting by weight of concrete, vibration or by floatation. For supporting horizontal cables, necessary and strong mild steel saddles or horizontal bars will be used. For this purpose prefabricated saddles welded to MS bars will be embedded in earlier pours for rigid supports.
  - Vertical sheaths (or temporarily stiffened flexible sheaths) shall be held firmly in

position just above the top of the forms by temporary members. When vertical sheaths are to be deviated around opening they shall be pre-bent to the correct profile. In case of flexible sheaths, fixation will be in the sense convenient for threading cables. MS bars shall be used for supporting the vertical sheaths.

- Points of supports for horizontal cables should normally be at 1 m c/c but not to exceed 1.5 m. The sag between such supports should in no case exceed 5 mm in a length of 1.5 m.
- Cable alignment must be true in order to reduce wobble losses. A maximum deviation of 5mm in any direction from the theoretical line within any segment of 3.0 m length may be permitted.
- For vertical cables, sheaths shall have to be temporarily stiffened by dummy cables or a pipe, which will descend at least 600 mm into the previous pour. In deviated portions preferably inflated duct tubes should be used as a core.
- Before concreting the works executed shall be checked as complying with the execution drawings, with particular attention to:
  - Position and tolerances
  - Minimum distances as shown on execution drawing, between ducts to prevent any communication
  - Strength of duct mountings
  - Absence of holes or other defects
  - Checking the duct section by passing a jig
  - Correct execution of connections
  - Installation of vents at points mentioned in the specification
  - Fitting of blanking plugs on all free duct ends, to prevent penetration of concrete or other foreign bodies
  - Possible repairs: During the sheath inspection before concreting the following defects may be observed.

    - Hole (caused by falling reinforcing bars, etc.)
    - Out of round or shock damage The possible repair for the former shall be having restored the sheath section around the fault, leak tightness shall be restored by adhesive PVC tape covering patch out of round or short damages

and for the latter, the damaged section shall be replaced by a serviceable section, connection applying the same specification as a normal sheath.

- **Testing and Quality Control**

Following inspection shall be carried out on sheaths.

- Diameter of the sheath to be checked
- Ovality of the sheath to be checked
- Sheath examined for local denting pinching etc.
- The free edges to be examined for burrs

- **Workability Test**

A sample of 1100mm long sheathing should be bent along the radius of 3m against a specifically fabricated template having radius of 3m. The bending shall be done on either side of three complete cycles. Finally the sample has to be inspected for deformation, opening of joints or dents in sheathing.

- **Dimensional Tolerance of Duct**

Test should be conducted as per Annexure A1 of FIB bulletin no. 7. Measurement shall be taken at both ends of the specimen in two directions at right angles to each other. The mean values should be calculated from the values obtained.

- **Flexural Behaviour of Duct**

The duct should be sufficiently rigid to limit deflections between duct supports due to temperature variations and during concreting, both for vertical and lateral deflections. The flexural behavior of duct should be determined as per Annexure-A2 of FIB Bulletin no.7. The test shall be conducted at 23^0 C.

- **Flexibility of Duct**

The duct should be flexible enough to allow easy bending to the specified minimum radius of curvature in the structure without excessive deformation of the duct section. The test shall be conducted as per Annexure-A3 of FIB Bulletin no. 7 at 23^0C. The

flexibility of the duct should be deemed acceptable if the test does not suffer any visual damage. Deformation of the duct should preferably not exceed 5% of the duct diameter and determined by passing a plunger through the duct.

- **Lateral Load Resistance of Duct**

  The duct should be sufficiently strong to sustain concentrated lateral loads introduced at tendon supports or as created during concreting including unintentional impact without undue deformation of the duct cross section. The test shall be conducted as per Annexure-A4 of FIB Bulletin no. 7 at 23^{0}C. The lateral load resistance test is deemed acceptable if the irreversible transverse deformations of the duct measured two minutes after the release of load are not exceeding 10% of the duct diameter or 5mm, whichever is smaller. Duct not satisfying above criteria should be tested again with stiffeners placed at the location of load application, which corresponds to the duct support location in practice. If the test criteria are then met, such stiffeners need to be specified for the system and provided on site at relevant locations of the duct supports.

- **Longitudinal Load Resistance of the Duct System**

  The duct, couplers between duct segments and connections between duct and anchorage, should be sufficiently strong to resist restrains due to temperature variations after installation into the reinforcing cage of structure before concreting. The test shall be conducted as per Annexure-A5 of FIB Bulletin no. 7 at 23^{0}C. The duct installed with a coupler and/or connection should be able to sustain an imposed longitudinal elongation (tension loading) of +8 mm per M of duct length outside connector, over a period of 10 minutes. The longitudinal load resistance shall be deemed to be acceptable if the applied elongation and/or load can be held during the test period without failure of duct or slippage of the duct/coupler connection.

- **Leak Tightness of The Duct System**

  The duct system including couplers and connections/vents should be sufficiently watertight when bend to the minimum radius of curvature specified in the post tensioning system and/or duct system documentation. The test shall be conducted as per Annexure-A6 of FIB Bulletin no. 7 at 23^{0}C. The specimen shall be same which is previously tested under 7.11.6.4, 7.11.6.5 and 7.11.6.6. The leak tightness should be tested for a differential pressure of 0.5 bar applied from both outside and inside of

duct. The leak tightness shall be deemed acceptable if there is no visually detectable loss of water during the test period.

- **Wear Resistance of Duct**

  The duct should be sufficiently resistant to wear caused by prestressing steel during stressing of tendons bent to the minimum radius of curvature specified. The test shall be conducted as per Annexure-A7 of FIB Bulletin no. 7 at 23^{0}C for each particular form and spacing of the corrugation and material selection. The wear resistance shall be deemed acceptable if the minimum residual wall thickness of the duct after testing is not less than 1.00 mm. These criteria will assure that the duct system will perform satisfactorily in most applications.

- **Bond Behaviour of Tendon**

  The bond between prestressing steel and grout is usually inferior to the bond between grout and duct or between duct and concrete. However, the bond behavior of the tendon inside the grouted HDPE duct should be declared duct system documentation. This test shall be conducted as per Annexure-A8 of FIB Bulletin No. 7 at 23^{0}C. The bond strength should allow anchoring the characteristic ultimate tendon force in bond length of 40 times duct diameter.

- **Friction Parameters**

  Friction and Wobble co-efficient between duct and prestressing steel are typically in the range of 0.10 to 0.17 for friction co-efficient and 0.001/m to 0.002/m for wobble co-efficient. These values should be confirmed by conducting tests on site.

- **Manufacture and Handling of Cables**

  The Weight of the cable when assembled will be exceeding 20 kg/m and as such would require special methods and techniques for the manufacture and placing of cables. It is preferable that cable ducts duly be embedded in concrete and the cable threaded into the ducts afterwards for all cables. Alternatively, in special cases, assembled cables may be placed in-situ and cable ducts threaded over it and taped and sealed before concreting.

- **Cable Threading Machine**

  The cable should be threaded into duct by the use of cable threading machine specially made for this purpose, which are capable of pulling a strand from the coil directly and push the cable into the duct. The cables are threaded singly one after other into the duct.

Special steel caps should be mounted on the leading end of the strand to protect the strand from opening out and to avoid damage to the sheathing. The strand should be cut by mechanical devices in such a way as not to cause the opening out of individual strands.

- **Identification**

Generally all the strands from a cable should be made from coils belonging to the same batch of manufacture. All the records of high tensile strands during the various stages of handling should be kept in such a way that it should be possible to identify a particular strand in final location to its source of supply from the various stages of handling, finally connecting the same to the test certificates and strength, dimensions, E-value and other certificates supplied by the manufacturer or specially carried out by the Contractor/ Engineer.

Each coil of cables delivered to site shall be visually checked for the following:

Geometrical appearance of coils: Any ring with defective hoping flattered or tangled turns or dimensions not conforming to the order shall be rejected.

Strand surface aspect: Any coil with a strand surface aspect below grade B on the corrosion scale as shown below shall be rejected.

TABLE-3.2 CORROSION SCALE

Definition	Visual Characteristics	Inspection operations
A "Excellent"	-Uniform colour -Slight local oxidation marks -A few scratches showing bare metal -(shining) -No foreign matter -No depression	No cleaning for inspection.
B "Good"	-A few marks -General but slight oxidation -Traces of scratches showing shiny bare metal -Traces of foreign matter -No depressions -A few spots where the oxide film has come loose.	Cleaning required with a cloth before Visual inspection

C "Acceptable"	-Overall marks Significant oxidation -Scratches showing shiny bare metal -Traces of foreign matter -No depression Several spots where the oxide film has come loose.	Before inspection several areas require scraping
D "Mediocre"	-Complete colour change -Considerable oxidation -Deep damage or scratches; -Foreign matter encrusted between the wires of the strands -No depressions -Overall loosening of the oxide film	Entire surface requires scraping With glass paper of stiff wire brush
E "Bad" Non-recoverable	-Entirely covered with small pitting or considerable embed-ded foreign matter -Complete colour change -Very deep damage	Entire surface requires scraping with glass paper of stiff wire brush

- **Coil Labeling:**

  Any coil without labeling or conforming to specified conditions shall be rejected. Each coil shall be subjected to further visual inspection when placed on the winding drum, before threading the strands.

- **Surface Aspect:**

  - The strands shall conserve the efficient protection applied in the workshop (water soluble oil). Surface aspect shall conform to minimum grade B in the above corrosion scale.
  - A surface aspect worse than grade C in the corrosion scale shall be considered as a critical defect and such a coil, shall be permanently rejected.
  - A grade C surface aspect shall be considered as a minor defect and such a coil shall be provisionally rejected. Oxidised areas shall be scrapped, and inspected or tested in a laboratory before a decision is taken by the engineer for utilization or rejection.

- **Vent/ Drainge Points**

Vent/drainage pipes should be provided on all cable making use of tube of 15/19mm at the entry of each cable and at high and low points of horizontally deviated cables by means of PVC insulation tapes to serve the following:

- Generally to serve as emergency injection points in case of blockages of very long cables in wall or to act as drainage points or air outlets. :
- To permit boosting of pressures of vertical cables in prestressed wall in case the pumping pressures at bottom are inadequate (vertical cables are to be grouted from the bottom).

- **Tolerance**

Tendon duct shall be fixed in smooth alignment and free from any sudden change in direction. This shall be rigidly held in the location of prestressing cable with a tolerance of plus or minus 5mm in the direction of the depth: (thickness) of the member. In the direction at right angle to the depth tolerance of plus or minus 20 mm from the theoretical location may be permitted.. However, it is important to minimize the losses due to wobble effect of the duct. The spacing of the supports and tolerance in the fixing may have to improve if the overall fixation loss is found to be higher than that assumed in the design.

13.01.15 Tensioning

- Before commencing tensioning operations, the Contractor shall equip the site with field telephones to facilitate communication between tensioning personnel at either end of cable, other cables being tensioned simultaneously, and central control. Provision of such facility is considered essential particularly while tensioning the cables where communication may be rendered impossible because of distance, lack of visual and audible contact, sight, noise, etc.
- Before commencing tensioning operations the Contractor shall check:
  - Reference marking of tendon to be tensioned (number marked on ends).
  - Accessibility of both ends.

Serviceable means of communication between two cable ends (telephone); Communication of the following design data to the Chief Operator:

- * Tension sequence / steps
- * Tension to be achieved

- * Calculated elongation.
- * Instructions in the event of an accident
  - Equipment serviceability (pump, jacks, hose)
- Tensioning followed by blocking shall be carried out with approved jacks recommended by the manufacturer. Before commencing stressing, all contact surfaces between the anchorage block and the guide as well as conical holes receiving grips, and outer and inner surfaces of grips shall be carefully inspected and cleaned of laitance, slurry and dirt which might be adhering to the surface. The grips should be inspected for sharpness of teeth and general soundness by checking for presence of any crack or roughness of edges, rusting etc. and all defective pieces discarded and replaced by good grips. The portion of the strands where grips are expected to bite shall pulled out of the cable just before tensioning at both ends and cleaned of all rust, dust etc. with emery paper and acetone or petrol at the cost of contractor. Before commencing stressing operation, it shall be checked that the cable should be free to move in ducts. Cleanliness of all the components is absolutely essential for proper and successful tensioning and blocking operations. The amount of tension given to the cables shall conform to a schedule of cable tensions to be supplied by the Engineer and will be based on the test data for the prestressing wires /strands. The cable tension shall be measured by the pressure readings of the digital pressure gauge of the pump and checked by means of the elongation of the strands and the Engineer's approval obtained for each Cable before blocking of wires/strands take place. Shortfall in elongation may have to be made good by re-tensioning cables as required by the Engineer.
- The accuracy of the pressure gauges shall be checked frequently by dead weight type of testing equipment and kept good. Pump pressure gauges shall be regularly checked using a reference pressure gauge kept in a sheltered location on the site. Pressure gauge shall be checked at least – i) once in every 180 days, and ii) every 300 tensioning operations,
- Elongations in millimeters are to be measured on the jack cylinder at pressures in multiples of 50 kg/cm^2 and at the final pressure. No defective gauge shall be used in stressing operation.
- The normal maximum allowable slippage at blocking is 10 mm for stranded cables. Larger slips will be corrected by re-tensioning and if necessary by replacement of the anchorage and strands. Occasional higher slippages may be accepted by the Engineer

after verifying each case and its effect on the structure. The decision of the Engineer in this respect shall be final and binding on the Contractor

- The Contractor shall maintain record on forms supplied by the Engineer, a record for all extensions and pressure readings for each cable and supply the same to Engineer for check and approval.
- The contractor will be required to stress up to 80% of the break load of cables as per the sequence required by the Engineer. Equipments, tools, manpower and other materials must be adequate for this purpose and pace of work.
- Stressing of cable should be monitored by both Jack force (Pressure) and through the elongation. Elongation and pressure shall not be more than the stipulated values given in the stressing schedule. Variation between actual elongation of cable and the estimated value shall not be more than the specified in the stressing schedule. Similarly, variation between actual pressure with which the cable is stressed and the estimated value shall not be more than the specified in the stressing schedule.

- **Auto Blocking / Lock in**

  Cables required to be stressed from one end only shall be auto blocked at non-tensioning end. Auto blocking shall be done by hammering in wedges with wooden mallet over a steel tube resting directly over all pieces of the wedge together through which the strand is freely passed. During the tensioning, the pulling of grips at the auto-blocked end shall be observed and the total elongation imparted to the cable shall be adjusted accordingly.

- **Equipment Maintenance**

  All equipment must be used in accordance with the specification of manufacturer and must at all times be maintained in good condition. Pressure tests of Jacks must be executed with pressure 10% higher than the maximum operating pressure of the system if not otherwise specified by the manufacturer.The internal friction of the Jacks must be tested periodically and after overhauling the jacks or replacement of seal etc. The combined jack and pump systems should be checked for correct behavior. The accuracy of the various measuring devices should be such as to give the correct measurements of the force applied to the cable within 2% measured cumulatively. The frequency of maintenance shall be as mentioned in the stressing sequence report.

13.01.16 Grouting with Cement Grout

The purpose of grouting the post-tensioned tendons is to provide permanent protection to the post-tensioned steel against corrosion & bonding strands with the concrete. The grout ensures encasement of steel in an alkaline environment for corrosion protection and by filling duct space it prevents water collection and freezing.

- **Materials**
- **Cement:**

Ordinary Portland cement conforming, to grade 43 / 53 of IS: 8112 should be used for preparation of the, grout. It should be as fresh as possible and free from any lumps. Pozzolana cement shall not be used. The cement used for grout shall have chloride content less that 0.02%, no sulphate or any other element likely to cause steel corrosion.

- **Water: - complies as per IS 456 - 2000**

Only clean potable water free from impurities such as oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to the grout or prestressing steel shall be used. No sea or creek water shall be used at all. It should not contain more than 250 mg Cl-ion per litre or any organic matter. The suitability of the water can be tested by comparing the setting time, and the compressive strength of grout of similar proportion made using distilled water. The setting time should not differ by more than 25% and the compressive strength after 14 days should not vary more than 5%.

- **Admixture:**

Acceptable admixtures conforming to ASTM C-494 may be used, if tests have shown that their use improves the properties of grout i.e. increasing fluidity, reducing bleeding, entraining air or expanding the grout. Admixture must not contain chlorides, nitrates, sulphides, sulphates or any other product, which are likely to damage the steel or grout. When an expanding agent is used, the total unrestrained expansion should not exceed 10%. Admixture emitting hydrogen as expansive gas shall not be used.

- **Temporary Protection**

If there is a delay of more than seven days between inserting strands in the sheathing to final grout the cable shall be protected from corrosion by injecting mixture of water and water-soluble oil like 'Dromas-B', or equivalent at intervals as directed by the Engineer at no extra cost.

- **Equipment**
- **Grout agitator and pump:**

  Suitable colloidal mixer with a speed of 1000 RPM shall be used for mixing the grout. Grout shall be kept in uniform consistency using a slow speed blade agitator.

  The pump should be a positive displacement type and should be capable of injecting the grout in a continuous operation and not by way of pulses. The grout pump must be fitted with a pressure gauge to enable pressure of injection to be controlled. The pump should be capable of exerting pressure of at least 30 kg/sq.cm. A safety device should guard against the build-up of pressure above 35 kg/sq.cm.

  The capacity of the grout pump should be such as to achieve a forward speed of grout of around 6 to 10 meters per minute. The slower rates are preferable as they reduce the possibility of occurrence of voids.

  Hand pumps should not be used for grouting, compressed air operated equipment should not be used for injection. The pump and injection equipment shall have a system of recirculating the grout while grouting is not in progress.

- **Water pump:**

  Before commencement of grouting a stand by direct feed high pressure water pump should be made available at site for any emergencies. In case of any problem in grouting the ducts, such pump shall immediately be connected to the duct and all grout flushed out by use of high pressure water with not exceeding pressure 18 kg/sq. cm. Adequate storage of clean potable water should be made available for operation of the water pump for such emergencies.

- **Grout screen:**

  The grout should be passed through a sieve to verify the absence of lumps. A- 16 mesh sieve is recommended.

