SECTION -7

TECHNICAL SPECIFICATION

PROPOSED WORKS OF ARTIFICIAL TURF AND CIVIL WORKS FOR AIFF NATIONAL CENTER OF EXCELLENCE KOLKATA, WEST BENGAL, INDIA

FOR

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CIVIL WORKS

MATERIAL & WORKMANSHIP

I. GENERAL

Materials and Workmanship Specifications

The specifications listed in this Part of the Employer's Requirements may be modified by the Tenderer at the time of submitting the Tender to suit the requirements of the Tenderer's design. Any such modifications shall be submitted with the Tender.

When considering any changes, it shall be noted that the specifications given in this Part shall represent the minimum required standards for material and workmanship to be followed in the construction of the works.

Where there is any discrepancy between this Part 4 of Employer's Requirements and either Part 2 or Part 3 of the Employer's Requirements, the requirements of Part2 and Part 3 shall take precedence.

Standard of Works

The whole of the materials employed in connection with the permanent work of the Contract shall be new and of the best quality and description of their respective kinds and, except where otherwise called for, shall be of the highest grade described in Indian or other relevant Standards for such materials and shall be tested as prescribed therein; similarly, the workmanship in every case shall be of the best character, and the whole shall be subject to the approval of the Engineer.

Standards & Code

Any Indian, British, American or other International Standard or Code of Practice referred to in the documents relating to the Contract shall be held to be the latest edition published at the time of Tender. Where alternative Standards or Codes of Practice have been published in metric units, these shall take precedence over the publication in imperial units.

Equivalent Standards

a) Subject to the approval of the Engineer, materials may be supplied conforming with other recognised Standards which correspond closely with the relevant Specified Standards.

b) In the event that the Contractor proposes use of an alternative Standard he shall provide to the Engineer a copy of the Standard proposed together with an authoritative translation into English where the original is in a language other than English.

Alternative Materials & Equipment

a) In all cases where the name of a particular type or make of equipment or material is referred to on the Drawings or elsewhere in this Specification, this is intended to indicate only the acceptable standard.

b) The Contractor may offer alternative materials to equipment to that specified and in all such cases the Contractor's offer shall be at least of equal quality. When alternatives are offered the Contractor shall submit to the Engineer for approval, a statement detailing the alternative(s) and shall include full technical descriptions, drawings, specifications, test certificates etc and shall provide such full information as is required to enable the Contractor to demonstrate to the Engineer that the

alternative(s) is (are) equivalent to the item specified. Any further information that the Engineer may require shall be produced by the Contractor when called for.

Approval of Materials & Items of Equipment

a) As soon as possible after the Contract has been awarded, the Contractor shall submit to the Engineer a list of suppliers from whom he proposes to purchase the materials required for the Works. Each supplier must be willing to admit the Engineer, or his representative, to his premises during ordinary working hours for the purpose of obtaining samples or inspection of the works and processes. In addition, if required by the Engineer, the Contractor shall deliver samples to the offices of the Engineer or to nominated testing laboratories or to the site of the Works. The cost of such samples shall be borne by the Contractor.

b) The Contractor shall provide at least the following information when seeking approval of materials and items of equipment.

- A Description of the material/item
- Name of proposed supplier
- Indian Standard, or other approved Standard applicable
- Test Certificates as applicable

c) The Contractor shall use locally produced materials in preference to imported providing they comply with the requirements of the Specification.

Supply of Samples

a) The whole cost of supplying adequate samples of any materials to be used in the Works for testing either at the Manufacturer's Works or at the site or at an independent Laboratory nominated by the Engineer, shall be deemed to be included in the rates or sums entered in the Price Schedule.

b) Samples shall be taken at regular intervals and tested in accordance with relevant standards.

Material – General

a) Sources of supply :

b) The sources of supply of materials shall not be changed from those approved without the written permission of the Engineer.

c) Quality of supply :

d) Materials subsequently supplied shall be at least equal to the approved sample in all respects.

e) Rejected materials :

f) Rejected materials are to be removed promptly from the Site.

g) Copies of orders :

h) The Contractor shall, at the Engineer’s request, forward to the Engineer copies of orders for materials to be incorporated into the Works.

i) Manufacturers instructions :

j) All materials, goods etc., shall be used or installed in accordance with the instructions of the Manufacturer or Supplier unless otherwise specified or instructed by the Engineer.

Testing of Samples

a) At the Manufacturer's Works :

b) The costs of testing at Manufacturer's Works of any materials to be used in the Works and the supply of "proof" or test certificates by the Manufacturer shall be deemed to be included in the rates or sums entered in the Price Schedule.

c) At an Independent Laboratory :

d) In addition to those tests required by the Employer's Requirements and relevant Standards, the Engineer may at any time instruct the Contractor to supply samples of materials to be used in the Works for test by an Independent Laboratory. The costs of transport to the Independent Laboratory and laboratory charges, fees of independent inspectors, etc, shall be paid for under the appropriate item in the Price Schedule, except where a sample is found not to be in accordance with the specified requirements, in which case the costs shall be borne by the Contractor.

e) Sampling and Testing frequency:
The sampling and test frequencies shall be as per the relevant IS codes. Where the relevant IS code does not lay down any frequency for sampling and testing, the same shall be as given in the table below or as directed by the Engineer

II. TECHNICAL SPECIFICATIONS FOR STRUCTURE, CIVIL & FINISHING WORKS

1. TECHNICAL SPECIFICATION FOR EARTHWORK EXCAVATION

This specification covers the general requirements of earthwork. The earthwork shall consist of all works involved in site grading, excavation, shoring, filling around foundations, filling in plinths, disposal of spoils as directed by the Engineer, and such other relevant items. The area to be excavated or filled with the excavated materials shall be clearly demarcated in the field by the Contractor.
The earthwork shall also include, where required, temporary bracing and shoring to maintain excavation etc.
All excavation work shall be inspected and approved by the Engineer before any further works in excavated areas are allowed to commence.
Excavation shall be in all kinds of soils and shall include careful removal of all materials of whatever nature, whether dry or wet, necessary for the construction work, exactly in accordance with lines, levels, grades, curves etc. shown on the drawings. It shall be done to the exact length, width, depth and profile as shown in relevant drawings or as directed by the Engineer. Bottom of excavation shall be levelled both longitudinally and transverse direction and it shall be free of loose unconsolidated material. If excavated to greater length, width or depth, the contractor shall fill such extra excavation with M-10 grade concrete at his own expense and well rammed. If permitted by the Engineer, the extra length and width shall be filled in with good excavated earth or murrom and well rammed as directed. Extra excavation shall not be measured for payment. All bottom of excavation shall be lightly watered and thoroughly rammed before laying the next required material layer.
The contractor shall have full responsibility for the stability of the excavation.
The method of excavation, sheet piling and or other strutting system and methods shall be in every case be subject to the approval of the Engineer. The contractor

shall ensure the stability and safety of the excavations and protect the sides of foundation with proper strutting system.

Any dewatering, shoring, strutting and timbering or cutting of extra width of trenches required for the work and safety of workmen and equipment shall be done by the Contractor at his expense. Water from the dewatering shall be drained off in such a way that it does not cause any damage to any property or any nuisance to others.

The Contractor shall erect and maintain during progress of work temporary fences around dangerous excavations.

Excavation material required for filling shall be stacked or dumped where indicated by the Engineer. Excavated material not required for filling, unsuitable material (what is suitable and what is unsuitable is left to the sole discretion of the Engineer) and any surplus material from the stacks or dumps retained for filling, shall be removed and spread on the site where and as directed by the Engineer or carted away from the site as directed by the Engineer. Dumping of this surplus material shall be in an orderly manner and according to the levels/grades as indicated by Engineer.

Water accumulated within excavated areas from whatever causes shall be bailed or pumped out at Contractor's expense till such time, as backfilling operations are complete.

Contractor shall take necessary measures for protection and maintenance of earthwork. Any damage to the earth work shall be made good at Contractor's cost.

Backfilling around foundations in pits, trenches, plinth and under floors :

a) All clods of earth shall be broken or removed. Material for backfilling shall generally be obtained from the spoil of excavation. But, the Engineer shall have the option, in case of shortage of good selected earth obtained from excavation, to direct the Contractor to get the filling materials from approved borrow pits within the site. The Contractor shall make necessary access roads to borrow area at his own expense and maintain the same, if such access roads do not exist.

b) After the concrete or masonry in the foundation has fully set, the spaces around the foundation structure in pits and trenches shall be cleared of all debris, brick bats, mortar dropping etc. and filled with earth in layers not exceeding 15 cm each layer being watered, rammed and properly consolidated before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of the Engineer. Back filling shall be done in such a manner as not to cause undue thrust on any part of the structures. The final surface shall be trimmed and levelled to proper profile as directed by the Engineer. Decision of the Engineer concerning proper consolidation shall be final and binding.

c) The plinth and under floors shall be similarly filled with approved materials as described herein before in layers not exceeding 15 cm watered and consolidated with mechanical machines to the satisfaction of the Engineer. When the filling reaches finished level, the surface shall be flooded with water for atleast 24 hours, allowed to dry and then rammed and consolidated, in order to avoid any settlement at a later stage. The finished level of the filling shall be trimmed to the level specified.

Site levelling

Earth for area filling and levelling shall be obtained from the cut areas of work and if necessary the balance with approved good fill material from approved quarry or from any other source outside the boundary including all lifts and leads, laying in layers of

250 mm and below breaking clods, dressing to required lines, grades and levels, watering and compacting with power roller of 10 tonnes.

Clearing site

a) The ground over which the cutting is to be done and the ground over which filling is to be formed shall be cleared of all trees, brushwood, loose stones, vegetation, bushes, stumps and all other objectionable materials. The holes dug up for grubbing roots etc. shall be filled with suitable excavated material and compacted. Materials obtained from clearing site shall be disposed off by burning or disposal to areas outside the boundary of the project in such a way that there is no chance of their getting mixed with materials for filling.

b) For removal of vegetation etc. crawler mounted dozer of adequate capacity shall be used. The work will be supplemented by using manual methods wherever required. The dozer shall have ripper attachment for removal of stumps, roots, etc. All trees, stumps etc. falling within excavation and fill area shall be cut to such depth below ground level that in no case these fall within 50 cm of the sub grade bottom.

Setting out

After clearing the site, the area shall be set out as shown on the plans or as directed in writing. The contractor shall provide all labour, tools, tackles, instruments and materials required for setting out and establishing bench marks and grid pillars. The contractor will be responsible for maintaining bench marks, profiles, grid pillars as long as they are required. Levels and sections shall be taken by the contractor in presence of the representative of the Main contractor before the excavation/filling is started.

Materials

The contractor shall utilise all useful and acceptable material obtained from the cutting from anywhere within the site for filling of low areas anywhere within the site. The contractor shall obtain additional good quality material from approved quarries or from any other source. The filling material should be soil, murum or a mixture of soil, sand, murum, gravel, small boulders having laboratory dry density of at least 1.44 gm/cc. Rejected material if brought to site will be ordered to be removed at contractors cost. Any objectionable material found in the filling material shall be hand picked and removed.

The contractor shall be responsible for payment of rents, compensation, fees, royalty etc. and these are deemed to be included in the rates. The Main contractor shall remain indemnified regarding any claims that may be made by private owners.

Equipment

Pickaxes, crowbars, phawras and pans may be used for manual work. Scrapers, dozer, graders, dumpers, shovels, trucks, trolleys etc. may be used for mechanised work. Three wheeled 10 tonne power roller or sheep foot roller may be used for compaction. Mechanically driven tankers may be used for watering.

Construction Methods

Before any material is laid on the ground, the same shall be cleared of all rubbish etc. When the filling is to be laid on slopes, the existing slopes shall be ploughed deeply to give proper hold. The top layer of the ploughed surface shall be scarified and watered and compacted before any filling material is laid.

Whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical on 4 horizontal, such faces shall be benched as mentioned below immediately before placing the subsequent fill.

Continuous horizontal benches, each at least 300 mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh filling material to be added. However, when the existing slope against which the fresh material is to be placed in flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

All permanent faces of side slopes of cut and fill formed areas shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the Engineer by tracking a tracked vehicle considered suitable by the Engineer, on slope or any other method approved by the Engineer.

The finished side slopes of cut and fill formed areas shall be 2 to 1 (i.e. 2 horizontal to 1 vertical) slope or the slope required by the Engineer.

When the fill level is higher than the adjacent area outside the boundary of the project then the layers shall be laid in a suitable slope upto the ground level at the boundary line.

Laying the filling material

Filling material shall be placed in successive horizontal layers of 250 mm consolidated thickness or in thickness less than 250 mm if required by the Engineer extending to the complete area of filling. The extra loose stuff at the edges shall be trimmed after completion of earthwork without extra cost. When boulders, broken stones and hand materials are mixed up with the filling materials, care shall be taken to see that they are distributed evenly and uniformly into the earth and no hollows are left near them. No stone or hard material shall project above the top of any layer. Each layer of filling shall be levelled, watered, compacted and tested before the succeeding layer is placed. The surface of the filling at all times shall shed water and prevent ponding.

All clods, lumps, boulders, etc shall be broken to have a maximum size of 75 mm before filling and compaction.

Protection

The contractor shall take the necessary measures and precautions for the protection of the earthwork. Any damage to the earthwork shall be made good at the contractor's cost.

The contractor will have to make his own arrangements so that water is adequately and effectively drained and this arrangement may left after completion of earthworks if so desired.

Rolling

The layers shall be compacted with Power driven rollers of 8 to 10 Tonnes capacity. The roller shall pass atleast twice over the same area once in forward move and the second time in backward move.

Finishing

The filling shall be finished and dressed smooth and even in conformity with the alignment, levels, cross-sections and dimensions shown on the drawings with due allowance for shrinkage. All damages caused by rain, movement of vehicles or any other reason shall be made good in the finishing operations.

The contractor shall not excavate beyond the specified levels / dimensions on the drawings.

The finished cut and fill formation shall satisfy the permitted surface tolerances of +20 mm or -25 mm.

Where the finished surfaces fall outside the above specified tolerances, the contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density.

Maintenance

The contractor shall be responsible for maintaining the earth work satisfactorily at his cost till finally accepted including making good any damages.

Excess excavation

Any excess depth excavated below the specified levels shall be made good by dozing, grading and refilling with suitable material of similar characteristics to that removed and watered and compacted to achieve specified density.

Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during execution. Smooth wheeled, vibratory, pneumatic tyred, sheep foot or pad foot rollers etc. of suitable size and capacity as approved by the Engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of vibratory roller of 8 to 10 tonne static weight with plain or pad foot drum or heavy pneumatic tyred roller of adequate capacity capable of achieving required compaction.

The contractor shall demonstrate the efficiency of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for these site trials shall first be submitted to the Engineer for approval.

Rollers of adequate capacity shall be used to achieve the required compaction by artificial watering and rolling. Subsequent layer shall be placed after each finished layer is approved. The level of compaction required is 90% of Standard Proctor Density for all areas except where Roads and Building works are to be provided. At such places the required compaction density of Standard Proctor shall be as given below :

Roads	:	95%

Buildings

Top Layer	:	98%
500 mm below top layer	:	95%
Below 500 mm	:	90%

The top layer of filling shall be brought to the specified line, levels and grade as shown in the drawings or as directed.

2. TECHNICAL SPECIFICATION FOR CONCRETE WORKS

This specification covers the general requirements for plain and reinforced cement concrete of different grades.

The requirements for concrete shall be materials, storage of materials, design of concrete mix, sampling and testing, form and formwork, construction joints, preparation and placement of concrete including batching, mixing, conveying, depositing and curing, finishing, grouting, inspection, clean-up etc. The concrete shall generally comply with the requirements of latest IS : 456.

Unless otherwise specified, the rates for all RCC will be exclusive of reinforcements. Reinforcements will be paid for separately. Unless otherwise specifically mentioned, the rates for all plain and RCC works shall be inclusive of formwork, centering and shuttering.

MATERIALS :

Cement :

Unless otherwise specified, ordinary Portland cement of 43 grade conforming to latest IS : 8112 shall be used for all concrete works. Test certificates from the manufacturers to show that the cement brought by the contractor to site for use in the works fully complies with the relevant IS Specification shall be submitted to the Engineer at the Contractor's own cost. In addition, field test shall be conducted for every consignment of cement for the purpose of concrete design mix. Cement shall be stored and neatly packed in piles not exceeding 10 bags high in weather proof sheds with raised wooden plank flooring to prevent deterioration by dampness or intrusion of foreign matter. It shall be stored in such a way as to allow the removal and use of cement in chronological order of receipt, i.e. the first received being first used. Cement deteriorated and/or clotted shall not be used on work but shall be removed at once from the site. Daily record of cement received and consumed shall be maintained by the contractor in an approved form and a copy submitted to the Engineer once a week. Not withstanding the above, the Engineer, for any reasons whatsoever, may at his discretion order to retest, the cement brought to site in an approved testing laboratory and fresh certificate of its soundness shall be produced at the Contractor's own cost. Cement ordered for retesting shall not be used for any work pending results of re-test.

Aggregates :

Fine and coarse aggregates shall conform to IS 383. If required, the aggregates shall be washed and screened. Sampling and testing shall be as per IS : 2386.

Each size of aggregate shall be stored on a separate platform and shall avoid mixing and contamination with foreign material. Segregated aggregates shall be rejected. Cost of stacking, washing, screening and cost of all tests, sampling etc. shall be borne by Contractor.

Fine Aggregate :

Sand shall conform to IS: 383. It shall pass through I.S sieve 4.75 mm (3/16 B.S) test seive, leaving a residue not more than 5%. It shall be from a natural source approved by the Engineer. It shall be washed if directed to reduce the percentage of deleterious substances to acceptable limits at Contractors own cost. Sand shall not contain any trace of salt and sand containing any trace of salt shall be rejected.

The fine aggregate for concrete shall be graded within limits as specified in IS : 383 and the fineness modules shall range between 2.60 to 3.20.The fine aggregate shall be stacked carefully on a clean hard dry surface so that it will not get mixed up with deleterious foreign materials. If such a surface is not available a platform of planks or corrugated sheets or brick floor or concrete floor shall be prepared.

IS Sieve Designation	**Percentage Passing**			
	Grading	**Grading**	**Grading**	**Grading**

n	Zone I	Zone II	Zone III	Zone Iv
10 mm	100	100	100	100
4.75	90 - 100	90 - 100	90 - 100	95 - 100
2.36	60 - 95	75 - 100	85 - 100	95 - 100
1.18	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

Coarse Aggregate :

Coarse aggregate shall conform to IS : 383. It shall consist of crushed or broken stone, 95% of which shall be retained on 4.75 mm IS test sieve. It shall be obtained from crushed granite, trap, besalt or similar approved stones from approved quarry. Coarse aggregate shall be chemically inert when mixed with cement & shall be angular in shape and free from soft friable thin porous laminated or flaky pieces. It shall be free from dust and other foreign matter. Gravel/shingle of desired grading may be permitted as a substitute in part or full in plain cement concrete if the Engineer is otherwise satisfied about the quality of aggregate.

IS Sieve Designation	A						B			
	% Passing for single sized aggregate of nominal size						% Passing of graded aggregate of nominal size			
80 mm										
63 mm										

IS Sieve Designation	A						B			
	% Passing for single sized aggregate of nominal size						% Passing of graded aggregate of nominal size			
40 mm										
20 mm										
16 mm										
12.5 mm										

IS Sieve Designation	A						B			
	% Passing for single sized aggregate of nominal size						% Passing of graded aggregate of nominal size			
10 mm										
4.75 mm										
2.36 mm										

Unless otherwise specifically stated for all RCC works, the size of coarse aggregate shall be 20 mm and down size.

Water :

Water used for mixing concrete and curing shall be potable quality, fresh, clean, free from oil, salts, acids, alkali and shall be in accordance with the clause 4.3 of IS 456. The contractor shall produce test results of water proposed to be used on the job for approval by the Engineer for the mixing before casting any concrete.

Reinforcement : Refer separate specification given elsewhere.

Admixtures :

The use of admixtures may be allowed only if approved by the Engineer and his decision in this regard shall be final.

Concrete :

Concrete shall be specified in various graded designations as M-10, M-15, M-20, M-25, M-30, M-40,M-45, M-50 etc. The letter 'M' refers to the mix and the number to the minimum compressive strength in N/Sq.mm to be established by 28 day of 15

cms works cube tests with the probability of not more than 1 test out of 10 falling below that minimum.

The proportions of ingredients for concrete shall be such that in addition to complying with the strength requirement, the concrete shall have adequate workability and proper consistency to permit it to be worked readily into the forms and around reinforcement, under the conditions of placement to be employed without excessive segregation or bleeding.

All ingredients shall be proportioned and measured by weight using approved weigh-batching equipment. There shall be full field control of (1) predetermined grading of all aggregates that go into concrete (2) predetermined proportion of course aggregate, fine aggregate, cement and water for the required strength.

Design Mix :

The Contractor is responsible for the design of the concrete mix. The Contractor shall design the mix and submit for the approval of the Engineer. No concreting works shall be commenced without the approval of the design mix of concrete.

