

SECTION - 8B

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATION

S-01: GENERAL

Bi-RIDE

ADDITIONAL SPECIFICATION - GENERAL

1.1 General:

- 1.1.1 These Specifications contained herein shall be read in conjunction with other tender documents.
- 1.1.2 The Work shall be carried out in accordance with the "Good for Construction" drawings and designs as would be issued to the Contractor by the Engineer duly signed and stamped by him. The Contractor shall not take cognizance of any drawings, designs, specifications, etc. not bearing Engineer's signature and stamp. Similarly, the Contractor shall not take cognizance of instructions given by any other authority except the instructions given by the Engineer in writing.
- 1.1.3 The work shall be executed and measured as per metric units given in the Schedule of Quantities, drawings etc. (FPS units where indicated are for guidance only) (Not applicable for Viaduct D&B Works).
- 1.1.4 Absence of terms such as providing, supplying, laying, installing, fixing etc. in the descriptions does not even remotely suggest that the Contractor is absolved of such providing, supplying etc. unless an explicit stipulation is made in this contract. The Employer / Owner shall bear no costs of materials, labour, equipment, duties, taxes, royalties etc.
- 1.1.5 The specifications may have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account interrelations between various parts of works/trades. No claim shall be entertained on the basis of compartmental interpretations.
- 1.1.6 The classification of various items of works for purpose of measurements and payments shall be as per schedule of payment. Except where distinguished by BOQ, the rates apply to all heights, depths, sizes, shapes and locations. They also cater for all cuts and wastes. No floor wise separation shall be made for the rates. Likewise all heights of centering, shuttering, staging, formwork and scaffolding, launching trusses and other launching methods are covered by the rates including multi stage propping for heights greater than one floor as per drawings.
- 1.1.7 Reference to the Standard Codes of Practice:
- 1) The contractor shall make available at site all relevant Codes of practice as applicable.
 - 2) **Legend:**

ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
BS	British Standard
CPWD	Central Public Works Department
DIN	Deutsches institute fur Normunge.V.
IRC	Indian Road Congress
IRS	Indian Railway Standards
IS	Indian Standards
JIS	Japanese Industrial Standard
MORTH	Ministry of Road Transport and Highways
API	American Petroleum Industry (API) Standard 1104
RDSO	Guidelines for Certification of Metro 2015 with Amendment upto date.
IR SOD2022	Indian Railway SOD 2022 with latest amendment for the works wherever

needs to work adjacent to Railway Track below or above Railway Track with relevant Safety Manual etc.

BI-RIDE
DBR

MoHUA Guidelines	Indian Standard Hand Book on Steel Section Part – I
Indian Railway Manual	Design and Construction of well and Pile Foundations
UIC/772-R	The International Union of Railway Publication
CIRIA Report 80A	Review of Instruments for Gas and Dust Monitoring Underground
CIRIA Report 81	Tunnel Water Proofing
CIRIA Report 44	Model Code of Practice for Work in Compressed Air
CIRIA Report C660	Early Age Thermal Crack Control in Concrete
CIRIA Report 91	Early Age Thermal Crack Control in Concrete
Swedish Standard 05 59 00	
PCI STD – 112 – 84	
CRR1 & IOC	New Delhi Bituminous Road

1.1.8 Contractor to Provide:

The Contractor shall provide and maintain at site throughout the period of works the following at his own cost and without extra charge, Except for the items specified in the Bill of Quantities the cost being held to be included in the Contract Price.

1. General works such as setting out, site clearance before setting out and on completion of works. All weather approach roads to the site office should also be constructed and maintained in good condition.
2. All labour, materials, plant, equipment and temporary works, Overhead charges as well as general liabilities, obligations, insurance and risks arising out of GCC required for completing and maintaining the works to the satisfaction of the Engineer.
3. Adequate lighting for night work, and also whenever and wherever required by the Engineer.
4. Continuous and rigid temporary fences, barricades, guards, lights and protective work necessary for protection of workmen, supervisors, engineers, general public and any other persons permitted access to the site. Contractor shall provide proper signages as directed.
5. All fences, barricade shall be painted with colour shades / designs as specified by the Engineer. The barricading should be of adequate height to ensure visual obstruction of work from public view.
6. All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.
7. Design mixes and testing them as per relevant clauses of specifications giving proportion of ingredients, sources of aggregates and binder along with accompanying trial mixes. Test results to be submitted to the Engineer for his approval before adoption on works.
8. Method Statements, for each main activity of the work (temporary and permanent) to be executed detailing the purpose, scope, resources required, sequence / procedure of execution, persons responsible, time frame, safety requirements & measures, risk analysis, Inspections, and Test Procedures along with standard values / acceptable criteria etc. duly approved by the Engineer before start of that particular activity at site.

9. Contractor shall also prepare / approve and make available to the Site Engineer the work procedure for each sub-activity to be done at the site, detailing the procedure / process to be followed including work sequence, safety measures, to be followed, level of quality to be maintained, type of material to be used, type of finishing required and responsibility assigned etc.
10. Cost of preparation and compliance with provision of a quality assurance control program.
11. Cost of safe guarding the environment.
12. Cost of safety measures and requirements of site safety plan.
13. A testing laboratory as specified by the Engineer equipped with the apparatus as mentioned in Employers requirement will be set up.
14. A testing laboratory as specified by the Engineer equipped with no limited to the following apparatus, materials and competent trained staff required for carrying out test as specified in the relevant Sections of the Specifications in adequate quantity.

1.1.9 **Quality Assurance & Quality Control:**

- 1 The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. The Contractor shall conform to the Quality standards prescribed, which shall form the backbone for the Quality Assurance (QA) and Quality Control (QC) system.
- 2 At the site, the Contractor shall arrange the materials, their stacking/storage in appropriate manner to ensure the quality. The Contractor shall provide all the necessary equipment and qualified manpower to test the quality of materials, assemblies etc., as directed by the Engineer. The cost of all such testing shall be included in the quoted rates and nothing extra shall be paid for in this regard. The tests shall be conducted at specified intervals and the results of tests properly documented. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surfaces.
- 3 The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor may provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.
 - (a) The tests shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory selected by the Engineer.
 - (b) The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of the Contractor failing to arrange transportation of the samples in proper time, the Engineer shall have them transported and recover two times the actual cost towards transportation and testing from the Contractor's bills.
 - (c) All testing shall be performed in the presence of Engineer. Testing may be witnessed by the Contractor or his authorized representative if permitted by the Test House. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.

- (d) Cost of all such tests shall be borne by the Contractor and nothing extra shall be payable on this account
- 4 The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, all equipment including the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained prior to starting of the particular item of work. This shall however, not relieve the Contractor of his responsibilities. All materials which do not conform to these specifications shall be rejected and shall be removed from the site immediately. The Engineer shall have the powers to cause the Contractors to purchase and use materials from any particular source as may in the Engineer's opinion be necessary for the proper execution of work. Nothing extra shall be payable to the contractor on this account.

1.1.10 Dimensions:

- 1 Figured dimensions on drawings shall only be followed and drawings to a large scale shall take precedence over those to a smaller scale. Special dimensions or directions in the specifications shall supersede all others. All dimensions shall be checked on site prior to execution.
- 2 The dimensions where stated do not allow for waste, laps, joints, etc. but the Contractor shall provide at his own cost sufficient labour and materials to cover such waste, laps, joints, etc.
- 3 The levels, measurements and other information concerning the existing site as shown on the drawings are believed to be correct, but the Contractor should verify them for himself and also examine the nature of the ground as no claim or allowance whatsoever will be entertained on account of any errors or omissions in the levels or the description of the ground levels or strata turning out different from what was expected or shown on the drawings.

1.1.11 Setting out of Works:

The Contractor shall set out the works indicated in the tender documents. The Contractor shall provide suitable stones with flat tops and build the same in concrete for temporary bench marks. All the pegs for setting out the Works and fixing the levels required for the execution thereof shall, if desired by the Engineer, likewise be built in masonry at such places and in such a manner as the Engineer may direct. The Contractor shall carefully protect and preserve all bench marks and other marks used in setting out the works. The contractor will make overall layout of complete work and get it checked from engineer. The cost of all operations of setting out including construction of bench marks is deemed to be included in the contract price.

All the survey work except levelling work shall be carried out using total stations with one second accuracy. The levelling work shall be carried out using Auto level.

The triangulation points given by the Client before start of work shall be maintained during execution and handed over back to the Client after completion of work.

1.1.12 Materials:

1. Source of Materials:

It shall be the responsibility of the contractor to procure all the materials required for construction and completion of the contract. The contractor shall indicate in writing, the source of materials well in advance to the Engineer, after the award of the work and before commencing the work. If the material from any source is found to be unacceptable at any time, it shall be rejected by the Engineer and the contractor shall forthwith remove the material immediately from the site as directed by the Engineer.

2. Quality:

All materials used in the works shall be of the best quality of their respective kinds as specified herein, obtained from sources and suppliers approved by the Engineer and shall comply strictly with the tests prescribed hereafter, or where tests are not laid down in the specifications, with the requirements of the latest issues of the relevant Indian Standards.

3. Sampling and Testing:

All materials used in the works shall be subjected to inspection and test in addition to manufacturer's test certificates. Samples of all materials proposed to be employed in the permanent works shall be submitted to the Engineer at least 45 days in advance for approval before they are brought to the site.

Samples provided to the Engineer for their retention are to be labelled in boxes suitable for storage. Materials or workmanship not corresponding in character and quality with approved samples will be rejected by the Engineer.

Samples required for approval and testing must be supplied sufficiently in advance in required quantity and number to allow for testing and approval, due allowance being made for the fact that if the first samples are rejected further samples may be required. Delay to the works arising from the late submission of samples will not be acceptable as a reason for delay in completion of the works.

Materials shall be tested before leaving the manufacturer's premises, quarry or resource, wherever possible. Materials shall also be tested on the site and they may be rejected if not found suitable or in accordance with the specifications, notwithstanding the results of the tests at the manufacturer's works or elsewhere or test certificates or any approval given earlier.