- **Connection and air vents:**

  Standard details of fixing inlets, outlets and air vents to the sheathing and or anchorage should be followed as recommended by specialist supplier of the system of prestressing. All connections shall be of the "Quick Couple" type and at change of diameters suitable reducers shall be provided.

- **Properties of the Grout**
  - If Small lumps remain on sieving, the mix should be rejected. It is not recommended

that the sieve be used to eliminate the small lumps from the grout as the smaller lumps may still pass through and cause blockages.

- The viscosity of the grout shall be such as to empty the flow cone within 12 to 18 seconds. This should be achieved with water cement ratio as low as possible consistent with the adequate grout ability.
- Maximum limit of water cement ratio shall be 0.45.
- In case the above viscosity measurements are not feasible at site, the fluidity of the grout shall be assessed by measuring the grout flow by using flow cone as given in ASTM C-939.
- PH value of the grout should be less than 9. The bleeding of the grout at 20 deg C should not exceed 2% of the volume in 3 hours after mixing and a maximum of 4%. In addition the separated water must be absorbed after 24 hours.
- Before grouting, the properties of the grout mix should be tested in laboratory. Test should be conducted for each job separately. The following test is recommended. The compressive strength of 100 mm cubes of the grout shall be at least 170 kg/sq.cm at 7 days. The cubes shall be cured in a moist atmosphere for the first 24 hours and subsequently in water. These tests should be conducted in advance to ascertain the suitability of the grout mix.
- The Temperature of the grout shall not be more than 25 deg C.

- **Mixing of Grout**
  - Mixing must be carried out mechanically to obtain a homogeneous grout. Batching of the material should be by weight. After mixing the grout should be kept in continual movement. The mixer shall be of high speed type with a minimum speed of 1000 rpm. The maximum speed of any one of the parts of the mixer in the grout shall not exceed 15 m / sec. It is not recommended that the grout be mixed for longer than 4 minutes. The pump used for grouting should be of the positive displacement type capable of exerting pressures of at least 30 Kg/sq.cm, with a safety device to guard against the buildup of pressures not more than 35 Kg/sq.cm. The capacity of the pump should be such that a forward speed of the grout in the duct of about 6 to 12 m per minute can be achieved. The use of compressed air for grouting is not allowed. The pump and injection equipments shall have a system of re-circulation of the grout while actual grouting is not in progress. All the connections, bends, pipes, etc. should be leak tight and also should not allow any air to be sucked into the grout.

- Properties of materials should be based on field trials made on the grout before commencement of grouting, but subject to the limits specified above. The materials should be measured by weight.
- Water should be added to the mixer first, followed by Portland cement. Admixture, if any may be added as recommended by the manufacturer.
- Normally the mixing time is between 2 and 3 minutes, which depend upon the type of the mixer. However should be for such duration as to obtain uniform and thoroughly blended grout, without excessive temperature increase or loss of expansive properties of the admixtures. It is not recommended that the grout be mixed for longer than 4 minutes. The grout continuously agitated until it is injected.
- Once mixed no water shall be added to the grout to increase its fluidity.
- Hand mixing is not permitted.

- **Preparation of the Duct Before Grouting**
  - After tensioning the cable the ends shall be sealed using grout cap leaving a GI pipe of suitable size depending on the system of anchored used at each end for the inlet and outlet of the grout. The intermediate drainage and air vent should be inspected and made ready for use by cleaning etc. Use of cement mortar dry pack for specific locations may be permitted in lieu of grout cap with the approval of the Engineer.
  - The duct shall allow the free passage of grout and should be free of any foreign bodies which might cause obstruction. This shall be ensured by protecting horizontal tendon entries, the use of checking jigs and the threading of the tendon. The vertical ducts should be checked by passing 100 mm dia. bullet head after every third lift of the wall.
  - Grouting should be preferably carried out as early as possible but not later than 3 days after stressing the tendon.
  - Any traces of oil, if applied to steel for preventing corrosion, should be removed before grouting operation
  - Ducts shall be flushed with water for cleaning the holes and remove all traces of oil etc., as well as for wetting the surface of the duct walls. Water used for flushing should be same quality as used for grouting. All water in the duct should be blown out with oil free compressed air at a pressure of 6 kg/sq.cm and duct should be dried. It should be followed by compressed air to drive away water from the ducts. Drainage at the lower points to remove the water should not be relied upon. Grout

caps shall be used to hold the grout under pressure after completion of the grouting operation.

- All the connections like that between the nozzle of the injection pipe and duct, bends, pipes, etc. should be leak tight and also should not allow any air to be sucked into the grout.
- All outlet points including the vent openings should be kept open prior to the commencement of grouting.

- **Grouting Operation**
  - Grouting should be carried out by water displacement method as early as possible after tensioning of the cable. The parallel ducts which are closer than two times of the dia of the sheathing center to center should be grouted one after the other in the same shift. However, such requirement may be specified in the drawings based on which grouting sequence has to be carried out.
  - The grouting should be carried out under following pressures:
  - 3 TO 5 kg/sq. cm for horizontalall cables and the pressure shall be continuously monitored and shall not exceed 10 kg/sq.cm. at the duct entry.
  - 9.5 kg/sq.cm for vertical cable and vertical portion of 'J' cables and the pressure should be continuously monitored and shall not exceed 18 kg/sq.cm.
  - The forward speed of the grout should be such that the full duct is filled up properly without trapping air inside. The grouting of cable should be continued without stoppage until the grout flowing from the free end and the vent opening is the same as that of injected grout. The vents are successively closed. The leak tightness of the vent after closure should be checked and ensured to prevent the grout flowing out of the duct after grouting. The pressure must be kept for 1 minutes at 3 to 5 Kg/sq.cm after the outlet has been closed. For vertical cables grouting should be done from the lower points. All openings and air vents should be hermetically sealed after final grouting to prevent the ingress of water. The anchorage should be properly protected to prevent corrosion of anchorage element.
  - After cleaning and drying of the duct, the grout should be pumped at a steady continuous rate as specified in the previous clause above. Sufficient grout should be allowed to flow out till the properties of the grout flowing from the other end and vent opening are **of** similar **consistency** to the pumping end.

- **Finishing**

  All plastic tubes shall be withdrawn. In cases where this is not possible the tube shall be cut away 40mm within concrete. The grout hole shall be dry packed. All holes as well as edges of dry packed pockets lying on the inside of the containment shall be caulked with epoxy mortar before installing the steel covering plates wherever required.

13.01.17 Precautions

- Cable shall not be subjected to excessive temperature, welding sparks for ground current. To ensure this, burning, welding operations shall not be conducted in the vicinity of cables without prior approval. Superfluous extension of cables beyond anchorages may be removed by rapid acetylene burning, unless such procedures are contrary to the recommendations of the manufacturer of the steel.

- **Controls:**

  In order to ensure that cables are not being trapped by leaking laitance, they shall be frequently hammered back and forth within their sheaths while the concrete is setting.

  - Adequate safety precautions must be taken during handling and stressing operations to safeguard the workers as well as materials and equipment strand drums must be fitted with a suitable breaking system to control the rate of feeding.
  - Connections between sheathing shall be such that internal projections at free ends are avoided which can cause blockage during threading or cause unwinding of the spirally formed sheathing. Special care should be taken not to damage sheathing while removing end shuttering through which cable ducts pass at the construction joints.
  - All prestressing operations should be carried out only by the trained personnel to the predetermined procedures which shall include instructions for handling likely emergencies. The procedure and the format of records should be got approved from the Engineer prior to start of stressing operations.
  - All equipment should be tested before starting stressing operations apart from the regular periodic testing/calibrations in the presence of the authorized representative of the Engineer, as specified in the stressing schedule.

Mode of Measurement : The mode of measurement shall be MT of Strand. This is inclusive of designs of PT structure & approvals, cost towards execution including of strand, ducts, supply , fixing, profiling of tendons, stressing, grouting, complete. In case there is a breakage of strand during prestressing the same will not be payable.

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6.00 STRUCTURAL STEEL WORK

Applicable Codes and Standards

The codes and standard generally applicable to the work of this section is listed hereinafter.

(1)	IS 210	Grey iron castings
(2)	IS 451	Technical supply conditions for wood screws
(3)	IS 800	Code of Practice for use of structural steel in general building construction.
(4)	IS 801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
(5)	IS 803	Code of practice for design, fabrication and erection to vertical mild steel cylindrical welded storage tanks.
(6)	IS 806	Code of Practice for use of steel tubes in general building construction.
(7)	IS 808	Dimension for hot rolled steel sections.
(8)	IS 813	Scheme of symbols for welding.
(9)	IS 814	Covered electrodes for metal arc welding of (Part I & II) structural steel.
(10)	IS 816	Code of practice for use of metal arc welding and general construction in mild steel.
(11)	IS 822	Code of Practice for inspection of welds.
(12)	IS 961	Structural steel (high tensile)
(13)	IS 1024	Code of practice for use of metal arc welding and general construction in mild steel.
(14)	IS 1030	Carbon Steel casting for general engineering purpose.
(15)	IS 1120	Coach Screws.
(16)	IS 1149	Specification for light tensile steel rivet, bars for structural purposes.
(17)	IS 1161	Steel tubes for Structural purposes

(18)	IS 1182	Recommended practice for Radiograph examination of fusion welded butt joints in steel plates.
(19)	IS 1200	Method of measurement in Building Civil Engineering work.
(20)	IS 1239	Mild steel tubes, tubulars and other wrought steel fittings
	Part I	Mild Steel
	Part II	Mild steel tubulars and other wrought sheet pipe fittings.
(21)	IS 1363	Black hexagonal bolts, nut and black hexagon screws product of Grade C (size range M25 to M64) (Part 1 to 3).
(22)	IS 1365	Slotted counter sunk screws.
(23)	IS 1367	Technical supply conditions for threaded fastners.
(24)	IS 1477	Code of practice for painting of (Part I and II) ferrous metal in buildings.
(25)	IS 1852	Rolling and cutting tolerances for hot rolled steel products.
(26)	IS 1915	Code of Practice for steel bridges.
(27)	IS 1977	Structural steel (ordinary quality)
(28)	IS 2016	Plain washer.
(29)	IS 2062	Structural steel (fusion welding quality)
(30)	IS 2079	Ready mix paint, air drying, red oxide zinc chrome and priming.
(31)	IS 2595	Code of practice for Radiographic testing.
(32)	IS 3063	Single coiled rectangular section spring warms for bolts, nut and screws.
(33)	IS 3443	Crane rail sections.
(34)	IS 3600	Code of practice for testing of fusion welded (Part-I) joints and weld metal in steel
(35)	IS 3658	Code of practice for liquid penetrant
(36)	IS 3757	Specification for High Tensile Friction grip bolts
(37)	IS 4000	High strength bolts in steel structures Code of practice.
(38)	IS 4923	Hollow steel sections for structural use.
(39)	IS 5334	Code of practice for magnetic particle flaw detection of welds.
(40)	IS 5369	General requirements for plain washer and lock washers.

(41)	IS 5372	Taper washers for channels.
(42)	IS 5374	Taper washers for I beam
(43)	IS 5624	Specification for foundation bolts.
(44)	IS 6227	Code of practice for use of metal arc welding in tubular structure.
(45)	IS 6610	Heavy washers for steel structures.
(46)	IS 7215	Tolerances for fabrication of steel structures.
(47)	IS 8500	Structural steel- Micro alloyed (medium and high strength qualities)
(48)	IS 9595	Recommendations for metal arc welding of carbon and carbon manganese steel.

NS FOR STEELWORK

1. Exchange of Information

Before the beginning of the execution of the contract, the Steel Fabrication and / or Erection contractor shall ensure that he is in the knowledge of the following information from the team of architect, structural consultant, services consultant, Project Managers, Supervisors, Clerk of Works and the Owner.

a. Site plans showing in plan and elevation of the proposed location and main dimensions of the building or structure;
b. Ground levels, existing and proposed;
c. Site plans showing in plan and elevation of the proposed location and main dimensions of the building or structure;

d. Particulars of buildings or other constructions which may have to remain on the actual site of the new building or structure during the erection of the steelwork;
e. Particulars of adjacent buildings affecting, or affected by, the new work;
f. Stipulation regarding the erection sequence or time schedule;
g. Conditions affecting the position or continuity of members;
h. Limits of length and weight of steel members in transit and erection;
i. Drawings of the substructure, proposed or existing, showing:
j. levels of stanchion foundations, if already determined

k. any details affecting the stanchion bases or anchor bolts

l. permissible bearing pressure on the foundation and

m. provisions for grouting

n. The grade of fire resistance appropriate to the occupancy as may be required.

o. Climatic conditions at site-seasonal variations of temperature, humidity, wind velocity and direction;

p. Nature of soil. Results of the investigation of sub-soil at site of building or structure;

q. Accessibility of site and details of power supply;

r. Whether the steelwork contractor will be required to survey the site and set out or check the building or structure lines, foundations and levels;

s. Setting-out plan of foundations, stanchions and levels of bases;

t. Cross sections and elevations of the steel structure, as necessary, with large-scale details of special features;

u. Whether the connections are to be bolted, riveted or welded. Particular attention should be drawn to connections of a special nature, such as turned bolts, high strength friction grip bolts, long rivets and overhead welds;

v. Quality of steel, and provisions for identification;

w. Requirements in respect of protective paintings at works and on site, galvanizing or cement wash;

x. Approximate dates for commencement and completion of erection;

y. Details of any tests which have to be made during the course of erection or upon completion; and

z. Schedule of quantities. Where the tenderer is required to take off quantities, a list should be given of the principal items to be included in the schedule.

2. Drawings

2.1. Before the commencement of fabrication or erection of any steelwork, the relevant drawings showing the details of fabrication, dimensions and geometrical specifications and nomenclature of members, layout and diameter of holes, chamfers, curves, radii, provisions for assembly of steelwork and methods of erection shall be furnished by the Contractor for obtaining the approval of the Engineer.

2.2. Where welding is to be used, the shop drawings shall give full particulars of “weld preparation” and procedure of carrying out the work. Four copies of each drawing shall be submitted before commencement of fabrication to enable the Engineer to check the drawings and no work shall be carried out before obtaining his final

approval after incorporating any comments and suggestions that he might have offered during the course of verifying the shop drawings with respect to the design drawings. All work shall be fabricated in accordance with the approved drawings.

3. Materials

3.1. The Contractor shall, if requested, furnish the Engineer with copies of test certificates showing that all the principal materials comply with the requirements of IS 226 or other applicable standards. If the Engineer requires further tests to be carried out, the Contractor shall provide the necessary test- pieces or samples at his cost, and shall transport them to an approved testing laboratory. The frequency and the type of test on steel to be as per relevant IS code.

3.2. All steel shall be straight, sound, free from defects such as twists, segregation, cracks, surface flaws, laminations, imperfect edges, and other defects.

4. Storage of materials

4.1. All material shall be stored properly on a raised platform. It shall be kept clean and properly drained. Structural steel shall be so stored and handled that members are not subjected to excessive stresses and damage. Long members, such as columns shall be supported so as to prevent excessive deflection.

5. Design Drawings and Bill of Quantities

Description of structural steel members, notes, dimensions, instructions, sequence of construction, loading standards, connection details, specific tolerances, material specifications etc. shown on drawings shall be overriding those mentioned in the Bill of Quantities and these Specifications.

Description of structural steel members, notes, dimensions, instructions, sequence of construction, loading standards, connection details, specific tolerances, material specifications etc. mentioned in the Bill of Quantities shall be overriding those mentioned in these Specifications.

In absence of any mention of specifications of material, workmanship, sequence of work, tolerances, connection details, etc., these specifications shall be used. However, in case of discrepancy observed among any parts of information in any two or more construction documents related to a specific instance, the structural consultants must be approached immediately and clarification sought in writing before proceeding to execute further work.

6. Mode of Measurement:

The length of the members as laid shall be measured and it shall be converted into weight using standard IS tables for steel and paid for in **Metric Tonnes / Kg**. Also the weight of permanent bolts, nuts, washers will be calculated using standard IS tables. Nothing extra shall be paid for wastage / rolling margins in case of overweight. However in case of underweight, actual shall be paid for. The mode of Measurement will be in MT

B. FABRICATION

1. Fabrication

1.1. All the steelwork shall be fabricated in shops, duly approved by the Engineer, and assembled/bolted at site. Before commencement of fabrication of any steelwork, all plates and sections shall be carefully examined for laminations and other defects likely to affect the finished structure. Sections and plates shall be straightened and made true by approved methods so that when assembled the adjacent surfaces at connections will be in close contact throughout.

1.2. Accuracy shall be maintained during fabrication to ensure that all parts fit together properly during erection. All corresponding parts shall be similar and interchangeable.

2. Workmanship

2.1. **General**

The workmanship shall be equal to the standard practice followed in modern structural shops. All similar parts shall be manufactured accurately so that the same could be interchanged with other parts having the same identification marks.

2.2. **Templates**

Templates used shall be of steel In case where actual parts have been used as templates for drilling similar pieces, the Engineer shall decide whether they are fit to be used.

2.3 **Straightening**

All members shall be reasonably straight and free from twists. If considered necessary, the same shall be straightened and/or attended to, in order to bring it to the specified configuration by pressure or by methods that will not reduce the properties of the material below the values used in design. Local application of pressure at room or elevated temperature or other thermal means may be used for straightening, provided the above is satisfied.

2.4. **Clearance**

Individual members shall be cut to such lengths that the erection clearance for cleated ends of members connecting steel to steel should not be greater than 2 mm at each end. The erection clearance at ends of beams without cleats should not be more than 3 mm at each end; but for practical reasons, if greater clearance is considered necessary, suitably designed seatings or connections shall be provided.

3. Shearing, flame cutting and planning

3.1. Cutting

a. Cutting shall be effected by sawing, shearing, cropping, machining or thermal cutting process. Shearing, cropping and gas cutting shall be clean, reasonably square, and free from any distortion. Should the inspector find it necessary, the edges shall be ground after cutting. Planing or finishing of sheared or gas-cut edge of plates or shapes shall not be required, unless specially noted on drawing or included in stipulated edge preparation for welding or when specifically required in the following section.

b. Re-entrant corners shall be free from notches and shall have largest practical radii with a minimum radius of 15 mm.

c. Chipping of angle flanges and edges of plates wherever necessary shall be done without damaging the parent metal. Chipped edges shall be ground to a neat finish and sharp corners and hammered rough faces shall be rounded off.

d. The butting surfaces at all joints shall be planed so as to butt in close contact throughout the finished joint.