The Contractor shall make trial mixes using coarse aggregates, sand, water and cement actually available at site to be used for making concrete. Before making trial mixes all the ingredients shall be tested in the field laboratory and should conform to the relevant IS Specifications. Suitable proportions of sand and the several sizes of coarse aggregates for each grade of concrete shall be selected to give as nearly as practicable the maximum density, this is to be determined by mathematical means, laboratory tests, field trials or other means.

The minimum cement contents for design mix concrete of various grades shall be as per relevant IS 456:2000

The mix required to produce, place and compact the specified grade of concrete shall be designed by the Contractor. He shall carry out preliminary tests of specimen at his own cost at field laboratory as per IS : 456 and IS : 516 and he shall furnish to the Engineer a statement of proportions proposed to be used for various concrete mixes and grades of concrete for approval.

The minimum strength requirements shall be as follows :

Minimum compressive strength of 15 cm cubes at 7 days and 28 days after mixing, conducted in accordance with IS : 516.

Grade of Concrete	**Preliminary Test N/Sqmm**		**Work Test N/Sqmm**	
	At 7 days	**At 28 days**	**At 7 days**	**At 27 days**
M - 10 M - 20 M - 25	9.0 17.5 22.0	13.5 26 32	7.0 13.5 17.0	10 20 25

Once a mix including water cement ratio has been determined and specified for use by the Engineer, that W/C ratio shall be maintained.
Details of design mix concrete approved by the Engineer shall be submitted to the Engineer for record along with the results of sieve analysis and such other tests on cement, aggregates and water etc. The approved design mix shall then be followed for subsequent concreting operations at site till a variation in some characteristics of any ingredient is observed or till a variation in the degree of quality control necessitates a change in the mix.

Batching and Mixing of Concrete :

All materials for controlled concrete shall be batched as per approved design mix in suitable weigh batcher of adequate capacity and of approved design. Mixers for concrete may be stationary mixers of either the tilting or non-tilting type, or truck mixers of approved design. Thorough mixing of the concrete is essential and mixers shall be capable of combining the materials into a uniform mixture, uniform colour and of discharging this mixture without segregation. The mixers should always be operated at the speed and time recommended by the makers. The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. The consistency of the concrete produced from the mixers should have sufficient workability to enable it to be well consolidated, to be worked into the corners of the shuttering and around the reinforcements.
The slump for concrete as determined by slump tests as per Indian Standard 1199 latest edition, shall not exceed the maximum slumps indicated below for each type of construction using high frequency vibration unless otherwise approved or directed by the Engineer.
The contractor shall not place concrete having a slump outside the limits specified without the approval of the Engineer.
Atleast one slump test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in job conditions, or if required by the Engineer.

Transporting :

shall be conveyed from the place of mixing to the place of final deposit as rapidly as practicable by methods which will prevent segregation or loss of any of the ingredients. If segregation does occur during transport, the concrete shall be remixed before being placed. Normally not more than 30 minutes shall lapse between mixing and consolidation in position. All means of conveyance shall be adopted to deliver concrete of the required consistency and plasticity without segregation or loss of slump.

Concrete should be transported only by transit mixers

Placing :

Method of placing shall be such as to preclude segregation and as far as practicable the placing shall be continuous. Special care shall be taken in accordance with latest IS : 456 while laying concrete under extreme weather.
Concrete shall be transported by transit mixers and placed in position without segregation. It is important that the concrete be placed in its final position before the cement reaches its initial set. The concrete should normally be compacted in its final position within 30 min. of leaving the mixer, and once compacted, it should not be disturbed. Before the concrete is actually placed in position, the insides of the forms should be inspected to see that they have been cleaned and oiled, care being taken to

see that the reinforcements do not get contaminated. Temporary openings should be provided to facilitate inspection, especially at the bottom of columns, to permit the removal of all sawdust, wood shavings etc. Openings should be placed so that the water used to flush the forms will drain away. No water should be left in the forms. The concrete should be spread evenly in the form to avoid segregation and should completely fill all corners of the form work and the space between the reinforcement. Vibrator should not be used for spreading the concrete. Concreting should be carried on without interruption between predetermined construction joints.

Compacting :

The object of compacting concreting is to achieve maximum density. The concrete should therefor, be placed a little in excess of its specified depth so that after proper compaction its final desired depth is obtained. Manually rodding and tapping the concrete and tapping the form work on its external face shall be continuously carried out at the actual pouring head, while compacting the concrete with mechanical vibrators shall be done sufficient distance away from the pouring head, so that the vibrator is utilised only to compact the concrete and not to spread it. The Engineer may, however, at his absolute discretion, permit concreting by increasing the slump and correspondingly increasing the cement contents at contractor's cost. Except for shallow or inaccessible concrete the vibrator shall be penetrated vertically and at regular distance intervals, not at an angle and not at haphazard intervals. At corners, obstructions, embedded fixtures and congested reinforcement areas, the vibrators shall be manipulated with the utmost care and handled only by the most experienced workmen.

The number and type of vibrator to be used shall be subject to the approval of the Engineer and in general immersion type vibrators shall be used. Consolidation by using immersion vibrator will be in accordance with IS Code : 3558. Sufficient number of reserve vibrators in good working condition shall be kept on hand at all times, so as to ensure that there is no slacking of interruption in compacting.

Protection of Concrete :

All freshly placed concrete surfaces shall be protected from damages by workmen equipment or any other cause. The surface shall be protected from dry wind and direct sun rays. The Contractor shall provide and use, where directed by the Engineer enough tarpaulins or other suitable materials to cover completely or enclose all freshly finished concrete.

Curing :

As soon as the concrete is hardened sufficiently, it shall be cured by maintaining the concrete in a damp condition by application of wet sacking or other approved moisture retaining covering for a period of 28 days after placing the concrete. In floors curing should be carried out by ponding and covering with polythene sheets to reduce evaporation losses. Extreme care should be taken to ensure that all surfaces are kept in a moist condition and no local area shall be allowed to dry out intermittently. Curing shall be done with potable water free from sediments of any kind.

Construction Joints :

Construction joints in exposed concrete work shall be made only where shown on the drawings or directed by the Engineer and shall be in accordance with the details shown or approved by the Engineer. The procedure given in clause 20.1.4.2 of IS : 456 shall be followed for general guidance. All foreign matters shall be removed

from the concrete before it is allowed to fully harden. The removal shall be effected by scrubbing the concrete surface with wire and with bristle brushes and washing down to expose clearly the aggregate. However care shall be taken to avoid dislodgment of particles of aggregate. If concrete has been allowed to harden excessively the surface shall be chipped over its whole surface and thereafter thoroughly washed. Before fresh concrete is added on the construction joints, the surface of the old concrete shall be thoroughly wetted and covered with a thin layer of cement mortar 1:1.

Construction joints in concrete floors and walls of basement, water tanks or any other structures in contact with water or earth, shall be provided with PVC water stops of approved make coated on either side with hot asphalt. The longitudinal joints, in water stops, shall preferably be not welded or overlapped atleast 200 mm.

Sampling and strength test of concrete :

Sampling and testing of concrete shall be conducted in accordance with the latest issue of Indian Standard 1199, 516 and 456.

During the progress of construction compression tests shall be made to determine whether the concrete being produced complies with the strength requirements specified. The test will be made in accordance with Indian Standard 516 latest edition.

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following :

Quantity of concrete in the work, Cum	**Number of Samples**
1 - 5	1
6 - 15	2
16 - 30	3
31 - 50	4
51 and above	4 Plus one additional sample for each additional 50 Cum or part thereof

NOTE :

At least one sample shall be taken from each shift

A set of six specimens from random mixer batches, shall constitute a test, three being tested for 7 days and three being tested for 28 days strength.

The strength test result shall be the average strength of the three companion test specimens, tested at 28 days, except that, if one specimen in a test shows manifest evidence of improper sampling, moulding or testing the result shall be discarded and the remaining two strengths averaged. Separate procedures shall be established when cements other than Portland cement are used.

Normally, 7 day and 28 day tests shall be made on specimens. For any mix, a correlation between 7 day and 28 day strengths may be made in the laboratory. Soon after a job starts, a similar correlation will evolve for samples of concrete taken from the mixer. After that correlation has been established, the results of the 7 day tests may be used as an indicator of the compressive strengths which should be expected at 28 days, provided such results are consistent. If 7 day tests show compressive

strengths that are too low, measures shall be taken at once, at the Engineer's direction, without waiting for the results of the 28 day tests.

A. The concrete shall be deemed to comply with the strength requirements if:

a) every sample has a test strength not less than the characteristic value ; or

b) the strength of one or more samples though less than the characteristic value, is in each case not less than the greater of ;

i) the characteristic strength minus 1.35 times the standard deviation; and

ii) 0.80 times the characteristic strength and the average strength of all the samples is not less than the characteristic strength plus

$$\left[1.65 - \frac{1.65}{\sqrt{\text{number of samples}}}\right] \text{times the standard deviation}$$

B. The concrete shall be deemed not to comply with the strength requirements if :

a) The strength of any samples is less than the greater of:

i. the characteristic strength minus 1.35 times the standard deviation and;

ii. 0.80 times the characteristic strength; or

b) the average strength of all the samples is less than the characteristic strength plus

$$\left[1.65 - \frac{3}{\sqrt{\text{number of samples}}}\right] \text{times the standard deviation}$$

C. Concrete which does not meet the strength requirements as specified in para (A) but has a strength greater than that required by para (B) may be accepted as being structurally adequate without further testing by the Engineer in consultation with designer.

In the event that concrete tested in accordance with the requirements of the above clause, fails to meet the specification, the Engineer shall have the right to require any one or all the following :

a) Changes in the concrete mix proportions for the remainder of the work

b) Coring and testing of the concrete represented by the tests which failed as per IS : 456.

c) Load tests on part of structures as per IS : 456.

d)Removal and replacement of any such portions of the structure.

e)Extended curing of the concrete represented by the specimen.

The Contractor shall carryout all such measures as directed at his own expense, if the concrete cannot be accepted due to reasons attributable to the Contractor.

The unit rate of concrete shall be inclusive of all tests and remedial measures.

FORM WORK :

The formwork shall conform to the shapes, lines and dimensions for all the elements as shown on the drawing. The formwork shall be designed and constructed so that the concrete can be properly placed and thoroughly compacted to obtain the required shape, position and level subject to specified tolerances. The designed formwork arrangement shall be got approved by the Engineer. Approval of the proposed

formwork by the Engineer will not diminish the Contractor's responsibility for the satisfactory performance of the formwork, nor for the safety and co-ordination of all operations.
Formwork for architectural shapes for columns, ring, beams, circular or spherical walls, shell roofs or bottoms in the case of water reservoirs or any other structure shall be made from approved wrought and put up timber or steel plates and frames.
The form work to be used shall be of an approved system type
Wooden props are strictly prohibited. Note that all RCC works are form finished. Any rectification's at Contractors Cost.

Erection of Formwork :

The following shall apply to all formwork.
1. The contractor shall obtain the approval of the Engineer for the design of forms and the type of material used before fabricating the forms.
2. All shutter planks and plates shall be adequately backed to the satisfaction of the Engineer by a sufficient number and size of walers or framework to ensure rigidity during concreting. All shutters shall be adequately strutted, braced and propped to the satisfaction of the Engineer to prevent deflection under deadweight of concrete and superimposed live load of workmen, materials and plant, and to withstand vibration and wind. No joints in props shall be allowed.
3 Vertical props shall be supported on wedges or other measures shall be taken where the props can be gently lowered vertically during removal of the formwork. Props for an upper storey shall be placed directly over those in the storey immediately below and the lowest props shall bear on a sufficiently strong area.
4. Care shall be taken that all formwork is set plumb and true to line and level or camber or batter where required and as specified by the Engineer.
5. If formwork is held together by bolts or wires, these shall be so fixed that no iron will be exposed on surface against which concrete is to be laid. In any case wires shall not be used with exposed concrete formwork. The Engineer may at his discretion allow the Contractor to use tie-bolts running through the concrete and the Contractor shall decide the location and size of such tie-bolts in consultation with the Engineer. Holes left in the concrete by these tie-bolts shall be filled as specified by the Engineer at no extra cost. No through tie will be permitted in all cases where water is likely to be retained and gas tightness of the structure is to be ensured.
6.Provision shall be made in the shuttering for beams, columns and walls for a port hole of convenient size so that all extraneous materials that may be collected could be removed just prior to concreting.
7. Formwork shall be arranged as to permit removal of forms without jarring the concrete Wedges, clamps and bolts shall be used wherever practicable instead of nails.
8. An approved mould oil or other material shall be applied to faces of formwork in contact with the wet concrete to prevent adherence of concrete. The use of oil which darkens the surface of the concrete shall not be allowed. Oiling shall be done before reinforcement has been placed and care shall be taken that no oil comes in contact with the reinforcement while it is being placed in position. The formwork shall be kept thoroughly wet during concreting and the whole time that it is left in place.
9. Formwork for beams and slabs shall be so erected that the shuttering on the side of the beams and soffits of slabs can be removed without disturbing the beam bottoms.

Immediately before concreting is commenced, the formwork shall be carefully examined to ensure the following :

a) Removal of all dirt, shavings, sawdust and other refuse by brushing and washing.

b) The tightness of joints between panels of sheathing and between these and any hardened core.

c) The correct location of tie bars, bracing and spacers, and especially connections of bracing.

d) That all wedges are secured and firm in position.

e) That provision is made for traffic on formwork not to bear directly on reinforcing steel.

The Contractor shall obtain the Engineer's approval for dimensional accuracies of the work and for the general arrangement of propping and bracing. It is imperative that for scaffolding heights of 3.6 M and above, timber posts or steel scaffolding be used with adequate bracings in horizontal and vertical planes. The Contractor shall be entirely responsible for the adequacy of propping and for keeping the wedges and other locking arrangements undisturbed through the decentering period.

Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any distress the work shall be stopped and remedial action taken.

Exposed Concrete Work **:**

Exposed concrete surfaces shall be smooth and even, originally as stripped without any finishing or rendering. Where directed by the Engineer, the surface shall be rubbed with carborundum stone immediately on striking the forms. The Contractor shall exercise special care and supervision of formwork and concreting to ensure that the cast members are made true to their sizes, shapes and positions and to produce the surface patterns desired. No honeycombing shall be allowed. Honeycombed parts of the concrete shall be removed by the Contractor as directed by the Engineer and fresh concrete placed without extra cost, as instructed by the Engineer.

All materials, sizes and layouts of formwork including the locations for their joints shall have the prior approval of the Engineer.

Camber :

Forms and falsework shall be generally cambered as indicated in the drawings or as instructed by the Engineer. However, for beams upto 5 M span and slabs upto 4 M span camber is not normally required to be provided.

Age of Concrete at removal of formwork :

Unless otherwise permitted in writing by the Engineer, the minimum period of keeping formwork in position after concreting the members in normal circumstances and where ordinary portland is used shall conform to the Indian Standard Specifications and shall be as follows :

a)	Walls, columns and vertical faces of all structural members	24 to 48 hours as may be decided by the Engineer.
b)	Slabs (props left under)	3 days
c)	Beam soffits (props left under)	7 days
d)	Removal of props under slabs :	
	i. Spanning up to 4.5 m	7 days

	ii.	Spanning over 4.5 m	14 days
e)	Removal of props under beams and arches		
	i.	Spanning up to 6 m	14 days
	ii.	Spanning over 6 m	21 days

For other cements, the stripping time recommended for ordinary Portland cement may be suitably modified.

The Engineer may vary the above period if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

Stripping of Formwork :

Formwork shall be removed carefully without jarring the concrete, and shall be eased off carefully in order to allow the structure to take up its load gradually and curing of the concrete shall be commenced immediately. Immediately after the shuttering is removed, all the defective areas such as honeycombed surfaces, rough patches, holes left by form bolts etc. shall be brought to the notice of Engineer who may permit patching of the defective areas or reject the concrete work. Rejected concrete shall be removed then replaced by Contractor at his own cost. After removing loose materials, the surface shall be prepared and saturated with water for 24 hours before patching is done with 1:1.5 CM. The use of epoxy for bonding fresh concrete shall be carried out as directed by Engineer. Concrete surfaces to be exposed shall, where required by the Engineer, be rubbed down with carborundum stone to obtain a smooth and even finish. Where the concrete requires plastering or other finish later the concrete surface shall be immediately hacked lightly all over as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

In the case of folded plates and shell roofs the contractors should take approval for the pattern of centering and shuttering along with programme for deshuttering.

Repropping :

For multistoried buildings the floors may need repropping to support the loads of the upper floors under construction. The extent of such repropping shall be as directed by the Engineer. Such repropping shall not be paid for separately and the cost of such repropping shall be deemed to have been included in the Contractor's rates.

Reuse of Forms :

The Engineer may in his absolute discretion order rejection of any forms he considers unfit for use for a particular item, and order removal from the site of any forms he considers unfit for use in the works.

Hacking-out :

1. Immediately after removal of forms, the concrete surfaces to be plastered shall be roughened with a brush-hammer or with chisel and hammer as directed by the Engineer to make the surfaces sufficiently coarse and rough to provide a key for plaster.

This shall not be paid for separately and shall be deemed to have been included in the Contractor's rates.

2. No payment shall be made for temporary formwork used in concreting, nor for formwork required for joints or bulkheads, in floors, or elsewhere, whether such joints are to be covered later with concrete or mastic or other material.

Inspection :

All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Engineer. Materials rejected shall be replaced by Contractor immediately at his own cost.

Clean-up :

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood etc. resulting from the work shall be removed and the premises left clean.

PRECAST CONCRETE :

All precast concrete shall be cast over vibrating tables or by using form vibrators. Exposed surfaces of precast members shall be finished as called for on the drawings. All jointing surfaces shall be wire brushed and hosed down until the aggregate is free from cement slurry. Castellations shall be provided wherever called for. Leave grouting holes, grooves, inserts, projections, reinforcements, lifting hooks, etc., to conform to the erection procedure. All edges and delicate projections likely to be damaged during handling and erection shall be protected by means of wooden cover fillets, until placed in position.

MATERIALS :

The materials used for the construction shall conform to IS- 456 latest.

MOULD :

The mould used for manufacturing precast components normally consist of two parts, (a) bottom mould, and (b) side moulds. The bottom mould can be made out of timber, masonry, concrete, steel, FRP, plastic or any other material acceptable to the Engineer. The side moulds similarly can be of timber, steel, FRP, or plastic. When using masonry or concrete moulds, the top surface shall be finished to the required accuracy and made smooth.

In case of masonry moulds, the use of chicken mesh or fibre reinforcements in the top surface will help in making the mould last longer for higher efficiency.

In the case of cored units the voids can be created either by an extrusion process, by inflated tubes, Mild steel tubes, timber, cardboard / hard paper or any other materials.

The castellations / depressions / roughening of required depth shall be provided in the sides of the precast units. Suitable provisions in the side shutters of the mould may create better keying between in situ concrete and precast concrete units at the joints.

REINFORCEMENT COVER :

Minimum cover for the reinforcement for precast units shall be as follows ;

a) For reinforcement in the flange, 12 mm clear in all directions. This shall be increased to 15 mm when surfaces of precast members are exposed to corrosive atmosphere and

b) For main reinforcement in the rib, 20 mm or diameter of bar whichever is greater. In case of corrosive atmosphere, this shall be increased to 25 mm, or diameter of bar, whichever is greater.

It shall be ensured that the reinforcement cages are not in any way distorted during storage, handling, placement and casting. In the case of mass production in large precasting factories, the use of reinforcement ladders and mesh made by using a resistant welding machine will be advantageous for improving production.

CONCRETE :

The concrete mix used shall be minimum of M-15 grade in accordance with IS: 456 latest but M 25 and above grade of concrete is preferred for reinforced concrete units. The concrete mix as specified in the drawings shall be used for respective units in accordance with IS: 456 latest.

CASTING & CURING OF UNITS :

Mechanical vibration either through mould/table vibrators or screed vibrators is essential to ensure good compaction. Needle vibrators can be used for compacting concrete in the ribs and screed vibrators for compacting concrete in the flange. For larger factories, concrete placing machine, which level, vibrate and finish the concrete units can be advantageously utilized for this purpose.

Curing shall be done as per IS 456 latest. If necessary, low pressure steam curing may be provided to get early stripping / release strength.

SAMPLING AND TESTING OF UNITS

Sampling :

Sampling shall be done in accordance with latest load test : Load tests shall be carried out in accordance with IS 456 latest. All the units passing the load test can be used in the constructions.

TRANSPORTATION AND ERECTION OF PRECAST ELEMENTS :

Lifting Hooks

Wherever lifting hooks / holes are used these shall be provided at structurally advantageous points (for example, 1/5 of the length from the end of the element) to facilitate demoulding and erection of the precast unit. The lifting hooks can be formed out of normal Mild steel reinforcing bars with adequate carrying capacity to carry the self weight during demoulding, handling and erection. After erection, the hooks can either be cut or bent down inside the screed or joint concrete that will be laid subsequently.

Lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stress to or in the units. Lifting and handling positions should conform to the Engineers directions.