The contractor will bear all expenses for sampling and testing, whether at the manufacturer's premises at source, or at site or at any testing laboratory or institution as directed by the Engineer. No extra payment shall be made on this account.

4. Dispatch of materials:

Materials shall not be dispatched from the manufacturer's works to the site without written authority from the Engineer.

5. Test certificates:

All manufacturer's certificates of test, proof sheets, etc. showing that the materials have been tested in accordance with the requirement of this specification and of the appropriate Indian Standard are to be supplied free of charge on request to the Engineer.

6. Rejection:

Any materials that have not been found to conform to the specifications will be rejected forthwith and shall be removed from the site by the Contractor at his own cost within three days or as instructed by the Engineer.

7. The Engineer shall have power to cause the Contractors to purchase and use such materials from any particular source, as may in his opinion be necessary for the proper execution of the work.

1.1.13 Storing of Materials at site:

All materials used in the works shall be stored on racks, supports, in bins, under cover etc. as appropriate to prevent deterioration or damage from any cause whatsoever to the entire satisfaction of the Engineer.

The storage of materials shall be in accordance with IS 4082 "Recommendation on stacking and storage of construction materials on site" and as per IS 7969 "Safety code for handling and storage of building materials".

The materials shall be stored in a proper manner at places at site approved by the Engineer. Should the place where material is stored by the Contractor be required by the Employer for any other purpose, the Contractor shall forthwith remove the material from that place at his own cost and clear the place for the use of the Employer.

1.1.14 Water:

1. Water from approved source:

Potable water only shall be used for the works. Contractor shall have his own source of water duly approved by Engineer. The water shall be free from any deleterious matter in solution or in suspension and be obtained from an approved source. The quality of water shall conform to IS 456.

2. Storage:

The Contractor shall make his own arrangements for storing water, if necessary, in drums or tanks or cisterns, to the approval of the Engineer. Care shall be exercised to see that water is not contaminated in any way.

3. Testing:

Before starting any concreting work and wherever the source of water changes, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of arranging, storing and testing of water shall be deemed to be included in the quoted rates in the Bill of Quantities and nothing extra shall be payable in this regard.

1.1.15 Workmanship:

1. All works shall be true to level, plumb and square and the corners, edges and arises in all cases shall be unbroken and neat.
2. Any work not to the satisfaction of the Engineer or his representative will be rejected and the same shall be rectified or removed and replaced with work of the required standard of workmanship at no extra cost.

1.1.16 Load Testing on Completed Structures

1.1.16.1 During the period of construction or within the defect liability period the Engineer may at his discretion order the load testing of any completed structure or any part thereof if he has reasonable doubts about the adequacy of the strength of such structure for any of the following reasons:

- a) Results of compressive strength on concrete test cubes falling below the specified strength.
- b) Premature removal of formwork.
- c) Inadequate curing of concrete.
- d) Over loading during the construction of the structure or part thereof.
- e) Carrying out concreting of any portion without prior approval of the Engineer.
- f) Honey combed or damaged concrete which in the opinion of the Engineer is particularly weak and will affect the stability of the structure to carry the design load, more so in important or critical areas of the structure.

- g) Any other circumstances attributable to alleged negligence of the contractor which in the opinion of the Engineer may result in the structure or any part thereof being of less than the expected strength.
- 1.1.16.2 All the load tests shall be carried out by the contractor strictly in accordance with the instructions of the Engineer, as per IRS: CBC-2014 Clause 18 and IRC: SP-51, as indicated in the Bill of Quantities and as indicated hereunder. Such tests shall be carried out only after expiry of minimum 28 days from day of casting or such longer period as directed by the Engineer.
- 1.1.16.3 Deleted.
- 1.1.16.4 In such cases the portion of the work concerned shall be taken down or cut out and reconstructed to comply with the specifications. Other remedial measures may be taken to make the structure secure at the discretion of the Engineer. However such remedial measures shall be carried out to the complete satisfaction of the Engineer.
- 1.1.16.5 All costs involved in carrying out the tests (unless and until mentioned otherwise in these specification) and other incidental expenses thereto shall be borne by the contractor regardless of the result of the tests. The contractor shall take down or cut out and reconstruct the defective work or shall make the remedial measures instructed at his own cost. If the load testing is instructed on any ground other than mentioned in a) to g) of 1.1.16.1, then the cost of the same shall be reimbursed if the result of the test are found to be satisfactory. The load testing of spans / piles etc. shall be done using certified and calibrated dial gauges only. Use of levelling instruments for measuring deflections shall not be allowed.
- 1.1.16.6 In addition to the above load tests, non-destructive test methods such as pile integrity test, and ultrasonic pulse velocity test shall be carried out by the contractor at his own expense if so desired by the Engineer. Such tests shall be carried out by an agency approved by the Engineer and shall be done using only recommended testing equipment. The acceptance criteria for these tests shall be as specified by the testing agency or good engineering practices in accordance with the relevant codal provisions and as approved by the Engineer.

1.2 Structural Work:

- 1.2.1 Unless specified, only controlled concrete with design mix and weigh batching is to be used for the work.
- 1.2.2 Minimum cement content specified in CPWD specification is purely from durability point of view. Larger content of cement shall have to be provided if demanded by mix design.
- 1.2.3 Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.
- 1.2.4 Mix design using smaller aggregates of 10mm down size shall also be done in advance for the use in the junctions having congested reinforcement.
- 1.2.5 Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations if not otherwise directed by the Engineer.
- 1.2.6 All the water tanks and other liquid retaining concrete structures shall undergo hydro testing.

- 1.2.7 Special benches shall be provided at site for stacking reinforcement bars of different sizes.
- 1.2.8 Formwork for beams of RCC areas shall be designed in such a way that the formwork of the adjacent slabs can be removed without disturbing the props / supports of the beams.
- 1.2.9 Wherever there are tension / suspended concrete members which are suspended from upper level structural members, the shuttering / scaffolding of such members at lower level shall have to be kept in place till the time the upper level supporting members gain minimum required strength. Cost of such larger duration of keeping in place the shuttering/scaffolding shall be deemed to be included in the price quoted for respective structural members.
- 1.2.10 Formwork is required for full height at all locations. Special precaution for such tall formwork shall be taken to ensure its safety. Extra costs for such formwork shall be deemed to have been included in the price quoted against relevant items.
- 1.2.11 During the mobilization period, the contractor shall carry out expeditiously and without delay the following works:
- Material testing and mix designs of various grades of concrete as contemplated in the specifications.
 - Setting up of full-fledged site laboratory as per the requirements of these specifications.
 - Any other pre-requisite items required for final execution.
 - Site office for the use of the Engineer staff.
 - Casting yard with full facilities.
 - Setting up concrete batching and mixing plant.
 - Any other prerequisite items required for final execution.
- 1.2.12 Casting yard to have following minimum facilities.
- Casting beds as required.
 - Sets of form work /moulds as required.
 - All handling facilities for precast elements.
 - Curing arrangements as required.
 - Stacking arrangements for precast elements.
 - Storing of materials.
 - Segments shall be stacked with Three-Point support in stacking yard, Two tier stacking of girders is acceptable in Pre-cast yard subject to the satisfaction of Engineer-in-Charge.
 - Proper drainage and approach roads.

1.3 Supply of Progress photographs and albums:

The work covers the supply of colour photographs, negatives and albums to serve as a permanent record of various stages/facets of work needed for an authentic documentation as approved by the Engineer.

The photographs shall be of acceptable quality and they shall be taken by a professionally competent photographer with camera having the facility to record the date of the photographs taken in the prints and the negative. Each photograph in the album shall be suitably captioned and dated.

The photographs and materials including negatives/softcopies shall form a part of the records of BSTP and prints of the same cannot be supplied to anybody else or published without the written permission of the client.

1.4 Supply of Video CDs:

The work consists of taking video films of important activities of the works as directed by the Engineer during the currency of the Project and editing them to a video film of playing time not less than 60 minutes. It shall contain narration of the activities in English by a competent narrator. The edition of the film and script of the narration shall be approved by the Engineer.

1.5 Survey Work:

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points, triangulation points, bench marks, grid layout for all the piers and other structures maintaining horizontal and vertical control within the permissible limits, incorporating changes (if any), submission of full data in the tabulation form and survey drawings including setting and layout of various works during the progress of work and matching of the station area track alignment with the alignment of the approaches at station ends and incorporating the changes (if any).

1.6 Barricading

The work includes/covers barricading for the work to be carried out along the median and areas affecting road traffic. Barricading for the areas like casting yard, batching plant, storage and similar working area shall be done at own cost by the contractor. Other barricading along the median and areas affecting road traffic will be paid as schedule A (General Works) of BoQ. The detailed scope of work is as follows:

- i. Providing and installing the barricades of the design and type as shown in the typical sketch furnished as per the approved plan firmly to the ground and maintaining it during the progress of work.
- ii. It is the primary responsibility of the contractor to ensure sufficient illumination (e.g.: rope lights etc.) along the barrication line to guide the road traffic. Any shortfall in this regard shall attract a penalty of ` 5000/- per instance or as decided by the Engineer-in-Charge.
- iii. In case of EOT granted to the contractor for any reason whatsoever, no additional compensation shall be paid to the contractor.
- iv. Dismantling of barricading and other temporary installations from the site and cleaning the site as per direction of Engineer upon completion and acceptance of work. The barricading boards shall be the property of the contractor upon completion of the work.
- v. 50 % of the barrication boards shall be painted and the remaining 50% shall be filmed as per the approved scheme and methodology. Repainting and re-filming of the same shall be ensured without fail at a regular interval of every six months. Nothing extra shall be paid in this regard.
- vi. To facilitate certain category (ies) of construction activities, it may be necessary to temporarily remove the barricades from a particular location and reinstall the same at the same location. No additional payment shall be made or can be claimed on account of such reinstallation(s). However permanent removal of barrication boards from any location shall be permitted only just prior to road restoration.

Tentative Road Safety Devices

Brief Description

No.