3.2. Shearing

a. Shearing of items over 16 mm thick to be galvanized and subject to tensile force or bending moment shall not be carried out, unless the item is stress relieved subsequently.

b. The use of sheared edges in the tension area shall be avoided in location subject to plastic hinge rotation at factored loading.

c. Shearing or Sheared members shall be free from distortion at sheared edges.

3.3. Thermal Cutting

a. Gas cutting of high tensile steel by mechanically controlled torch may be permitted, provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Hand flame cutting may be permitted only subject to the approval of the inspector. Flame cutting may be used at the Contractor's option provided, a mechanically controlled cutting torch is used for the flame-cutting and the resulting edge is reasonably clean and straight. Edge preparation for welding may be done by machine controlled flame cutting with edges free of burns, clean and straight.

b. When gas cutting is adopted, the flame cut edges shall be machined to a depth of 3 to 5 mm depending on the thickness of the member. Thermally cut free edges, which shall be subject to calculated static tensile stress shall be free from round bottom gouges greater than 5 mm deep. Gouges greater than 5mm deep and notches shall be removed by grinding. All flame-cut edges shall be planed, unless they are clean, square and true to shape.

c. Except where the material is subsequently joined by welding, no load shall be transmitted through a gas cut surface.

4. Machining of Butts, Caps and Bases

4.1. Column splices and butt joints of struts and compression members, depending on contact for stress transmission, shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.2 mm locally at any place. Sum of all such clearance shall not be more than 30% of the contact area for stress transmission. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels, etc. after connecting together should be accurately machined so that clearance between the contact surfaces does not exceed 2 mm locally, subject further to the condition that sum total of all such clearance does not exceed 30% of the total contact area for stress transmission. Care should be taken that these gussets, connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2.0 mm.

4.2. Where sufficient gussets and rivets or welds are provided to transmit the entire loading (Section **4**), the column ends need not be machined.

4.3. Slab Bases and Caps – Slab bases and slab caps, except when cut from material with true surfaces, shall be accurately machined over the bearing surfaces and shall be in effective contact with the end of the stanchion, bearing face which is to be grouted to fit tightly at both top and bottom, unless welds are provided to transmit the entire column face.

4.4. To facilitate grouting, sufficient gap shall be left between the base plates and top of pedestal and holes shall be provided where necessary in stanchion bases for the escape of air.

5. Holing

5.1. Drilling - Holes through more than one thickness of material for members, such as compound stanchion and girder flanges shall be, where possible, drilled after the members are assembled and tightly clamped or bolted together. A round hole for a bolt shall either be machine flame cut, or drilled full size, or sub-punched 3 mm undersize and reamed to size, punched full size.

5.2. Hand flame cutting of a bolt hole shall not be permitted except as a site rectification measure for holes in column base plates.

5.3. Punching − A punched hole shall be permitted only in material whose yield stress (fy) does not exceed 360 MPa and where thickness does not exceed (5600/fy) mm. In cyclically loaded details, punching shall be avoided.

5.4. For greater thickness and cyclically loaded details, holes shall be either drilled from the solid or sub-punched or sub drilled and reamed.

5.5. The die for all sub-punched holes or the drill for all sub-drilled holes shall be at least 3mm smaller than the required diameter of finished hole.

5.6. Oversize holes − A special plate washer of minimum thickness 4 mm shall be used under the nut, if the hole diameter is larger than the bolt diameter by 3 mm or more.

5.7. Oversize hole shall not exceed 1.25d or (d+8) mm in diameter, where d = nominal bolt diameter in mm

5.8. A short slotted hole shall not exceed the appropriate hole size in width and 1.33d in length, A long slotted hole shall not exceed the appropriate hole size in width and 2.5d in length. If the slot length is larger than those specified, shear transfer in the direction of slot is not admissible even in friction type of connection

5.9. Slotted holes shall be punched either in one operation or else formed by punching or drilling two round holes apart and completed by high quality mechanically controlled flame cutting and dressing to ensure that bolt can freely travel the full length of the slot.

5.10. Fitted Bolt Holes − Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to tolerance specified in IS: 919. Preferably, parts to be connected with close tolerance or barrel bolts shall be firmly held together by tacking bolts or clamps and the holes drilled through all the thicknesses at one operation and subsequently reamed to size. All holes not drilled through all thicknesses at one operation shall be drilled to a smaller size and reamed out after assembly. Where this is not practicable, the parts shall be drilled and reamed separately through hard bushed steel jigs.

5.11. Holes for rivets or bolts shall not be formed by gas cutting process.

6. Assembly

6.1. All parts of bolted and welded members shall be held firmly in position by means of jigs or clamps while bolting or welding. No drifting of holes shall be permitted except to draw the parts together and no drift shall be larger than the nominal diameter of bolt. Drifting carried out during assembly shall not distort the metal or enlarge the holes.

6.2. Trial assemblies shall be carried out at the fabrication stage to ensure accuracy of workmanship. These checks shall be witnessed by the Engineer.

6.3. The component parts shall be assembled and aligned in such a manner that they are neither twisted nor otherwise damaged, and shall be so prepared that the specified cambers, if any, is provided.

6.4. Holes in Assembly − When holes are drilled in one operation through two or more separable parts, these parts, when so specified by the engineer, shall be separated after drilling and the burrs removed.

6.5. Matching holes for rivets and black bolts shall register with each other so that a gauge of 1.5 mm or 2.0 mm (as the case may be depending on whether the diameter of the rivet or bolt is less than or more than 25 mm) less in diameter than the diameter of the hole will pass freely through the assembled members in the direction at right angle to such members.

6.6. Drilling done during assembly to align holes shall not distort the metal or enlarge the holes

6.7. Holes in adjacent part shall match sufficiently well to permit easy entry of bolts. If necessary, holes except oversize or slotted holes may be enlarged to admit bolts by moderate amount of reaming.

6.8. Thread length − When design is based on bolts with unthreaded shanks in the shear plane, appropriate measures shall be specified to ensure that, after allowing for tolerance, neither the threads nor the thread run-out will be in the shear plane.

6.9. The length of bolt shall be such that at least one clear thread shows above the nut and at least one thread plus the thread run out is clear beneath the nut after tightening. One washer shall be provided under the rotated part.

6.10. Assembly subjected to vibration − If non-preloaded bolts are used in structure subject to vibration, the nuts should be secured by locking devices or other mechanical means. The nuts of preloaded bolts may be assumed to be sufficiently secured by the normal tightening procedure.

6.11. Washers – Washers are not normally required or non-preloaded bolts, unless specified otherwise. Tapered washers shall be used where the surface is inclined at more than 3o to a plane perpendicular to the bolt axis.

6.12. Hardened washer shall be used for preloaded bolts or the nut whichever is to be rotated.

6.13. All material within the grip of the bolt shall be steel and no compressible material shall be permitted in the grip.

7. Riveting

7.1. Rivets shall be heated uniformly throughout their length, without burning or excessive scaling, and shall be of sufficient length to provide a head of standard dimensions. They shall, when driven, completely fill the holes and, if countersunk, the countersinking shall be fully filled by the rivet, any protrusion of the countersunk head being dressed off flush, if required.

7.2. Riveted member shall have all parts firmly drawn and held together before and during riveting, and special care shall be taken in this respect for all single-riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

7.3. Wherever practicable, machine riveting shall be carried out by using machines of the steady pressure type.

7.4. All loose, burned or otherwise defective rivets shall be cut out and replaced before the structure is loaded, and special care shall be taken to inspect all single riveted connections.

7.5. Special care shall be taken in heating and driving long rivets.

8. Bolting

8.1. In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness or the parts bolted together, unless accounted for in design.

8.2. Pretensioned bolts shall be subjected initial tension to the proof stress by an appropriate precalibrated method.

9. Welding

Welding of structural steelwork shall be carried out by the metal arc process and shall be in accordance with the following Indian Standards:

IS 8OO	General Construction in Steel
IS 816	Metal-arc welding for general construction in mild steel
IS 817	Training & Testing of metal-arc welders

9.1. Welding Electrodes

Welding electrodes shall comply with IS 814 and shall be chosen so as to produce welds with mechanical properties which are at least equal to those required for the base material. Welding electrodes shall be kept in a dry state in unbroken packets and shall be accompanied by the manufacturer's certificate of date of manufacture and guarantee of compliance with IS 814 and the same shall not be used in a damp or damaged condition.

9.2. Welding Plant

Welding plant shall be capable of maintaining the voltage and current specified by the manufacturer of the electrodes. The Contractor shall supply instruments for verifying the voltage and current as and when required by the Engineer.

a. When an automatic process of welding is adopted, the deposited metal must have mechanical properties equal to those obtained by the use of electrodes complying with IS 814.

b. Manual Welding

Manual welding shall be carried out by qualified welders equipped with plant suitable for the purpose. All welders shall be qualified in accordance with IS 8171 and details of such qualification shall be submitted to the Engineer.

9.3. Welding Procedure and Trials

a. Before welding of any of the permanent works is carried out, the contractor shall furnish details of welding procedure for each welding operation.

b. Welding trials shall be carried out and completed on representative samples of the materials before the start of fabrication, as directed by the Engineer.

c. Welding trials are intended to establish welding procedure prior to the commencement of fabrication and for this purpose assemblies shall be made from plate or section cuttings large enough to simulate the joint selected for trial. The trial shall be representative of actual fabrication conditions including:

c.1 Preparation and fit-up.

c.2 Preheat.

c.3 Welding position.

c.4 Restraint (so far as is practicable)

d. Welding trials on material 2O mm thick will be taken to include all material under 2O mm thick and trials on material 4O mm thick to include material between 2O mm and 4O mm thick. The trials shall include specimen weld details from the actual construction which shall be welded in a manner simulating the most unfavourable instances of fit-up and preparation which it is expected will occur in the particular fabrication.

e. Assembly and welding shall be carried out in such a way to minimize distortion and residual stress and that the final dimensions are within appropriate tolerances.

f. The general welding program for shop and site welds, including particulars of the preparation of fusion faces, pre-heating where required and method of making welds shall be submitted in writing to the Engineer for approval before the work is put in hand. No departure from the welding program shall be made without the prior approval of the Engineer.

g. In the fabrication of built up assemblies all butt welds in each component part shall be completed before the final assembly. Wherever practicable, clamps, magnets, holding devices or other setting-up fixtures shall be used in assembling parts of the structures so as to avoid tack-welding as far as possible.

h. In fit-ups where clamps cannot be used, spacer-strips shall be used to ensure the correct root gap.

i. Where tack welds are used, they shall be of the same quality and size as the first run of main weld. All tack welds shall be cleaned and ground to sound material prior to welding of the root pass. The main weld shall fuse completely with the end of the tack weld to form a regular profile. Where preheat is required for the main welds, the tack welds shall be made under the same heat conditions. The indiscriminate use of tack-welds during assembly shall be avoided.

j. All welds shall be visually inspected. Cracked or badly formed welds shall be cut out to the approval of the Engineer before re- welding them.

k. As far as practicable, all welding shall be carried out in the downhand position.

l. Where structural steelwork is painted before fabrication or erection, the metal surface within 75 mm of any weld shall be coated with primer only.

10. Supervision and Inspecting of Welding

10.1. The contractor shall appoint welding supervisors whose competence and qualifications shall be subject to the approval of the Engineer and all welding work shall be carried out under their direction.

10.2. The Contractor shall co-ordinate his activities so that all inspection work can be carried out before the removal of scaffolding and before the welds are covered by painting or field coating.

11. Criteria for Tests

The Contractor shall conduct tests in accordance with the following norms:

a. Visual examination - Hundred per cent (1OO%) of the welded joints.

b. Atleast 1O% welds shall be checked by dye-penetration test.

c. Atleast 4% welds shall be checked by Radiography tests.

Defective welding revealed by testing shall be made good to the satisfaction of the Engineer at the cost of the Contractor.

12. Painting

12.1. Painting shall be done in accordance with IS: 1477 (Part 1) and IS: 1477 (Part 2) with suggested primers, coatings, temporary coatings, permanent finishes etc. as the case may be.

12.2. All surfaces, which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust.

12.3. Shop contact surfaces need not be painted unless specified. If so specified, they shall be brought together while the paint is still wet.

12.4. Surfaces not in contact, but inaccessible after shop assembly, shall receive the full specified protective treatment before assembly. This does not apply to the interior of sealed hollow sections.

12.5. Chequered plates shall be painted but the details of painting shall be specified by the purchaser.

12.6. In case of surfaces to be welded, the steel shall not be painted or metal coated within a suitable distance of any edges to be welded if the paint specified or the metal coating would be harmful to welders or impair the quality of the welds.

12.7. Where two surfaces will be in permanent contact after assembly each of them shall receive, immediately before being assembled after being thoroughly scraped, one coat of red-lead paint and surface shall be brought together while the paint is still wet. Welds and adjacent parent metal shall not be painted prior to deslagging, inspection and approval.

12.8. Steelwork which will be entirely embedded in concrete shall not to be painted but coated with two coats of Portland cement wash of the consistency of cream, the second coat being applied immediately prior to encasing.

12.9. Contact surface in friction type connection shall not be painted in advance.

13. Inspection before Erection

13.1. All fabricated members shall be inspected by the Engineer prior to erection. The Contractor shall be responsible for informing the Engineer as soon as any structural member is ready for inspection, and shall afford all the facilities necessary for inspection by the Engineer.

13.2. Any material or workmanship at any stage of construction, which in the opinion of the Engineer does not comply with the specified requirements, shall be rejected and not incorporated in the works.

14. Marking

14.1. Each piece of steel work shall be distinctly marked before dispatch in accordance with a marking diagram, and shall bear such other marks as will facilitate erection.

14.2. All structural steel work members shall be clearly marked with an erection number. The Contractor shall show, on the fabrication Drawings, the positions, where the erection number is to be found and the method of marking it. Metal die-stamps shall not be used for making erection marks.

14.3. The Contractor shall be responsible for any delay caused in the program by rejection of any such Works.

15. Packing

All projecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases, so as to prevent damage or distortion during transit.

16. GROUTING UNDER BASE PLATES

Grouting under base plates shall be done after erection of the structural steel unless otherwise approved by the Engineer-in-charge. All bearing plates, bearing assemblies and masonry plates shall be steel level and to the elevations shown on plans. These shall be shimmed with approved means and grouted to assure full bearings on the supporting substrata regardless of the tolerances otherwise permitted.

The grout to be used in superstructure stanchion bases shall be cement mortar 1 : 2 (1 cement : 2 coarse sand) and shall have a 28 days compressive strength of at least 300 kg/sqm. The surface which are to receive the grout shall be thoroughly cleaned immediately prior to the grouting operation. The grout shall be carefully worked under the base plates and shall completely fill the space under the base plates. Air pockets in the grout packing shall be avoided. Alternatively Non-Shrink cemettious grout to be provided specified in the BOQ.

After the grout has had its initial set, the grout shall be cut back flush with the base plate and the surplus grout shall, be removed. Before leaving the site the Contractor shall retighten the nuts of all anchor bolts.

C. ERECTION

1.0 General :

1.1. Erection of structural steelwork shall be carried out in accordance with the relevant IS Code in conformity with the drawings and specifications, in an expeditious manner.

1.2. The suitability and capacity of all plant, equipment etc, used for erection shall be to the satisfaction of the Engineer.

2. Scope of Erection Work

2.1. The Contractor shall provide all construction material and equipment, transport facilities, tools, tackles, consumables, labour, supervision for erection, including carrying out the following:

2.2. Receiving, unloading, checking and moving into the storage facility at site, as outlined under General Conditions of contract inclusive of attending to all Insurance matters in respect of materials arriving at site.

2.3. Transporting from site, storage, handling, rigging, assembling, riveting, bolting, welding, and installation of all fabricated materials in proper location according to drawings or as directed by the Engineer.

2.4. Checking center lines, levels of all foundations blocks including checking line & level, position and plumb of all bolts and pockets. Any defect observed in the foundation shall be brought to the notice of the Engineer. The Contractor shall satisfy himself regarding the correctness of the foundations before installing the

fabricated structures on the foundation blocks. Aligning, leveling, riveting, bolting, welding, fixing in position fabricated materials in accordance with drawings or as directed by the Engineer.

2.5. Supply of all required consumables, construction and erection materials, including but not limited to gauges, welding & brazing, rods, electrodes and wires, oxygen, acetylene, fuel, bolts, nuts, rivets, shims and temporary supports etc, as required for the incidental works and for the completion of erection.

2.6. Erection shall also include the following work:

2.6.1. All minor modification such as:

2.6.2. Removal of bends, kinks, twists etc of parts damaged during transport and handling.

2.6.3. Cutting, chipping, filling, grinding etc, for preparation and finishing of site connections.

2.6.4. Reaming for use of the next higher size of rivet or bolt for holes which do not register or which are found to be damaged.

2.6.5. Welding of connections in place of riveting or bolting for which holes are either not drilled or wrongly drilled during fabrication.

2.6.6. The following shall be considered as a legitimate part of erection work:

2.6.7. Re-fabrication work in respect of parts damaged beyond repair during transport and handling or in respect of those that are incorrectly fabricated.

2.6.8. Fabrication of parts omitted during fabrication due to an error, or subsequently found to be essential by client, architect, structural engineer, fabricator or by agency preparing the shop drawings.

2.6.9. Plug welding and re-drilling of holes which do not register and which cannot be reamed for the use of next size of rivet or bolt.

2.6.10. Drilling of holes which are either not drilled at all or are drilled in incorrect positions during fabrication.

2.6.11. Drilling of holes which are found necessary after completion of fabrication in shop or at site by client, architect, structural engineer, fabricator or by agency preparing the shop drawings.

3. Erection Drawings

3.1. The approved erection drawings and any approved arrangement drawings, specifications or instructions accompanying them shall be followed while erecting the structural steel work. Erection drawings for structural steel work shall be prepared by the Contractor and shall consist of line-diagrams showing every member in position with the respective erection mark.

3.2. Erection marks shall appear on the structural steel members as detailed and all steel work shall be erected with the marks in the same relative position as shown on the plan or elevation.