Stacking of Units

After removal from moulds the precast units shall be stacked over supports placed at about 1/6 of span from ends. Care shall be taken to see that no support is placed at the centre of span. Care also shall be taken to see that the main reinforcement is always at the bottom of stacked units.

TRANSPORTATION :

The units shall be transported always with the main reinforcement at the bottom. For transporting and erecting the units, rope slings shall be tied near the ends at 1/5 of the length from either end of the unit. In case the units are transported in trolleys, the over-hang of the units from the trolley shall not be more than 1/5 of the length. The unit shall be lifted manually or with the help of chain pulley blocks or mechanically with a hoist or a crane.

PLACING AND ALIGNING :

The units shall be placed and aligned side by side across the span to be covered. While placing the units, care shall be taken to see that they have the specified bearing on supporting wall / beam. Placing of units shall be started from one end of the building.

BEARING :

The precast units shall have a minimum bearing of 75 mm on the beams and 100 mm on the conventional masonry wall.

CURING OF IN SITU CONCRETE IN JOINTS :

The in situ concrete in the joint shall be cured for at least 7 days in accordance with IS 456 latest. The concrete shall then be allowed to dry for at least a week. A coat of cement slurry may be applied to the joints to fill the hairline cracks that might have developed. Joints shall be finished as specified in the drawings.

FIXTURES :

Designers shall indicate provisions for fixtures like fan hooks / inserts / electric conduits, etc., to be incorporated within the precast units or the in situ joints / screed concrete.

In case of concealed wiring, conduits may be placed within the joints along the length or within the screed before concreting. If adequate thickness is available this may be concealed within the floor / roof finish.

Holes, openings and fixtures required to be provided within the precast units shall be fixed accurately with adequate embedment at the precasting stage. Drilling of holes / cutting of edges shall not be made unless permitted by the Engineer.

DEFECTS IN CONCRETE :

Immediately on removal of form work, the surface of the concrete shall be examined by the contractor and any honeycombs or other imperfections shall be brought to the notice of the Engineer. The acceptability or otherwise of such defective concrete shall be at the sole discretion of the Engineer who may direct the contractor to repair the defective work or ask for demolition and replacement of such defective work at the risk and cost of the contractor.

PROTECTION OF CONCRETE :

All concrete shall be protected from damage by workmen, equipment, overload or any other cause. All edges, corners and projections of concrete members likely to be damaged shall be protected by means of cover fillets or as directed by the Engineer.

EQUIPMENT FOUNDATION :

The contractor shall provide concrete foundations for the various equipments in accordance with the drawings. All concrete for equipment foundations shall be of specified grade as per drawing. Bolts, inserts and other anchoring features shall be left in their correctly assigned position to templates prepared for this purpose at the time of casting. Where it is not possible to leave bolts, etc., in position, pockets of suitable sizes shall be left in the concrete foundations to receive the bolts. Pockets shall be formed by suitable form work as directed by the Engineer. Bolts shall be grouted by expanding cement mortar, non-shrink grouting compound and finished neat.

It is essential that the Engineer who is in-charge of the construction of all concrete work, whether plain or reinforced shall be well experienced in this class of work and shall superintend personally the whole construction and pay special attention to:-

a) Quality Control in respect of selection of materials, proportioning and mixing, etc.

b) Placing and consolidation of concrete.

c) Accuracy in cutting, bending, placing and binding of reinforcement.

d) Accuracy in fabrication, assembly and erection of form work.

e) Casting, handling, transportation and erection of precast members.

3. TECHNICAL SPECIFICATION FOR STEEL REINFORCEMENT

This specification covers the general requirements of steel reinforcement.

Steel reinforcement shall be either mild steel of tested quality high yield strength deformed bars of grade Fe-500D conforming to IS:1786 or as called for on the drawings. Fabric reinforcement where called for shall be of hard drawn mild steel wire mesh conforming to IS:1566. Bars shall be free from deleterious materials, mill scale, loose rust, oil or paint.

The contractor shall submit bar bending schedules for approval of the Engineer prior to commencement of fabrication. These shall indicate the accurate dimensions and bending of bars as called for on the structural drawings.

Fabrication shall be accurately done to the dimensions, spacing and ensuring minimum cover as called for on structural drawings.

All reinforcing steel within the limit of a day's pour shall be in place and firmly wired atleast one day prior to the date of pour to permit inspection. The contractor shall also ensure that all conduits embedments and inserts are in position before placing concrete.

Bending :

All reinforcement bars shall be made straight before bending. Bars shall be bent cold gradually by machine or other approved means without the use of heat. Bars having cracks or splits on the bends shall rejected. Bars incorrectly bent once shall not be used without the approval of the Engineer.

The Contractor shall prepare bar bending schedules as per details given in IS 2502 and get them approved before proceeding with cutting and bending of bars.

All bars shall be carefully and accurately bent by the Contractor in accordance with the drawings and special care shall be taken such that :

a) the depth of the crank is correct as per the drawing or the Bar Cutting and Bending Schedule.

b) the rods are placed in exact positions. The bars should not be bent or straightened in any manner that will injure the material

c) hooks where indicated shall be either a complete semi- circular turn with a radius of not less than four and not more than six bars diameters, plus an extension of atleast four bar diameters at the free end, or a 90 degree bend having a radius of not less than 4 bar diameters plus an extension of 12 bar diameters, as shown or implied on the drawings.

No reinforcement shall be bent when in position in the works without approval whether or not it is partially embedded in hardened concrete.

Lapping :

As far as possible bars of maximum length available shall be used.

Unless otherwise specified or shown on the drawings, all laps shall be 50 times the diameter of bar. Not more than 33% (Thirty Three Percent) of the bars shall have lapped joints at the same location.

Welding :

Only where specifically shown on the drawings, reinforcement shall have welded joints.

All welding shall be carried in accordance with IS : 2751. Only qualified welders shall be permitted to carry out such welding.

The welding procedure shall be approved by the Engineer and tests shall be made to prove the soundness of the welded connection.
Rate quoted for steel reinforcement work shall be deemed to include the cost of such weldings wherever specified.

Cleaning, Placing and Fastening :

All reinforcement shall be cleaned to remove loose mill scale, loose rust, oil and grease or any other harmful matter immediately before placing the concrete. Dowel bars will be provided where shown on drawing or where required.
All steel reinforcement shall be accurately placed in position shown on the drawing tied with 18 gauge GI annealed steelwire and firmly held during the placing and setting of concrete.
The vertical distance required between successive layers of bars shall be maintained by providing space bars, inserted at such intervals that main bars do not perceptibly sag between adjacent space bars.

COVER FOR REINFORCEMENT :

Reinforcement shall have cover as shown on the structural drawings and where not specified the thickness of cover shall be as follows.

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

b) For a longitudinal reinforcing bar in a column not less than 40 mm nor less than the diameter of such bar. In the case of columns of minimum dimension of 20 cm. or under whose reinforcing bars do not exceed 13 mm., the cover 25 mm shall be used.

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

d) For tensile, compressive, shear or other reinforcement in a slab not less than 13 mm., nor less than the diameter of such reinforcement.

e) For any other reinforcement not less than 13 mm., nor less than diameter of such reinforcement. For giving the necessary covers, concrete cover blocks of same strength of concrete proposed for the structure shall be used. All cover blocks shall be secured firmly so that they are not disturbed during compaction.

4. TECHNICAL SPECIFICATION FOR STRUCTURAL STEEL WORK

General :

This Specification covers the Supply, Fabrication, Painting, Transportation to site and Erection on prepared Foundations, Structural Steelwork consisting of Columns, Beams, Lattice girders, trusses, purlins, bracings, built-up sections, sag rods, girts, etc.
Fabrication, Erection and approval of Steel Structures shall be in compliance with :

- These General Specifications, IS : 800 and other relevant Indian Standards as listed in clause 12.
- Drawings and supplementary drawings to be supplied to the Contractor by Engineer during execution of the work.

In case of conflict between the clauses mentioned here and the Indian Standards, those expressed in this Specification shall govern.

Scope :

The Fabrication and Erection of the Steelwork consist of accomplishing of all Works herein enumerated including providing all labour, tools and plants, all materials and consumables such as welding electrodes, bolts and nuts, oxygen and acetylene gases, oils for cleaning, etc. of approved quality as per relevant Indian Standards. The work shall be executed in a workman like manner to the complete satisfaction of Engineer.

Fabrication Drawings :

Fabrication and erection drawings shall be prepared by the Contractor on the basis of Design drawings supplied to him and submit the same to Engineer (EIC) for review in triplicate. Engineer may review at his option some, all or none of the Fabrication drawings. Wherever such reviews are carried out, the same shall be restricted to the following :

- Structural layout, orientation and elevation of Structures and Members.
- Sizes of members
- Adequacy of critical connections and joints for required strength.
- Shop / Field welding details from viewpoint of erection.

In those cases where EIC carries out either full, or partial review, one copy of drawing submitted by the Contractor shall be returned to him and Contractor shall incorporate the amendments and submit further three copies of amended drawings for final review. In those cases where EIC does not review the drawings, he shall return 1 copy of drawings, stamped "Not reviewed proceed at Contractor's responsibility", to the Contractor for further action.

Fabrication drawings shall include the following :

- Structural layout and Elevations
- Sizes of Structural Members
- Adequacy of Connections and joints
- Design and detailing of structural joints for required strength and erection
- Type and dimension of welds and bolts
- Shapes and sizes of edge preparation for welding
- Details of shop and field joints included in the Assembly
- Bill of Materials
- Quality of Structural steel, welding electrodes, bolts, nuts and washers to be used
- Erection assemblies identifying all transportable parts and sub-assemblies associated with special erection instructions, if required.
- Non Destructive Testing (NDT)

  Crane Girders - 20% Dye Penetrant Examination (DPE) of rootruns.
  - 10% radiography of all butt welds

  Others - 10% DPE

Review by Engineer fully/partially or non-review of Fabrication drawings submitted by Contractors shall not absolve the Contractor of his responsibility and he shall modify /rectify the structures at any stage of work when pointed out by Engineer that such work is not in conformity with specification and/or standard practice. Connections, splices etc. other details not specifically detailed in Design drawings shall be suitably given on Fabrication drawings considering normal detailing practices and developing full member strengths. Where asked for calculations for the same, these shall also be submitted for approval.

Any alternate design or change in section is allowed only when approved in writing by the Engineer.
However if any variation in the scheme is found necessary later, the Contractor shall incorporate these changes in his Shop Drawings, at no extra cost and resubmit for review.
The contractor shall supply six prints each of the final reviewed drawings to Engineer within a week from the date of final review, at no extra cost, for reference and record of Main Contractor.
The Engineer will verify the correct interpretation of his requirements.
If any modification is made in the Design drawing during the course of execution of the work, revised Design drawings will be issued to the Contractor. Further changes arising out of these shall be incorporated by the Contractor in the Fabrication drawings already prepared at no extra cost and the revised Fabrication drawings shall be duly got reviewed as per the above clauses.

MATERIALS :

Rolled Sections

The following grades of steel shall be used for steel structures.
Structural steel shall conform to IS 2062 Gr. 'A' (for thickness upto 20 mm) & IS 2062 Gr. 'B' (for thickness above 20 mm).
For purlins and girts cold rolled Z sections of TI Metal sections Ltd. or equivalent shall be used.
Z sections shall be manufactured from tested HR coils to IS : 10748 and the sections shall conform to IS : 801 and IS : 811.
The size and sectional properties shall be as follows :

Span	Size	Thickness (mm)	Zx (top) cm^3	Zx (bottom) cm^3	Zy cm^3
4 M	150230	2.3	31.14	29.92	8.56
5 M	165255	2.55	36.40	35.55	8.26
6 M	230255	2.55	65.08	63.39	11.22

Z purlin shall be supplied with sleeves duly drilled / punched, sag rods and fasteners.

WELDING MATERIALS :

Welding Electrodes shall conform to IS : 814 & AWS

E 6013 | For thickness upto 20mm

| For thickness | above20mm- AWS

| E7018

Approval of welding procedures shall be as per IS : 816

BOLTS, NUTS AND WASHERS :

Bolts and nuts shall be as per IS 1363 & IS 1367 class 8.8. Washers shall be as per IS : 2016, IS : 5372 & IS : 5374.
All materials shall conform to their respective specifications. The use of Equivalent or higher grade or alternate materials will be considered only in very special cases subject to the approval of the Engineer in writing.

Any defective material used, pointed out at any stage of work, shall be replaced by Contractor at his own expenses. Care shall be taken to prevent any damage to the other portion of work during removal.

Receipt and Storing of Materials :

Each rolled section must be marked for identification and each lot should be accompanied by Manufacturer's quality certificate, confirming chemical analysis and mechanical characteristics.

All steel parts furnished by Supplier shall be checked, sorted out, straightened and arranged by grades and qualities in stores.

Structural with surface defects such as pitting, cracks, laminations etc. shall be rejected if the defects exceed the allowable tolerances specified in relevant Standards.

Welding electrodes shall be stored separately by qualities and lots inside a dry and enclosed room, in compliance with IS : 816 and as per instructions given by Engineer. Electrodes shall be perfectly dry and drawn from an Electrode oven, if required.

Checking of quality of bolts of any kind as well as storage of same shall be made conforming to relevant standards.

Each lot of electrodes, bolts, nuts etc. shall be accompanied by Manufacturer's test certificates.

The Contractor may use alternative materials as compared to Design Specifications only with the written approval of Engineer.

Material Tests :

Contractor shall be required to produce Manufacturer's quality certificate for the material or wherever quality certificates are missing or incomplete or when material quality differs from standard Specifications the Contractor shall conduct all appropriate tests as directed by the Engineer, at no extra cost, in approved test houses.

Materials for which Test Certificates are not available or for which test results do not tally with relevant standard Specification, shall not be used.

Fabrication :

Fabrication shall be in accordance with IS : 800 Section - V in addition to the following :

Fabrication shall be done as per approved Fabrication drawings adhering strictly to work points and work lines on the same. The connections shall be welded or bolted as per Design drawings. Work shall also include fabricating built up sections. (Fabrication of basic rolled sections equivalent from plates is not included).

All the fabricated and delivered items shall be suitably packed to be protected from any damage during transportation and handling. Any damage caused at any time shall be made good by the Contractor at his cost.

Any faulty fabrication pointed out at any stage of work shall be made good by the Contractor at his cost.

Preparation of Materials :

Prior to release for fabrication, all rolled sections warped beyond allowable limits shall be pressed or rolled straight and free from twists, taking care that uniform pressure is applied.

Minor warpings, corrugations etc. in rolled sections shall be rectified by cold working.

The sections shall be straightened by hot working where the Engineer so directs and shall be cooled slowly after straightening.
Warped members like plates and flats may be used as such only if wave like deformation does not exceed L/1000 but limited to 3 mm (L = Length).
Surfaces of Members that are to be joined by lap or fillet welding or bolting shall be even so that there is no gap between overlapping surfaces.

Marking :

Marking of Members shall be made on horizontal pads, or on appropriate racks or supports in order to ensure horizontal and straight placement of such Members.
Marking accuracy shall be within ± 1 mm.

Cutting :

Members shall be cut mechanically (by saw or shear) or by oxyacetylene flame.
All sharp, rough, or broken edges, and all edges of joints which are subjected to tensile or alternating stresses, shall be ground.
No electric metal arc cutting shall be allowed.
All edges cut by oxyacetylene process shall be cleaned of impurities and slag prior to assembly.

Cutting tolerances shall be as follows :

a) For members connected at both ends ± 1 mm
b) Elsewhere ± 3 mm.

The edge preparation for welding of members more than 12 mm thick shall be done by flame cutting and grinding. Cut faces shall not have cracks or be rough.
Edge preparation shall be as per IS : 816

Drilling :

Bolt holes shall be drilled. Materials of thickness upto 16 mm, may be punched.
Drilling shall be made to the diameter specified in drawings.
No enlarging of holes by filing, mandrilling or oxyacetylene flame shall be allowed.
Allowable variations for holes (out of roundness, eccentrically, plumb-line deviation) shall be as per IS : 800.

- Maximum deviation for spacing of two holes on the same axis shall be ± 1 mm.
- Two perpendicular diameters of any oval hole shall not differ by more than 1 mm.

Drilling faults in holes may be rectified by reaming holes to the next upper diameter, provided that spacing of new hole centres and distance of hole centres to the edges of members are not less than allowed and that the increase of hole diameter does not impair the structural strength. Hole reaming shall be allowed if the number of faulty holes does not exceed 15% of the total number of holes for one joint.

Unless otherwise noted in the drawing - Pitch of holes - 3D
Edge distance-Shear and edge - 1.5 D
Rolled edge - 1.25 D

Bending :

Bending of plates, flats and sections shall be carried out on bending rolls or in presses.

Cold bending may be accepted when bending radius is equal or more than ;

- 25 times member thickness for plates and flats

- 25h or 25b for rolled steel beams and channels according to bending plane
- 45b for angle

Where h = section height and b = flange width.
When bending radius is less than that indicated in 5.6.2, bending shall be done by heating the member up to 850 - 900^{o}C (light red radiance). Cooling shall be done slowly as directed by Engineer.
Bending shall be discontinued when temperature drops below 500^{o}C.
Accuracy of bending operations shall be checked by means of Templates and the clearance between member and template shall not be more than 1 mm.
Bent members shall not have cracks or deep indentations from bending equipment.

Preparation of Members for Welding :

Assembly of structural Members shall be made with proper jigs and fixtures to ensure correct positioning of members (angles, axes, nodes, etc.)
Sharp edges, rust of cut edges, notches, irregularities and fissures due to faulty cutting shall be chipped or ground or filled over the length of the affected area, deep enough to remove faults completely.
Edge preparation for welding shall be carefully and accurately made so as to facilitate a good joint.
Generally no special edge preparation shall be required for members under 8 mm thick.
Edge preparation (bevelling) denotes cutting so as to result in V,X,K or U seam shapes as per IS : 816.
Unless otherwise noted in the drawing :

$\leq$ 6 mm	-	Square butt
8 - 11 mm	-	Single V
$\geq$ 12 mm	-	Double V

The members to be assembled shall be clean and dry on the welding edges. Under no circumstances shall wet, greasy, rust or dirt covered parts be assembled. Joints shall be kept free from any foreign matter, likely to get into the gaps between members to be welded.
Before assembly the edges to be welded as well as adjacent areas extending for atleast 20 mm shall be cleaned (until metallic polish is achieved).
When assembling members, proper care shall be taken of welding shrinkage and distortions, as the drawing dimensions cover finished dimensions of the Structure.
The elements shall be got checked and approved by the Engineer or his authorised representative before assembly.
The permissible Tolerances for assembly of members preparatory to welding shall be as per IS : 816.
After the assembly has been checked, temporary tack welding in position shall be done by electric welding, keeping in view finished dimensions of the Structure.
Preheating of members to be joined to be carried out as per standards wherever necessary.

Welding Procedures :

Welding shall be carried out only by fully trained and experienced welders as tested and approved by the Engineer or his representative or the Inspectors. The cost involved for such tests shall be borne by the Contractor himself.
Qualification tests for Welders as well as tests for approval of electrodes will be carried out as per IS : 816. The nature of test for performance qualification of

welders shall commensurate with quality of welding required on this work as judged by the Engineer.

Unless otherwise noted in the drawing : $\leq$ 20 mm - Electrodes to AWS E 6013
> 20 mm - Electrodes to AWS E 7018

The Steel structures shall be automatically, semi-automatically or manually welded.

Welding shall begin only after the checks shown under 5.7 have been carried out.

Welding procedures and Tests for Welders skill shall be conducted as per IS : 816 and approved by the Engineer.

The welder shall mark his Identification mark on each element welded by him.

When welding is carried out in open air, steps shall be taken to protect the place of welding against wind or rain. The electrodes, wires and parts being welded shall be dry.

Before beginning the welding operation, each joint shall be checked to ensure that the parts to be welded are clean and root gaps provided as per IS : 816.

For continuing the welding of seams discontinued due to some reason, the end of the discontinued seam shall be melted in order to obtain a good continuity. Before resuming the welding operation, the groove as well as the adjacent parts shall be well cleaned for a length of approximately 50 mm.

For single butt welds (in V,1/2V or U) and double butt welds (in K, double U, etc) the rewelding of the root butt is mandatory but only after the metal deposition on the root has been cleaned by back gouging or chipping.

The welding seams shall be left to cool slowly. The Contractor shall not be allowed to cool the welds quickly by any method.

For multi-layer welding, before welding the following layer, the formerly welded layer shall be cleaned by light chipping and wire brushing. Backing strips shall not be allowed.

The order and method of welding shall be so that :

- no unacceptable deformation appears in the welded parts
- due margin is provided to compensate for contraction due to welding in order to avoid any high permanent stresses.

The defects in welds must be rectified according to IS : 816 and as per instruction of Engineer.

Weld Inspection :

The weld seams shall satisfy the following :

- shall correspond to Design shapes and dimensions
- shall not have any defects such as cracks, incomplete penetration and fusion, under-cuts, rough surfaces, burns, blow holes and porosity etc. beyond permissible limits (See Annexure-I).