1. Supply of Red portable heavy duty traffic cones of 750 mm height with white reflective tape bands on min. 100 mm width all around.
2. Hazard warning light flasher with rechargeable, maintenance free battery & charging system.
3. Safety light island post with 11 nos. parallel reflector.
4. Red reflective arrow fitted on enamelled mild steel board of 360 x 220 mm size.
5. Traffic Triangular Tripod made of fluorescent cloth fitted on steel frame.
6. Retro-reflective tape (I) 50 mm width.

7. Fluorescent Jackets with reflective tape all around.
8. Yellow reflective cat eyes of size 115 x 11 x 22 mm made of ABS material having 19 glass beads on each side.
9. Metal Tubular Delineator of 610 mm height with reflective tapes.
10. Retro-reflective arrows diversion board 450 x 900 mm with crystal clear protective transparent coat to avoid damage on 14 gauge Mild Steel sheet with and without pole.
11. Retro-reflective "Men at work" triangular board of size 900 mm with crystal protective transparent coat to avoid damage on 14 gauge Mild steel board with and without poles.
12. Retro-reflective board for "Go Slow Work in progress" of size 1200 x 750 mm with crystal clear protective transparent coat to avoid damages to the Mild Steel sheets with and without pole.
13. Retro-reflective advance direction sign cum diversion boards of size 1200 x 900 mm with crystal clear protective transparent coat to avoid damage to the 14-gauge mild steel sheet with and without pole.
14. Retro-reflective speed limit circular sign boards of 600 mm diameter with crystal clear protective transparent coat to avoid damage to the 14-gauge mild steel sheet (without pole).
15. 'SORRY FOR INCONVENIENCE' Retro-reflective boards of size 900 x 300 mm size with crystal clear protective transparent coat to avoid damage to the 14 gauge Mild Steel Sheet (without pole).
16. HAZARD MARKERS (Yellow & Black) must be put all over the construction site. This Retro- reflective board is of size 300 x 900 mm with crystal clear protective transparent coat to avoid damage to the 14 gauge mild steel sheet with or without pole.
17. 'CAUTION' tape which is normally yellow tape of special polythene material having 75 mm width 'CAUTION' written all over with black colour in rolls of 300 meter.

Measurement

The barricading including all the required safety devices as listed under the above table shall be measured as per relevant item in BOQ.. Payment shall be deducted for the period during which the barricading and arrangements for traffic diversion are not satisfactory to the Engineer.

1.7 Transplantation of Tree

The item shall be carried out as per the approved plan by the Engineer after the identification of the trees to be transplanted. The actual number of trees shall be finalized after the necessary clearances by the concerned departments. The item is complete and including all expenditures for carrying out all operations i.e., excavation, watering, feeding of chemicals, back filling, lifting of trees by crane and transporting to the designated site where it is to be transplanted and all necessary care to be taken for the specified initial period till the tree gets settled at new site and up to the full satisfaction of the Engineer.

1.8 Finishing Work:

- 1.8.1 The Contractor shall incorporate seismic considerations of anchoring and isolation in the design and detailing of the finishes as directed by the Engineer. The element to be anchored shall have its motion suitably restrained whilst at the same time it shall be suitably isolated so as not to be affected by the deformations/ vibrations of the building during Construction.

- 1.8.2 Sub-Contractor:

Works as listed below and those dealing with proprietary materials/ products may be carried out by the Contractor through the Sub-Contractors as may be approved by the Engineer in writing. The Sub-Contractors must be firms of repute and long standing, having adequate experience and complete facilities to carry out all items of work required for completion as per Specifications and expected quality to the satisfaction of the Engineer. The Sub- Contractor must also have personnel experienced in preparing shop drawings. All such

works shall be carried out under the direct supervision of the manufacturers of the proprietary materials/ products or their trained and accredited licensee.

- (a) Waterproofing
- (b) Caulking & Sealants
- (c) Seismic Joints
- (d) Expansion joints
- (e) Application of Silicone water repellent solution where specified.
- (f) Bearings
- (g) Structural Glazing/cladding
- (h) Landscaping
- (i) Roof sheeting

1.8.3 Guarantees and Building Maintenance for Finishes:

The Contractor shall guarantee and undertake to maintain and rectify the various components of the Civil Works for their successful performance for the periods as specified below. The Contractor shall indemnify the Engineer for a similar period against any damage to property and injury to persons on account of any defective work or maintenance carried out by the Contractor. The format and text of the Guarantee and the Indemnity Bond shall be as followed in CPWD or as approved by the Engineer.

- a. External/Internal cladding of Stone, Marble and Granite shall be guaranteed for 5 years.
- b. All Fire Rated Door sets shall be guaranteed to remain integral and absolutely stable in the event of a fire. All moving parts of the Fire Rated Door sets shall be guaranteed to give trouble free service for 5 years and the finish shall be guaranteed to last for at least 5 years.
- c. Waterproofing for basements (which include raft, retaining walls, and expansion/ separation joints in retaining walls) and roofs shall be guaranteed for 10 years. The waterproofing shall include all allied works on the roof such as concrete screed and the China Mosaic roof finish/ stone cladding on the parapet between which the waterproofing treatment shall be sandwiched.
- d. Waterproofing for the other areas such as toilets, kitchens, chhajjas etc. shall be guaranteed for 10 years. The waterproofing shall include all allied works on the slab etc. such as concrete/ mortar screeding, if any, floor finish between which the waterproofing treatment shall be sandwiched.
- e. The manufacturer / Supplier / fabricator/ contractor of the roofing system shall give a guarantee for 15 years with regarding to its composition, surface and tensile strength.

1.8.4 Responsibility for Shop drawings, Samples and Mock-ups:

Approval of shop drawings, samples and mock-ups for the various components shall not absolve the Contractor of his responsibility of completing the work to the specifications, standards, tests for performance and guarantees given in these documents and to a quality of finish as desired by the Engineer.

1.8.5 Cleaning:

Surfaces on which finishes are to be provided shall be cleaned with water jets or oil free compressed air or power tools with wire brushes and detergents all as approved by the Engineer.

1.8.6 Expansion bolts/fasteners:

- 1. Unless specified otherwise all expansion bolts/ fasteners shall be fabricated from austenitic stainless steel sheet, strip or plate conforming to ASTM A 240 Gr 304 or bar to ASTM A 479 Gr 304 of approved make and design. The material of the bolt shall not cause any bimetallic corrosion with the reinforcing bars of the RCC/ brickwork or with any other fixings or doors or windows or skylights etc.
- 2. For steel backings the fasteners shall be prevented from contact with other metals, which would lead to bimetallic corrosion.

3. For brick masonry backing the sleeves of the expansion bolts shall be fixed in wedge shaped pockets having an area of 75mm x 75mm at the surface and 100mm x 100mm at the inner surface and shall be 125mm deep. The wedge could also be as a truncated cone of 75mm dia/ 100mm dia. The dimensions shall be reviewed by the Engineer during execution of the work. The wedge shall be filled with PCC 1:1:2 (1 Cement, 1 Sand and 2 Coarse Aggregate) mixed with non-Shrink Compound in the proportion as recommended by the manufacturer.
 4. The holes drilled for the expansion fasteners shall be cleaned of all ground material, dust etc. before inserting the expansion sleeves.
 5. All expansion bolts fixed into soffits shall be bonded to the backing with epoxy/ polyester resin of approved make.
 6. All expansion bolt fixings shall be tightened in accordance with the recommended torque figures by the manufacturer. Where such values are not available the Contractor shall test at least 6 samples to determine the safe torque values. All bolts shall be tightened using torque spanner/ wrenches. All bolts shall be checked 24 hours (minimum) after installation and retightened if necessary.
- 1.8.7 No walls, terraces shall be cut for making any opening after water proofing has been done without written approval of the Engineer. Cutting of waterproofing when authorised by the Engineer in writing shall be done very carefully so that no other portion of the waterproofing is damaged. On completion of the work at such places, the water proofing membrane shall be made good and ensured that the opening / cutting is made fully water proof as per specifications and details of water proofing approved by the Engineer at no extra cost. No structural member shall be cut or chased without the written permission of the Engineer.
- 1.8.8 Provision of grooves in plaster, drip courses etc., if directed, at junction of walls-ceilings, columns-walls, frames-plaster and such other generally typical locations shall not be paid extra, including grooves in concrete, masonry, stonework. **Painting of concrete surfaces.**
- 1.8.9 All exposed concrete surfaces, either bare or plastered visible to the common public shall be provided with epoxy paint of approved colour as per relevant IS and IRS codes specification except for the surfaces which are provided with cladding material.

1.9 **Applicable Codes, Standards & Publications for Structural Work:**

The more important Codes, Standards and Publications to Contract are listed here under:

/General

IS: 875 (Part 1 to 5)	Code of practice for design loads (other than earthquake) for buildings and structures
IS: 1893	Criteria for earthquake resistant design of structures
SP-7	National Building Code of India
SP-23 (S&T)	Hand Book on Concrete Mixes
IS:2572	Code of Practice for construction of hollow concrete block masonry
IS:6408 (Parts 1,2)	Recommendations For Modular Co-Ordination in Building Industry - Tolerances
IS:10958	General check list of functions of joints in building
IS:11817	Classification of joints in buildings for accommodation of dimensional deviations during construction
IS:11818	Method of test for laboratory determination of air permeability of joints in buildings
IS:12440	Precast concrete stone masonry blocks