3.3. Any discrepancy between drawings and specifications shall be brought to the attention of the Engineer for obtaining his decision.

4. Storing and Handling of Material

4.1. The fabricated materials shall be carefully unloaded at site, examined for defects, checked, sorted out for each building and stacked properly above the ground level, to be kept clean and properly drained. The handling and storing of the component parts of a structure shall involve the use of method and appliances not likely to produce injury by twisting, bending or otherwise deforming the metal. No member slightly bent or twisted shall be put in place until the defects are corrected.

4.2. All small bends or twists detected in members shall be rectified before such members are put in place. Any serious bends or defects shall be reported at once to the Engineer. The straightening of bent edges of plates, angles and other shapes shall be done by methods not likely to produce fracture or other injury. Following the completion of the straightening of a bend or buckle, the surface of the metal shall be carefully inspected by the Contractor for evidence of incipient or any other type of fractures. The Contractor shall report to the Engineer about the presence of such evidence and act according to his instructions.

5. Setting Out

5.1. The Contractor shall be responsible for checking the alignment and levels of foundations, correctness of foundation-bolt centers, their projected height above the foundation tops, the length of threading provided and the provision and fitment of nuts for the foundation bolts. These shall be checked well in advance of starting the erection work and the Contractor shall be responsible for any consequences for non-compliance thereof. Discrepancies, if any, shall immediately be brought to the notice of the Engineer for his advice.

5.2. One set of reference axes and one Bench mark level will be furnished to the Contractor. These shall be used by him for the setting out operation.

5.3. The Contractor shall assume full responsibility for the correct setting out of all steel work and erecting it correctly as per the alignment and levels shown on the drawings and for the verticality of members. Notwithstanding any assistance rendered to the Contractor by the Engineer, if at any time during the progress of the work any error should appear or arise therein, the Contractor shall remove and amend the work to the satisfaction of the Engineer, at his own cost.

6. Assembly and Erection

6.1. Before the commencement of structural steel work, the Contractor shall submit a Schedule of Operations, detailing the erection procedures to be followed. The Schedule shall include provisions for any temporary bracing that may be considered necessary during the erection.

6.2. During the erection of a structure, the steel work shall be securely bolted or otherwise fastened and if necessary temporarily braced, so as to make adequate provision for all erection stresses and conditions, including those due to erection equipment and its operation. Such temporary bracing shall be maintained in position until the erection work is sufficiently advanced, and it is ascertained that the bracing provided is no longer required.

6.3. Connections for temporary bracing and additional holes, members or cleats used to facilitate handling or erection, shall be provided in a manner which does not weaken

the steel work already erected. The alignment of each portion of the structure shall be carried out progressively, soon after that portion is erected. Permanent connections shall not be made until proper alignment has been obtained and a sufficiently large portion of the structure has been erected and temporarily connected so as to ensure that the members thus connected shall not be over stressed or displaced during the progressive alignment of the remainder of the structure.

7. Site Erection

7.1. Plant and Equipment − The suitability and capacity of all plant and equipment used for erection shall be to the satisfaction of the engineer.

7.2. Storing and Handling − All structural steel should be so stored and handled at the site that the members are not subjected to excessive stresses and damage by corrosion due to exposure to environment.

7.3. Setting Out − The positioning and leveling of all steelwork, the plumbing of stanchions and the placing of every part of the structure with accuracy shall be in accordance with the approval drawings and to the satisfaction of the engineer in accordance with the deviation permitted below.

7.4. Erection Tolerances − The unloaded steel structure, as erected shall satisfy the criteria specified in Table 1 within the specified tolerance limits.

TABLE 1 NORMAL TOLERANCES AFTER ERECTION

Criterion	**Permitted deviation**
Deviation of distance between adjacent columns	5 mm
Inclination of a column in a multi-storey building between adjacent floor levels	0.002hs where hs is the storey height
Deviation of location of a column in a multi-storey building at any floor level from a vertical line through the intended location of	0.0035∑hb/n0.5 where ∑hb is the total height from the base to the floor level concerned and n is the number of

the column base	storeys from the base to the floor level concerned
Inclination of a column in a single storey building, (not supporting a crane gantry) other than a portal frame	0.0035hc where hc is the height of the column
Inclination of the column of a portal frame (not supporting a crane gantry)	Mean: 0.002hc Individual : 0.010hc

7.5. Each criterion given in the table shall be considered as a separate requirement, to be satisfied independently of any other tolerance criteria. The erection tolerances specified in Table 1 apply to the following reference points:

7.6. For a column, the actual centre point of the column at each floor level and at the base, excluding any base-plate or cap-plate. The level of the base plate on pedestal shall be so as to avoid to contact with the soil and corrosion environment

7.7. For a beam, the actual centre point of the top surface at each end of the beam, excluding any end-plate.

7.8. The straightness tolerances specified in Table 2 have been assumed in the derivation of the design stress for the relevant type of member. Where the curvature exceeds these values, shall be reviewed the effect of additional curvature on the design calculations shall be reviewed.

7.9. A tension member shall not deviate from its correct position relative to the members to which it is connected by more than 3 mm along any setting axis.

8. Clearances

8.1. The erection clearance for cleated ends of members connecting steel to steel should preferably be not greater than 2.0 mm at each end. The erection clearance at ends of beams without web cleats should be not more than 3mm at each end. Where for practical reasons, greater clearance is necessary, suitably designed seatings should be provided.

8.2. In bearing type of connections, the holes may be made not more than 1.5 mm greater than the diameter of the bolts in case of bolts of diameter less than 25 and not more than 2 mm in case of bolts of diameter more than 25 mm, unless otherwise specified by the engineer. The hole diameter in base plates shall be not more than 6 mm greater than the anchor bolt diameter.

8.3. In friction type of connection the clearance may be maintained, unless specified otherwise in the design document.

9. Shop Erection

9.1. The steel work shall be temporarily shop erected complete or as arranged with the inspector so that accuracy of fit may be checked before dispatch. The parts shall be shop assembled with sufficient numbers of parallel drifts to bring and keep the parts in place.

9.2. In the case of parts drilled or punched, through steel jigs with bushes resulting in all similar parts being interchangeable, the steelwork may be shop erected in such position as arranged with the inspector.

9.3. In case of shop fabrication using numerically controlled machines controlled by data generalised by CAD software, the shop erection may be dispensed with at the discretion of the inspector.

10. Safety during Fabrication and Erection.

10.1. All steel materials including fabricated structures either at fabrication shop or at erection site shall be handed only by worker skilled in such jobs-where necessary with

load tested lifting devices having tested wire rope slings of correct size, from damage. The devices should be well maintained and operated by experienced operators.

10.2. Oxygen and Acetylene cylinders and their hoses shall have distinctive colours. Cylinders should be stored in upright position in well-ventilated rooms or in open air- not exposed to flames, naked lights or extreme heat and should also be in upright position when they are being used. All gas cutting works shall be done only through experienced skilled gas cutters equipped with gloves, boots, aprons, googles and good cutting sets of approved make.

10.3. While doing any welding work, it should be ensured that the welding machine is earthed and the welding cables are free from damage. The welder and his assistant shall use a face shield or head shield with a welding lens and clear cover glass and their hands legs and bodies shall be well protected by leather gloves, shoes and aprons. Combustible materials should be kept away from the sparks and globules of molten metals generated in any arc welding. In case of welding in a confined place, it should be provided with an exhaust system to take care of the harmful gases, fumes and dusts generated.

10.4. In addition to precautions against all the hazards mentioned above, erection workers shall be protected in the following manner:

10.5. All workers must wear helmets and should also be provided with gloves and shoes. In addition those working at heights shall be forced to use safety belts.

10.6. All structures should be so braced/guyed during erection that there is no possibility of collapse before erection work is completed.

10.7. Warning signs such as “Danger”, “Caution”, “440 volts”, “Don not smoke”, “Look ahead” etc. should be displayed at appropriate places

10.8. For detailed safety precautions during erection, reference shall be made to IS: 7205.

11. Field Connections

11.1. Field riveting − Rivets driven at the site shall be heated and driven with the same care as those driven in the shop.

11.2. Field bolting − Field bolting shall be carried out with the same care as required for shop bolting.

11.3. Fillet welding − All field assembly and welding shall be executed in accordance with the requirements for shop fabrications excepting such as manifestly apply to shop conditions only. Where the steel has been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joint.

12. Bedding Requirement

12.1. Bedding shall be carried out with Portland cement grout or mortar, as described under 15.4 or fine cement concrete in accordance with IS: 456

12.2. For mult-storeyed buildings, this operation shall not be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, leveled and plumbed and sufficient floor beams are in position.

12.3. Whatever method is employed the operation shall not be carried out until the steel-work has been finally leveled and plumbed, stanchion bases being supported meanwhile by steel wedges or nuts; and immediately before grouting, the space under the steel shall be thoroughly cleaned.

12.4. Bedding of structure shall be carried out with grout or mortar, which shall be of adequate strength and shall completely fill the space to be grouted and shall either be placed under pressure or by ramming against fixed supports. The grouts or mortar used shall be non-shrinking variety.

13. Tolerances

13.1 . Erection tolerances shall be provided strictly in accordance with the requirements of IS 7215.

TABLE 2 STRAIGHTNESS TOLERANCES INCORPORATED IN DESIGN RULES

Criterion	Permitted deviation
Straightness of a column (or other compression member) between points which will be laterally restrained on completion of erection	0.001L generally. 0.002L for members with hollow cross-sections. Where L is the length between points which will be laterally restrained.
Straightness of a compression flange of a beam, relative to the weak axis, between points, which will be laterally restrained on completion of erection.	0.001L generally. 0.002L for members with hollow cross-sections. Where L is the length between points which will be laterally restrained.

14. Maintenance

14.1. **General** – Where steelwork is to be encased in solid concrete, brickwork or masonry, the question of maintenance should not arise, but where steelwork is to be housed in hollow fire protection or is to be unprotected, particularly where the steelwork is exposed to a corroding agent, the question of painting or protective treatment of the steelwork should be given careful consideration at the construction stage, having regard to the special circumstances of the case.

14.2. Connections – Where connections are exposed to a corroding agent, they should be periodically inspected, and any corroded parts should be thoroughly cleaned and painted.

14.3. Where bolted connections are not solidly encased and are subject to vibratory effects of machinery or plant, they should be periodically inspected and all bolts tightened.

15. Painting after Erection

15.1. Before painting of such steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dry and thoroughly cleaned from all loose scale and rust, as required by the surface protection specification.

15.2. The specified protective treatment shall be completed after erection. All rivet and bolt heads and the site welds after de-slagging shall be cleaned. Damaged or deteriorated paint surfaces shall first be made good with the same type of paint as the shop coat. Where specified, surfaces, which will be in contact after site assembly, shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet. No painting be used on contact surfaces in the friction connection, unless specified otherwise by the design document.

15.3. Where the steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds and site rivets or bolts, but subject to the approval of the engineer. Painting on site may complete protection. Bolts, which have been galvanized or similarly treated, are exempted from this requirement.

15.4. Surface, which will be inaccessible after site assembly shall, receive the full-specified protective treatment before assembly.

15.5. Site painting should not be done in frosty or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted.

16. Tolerances

16.1. References may be made to IS: 7215, ‘Indian Standard tolerances for erection of steel structures’, and the Handbook for fabrication, erection and inspection of steel structures’ for general guidance.

16.2. Tolerances for fabrication of steel structures shall conform to IS:7215. Tolerances for erection of steel structures shall conform to the relevant Indian Standard (IS:12843) and Handbook for Fabrication, Erection, Painting and Inspection of Steel Structures. For general guidance on fabrication by welding, reference may be made to IS: 9595.

D. INSPECTION AND TESTING

1. The inspector shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steel work and shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of this standard.

2. Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

3. The manufacturer shall guarantee compliance with the provisions of this standard, if required to do so by the purchaser.

4. Should any structure or part of a structure be found not to comply with any of the provisions of this standard, it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for test, except in cases where the purchaser or his authorized representative considers the defect as rectifiable.

5. To facilitate inspection, the contractor should during all working hours, have a foreman or properly accredited charge hand available on the site, together with a complete set of contract drawings and any further drawings and instructions which may have been issued from time to time.
6. Defects, which may appear during fabrication, shall be made good with the consent of and according to the procedure laid down by the inspector.

7. All gauges and templates necessary to satisfy the inspector shall be supplied by the manufacturer. The inspector, may, at his discretion, check the test results obtained at the manufacturer's works by independent tests at the Government Test House or elsewhere, and should the material so tested be found to be unsatisfactory, the costs of

such tests shall be borne by the manufacturer, and if satisfactory, the costs shall be borne by the purchaser.

E. MS INSERTS / MS HOLDING DOWN THREADED BOLTS, NUTS, WASHERS

MS inserts shall be using MS rolled sections like Channels, angles, "T", "I" sections, plates, flats etc. of approved make with necessary lugs/ bolts as per drawings and details. Inserts, bolts etc. shall be provided in masonry and concrete works as indicated on the drawing. It is imperative that all inserts, bolts fixtures and fittings shall be provided in their position very accurately. Such inserts and bolts are to be fixed with necessary templates. If due to negligence on the part of the contractor, the inserts, bolts fixtures, and fittings etc, are out of alignment the contractor shall make arrangements to have the inserts and bolts removed and refitted in their proper position as directed by the engineer, at no extra cost. The inserts shall be painted with shop coat of primer followed by one coat of primer and two or more coats of synthetic enamel paint of approved make and quality on completion.

Mode of Measurement: The area of the plates as laid shall be measured and it shall be converted into weight using standard IS tables for steel and paid for in Kilogram. Nothing extra shall be paid for wastage's / rolling margins in case of overweight. However in case of underweight, actual shall be paid for.

The MS holding down bolts of specified diameter, length and shape shall be provided as per the drawings in line and level. These shall be fixed to RCC work or brickwork by grouting it with concrete. The bolt shall be provided with nuts and washers. The grease shall be applied to the threaded portion. If the bolts need some adjustment, it shall be provided with a wooden piece 75 x 75mm or 50mm diameter. GI pipe around bolt shall be provided at the time of concreting and shall be removed after initial set. If required template / double template should be provided.

E. CHECKLIST FOR STEELWORK INSPECTION

The inspector shall ensure that the following points are complied with and should tick √ or X against e ach checklist item.

1. Drawings and Documents

1.1. Relevant architectural drawings are present on the site.

1.2. Relevant structural drawings for reference are present on the site.

1.3. Relevant approved Fabrication drawings are present on the site.

1.4. Document related to methodology of fabrication and erection is present on the site

1.5. Weld preparation detail is present on the site (if stated specifically in the methodology)

2. Materials

2.1. Copies of test certificates for the materials to be used are present on the site.

2.2. Test results are satisfactory

2.3. All members to be used in the fabrication are straight.

2.4. All members to be used in the fabrication are free from defects such as

a. pitting

b. rust

c. twists

d. cracks

e. surface flaws

f. lamination

g. imperfect edges

h. any other defects.

3. Storage of materials

3.1. All material is stored properly on a raised platform.

3.2. It is kept clean and properly drained.

3.3. Structural steel is so stored and handled that members are not subjected to excessive stresses and damage.

4. Fabrication

4.1. Fabrication is taking place in Workshop / Site

4.2. Are fabrication parts numbered for erection purpose?

4.3. Are templates / jigs being used to fabricate all similar parts?

4.4. Template / jig dimensions checked and found satisfactory.

4.5. The dimensional accuracy of the members is within 2 mm at each end.

4.6. Which method is used for cutting the members ? Saw cutting / Flame Cutting

4.7. Are the edges of the cut members being ground to a depth of 2 to 3 mm ?

4.8. In case of butt joints and full bearing surfaces, the cut edges / machined surfaces are in full contact.

4.9. All cut edges are perfectly perpendicular to their surfaces unless specifically mentioned otherwise in the drawings.

4.10. Holes for bolts are made by drilling / gas cutting (Reject gas cut holes)

4.11. Has a trial assembly been made on the ground before proceeding to erection?

5. Welding

5.1. Are qualified welders present on the site?

5.2. Welder's qualification certificate is available with the fabricator ? Seen / Not seen

5.3. Welding electrodes seen and confirmed as complying with IS 814 or equivalent

5.4. Welding procedure document is available on site.

5.5. Is all welding complete before erection of member in place?

5.6. Are clamps being used during welding to avoid warping of members?

5.7. Are spacers being used to ensure correct root gap?

5.8. Are tack welds being used for initial fit out before carrying out full welding ?

5.9. Are thicker members being pre-heated to required temperatures before welding ?

5.10. Are welding rods being de-moisturized in an oven before using them for welding ?

5.11. Is there a case of overhead welding ?

5.12. Is a welding supervisor present on the site ?

5.13. Results of 100 % visual inspection of the welds - Satisfactory / correction required

5.14. Results of 10% welds tested with dye-penetration test – Satisfactory / Correction required

5.15. Is radiography test recommended by designer ?

5.16. Results of radiography tests – Satisfactory / rejected

6. Painting

6.1. Surface cleaning carried out before painting with primer.

6.2. Steel work to be embedded in concrete is not painted. If painted, should be completely cleaned and bare surface to be exposed.

7. Erection

7.1. Checking centerlines, levels of all foundations blocks including checking line & level, position and plumb of all bolts and pockets.

7.2. Is Re-fabrication work in respect of parts damaged beyond repair during transport and handling or in respect of those that are incorrectly fabricated required ?

7.3. Are the members being stressed, bent after erection?

7.4. Adequate lifting and positioning equipment is available on the site?

7.5. Is there an erection procedure document on the site ?

7.6. Are all members painted with primer before erection ?

7.7. Is temporary bracing suggested by designer in the methodology of erection ? Has it been provided at site ?

7.8. Proper alignment has been done prior to permanent connections ?

7.9. Are all bolts tightened ?

7.10. Are all connections fully welded after erection wherever specified in drawings ?

Project Reference :
_____

Structure Reference :
_____

Name of the inspector :
_____

Representing : M/s
_____

Designation : _____ Signature :
_____

Inspection carried out in the presence of :
_____

Representing : M/s
_____

Designation : _____ Signature :
_____

Reference Drawing Nos.