During the welding operation and approval of finished elements, inspections and tests shall be made as shown in Annexure - II.

The mechanical characteristics of the welded joints shall be as in IS : 816.

Preparation of Members for Bolting :

The Members shall be assembled for bolting with proper jigs and fixtures to sustain the assemblies without deformation and bending.

Before assembly, all sharp edges, shaving, rust, dirt etc. shall be removed.

Before assembly, the contacting surfaces of the members shall be cleaned and given a coat of red oxide primer.

The members which are bolt assembled shall be set according to drawings and temporarily fastened with erection bolts (minimum 4 pieces) to check the coaxiality of the holes.
The members shall be finally bolted after the deviations have been corrected, after which there shall not be gaps.
Before assembly, the member shall be checked and got approved by the Engineer.
The difference in thickness of the Sections that are butt assembled shall not be more than 3% or maximum 0.8 mm whichever is less. If the difference is large, it shall be corrected by grinding or filling.
Reaming of holes to final diameter or cleaning of these, shall be done only after the parts have been check assembled.
As each hole is finished to final dimensions (reamed if necessary) it shall be set and bolted up. Erection bolts shall not be removed before other bolts are set.

Bolting Up :

Final bolting of the members shall be done after the defects have been rectified and approval of joints obtained.
The bolts shall be tightened starting from the centre of the joint towards the edge.

Holes for Field Joints :

Holes for field joints shall be drilled in the shop to final diameters and tested in the shop, with trial assemblies. Gas cutting of holes shall not be permitted.
When three-dimensional assembly is not possible in the shop, the holes for field joints may be drilled in shop and reamed on site after Erection, on approval by the Engineer.
For bolted steel structures, trial assembly in shop is mandatory.
The tolerance for spacing of holes shall be ± 1 mm.

Tolerances :

All tolerances regarding dimensions, geometrical shapes and sections of Steel Sections, shall be as per IS 808 & IS 1852, if not specified in the drawing.

Marking for Identification :

All elements and members prior to despatch for Erection shall be shop marked.
The members shall be visibly marked with a weatherproof light coloured paint. The size and thickness of the numbers shall be so chosen as to facilitate the identification of members.
For the small members that are delivered in bundles or crates, the required marking shall be done on small metal tags securely tied to the bundle, while the crates shall be marked directly.
Each bundle or crate shall be packed with members for one and the same assembly in the same bundle or crate, general utility members such as bolts, gussets, etc. may be packed.
All bills of materials showing weight, quality and dimension of contents shall be placed in the crates.
The members shall be marked with a durable paint, in a visible location, preferably at one end of the member so that these may be easily checked during storage and erection.
The members shall be marked in the shop before inspection and acceptance.
When the member is being painted, the marking area shall not be painted but bordered with white paint.

The marking and job symbol shall be registered in all shop delivery documents (transportation, for erection etc.)

Shop Test Pre-assembly :

For Steel Structures that have the same type of welding the shop test pre-assembly shall be performed on one out of every 10 members minimum.

In case one member does not meet the limiting deviations specified in the general specification in pre-assembly shop test, all members shall be shop tested.

For bolted Steel Structures, shop test pre-assembly is mandatory for all elements as well as for the entire structure in conformity with clause 5.12.

Shop Inspection and Approval :

General :

The Engineer or his representative shall have free access at all reasonable times to the Contractor's Fabrication Shop and shall be afforded all reasonable facilities for satisfying himself that the Fabrication is being undertaken in accordance with Drawings and Specifications.

Technical approval of the Steel Structure in the shop by the Engineer is mandatory.

The Contractor shall not limit the number and kinds of Tests, final as well as intermediate ones, or extra tests requested by the Engineer.

The Contractor shall furnish necessary tools gauges, instrument etc. and technical and non-technical personnel for shop tests required by Engineer, free of cost.

Shop Acceptance :

The Engineer shall inspect and approve at the following stages.

The following approvals may be given in shop :

- Intermediate approvals of work that cannot be inspected later.
- Partial approvals.
- Final approvals.

Intermediate approvals of work shall be given when a part of the work is performed later

- Inspection would be difficult to perform and results not be satisfactory.
- Cannot be inspected later

Partial approval in the shop is given on members and assemblies of Steel Structures before the primer coat is applied and includes :

- Approval of material
- Approval of field joints
- Approval of part with planed surface
- Test Erection
- Approval of members
- Approval of markings
- Inspection and approvals of special features, like rollers, loading platform mechanism etc.

During the partial approval, intermediate approvals as well as former approvals shall be taken into consideration.

Final Approval in the Shop :

The final approval refers to all elements and assemblies of the Steel Structures with shop primer coat, ready for delivery from shop, to be loaded for transportation or stored.

The final approval comprises :

- Partial approvals.
- Approvals for shop primer coat
- Approval of mode of loading and transport
- Approval of storage (for materials stored)

Inspection by EIC shall be only at random and on critical factors and shall not absolve the contractor of the responsibility to fabricate the structures as per the specified standards & specifications.

Painting and Delivery :

Preparation of Parts for Shop Painting and Site Painting :

Painting shall consist of providing sand blasting to standard SSPC - SP10 (Sa 2-1/2) and two coats of epoxy polymide based red oxide zinc phosphate primer of Dry Film Thickness (DFT) 25 microns for each coat and over this painting one coat of epoxy polymide based finish to DFT of 35 microns as specified under specialised painting work given elsewhere to Steel members before despatch from shop.

Site Painting :

Two coats of primer as per the spefification in Schedule of Quantities to be done at shop. 2 coats of Epoxy polymide based finish is to be done at site only. Touchnig up shall be done wherever required and as directed by the Engineer.

Primer coat shall not be applied unless :

- Surfaces have been sandblasted to clean, dust, oil, rust, etc.
- Erection gaps between members spots that cannot be painted or where moisture or other aggressive agents may penetrate have been filled with an approved type of oil and putty.
- The surfaces to be painted are completely dry.
- Members and parts have been inspected and accepted.
- Welds have been accepted.

The following are not to be painted or protected by any coating.

- Surfaces which are in the vicinity of joints to be welded at SITE.
- Surfaces bearing markings.
- Other surfaces indicated in the Design.

The following shall be given a coat of hot oil or any approved resistant lubricant only:

- Planed surfaces.
- Holes for links.

The surfaces that are to be embedded or in contact with the concrete, shall not be painted.

The other surfaces shall be given a primer coating.

Special attention shall be given to locations not accessible, where water can collect and which after assembly and erection cannot be inspected, painted and maintained.

Holes shall be provided for water drainage and inaccessible box type sections shall be hermetically sealed by welds.

Packing, Transportation, Delivery :

After final shop acceptance and marking, the item shall be packed and loaded for transportation.

Packing must be adequate to protect items against warping during loading and unloading.

Proper lifting devices shall be used for loading, in order to protect items against warping.

Slender projecting parts shall be braced with additional steel bars before loading for protection against warping during transportation.
Loading and transportation shall be done in compliance with transportation rules.
If certain parts cannot be transported in the lengths stipulated in the Design, the position and type of additional splice joints shall be approved by Engineer.
Items must be carefully loaded on platforms for transportation with adequate means to prevent warping, bending or falling during transportation.
The small parts such as fish plates, gussets etc. shall be securely tied with wire to their respective parts.
Bolts, nuts and washers shall be packed and transported in crates or bags.
The parts shall be delivered in the order stipulated by the Engineer and shall be accompanied by documents showing :

- Quality and quantity of structure of members
- Position of member in the structure
- Particulars of structure
- Identification number/job symbol

Field Erection :

The Contractor shall satisfy himself about the levels, lines etc. of the Foundations well in advance, before starting the Erection. Minor chipping etc. shall be carried out by the Contractor at his expense.
Any faulty Erection done by the Contractor, shall be made good at his cost.
Approval by the Engineer or his representative at any stage of work does not relieve the Contractor of any of his required guarantees of the Contract.

Storage and Preparation of Parts prior to Erection :

The storage place for Steel Parts shall be prepared in advance and got approved by the Engineer before the Steel structures start arriving from the shop.
A platform shall be provided by the Contractor near the Erection Site for preliminary Erection work.
The contractor shall make the following verifications upon receipt of material at site.
For Quality Certificates regarding Materials and Workmanship according to these general Specifications and Drawings.
Whether parts received are complete without defects due to transportation, loading and unloading and defects, if any, are well within the admissible limit.
For the above work sufficient space must be allotted in the storage area.
Step shall be taken to prevent warping of items during unloading.
The parts shall be unloaded, sorted and stored so as to be easily identified.
The parts shall be stored according to construction symbol and markings so that these may be taken out in order of Erection.
The parts shall be set at least 150 mm clear from ground on wooden or steel blocks for protection against direct contact with ground and to permit drainage of water.
If rectification of members like straightening etc. are required, these shall be done in a special place allotted which shall be adequately equipped.
The parts shall be clean when delivered for Erection.

Erection and Tolerances :

Erection in general shall be carried out as required and approved by the Engineer.
Positioning and levelling of the structure, alignment and plumbing of the Stanchion and fixing every member of the structure shall be in accordance with the relevant drawings and to the complete satisfaction of the Engineer.

The following checks and inspection shall be carried out before, during and after Erection.

- Damages during transportation.
- Accuracy of alignment of Structures
- Erection according to Drawings and Specifications.
- Progress and workmanship.

In case there be any deviations regarding positions of foundations, or anchor bolts, which would lead to Erection deviations, the Engineer shall be informed immediately. Minor rectifications in foundations, orientation of bolt holes etc. shall be carried out as a part of the work, at no extra cost.

The various parts of the Steel Structure shall be so erected as to ensure stability against inherent weight, wind and Erection stresses.

The structure shall be anchored and final erection joints completed after plan and elevation positions of the Structural members have been verified with corresponding drawings and approved by the Engineer.

The bolted joints shall be tightened so that the entire surface of the bolt heads and nuts shall rest on the member. For parts with sloping surfaces, tapered washers shall be used.

Site painting after erection shall be as per clause 7.1.1

Final Acceptance and Handling Over of Structure :

At acceptance, the Contractor shall submit the following documents :

a)Shop and Erection Drawings - either in tracings or reproducibles.

b)6 copies each of the following.

- Shop acceptance documents
- Quality Certificates for Structurals, Plates, electrodes, welding wire, bolts, nuts, washers etc.
- List of Certified Welders, who worked on Erection of Structure. (With documents or qualification tests)
- Acceptance and Intermediate Control Procedure of Erection Operations.

Approval by the Engineer at any stage of work does not relieve the Contractor of any of his required guarantees of the Contract.

Miscellaneous Steelwork :

Anchor Bolts :

All materials supplied by the Contractor shall be of tested quality as per Specifications below and Test Certificates of raw materials shall be provided by the Contractor.

Fabrication of Anchor Bolts shall be in compliance with the Specifications.

Complete Anchor Bolt assembly shall be as per drawings, and will include the cost of sleeve pipes, bottom plates, and other fixtures including all welding work if involved.

a) Bolts shall be turned from M.S rounds conforming to IS 2062 Gr ‘A’

b) Nuts shall be Hexagonal type conforming to IS 1363.

c) Plain washers shall be of mild steel conforming to IS 2016/IS 2062 Grade ‘A’

d) Threads shall be of coarse type conforming to IS 1367 & IS 4218.

The surface not to be covered with concrete shall be greased and protected from damage by wrapping and tying jute cloth/polythene.

Tolerances allowed in the Erection of Plant Building without Cranes :

The maximum tolerances for line and level of the Steelwork shall be ± 3.0 mm on any part of the Structure. The Structure shall not be out of plumb more than 5.0 mm on each 10 M section of height and not more than 8.0 mm per 30 M section. These tolerances shall apply to all parts of the Structure unless the Drawings issued for Erection purposes state otherwise.

Component	Description	Variation Allowed
Main column and roof posts	Shifting of column axis at foundation level with respect to building line :	
	In longitudinal direction	± 5.00 mm
	In lateral direction	± 5.00 mm
	Deviation of both Major Column Axis from Vertical between Foundation and Other Member connection Levels.	
	For a Column upto and including 10 M height.	± 5.00 mm from True Vertical.
	For a column greater than 10 M but less than 40 M height.	± 5.00 mm from True Vertical for any 10 M length measured between connection levels, but not more than ± 8.00 mm for upto 40 M height.
	For Adjacent Pairs of Columns across the	± 5.00 mm of True Span.

Component	Description	Variation Allowed
	width of the Building prior to placing of Truss.	
	For individual Column Deviation of any Bearing or resting level from levels shown on Drawings.	± 5.00 mm
	For Adjacent Pairs of Columns either across the width of Building or Longitudinally Level Difference allowed between Bearing or Seating Level supposed to be at the same level.	± 5.00 mm
Trusses	Deviation of Centre of Span or Upper Chord Member from Vertical Plane running through Centre of Bottom Chord.	1/1500 of the span or 10 mm whichever is less.
	Lateral Displacement of Top Chord at Centre of Span from Vertical Plane running through Centre of Supports.	1/250 of Depth of Truss or 20 mm whichever is less.
Crane girders and tracks	Difference in levels of Crane rail measured between Adjacent columns.	± 2.0 mm
	Deviation to Crane rail gauge	± 3.0 mm
	Relative Shifting of Ends of Adjacent Crane Rail in Plan and Elevation after Thermit	± 2.0 mm

Component	Description	Variation Allowed
	Welding.	
	Deviation of Crane Rail Axis from Centre Line of Web.	± 3.5 mm
Setting of Expansion Gaps	At the time of setting of the Expansion Gaps, due regard shall be taken of the Ambient Temperature above or below 30^{o}C. The co-efficient of Expansion or Contraction shall be taken as 0.000012 per unit Length per degree Celsius.	

INDIAN STANDARD SPECIFICATIONS (BIS) RELEVANT TO STEEL CONSTRUCTION & CLOAKING

IS 123 : RED OXIDE PRIMER
IS 277 : GALVANIZED STEEL SHEETS (PLAIN & CORRUGATED)
IS 459 : CORRUGATED & SEMI-CORRUGATED A.C. SHEETS
IS 730 : HOOK BOLTS FOR CORRUGATED SHEET ROOFING
IS 800 : COP FOR GENERAL CONSTRUCTION IN STEEL
IS 806 : COP FOR USE OF STEEL TUBES IN GENERAL BUILDING CONSTRUCTION
IS 808 : DIMENSIONS OF HR STEEL BEAMS, CHANNELS & ANGLES
IS 811 : COLD FORMED LIGHT GAUGE STRUCTURAL STEEL SECTIONS
IS 812 : GLOSSARY OF TERMS RELATING TO WELDING & CUTTING
IS 813 : SCHEME OF SYMBOLS FOR WELDING
IS 814 (P 1 & 2) : COVERED ELECTRODES FOR METAL ARC WELDING OF STRUCTURAL STEELS
IS 815 : CLASSIFICATION CODING OF COVERED ELECTRODES FOR METAL ARC WELDING OF STRUCTURAL STEELS
IS 816 : COP FOR METAL ARC WELDING FOR GENERAL CONSTRUCTION IN MS
IS 817 : COP FOR TRAINING & TESTING OF METAL ARC WELDERS
IS 822 : COP FOR INSPECTION OF WELDS
IS 875(P 1 TO 5) : COP FOR DESIGN LOADS FOR BUILDINGS & STRUCTURES
IS 961 : HIGH TENSILE STRUCTURAL STEELS
IS 1079 : HR CARBON STEEL SHEET & STRIP
IS 1161 : STEEL TUBES FOR STRUCTURAL PURPOSES
IS 1239 (P 1 & 2) : MS TUBES & TUBULARS
IS 1254 : CORRUGATED ALUMINIUM SHEETS
IS 1363(P 1 TO 3) : HEXAGON HEAD FASTENERS OF PRODUCT GRADE 'C'
IS 1364(P 1 TO 5) : HEXAGON HEAD FASTENERS OF PRODUCT GRADE A & B
IS 1367 : TECHNICAL SUPPLY CONDITIONS FOR THREADED
(P1 TO 18) : STEEL FASTENERS
IS 1477 (P 1 & 2) : COP FOR PAINTING OF FERROUS METALS IN BUILDINGS

IS 1626 (P 2 & 3) : A.C. GUTTERS, PIPES & ROOFING ACCESSORIES
IS 1852 : ROLLING & CUTTING TOLERANCES FOR HR STEEL PRODUCTS
IS 1977 : STRUCTURAL STEEL - ORDINARY QUALITY
IS 2016 : PLAIN WASHERS
IS 2062 : WELDABLE STRUCTURAL STEEL
IS 2074 : RED OXIDE ZINC CHROME PRIMER
IS 2339 : ALUMINIUM PAINT
IS 2527 : COP FOR FIXING GUTTERS & RAIN WATER PIPE FOR ROOF DRAINAGE
IS 2932 : SYNTHETIC ENAMEL PAINTS
IS 3007 (P 1 &2) : COP FOR LAYING A.C. SHEETS
IS 3444 : CRANE RAIL SECTIONS
IS 3502 : STEEL CHEQUERED PLATES
IS 3548 : COP FOR GLAZING IN BUILDING
IS 4000 : COP FOR ASSEMBLY OF STRUCTURAL JOINTS USING HSFG FASTENERS
IS 4923 : HOLLOW STEEL SECTIONS FOR STRUCTURAL USE
IS 5372 : TAPER WASHERS FOR CHANNELS
IS 5374 : TAPER WASHERS FOR BEAMS
IS 5624 : FOUNDATION BOLTS
IS 6639 : HEXAGONAL BOLTS FOR STEEL STRUCTURES
IS 7205 : SAFETY CODE FOR ERECTION OF STRUCTURAL STEELWORK
IS 7215 : TOLERANCES FOR FABRICATON
IS 8869 : WASHERS FOR CORRUGATED SHEET ROOFING
IS 12093 : COP FOR LAYING & FIXING SLOPED ROOF COVERINGS USING PLAIN & CORRUGATED GALVANISED STEEL SHEETS
IS 12843 : TOLERANCES FOR ERECTION OF STEEL STRUCTURES
COP : Code of Practice

COMMON WELD DEFECTS FOR FILLER WELDS IN STRUCTURAL STEEL FABRICATION

1. Incomplete Fusion - is defined as the failure to fuse together adjacent layers of weld metal or weld metal and base metal.

Causes :

i) Failure to raise the temperature of base metal (or previously deposited weld metal) to the melting point.

ii) Improper cleaning of the oxides or other foreign material present on the surface to which the deposited metal must fuse.

iii) In-experienced welders.

2. Inadequate Penetration is defined as the failure of the filler metal and base metal to fuse integrally at the root of the weld.

Causes :

Heat transfer conditions such as,

i) Use of too large an electrode.

ii) An abnormally high rate of travel.

iii) Use of insufficient welding current, is a frequent source of this defect.

3. Cracks :

In multilayer welds, cracking mostly occurs in the first layer of the weld and unless repaired, will continue through other layers as they are deposited. Cracks may be longitudinal, transverse or crater cracks.

Causes :

i) Improper electrode manipulation or electrical conditions.

ii) Higher speed of travel resulting in lesser thickness of the deposit.

iii) Higher base metal thickness (which may require pre-heating.)

iv) Wrong type of electrode.

4. Under cut - is defined as the melting away of the sidewall of a joint at the edge of a layer or bead thus forming a sharp recess in the sidewell.

Causes :

i) Too high a current

ii) Too long an arc.

iii) Magnetic arc below.

5. Slag inclusions - are defined as oxides and non-metallic solids that are entrapped in weld metal or between weld metal and base metal.

Causes :

i) High viscosity of the weld metal.

ii) Rapid solidification of weld metal.

iii) Too low a welding temperature.

iv) Improper cleaning between passes.

v) Improper electrode manipulation.

6. Porosity - is defined as gas pockets or voids, free of any solid material, that are frequently found in welds. It may be present as uniformly scattered porosity, cluster porosity or linear porosity.

Causes :

i) Excessive Current.

ii) Excessive arc length.

iii) Wet/unclean joint surfaces.

iv) Eccentric burning of electrode.

v) Frequent interruptions.

7. (a) Incorrect Weld Profiles.

Causes :

i) Desirable weld profile.

ii) Acceptable fillet weld profile.

iii) Insufficient lag.

(b) Insufficient throat.

(c) Excessive convexity.

8. Overlap - is the condition in which weld metal protrudes beyond the bond lines at the toe of a weld.

Causes :

i) Incorrect welding technique.

ii) Improper electrical conditions i.e. excessive current or arc length

EXTENT OF INSPECTION AND TESTING

Sl. No.	*Inspection of Test*	*Coverage*	*Procedure*	*Evaluation Findings and remedy of defect*
1.	Inspection of weld seam appearance.	All Welds	Naked eye or lens.	All faulty welds shall be rectified.
2.	Checking of sizes.	Atleast one for each weld seam.	Ordinary Measuring instruments (rule, templates)	Should faulty weld be found, all welds shall checked and all defect shall be rectified.
3.	Mechanical Test for welding procedures performance and Electrodes.	---	As per IS 816	As per IS 816

5. TECHNICAL SPECIFICATION FOR PLASTERING WORK

This Specification covers the general requirements for wall and ceiling plastering.