BS:476 (Part 7)	Method for classification of the surface spread of flame of products
BS:476 (Part 20)	Method of determination of the fire resistance of elements of construction (general principles)
BS:476 (Part 22)	Methods for determination of the fire resistance of non-load bearing elements of construction
BS:5215	Specification for one-part gun grade polysulphide-based sealants
BS:5606	Guide to accuracy in building
BS:6093	Code of practice for the design of joints and jointing in building construction
BS:8200	Code of practice for the design of non-load bearing external vertical enclosure of building
ASTM C 332	Specification for light weight aggregate for insulating concrete
B. Bitumen	
IS :702	Industrial Bitumen Specification for bitumen primer for use in waterproofing and damp-proofing
IS : 73-1992	Paving Bitumen
IS : 217-1988	Cutback Bitumen
IS : 1322-1993	Bitumen felts for water proofing and damp-proofing
IS:3384	Specification for bitumen primer for use in waterproofing and damp-proofing
C Building Construction Practices	
IS:1838 Part I & II	Specifications for preformed fillers for expansion joint in concrete pavements and structures
IS: 1946	Code of Practice for use of fixing devices in walls, ceilings, and Floors of solid construction
IS: 3414	Code of Practice for Design and installation of joints in buildings
IS: 6509	Code of Practice for installation of joints in concrete
IS: 11134	Pavements. Code of Practice for setting out of buildings.
IS: 11433	Parts I and II. Specifications for one part Gun grade polysulphide based joint sealant
IS: 12200	Code of Practice for provision of water stops at transverse contraction joints in masonry and concrete dams
D. Cement	
IS: 455	Portland Slag Cement
IS: 650	Specification for standard sand for testing cement
IS: 6925	Specification for Methods of Test for Determination of Water Soluble Chlorides in Concrete Admixtures
IS: 8042	White Portland Cement
IS: 8112	Specification for 43 grade ordinary Portland cement
IS: 12269	Specification for 53 grade ordinary Portland cement
IS: 12330	Specification for sulphate resistant Portland cement
IS: T 40	Indian Railways standard specifications for special grade cement for use in concrete sleepers
IS:269-2015	Ordinary Portland cement
IS:1489 (Part 1)	Portland pozzolana cement: Fly ash based
IS:1489 (Part 2)	Portland pozzolana cement: Calcined clay based
IS:3535	Method of Sampling Hydraulic Cements

IS:4031	(Parts 1 to 15) Methods of physical tests for hydraulic cement.
IS:4032	Method of chemical analysis of hydraulic cement.
E Concrete	
IS: 456	Code of practice for plain and reinforced concrete
IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures
IS: 460 (Part I to II)	Specification for Test Sieves
IS: 516	Methods of test for strength of concrete
IS: 1199	Methods of sampling & analysis of concrete
IS: 1200	Method of measurement of building and civil engineering
IS: 1343	Code of practice for prestressed concrete
IS: 1607	Method of Test Sieving
IS: 2386 part I-VIII	Methods of tests for aggregates for concrete
IS: 2430	Methods of Sampling of Aggregates of Concrete
IS: 2438	Specification for roller pan mixer
IS: 2514	Specification for concrete vibrating tables
IS: 2571	Code of practice for laying in-situ cement concrete flooring
IS: 2645	Specification for integral cement water proofing compounds
IS: 2722	Specification for portable swing batchers for concrete (double bucket type)
IS: 2770	Method of testing bond in reinforced concrete part I pull out test
IS: 3025	Methods of sampling and test (physical and chemical) for water & waste water
IS: 3935	Code of practice for composite construction
IS: 4326	Code of practice for earthquake resistant construction of building
IS: 6925	Methods of tests for determination of water soluble chlorides in concrete admixtures
IS: 7242	Specification for concrete spreaders
IS: 7251	Specification for concrete finishers
IS: 7861 parts I & II	Code of practice for extreme weather concreting
IS: 7969	Safety code for handling and storage of building materials
IS: 8989	Safety code for erection of concrete framed structures
IS: 8142	Methods of tests for determining setting time of concrete by penetration resistance
IS: 9103	Specification for admixtures for concrete
IS: 9013	Method of making, curing and determining compressive strengths of accelerated cured concrete test specimens
IS: 9284	Method of test for abrasion resistance of concrete
IS: 10262	Recommended guidelines for concrete mix design
MORTH	Specifications for Road and Bridge Works, Ministry of Road Transport and Highways (Roads Wing).
IRS	Concrete Bridge Code Standard Specification and Code of Practice for Road Bridges Section III Cement Concrete (Plain & Reinforced (First Revision)
IS:3370	Code of practice for concrete structures for storage of liquids
IRC -112-2011	Concrete Bridge Codes
ASTM - C - 94	Ready Mix Concrete
IS 4926:2003	Ready Mixed Concrete - Code of Practice

ASTM - C - 1240	Specifications for Silica Fume for use in Hydraulic Cement and Mortar
F. Construction Plant and Machinery	
IS: 1791	Specification for batch type concrete mixers
IS: 2505	General requirements for concrete vibrators: Immersion type
IS: 2506	General Requirements for screed boards concrete vibrators
IS: 3366	Specification for pan vibrators
IS: 3558	Code of Practice for use of immersion vibrators for consolidating concrete
IS: 4656	Specifications for form vibrators for concrete
IS: 4925	Specification for concrete batching and mixing plant
IS: 11993	Code of Practice for use of screed board concrete vibrators
G Formwork	
IS: 4990	Specification for plywood for concrete shuttering work
IS: 87	Guidelines for the design and erection of false work for Road bridge
IS: 806	Code of Practice for use of steel tubes in general building construction
IS: 1161	Specification of steel tubes for structural purpose
IS: 1239	Specification for mild steel tubes, tubular and other wrought steel fittings
H Gypsum and Gypsum Board	
IS:2095	Gypsum plaster boards
IS:2542 (Part 1/Sec 1 to 12)	Methods of test for gypsum plaster, concrete and products: plaster and concrete
IS:2542 (Part 2/Sec 1 to 8)	Methods of test for gypsum plaster, concrete and products: Gypsum products
IS:2547 (Part 1)	Gypsum building plaster: Excluding premixed lightweight plaster
IS:2547 (Part 2)	Gypsum building plaster: Premixed lightweight plaster
I Handling and Storage	
IS: 4082	Recommendation of slacking and storage of construction materials
IS: 8348	Code of Practice for stacking and packing of stone slabs for transportation
J Instruments for Testing cement and Concrete	
IS: 5513	Specification for Vicat Apparatus
IS: 5514	Specification for apparatus used in Le-Chatelier
IS: 5515	Specification for compaction factor apparatus
IS: 7320	Specification for concrete slump test apparatus
IS: 7325	Specification for apparatus to determine constituents of fresh concrete
IS: 10080	Specification for vibration machine
IS: 10086	Specification for moulds for use in tests of cement and concrete
IS: 10510	Specification for Vee-bee consistometer
K. Joint Fillers	
IS: 1838 (part 1)	Preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type): Bitumen impregnated fib
L Paints and Coatings	
IS: 2074	Ready mixed paint. Air drying, red oxide-zinc chrome, priming
BS:EN:10152	Specification for electrolytically zinc coated cold rolled steel flat products
ASTM 164-71	Technical delivery conditions. Specification for electrodeposited coatings of zinc on steel

IS:109	Ready mixed paint, brushing, priming, plaster, to Indian Standard Colour No. 361 and 631 white and off white.
IS:347	Varnish, shellac, for general purpose.
BS:6496	Specification for powder organic coatings for application and stoving to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated with powder organic coatings
IS 102	Ready mix paint, brushing red lead non sealing
M. Pigments for Cement	
BS: 1014	Specification for pigments for Portland cement and Portland cement products
N. Reinforcement & Structural Steel	
IS: 806	Code of Practice for use of Steel Tubes in General Building Construction
IS: 210	Grey Iron Castings
IS: 280	Mild steel wire for general engineering purposes
IS: 432	Part I. Mild steel and medium tensile steel bars. Part II Hard drawn steel wire.
IS: 451	Technical Supply conditions for Wood Screws
IS: 815	Classification coding of covered electrodes for metal arc welding of structural steels
IS: 1239	Specification for mild steel tubes, tubulars and other wrought steel fittings
IS: 1363	Black hexagon bolts, nuts and lock nuts and black hexagon screws.
IS: 1365	Slotted countersunk screws.
IS: 1566	(Part-I) Specifications for hard-drawn steel wire fabric for concrete reinforcement.
IS: 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS: 2502	Code of Practice for bending and fixing of bars for concrete reinforcement.
IS: 2629	Recommended practice for hot-dip galvanising of iron and steel.
IS: 2751	Code of Practice for welding of mild steel plain and deformed bars for reinforced concrete construction.
IS: 4759	Hot-dip zinc coating on structural steel and other allied products.
IS: 9417	Recommendations for detailing of reinforcement in reinforced concrete works
IS: 14268	Uncoated stress relieved low relaxation steel class 2 for Prestressed concrete
IS: 226	Structural steel (Standard Quality)
IS: 800	Code of practice for use of structural steel in general building construction.
IS: 813	Scheme of symbols for welding.
IS: 814	Covered electrodes for metal arc welding of structural Steel. (Part I & Part II)

IS: 816	Code of practice for use of metal arc welding for general construction in mild steel.
IS: 822	Code of practice for inspection of welds.
IS: 961	Structural steel (High Tensile)
IS: 1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.
IS: 1030	Carbon steel casting for General Engineering Purposes
IS: 1120	Coach Screws
IS: 1367	Technical Supply Conditions for Threaded Fasteners
IS: 1161	Steel tubes for structural purposes.
IS: 1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
IS: 1915	Code of Practice for Steel Bridges
IS: 2016	Plain Washers
IS: 2062	Structural steel (Fusion welding quality)
IS: 3063	Single Coil Rectangular Section Sprint Washers for Nuts, Bolts and Screws
IS: 3443	Crane Rail Sections
IS: 3757	Specification for high tensile friction grip bolts.
IS: 3600	Code of practice for testing of fusion welded (Part I) joints And weld metal in steel.
IS: 5624	Specification for foundation bolts.
IS: 4923	Hollow steel sections for structural use.
IS: 6227	Code of practice for use of metal arc welding in tubular structure.
IS: 801	Code of practice for use of cold formed light gauge steel structural members' in general building construction.
IS: 811	Specifications for cold formed light gauge structural steel sections.
IS: 8500	Structural Steel Micro alloyed (Medium and high strength qualities) .
IS: 8910	General requirements of supply of weldable structural steel.
IS: 9595	Recommendations for metal arc welding of carbon & carbon-Manganese steels.
IS:7205	Safety Code for erection of Structural Steel Works
IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works