Architectural : _____ Structural :
_____

Fabrication Drawing : _____Erection Drawing :
_____

*** * * * ***

VOLUME - I

7.00 MASONRY WORK

PART-I– FLY ASH BRICKS / CLAY BRICKS

1.0 GENERAL

1.1 Standards

Work shall be carried out according to Indian Standards and Code of Practices. In absence International Standards shall be followed. These shall be latest issue. List given here under is not to be considered as conclusive and is for reference and guidance only. Any discrepancies/conflict noticed shall be directed to the Engineer-in-charge for his direction/approval. However as a general rule more stringent specification shall take precedence.

(1)	IS 226	Specification for Structural steel standard quality
(2)	IS 269	Specification for 33 grade OPC
(3)	IS 2116	Specification for sand for masonry mortars
(4)	IS 2250	Code of practice for preparation and use of masonry mortars.
(5)	IS 8112	Specification for 43 grade OPC
(6)	IS 1489	Specification for Portland pozzolana cement
(7)	IS 3466	Masonry Cement
(8)	IS 3812	Specification for fly ash use as Pozzolana and admixtures
(9)	IS 12894	Specification for Pulverised Fuel Ash – Lime Bricks
(10)	IS 1077	Common Burnt clay building bricks
(11)	IS 3102	Classification of burnt clay bricks
(12)	IS 2180	Burnt clay building bricks, heavy duty
(13)	IS 3495	Method of Sampling and testing clay building bricks.
(14)	IS 2691	Burnt clay facing bricks
(15)	IS 2221	Code of practise for Brickwork
(16)	IS 2185	Load bearing hollow concrete blocks
(17)	IS 5498	Lime-cement-cinder hollow concrete blocks
(18)	IS 3115	Lime-cement cinder solid blocks
(19)	IS 1597	Code of practise for construction of Stone masonry (Part-I)

1.2 Quality assurance

1.2.1 All material used in the work shall comply with latest standards listed above or in absence to International Standards if specified to be followed. Further it must be noted that it should meet approvals and requirements of local authorities and shall be used only after approval of the Engineer-in-charge in writing..

1.2.2 Material shall conform to IS specification when read in conjunction of bills of quantities, drawings and instruction of the Engineer-in-charge.

1.2.3 Material shall be tested through an independent authorised testing laboratory / agency who is equipped and experienced to carry out test as per IS standards.

1.2.4 Bricks shall be of uniform quality, hard, sound, uniform texture, colour / blend within acceptable ranges / characteristics, uniformly shapes, free from cracks, warp edges, organic matter, pebbles, nodules of free lime etc. Source of supply shall be restricted to one or two.

1.2.5 Samples shall be tested for compressive strength, water absorption, dimensional tolerances, Thermal Conductivity and efflorescence etc. as per standards prior to approval and during construction at independent authorised laboratory.

1.2.6 Build sample panels of about 1800x1800mm for each type using tested and approved materials prior to actual work proceeds showing masonry colours and textures, use of reinforcement, ties, joints, coursing, mortar and workman ship.

1.2.7 Build mockup to verify selections made under sample submittals and to demonstrate aesthetic effects, qualities of material and execution.

1.3 Submittals

1.3.1 Full size samples showing full range colours, texture dimensions to be expected.

1.3.2 Reinforcement steel accessories to be embedded in masonry.

1.3.3 Fabricated flashing details for special applications.

1.3.4 Material test reports for mortar grout.

1.3.5 Shop-drawings for

i) All design loads and design criteria

ii) Setting out arrangements, including the heights of all openings

iii) Junction details of masonry with RCC structural elements such as columns, shear walls, beams, slabs etc. including fixing of anchor rages / dowels, bituminous impregnated boards, mix of mortar etc.

iv) Fixing details of door frames / sub frames along with hold fasts, anchors, fasteners etc.

v) All Service penetrations

vi) Interfacing details with adjacent finishes and materials

vii) Construction details of expansion or control joint shall be designed and detailed.

1.3.6 The Submittals by the Contractor does not authorise the Contractor to use it in work unless it is approved in writing by the Engineer-in-charge.

1.4 Delivery, Storage and Handling

1.4.1 Store materials on elevated platforms in dry location so that it will not be damaged or contaminated during the storage period.

1.4.2 Store cementitious material on elevated platform, under cover and in dry location. Do not use damped cementitious material.

1.4.3 Store aggregate to maintain grading and characteristic.

1.4.4 Store accessories in dry, covered place to prevent corrosion and accumulation of dirt and oil.

1.4.5 Handle and transport all material with care so as to avoid damage, breaking, cracking, chipping, and distortion.

1.5 Samples

1.5.1 It is obligatory that for all materials used in work; samples shall be submitted along with technical specifications, test reports, source of supply, catalogues of manufacturer, bills of quantities item reference number etc. minimum 30 days prior to incorporation of same in work or minimum 15 days prior to placing of order allowing minimum required lead time for manufacturer / supplier to deliver material at site.

1.5.2 Sample of Material to be submitted

a) Fly Ash- lime Bricks
b) Sand
c) Cement
d) Readymade mortar mix
e) DPC course material
f) Hot dipped GI hold fast
g) Hot dipped anchors
h) Metal reinforcement
i) Metal Wall Ties
j) Compressive Joint filler
k) Admixtures
l) Wall insulation
m) Pigments
n) Protection Board

1.6 Inspection

1.6.1 Allow minimum 24 hours for inspection of mock-up by the Engineer before proceeding with the work. The inspection is to be carried out to ensure satisfactory performance and recommended practice of workmanship is followed at every stage of work.

1.6.2 Inspection may be made for but not limited to

a) Damp proof course in position

b) Flashing in position

c) Bottom of cavities, after cleaning out

d) Bottom of core holes before grouting

e) Control and movement joints ready for insertion of joint filler

f) Lintels in position

g) Structural steel work, including bolts and shelf angles in position

1.6.3 The Contractor has to inspect and assure work of previous trades prior to the commencement of work that all such required preceding activities, work completed.

1.6.4 Commencement of work implies acceptance of conditions as being satisfactory to proceed with the masonry installation.

2.0 MATERIAL

2.1 Fly Ash Lime Bricks

2.1.1 Bricks shall conform to IS 12894. Bricks shall be solid, sound, compact and uniform in shape free from cracks, warp edge, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side.

2.1.2 Fly ash Bricks shall be as specified and detailed in the BOQ. It shall have to be approved prior to procurement. Bricks shall be obtained from an approved source and shall confirm all requirements of project / Indian Standards. Maximum water absorption shall not be more than 20% of its dry weight on immersion in water for 24 hours and Minimum crushing strength shall be 75 kg/sq cm if not specified in the BOQ / Schedule.

2.1.3 Fly ash Bricks of approved quality and quantity shall have to be procured by the Contractor at the desired time. No delay or extra cost due to non-availability shall be accepted. The Contractor is obliged to carry out the work as specified. It shall be the responsibility of the Contractor to procure sufficient quantities of bricks and stack them at site or elsewhere to avoid delays.

2.2 Clay Bricks

2.2.1 Bricks used in works shall be bricks of specified crushing strength as described in the Schedule of Quantities. They shall have the following general properties:

They shall be sound, hard, and homogenous in texture, well burnt in kiln without being vitrified, table moulded, deep red, cherry or copper coloured, of regular shape and size and shall have sharp and square edges and paralleled faces. The bricks shall be free from pores, chips, flaws or humps of any kind. Bricks containing ungrounded particles and which absorb water more than 1/5th of their weight when soaked in water for twenty-four hours shall be rejected. Over burnt or under burnt bricks shall be liable to rejection. The bricks shall give a clear ringing sound when struck.

2.2.2 Samples of bricks shall be submitted before starting the brickwork to the Engineer for approval. Bricks supplied shall confirm to the approved samples. Brick sample shall be got tested as per IS 3495 by Contractor at no extra cost. Bricks rejected by Engineer shall be removed from the site of works within 24 hours.

2.3 Mortar

2.3.1 Mix for cement mortar shall be as specified in the respective items of work. Gauge boxes for sand shall be of such dimensions that one complete bag of cement containing 50 kgs. of cement forms one unit. The sand shall be free from clay shale, loam, alkali, and organic matter and of sound, hard, clean and durable particles. Sand shall be approved by the engineer. If so directed by the engineer sand shall be thoroughly washed till it is free of any contamination.

2.3.2 For preparing cement mortar the ingredients shall first be mixed thoroughly in dry condition. Water shall then be added and mixing continued to give a uniform mix of required consistency. Cement mortar shall preferably be machine mixed, through mixing in a thorough manner may be allowed. The mortar so mixed shall be used within 30 minutes of mixing. Mortar left unused in the specified period shall be rejected.

2.3.3 The Contractor shall arrange for test on mortar samples if so directed by the engineer re-tempering of mortar shall not be permitted.

2.3.4 If mentioned in the BOQ, Ready mix mortar to be used as per the specification of the manufacturer.

2.4.0 Cement

Cement used shall be ordinary Portland cement / Portland pozzolana cement (Fly ash or Blast furnace slag blended) conforming to IS. Portland Pozzolana cement shall be preferred for the work.

2.5.0 Water

Water used for masonry shall be clean and free from injurious amounts of deleterious materials.

2.6.0 Fine aggregate (sand)

2.6.0.1 Natural sand deposited by stream or glacial agencies as a result of disintegration of rock is the best form of fine aggregate. The fine aggregate shall conform to following standards.

(i)	For plain and reinforced concrete	IS 383 Specification for coarse and fine aggregates from natural sources for concrete.
(ii)	Mortar and grout	IS 2116 Specification for sand for masonry mortars.

2.6.0.2 Sea sand should not be used unless approved by the Engineer-in-charge. If approved, the required treatment shall be done at the Contractor's cost.

2.2.4.2 Sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain any appreciable amount of clay. Sand shall not contain harmful impurities such as iron, pyrites, coal particles, lignite, mica shale or similar laminated material, alkali, and organic impurities in such form or quantities as to affect the strength or durability of concrete or mortar. Also it should not contain any material liable to attack the steel reinforcement.

2.2.4.2.1 When tested as per IS 2386 Part I and Part II, fine aggregate shall not exceed permissible quantities of deleterious materials as given in IS 383 “Limits of Deleterious materials (aggregates)”.

2.2.4.2.2 Fine aggregate shall be thoroughly washed at site with clean fresh water such that the percentage of all deleterious material is within the permissible limits laid down.

2.3 Damp proof course

2.3.1 A layer of concrete shall be a 40 mm thick mix in the ratio of 1:2:4 (1 cement: 2 sand: 4 stone aggregate, 10 mm nominal size). The concrete layer shall be provided with a water proofing treatment which may either be a surface treatment or with integral waterproofing compounds. For surface treatment of concrete, hot bitumen at the rate of 1.7 kg/100 sq m shall be used.

2.3.2 Slate and cuddappa stone slabs used shall be of minimum 40 mm thickness.

2.4 Metal reinforcement

2.4.1 M S Plain

Rolled mild steel and medium tensile steel plain round bars shall conform to IS 432 - 1982 Part I. Steel received shall conform to the following IS with regard to manufacturing and chemical composition.

1. M.S. bar Grade I Steel designation Fe 410-S of IS 2062 - 1992.
2. M.S. bar Grade II Steel designation Fe 210-O of IS 1977 - 1975.
3. Medium Tensile Steel designation Fe 540 W-HT Steel bars IS 8500 -1991

Nominal sizes and tolerances shall be as specified in IS432 - 1982Part I. Physical requirements shall be determined in accordance with IS 1608, read in conjunction with IS 2062 - 1992.

2.4.2 TMT Steel

High Strength deformed bars for use as reinforcement shall be of grade Fe 415, Fe 500 and Fe550 conforming to IS 1786 – 1985

Chemical composition shall conform to IS 1786 - 1985 when made as a relevant part of IS 228 -1959.

Nominal sizes, cross sectional areas and their mass shall be as specified in IS 1786 - 1985, allowing due consideration for tolerances specified therein.

Physical properties

1) It shall satisfy IS 1599 - 1985 test for bend and rebend test in conjunction with IS 226.
2) Bond requirements shall be deemed to have been satisfied if it meets clause 4.0 of IS 1786 - 1985.
3) Tensile, proof stress and percent elongation shall be as per Table 3 of IS 1786 - 1985.

2.4.3 Metal reinforcement

a)	IS 226	Specification for steel standard quality
b)	IS 412	Specification for Expanded metal steel sheet for general purpose
c)	IS 1566	Specification for Steel fabric or hard drawn steel wire

3.0 MORTAR

3.1 Mortar shall be prepared by mixing fine graded aggregate with cement in the proportion specified for respective items of work as detailed in the BOQ. Mixing of mortar shall be done by mechanical mixers only. Hand mixing may be permitted in specified cases on the written permission of the Engineer-in-charge.

3.2 Mortars shall be specified by proportion. Volumetric mixing shall be based on dry volumes of each ingredient. For convenience, measurement shall correspond to volume of one cement bag i.e. 0.035 cu m. Boxes shall be of size 40 X 35 X 25 cm. These shall be marked as mortar mixing boxes by red paint and shall be used throughout the contract. Hand mixing or mechanical mixing proportions shall be done with the use of these boxes.

3.3 Cement mortar shall be prepared by mixing cement and sand in specified proportions. Proportioning shall be carried out as detailed above. Sand shall be added suitably to allow for bulkage if required. Bulkage shall be determined as specified in IS 2386 Part III. Cement and sand added to mixer shall be thoroughly mixed and water shall be added to it gradually. After addition of water the mixer shall run for a minimum of 3 minutes. The mortar mixed shall be consumed within 30 minutes of its mixing.

3.4 If mentioned in the BOQ, Ready mix mortar to be used as per the specification of the manufacturer.

4.0 WORKMANSHIP

4.1 IS code 2212 Code of practices recommendation shall be followed.

4.2 Bricks used for masonry in cement mortar shall be wetted by sprinkling water prior to start of actual laying.

4.3 Bricks shall be laid in English bond unless otherwise specified. Half or cut bricks shall be used only for the purpose of bond and at no other place.

4.4 Work shall be true to horizontal lines and perfect plumb. Vertical joints shall be truly vertical and those in alternate courses shall be in the same vertical line. Joints of each course shall be within the limit of 6 mm to 10 mm depending upon the size of bricks. Total height of 9 cm brick with 5 courses and 5 mortar joints shall be 50 cm. In no case shall joint thickness of horizontal and vertical be more than stated above. Joints should be filled to full depth and checked each time. Prior to start of work it must be noted and checked that bricks on top are full-size bricks (flat or brick on edge). To achieve this, precautions should be taken from the start of the first layer. Thickness of joints shall be so adjusted so as to have full bricks on top. Also it must be noted and checked that all horizontal joints on every floor are at the same level, so as to allow proper bonding at junctions.

Required datum levels must be established throughout the floor and only then should work start.

It is equally important to take into account levels of window sills, lintels, etc. while finalizing courses and joint thickness.

In normal practice Engineer-in-charge do take care of these while finalizing levels, but it is difficult to expect the ideal situation at all places. In such situations, the decision of the Engineer-in-charge shall be taken such as providing brick on edge, concrete sills, etc.

In addition, for convenience and speed, gauge boards of exact width shall be fixed at the edges of masonry to correct line and plumb. These boards shall be marked with course levels to achieve exact height of each course and full bricks at the top.

4.5 One or half brick thick wall shall have minimum one face in true plumb.

4.6 It is imperative to raise the brick work uniformly over complete Work joined together. If this is not possible, raked brick work shall be done at 45 degrees to the vertical. Toothing shall not be accepted.

4.7 All iron fixtures, pipe outlets, hold-fasts for doors and windows shall be fixed when the brick work is in progress. It must be embedded in cement mortar or concrete as specified or as directed by the Engineer-in-charge. Required treatment to fixtures shall be carried out prior to embedding.

4.8 To achieve better results and proper working, the following tools should be available with masons working at site :

1. Spirit level
2. Wooden / Aluminium straight edge 3 m long
3. 3 metre steel tape
4. Right angle 1/2 metre long
5. Line and pin strings
6. Plumb
7. Storey rods

4.9 Joint thicknesses shall be provided as discussed above. Joints shall be filled to full depth before second course is laid. Frogs shall be upward at all times. Joints shall be raked back to a minimum 10 to 15 mm while the mortar is green. Surface of brick work shall be cleaned with coir string, wire brushes, etc. to keep the surface free for the next operation. All dropped and spoiled mortar, brickbats, etc. shall be cleared from the floor before work is closed for the day.

4.10 Protection and curing

Green work shall be protected from rains by suitable approved covering. Masonry in cement mortar shall be kept constantly moist on all the faces for a minimum period of ten days. The top of masonry shall be left flooded with water at close of the day.

4.11 Scaffolding

Scaffolding independent of brick work i.e. double scaffolding shall be provided. It should be tied to brick work or structure at suitable intervals in both directions. Two rows of planks shall be provided all around. Planks shall be at least 50 mm thick and well-tied to scaffolding. Railing to the outside face shall be provided. While erecting scaffolding, the following points must be noted and closely followed :

1. Minimum number of holes in the horizontal direction. Holes shall be formed by omitting header brick.
2. No holes in pillars under 1 metre in width.
3. No holes near the skew backs of arches.
4. Scaffolding must be sound and strong and easy to maintain.
5. Holes left must be closed while finishing the plaster.

5.0 TYPES OF BRICK WORK

5.1 Walls 230 mm thick or more

5.1.1 Walls of 230 mm thickness or more shall be constructed with approved and selected bricks. Mortar shall be as specified in the BOQ. Points discussed above shall be followed for workmanship.

Brick wall of 230 mm thickness shall be constructed from one side and one face shall be true and plumb. Thicker walls shall be constructed with masons on both faces and both the faces shall be true and plumb.

5.2 Half brick work - plain or reinforced

5.2.1 115 / 100 mm thick brick work shall be called as half brick work. It shall be built by laying bricks in stretcher bond. Mortar shall be as specified in the BOQ.

These walls may be used for forming cavities or partition walls inside buildings. Brick work shall be reinforced with either of following methods:

1) With 8 mm dia bars, 2 bars at every third layer.
2) GI metal lath / GI hoop iron 25 mm X 1.6 mm shall be used at every third layer as detailed by the manufacturer.