The contractor shall furnish all materials labour scaffolding equipments, tools, plant and incidentals necessary and required for the completion of all plaster and wall finishes, subject to approval by the Engineer.

Plaster as herein specified shall be applied to all internal and external surfaces where called for. Glazed tile dado, terrazzo dado and other wall finishes shall be provided where indicated on drawings and schedule of finishes. Areas called for on drawings and typical shall be considered to apply to appropriate adjoining areas whether shown on same drawings or not and whether indicated or not.

All plaster work and other wall finishes shall be executed by skilled workmen in a workmanlike manner and shall be of the best workmanship and in strict accordance with the dimensions on drawings subject to the approval of the Engineer.

PLASTER WORK :

The primary requirement of plasterwork shall be to provide absolutely water tight enclosure, dense, smooth and hard and devoid of any cracks on the interior and/or exterior. The contractor shall do all that is necessary to ensure that this objective is achieved. All plastering shall be finished to true plane, without any imperfections and shall be square with adjoining work and form proper foundation for finishing materials such as paint etc.

Masonry and concrete surfaces which call for applications of plaster shall be clean, free from efflorescence, damp and sufficiently rough and keyed to ensure proper bond, subject to the approval of the Engineer.

Wherever directed by the Engineer, all joints between concrete frames and masonry in filling shall be expressed by a groove cut in the plaster. The said groove shall coincide with the joints beneath as directed. Where grooves are not called for, the joints between concrete members and masonry in filling shall be covered by 24 gauge galvanised chicken mesh strips 400 mm wide or as called for on drawings/ documents which shall be in position before plastering.

CHASING & BREAKAGES :

All chasing, installations of conduits, inserts boxes etc., shall be completed before any plastering or other wall finish is commenced on a surface. No chasing or cutting of plaster or other finish on a surface shall be permitted. Broken corners shall be cut back not less than 150 mm on both sides and patched with plaster of paris as directed. All corners shall be rounded to a radius of 8 mm or as directed by the Engineer.

SAMPLES :

Samples of each type of plaster & other wall finish shall be prepared well in advance of undertaking the work for approval by the Engineer.

MATERIALS :

CEMENT : Ordinary Portland cement of 43 Grade conforming to IS:8112 shall be usedand as specified under concrete work

WATER : As specified under concrete work

SAND : For internal plaster - washed fine sand.

WATERPROOFING COMPOUND : CICO NO.1 or approved quality.

PROPORTIONS :

The materials used for plastering shall be proportioned by volume by means of gauge boxes.

PREPARATIONS OF SURFACES :

The joints in all walls, both existing and freshly built shall be raked to a depth of 15 mm, brush cleaned with wire brushes, dusted and thoroughly wetted before starting plastering work. Concrete surfaces to receive plaster shall be roughened by hacking over the entire surface so that the skin of the concrete is completely removed, as approved by the Engineer to ensure proper key for the plaster.

PLASTER TO WALLS :

Plaster to internal faces of walls shall be 12 to 15 mm thick comprising of one part cement and five part clean fine sand or as specified in the item specification. The external surfaces of external wall shall have plaster of 12 mm thickness comprising of one part of cement and five parts of clean fine sand or as specified in the item specification to form base for vapour barrier.

MORTAR MIXING :

Mixing of mortar shall be done in a mechanical mixer. Hand mixing shall be resorted to only when specifically permitted by the Engineer. Cement and sand shall be mixed dry thoroughly and then water shall be added gradually. Wet mixing shall be continued till mortar of the consistency of a stiff paste and uniform colour is obtained. Only the quantity of mortar which can be used within thirty minutes of its mixing shall be prepared at a time.

Mortar shall be used as soon as possible after mixing and before it has begun to set and in any case within thirty minutes after the water is added to the dry mixture. Mortar left un-used for more than thirty minutes after mixing shall be rejected and removed from the site of work.

APPLICATIONS :

Plaster application shall be commenced only after the preparatory work is approved by the Engineer. Correct thickness of plaster shall be obtained by laying plaster screeds (gauges) at intervals of 1.5 mtrs. as directed. Mortar shall be firmly applied, spread evenly well pressed into the joints, rubbed, smoothened with straight edge, wooden float and trowel and finished as approved by the Engineer to give a smooth, true and even surface.

CURING :

Finished plaster shall be kept wet for at least 10 days after completion. In hot weather, walls exposed to such shall be screened with matting kept constantly wet or by any other approved means.

CEILING PLASTER :

Plaster to ceilings, soffits or stairs flight slabs and similar locations, where called for, shall be 12 mm thick and comprise of one part of cement and three parts of clean fine sand or as specified in the item.

PREPARATION OF SURFACE :

The surfaces to be plastered shall be prepared as called for earlier. The surface shall be brushed, swept clean and thoroughly wetted before plastering.

APPLICATIONS :

Mortar shall be applied firmly, pressed to the surface rubbed and finished to a smooth and even surface subject to the approval of the Engineer.

CHICKEN MESH TO WALLS :

Galvanized chicken mesh (24 gauge, 12 mm size) shall be provided at junctions of brick masonry and concrete members, to be plastered and other locations 150 mm on either side of the junction in double fold or as called for, properly

stretched and nailed, ensuring equal thickness of plaster on both sides of the mesh. The rate includes in the plaster works.

CEMENT MORTAR :

Cement mortar shall be of proportion specified for each type of work. It shall be composed of portland cement of 43 grade and sand. The ingredients shall be accurately gauged and shall be evenly mixed together in a mechanical mixer. Care should be taken not to add more water than necessary. If hand mix is allowed it shall be done on pucca waterproof platform. The gauged materials shall be put on platform, and thoroughly mixed dry. Water shall then be added and the whole mixed thoroughly until the mix is homogeneous and of uniform colour, quantity of mortar mixed should not be more than what can be consumed within half an hour of mixing.

Cement mortar mix are specified as 1:2, 1:3, 1:4, 1:5 etc. The first figure will mean one part of portland cement by volume, the second figure will mean so many parts of sand by volume. For example, cement mortar 1:4 would mean one part of cement and four parts of sand. Cement & sand must conform to relevant IS specification. Plaster shall not in any place be thinner than specified. Any extra thickness of plaster required to be plastered in the case of brick masonry or extra thickness required due to raking of the joints or filling up depressions formed in concrete surface during the course of roughening or due to bad casting or centering shall not be paid separately, but shall be covered by the general rate for plastering.

The rate for plastering shall include the cost of scaffolding (NO WOODEN SCAFFOLDING IS ALLOWED), platform, swing etc. needed for carrying out the plaster work and shall cover the extra labour for plastering the joints, sills and soffits of openings. No extra payment shall be made for roughening the surface to obtain key for plastering work.

6. TECHNICAL SPECIFICATION FOR WATER PROOFING WORK

SCOPE

This specification covers the general requirements for water proofing to the underground structure, machinery foundation, pits, trenches, lift pits, roof slab, toilet sunken slab etc.

GENERAL REQUIREMENTS

Waterproofing treatment shall be done with waterproofing materials of approved reputed manufacturers and applied by specialist firms with long experience in the particular trade and proven track record.

The Contractor shall furnish all skilled and unskilled labour, plant, tools, tackle, equipment, men, materials required for complete execution of the work in accordance with the drawings and as described herein and/or as directed by the Engineer.

The Contractor shall strictly follow, at all stages of work, the stipulations contained in the Indian Standard Safety Code and the provisions of the Safety Rules as specified in the General Conditions of the Contract for ensuring safety of men and materials.

Any approval, instructions, permission, checking, review etc. whatsoever by the Engineer shall not relieve the Contractor of his responsibility and obligation regarding adequacy, correctness, completeness, safety, strength, workmanship etc.
The treatment shall include both external and internal type at different stages of execution involving various operations of preparation, application and induction of chemicals as water proof barrier in order of sequence.
The treatment shall be done as per the specifications and instructions of manufacturers including cost of all materials all leads and lifts, cleaning, scaffolding, curing, conducting, leakage test etc.

All spaces underneath the tiered seating completely watertight and designed as habitable spaces

CODES AND STANDARDS

The applicable Indian Standard and Code is given below :

IS : 2645 : Integral cement water proofing compounds.
IS : 9103 : Admixtures for Concrete

MATERIALS

Cement conforming	:	Ordinary Portland cement of 43 Grade to IS : 8112 shall be used.
Coarse Aggregate	:	Coarse aggregate shall conform to IS:383
Sand :2116	:	Sand shall conform to IS : 383, IS :1542 and IS
Water	:	Water shall conform to IS : 456.
Water Proofing Compound	:	Waterproofing compound shall conform to IS:2645

SURFACE PREPARATION

The surface to receive the waterproofing shall be cleaned of all dust, dirt, loose material, debris, mortar droppings, laitance, oil, grease or any other form of foreign matter which might affect adhesion and left in a saturated, surface dried condition and approval of Engineer taken before starting the work. The surface to be treated in underground structures shall be kept dry by continuous pumping of water.
The surface preparation shall be done as per specification and instructions of the manufacturer.

DIFFERENT STAGES OF TREATMENT TO UNDERGROUND STRUCTURES

Treatment on PCC levelling course :

Treatment on the top surface of PCC levelling course before casting of base slab : After laying of PCC to proper level and line, the surface shall be cured for the required period.
The PCC surface shall be prepared as described above and kept dry by continuous pumping of water.
12 mm thick plaster with cement sand mortar (1:3) admixed with approved normal setting integral cement water proofing compound like **CICO No.1 – (Normal Setting Integral Waterproofing Compound) Conforming to IS : 2645** @ 2% by weight of cement, or approved equivalent at the rate specified by the manufacturer shall be laid on top of the PCC surface as per specifications and instructions of the

manufacturer. The plaster shall be finished smooth with a steel trowel and cured for 1day.
The plastered surface shall then be coated with two (2) coats of **TAPECRETE – Acrylic Polymer modified cementitous coating**, or approved equivalent as per manufacturer's specification and instructions. The coating shall be cured with water for 1 day.
The surface shall then be covered with another 12 mm thick plaster as described under clause (c) above. The treated surface shall be cured for 5 days.
Base slab concrete admixed with **CICO No.1 (Normal Setting Integral Waterproofing Compound) Conforming to IS : 2645** or **CICO SUPAPLAST Super Plasticiser-cum-High Range Water Reducing Admixture-Cum-Waterproofer conforming to IS : 9103 as Plasticiser and IS : 2645 as Integral Waterproofer** as per recommended dosage or approved equivalent shall be laid over this treated surface.
Note :
Applicable to PCC levelling course below base slab of under ground sump, under ground structure, lift pit, machinery foundations, trenches etc.
Chemical injection treatment to base slab :
Chemical injection treatment in the form of pressure grouting to the concrete mass of base slab :
The treatment shall be as per manufacturers specification adopting following general operation details :
After casting of base slab and side wall, the surface shall be cured as per the standard practice.
18 mm dia. holes shall be drilled on top of base slab to required depth using pneumatic hammer drill in grid pattern at a spacing not exceeding 1 M centre to centre. Particular care should be taken to drill holes and fix nozzles along the construction joint line wherever it occurs and on other vulnerable areas.
The depth of nozzles shall be adequate to push the grout at all depth. GI nozzles shall be fixed in the holes drilled using single component rapid setting mortar like CICO No.3, or approved equivalent.
Cement slurry mixed with grout admixture like **CICO Non-Shrink Polymer Waterproof Grouting Compound** at 2% by weight of cement or approved equivalent as per specification and instruction of the manufacturer shall be prepared to the required consistency.
The prepared slurry shall be injected through the prefixed nozzles under pressure using grout pump to fill all possible pores and gaps left within the concrete mass. When the flow of the grout stops the grout mains shall be disconnected.
The GI nozzles shall be sealed off with single component rapid setting mortar like **CICO NO. 3,** or approved equivalent after the injection operation is over.
The grout holes shall then be finished after cutting the projected nozzles.
Note :
Applicable to base slab of underground sump, underground structure, pile and pipe cap, lift pit, trenches etc.
Treatment to side wall
Treatment to side wall from exterior surface
Casting of RCC walls shall be done with specified grade of concrete admixed with **CICO No.1 (Normal Setting Integral Waterproofing Compound) Conforming**

to IS : 2645 or **CICO SUPAPLAST Super Plasticiser-cum-High Range Water Reducing Admixture-Cum-Waterproofer conforming to IS : 9103 as Plasticiser and IS : 2645 as Integral Waterproofer** as per recommended dosage or approved equivalent, shall be laid over this treated surface.
After casting of side wall to the required height, the surface shall be cured as per the standard practice.
Chemical injection treatment in the form of pressure grouting shall be done as given below :
18 mm dia. holes shall be drilled on exterior surface of wall to required depth using pneumatic hammer drill in grid pattern at a spacing not exceeding 1 M centre to centre. Particular care should be taken to drill holes and fix nozzles along the construction joint line wherever it occurs and on other vulnerable areas.
The depth of nozzles shall be adequate to push the grout at all depth. GI nozzles shall be fixed in the holes drilled using single component rapid setting mortar like CICO No.3, or approved equivalent.
Cement slurry mixed with grout admixture like **CICO Non-Shrink Polymer Waterproof Grouting Compound** at 2% by weight of cement or approved equivalent as per specification and instruction of the manufacturer shall be prepared to the required consistency.

The prepared slurry shall be injected through the prefixed nozzles under pressure using grout pump to fill all possible pores and gaps left within the concrete mass. When the flow of the grout stops the grout mains shall be disconnected.
The GI nozzles shall be sealed off with single component rapid setting mortar like **CICO NO. 3,** or approved equivalent after the injection operation is over.
The grout holes shall then be finished after cutting the projected nozzles.
The outside surface of wall shall be prepared as described under head "Surface Preparation" after the chemical injection treatment is over.
The prepared exterior surface shall be coated (2 coats) with **TAPECRETE – Acrylic Polymer modified cementitous coating**, or approved equivalent as per Manufacturer's Specification and instructions. The surface shall be cured with water for 1 day.
On top of the coating a 12 mm thick plaster with cement sand mortar (1:3) admixed with **CICO NO. 1 – Normal Setting Integral Waterproofing Compound conforming to IS : 2645**, or approved equivalent at the rate specified by the manufacturer shall be applied as per specifications and instructions of the manufacturer. The plaster shall be finished smooth with a steel trowel and cured for 5 days.
In case of nil accessibility owing to constructional hazards, etc. the interior surface of wall may be treated as mentioned above to produce same effect.
Note :
Applicable to side walls of underground sump, underground structure, trenches and retaining wall. In the case of underground sump interior surface of walls shall be treated.
GUARANTEE
Guarantee for watertight performance of the structure for a minimum period of 10 years from the date of completion shall be given in the prescribed form given below. This guarantee shall be in legal paper in an acceptable form. The guarantee shall be

enforceable by the Owner. If, during the guarantee period, water leaks are noticed in the structure from the portions treated by the Contractor, the same shall be rectified when called upon immediately, all at no extra cost to the entire satisfaction of the Owner.

7. TECHNICAL SPECIFICATION FOR ROAD WORK

NOTE

1. Relevant clauses of Ministry of Surface Transport **(MOST)** Specifications for Roads and Bridges relevant to this tender only are reproduced.

2. In case of any variation between the reproduced specification and the original specification of **MOST** Publication, the reproduce publication shall prevail and shall be construed accordingly.

3. If **MOST** clauses referred to in the reproduced specifications herein are not included in the latter, the same shall be read from **MOST** specifications.

301. EXCAVATION FOR ROADWAY AND DRAINS

Please refer to the Clause/Section No. 301 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Excavation for Roadway and Drains.

304 EXCAVATION FOR STRUCTURES

Please refer to the Clause/Section No. 304 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Excavation for Structures.

305 EMBANKMENT CONSTRUCTION

Please refer to the Clause/Section No. 305 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Embankment Construction.

401 GRANULAR SUB-BASE

Please refer to the Clause/Section No. 401 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Granular sub-base.

406 WET MIX MACADAM SUB-BASE/BASE COURSE

Please refer to the Clause/Section No. 406 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Wet Mix Macadam for Sub-base or Base course.

409 FOOTPATHS

Please refer to the Clause/Section No. 409 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Footpath works.

501 PREPARATION OF BASE

Please refer to the Clause/Section No. 501 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Preparation of Base works.

502 PREPARATION OF WET MIX MACADAM

Please refer to the Clause/Section No. 502 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Prime coat over granular base.

503 TACK COAT

Please refer to the Clause/Section No. 503 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Tack coat.

504 BITUMINOUS MACADAM

504.1 SCOPE

The work shall consist of construction, in a single course, of 50mm thickness of compacted crushed aggregates premixed with a bituminous binder, to serve as base/binder course, laid immediately after mixing, on a base prepared previously in accordance with the requirement of these specifications and in conformity with the line, grades and cross sections shown on the drawing or as directed by the Engineer.

504.2 MATERIALS

504.2.1 Bitumen :

The bitumen shall be paving bitumen of suitable penetration grade 60/70 as per IS: 73. The actual grade of bitumen to be used shall be decided by the Engineer appropriate to the region, traffic, rainfall and other environmental conditions. Guidelines on selection of the grade of bitumen are given Appendix-4.

504.2.2 Aggregates :

The aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, strong, durable of fairly cubical shape and free from disintegrated pieces, organic or other deleterious matters and adherent coating. The aggregates shall preferably be hydrophobic and of low porosity. If hydrophilic aggregates are to be used the bitumen shall preferably be treated with anti stripping agents of approved quality in suitable doses as per Appendix-5. The aggregates shall satisfy the physical requirements set forth in Table 500-3.

TABLE: 500-3

PHYSICAL REQUIREMENT OF AGGREGATE FOR B. MACADAM

Sl. No	Test	Test method	Requirement
1	Los Angeles Abrasion Value *	IS:2386 (Part 4)	40% Maximum
2	Aggregate Impact Value *	IS:2386 (Part 4)	30% Maximum
3	Flakiness and Elongation Indices (total)	IS:2386 (Part I)	30% Maximum
4	Coating and Stripping of Bitumen Aggregate Mixtures	AASHTO T 182	Minimum retained coating 95%.
5	Soundness: Loss with Sodium Sulphate 5 Cycles Loss with Magnesium Sulphate 5 Cycles	IS:2386 (Part-5)	 12% max. 18% max.
6	Water absorption	IS:2386 (Part-3)	2% Maximum

*Aggregate may satisfy requirements of either of the two tests

**To determine this combined proportion; the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles are separated out from the remaining (non-flaky) stone metal. Elongation index is flakiness index and elongation index so found are added up.

Note: If crushed slag is used Clause 404.2.3 shall apply.

504.2.2.1. The aggregate for bituminous macadam shall conform to the one of two grading in Tables 500-4, depending on the compacted thickness; the actual grading shall be specified in the Contract.

504.2.3 Proportioning of Materials :

The bitumen content for premixing shall be 3 to 3.5 percent by weight of total mix except when otherwise directed by the Engineer.

TABLE:
500-4

AGGREGATE GRADING FOR BITUMINOUS MACADAM

IS Sieve Designation	Percent by weight passing the Sieve	
	Grading-1	Grading-2
45.0mm.	100	--
26.5 mm.	75-100	100
22.4 mm.	60-95	75-100
11.2mm.	30-55	50-85
5.6mm.	15-35	20-40
2.8	5-20	5-20
90 micron	0-5	0-5

The maximum compacted thickness of a layer shall be 100mm.

The quantities of aggregate to be used shall be sufficient to yield the specified thickness after compaction.

504.2.4 Variation in proportioning of Material :

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content +0.3 percent by weight of total mix shall, however, be permissible for individual specimens taken for quality control tests vide Section 900.

504.2.5 Variation in proportioning of Material :

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content +0.3 percent by weight of total mix shall, however, be permissible for individual specimens taken for quality control tests vide Section 900.

504.3 CONSTRUCTION OPERATION

504.3.1 Weather and Seasonal Limitations :

The work of laying shall not be taken up during rainy or foggy weather or when the base course is damp or wet, or during dust storm or when the atmospheric temperature in shade is 100C or less.

504.3.2 Preparation of the Base:

The base on which bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grades and cross sections in accordance with Clause 501, and a priming coat where needed shall be applied in accordance with clause 502 as directed by the Engineer.

504.3.3 Tack Coat:

A tack coat as per Clause 503 shall be applied over the base.

504.3.4 Preparation and Transport of Mix:

Bituminous macadam mix shall be prepared in a hot mix plant of adequate capacity and capable to yield a mix of proper and uniform quality with thoroughly coated aggregates.