O Aggregates

IS:383	Coarse and fine aggregates from natural sources for concrete.
ASTM C117	Standard test method for materials finer than 75 μ (No.200) sieve in mineral aggregates by washing

P Scaffolding

IS:2750	Specification for steel scaffoldings
IS:3696 (Part 1)	Safety Code of scaffolds and ladders: Scaffolds
IS:3696 (Part 2)	Safety Code of scaffolds and ladders: Ladders
IS:4014 (Part 1)	Code of practice for steel tubular scaffolding: Definition and materials
IRC: 87	Guidelines for the design and erection of false work for road bridges

Q Sealants

IS:10959	Glossary of terms for sealants for building purposes
IS:11433 (Part 1)	One part gun- grade polysulphide based joints sealants: General requirements
IS:11433 (Part 2)	One part gun- grade polysulphide based joint sealants: Methods of test

IS:13055		Methods of sampling and test for anaerobic adhesives and sealants
BS:5889		Specification for one part gun grade silicone-based sealants.
R	Wood	
IS:303		Plywood for General Purposes
IS:848		Synthetic resin adhesives for plywood (phenolic and aminoplastic)
IS:1141		Seasoning of Timber - Code of Practice
IS:1328		Veneered decorative plywood
IS:1659		Block Boards
IS:2046		Decorative thermosetting synthetic resin bonded laminated sheets
IS:2202 (Part 1)		Wooden flush door shutters (solid core type): Plywood face panels
IS:2202 (Part 2)		Wooden flush door shutters (solid core (type): Particle face panels and hardboard face panels
S	Bearings	
IRC:83	Part-II	Standard specifications and code of practice for road bridges Elastomeric Bearings
IRC:83	Part-III	Standard specifications and code of practice for road bridges Pot Bearings
T	UPVC Pile for Drainage	
IS 4985		Un-plasticized PVC Pipes for portable water supplies
U	Piling	
IS :2911 PART-I		Bored Cast in-situ Concrete Piles
IRC:78		Standard specifications and code of practice for road bridges Foundation and Substructure
IS: 3764		Code of safety for excavation work RDSO guidelines and Bridge manual
V	All Indian Railway Standards Metal	
ASTM B 221		Specification for aluminium and Aluminium-alloy extruded bars, rods, wires, shapes, and tubes
W	Glazing	
X	Stone and Facing/Linings	
IS 9077		Code of practice for corrosion protection of steel reinforcement in RB and RCC construction
Y	Indian Railway and RDSO Guidelines	
Z	MORT&H Specifications for Road and Bridge works (latest Revision)	
A1	CPWD Specifications & KPWD Specifications (Latest Revisions)	

**TECHNICAL
SPECIFICATION-S02:
EARTHWORK**

**REFER RDSO/2020/GE: IRS-0004 (SEPT
2020) or LATEST GUIDELINES**

S.02: EARTHWORK

- 2.1 These specifications shall be read in conjunction with the CPWD specifications 2019 / latest specifications with up-to-date correction slips, and other relevant specifications described in the S.01 of Section-VII-F of these specifications.
- 2.2 Results of the sub-surface investigations conducted at the project site are enclosed with the tender document. This information about the soil and sub-soil water conditions is being made available to the Contractor in good faith and the Contractor is advised to obtain details independently as may be considered necessary by him before quoting rates in the tender. No claim whatsoever on account of any discrepancy between the sub-surface conditions that may be actually encountered at the time of execution of the work and those given in these Tender Documents shall be admissible to the Contractor under any circumstances whatsoever.
- 2.3 Excavation of rock may be carried out by chiselling, jack hammers, crow bars, wedging and using cutting machine or by any other method approved by the Engineer, use of non- explosive demolition compounds shall also be permitted.

Open blasting is not permitted under scope of this contract but at discretion of the Engineer, controlled blasting may be permitted only in very special cases where all alternative methods have failed to achieve the satisfactory results. The Blasting, if permitted, shall be carried out within the pre-defined fixed period to be decided in consultation with and due permission of local authorities and approved by Engineer. Contractor shall take all necessary precautions to prevent flying of blasted stones outside the excavation pit and damage to adjacent structure etc. by controlling spacing and quantity of explosive charge and covering the sufficient area of blasting by steel plates loaded with adequate amount of sandbags. All operations of controlled blasting shall be carried out under the supervision of a responsible authorised blasting agent. Contractor shall be responsible for any damage arising out of blasting operation to workmen, public or any property. Contractor shall obtain all necessary permission from Traffic Police and other concerned authorities for blasting as required. Non- granting of permission for blasting by concerned authorities will not be considered as reason for delay or any claim thereof.

- 2.4 Excavation for all works and of materials required for filling shall be to the exact width length and depth shown on the drawings or as directed by the Engineer. Where the nature of soil or the depth of the trench and season of the year, do not permit vertical sides, the contractor at his own expense shall put up the necessary shoring, strutting and planking with due regard to the safety of personnel and works and to the satisfaction of the Engineer.

The construction barricading will have a width of 9.0m (outside to outside of barricading). This can be increased at specific locations with approval of Engineer. The Contractor shall submit method statements for approval of Engineer demonstrating how this will be achieved at site. If required, driving of rolled section / sheet pile of suitable size shall be done into the soil to retain earth as directed by Engineer. Measurement of plan area for excavation for payment in case of foundation works shall be deemed inclusive in the quoted cost of foundation works in BOQ.

If excavation is carried out to greater depth than required beyond the level specified, for any reason whatsoever, such volume shall be made good by filling with PCC M10 having coarse aggregates 40 mm and downgraded and brought to level to receive the levelling course below foundations. If excavation is carried out to greater width and length, such extra width and length shall be filled in by sand. No extra payment will be made on this account.

Propping shall be undertaken when any foundation or stressed zone from an adjoining structure is within a line of 1 vertical to 2 horizontal from the bottom of the excavation.

All excavations shall be carried out in conformity with the directions laid hereunder and in a manner approved by Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand.

- 2.5 The last 200mm depth of excavation shall be done not earlier than 36 hours before laying the levelling course below foundations.
- 2.6 The Contractor shall make provision for all shoring, dewatering, dredging, bailing out or draining water whether subsoil or rain or other water and the excavation shall be kept free of water while the masonry work or concrete work is in progress and until the Engineer considers the work well set (Refer IS: 3764 Safety Code for Excavation Work). The sides of trenches shall be kept vertical and the bottom horizontal and shall be run level throughout or properly stepped as directed by the Engineer. No extra payment shall be made on this account.
- Dewatering shall be carried out by suitable means with adequate stand-by arrangements as may be approved by the Engineer. The level of ground water shall be maintained at least 300mm below the lowest level of excavation during the laying of foundations. The Contractor shall be deemed to have satisfied himself with regard to feasibility of all aspects of dewatering including site constraints due to existing structures. Though the method of dewatering is left to the contractor, he shall be required to submit method statement of dewatering scheme including requisite justifications to the Engineer and seek his prior written approval.
- Approval of the Engineer, however shall not relieve the contractor of the responsibility of adequacy and appropriateness of dewatering and protection arrangements for the quality and safety of the work. The contractor shall satisfy the Engineer as to the capacity of the drains or disposal site to take the required quantity and flow of water to be pumped out at various stages of excavation. The Contractor shall obtain necessary approvals of local bodies for discharging the pumped out water. All the dewatering pumps shall therefore also have dedicated D.G. Power supply which shall come on automatically in case of failure of electrical supply from the mains. The cost of dewatering provisions shall be deemed inclusive in the quoted cost of the work for foundation works and embankment works in BOQ.
- 2.7 The Contractor shall erect and maintain during progress of works temporary fences with all safety measures around dangerous excavations at contractor's cost.
- Near habitations and traffic prone areas, trenches and foundation pits or any other excavation work shall be fenced, provided with proper caution signs and marked with red lights, reflectors at night to avoid accidents. The contractor shall take all adequate protective measures to see that excavation operations do not affect or damage adjoining structures.
- 2.8 Excavation material required for filling shall be stacked or dumped where indicated by the Engineer. Excavated material not required for filling and any surplus material shall be removed or spread on the site 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 environmental in friendly manner using tarpaulin cover, dumper, placer etc. and according to the levels/grades as indicated by the Engineer. The cost of such removal and spreading shall be borne by the Contractor and deemed to be included in the Contract Rates. Necessary approval from the local authorities for carting and dumping surplus material is to be obtained by the contractor.
- 2.9 The Contractor shall notify to the Engineer when the excavation is completed and no base or Concrete or Masonry shall be laid until the Engineer has inspected and approved of the soil conditions obtained for each individual footing or the full raft area.
- 2.10 The Contractor shall ensure the stability of the excavation so that the surrounding ground and all adjoining structures and plants will be safe against settlement, subsidence and damage and that there is no risk of injury to personnel.
- 2.11 In case of any underground structures that need to be protected (like underground sewer lines etc.) are encountered, the Contractor shall bring the same to the notice of the Engineer immediately and shall take all such steps as the Engineer may instruct for protection of such structures. Such protective measures shall be done at the Contractor's cost. If any damage occurs to such items which were required to be protected during execution, the same shall be made good by contractor at his own cost otherwise employer will arrange to make it good at the risk and cost of contractor.
- 2.12 The Contractor may dispose of the surplus earth from the project site to a place/ places as may be permitted by the Engineer. The

transportation of the surplus earth shall be done by mechanical means only. The Contractor shall at his own cost obtain necessary clearances/ permissions statutory or otherwise needed for the purpose. Dumpers may be used for transporting slushy material excavated from pile boring / well boring / pile cap / Open Foundation with precautions for non-spillage of muck.