3) Patli Beams of 115 x 100 mm high in M20 grade concrete shall be casted. Beam shall be reinforced with 2 nos. of 8 mm dia Tor bars and 6mm dia M.S. links at 300mm C/C. Patli beams shall be at every 1000 mm interval in height.

Embedding of reinforcement shall be done very carefully. All precautions shall be taken so that edges are not exposed. Lapping of bars and lath shall be proper and staggered.

5.3 Brick on edge coping

The top course of all plinths, parapets, steps and tops of walls below R.C.C. slabs or beams shall be laid with brick on edge, unless otherwise specified. Proper care shall be taken that the bricks forming the top corners and end of walls shall be properly radiated and keyed into position.

5.4 Cavity walls

5.4.1 Walls constructed on both faces of the cavity shall be termed as cavity walls.

Both faces of walls shall be tied with each other by means of specially made wall ties for required cavity. These may be G.I. flats twisted at centre or G.I. wires of 2 mm formed in butterfly shape or as approved. Ties shall be provided at 450 mm centre to centre in both directions but staggered all round. Approximately there shall be 5 ties per square meter. Ties shall be fixed such that water flows towards the outer edge.

5.4.2 There shall be a small opening in the outer skin, approximately 2 meters apart at start of masonry viz; generally plinth level. At the end of construction, the cavity shall be cleaned, drained, and the opening sealed.

5.4.3 It is imperative to have a cleaned and clear cavity to achieve the best intended results. While work is being carried out, a plank tied with binding wire shall be inserted into the cavity and rested on wall ties to prevent mortar falling in the cavity. Plank shall be of the width of cavity and continuously lifted upward by means of tied wire as the work progresses.

6.0 RATE

6.1 The rate shall include the cost of all the materials and labour as described in their respective items of work and for all the operations as detailed in the respective specifications for the various items of work. Brick on edge courses, cut brick corners, splays, reveals, cavity walls, shall be included in BRICK WORK - for the purpose of payment.

6.2 The following operations shall be included in the rate for BRICK WORK -:

a) Raking out joints for plastering or for pointing done as a separate process or for finishing joints flush as work proceeds;

b) Preparing tops and sides of existing walls and the like for raising.

c) Rough cutting and waste for forming gables, cores of arches, splays at caves and the likes and all rough cutting in the body of brick- work, unless otherwise stated;

d) Plumb to angles and battered surfaces;

e) Forming reveals to jambs where fair cutting on exposed faces is not involved;

f) Leaving holes for pipes, etc.;

g) Building-in holdfasts, air bricks, fixing bricks, etc.;

h) Building-in ends of beams, joists, slabs, lintels, sills, trusses, etc.;

i) Forming openings and flues for which no deduction is made;

j) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets, etc., in or on walls, if not covered in their respective trade.

k) Leaving chases of section not exceeding 50 cm in girth.

l) Scaffolding.

m) Curing and protection.

n) Work at all heights, leads, lifts, etc.

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PART – II

CONCRETE BLOCK MASONRY WORK

1.0 GENERAL

1.1 Indian Standards

Work shall be carried out to Indian Standards and Code of practices. In absence International standards shall be followed. These shall be latest issue. List given hereunder is not to be considered as conclusive and is for reference, guidance only. Any discrepancies / conflict noticed shall be directed to the Architect for his direction / approval. However as a general rule more stringent specification shall take precedence.

1.	IS 269	Specification for ordinary and low heat portland cement grade 33
2.	IS 383	Specification for coarse and fine aggregates from natural sources for concrete.
3.	IS 456	Code of Practice for plain and reinforced concrete.
4.	IS 2185	Specification for concrete masonry units
	Part – 1	Hollow and solid concrete blocks
	Part – 2	Hollow and solid light weight concrete blocks
	Part – 3	Autoclave Cellular (Aerated) concrete blocks
5.	IS 2572	Code of Practice for construction of hollow concrete block masonry.
6.	IS 6041	Code of practice for construction of autoclave celluar concrete block masonry
7.	IS 6441	Method of test for autoclaved cellular concrete products
	Part – 1	Determination of unit weight or bulk density and moisture content
	Part – 2	Determination of drying shrinkage
	Part – 4	Corrosion protection of steel reinforcement of steel reinforcement in autoclave cellular concrete
	Part – 5	Determination of compressive strength

	Part – 6	Strength, deformation and cracking of flexural members subject to bending short duration loading test
	Part – 7	Strength, deformation and cracking of flexural members subjected for bending – sustained loading test
	Part – 8	Loading tests for flexural members in diagonal tension
	Part – 9	Jointing of autoclaved cellular concrete elements
8.	IS 8112	Specification for ordinary portland cement grade 43.
9.	IS 9103	Specifications for admixtures for concrete.
10.	IS 412	Expanded Metal Steel Sheet
11.	IS 1838	Specification for performed fillers for expansion joints in concrete pavement and structures (non extruding and resilient)
	Part – I	Bitumen impregnated fibre
12.	IS 1489	Pozzolana Cement
13.	IS 455	Specification for Portland slag cement.
14.	IS 1269	Specification for 53 grade ordinary Portland cement
15.	IS 13757	Burnt clay fly ash building bricks
16.	IS 1661-1972, IS 2250-1965, IS 2402-1963	Codes for Parameters for mortar.
17	ASTMC 1660-09	Jointing material for thin Bed application for AAC/CC Blocks

1.2 Quality assurance

1.2.1 All material used in the work shall comply with latest standards listed above or in absence to International Standards if specified to be followed. Further it must be noted that it should meet approvals and requirements of local authorities.

1.2.2 Contractor shall procure block from approved concrete block manufacturer.

1.2.3 Block manufacturer should have minimum five years experience in manufacturing of blocks.

1.2.4 Manufacturer shall give certificates that blocks manufactured are of specified minimum crushing strength conforming to IS and are fully cured.

1.2.5 Manufacturer shall confirm materials used and method of casting , required plants, equipments meets conform to IS.

1.3 Submittals

1.3.1 Submit product literature from manufacturer

1.3.2 Certificate of independent laboratory for compressive crushing strength.

1.3.3 Samples of

- Concrete blocks of each size and type
- Ties
- Joint fillers
- Reinforcing joint fillers
- Fine sand
- DPC Course
- Hot dipped GI holdfast
- Hot dipped anchors

1.3.4 It is obligatory that for all materials used in work samples shall be submitted along with technical specifications, test reports, source of supply, catalogues of manufacturer, bills of quantities item reference no minimum 30 days prior to incorporation of same in work or minimum 15 days prior to placing of order allowing required load time by manufacturer / supplier.

1.3.5 Shop drawings for

i) Junction details of masonry with RCC structural elements such as columns, shear walls, beams, slabs etc. including fixing of anchor rages / dowels, bituminous impregnated boards, mix of mortar etc.

ii) Fixing details of door frames / sub frames along with hold tests.

iii) Construction details of expansion or control joint if shown in drawing.

1.4 Delivery, Storage and Handling

1.4.1 Load, unload deliver, store all concrete blocks with due care, at site to be free from damage, dirt, intrusion of foreign materials etc.

1.4.2 Store all concrete block units on raised solid platforms.

1.4.3 Protect block from any excess of weather conditions.

2.0 MATERIAL

2.1 Cement

2.1.1 Cement used shall be ordinary portland cement conforming to IS and shall be of grade 43 or 33. Pozzolona cement shall be acceptable and preferred in work.

2.1.2 It shall be received in bags of 50 kg or loose in tankers and each batch shall be accompanied with a test certificate of the factory. Also it shall be tested before use to ascertain its strength, setting time, etc. In case cement has been stored for over 3 months or for any reasons the stored cement shows signs of deterioration or contamination, it shall be tested as per the direction of the Architect prior to use in the works.

2.2 Aggregates

2.2.1 Aggregate shall conform to IS 383 requirements. Coarse aggregate shall be obtain from natural sources such as stone, gravel etc. crushed or uncrushed from approved quarries. Aggregate shall be hard, durable, clean and free from adherent coatings. Grading shall be as indicated in IS 383. Fineness modules of the combined aggregates shall be between 3.6 and 4.

Coarse aggregates shall be free from harmful materials such as iron, pyrites, coal, mica, shale or similar laminated material, clay, alkali, soft fragments sea shells, organic impurities etc. Impurities present within acceptable limits shall not adversely affects strength and durability.

2.2.2 Fine aggregates

Sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain any appreciable amount of clay. Sand shall not contain harmful impurities such as iron, pyrites, coal particles, lignite, mica shale or similar laminated material, alkali, and organic impurities in such form or quantities as to affect the strength or durability of concrete or mortar.

When tested as per IS 2386 part I & II, fine aggregate shall not exceed permissible quantities of deleterious materials as given in IS 383 table1 “Limits of deleterious materials (Aggregate)”.

2.3 Water

2.3.1 Water used for mixing and curing shall be clean reasonably clear and free from objectionable quantities of selfs, silts, alkalies, acids etc.

2.3.2 Water tested shall be in accordance with IS 3025. Maximum permissible limits of deleterious materials in water as given in IS 456.

2.4 Concrete block

Concrete blocks may be hollow (open or closed cavity) or solid and shall be referred to by its nominal dimension. The term nominal dimension includes the thickness of the mortar joint. Actual dimensions shall be 10 mm short of the nominal dimensions. Blocks shall be made in sizes and shapes to fit different construction needs. It includes stretcher, corner, double corner or pier, jambs, header, bullnose, partition block and concreted floor units. Nominal dimensions of concrete blocks shall be,

Length - 400, 500, or 600 mm

Height - 200 or 100 mm

Width - 100, 150, 200, 250, or 300 mm

Maximum variations in length shall be 5% in length and 3% in width and height.

Face shells and webs shall not be less than the values given in IS 2185 Part I – Table 1 "Minimum face shell and web thickness".

2.4.2 Concrete shall be mixed in the mechanical mixer. Blocks shall be moulded, laid and compacted with automatic machines. No hand/manual compaction shall be permitted unless approved by the Architect in writing for special blocks. Care shall be taken to see that the mix is placed in layers and each layer thoroughly tamped until the whole mould is filled up. Blocks shall be protected until they are sufficiently hardened to permit handling without damage.

Blocks shall be cured in the curing yard by keeping them continuously moist for at least 14 days. Steam-cured blocks shall be preferred. Cured blocks shall be allowed to dry for a period of 4 weeks before being used. The blocks shall be allowed to complete their initial shrinkage before they are laid in the wall.

2.4.3 All blocks shall be sound and free of cracks or other defects. For exposed construction face or faces shall be free of chips, or other imperfections, and the overall dimensions of the blocks shall be in accordance to tolerance as specified.

2.4.4 Blocks shall be considered as per IS if requirements of conditions mentioned in 11.2 to 11.5 of IS 2185 (Part I) are satisfied.

1. The number of blocks with dimensions outside the tolerance limit and/or with visual defects, among those inspected shall not be more than two.

2. Density and compressive strength shall be greater than or equal to the minimum limit specified in table 2 of IS 2185 (part I) "Physical requirements (Concrete blocks)".

3. Drying shrinkage shall not exceed 0.1 percent.

4. Water absorption shall not be more than 10 percent by mass.

2.5 Light weight blocks

2.5.1 Light weight cement concrete blocks to be as per make list. Blocks are manufactured under patent and brand. Blocks sizes are as per Manufacturer's specification.

2.5.2 Blocks should have minimum crushing strength 15 Kg/Sqcm for 100mm thick blocks and 30 Kg/Sqm for 150mm and 200mm thick blocks

2.5.3 Block shall be manufactured conforming to IS 2185 Part-III.

2.5.4 All blocks shall be sound and free of cracks or other defects. For exposed construction face or faces shall be free of chips, or other imperfections, and the overall dimensions of the blocks shall be in accordance to tolerance as specified.

2.6 Admixtures

Additives or admixtures may be added to the cement or concrete mix conforming to the following Indian Standard specifications.

1. IS 9103 Specifications for admixtures for concrete.
2. IS 3812 Specification for fly ash for use as pozzolana and admixture.
3. IS 2645 Specifications for integral water proofing compound.

Other additives or admixtures not being governed by Indian Standards shall be tested and checked that the same are not detrimental to durability. Any usage shall only be after the approval of the Architect.

2.7 Joint Fillers

Bituminous impregnated, premoulded joint filler board shall be of approved quality, manufacturer and conform to IS 1838 part I.

2.8 Metal reinforcement

Expanded metal used shall comply IS 412.

3.0 SCOPE OF WORK

3.1 Provide, construct concrete block masonry of specified type and strength conforming to IS code in specified cement mortar mix.

3.2 Provide and install required reinforcement.

3.3 Provide and install required stiffeners

3.4 Provide and construct construction and expansion joints.

3.5 Provide and install door frames / sub frames with using required fixtures

3.6 Provide and install lintels, louvers, sleeves braces

3.7 Provide and install hollow steel metal door frames and grout the voids.

3.8 Provide, pointing, reclining, cleaning of joints

3.9 Carry out curing and protect the work.

4.0 WORKMANSHIP

4.1.0 Mortar

4.1.1 Mortar shall be prepared by mixing fine graded aggregate with cement and approved non-shrinking compound (as specified by manufacturer of approved chemical) in the proportion specified for respective items of work as detailed in the BOQ. Mixing of mortar shall be done by mechanical mixers only. Hand mixing may be permitted in specified cases on the written permission of the Architect.

4.1.2 Mortars shall be specified by proportion. Volumetric mixing shall be based on dry volumes of each ingredient. For convenience, measurement shall correspond to volume of one cement bag i.e. 0.035 Cum. Boxes shall be of size 40 x 35 x 25 cm. These shall be marked as mortar mixing boxes by red paint and shall be used throughout the contract. Hand mixing or mechanical mixing proportions shall be done with the use of these boxes.

4.1.3 Cement mortar shall be prepared by mixing cement and sand in specified proportions. Proportioning shall be carried out as detailed above. Sand shall be added suitably to allow for bulkage if required. Bulkage shall be determined as specified in IS 2386 Part–III. Cement and sand added to mixer shall be thoroughly mixed and water shall be added to it gradually. After addition of water the mixer shall run for a minimum of 3 minutes. The mortar mixed shall be consumed within 30 minutes of its mixing.

4.1.4 If mentioned in the BOQ, Ready mix mortar to be used as per the specification of the manufacture

4.2 Installation

4.2.1 Concrete blocks shall not be wetted like brick masonry prior to use. In total dry climate top and sides may be slightly moistened to avoid absorption of water from mortar.

4.2.2 Concrete block work shall be laid in English bond. Joints shall not be bigger than 10 mm and will be perfectly horizontal and vertical. Joints shall be raked 10 mm deep while mortar is green.

4.2.3 Cut blocks shall not be used. Special solid precast blocks at site shall be cast well in advance to be used as spacers and to adjust breaking of vertical joints.

4.2.4 Cracks in block masonry are due to shrinkage or expansion of blocks or due to load settlement, thermal expansion or changes in moisture content in the structural members enclosing the block walls. The following measures are recommended to prevent formation of cracks.

a. While curing, the block masonry should be lightly sprinkled with water and not made excessively wet.

b. Expansion joints shall be provided in walls exceeding 6 m in length. However for more the 5 m length vertical stiffeners shall be provided.

c. Reinforcement should be provided in the bed joints in block work, one course above and one course below windows and above doors in order to distribute the shrinkage/ temperature stresses occurring at the corners of openings, more uniformly throughout the walls.

d. In framed structures, erection of partition and panel walls should be delayed to take care of deformations due to structural loads.

e. Partition walls should be suitably reinforced in lower courses to strengthen against excessive deflections of floor slabs and should be separated from the ceiling by a layer of resilient material. Joint shall be carried out in plaster or any other finish.

4.2.5 Where required damp proof course layer shall be laid as specified.

4.2.6 Exposed faces and corners of masonry damaged during construction shall be removed and repaired as acceptable to Architect.

4.2.7 Scaffolding :

Scaffolding independent of block work i.e. double legged scaffolding shall be provided. It should be tied to block work or structure at suitable intervals in both directions. Two rows of planks shall be provided all around. Planks shall be at least 50 mm thick and well-tied to scaffolding. Railing to the outside face shall be provided. While erecting scaffolding, the following points must be noted and closely followed:

1. Minimum number of holes in the horizontal direction.

2. No holes near the skew backs of arches.

3. Scaffolding must be sound and strong and easy to maintain.

4. Holes left must be closed while finishing the plaster.

4.2.8 Raking back shall be carried out at an angle not steeper than 45 degrees in case all the block work is not raised together.

4.2.9 The block should be of full height and no cut pieces shall be allowed. PCC levelling course shall be laid to fill up the gap.

4.2.10 Protection and curing

Fill all joints and rack the joints neatly. Clean the exposed surface neatly making sure no stain or deposits of mortar seen on the surfaces. Clean all surfaces with coir brush.

Green work shall be protected from rains by suitable covering. Masonry in cement mortar shall be kept constantly moist on all the faces for a minimum period of ten days. The top of masonry shall be left flooded with water at close of the day.

4.3

- Set out all work including opening for doors and with help of setting out rods heights of doors, sills of window as per approved architectural drawings.
- Ensure that full size block is at finish level. Provide cut size blocks or adjusting PCC course start of masonry.
- Laying of masonry shall be true to line, level and plumb. All courses vertical joints shall be uniform height and width (i.e. not more than 10 mm).
- Damaged, broken, defective (chipped, spalled, cracked) units shall not be used.
- In slope cut bottom course to maintain horizontal level jointing spread the mortar to extent it is practical to work before mortar gets stiffened.
- Stop vertical joints in steps.
- Maximum height of work in a day should be limited to 1.8 m and difference in adjacent wall shall be more than 1200 mm.
- Cutting and fitting shall be cut accurately. Holes made shall be neatly cut to proper size.
- Chases, recesses, anchors, inserts, reglets, door frames, access doors, louvers, panel boards, junction boxes, grounds, lintels, bearing plates, steel bearing on masonry work and all other provisions for works of others shall be built into the masonry work as it progresses; not cut in. all such items built into masonry work shall be accurately located, plumb, level and true, free of distortions, and in proper alignment.