Hot mix plant shall be of suitable capacity preferably of batch mix type. Total system for crushing of stone aggregates and feeding of aggregate fractions in required proportions to achieve the desired mix, deployed by the Contractor must be capable of meeting the overall Specification requirements under stringent quality control. The plant shall have the following essential features:

A. General

a) The plant shall have coordinated set of essential units capable of producing uniform mix as per the job mix formula.

b) Cold aggregate feed system with minimum 4 bins having belt conveyor arrangement for initial proportioning of aggregates from each bin in the required quantities. In order to have free flow of fines from the bin, it is advisable to have vibrator fitted on bin to intermittently shake it.

c) Belt conveyers below each bin should have variable speed drive motors. There should be electronic load sensor on the main conveyer for measuring the flow of aggregates.

d) Dryer unit with burner capable of heating the aggregate to the required temperature without any visible unburnt fuel or carbon residue on the aggregate and reducing the moisture content of the aggregate to the specified minimum.

e) The plant shall be fitted with suitable type of thermometric instruments at appropriate places so to indicate or record/register the temperature of heated aggregate, bitumen and mix.

f) Bitumen supply unit capable of heating, measuring/metering and spraying of bitumen at specified temperature with automatic synchronisation of bitumen and aggregate feed in the required proportion.

g) A filler system suitable to receive bagged or bulk supply of filler materials and its incorporation into mix in the correct quantity, wherever required.

h) A suitably built-in dust control system for the dryer to contain/recycle permissible fines into the mix. It should be capable of preventing the exhaust of fine dust into atmosphere for environmental control wherever so specified by the Engineer.

i) The Plant should have centralised control panel/cabin capable of pre-setting, controlling/synchronising all operations starting from feedinsg of cold aggregates to the discharge of the hot mix to ensure proper quality of mix. It should have indicators for any malfunctioning in the operation.

j) Every hot mix plant should be equipped with siren or horn so that the operator may use the same before starting the plant every time in the interest of safety of staff.

B. For Batch Type Plant

i) Gradation control unit having vibratory screens for accurate sizing of hot aggregate and storing them in separate bins. This unit should be fully covered to reduce the maintenance cost and for better environmental condition.

ii) Proper arrangement for accurate weighing of each size of hot aggregate from the control panel before mixing.

iii) Paddle mixer unit shall be capable of producing a homogeneous mix with uniform coating of all particles of the mineral aggregate with binder.

C. For continuous Type Plant

i) Gradation control unit having vibratory screens for accurate sizing of hot aggregate and storing them in separate bins. This should be fully covered to reduce the maintenance cost and for better environmental condition.

ii) There should be appropriate arrangement for regulating and volumetric control of the flow of hot aggregate from each bin to achieve the required proportioning.

iii) Paddle mixer unit shall be capable of producing a homogeneous mix with uniform coating of all particles of the mineral aggregate with binder.

D. For Drum Mix Plant

i) It is prerequisite that only properly screened and graded materials are fed to the bins. If required a vibratory screening unit should be installed at the plant site to ensure the same.

A primary 4-deck vibratory screening unit shall be installed before the multiple bin cold feed system for screening the aggregates and grading the same.

ii) Belt conveyors below each bin should have variable speed drive motors. There should be electronic load sensor on the main conveyor for measuring the flow of aggregate.

iii) There should be arrangement to measure moisture content of the aggregate (s) so that moisture correction may be applied for working out requirement of binder and filter.

The temperature of binder at the time of mixing shall be in the range of 1500C to 1630C and that of the aggregate in the range of 1550C to 1630C, provided that the difference in temperature between the binder and aggregate at no time exceed 140C.

Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregate are coated uniformly, and the discharge temperature of mix shall be between 1300C to 1600C.

D. The mixture shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for transport shall be clean and be covered over in transit if so directed by the Engineer. Any tipper causing excessive segregation of materials by its spring suspension or other contributing factors or that which shows undue delay shall be removed from the work until such conditions are corrected.

504.3.5 Spreading :

The mix transferred from the tipper at site to the paver shall be spread immediately by means of self propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix true to the specified lines, grades and cross sections. the paver finisher shall have the following essential features.

i. Loading hoppers and suitable distributing mechanism

ii. All drives having hydrostatic drive/control

iii. The machine shall have a hydraulically extendable screed for appropriate width requirement.

iv. The screed shall have tamping and vibrating arrangement for initial compaction to the layer as it is spread without rutting or otherwise marring the surface. It shall have adjustable amplitude and infinitely variable frequency.

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

vi. The paver shall be fitted with an electronic sensing device for automatic levelling and profile control within the specified tolerances.

vii. The screed shall have the internal heating arrangement.

viii. The paver shall be capable of laying either 2.5 to 4.0m width or 4.0 to 7.0m width as stipulated in the Contract.

ix. The paver shall be so designed as to eliminate skidding/slippage of the tyres during operation.

However, in restricted locations and in narrow widths where the available plant cannot be operated in the opinion of the Engineer, he may permit manual laying of the mix.

The temperature of the mix at the time of laying shall be in the range of 1200C 1600C. In multi layer construction the longitudinal joint in one layer shall offset that in the layer below by about 150mm. However, the joint in the top most layers shall be at the centre line of the pavement.

Longitudinal joint and edges shall be constructed true to the delineating line parallel to the central line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material. Longitudinal and transverse joints shall be offset by at least 250mm. from those in the lower courses and the joint on the top most layers shall not be allowed to fall within the wheel path. All transverse

joints shall be cut vertically to the full thickness of the previously laid mix with asphalt cutter/pavement breaker and surface painted with hot bitumen before placing fresh material. Longitudinal joints shall be preferably hot joints. Cold longitudinal joints shall be properly heated with joint heater to attain a suitable temperature of about 800C before laying of adjacent material.

504.3.6 Compaction:

After the spreading of mix, rolling shall be done by 80 to 100 KN rollers or other approved equipment. Rolling should start as soon as possible after the material has been spread deploying a set of rollers as the rolling is to be completed in limited time frame. The rolling move at a speed not more than 5 km/hr. Rolling shall be done with care to keep from unduly roughening the pavement surface.

Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this the rolling shall commence at the edges and progress towards the centre longitudinally except that one super-elevated portions, it shall progress from the lower to the upper edge parallel to the central line of the pavement.

The initial or break down rolling shall be done, with 80 to 100 KN static weight smooth wheel roller (3 wheels or tandem), as soon as it is possible to roll the mix without cracking the surface or having the mix pick up on the roller wheels. The second or intermediate rolling shall follow the break down rolling with vibratory roller of 80 to 100 KN static weight or pneumatic tyred roller of 150 to
250 KN weight, with minimum 7 wheels and minimum tyre pressure of 0.7 MPa as closely as possible to the paver and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while material is still workable enough for removal of roller marks with 60 to 80

KN tandem roller. During the initial or break down rolling and final rolling, vibratory system shall be switched off. The joints and edges shall be rolled with a 80 to 100 KN static roller.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding mix material. The rolling shall then be continued till the entire surface has been rolled to 95 percent of the average laboratory density (obtained from Marshall Specimens compacted as defined in Table 500-10), there is no crushing of aggregates and all roller marks have been eliminated. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. The roller wheel shall be kept damp if necessary to avoid bituminous material from sticking to the wheels and being picked up. In no case shall fuel lubricating oil be used for this purpose, nor excessive water to be poured on the wheels.
Rolling operations shall be compacted in every respect before the temperature of the mix falls below 1000C.

Roller (s) shall not stand on newly laid material while there is a risk that it will be deformed thereby. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate bidder before the new mix is placed against it.

504.4 SURFACE FINISH AND QUALITY CONTROL OF WORK

The surface finish of construction shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

504.5 The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, without any delay. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Clause 513 before allowing any traffic over it. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

504.6 ARRANGEMENTS OF TRAFFIC

During the period of Construction, arrangement of traffic shall be done to Clause 112.

504.7 MEASUREMENTS FOR PAYMENT

The work shall be measured as finished work in cubic metres or by weight in metric tonnes as per provided in the Contract.

504.8 RATE

The contract unit rate for the work shall be payment in full for carrying out the required operations including full compensation for:

i) Making arrangements for traffic to Clause 112 except for initial treatment to verge shoulders and construction of diversions.

ii) Preparation of base except for laying of profile corrective course but including filing of pot holes.

iii) Providing all materials to be incorporated in the work including all royalties, fees, rents where necessary and all leads and lifts,

iv) All labour, tools, equipment, plants including installation of hot-mix plant, power supply units and all machineries incidentals to complete the work to the specifications;

v) Carrying out the work in part widths of the road where directed;

vi) Carrying out all tests for control of quality; and

vii) The rate shall cover the provision of bitumen at 3.5 percent of weight of total mix, with the provision that the variation of quantity of bitumen will be assessed and the payment adjusted as per the rate of bitumen quoted.

507 DENSE GRADED BITUMINOUS MACADAM

507.1. Scope

This clause specifies the construction of Dense Graded Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. DBM is also intended for use as road base material. This work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 to 100 mm.

507.2.Materials

507.2.1. Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS: 73, and o f the penetration indicated in Table 500-10 for dense bitumen macadam, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

507.2.2. Coarse aggregates: The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected so urce of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, without additional p ayment. Before approval of the source, the aggregates shall be tested for stripping. The aggregates shall satisfy the physical requirements specified in Table 500-8, for dense bituminous macadam.

Where crushed gravel is proposed for use as aggregate, not less than 90 % by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

507.2.3. Fine aggregates: Fine aggregates consist of crushed or naturally occurring mineral material, or a combination of the two, passing the 2.36 mm sieve and

retained on 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter.

The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part 37).

The plasticity index of the fraction passing the 0.425 mm sieve shall not exceed 4. When tested in accordance with IS: 2720 (Part 5)

TABLE 500-8. PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE FOR DENSE GRADED BITUMINOUS MACADAM

Property	Test	Specification
Cleanliness (dust)	Grain size analysis[1]	Max 5 % passing 0.075 mm sieve
Particle shape	Flakiness and Elongation Index (Combined)[2]	Max 30 %
Strength *	Loss Angeles Abrasion Value[3]	Max 35 %
	Aggregate Impact Value[4]	Max 27 %
Durability	Soundness: Sodium Sulphate Magnesium Sulphate	 Max 12 % Max 18 %
Water Absorption	Water absorption	Max 2 %
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures	Minimum retained coating 95 %
Water Sensitivity**	Retained Tensile Strength	Min 80 %

Notes: 1. IS: 2386 Part 1 5. IS: 2386 Part 5

2. IS: 2386 Part 1 6. IS: 2386 Part 3

(the elongation test to be done only on non-flaky aggregates in the sample)

3. IS: 2386 Part 4* 7. IS: 6241

4. IS: 2386 Part 4* 8. AASHTO T 283**

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

** The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95 %.

507.2.4. Filler: Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer.

The filler shall be graded within the limits indicated in Table 500-9.

TABLE 500-9. GRADING REQUIREMENTS FOR MINERAL FILLER

IS Sieve (mm)	Cumulative per cent passing by weight of total aggregate
0.6	100
0.3	95 – 100
0.075	85 – 100

The filler shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. When the coarse aggregate is gravel, 2 per cent by weight of total aggregate, shall be Portland cement or hydrated lime and the percentage of fine aggregate reduced accordingly. Cement or hydrated lime is not required when the limestone aggregate is used. Where the aggregates fail to meet the requirements of the water sensitivity test in Table 500-8, then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional coat.

507.2.5. Aggregate grading and binder content: When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler for the particular mixture shall fall within the limits shown in Table 500-10, for dense bituminous macadam grading 1 or 2 as specified in the Contract. The type and quality of bitumen, and appropriate thickness, are also indicated for each mixture type.

TABLE 500-10. COMPOSITION OF DENSE GRADED BITUMINOUS MACADAM PAVEMENT LAYERS

Grading	**1**	**2**
Nominal aggregate size	40 mm	25 mm
Layer Thickness	80 – 100 mm	50 – 75 mm
IS Sieve[1] (mm)	Cumulative % by weight of total aggregate passing	
45	100	-
37.5	95 – 100	100
26.5	63 – 93	90 – 100
19	-	71 – 95
13.2	55 – 75	56 – 80
9.5	-	-
4.75	38 – 54	38 – 54

2.36	28 – 42	28 – 42
1.18	-	-
0.6	-	-
0.3	7 – 21	7 – 21
0.15	-	-
0.075	2 – 8	2 – 8

Grading	**1**	**2**
Bitumen content % by mass of total mix[2]	Min 4.0	Min 4.5
Bitumen grade (pen)	65 or 90	65 or 90

Notes: 1.The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

Determined by the Marshall method.

507.3.Mixture Design

507.3.1. Requirement for the mixture**:** Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-11.

TABLE 500-11. REQUIREMENTS FOR DENSE GRADED BITUMINOUS MACADAM

Minimum stability (kN at 60^0C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3 – 6
Per cent voids in mineral aggregate (VMA)	See Table 500-12 below.
Per cent voids filled with bitumen (VFB)	65 – 75

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

TABLE 500-12. MINIMUM PER CENT VOIDS IN MINERAL AGGREGATE (VMA)

Nominal Maximum Particle Size[1]	Minimum VMA, Per cent Related to

(mm)	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Notes:

1. The nominal maximum particle size is one size larger than the first sieve to retain more than 10 per cent.

2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

507.3.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-11 and the traffic volume specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-
2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on 22.4 mm sieve, where approved by the Engineer.

Where 40 mm dense bituminous macadam mixture is specified, the modified Marshall method described in MS-2 shall be used. This method requires modified equipment and procedures; particularly the minimum stability values in Table
500-11 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

507.3.3. Job mix formula: The Contractor shall inform Engineer in writing, at least
20 days before the start of the work, of the job mix formula proposed for be used in the works, and shall give the following details:

(i) Source and location of all materials;

(ii) Proportions of all materials expressed as follows where each is applicable:

(iii) Binder type, and percentage by weight of total mixture;

(iv) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;

(v) A single definite percentage passing each sieve for the mixed aggregate; (vi) The individual gradings of the individual aggregate fractions, and the proportion of each in the combined grading.

(vii) The results of tests enumerated in Table 500-11 as obtained by the Contractor;

(viii) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch,

(ix) Test results of physical characteristics of aggregates to be used; (x) Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

The approved job mix formula shall remain effective unless and until a revised Job Mix Formula is approved. Should a change in the source of materials be proposed, a new job mix formula shall be forwarded to the Engineer for approval before the placing of the material.

507.3.4. Plant trials - permissible variation in job mix formula: Over the laboratory job mix formula is approved, the Contractor shall carry out plant trials at the mixer to establish that the plant can be set up to produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 500-13. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

TABLE 500-13. PERMISSIBLE VARIATIONS FROM THE JOB MIX FORMULA

Description	Permissible variation	
	Base/binder course	Wearing course
Aggregate passing 19 mm sieve or larger	$\pm$ 8 %	$\pm$ 7 %
Aggregate passing 13.2 mm, 9.5 mm	$\pm$ 7 %	$\pm$ 6 %
Aggregate passing 4.75 mm	$\pm$ 6 %	$\pm$ 5 %
Aggregate passing 2.36 mm, 1.18 mm, 0.6 mm	$\pm$ 5 %	$\pm$ 4 %
Aggregate passing 0.3 mm, 0.15 mm	$\pm$ 4 %	$\pm$ 3 %
Aggregate passing 0.075 mm	$\pm$ 2 %	$\pm$ 1.5 %
Binder content	$\pm$ 0.3 %	$\pm$ 0.3 %
Mixing temperature	$\pm$ 10^0C	$\pm$ 10^0C

Once the plant trials have demonstrated the capability of the plant, and the trials are approved, the laying operation may commence. Over the period of the first month of production for laying on the works, the Engineer shall require additional testing of the product to establish the reliability and consistency of the plant.

507.3.5. Laying Trials: Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid, and compacted all in accordance with Clause 501. The laying trial shall be carried out on a suitable area which is not to form part of the works, unless specifically approved in writing, by the Engineer. The area of the laying trials shall be a minimum of 100 sq. m. of construction similar to that of the project road, and it shall be in all respects, particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor shall previously inform the Engineer of the proposed method for laying and compacting the material. The plant trials shall then establish if the

proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion required further laying trials.

507.4.Construction Operations

507.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

507.4.2. Preparation of base**:** The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

507.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 703.

507.4.4. Stress absorbing layer: Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 522.

507.4.5. Prime coat: Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in accordance with the provisions of Clause 502, or as directed by the Engineer.

507.4.6. Tack coat: Where the material on which the dense bituminous macadam is to be placed is a bitumen bound surface, a tack coat shall be applied as specified, in accordance with the provisions of Clause 503, or as directed by the Engineer.

507.4.7. Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3 and 501.4 shall apply.

507.4.8. Spreading: The provisions of Clauses 501.5.3 and 501.5.4 shall apply.

507.4.9. Rolling: The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trails. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

507.5. Opening to Traffic

The newly laid surface shall not be open to traffic for at least 24 hrs after laying and completion of compaction, without the express approval of the Engineer in writing.

507.6. Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of this Specification.

507.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

507.8. Measurement for Payment

Dense Graded Bituminous Materials shall be measured as finished wok either in cubic metres, tons or by the square metre at a specified thickness as detailed on the Contract drawings, or documents, or as directed by the Engineer.

507.9. Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out the all required operations as specified, and shall include, but not necessarily limited to all components listed in Clause 501.8.8.2 (i) to (xi). The rate shall include the provision of bitumen, 4.25 per cent by weight of the total mixture.

The variance in actual percentage of bitumen used will be assessed and the payment adjusted, up or down, accordingly.

508 SEMI-DENCE BITUMINOUS CONCRETE

508.1. Scope

This clause specifies the construction of Semi Dense Bituminous Concrete, for use in wearing/binder and profile corrective courses. This work shall consist of construction in a single or multiple layers of semi dense bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25mm to 100 mm in thickness.

508.2. Materials

508.2.1. Bitumen: The bitumen shall be paving bitumen of Penetration Grade complying with Indian Standard Specifications for Paving Bitumen, IS: 73 and of the penetration indicated in Table 500-15, for semi dense bituminous concrete, or this bitumen as modified by one of the methods specified in Clause 521, or as otherwise specified in the Contract. Guidance on the selection of an appropriate grade of bitumen is given in The Manual for Construction and Supervision of Bituminous Works.

508.2.2. Coarse aggregates**:** The coarse aggregates shall be generally as specified in Clause 507.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-14.

508.2.3. Fine aggregates: The fine aggregates shall be all as specified in Clause 507.2.3.

508.2.4. Filler: Filler shall be generally as specified in Clause 507.2.4. Where the aggregates fail to meet the requirements of the water sensitivity test in Table

500-14 then 2 per cent by total weight of aggregate, of hydrated lime shall be added without additional cost.

508.2.5. Aggregate grading and binder content: When tested in accordance with IS: 2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and added filler shall fall within the limits shown in Table 500-15 for gradings 1 or 2 as specified in the Contract.

508.3. Mixture Design

508.3.1. Requirement for the mixture: Apart from conformity with the grading and quality requirements for individual ingredients the mixture shall meet the requirements set out in Table 500-16.

TABLE 500-14 . PHYSICAL REQUIREMENTS FOR COARSE AGGREGATE FOR SEMI DENSE BITUMINOUS CONCRETE PAVEMENT LAYERS

Property	Test	Specification
Cleanliness (dust)	Grain size analysis [1]	Max 5 % passing 0.075 mm sieve
Particle shape	Flakiness and Elongation Index (Combined)[2]	Max 30 %
Strength *	Loss Angeles Abrasion Value[3]	Max 35 %
	Aggregate Impact Value[4]	Max 27 %
Polishing	Polished Stone Value[5]	Min 55
Durability	Soundness:[6] Sodium Sulphate Magnesium Sulphate	 Max 12 % Max 18 %
Water Absorption	Water absorption[7]	Max 2 %
Stripping	Coating and Stripping of Bitumen Aggregate Mixtures[9]	Minimum retained coating 95 %
Water Sensitivity**	Retained Tensile Strength[8]	Min 80 %

Notes: 1. IS: 2386 Part 1 6. IS: 2386 Part 5

2. IS: 2386 Part 1 7. IS: 2386 Part 3 (the elongation test to be done only on non-flaky aggregates in the sample)

3. IS: 2386 Part 4* 8. AASHTO T 283**

4. IS: 2386 Part 4* 9. IS: 6241

5. BS: 812 Part 114

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

** The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95 %.

The requirements for minimum per cent voids in mineral aggregate (VMA) are set out in Table 500-12.

508.3.2. Binder content: The binder content shall be optimised to achieve the requirements of the mixture set out in Table 500-16 and the traffic volume specified in the Contract. The Marshall method for determining the optimum binder content shall be adopted as described in The Asphalt Institute Manual MS-2, replacing the aggregates retained on the 26.5 mm sieve by the aggregates passing the 26.5 mm sieve and retained on 22.4 mm sieve, where approved by the Engineer.

TABLE 500-15. COMPOSITION OF SEMI DENSE BITUMINOUS CONCRETE PAVEMENT LAYERS

Grading	**1**	**2**
Nominal aggregate size	13 mm	10 mm
Layer Thickness	35 – 40 mm	25 – 30 mm
IS Sieve[1] (mm)	Cumulative % by weight of total aggregate passing	
45	-	-
37.5	-	-
26.5	-	-
19	100	-
13.2	90 – 100	100
9.5	70 – 90	90 – 100
4.75	35 – 51	35 – 51

2.36	24 – 39	24 – 39
1.18	15 – 30	15 – 30
0.6	-	-
0.3	9 – 19	9 – 19
0.15	-	-
0.075	3 – 8	3 – 8
Bitumen content % by mass of total mix[2]	Min 4.5	Min 5.0
Bitumen grade (pen)	65*	65*

Notes: 1. The combined aggregate grading shall not vary from the low limit on one sieve to the high limit on the adjacent sieve.