- 2.13 In the foundation the backfilling shall be done in layers not more than 200 mm thick and shall be thoroughly watered and consolidated by approved method.
- 2.14 In case sand is used for backfilling in foundation and plinth, it shall be approved by the Engineer. In the foundation, the backfilling shall be done in layers not more than 200 mm thick and shall be thoroughly watered and consolidated by approved method. The rate for backfilling using sand in foundation is deemed to have been included in the contract price.
- 2.15 For open foundation resting on rock, if the sound rock is located at very shallow depth, the contractor is required to cut the rock (of all type or strength) to a depth so that open foundation with a minimum earth cushion of 500mm can be accommodated.
- 2.16 Measurement and Payment
- Payment for excavations in soil and/or rock, including providing and installing shoring / strutting, dewatering, pumping and bailing out water shall be made as per the quoted rate of the respective items of excavation as specified in BOQ. However, unless stated otherwise, the quoted rates for concrete in foundation (upto ground level) shall be deemed to include the cost of shoring, strutting, dewatering and backfilling using earth or sand wherever required with compaction of the same.

TECHNICAL SPECIFICATION S-03 CONCRETE: PLAIN & REINFORCED

S.03: CONCRETE: PLAIN & REINFORCED

These specifications shall be read in conjunction with the CPWD specifications 2019 or latest specification with up- to-date correction slips, IRS Concrete Bridge code, IS 456, MOST/MORTH Specifications for Road and Bridge Works 2013 (Fifth Revision) and other relevant specifications with up-to-date correction slips described in the S.01 of Section-VII-F of these Specifications.

3.1 Materials

Before bringing to the site, all materials for concrete shall be approved by the Engineer. All approved samples shall be deposited in the office of the Engineer before placing orders for the materials with suppliers. The materials brought for works shall conform in every respect to their approved samples.

Fresh samples shall be deposited with Engineer whenever type or source of any material changes. The contractor shall check fresh consignment of materials as it is brought on to the works to ensure that they conform to the specifications and/or approved samples.

The Engineer shall have the option to have any of the materials tested to find whether they are in accordance with specifications at the contractor's expense. All bills, vouchers and test certificates which in the opinion of the Engineer are necessary to convince him as to the quality of materials or their suitability shall be produced for his inspection when required.

If fly ash is used in concrete, the contractor shall demonstrate the quality control procedure including source of fly ash, its properties, handling as per the relevant IS & international codes etc. and shall use in slabs and walls only after "no objection" to the same has been obtained from the Engineer.

Any materials which have not been found to conform to the specifications and not approved by the Engineer shall be rejected forthwith and shall be removed from the site by the contractor at his own cost within the time stipulated by the Engineer. The Engineer shall have the powers to cause the contractor to purchase and use materials from any particular source, as may in his opinion be necessary for the proper execution of work.

Contractor shall also ensure that all constituents of exposed concrete shall be taken from same sources to achieve a uniform colour and texture.

3.1.1 Cement

3.1.1.1 The cement used shall be of the following types:

- a) 53 grade Ordinary Portland Cement conforming to IS:269 – 2015.
- b) Blended Cement as per IS 1489 Part-1:2015 on the specific approval by Engineer.
- c) IRST-40 Indian Railway standard specifications for special grade cement for use in concrete sleepers

For piling works, type of cement shall be as mentioned in **S.08** of Section-VII-F for pile foundations.

3.1.1.2 Whenever possible all cements of each type shall be obtained from one constant source throughout the contract, cement of different types shall not be mixed together. Different brands

of cement, or the same brand of cement from different sources, shall not be used without prior approval of the Engineer.

- 3.1.1.3 Packaged cement shall be delivered to the site in original sealed bags which shall be labelled with the weight, name of manufacturer, brand and type. Cement received in torn bags shall not be used. Cement shall be used in the order in which it is received. Cement in bags in storage for more than 3 months shall be retested before use. A sample taken once for every 1000 bags or part therefor as per Engineer's decision shall be tested.

Contractor may obtain cement in bulk and store it in suitable silos of adequate capacity. Each type of cement shall be stored in a separate silo and it shall be ensured, that cements of different quality are not mixed up. Contractor should submit MILL test reports to the Engineer/Employer.

Supply of cement in bulk and storage in silos is compulsory at casting depots. Cement supply in bags will be only with the specific approval of the Engineer.

- 3.1.1.4 All cement shall be fresh when delivered and at ambient atmospheric temperature.
- 3.1.1.5 In fair faced elements, the cement used in the concrete for any complete element shall be from 3 single consignments. All cement for exposed concrete shall be from the same approved source and uniform in colour.
- 3.1.1.6 With each and every delivery of cement the contractor shall provide manufacturer's certificate that the cement conforms to the relevant Indian standard. The contractor shall provide complete facilities at site for carrying out the following tests:
- a) Setting time by vicat's apparatus as per IS:4031 and IS:5513.
 - b) Compressive strength of cement as per IS: 4031, IS:650, IS: 10080.
 - c) Fineness & Soundness

The Engineer may require any other form of sampling and tests including chemical analysis (IS 4032) in case the cement supplied is of doubtful quality. The cost of such additional tests shall be borne by the Contractor.

- 3.1.1.7 Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO₃), shall in no case exceed 2.5 percent and 3.0 percent when tri-calcium aluminate per cent by mass is upto 5% or greater than 5% respectively
- 3.1.1.8 All physical and chemical properties of OPC-53 should meet the requirements as per IS 269 – 2015. Sampling and testing of OPC 53 grade cement shall be done as per IS 269-2015. The cost of testing shall be borne by the contractor and nothing extra shall be paid in this regard.

Usage of Fly-Ash as part replacement for Cement is permitted as an eco-friendly move subject to the following conditions:

- a) Fly ash cannot be used as part replacement for cement in PSC members.

- b) Fly ash to be used as part replacement for cement shall conform to the provisions listed in IS 3812 Part I
- c) Blended concrete constituent shall be as per IS 1489 (Part I):2015
- d) Should comply minimum and maximum cement as well as cementitious requirements as per latest revision / amendments / correction slip of the Specifications stated or referred in this contract.

3.1.2 Aggregate

Aggregates from natural sources shall conform to the provisions specified in IS:383. Prior to commencing any concrete work, the Contractor shall obtain the Engineer's approval of the proposed types and sources of aggregate. Sampling of aggregates shall be as per IS 2430. The contractor shall submit to the Engineer, certificates of grading and compliance for all consignments of aggregate. In addition, at site from time to time, the contractor shall allow for carrying out such tests and for supplying test records to the Engineer. The aggregates shall be procured from approved sources only as directed by the Engineer from time to time.

For fair faced concrete, the contractor shall ensure that aggregates are free from iron pyrites and impurities, which may cause discoloration. Aggregates shall be stored on paved areas in different compartments according to their nominal size.

3.1.2.1 Fine Aggregate

The contractor shall provide complete facilities at site for determining grading of aggregates by sieves as per IS: 383, IS: 460, IS: 1607, and IS: 2386. The fine aggregate shall be river sand pit sand, crushed sand. It shall be free from clay, loam, earth or vegetable matter, salt or other harmful chemical impurities. It shall be clean, sharp, strong, angular and composed of hard siliceous material. If considered by the Engineer as necessary, the sand shall be washed in screw type mechanical washers in potable water to remove silt, clay and chlorides. This shall be done at least one day before using it in concrete. The washed sand shall be stored on a sloping concrete platform and in such a manner as to avoid contamination. Such sand washing, storing, etc. shall be at the Contractor's cost. The grading of fine aggregate when determined as described in IS: 2386 (part I), shall be within the grading zones I, II. (Usage of stone dust or M. Sand shall only be permitted if the Engineer is satisfied with the performance and Quality of the material. Decision of the Engineer will be deemed as final)

The Contractor shall carry out the following tests at Site and ensure that the appropriate provisions of Indian or other standards, as may be applicable, are complied with:

- a. Proportion of clay, silt and fine dust by sedimentation method as per IS 383 and IS 2386 (Part II)
- b. Moisture content in fine aggregate as per IS 2386 (Part III)
- c. Water absorption as per IS 2386 (Part III) and IRC: 15 (CL. 3.3.4)
- d. Bulk Density of Bulkage as per IS 2386 (Part III)
- e. Grading of fine aggregate as per IS 383 and IS 2386 (Part I)

3.1.2.2 Coarse Aggregate

The nominal maximum size of the coarse aggregate shall be 20 mm, unless otherwise mentioned in the Drawings. The coarse aggregate shall be crushed stone, crushed gravel, natural gravel or a suitable combination thereof. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any deleterious material.

River gravel or pit gravel shall be sound, hard, clean, non-porous, suitably graded in size with or without broken fragments and free from flat particles of shale, clay, silt, loam, and other impurities.

Except where it can be shown to the satisfaction of the Engineer that a supply of properly graded aggregate of uniform quality can be maintained over the said period of the works, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in correct proportions as and when required. Aggregate shall be stored in such a way as to prevent segregation of sizes and avoid contamination with fines.

All coarse aggregate shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386, Parts I to VIII.

The maximum size of coarse aggregate shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. The grading of coarse aggregate shall be such that not more than 5% shall be larger than the maximum size and not more than 10% shall be smaller than the smallest size. Between these sizes the coarse aggregate shall be well graded. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

The Contractor shall carry out the following tests at site and ensure that the appropriate provisions of following Indian standards as may be applicable are complied with:

- a. Moisture content in coarse aggregate as per IS 2386 (Part III)
- b. Water absorption as per IS 2386 (Part III) and IRC 15 (CL. 3.3.3)
- c. Bulk density and voids as per IS 2386 (Part III)
- d. Grading of coarse aggregate as per IS 383 and IS 2386 (Part I)

3.1.2.3 Chloride Content

The chloride content of aggregates shall be within the recommended limits stated in IS: 383 or BS 882 and the chloride content of the concrete mix shall be within the recommended limit of IS: 456 or BS 8110. Chloride levels shall be determined daily in accordance with the methods described in BS 812.

3.1.2.4 Alkali-Silica Reactivity

If aggregates contain any materials which are reactive with alkalis in any of the constituents of the concrete, or in water which will be in contact with the finished work, then the Contractor shall take samples of these materials every week. The Contractor shall ensure that the concrete mix complies with the requirements of this Specification regarding "Minimising risk of alkali-silica reaction in concrete", vide clause 3.4. The results of the Contractor's weekly monitoring tests shall be submitted in writing to the Engineer.