- Verify approval has been obtained of installation of pipes, conduits, ducts, etc. before building chases or enclosing with masonry.
- No chases will be permitted in exposed masonry work.
- Do not remove braces for door frames until door frames have been built completely into masonry work and masonry has attained full strength.
-

5.0 MEASUREMENT

Hollow or solid cement concrete block work shall be measured in Cubic meter unless mentioned in BOQ.

6.0 RATE

6.1 The rate shall include the cost of all the materials and labour as described in their respective items of work and for all the operations as detailed in the respective specifications for the various items of work. Block on edge courses, cut block corners, splays, reveals, cavity walls, shall be included in BLOCK WORK - for the purpose of payment.

6.2 The following operations shall be included in the rate for BLOCK WORK -:

a) Raking out joints for plastering or for pointing done as a separate process or for finishing joints flush as work proceeds;

b) Preparing tops and sides of existing walls and the like for raising.

c) Rough cutting and waste for forming gables, cores of arches, splays at caves and the likes and all rough cutting in the body of block- work, unless otherwise stated;

d) Plumb to angles and battered surfaces;

e) Forming reveals to jambs where fair cutting on exposed faces is not involved;

f) Leaving holes for pipes, etc.;

g) Building-in holdfasts, air blocks, fixing blocks, etc.;

h) Building-in ends of beams, joists, slabs, lintels, sills, trusses, etc.;

i) Forming openings and flues for which no deduction is made;

j) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets, etc., in or on walls, if not covered in their respective trade.

k) Leaving chases of section not exceeding 50 cm in girth.

l) Scaffolding.

m) Curing and protection.

n) Work at all heights, leads, lifts, etc.

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VOLUME - I

7.00 PLASTERING WORK

1.0 GENERAL

1.1 INDIAN STANDARDS

Indian and other international standards followed for this section shall be as listed below. In case any discrepancies or ambiguities noticed it shall be brought to notice of the Engineer-in-charge and clarification/confirmation sought. His decision shall be final. However as general rule more stringent specifications shall be followed.

1.	IS 383	Specification for coarse and fine aggregates for natural sources for concrete.
2.	IS 412	Specifications for expanded metal steel sheets for general purposes.
3.	IS 1489	Specification for Portland pozzolana cement.
4.	IS 1542	Specifications for sand for plaster
5.	IS 1661	Code of practice for application of cement and cement-lime plaster finishes.
6.	IS 2402	Code of practice for external rendered finishes.
7.	IS 2645	Specifications for integral cement water proofing compound.
8.	IS 6452	Beads for internal plastering and dry lining specification for galvanized steel beads.
9.	IS 8112	Specification for 43 grade ordinary Portland Cement.

1.2 Quality Assurance

1.2.1 All material used in the work shall comply with latest standards listed above or in absence to International Standards if specified to be followed. Further it must be noted that it should meet approvals and requirements of local authorities and shall be used only after approval of the Engineer-in-charge in writing.

1.2.2 Material shall conform to IS specification when read in conjunction of bills of quantities, drawings and instruction of the Engineer-in-charge.

1.2.3 Material shall be tested through an independent authorised testing laboratory / agency who is equipped and experienced to carry out test as per IS standards.

1.2.4 GI beads shall be of approved quality.

1.2.5 Metal reinforcement used shall be as specified and conforming to IS.

1.3.0 Submittal

1.3.1 The Contractor shall submit product literature with samples for the approval of the Engineer-in-charge.

1.3.2 Samples

Samples of following products shall be submitted for approval samples shall be minimum 300 mm long and 300 mm square. Minimum 3 nos. of each samples shall be given.

1. GI beads
2. GI Chicken mesh
3. GI metal reinforcement

1.3.3 The Submittals by the contractor do not authorised it use in work unless it is approved in writing by the Engineer.

1.4 Mockups

Prior to start of work contractor shall prepare panels for each type of finish and application required to verify samples submitted and to observe / test aesthetic effects, quality of material and workmanship.

Mockup shall comply with

a) Demonstrate the proposed range of aesthetic effect and workmanship.

b) Erect mockup of full size and thickness including joints, supporting system if any, using proposed material.

c) Notify the Engineer-in-charge 7 days in advance of date of mock to be ready.

Retain mockup till ordered to be removed by the Engineer-in-charge.

1.5 Delivery, Storage and Handling

1.5.1 Store materials on elevated platforms in dry location so that it will not be damaged or contaminated during the storage period.

1.5.2 Store cementitious material on elevated platform, under cover and in dry location. Do not use damped cementitious material.

1.5.3 Store aggregate to maintain grading and characteristic.

1.5.4 Store plastering accessories in dry, covered place to prevent corrosion and accumulation of dirt and oil.

1.5.5 Handle and transport all material with care so as to avoid damage, breaking, cracking, chipping, and distortion.

2.0 MATERIALS

2.1 Cement

2.1.1 Cement shall be ordinary Portland Cement conforming to IS and shall be of grade 43 or Portland pozzolana cement as approved by the Engineer-in-charge. Pozzolana cement shall be preferred.

It shall be received in bags of 50 kg and each batch shall be accompanied with a test certificate of the factory. Also it shall be tested before use to ascertain its strength, setting time, etc. In case cement has been stored for over 2 months or for any reasons the stored cement shows signs of deterioration or contamination, it shall be tested as per the direction of the Engineer-in-charge prior to use in the works.

2.1.2 Cement shall be stored in such locations so as to prevent deterioration due to moisture dampness. A dry and water proof shed shall be best suited for this. Bags shall be stacked on rigid waterproof platforms about 15 to 20 cm clear above the floors and 25 to 35 cm clear or away from the surrounding walls. A maximum high stack of 12 bags is permitted. Stacks shall be so arranged that the first batches are used first, and (FIFO) that they permit easy access for inspection and handling.

2.2 Water

2.2.1 Water used for mixing and curing shall be clean, reasonably clear and free from objectionable quantities of silt, oils, alkalies, acids, salts so as not to weaken mortar. It shall conform to IS 456.

2.2.2 Water tested shall be in accordance with IS 3025. Maximum permissible limits of deleterious materials in water as given in IS 456 Table 1 “Permissible Limits for Solids (in water)”.

2.3 Coloured cement may be either ready-mixed material or may be obtained by mixing pigments and cement at site. The pigments to be mixed with cement shall conform to Appendix "A" of IS 2114 code of practice for laying in-situ Terrazzo Floor Finish.

2.4 Sand shall conform to IS 1542 specification for sand for plaster. For white or coloured renderings, only quartz or silica sand shall be used. For textured finishes produced by treatment of freshly applied final or finishing coat with a tool, coarser, particles used shall be screened through 3.35 mm IS sieve or 2.36 mm IS sieve. For torn texture a slightly larger portion of material coarser than 4.75 mm IS sieve shall be used.

2.5 Aggregate shall conform to IS 383.

2.6 Integral water proofing compound shall conform to IS 2645 (specification for integral water proofing compound).

2.7 Neeru shall be obtained by mixing lime putty and sand in equal proportions and chopped jute @ 4 kg/cum of mortar and ground to fine paste in the chemical grinder to give fine butter-like paste. Approved ready made neeru available may be permitted if desired by the contractor after testing at site.

2.8 Fibrous materials

Certain natural fibers, such as flax, sisal, manila, jute hemp, and coconut fibers may be used for incorporation in the mortar. They shall be clean, dry and free from oil.

2.9 Expanded metal

Expanded metal used as background for rendering shall comply with requirements of IS 412.

2.10 GI Chicken Mesh

Chicken mesh of 20 G with opening of 25 x 25 mm hot dipped galvanized shall be provided over junctions of two dissimilar material about 300 mm wide as directed by the Engineer-in-charge. Alternatively PVC chicken mesh can also be used.

2.11 Beads

2.11.1 Zinc coated steel for exterior work shall be used. Nominal size to be provided are 5 mm bead with 60 mm minimum expanded metal wings as manufactured by M/s Expamet bead ref. no. 558 or equal approved.

2.11.2 Casing beads

Zinc coated steel for exterior work shall be used. Nominal size shall be 5 mm return square edged bead with 75 mm wide expanded metal wing, depth to suit plaster thickness. Gauge and size shall be as recommended by the approved manufacturer. M/s Expamet plaster stop ref. no. 561 and 566 or equivalent shall be used.

2.11.3 Expansion joint beads

Zinc coated steel for exterior quality with adjustable openings size as shown in drawings and manufactured by expamet or equivalent approved shall be used. Gauge and size shall be as per recommendations of approved manufacturer.

2.11.4 Special Beads

Zinc coated steel beads of sizes and shape as shown in drawings to suit site conditions shall be used. Gauge thickness and other details shall be as per recommendations of approved manufacturer.

2.12 Bonding Agent

Chemical bonding adhesive of approved chemical admixture manufacture's shall be used as per recommendations of manufacturer over concrete surface.

2.13 Binder

Fiberglass fibers free of dirt, oil, grease, diterious material or other impurities about 12 to 50 mm long of approved manufacturer in proportion as recommended by manufacturer shall be used to achieve dense mix as per instruction of the Engineer-in-charge.

2.14 Coloured Curing compound to be used of approved make.

3.0 SCOPE OF WORK

3.1 Plastering work scope shall include preparing surfaces, applying plaster, providing reinforcement such as beads, chicken mesh, scaffolding, curing to correct line, level and plumb within acceptable tolerances. Work may be in single coat or multiple coats as specified.

3.2 Finish shall be as specified and approved by Engineer-in-charge.

3.3 Finishing of grooves, jams, cills, pattas, motifs, grooves, etc. shall be part of the work.

3.4 Work shall include required material and at all locations with required leads, lift and height.

- Internal single coat cement sand mortar plaster minimum 12 mm thick for wall.
- Internal single coat cement sand mortar plaster minimum 12 mm thick for ceiling.
- Internal to ducts double coat cement sand mortar plaster minimum 12 mm thick including waterproofing compound.
- External double coat cement sand plaster minimum 18 mm thick including waterproofing compound.

4.0 WORKMANSHIP

4.1 Mortar

4.1.1 Mortars shall be prepared by mixing fine graded aggregate with cement, the lime or a combination of these in the proportion specified for respective items of work as detailed in the BOQ. Mixing of mortars shall be done by mechanical mixers only.

4.1.2 Mortars shall be specified by proportion only and not by strength. Volumetric mixing shall be based on dry volumes of each ingredient. For convenience, measurement shall correspond to volume of one cement bag i.e. 0.035 cum. Boxes shall be of size 40 x 35 x 25 cm. These shall be marked as mortar mixing boxes by red paint and shall be used throughout the contract. Mechanical mixing proportions shall be done with the use of these boxes.

4.1.3 Cement mortar

Cement mortar shall be prepared by mixing cement and sand in specified proportions. Proportioning shall be carried out as detailed above. Sand shall be added suitably to allow for bulkage if required. Bulkage shall be determined as specified in IS 2386 Part III. Cement and sand added to mixer shall be thoroughly mixed and water shall be added to it gradually. After addition of water the mixer shall run for a minimum of 3 minutes. The mortar mixed shall be consumed within 30 minutes of its mixing.

4.1.4 If mentioned in BOQ, ready made (Pre-Mix) cement plaster complying with IS1661-1972, IS 2550-1965, IS2402-1963 to be used.

4.2 Application

4.2.1 Preparation of surfaces

a) Surfaces to be plastered must be clean and free from dust, loose material, oil, grease, mortar droppings, sticking of foreign matter, traces of algae, etc. It is very important to ensure that there should not be any chance of the plaster getting debonded due to presence of materials harmful for bonding.

b) Raking out of joints is expected to be carried out along with masonry but it should be checked thoroughly so as to receive good key.

c) Joints shall be racked and grouted / pointed with square crushed aggregates.

d) Apply rust removal to metal surfaces which are in contact with plaster.

e) Actual plastering shall be undertaken only on the approval of the Engineer-in-charge. Plaster work should follow the steps mentioned below :

- Surface must be thoroughly cleaned, hacked and applied with approved chemical adhesive over concrete surface to receive scratch coat. Joints shall be racked and grouted / pointed with square crushed aggregates.
- Plaster area must be provided with level dabs or spots allowing working and checking with 2-3 m straight edge. Depth of plaster must not be less than 20 mm at any point.
- Fix corner / stop / special beads at locations shown in drawing or required by Engineer-in-charge or suggested by bead manufacturer.
- Corner beads to true vertical plumb, level and of longest length to minimize joint shall be set at all external corners.
- Plaster stops shall be fixed to correct line, level and plumb where plaster terminates or abuts with other surfaces.
- Expansion joint beads shall be provided to correct line, level and location and shall be of specified size only. It shall be set exactly as detailed in drawing.

- Required concealing services must be completed and tested.
- No further cutting of masonry must be required.
- Repairs carried out to masonry or concealing work must be cured and dry.
- Surface must be sufficiently damp.
- Plaster dabs are checked for plumb and level by the Engineer-in-charge or his representative.
- Joints, concealing and repairing areas must be covered with GI mesh as per the Engineer-in-charge's instruction.

e) Walls should be sufficiently damp prior to plastering. Water from plastering mortar must not be absorbed by masonry under any condition.

f) Any unavoidable projections in masonry and concrete surfaces shall be chiseled back. Care shall be taken that surrounding surfaces are not damaged and reinforcement is not exposed.

4.2.2 **Application of Plaster**

a) All concrete surfaces shall be applied with 5 mm thick skim coat by 1st applying bonding agent as recommended by the manufacturer. Surface shall be cured for 3 days. Joints shall be racked and grouted / pointed with square crushed aggregates.

b) The method of application is also important and hence it is recommended that the mix be thrown on the surface rather than stuck with trowel. This increases the adhesion.

Apply 12-15 mm thick full depth coat material over skim / scratch coat with pressure to form full grip

c) Plaster shall be leveled and lined by aluminium hollow section, 2-3 m long. (This will give even and leveled surface). There shall not be more than 2 mm difference in level when checked with 3 m straight edge. It is important that enough pressing and beating is done to achieve compact filling of joints and that the area is fully compacted.

d) Corners, external or internal, shall be finished along with final coat. It is advisable to have rounded corners.

e) Finishing of plaster may be carried out with wooden float (randhas) or trowel led smooth with sheet metal trowels as specified. Care shall be taken to avoid excessive trowelling and overworking of the wooden float.

f) All corners, internal or external, shall be truly vertical or horizontal. These shall be finished with a proper template to achieve best workmanship for rounding and chamfering as specified or directed.

4.2.3 Plaster shall be cut to correct horizontal or vertical line at the end of the day or if work requires to be suspended for any reason.

4.2.4 It is advisable to limit the area of plaster to 15 sq m to avoid cracks due to thermal movements of dissimilar material in contact, it is advisable to provide joints treated with groove or any other detail as suggested by the Engineer-in-charge. These joints if not specified shall be treated with 150 mm wide reinforcing chicken mesh (approved by the Engineer-in-charge) fixed over joints by GI nails and the area plastered.

4.2.5 Plaster shall be cured for 14 days by wet curing except in neeru finish plaster. During this period plaster shall be protected from exposure to extremes of temperature and weather.

4.2.6 Scaffolding should be rigid, allowing free and safe movement on the platform and it should be at sufficient distance or height from the working areas. Scaffolding with railing gives more confidence to workers and improves the quality of work.

4.3 12 mm-15 mm thick Internal plaster

Single coat cement-sand plaster with cement-sand mix in proportion of 1:4 or as specified in BOQ / Schedule shall be carried out over the entire area as detailed above. This shall be finished just with wooden float to give the best smooth surface possible. This may be for internal or external areas. Thickness may be from 10 to 15 mm maximum or as specified in the item or drawing.

4.4 18 to 25 mm ordinary cement sand plaster

This is the same as for the 12mm thick single coat plaster except that this shall be carried out in two coats. Maximum thickness of the undercoat shall be 12-15 mm and balance in the second finishing coat. All operations remain the same and are as detailed in Clause 3.0 of this section.

4.5 Neeru finish plaster

12 to 18 mm thick internal plaster shall be carried out as above in single or two coats respectively. 2 to 3 mm thick neeru shall be applied over the plaster when it has just hardened. It shall be finished smooth by a steel trowel and worked over to achieve smoother finish. Curing shall start only after 24 hours after neeru punning has been completed. This shall not be hosed down like other plaster but kept green by slight sprinkling of water for a period of 10 days.

4.6 Cement finished plaster

This shall be carried out in the same manner as in Clause 4.3 and 4.4 of this section for specified thickness in single or double coat. Then it shall be finished uniformly over the entire area with a paste of neat cement when the plaster has just hardened and finished smooth with a steel trowel. It shall be worked over again to achieve a smooth leveled surface. Quantity of cement applied shall be about 1 kg/sqm.

4.7 White cement based putty

Providing and applying White cement based putty; "Birla White" or equal approved of average thickness of 1mm to 2mm as per approved manufacturer's specifications and instructions over pre-plastered surfaces or/and fare finished concrete surfaces including preparing, cleaning surfaces, finishes smooth etc. at all heights and leads as per specification, details, instructions to the entire satisfaction of the PM/EIC.

4.8 External Cement Plaster

4.8.1 This shall generally be carried out on the outside face and exposed area of masonry work and concrete work. It shall be of minimum 18 mm thickness and shall be in two coats. The coat shall be CM 1:4 (1 cement : 4 sand) mixed with water-proofing compound as per manufacturer specifications and applied as usual and surface shall be keyed.

4.8.2 The second coat shall be applied after 7 to 10 days and shall be of CM 1:3(1 cement : 3 sand). Mortar shall be mixed with slightly coarse sand. Mix shall be worked over with 3 m gauge or wooden float to achieve an uniform surface.

5.0 RATE

5.1 Description of item in the BOQ, unless otherwise stated, includes, wherever necessary, conveyance and delivery handling, unloading, storing, fabrication, hoisting, all labour for finishing to required shape and size, setting, fitting and fixing in position, straight cutting and waste, return of packings and other incidental charges.

5.2 Levels and heights shall be as indicated in the BOQ.

5.3 Preparation of surface shall be as approved by the Engineer-in-charge.

5.4 Trimming off the projections on masonry shall be included in the price.

5.5 Scaffolding and working platform shall be included in the price.

5.6 Materials as detailed and as required to complete item as specified shall be included in the price.

5.7 Curing of plaster shall be included in the price.

5.8 Cleaning of adjacent areas, windows, door frames, etc. including masonry surface in exposed masonry work, shall be included in the price.