2. Determined by the Marshall method.

*Only in exceptional circumstances, 80/100 penetration grade may be used, as approved by the Engineer.

TABLE 500-16. REQUIREMENTS FOR SEMI DENSE BITUMINOUS PAVEMENT LAYERS

Minimum stability (kN at 60^0C)	8.2
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Per cent air voids	3 – 5
Per cent voids in mineral aggregate (VMA)	See Table 500-12
Per cent voids filled with bitumen (VFB)	65 – 78

508.3.3. Job mix formula: The procedure for formulating the job mix formula shall be generally as specified in Clause 507.3.3 and the results of tests enumerated in Table 500-16 as obtained by the Contractors.

508.3.4. Plant trials - permissible variation in job mix formula: The requirements for plant trials shall be all as specified in Clause 507.3.4, and permissible limits for variation as shown in Table 500-13.

508.3.5. Laying Trials: The requirements for laying trials shall be all as specified in Clause 507.3.5.

508.4. Construction Operations

508.4.1. Weather and seasonal limitations: The provisions of Clause 501.5.1 shall apply.

508.4.2. Preparation of base: The surface on which the Semi Dense Bituminous Material is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot access, other approved methods shall be used as directed by the Engineer.

508.4.3. Geosynthetics: Where Geosynthetics are specified in the Contract this shall be in accordance with the requirements stated in Clause 703.

508.4.4. Stress absorbing layer: Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 522.

508.4.5. Tack coat: Where specified in the Contract, or otherwise required by the Engineer, a tack coat shall be applied in accordance with the provisions of Clause 503.

508.4.6. Mixing and transportation of the mixture: The provisions as specified in Clauses 501.3 and 501.4 shall apply.

508.4.7. Spreading**:** The general provisions of Clauses 501.5.3 and 501.5.4 shall apply.

508.4.8. Rolling: The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trails. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

508.5. Opening to Traffic

The newly laid surface shall not be open to traffic for at least 24 hours after laying and the completion of compaction, without the express approval of the Engineer in writing.

508.6. Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of this Specification.

508.7. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

508.8. Measurement for Payment

The work shall be measured as finished work in cubic metres as per provided in the Contract.

508.9. Rate

The contract unit rate shall be all as specified in Clause 507.9, except that the rate shall include the provision of bitumen at 4.75 per cent, by weight of the total mixture. The variance in actual percentage of bitumen used will be assessed and the payment adjusted up or down, accordingly.

512 CLOSE-GRADED PREMIX SURFACING (MIXED SEAL SURFACING)

512.1. Scope

512.1.1. This work shall consist of the preparation, laying and compaction of a close-graded premix surfacing material of 20 mm thickness composed of graded aggregates premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

512.1.2. Close graded premix surfacing shall be of Type A or Type B as specified in the Contract documents.

512.2. Materials

512.2.1. Binder: The binder shall be a penetration bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of IS: 73.

512.2.2. Coarse aggregates: The provisions of Clause 511.1.2.2 shall apply.

512.2.3. Fine aggregates: The fine aggregates shall consist of crushed rock quarry sands, natural gravel/sand or a mixture of both. These shall be clean, hard, durable, un-coated, mineral particles, dry and free from injurious, soft or flaky particles and organic or deleterious substances.

512.2.4. Aggregate gradation: The coarse and fine aggregates shall be so graded or combined as to conform to one or the other gradings shown in Table 500-26, as specified in the contract.

512.2.5. Proportioning of materials: The total quantity of aggregates used for Type A or B close-graded premix surfacing shall be 0.27 cubic metre per 10 square metre area. The quantity of binder used for premixing in terms of straight-run bitumen shall be 22.0 kg and 19.0 kg per 10 square metre area for Type A and Type B surfacing respectively.

TABLE 500-26. AGGREGATE GRADATION

IS Sieve Designation (mm)	Cumulative per cent by weight of total aggregate passing	
	Type A	Type B

13.2 mm	-	100
11.2 mm	100	88 – 100
5.6 mm	52 – 88	31 – 52
2.8 mm	14 – 38	5 – 25
0.090 mm	0 – 5	0 – 5

512.3. Construction operations

512.3.1. Weather and seasonal limitations: Clause 501.5.1 shall apply.

512.3.2. Preparation of surface: The underlying surface on which the bituminous surfacing is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross-section in accordance with Clause 501. A prime coat where needed shall be applied in accordance with Clause 502 as directed by the Engineer.

TABLE 500-23. QUANTITIES OF MATERIALS REQUIRED FOR 10 SQM OF ROAD SRFACE FOR 20 mm THICK CLOSE GRADED PREMIX SURFACING USING PENETRATION BITUMEN OR CUTBACK

Aggregates (a) Nominal Stone size 13.2 mm (passing 22.4 mm sieve and retained on 11.2 mm sieve) (b) Nominal Stone size 11.2 mm (passing 13.2 mm sieve and retained on 5.6 mm sieve). Total	 0.18 m^3 0.09 m^3 m^3
Binder (quantities in terms of straight run bitumen) (a) For 0.18 m^3 of 13.2 mm nominal size stone at 52 kg bitumen per m^3 (b) For 0.09 m^3 of 11.2 mm nominal size stone at 56 kg bitumen per m^3 Total	 9.5 kg 5.1 kg 14.6 kg

512.3.3. Tack coat: A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

512.3.4. Preparation of premix: Hot mix plant of appropriate capacity and type shall be used for the preparation of mix material. The hot mix plant shall have separate dryer arrangement for heating aggregate.

The temperature of binder at the time of mixing shall be in the range of 150^0C to 163^0C and that of the aggregate in the range of 155^0C to 163^0C provided that the difference in temperature between the binder and aggregates at no time exceeds 140^0C. Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particles of the aggregates are coated uniformly and the discharge temperature of mix shall be between 130^0C and 160^0C.

The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or hand barrows. The vehicles employed for transport shall be clean and the mix being transported covered in transit if so directed by the Engineer.

512.3.5. Spreading and rolling: The pre mixed material shall be spread by suitable means to the desired thickness, grades and cross-fall (camber) making due allowance for any extra quantity required to fill up depressions, if any. The

cross-fall should be checked by means of camber boards and irregularities levelled out. Excessive use of blades or rakes should be avoided. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 8–10 tonne rollers, smooth wheel tandem type, or other approved equipment. Rolling shall begin at the edge and progress towards the centre longitudinally, except that on the super elevated and unidirectional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions, which become apparent, shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled and all the roller marks eliminated. In each pass of the roller the preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels. In no case shall fuel/lubricating oil be used for this purpose. Excess use of water for this purpose shall also be avoided.

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below 100^0C. Joints along and transverse of the surfacing laid and compacted earlier shall be cut vertically to their full depth so as to expose fresh surface which shall be painted with a thin coat of appropriate binder before the new mix is placed against it.

512.4. Opening to traffic

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Excessive traffic speeds should not be permitted.

512.5. Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. For control on the quality of materials supplied and the works carried out, the relevant provisions of Section 900 shall apply.

512.6. Arrangements for Traffic

During the period of construction, arrangements for traffic shall be in accordance with the provisions of Clause 112.

512.7. Measurements for Payment

Close-graded premix surfacing, Type A or Type B shall be measured as finished work, for the area specified to be covered, in square metres at the specified thickness. The area will be the net area covered, and all allowances for wastage and cutting of joints shall be deemed to be included in the rate.

512.8. Rate

The contract unit rate for close-graded premix surfacing, Type A or Type B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. (i) to (xi)

B.1 PLUM CONCRETE FOR HEAD WALLS OF PIPE DRAINS

B.1.1 GENERAL

The item shall comply with specification for ordinary cement concrete subject to the following:

B.1.2 PROPORTION

The proportion for cement concrete shall be one 50 kg bag of cement, 105 litters of sand, and 210 litters of coarse aggregate. Water content shall be within the range specified or as directed by the Engineer.

B.1.3 AGGREGATE

Coarse aggregate shall be crushed or broken from sound stones of the specified type available in the region and approved by the Engineer. The maximum size of the coarse aggregate shall be 50 mm or 6 mm. The aggregate shall be properly graded from the maximum size to 5 mm. As indicated in specification gives a dense concrete. Samples of fine and coarse aggregates approved by the Engineer shall he deposited in the Engineer' s office for reference.

The plums to be used for the concrete shall be roughly cubical or rounded and shall be about 0.010 cum in volume. They may not have sharp edges and angles. The stones shall be more or less rounded without concave surfaces.

B.1.4 SLUMP

Slump as required for the suitable consistency shall be decided by the Engineer and the same shall be maintained throughout.

B.1.5 MIXING

Mixing shall be done in a mechanical mixer.

B.1.6 FORMS

The forms shall he either of timber lined with plain galvanised iron sheets or steel plates strengthened with suitable mild steel sections as may be found convenient by the contractor and shall be erected to else exact shape, dimensions, and R.L indicated on the plans or as ordered by the Engineer. The forms shall be prepared in panels or boards with V fillets as may be found convenient to obtain easily the false V notch joints on the surface of piers, abutments etc. The pattern of joints in abutments pairs, wings etc. shall be the same and from the top downwards the corresponding joints shall be at the same level unless directed otherwise by the Engineer. The design of forms and pattern and dimensions of V fillets for false joints shall be furnished in advance by the contractor for the approval or the Engineer. An addition or replacement of different members if found necessary and suggested by the Engineer, shall be provided by the

contractor. However, the entire responsibility regarding erection and removal of form work and scaffolding, safety of work and work- people shall rest on the contractor. The forms may be stripped after 48 hours after concreting.

B.1.7 DE-WATERING

If the area of the placement is under water, cofferdams and other necessary devices shall be provided and the water pumped out and the area kept dry throughout the process of laying concrete and till such time as is required for setting of concrete in the opinion of the Engineer. Pumping shall be carried out in such a manner as to avoid damage by movement of water through green or freshly laid concrete.

If concrete is required to be laid under water it shall be done as laid down as per specifications. Water content of concrete should be adjusted in such case if necessary. Cost of de-watering shall be included in the rate of concrete.

B.1.8 SCAFFOLDING

Necessary ladders, scaffolding, etc., shall be built up to convey the concrete to the site of placement. Service bunds, paths, hoists etc., as may be necessary for carrying out the item shall be provided by the contractor at his own Cost.

B.1.9 PLACING

The concrete shall be placed in one continuous operation without break for each lift of concrete. The top of each lift be kept a little uneven to allow bond with the concrete of the upper lift. The height of the layer shall be such as to allow compacting with immersion type vibrators conveniently. The height of lift to be concreted in one operation in the case of abutments, wing walls or returns and piers shall be got approved in advance. Successive heights shall be laid after three days when the concrete has attained adequate strength or as approved by the Engineer.

No operation shall be carried out causing vibration in the concrete already laid and partially set.

B.1.10 COMPACTION

The concrete shall be compacted with mechanical vibrators of the immersion type and also with steel rods worked along the mechanical vibrators to give a dense concrete. The concrete shall be rounded in all corners, edges and angles of the forms and along the form faces while it is being vibrated to get a good surface finish without honeycombing. Over vibration shall be avoided. Sufficient number of vibrators shall be provided to compact the concrete sufficiently. The vibrators shall be applied immediately after placing concrete. The form shall not be touched by the vibrators.

B.1.11 FINISHING

Immediately after the removal of tits forms any undulations, depressions, cavities, honeycombing broken edge or corners, high spots and other defects shall be made good and finished with cement mortar 1:2. Such finishing is however looked upon

only as an exception and the total surface, requiring finishing shall not exceed one percent on an average. If initial experience shows that this percentage is exceeded, the entire method of working shall be changed as ordered by the, Engineer to get the cast finish, V grooves as indicated on the drawings or as ordered by the Engineer shall be neatly finished to give the appearance of panels on the piers, abutments, returns, wing wall etc.

800 TRAFFIC SIGNS, MARKINGS AND OTHER ROAD APPURTENANCES:

Please refer to the Clause/Section No. 800 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for traffic signs, markings and other road appurtenances.

900 QUALITY CONTROL

901. GENERAL

901.1 All materials incorporated and all works performed shall be strictly in conformity with the Specification requirements. All works shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as approved by the Engineer subject to the permitted tolerances described hereinafter. The Contractor shall be fully responsible for the quality of the work in the entire construction within the Contract. He shall, therefore, have his own independent and adequate set-up for ensuring the same.

901.3 The Contractor shall carry out quality control tests on the materials and work to the frequency specified. In the absence of clear indications about method and/or frequency of tests for any item, the approval of the Engineer shall be obtained and he shall provide necessary co-operation and assistance in obtaining the samples for test and carrying out the field test as required by the Engineer from time to time. This may include provision of Labour, attendance, assistance in packing and despatching and any other assistance considered necessary in connection with the test.

901.6 For the work of embankment, Sub-grade and construction of subsequent layer of same or other material over the finished layer shall be done after obtaining approval from the Engineer. Similar approval from the Engineer shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.

901.7 The Contractor shall carry out modification in the procedure of work, if found necessary, as approved by the Engineer during inspection. Works falling short of quality shall be rectified by the Contractor as approved by the Engineer.

The Contract rate quoted for various items of works in the Bill of Quantities or the lump sum amount tendered shall be deemed to be inclusive of all costs of the quality control tests and operations necessary for ensuring quality of the material and work so as to be in conformity with the specification requirement.

902 PERMITTED TOLERANCES

a)Horizontal Alignments

Horizontal alignments shall be reckoned with respect to the centre line of the carriage way as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ±25 mm there from. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be ±40 mm.

b)Longitudinal Profile

The levels of the Sub-grade and different pavement courses as constructed shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as approved by the Engineer beyond the tolerances mentioned below:

Sub-grade ±15 mm Sub-

base ±20 mm Base

Course ±15 mm

Wearing Course ±10 mm

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

c)Surface Regularity

The surface regularity of completed Sub-grade, sub-bases, base courses and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table 901.1

The longitudinal profile shall be checked with a 3 metre long straight edge, at the middle of each traffic lane along a line parallel to the centre line of the road. The transverse profile shall be checked with a set of three camber boards at intervals of 10 metres.

a) Rectification

Where the surface irregularity of Sub-grade and the various courses fall outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer

i) Sub-grade

Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by adding fresh material. The degree of compaction and the type of material to be used shall conform to the Clauses 1.2 and 1.6

ii)Water Bound Macadam

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

iii)Bituminous Constructions

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

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to Specifications. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 metre long and not less than 1 lane wide.

Table 901.1 - Permitted Tolerance of Surface Regularity for Sub-grade and Pavement Courses

Sr. No	Type of Construction	Longitudinal profile with 3 metre Cross profile straight edge					
		Maximum permissible undulation mm	Maximum number of undulations permitted in any 300 metres length exceeding : mm				Maximum permissible variation from specified profile under camber template: mm
			18	12	10	6	
1	2	3	4	5	6	7	8
1	Earthen Sub-grade	24	30	-	-	-	15
2	Granular/Lime/ Cement/stabilised sub base	15	-	30	-	-	12
3	Water Bound Macadam with over size metal (45-90 mm size) or Wet Mix Macadam	15	-	30	-	-	12
4	Water Bound Macadam with normal size metal (22.4-53 mm and 45-63 mm size) or Wet Mix Macadam	12	-	-	30	-	8
5	Bituminous concrete	8	-	-	-	10@	4

Notes:

1. @ These are for machine laid surfaces. If laid manually due to unavoidable reasons, tolerance up to 50 percent above these values in this column may be permitted at the discretion of the Engineer. However, this relaxation does not

apply to the values of maximum undulation for longitudinal and cross profiles mentioned in columns 3 and 8 on the Table 901.1.

2. Surface evenness requirements in respect of both the longitudinal and cross profiles should be simultaneously satisfied.

903 TESTS

903.1 GENERAL

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to increase the frequencies of tests as he may deem necessary to satisfy himself that the materials and works comply with the appropriate Specifications.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the approval of the Engineer.

903.2 Tests on Earthwork for Embankment and Sub-grade Construction a)

Borrow material

1) Sand content [IS: 2720(Part IV)]

   1-2 tests per 8000 cu. metres of soil

2) Plasticity Test [IS: 2720(Part V)]

   Each type to be tested, 1-2 tests per 8000 cu. metres of soil.

3) Density Test [[IS: 2720(Part VII)].

   Each soil type to be tested, 1-2 tests per 8000 cubic metres of soil.

4) Deleterious Content Test [IS: 2720(Part XXVII)]

   As and when required by the Engineer

5) Moisture Content Test [IS: 2720(Part II)] One

   test for every 250 cubic metres of soil

6) CBR Test on materials to be incorporated in the Sub-grade on soaked/ unsoaked samples [[IS: 2720(part XVI)]

   One test for every 3000 m3 at least or closer as and when required by the Engineer

Compaction control:

Control shall be exercised by taking at least one measurement of density for each 1000 square metres of compacted area, or closer as required to yield the minimum number of test results for evaluation a day's work on statistical basis. Th e determination of density shall be in accordance with IS: 2720 (part XXVIII).Tests locations shall be chosen only through random sampling

techniques. Control shall not be based on the result of any one test but on the mean value of a set of 5-10 density determinations. The number of tests in one test in one set of measurements shall be 5 as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 gm/cc.

However, for earthwork in shoulders (earthen) and in top 500 mm portion of the embankment below the Sub-grade, at least one density measurement shall be taken for every 50 square metres of the compacted area provided further `that the number of tests in each set of measurements shall be at least 10. In other respects, the control shall be similar to that described earlier.

903.3 Tests on Sub-bases and Bases

(Excluding bitumen bound bases)

The tests and their frequencies for the different types of bases and sub-base shall be as given in Table 900.3. The evaluation of density results for compaction control shall be on lines similar to those set out in clause 903.2

Table –900.3

Control Tests and Their Frequencies for Sub-Bases and Bases

(Excluding Bitumen Bound Bases)

Sr. No.	Types of Construction	Test	Frequency
1.	Granular sub-base	(i) Gradation	One test per 200m^3
		(ii) Atterberg limits	One test per 200m^3
		(iii) Moisture content prior to compaction	One test per 250m^2
		(iv) Density of compacted layer	One test per 500m^2
		(v) Deleterious constituents	As required
		(vi) C.B.R.	As required
3	Wet Mix Macadam	(i) Aggregate Impact Value	One test per 200m^3 of aggregate
		(ii) Grading	One test per 100m^3 of aggregate
		(iii) Flakiness Index and Elongation Index	One test per 200m^3 of aggregate
		(vi) Atterberg limits of portion of aggregate passing 425 micron sieve	One test per 100m^3 of aggregate
		(v) Density of compacted layer	One test per 500 m^2.

903.4 Tests on Bituminous Constructions

The tests and their frequencies for the different types of bituminous works shall be as given in Table 900.4 hereunder.

Table – 900.4 - Control Tests and Their Frequency for Bituminous Works

Sr. No	Types of Construction	Test	Frequency
1.	Prime Coat/Tack Coat	(i) Quality of binder	Number of samples per lot and tests as per IS:73,IS:217 and IS:8887 as applicable.
		(ii) Binder temperature for application	At regular close intervals
		(iii) Rate of spread of Binder	One test per 500m^2 and not less than two tests per day
2	Open-graded Premix Surfacing / Close-graded Premix Surfacing	(i) Quality of binder	Same as mentioned under Serial No.1
		(ii) Aggregate Impact Value /Los Angeles Abrasion value	One test per 50m3 of aggregate
		(iii) Flakiness Index and Elongation Index	- do-
		(iv) Stripping value	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates
		(v) Water absorption of aggregates	- do-
		(vi) Water sensitivity of mix	Initially one set of 3 representative specimens for each source of supply. Subsequently when warranted by changes in the quality of aggregates (if required)
		(vii) Grading of aggregates	One test per 25m^3 of aggregate
		(viii) Soundness (Magnesium and Sodium Sulphate)	Initially, one determination by each method for each source of supply, then as warranted by change in the quality of the aggregates.
		(ix) Polished Stone value	As required
		(x) Temperature of binder at application	At regular close intervals
		(xi) Binder content	One test per 500m3 and not less than two tests per day.