3.1.2.5 Sulphate Content

The total acid soluble sulphate content of the concrete mix, expressed as SO₃, shall not exceed the recommended limit in IS: 456 or BS 8110.

3.1.2.6 Water

Water used in the works shall be potable water and free from deleterious materials. Water used for mixing and curing concrete as well as for cooling and/or washing aggregate shall be fresh and clean free from injurious amounts of oil, salts, acids, alkali, sugar, other chemicals and organic matter.

Water shall be from the source approved by the Engineer and shall be in accordance with clause 5.4 of IS: 456. However, chloride content in water shall not exceed 500 mg/litre.

Before starting any concreting work and wherever the source of water changes, the water shall be tested for its chemical and other impurities to ascertain its suitability for use in concrete for approval of the Engineer. No water shall be used until tested and found satisfactory. Cost of all such tests shall be borne by the contractor.

3.2 **Blending of aggregates:**

In order to obtain optimum workability, individual aggregates of nominal size 20 mm, 10 mm, 4.75 mm and 2.36 mm will be blended in such a way that the grading curve for all aggregates will be a smooth curve from size 0.15 mm to 25 mm falling within the established envelop grading curve. Contractor shall establish envelop grading curve for each grade of concrete for given maximum size of aggregates and get it approved by Engineer before finalising the mix design.

3.3 **Admixtures:**

- i Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, amount and method of use of any admixtures proposed by the Contractor shall be submitted to the Engineer for approval. The minimum cement content specified shall not be reduced on account of the use of these Admixtures.
- ii The contractor shall further provide the following information concerning each admixture to the Engineer
 - a. Normal dosage and detrimental effects if any of under dosage and over dosage.
 - b. The chemical names of the main ingredients in the admixtures.
 - c. The chloride content, if any, expressed as a percentage by weight of admixture. The admixture shall be chloride free.
 - d. Whether or not the admixture leads to the entrainment of air when used with in the manufacturer's recommended dosage.
 - e. Where two or more admixtures are proposed to be used in any one mix, the manufacturer's written confirmation of their compatibility
 - f. In reinforced concrete works, the chloride content of any admixture used shall not exceed 2 percent by weight of the admixture as determined in accordance with IS:6925 and the total chloride and sulphate contents in concrete mix shall not exceed 0.15 and 4.0 percent respectively by weight of cement.
 - g. The chemical admixtures when used shall conform to IS: 9103. The suitability of all admixtures shall be verified by trial mixes.
 - h. The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.
 - i. Retarding admixtures when used shall be based on ligneous-Phonates with due consideration to clause 5.2 and 5.3 of IS: 7861.
 - j. Fibre reinforcement will be Propex (Fiber mesh 300-e3 / Fiber mesh 150-e3) or equivalent make polypropylene fibres, shall be added to ready-mixed concrete

wherever the material is to be used for parapet, box girder etc. Bar reinforcement is still considered primary reinforcement. Under normal condition, add to the ready-mix at the plant in the quantity recommended by the manufacturer subjected to the approval of engineer-in-charge. If job conditions warrant fiber reinforcement may be added at the job site provided that fibers are evenly distributed in the mix. Notwithstanding the same, Fibre reinforcement shall conform to IRC:SP:46 (2013). Micro silica (Silica fume) when used as mineral admixture in to concrete shall be conforming to ASTM C 1240 latest standards, silica fume shall comply with requirements given in IS:15388, IS :456-2000, IRS-CBC to establish specified strengths, durability and to meet special design objectives.

- k Fly ash according to IS:456 confirming to grade I of IS:381 may be used as part replacement provided uniform blending with cement is ensured

3.4 Minimising the Risk of Alkali-Silica Reaction (ASR) in Concrete

1. Precautions against ASR in Concrete

Concrete mixes for use in the Permanent Works shall comply with one of the Subsections 2, 3 or 4. The Contractor shall notify the Engineer of his proposals for complying with this requirement.

2. The cementitious material shall have a reactive alkali content not exceeding a maximum value of 0.6% by mass when defined and tested as specified.

To combat the ASR, Microsilica shall be used in minimum 5% cement and shall not exceed 10% by the weight of cement in order to bind free alkalis early in plastic concrete and to reduce the permeability of concrete to prevent the moisture and external alkalis penetration.

OR

3. The total mass of reactive alkali in the concrete mix shall not exceed 3.0 kg/m³ of concrete when defined, tested and calculated as specified.

OR

4. The aggregate shall be classed as non-reactive in accordance with the definition in Subsection 14.
5. Cementitious Material (Hydraulic and Latent Hydraulic Binders):
6. The term alkali refers to the alkali metals sodium and potassium expressed as their oxides. The reactive alkali content of Portland cements shall be defined as the percentage by mass of equivalent sodium oxide (Na₂O) calculated from:-

$$\% \text{ equivalent Na}_2\text{O} = \% \text{ acid soluble Na}_2\text{O} + 0.658 \times (\% \text{ acid soluble K}_2\text{O})$$

7. The method used in determining the acid soluble alkali content of the materials shall be in accordance with BS 4550: Part 2: Subsection 16.2.
8. The Contractor shall make available the certified average acid soluble alkali content of Portland cement on a weekly basis.
9. The Contractor shall give immediate notice of any change which may increase the certified average acid soluble alkali content above the level used in the mix design for the concrete. A revised mix design for any concrete which would be affected by the increased alkali content shall be submitted for consent with notification of the change.
10. Minimising the Risk by Using Cementitious material containing less than 0.6% Reactive Alkali. The requirements of Subsection 2 will be met by Subsection 11 provided that the contribution of alkalis from other sources does not exceed 0.2 kg/m³ (see Subsections 14 and 21). Where alkalis exceed 0.2 kg/m³ the requirements of Subsections 12 to 15 shall apply.
11. The cementitious material shall be Portland cement complying with Indian Standard and shall have additionally a certified maximum acid soluble alkali content not exceeding 0.6%.

The Contractor shall provide on request weekly certificates which name the source of the cement and confirm compliance with the Specification.

12. Minimising the Risk by Limiting the Reactive Alkali Content of the Concrete to 3.0 kg/m³. The requirements of Subsection 3 will be met provided that Subsections 13, 14 and 15 are satisfied.
13. The reactive alkali content of the concrete contributed by the Portland cement to the concrete shall be calculated from:

$$\text{Portland cement A} = C \times a, 100$$

Where,

A = reactive alkali content of the concrete to the nearest

0.1 (kg/m³) C = target mean Portland cement content of

the concrete (kg/m³)

a = certified average acid soluble alkali content of the Portland cement (%).

14. Where reactive alkalis in excess of 0.2kg/m³ are contributed to the concrete from sources other than the cementitious material the limit of 3.0 kg/m³ from the cementitious material shall be reduced by the total amount so contributed.

The reactive alkali contributed by sodium chloride contamination of aggregates shall be calculated from:

$$H = 0.76 \times \{(NF \times MF) + (NC \times MC)\} \text{ (kg/m}^3\text{)}$$

Where H = equivalent alkali contribution made to the concrete by the sodium chloride

NF = chloride ion content of the fine aggregate as a percentage by mass of dry aggregates and measured according to BS 812: Part 4

MF = fine aggregate content (kg/m³)

NC = chloride ion content of the coarse aggregate as a percentage by mass of dry aggregate and measured according to BS 812: Part 4: 1976 (now in draft as Part 117)

MC = coarse aggregate content (kg/m³).

The factor 0.76 is obtained from a consideration of the composition of sea water.

The chloride ion content of aggregate sources containing 0.01% of chloride ion by mass or more shall be determined weekly in accordance with BS 812 or another approved method. When the chloride ion level is less than 0.01% it shall be regarded as nil.

15. The Contractor shall provide certificates on request confirming compliance with the Specification and stating:
 - (a) The target mean cementitious material content of the concrete.
 - (b) The names of the works manufacturing the cement.
 - (c) A weekly report of the cement alkali determinations in accordance with Subsection 6.
 - (d) The certified average acid soluble alkali content of the Portland cement.
16. Minimising the Risk by Using Selected Aggregates

Fine and coarse aggregate material shall comply with the requirements of IS:383 (and/or AASHTO Standard Specifications M60 and M80 respectively) to be taken out to conform to 512(2).

17. Water

Water for use in the manufacture of concrete shall be obtained from a public utility undertaking supply or from a source approved by Engineer and shall be of potable quality, and comply with the requirement of IS:456 and or BS 3148.

18. Where a potable mains supply is not available the Contractor shall obtain confirmation of the quality and reliability of the proposed source from the appropriate water authority and shall there after seek consent from the Engineer to use the proposed source.

19. Water other than from a public utility undertaking supply shall be sampled at a frequency to be determined by the Engineer and tested in accordance with the relevant provisions of IS:3025 or BS 3148. The sodium oxide and potassium oxide content shall be declared and expressed as equivalent Na₂O and shall be taken into account when calculating the total reactive alkali content of the concrete mix.
20. **Admixtures and Pigments**
Admixtures and pigments shall comply with the requirements of IS 9103 and IS:6925 or BS 5075 and BS 1014. The manufacturer's declared equivalent acid soluble alkali content and the dosage rate of any admixture or pigment to be incorporated shall be included with details of all concrete mixes submitted for consent.
21. The alkali content of admixtures shall be taken into account when determining the total equivalent alkali content of the concrete mix.
22. Microsilica (silica fume) shall be used in 5% by the weight of cement and shall not exceed 15% by the weight of cement.

3.5 **Batching Plants, Mixers and Vibrators:**

1. Unless specified in the schedule of items, for all structural concreting work the Contractor shall provide automatic weigh-batching plant of suitable capacity. The plant used shall conform to IS: 4925.
2. The Contractor shall provide Concrete mixers (IS: 1791 - Batch type concrete mixers, IS: 2438 - Roller Pan Mixer) and Vibrators (IS: 2505 - Concrete Vibrators Immersion Type, IS: 2506 - Screed board concrete vibrators, IS: 4656 - Form Vibrators for Concrete) supplied by recognised manufacturers.