5.9 Forming grooves for joints between beams/columns and masonry or at any other location etc. shall be included in the price.

5.10 Providing and fixing chicken mesh at junction of R.C.C., brick work, edges, corners, chiseled and repaired brick work prior to plaster over concealed conduit, etc. shall be as directed by the Engineer-in-charge. It shall be considered as part of item and no separate charge will be payable.

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VOLUME - I

9.00 WATER PROOFING WORK

1.0 GENERAL

1.1 Standards

Indian and other International Standards followed for this section shall be as listed below. Any discrepancies or ambiguities seen shall be brought to the notice of the Engineer-in-charge and clarification / confirmation sought. His decision shall be final. However, as a general rule, more stringent specifications shall be followed.

1.	IS 73	Paving Bitumen Specification
2.	IS 269	Specification for 33 grade ordinary and low heat Portland cement.
3.	IS 383	Specification for coarse and fine aggregates from natural sources.
4.	IS 702	Specification for Industrial Bitumen
5.	IS 1322	Specification for Bitumen Felts for waterproofing and Damp proofing
6.	IS 2645	Specification for integral cement water proofing compound.
7.	IS 3370	(Part – I) Code of practice for concrete structures for the storage of liquid : General Requirements
8.	IS 3495	Method of Test for Burnt clay building bricks.
9.	IS 6494	Code of practice for water proofing of underground reservoirs and swimming pool.
10.	IS 7193	Specification of Glass Fibre Bitumen Felts
11.	IS 8112	Specification for 43 grade ordinary Portland cement.
12.	IS 12118	(Part – I) General requirements: Specification for two part Polysulphide based cement
13.	IS 12432	(Part – III) Application for Spray Applied Insulation - Code of Practice Part-3 Polyurethane/ Polyisocyarurate
14.	IS 13826	Method of Test.

1.0 MATERIALS

2.1 Cement

2.1.1 Cement shall be ordinary Portland cement conforming to IS and shall be of grade 43 or 33.

It shall be received in bags of 50 kg and each batch shall be accompanied with a test certificate of the factory. Also it shall be tested before use to ascertain its strength, setting time, etc. In case cement has been stored for over 6 months or for any reasons the stored cement shows signs of deterioration or contamination, it shall be tested as per the direction of the Engineer-in-charge prior to use in the works.

2.1.2 Cement shall be stored in such locations so as to prevent deterioration due to moisture dampness. A dry and water proof shed shall be provided. Bags shall be stacked on rigid water-proof platforms about 15 to 20 cm clear above the floors and 25 to 35 cm clear or away from the surrounding walls. A maximum high stack of 12 bags is permitted. Stacks shall be so arranged that the first batches are used first (FIFO), and that they permit easy access for inspection and handling.

2.2 Sand

2.2.1 Natural sand deposited by stream or glacial agencies as a result of disintegration of rock is the best form of sand and shall be used.

2.2.1.1 Sometimes it is obtained from crushed stone screenings but often contains a high percentage of dust and clay. It tends to be flaky and angular. This type produces harsh concrete and should be avoided.

2.2.1.2 Sea sand shall not be used.

2.2.2 Sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain any appreciable amount of clay. Sand shall not contain harmful impurities such as iron, pyrites, coal particles, lignite, mica shale or similar laminated material, alkali, and organic impurities in such form or quantities as to affect the strength or durability of concrete or mortar.

2.2.2.1 When tested as per IS 2386 Part I and Part II, sand shall not exceed permissible quantities of deleterious materials as given in table 1of IS 383.

2.2.3 Grading of sand shall conform to IS and shall fall within limits.

2.2.4 Sand shall be stored in such a way that it does not get mixed with mud, grass, vegetables and other foreign matter. The best way is to have a hard surface platform made out of concrete, bricks or planks. It should be to the approval of the Engineer-in-charge.

2.3 Block bats

2.3.1 Block bats shall be of approved make light weight blocks. Flaky and elongated pieces shall be avoided. It should also be free from adherent coatings of soil or silt. Block bats should be free from alkalies, soft fragments, organic impurities, etc. in such quantities as not to affect strength and durability of concrete.

2.3.2 Water absorption for the blocks after 24 hours immersion in cold water shall not exceed 10%.

2.4 Water

2.4.1 Water used for mixing and curing shall be clean, reasonably clear and free from objectionable quantities of silt, oils, alkalies, acids, salts so as not to weaken mortar, or concrete or cause efflorescence or attack the steel in RCC while curing. It shall be free of elements, which significantly affects the hydration reaction. Potable water is generally satisfactory but it shall be tested prior to use in the works.

2.4.2 Water tested shall be in accordance with IS 3025. Maximum permissible limits of deleStone terious materials in water should be as given in IS 456.

2.4.3 Water storage tanks shall be such as to prevent any deleterious materials getting mixed with it.

2.4.4 Water shall be tested and approved in writing by the Engineer-in-charge prior to use in the works.

2.5 Stone

2.5.1 Stone tiles such as kota / shahbad shall be of best quality and free from any defects and of uniform thickness.

2.6 Water proofing Materials

2.6.1 Synthetic elastomeric polymerised semisolid liquid and forming a film on curing.

2.6.2 Properties shall confirm to requirement as under.

1.	Material	:	Free from sodium and chlorides
2.	Chemicals	:	Not detrimental to concrete or reinforcing steel.
3.	Colour	:	Manufacturer's standard
4.	Testing Standards		
	1. Water proofing	:	IS 3085
	2. High temperature stability	:	ASTM D-794
	3. Abrasion	:	ASTM D-968/57
	4. Salt spray test	:	IS 2074
	5. Acid / Alkali resistance	:	Un affected over a period of 30 days by sulphuric acid solution pH 1 and sodium carbonate solution pH 13.5

6.	U.V. resistance	:	ASTM D-322
7.	Sword hardness after one week	:	50
8.	Elongation	:	20%
9.	Impact	:	25 Lb. test
10.	Abrasion Index	:	10-13

2.6.3 Accessories

Primers, bonding agents, water stops or plugs etc. as per recommendations of the manufacturer.

2.6.4 Mixes

a) Mix materials in accordance with manufacturer's instructions

b) Mix in clear containers

c) Do not re-temper mix after initial set.

2.7 Delivery / Storage.

All materials shall be delivered and stored at site conforming to following minimum requirements.

a) Material received is approved by Engineer-in-charge.

b) Material is in unopened container and labelled with manufacturer's name, brand name and instructions for use.

c) Material received shall be along with manufacturer's certificate for quality and period of manufacture.

d) Material shall be stored in dry, well ventilated and covered storage if so desired by manufacturer.

e) Primers, adhesives etc. shall be as recommended by the membrane manufacturer.

3.0 SCOPE OF WORK

3.1 Work shall include design, supply, install and test proprietary waterproofing systems to underground structure, terraces, roofs, toilet sunk slabs, planters, Swimming pools, Water bodies, UG and Overhead water tanks etc. This shall be guaranteed for 10 years on Rs.100/- stamp paper in proforma to be approved by the Engineer-in-charge.

a) Water proofing of basement including sealing of services junctions, drain points, sumps shall be as per approved box type proprietary treatment.

b) Water proofing of terrace inclusive of grouting, sealing rainwater down takes outlets, other services outlets, junctions of walls, slab, beam, columns, parapet

wall etc., where required expansion joints all as per approved terrace proprietary treatment.

3.2 Waterproofing of toilet sunk portions and water tanks inclusive of grouting, sealing, outlet pipes of services, junctions of slab, beams, walls and covering with protective cement sand plaster coat / screed.

3.3 Work shall include design, supply, install and test proprietary box type system for basement and terrace system for sloped/flat roofs as approved by the Engineer-in-charge. This shall be guaranteed for 10 years on Rs.100/- Stamp paper in proforma to be approved by the Engineer-in-charge.

Work shall conform to minimum standards specified. Systems detailed hereunder are to clarify type of water proofing system expected. Contractor is at liberty to suggest and submit equivalent system with products meeting / exceeding standards.

3.4 Sub Contractor / Specialist shall be from the approved list and shall be approved by the Engineer-in-charge in writing before being employed by the Contractor.

3.5 The Contractor shall submit

Statement giving detailed brief of work he proposes to carry out.

a) Name of agency with his experience certificate and quantum of work carried out.

b) Technical Specifications

c) Product data sheets of material to be used

d) Shop drawing detailing

1. Sections co-ordinated with typical installation details
2. Vertical termination and sealing
3. Laps needed if any
4. Typical expansion, construction and control jointing details with minimum requirement.
5. Horizontal fixing and laying details.
6. Typical finishing arrangement.
7. Flashings if required.

e) Protective measures to be taken.

f) Installation guidance

g) Samples of each product in duplicate fixed over plywood boards or similar to enable proper cross sections.

h) Manufacturer's certificate that product and material to be used is correct and shall give intended results when applied through authorized agency.

4.0 WORKMANSHIP

4.1 Preparation of Surfaces

a) The surfaces to receive the treatment shall be thoroughly cleaned of

1. Laitance, scales, loose material on surface.
2. Grease, oil or other contaminants by etching with 10-15% of solution of muriatic acid using commercial grade alkaline cleaner, flushing with clean water drying and vacuuming.

b) Surfaces shall be examined and well-defined cracks grouted by making 'V' grooves/notches with cement slurry, shall be cured and dried well before treatment.

c) Any honeycombs shall be carefully cut and plugged, and cured well before treatment.

d) Examination of surface shall account for the fact that,

1. Surfaces are cured for 14 days and no condensation has taken place.
2. Horizontal and vertical surfaces have smooth finish, free from defects.
3. Surfaces are dry, clean, and free of grease, oil, dirt, rust, corrosion, other coatings and contaminants which could affect bond of water proofing system.

4.2 Box type Water proofing installation

A. **Stone method -** Designing, providing, installing Box-type waterproofing system below RCC foundation/raft and on outside of RCC retaining walls. System should follow progressive lifts of RCC retaining wall and should create 100% watertight barrier around the structure, etc. all complete to the approval of PM and system shall be guaranteed for 10 years on appropriate value stamp paper. System recommended and specified are as under.

Floor (50mm thick) - Single Layer of Stone slabs

1. Clean the PCC concrete surface with a brush. Remove sharp protrusion on the blinding layer by chipping and local repairs. If PCC top surface is wet/moist, the same shall be allow dry to the approval.

2. All construction joints to be chipped by making V ??? Groove up to a depth

of 25 mm and the same to be filled with 1:3 cement ??? sand mortar with approved cement waterproofing compound (200 ml / 50 kg of cement). Prior to doing the above activity, Acrylic polymer 1:1(Cement & polymer) should be applied on the chipped surface as a Bonding Coat.

3. Place the cement slurry mixed with waterproof cement compound, which penetrates into lean concrete and fills porous areas.

4. Provide insert sockets and pipes to release the subsoil water pressure (wherever required).??After 24 Hrs Grout the socket with cement slurry mixed with approved waterproofing cement compound (200 ml / 50 kg of cement).

5. Apply 30 mm thick 1:3 cement-sand mortar with water proof compound as bedding. Embed stone chips of 12 mm down in the laid mortar.

6. Over base coat, place average 25 mm thick rough finished low porosity stone slabs (Shahabad/Kota stone or similar stone) by keeping a minimum 15 mm gap in between stone slabs. After 3-4 Hrs. gap of stone to be racked out. Fill the joints between the stone slabs with cement grout mixed with water proof compound.

7. After 24 Hrs. apply 20 mm thick Protective coat over it by 1:3 cement-sand mortars with Polymer (200 ml / 50 kg of cement).

8. After 24 Hrs. Flood the treated area with water for 7 days.

Walls - Double Layer of Stone slabs

1. Preparing the surface including making 'V' grooves at junctions, joints, cracks etc. providing nozzles and grouting them under pressure. Grout shall be cement based mixed with expanded additive.

2. Hack the surface on a random basis.

3. Clean the surface by Wire/Coir brush to remove all laitance, loose particles, loose concrete lumps & oil stains, etc.Wash the surface with water Jet.

4. Fix 15 mm thick rough porous stone slabs with the help of cement paste applied on the internal face of stone slabs, having a gap of 15 mm between the external face of the RCC Structure and internal face of the slabs. The stone slabs are to be fixed side by side without leaving any gap between the edges. Maximum of 1200-1500 mm vertical layers of stone to be laid at a time.

5. Fill the gap between RCC structure and stone layer with cement grout mixed with Polymer (200 ml /50 kg of cement).

6. After 24 hours, apply another layer of stone in the similar manner.

7.Fill the gap between the stones with cement grout mixed with waterproofing compound.

8. Apply 25 mm thick. Cement-sand mortar plaster with approved waterproofing cement compound over stone slab as a protective coat.

4.3 Terrace waterproofing (Brick bat coba)

4.3.1 Various experienced water proofing specialists shall carry out the following or similar types of water proofing treatments. Terraces and roof slabs shall be treated with integral cement based waterproofing consisting of light weight block bat coba concrete laid to slope. The treatment shall be taken over vertical surfaces as required / specified. Final finished surfaces may be laid with paving tiles, stones or finished smooth in cement and marked with false chequered marking. Points given below are just for guide lines. The actual steps and details shall be submitted by the contractor for approval of the Engineer. Work shall be carried out as per approved method by the Engineer.

4.3.2 Surface preparation

The surface to be treated shall be cleaned and inspected thoroughly

a) All minor, medium cracks shall be marked.

b) All cracks shall be well defined and `V' groove made. These shall be cleaned with compressed air, grouted with cement sand mortar 1:5 (1 cement : 5 sand) slurry mixed with non shrinking and waterproofing compound. Areas well cured.

c) Then again surfaces shall be well cleaned of all loose particles, laintances, moss, oil/greasy material, cement etc.

d) Roof areas shall be well marked with spot datums to create ridge, lines, slopes and drain points for easy draining of water (Nominal slopes shall be about 1:100).

e) Cement sand mortar mixed in ratio 1:3 along with waterproofing and non shrinking compound as specified by manufacturer shall be mixed with clean water and layer of about 20 to 30 mm laid over the entire area to be treated; then well soaked saturated light weight brick bats shall be arranged by proper placing to create required slope as per datum established. Minimum thickness at draining point shall be 50 mm.

Rain water inlet, pipes etc. shall be well grouted; edge, corners shall be well rounded (watta) by taking up treatment about 300 mm above proposed finished level.

f) These mortar laid and bat fixed area shall be kept dipped in water for atleast 3 days.

g) Slab and roof soffits shall be examined for dampness from under. Any leakage / dampness noticed shall be treated with pressure grouting and again checked by dipping the area for 3 days.

h) When no dampness noticed, area shall be drained out and cement sand mortar mixed in ratio 1:3 (1 cement : 3 sand) shall be spread over the entire area and bats well grouted.

The top surfaces shall be finished to a neat horizontal datum level to achieve well defined ridges, gutters, watta etc. Edges shall be tucked in grooves in wall / parapet about 300 mm above proposed finished level.

i) Surfaces shall be finished with 20 mm thick waterproof screed of 1:3 with finishing of top with neat cement of 2.75 kg/sqm and line dori marking of 300*300.

j) All expansion joints shall be cleaned, primed and finished with sealant as specified by manufacturer of sealant and approved by Engineer-in-charge.

4.4 China mosaic work

The following are the guidelines for carrying out this treatment. All specialized Water Proofing Contractors have their own methods that may be used as per the approval of the Engineer-in-charge.

4.4.1 The surface that shall receive the treatment shall be cleaned and all well-defined cracks shall be cut to a "V" groove, cleaned and filled up flush with cement-sand slurry.

4.4.2 Well-defined cracks other than hair cracks in the roof shall be cut to "V" groove , cleaned and filled with cement-sand-mortar mix in a ratio of 1:3. The treated surface shall be cured for 7 days. It shall then be treated with chemical polymer modified coating sandwich with nylon mesh hand then provided with slopes 1:120. These slopes

shall be achieved by laying light weight block bat coba cement concrete as detailed above. It shall be cured and the following treatment shall be carried out.

4.4.3 The well-cured and dust-free surface shall be screeded with cement sand mortar in a ratio of 1:6 (1 cement : 6 sand), 12 mm thick.

4.4.4 While screed is still plastic but hardened a 3 mm thick floating coat of cement paste shall be applied. Whilst the floating coat is still green, china mosaic pieces (fully soaked in water) shall be set flat as close as possible in a pattern as specified or directed by the Engineer-in-charge. A light wooden roller or suitable tool shall be used to make sure pieces are placed firmly and the cement paste oozed out.

4.4.5 The surplus cement grout shall be cleaned off.

4.4.6 Testing

Treatment shall be tested again by pending water about 250 mm high for 72 hours. Surfaces shall be examined for leakage seepage, dampness, sweating etc.

5.0 TESTING

5.5.1 On completion of installation and prior to next operation or as directed by Engineer-in-charge work shall be tested by the Contractor. Required water shall be arranged and disposed of by the contractor at his cost.

a) All openings, drains etc. shall be plugged.

b) Water shall be flooded about 200 mm over the Sunk portion. Water shall be kept for 72 hours.

c) Surfaces shall be observed critically and in case any leakage is observed areas shall be treated again and tests to be carried out again to the satisfaction of the Engineer-in-charge.

5.5.2 Approval of water test does not relieve the contractor of his obligation of providing installed water proofing guaranteed for 10 years as per contract.

5.5.3 All arrangement of material, labour etc. required including preserving and maintaining areas flooded shall be carried out by the Contractor at his cost.

6.0 GUARANTEE

6.1 All waterproofing systems described above are to be referred as guide-lines only. The contractor shall propose the system along with his tender, giving full descriptions.

6.2 The system shall be guaranteed for 10 years against all defects and liabilities thereof from the date of completion of project. The guarantee shall be on Stamp Paper of Rs.100/- in proforma to be approved by Employer/ Engineer-in-charge. (The contractor

shall submit proforma to Engineer-in-charge for approval of Employer before being written on Stamp Paper.) The cost of Stamp Paper shall be to the contractor's account.

6.3 Work shall be carried through approved specialist agency as per method of working approved in writing by the Engineer-in-charge.

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