Sr. No	Types of Construction	Test	Frequency
		(xii) Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii) Percentage of fractured faces	When gravel is used, one test per 50m^3 of aggregate
3	Bituminous Macadam	(i) Quality of binder	Same as mentioned under Serial No.1
		(ii) Aggregate Impact / Los Angeles Abrasion value	Same as mentioned under Serial No.2
		(iii) Flakiness Index and Elongation Index	Same as mentioned under Serial No.2
		(iv) Stripping value of aggregates	Same as mentioned under Serial No.2
		(v) Water sensitivity of mix	-do-
		(vi) Grading of aggregates	Two tests per day per plant both on the individual constituents and mixed aggregates from the dryer
		(vii) Water absorption of aggregates	Same as in Serial No.2
		(viii) Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(ix) Percentage of fractured faces	Same as mentioned under Serial No.2
		(x) Binder content and aggregate grading	Periodic, subject to minimum of two tests per day per plant
		(xi) Control of temperature of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close intervals
		(xii) Rate of spread of mixed material	Regular control through checks of layer thickness
		(xiii) Density of compacted layer.	One test per 250m^2 of area.
4	Dense Bituminous Macadam / Semi Dense Bituminous	(i) Quality of binder	Same as mentioned under Serial No.1
		(ii) Aggregate Impact Value /Los Angeles Abrasion value	Same as mentioned under Serial No.2

Sr. No	Types of Construction	Test	Frequency
	Concrete	(iii) Flakiness Index and Elongation Index	- do-
		(iv) Stripping value	Same as mentioned under Serial No.2
		(v) Soundness (Magnesium and Sodium Sulphate)	Same as mentioned under Serial No.2
		(vi) Water absorption of aggregates	As in Serial No. 2
		(vii) Sand equivalent test	As required
		(viii) Plasticity Index	As required
		(ix) Polished Stone value	As required, for Semi Dense Bituminous Concrete/ Bituminous Concrete
		(x) Percentage of fractured faces	Same as mentioned under Serial No.2
		(xi) Mix grading	One set of tests on the individual constituents and mixed aggregate from the dryer for each 400 tonnes of mix subject to a minimum of two tests per plant per day
		(xii) Stability of Mix	For each 400 tonnes of mix produced, a set of 3 Marshall specimens to be prepared and tested for stability, flow value, density and void content subject to a minimum of two sets being tested per plant per day.
		(xiii) Water sensitivity of mix	Same as mentioned under Serial No.2
		(xiv) Swell test on the mix	As required for the Bituminous Concrete
		(xv) Control of temperature of binder in boiler, aggregate in the dryer and mix at the time of laying and rolling	At regular close intervals
		(xvi) Control of binder content and grading of the mix	One test for each 400 tonnes of mix subject to a minimum of two tests per day per plant
		(xvii) Rate of spread of mixed material	Regular control through checks on the weight of mixed material and layer thickness
		(xviii) Density of compacted layer	One test per 250m^2 area

Please refer to the Clause/Section No. 1000 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Materials for Structures.

1500 FORMWORK

Please refer to the Clause/Section No. 1500 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Formwork.

1700 STRUCTURAL CONCRETE

Please refer to the Clause/Section No. 1700 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Structural Concrete works.

2504. PITCHING/REVETMENT ON SLOPES

Please refer to the Clause/Section No. 2504 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Pitching or Revetment on slopes.

2900 PIPE DRAINS

Please refer to the Clause/Section No. 2900 of Ministry of Road Transport & Highways Specifications for Road and Bridge Works (Latest Revision) for detailed specifications for Pipe drain works.

B.2 PRECAUTIONS FOR SAFEGUARDING THE ENVIRONMENT

B.2.1 PRESERVATION OF VEGETATION

The contractor shall preserve existing trees, plants and other vegetation that are to remain within or adjacent to the works and shall use every precaution necessary to prevent damage or injury thereto.

All the works should be carried out in such a fashion that, the damage or disruption to the flora and fauna is reduced to minimum wherever possible. Trees and shrubs will only be felled or removed that impinge on the permanent works or necessary temporary works.

B.2.2 SITE CLEARANCE AFTER COMPLETION OF WORK:

On completion of works, all areas disturbed by the contractor's constr uction activities shall be restored to their original condition, or as may be acceptable to the Engineer. The cost of this work shall be deemed to be included in the rates generally.

B.2.3 SITE TRAINING:

If so requested by the Engineer, the contractor on two weeks notice shall make available site staff of foreman level and above for training in the environmental aspects of road constructions. The staff to be included in the training shall be chosen by the Engineer. The training shall be maximum for two working days duration and shall be held on the site. The Engineer shall arrange the training and the cost of providing personnel for the Environmental training is deemed to be included in the rates generally.

B.2.4 SITE DRAINAGE CONDITIONS:

The contractor should ensure that there is good drainage at all construction areas and there is no stagnation of water due to the construction activity.

B.2.5 POLLUTION FROM HOT-MIX PLANTS AND BATCHING PLANTS:

If contractor wishes to establish the hot mix plant (H.M.P.), then the site should be at least 500m away from the nearest habitation. The H.M.P. shall be fitted with the dust extraction unit in order that the exhaust gases comply with the requirements of the relevant current emission control legislation. All the operations at the plant shall be undertaken in accordance with all current rules and regulations protecting the environment.

B.2.6 SUBSTANCES HAZARDOUS TO HEALTH:

The use of any herbicide or other toxic chemical shall be strictly in accordance with the manufacturer's instructions. The Engineer shall be given at least 6 working day's notice of the proposed use of any herbicide or toxic chemical. A register of all herbicide and other toxic chemicals delivered to the site shall be kept and maintained up to date by the contractor. The register shall include the trade name, physical properties and characteristics, chemical ingredients, health and safety hazard information, Safe handling and storage procedures and emergency and first aid procedures for the product.

B.2.7 CONSTRUCTION VEHICLES:

The construction vehicles delivering materials to site shall be covered to avoid spillage of materials on the public roads and reduce the emission of dust. The discharge standards promulgated under the Environmental Protection Act (Latest version) shall be adhered to strictly. All the waste arising from the project shall be disposed off in manner, which is acceptable to State Pollution Control Board and the Engineer.

All the vehicles and machinery employed for the execution of the works shall be regularly maintained to ensure that pollutant emission levels comply with the relevant requirements of the current pollution control legislation. During the routine servicing operations, effectiveness of exhaust silencers must be checked and if found defective must be replaced. Notwithstanding this requirement, noise levels from any item of the plant must comply with the relevant legislation for levels of sound emission. Non-compliant plant shall be removed from site.

Vehicle maintenance and refuelling shall be carried out in such a fashion that spillage of fuels and lubricants do not contaminate the ground or nearby watercourses. An "Oil Inspector" shall be provided for wash down and refuelling areas. Fuel storage shall be in proper bounded areas. All spilt and collected petroleum product shall be disposed of in accordance with the relevant legislation.

All crushers to be used in construction shall confirm to relevant dust emission control as legislated. The contractor shall obtain the necessary clearance for sitting of the crushing plant from the Gujarat Pollution Control Board (GPCB). Alternatively, the Contractor shall use only crushers already licensed by GPCB.

B.2.8 TEMPORARY ACCOMMODATION AT THE SITE:

All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation must be strictly adhered to. Garbage bins must be provided in the camp and regularly emptied and garbage disposed off in hygienic manner. Construction camps should be sited away from vulnerable people and adequate health care is to be provided for the work force.

APPENDIX A

ADDITIONAL TECHNICAL SPECIFICATIONS FOR PAVER BLOCKS

1. **Raw Materials:**

1.1. **Cement:**

The cement used in the manufacture of high quality precast concrete paving block shall be conforming to IS 12269 (53 grade) ordinary Portland cement or IS 8112 (43 grade ordinary Portland cement). The minimum cement content in concrete used for making paver blocks should be 380 kg/cu.m.

1.2. **Aggregates:**

The fine and coarse aggregates shall consist of naturally occurring crushed or uncrushed materials which apart from the grading requirements comply with IS 383-1970. The fine aggregates used shall contain a minimum of 25 % natural silicon sand. Lime stone aggregates shall not be used. Aggregates shall contain no more than 3 % by weight of clay and shall be free from deleterious salts and contaminants.

1.3. **Water:**

The water shall be clean and free from any deleterious matter. It shall meet the requirements stipulated in IS: 456-2000.

1.4. **Other materials:**

Any other material/ingredients used in the concrete shall conform to latest IS specifications.

2. **Paver Blocks Characteristics:**

2.1. The concrete pavers should have perpendicularities after release from the mould and the same should be retained until the laying.

2.2. The surface should be of anti-skid and anti-glare type.

2.3. The paver should have uniform chamfers to facilitate easy drainage of surface run off.

2.4. The pavers should have uniform interlocking space of 2 mm to 3 mm to ensure compacted sand filling after vibration on the paver surface.

2.5. The concrete mix design should be followed for each batch of materials separately and automatic batching plant is to be used to achieve uniformity in strength and quality.

2.6. The pavers shall be manufactured in single layer only.

2.7. Skilled labour should be employed for laying blocks to ensure line and level for laying, desired shape of the surface and adequate compaction of the sand in the joints.

2.8. The pavers are to be skirted all round with kerbing using solid concrete blocks of size 100 mm x 200 mm x 400 mm or as directed by the engineer. The kerbing

should be embedded for 100 mm depth. The concrete used for kerbing shall be cured properly for 7 days minimum.

3. **LAYING OF PAVER BLOCKS:**

3.1. **Priming:**

It will be the responsibilities of the contractors to ensure that the manhole/pipeline cable trenches/circular drainage system etc. raised to driveway level using the requisite materials as per instruction of Engineer. The areas of potholes/deep depressions at the isolated locations also have to be filled up before laying the paver blocks. No extra payments will be made for this purpose.

It will be the responsibility of the contractors to ensure that undulations on the paver's blocks are eliminated after the traffic is allowed on it. Proper slope for drainage of water needs to be ensured by the Contractor. All necessary materials, tools, tackles are required to be arranged by the Contractor.

3.2. **Bedding sand course:**

The bedding sand shall consist of clean well graded sand passing through 4.75 mm sieve and suitable for concrete. The bedding should be from either a single source or blended to achieve the following grading –

In sieve size	**% Passed**
9.5 mm.	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm.	60-100
600 microns	25-60
300 microns	10-30
150 microns	5-15
75 microns	0-10

Contractor shall be responsible to ensure that single-sized, gap-graded sands or sands containing an excessive amount of fines or plastic fines are not used. The sand particles should preferably be sharp (not rounded) as sharp sand possess higher strength and resist the migration of sand from under the block to less frequency areas even though sharp sands are relatively more difficult to compact than rounded sands, the use of sharp sands is preferred for the more heavily trafficked driveways. The sand used for bedding shall be free of any deleterious soluble salts or other contaminants likely to cause efflorescence.

The sand shall be of uniform moisture content and within 4 % - 8 % when spread and shall be protected against rain when stock piled prior to spreading. Saturated sand shall not be used. The bedding sand shall be spread loose in a

uniform layer as per drawing. The compacted uniform thickness shall be of 45 mm and within +/- 5 mm. Thickness variation shall not be used to correct irregularities in the base course surface.

The spread sand shall be carefully maintained in a loose dry condition and protected against pre-compaction both prior to and following screeding. Any pre-compacted sand or screeded sand left overnight shall be loosened before further laying of paving blocks take place.

Sand shall be slightly screeded in a loose condition to the predetermined depth only slightly ahead of the laying of paving unit.

Any depressions in the screeded sand exceeding 5 mm shall be loosened, raked and rescreeded before laying of paving blocks.

3.3. **Laying of interlocking paver blocks:**

Paver blocks shall be laid in herringbone laying pattern throughout the pavement. Once the laying pattern has been established, it shall continue without interruption over the entire pavement surface. Cutting of blocks, the use of infill concrete or discontinuities in laying pattern is not to be permitted in other than approved locations.

Paver blocks shall be placed on the uncompacted screeded sand bed to the nominated laying pattern, care being taken to maintain the specified bond throughout the job. The first row shall be located next to an edge restraint. Specially manufactured edge paving blocks are permitted or edge blocks may be cut using a power saw, a mechanical or hydraulic guillotine, bolster or other approved cutting machine.

Paver blocks shall be placed to achieve gaps nominally 2 to 3 wide between adjacent paving joints. No joint shall be less than 1.5 mm not more than 4 mm. Frequent use of string lines shall be used to check alignment. In this regard the "laying face" shall be checked at least every two metres as the face proceeds. S hould the face become out of alignment, it must be corrected prior to initial compaction and before further laying job is proceeded with.

In each row, all full blocked shall be laid first. Closure blocks shall be cut and fitted subsequently. Such closer blocks shall consist of not less than 25 % of a full blocks.

To infill spaces between 25 mm and 50 mm wide concrete having screened sand, coarse aggregate mix and strength of 45 N/sq.mm shall be used. Within such mix the nominal aggregate size shall not exceed one third the smallest dimension of the infill space. For smaller spaces dry packed mortar shall be used.

Except where it is necessary to correct any minor variations occurring in the laying bond, the paver blocks shall not be hammered into position. Where adjustment of paver blocks, necessary care shall be taken to avoid premature compaction of the sand bedding.

3.4. **Initial Compaction:**

After laying the paver blocks, they shall be compacted to achieve consolidation of the sand bedding and brought to design levels and profiles by not less than two (2) passes of a suitable plate compactor.

The difference in level (lipping) between adjacent blocks shall not exceed 3 mm with not more than 1 % in any 3 m x 3 mm area exceeding 2 mm. Pavement which is deformed beyond above limits after final compaction shall be taken out and reconstructed to the satisfaction of the Engineer.

3.6. **Edge Restraint:**

Edge restrains need to be sufficiently robust to withstand override by the anticipated traffic to withstand thermal expansion and to prevent loss of the laying course material from beneth the surface course. The edge restraint should present a vertical face down t the level of the underside on the laying course.

The surface course should not be vibrated until the edge restraint together with any bedding or concrete hunching has gained sufficient strength. It is essential that edge restraints are adequately secured.

4.0 Concrete Block Making Machine

4.1 The block making machine should ensure the following:

1) High degree of dimensional accuracy (± 3 mm)
2) Precast blocks with spacer nibs (23 mm to ensure uniform joints)
3) High compaction energy (to produce blocks with high compressive strength)

The above can be generally achieve by machine with following feature –

Block making machine should have simultaneously application of high intense vibration to moulds at 3000 V.P.M. and hydraulic pressure 800 psi

4.2 Concrete Batching & Mixing Plant

The concrete Mix design should be followed for each batch of materials. The concrete ingredient should be mixed in concrete Batching & Mixing plant with suitable capacity. The plant should be equipped with automatic control panel for maintaining water cement ratio from batch to batch to obtain concrete of uniform quality and strength. The plant should be equipped with adequate mechanism for mechanized loading on raw materials into mixer and conveyor belt for transportation of concrete from mixer to concrete block making machine.

SAMPLING AND TESTING PROCEDURES FOR PAVER

BLOCKS Sample size

Internal – Average of minimum 3 samples per 5000 blocks – for paver block manufacturers.

Internal – Minimum 9 blocks per 5000 blocks. Average of minimum 9 blocks per site –

for captioned contractors.

1. **Sampling for testing:**

   Sampling for testing of paver blocks shall be done in accordance with Appendix-A.

2. **Compressive Strength:**

   Testing for compressive strength shall be undertaken in accordance with Appendix-B. The average compressive strength of the 80 mm. thick paver blocks tested shall be 50 N/Sq.mm and average compressive strength of the 60 mm. thick paver blocks tested shall be 45 N/Sq.mm.

3. **Water Absorption:**

   Testing for water absorption shall be in accordance with IS: 2185: 1979: Part- (Specifications for Concrete Masonry Blocks) Appendix C.

Sampling of Paver Blocks

1. **Method of sampling:**

   Before laying paver blocks, each designated section comprising not more than 50,000 blocks shall be divided into ten approximately equal groups. Nine blocks shall be drawn from each group.

2. **Marking and Identification:**

   All samples shall be clearly marked at the time of sampling in such a way that the designated section of part thereof and the consignment represented by the sample are clearly defined.

   The sample shall be dispatched to the approved test laboratory taking precaution to avoid damage to the paving in transit. Protect the paving from damage and contamination until they have been tested. The samples shall be stored in water at 20 ºC + 5 ºC for 24 hours prior to testing.

APPENDIX – B

PROCEDURE FOR TESTING OF COMPRESSIVE STRENGTH FOR PAVER BLOCKS (Reference: BS 6717 Part-I (1993) Specification for Paver Blocks)

B-1 **Testing Machine:**

The testing machines shall be of suitable capacity for the test and capable of applying the load at the rate specified. It shall comply as regards repeatability and accuracy with the requirements of relevant IS Specification.

B-2 **Procedure:**

The sample specimens shall be tested in wet condition after being stored for at least 24 hours in water maintained at a temperature of 20 C + 5 ºC before the specimens are submerged in water, the necessary area shall be determined.

The plates of the testing machine shall be wiped clean and any loose girt or other material removed from the contact faces of the specimen. Plywood normally 4 mm. thick shall be used as packing between the upper and lower faces of the specimen and the machine plates and these boards shall be larger than the specimen by a margin of at least 5 mm at all points. Fresh packing shall be used for each specimen tested. The specimen shall be placed in the machine with the wearing surface in a horizontal plane and in such a way that the axes of the specimen are aligned with those of the machine plates. The load shall be applied without shock and increased continuously at the rate of Approximately 15 N/sq.mm per minute until no greater load can be sustained. The maximum load applied to the specimen shall be recorded.

B-3 **Calculation of corrected strength:**

The compressive strength of each block specimen shall be calculated by dividing the maximum load by full cross section area and multiplying by appropriate factors.

Thickness and chamfer correction factors

For compressive strength

Work size thickness (mm)	Correction Factors	
	Plain block	Chamfered block
60	1.00	1.06
80	1.12	1.18
100	1.18	1.24

B-4 **Compressive strength calculation:**

The average corrected compressive strength for the designed block section shall be calculated.

APPENDIX – C

METHOD FOR THE DETERMINATION OF WATER ABSORPTION

1. The test specimens shall be completely immersed in water at room temperature for 24 hours.
2. The specimens shall then be weighed, while suspended by a metal wire and completely submerged in water.
3. They shall be removed from the water and allowed to drain for one minute.
4. Visible surface water should be removed with a damp cloth and immediately weighed.
5. Subsequent to saturation, all specimens shall be dried in a ventilated oven at 100 to 115 ºC for not less then 24 hours and until two successive weightings at intervals of 2 hours show an increment of loss not greater then 0.2 percent of the last previously determined mass of the specimen.
6. Calculate the absorption as follows -

$$\text{Absorption, kg/cum} = \frac{A - B}{A - C} \times 1000$$

$$\text{Absorption, percent} = \frac{A - B}{B} \times 100$$

Where;

A = Wet mass of unit in Kg.

B = Dry mass of unit in Kg and

C = Suspended immersed mass of unit in Kg.

8. TECHNICAL SPECIFICATION FOR SPORTS WORK

FOOTBALL TURF

Football Turf with UV resistant from America, Europe and Australian region only conforming to FIFA Quality Standard as per their latest Technical Specification FIFA 15 , including SBR Rubber granules as per manufacture's recommended quantities , unloading and staging of rolls, sewing and levelling equipment, brushing of fibres with all Polly hydraulic controlled equipment , painting of any lines with approved Synthetic turf paint.

III APPROVED MAKES OF MATERIAL

APPROVED MAKES OF MATERIAL

Acceptable makes of materials to be used in the work are enclosed. In case of non-availability of these makes, after the approval of the Authority, the Contractor can use the alternative makes only BIS marked materials. Non BIS marked materials may be permitted by the Authority only when BIS marked materials are not manufactured

SR. NO.	**NAME OF ITEM**	**MAKE APPROVED**
1)	ORDINARY PORTLAND CEMENT GRADE 43/53	BIRLA, JK, ACC, ULTRATECH, JAYPEE, AMBUJA,
2)	WHITE CEMENT	JK, BIRLA, ACC, JAYPEE, AMBUJA
3)	REINFORCEMENT STEEL	TATA , SAIL, RINL, JINDAL, JSW STEEL, SHYAM STEEL
4)	PAINT/POLISH/ PRIMER/ WATER PROOFING PAINT	BERGER, ASIAN, DULUX, BRITISH PAINT
5)	SILICON / POLYURETHANE SEALANT	FOSROC / G.E. SILICONES / DOW-CORNING,/ WACHER SILICON, /HOLEX,/

		DECOT, SIKA / CHOKSEY CHEMICALS
6)	PVC PIPE FOR WEEP HOLES	PRINCE, SUPREME, FINOLEX
7)	CONCRETE ADMIXTURES, OTHER CONSTRUCTION CHEMICALS	M.C.BAUCHEMIE,FOSROC,PIDILITE,CICO,SIKA,BASF,ASIAN LABORATORIES,ULTRACON
8)	STRUCTURAL STEEL/MS	TATA , SAIL, RINL, JINDAL, JSW STEEL, SRMB
9)	WATERPROOFING CHEMICALS/SYSTEM	BASF,SIKA,FOSROC,PIDLIE,CARLISLE,FIRE STONE
10)	RHS/SHS CLOSED STRUCTURAL	SAIL/TISCO / RINL /JSW
11)	SHUTTERING PLY	ARCHID,CENTURY,MERINO,KITPLY
12)	BRICKS	CLAY BRICKS,FLY ASH BRICKS
13)	COVER BLOCKS	FACTORY MADE CONCRETE COVER BLOCKS (ASTRA MAKE).
14)	READY MIX CONCRETE (RMC)	THE RMC SHALL BE PROCURED FROM THE SOURCE AS APPROVED BY ENGINEER – IN CHARGE.
15)	FOOTBALL TURF	DOMO/PLAYRITE/EQUIVALENT