3.6 **Grade of Concrete:**

The concrete is designated as follows:

Concrete M 25 / 20

The letter M refers to the mix

The number 25 represents the characteristic compressive strength of 15cm cubes at 28 days in MPa (Mega Pascal: 1 MPa: 10 kg/cm² approximately). M25 concrete thus, has a characteristic strength of 250 kg/cm². Other mix design will also be denoted in same way. The number 20 represents the nominal size of the aggregate in mm.

3.7 **Mix Design**

For all items of concrete, only design mix shall be used. Prior to the commencement of construction, the Contractor shall design the mix and submit the proportions of materials, including admixtures to be used to the Engineer for obtaining approval. Suitable water reducing admixtures or super-plasticizing and viscosity modifying agent (VMA) admixtures shall be used for achieving desired workability and strength of the concrete only after obtaining prior approval from the Engineer. **No extra payment shall be made for such admixtures.**

It is the complete responsibility of the Contractor to design the concrete mixes by approved standard methods and to produce the required concrete conforming to the specifications and the strength, workability requirements approved by the Engineer.

Mix Design Once approved must not be altered without prior approval of Engineer and shall be revalidated after every one year. However, should the contractor anticipate any change in quality of future supply of materials than that used for preliminary mix design, he should inform the Engineer quite in advance and bring fresh samples sufficiently in advance, to carry out fresh

trial mixes. Design mix will indicate by means of graphs and curves etc., the extent of variation in the grading of aggregates which can be allowed.

The total amount of acid soluble chloride content in RCC and PSC mix shall not exceed 0.6 Kg/Cum and 0.4 Kg/Cum respectively and sulphate contents in concrete mix shall not exceed 4.0 percent respectively by weight of cement.

Table 3.7.1 Limits of Water/ Cement ratio, Cement content & mineral admixtures in concrete mixes

	Description of Structural items/ elements	Applicable code	Grade of Concrete	Max. W/C ration	Min. cement content (kg/m³)	Type/ Grade of Cement	Use of mineral admixture
Track supporting structure	PCC works	IRS CBC	M20	0.50	240	OPC 43 or OPC 53 grade conforming to IS:269	Not permitted.
	Pile	IS 2911 (Part 1 Sec 2)	IRCC M35	Slump 150mm to 180mm	400	Slag Cement conforming to IS 455 or site blending OPC53+GGBS	In case slag cement not used, GGBS is permitted to be used for part replacement of OPC to max. 50% by weight.
	Pile cap/ footing/ raft foundation	IRS CBC	RCC M35	0.45	340	OPC 53 grade conforming to IS 12269	Permitted to use micro silica/ silica fumes or Fly ash as per IS 456 over and above minimum cement content as per mix design requirement.
	Pier and pier cap		RCC M50	0.45	340		
	Slab & beams		RCC M50	0.45	340	OPC 53 grade conforming to IS 12269	Not permitted
	Superstructure and PSC pier arms etc..		PSC M55	0.40	400		
Other than track	PCC works	IS 456 & IS 2911 Part 1 Sec 2	M20	0.50	240	OPC 43(IS8112) or OPC 53 grade conforming to IS:12269	Not permitted.
	Pile		RCC M35	Slump 150mm to 180mm	400	Slag Cement conforming to IS 455 or	In case slag cement not used, GGBS

	Pile cap/ footing/ raft foundation/ underground structures	IS 4 5 6	RCC M35	0.45	340	site blending OPC53+GGB S	is permitted to be used for part replacement of OPC to max. 50% by weight.
	RCC Columns		M35	0.45	340		
	Description of Structural items/ elements	Applicable code	Grade of Concrete	Max. W/C ration	Min. cement content (kg/m ³)	Type/ Grad e of Cement	Use o f mineral admixture
	Slabs & beams		M35	0.45	340	OPC 53 grade conforming to IS:12269	Permitted to use micr o silica/ silica fumes or Flyash as per IS 456 over and above minimum cement content as per mix design requirement.

Limits of Water and Cement Contents

Maximum water/cement ratio

- a) For RCC members including piles - 0.40
b) For PSC members - 0.40

For piling under water, water-cement ratio of 0.40 is applicable to cement concrete including 10% extra cement above the design mix or minimum cement whichever is greater.

Trial Mixes:

- a) The Contractor is entirely responsible for the design of the concrete mixes. However, the design shall have approval from the Engineer. At least 8 weeks before commencing any concreting in the works, the Contractor shall make trial mixes using samples of coarse aggregates, sand, water, superplasticiser and cement, typical of those to be used in the Works, and which have been tested in an approved laboratory. A clean dry mixer shall be used, and the first batch shall be discarded.
- b) The mix shall be designed to produce the grade of concrete having the required workability, durability and a characteristic strength. Trial mixes shall be prepared under full-scale site

- conditions and tested in accordance with IS 10262.
- c) Whenever there is a significant change in the quality of any of the ingredients concrete, the Engineer, at his discretion, may order the carrying out of fresh trial mixes. All costs for trial mixes and tests shall be borne by the Contractor's and held to be included in the contract rates.
 - d) Before commencing the Works, the Contractor shall submit full details of the preliminary trial mixes and tests to the Engineer for approval.

Cementitious Content

Maximum cementitious material content shall be limited to 500 Kg/Cum for both RCC and PSC work. Maximum cement content shall be limited to 450 Kg/Cum for both RCC and PSC work.

Cementitious content in concrete shall not be less than 400 kg/ cum for RCC work and 400 kg/ cum for PSC work under moderate exposure as per Clause 5.4 of IRS CBC (Note: The corrigendum 12 and addendum to this clause shall not be followed.) In case of piling work minimum cement content shall be as specified under Pile Foundations. Use of Fly Ash conforming to IS 3812 Part-I shall be permitted except for pre stressed superstructure.

As regards trial mixes, acceptance criteria, acceptance specification, lot size, sampling and testing and sampling size for piling work, PSC girders (cast-in-situ and precast post- tensioned) and general work, the requirement of the relevant codes, standards and directions of the Engineer shall be followed.

3.8 Additional tests for Concrete:

As frequently as the Engineer may require, additional testing shall be carried out for concreting in addition to mandatory tests specified in CPWD specifications 2019 / relevant IS Code / MOST/MORTH Specifications. All the codes shall be latest and updated irrespective of the version mentioned in these technical specifications.

- a. Permeability test for Concrete:
The concrete will be verified for permeability by the following procedure and shall confirm to IS: 3085-1965 - 'Permeability of Cement Mortar & Concrete', Section 1717.7.5 of MORTH Specification and DIN 1048.
- b. The Engineer shall select random batches of concrete for examination at his discretion and sampling will generally be done at the point of discharge from the mixer and at placing point.
From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.
- c. All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1717.7.5 of MORTH Specifications. The tests shall be carried out in a laboratory approved by the Engineer.
- d. At least two cylinders shall be made on each day's concreting until 60 cylinders have been made for each grade of concrete. The cylinders will be tested as per the procedure, given in Clause 5 next.

Permeability of concrete shall be checked as per the latest relevant standard for all the grade of concrete to the frequency set by the Engineer at own or 3rd party laboratory approved by the Engineer.

e. Test Procedure:

The permeability of concrete will be verified by the following procedure.

- i. Prepare a cylindrical test specimen of 150 mm dia and 160mm high.
- ii. After 28 days of curing, the test will be conducted between 28 and 35 days. The test specimen shall be fitted in a machine such that the specimen can be placed in water under pressure up to 7 bars. The typical machine shall be similar to one shown in Appendix 1700/I of MORTH.
- iii. The concrete specimen shall be subjected to a water pressure of 0.5N/mm² from the top for a period of 3 days. The pressure shall be maintained constant throughout the test period. If the water penetrates through to the underside of the specimen, the test may be terminated and specimen rejected as failed.
- iv. After three days, the pressure shall be released and the sample shall be taken out. The specimen shall be split in the middle by compression applied on two round bars on opposite sides above and below.
- v. The water penetration in the broken core is measured with scale and the depth of penetration assessed in mm (max permissible limit 25 mm).

f. Acceptability Criteria:

The concrete shall pass the permeability test if it is properly compacted and is not considered permeable when tested as per DIN, and the water penetration in the broken core is less than 25mm.

No extra payment shall be made for this test and cost of the same will be included in his rate for concrete work.

3.9 Batching of Concrete Ingredients:

Unless permitted by the Engineer, all concreting shall be either produced in automatic weigh batching plant installed at site or Ready Mix Concrete manufactured in automatic weigh batching plant. Prior approval of RMC plant shall be obtained from the Engineer before supply. The Engineer or his representative will evaluate the condition of plant, QMS and consistency of RMC in accordance with IS: 4925 to deliver quality concrete before giving the approval. Engineer has the power to reject approved RMC at any point of time if he is not satisfied with the quality or service maintained by the agency. Engineer's decision will be deemed as final.

3.10 Placing temperatures:

During extreme hot or cold weather, the concreting shall be done as per procedures set out in IS: 7861, Parts I & II.

In hot weather with temperature exceeding 40 degree Celsius, the stock piles of fine and coarse aggregates for concreting shall be kept shaded from direct rays of sun and the concrete aggregates sprinkled with water for a sufficient time before concreting in order to ensure that the temperature of these ingredients is as low as possible prior to batching. The

mixer and batching equipment shall be also shaded and if necessary painted white in order to keep their temperatures as low as possible. **The placing temperature of concrete shall be as low as possible in warm weather but in no case more than 35 degree Celsius** and care shall be taken to protect freshly placed concrete from overheating by sunlight in the first few hours of its laying. The time of day selected for concreting shall also be chosen so as to minimise placing temperatures. In case of concreting in exceptionally hot weather the Engineer may in his discretion specify the use of ice either flaked and used directly in the mix or blocks used for chilling the mixing water. In either case, the Contractor shall not be paid extra for cost of ice, additional labour involved in weighing and mixing etc. All salt and saw dust shall be removed from ice before use. Quality of water used for making ice shall confirm to IS: 456. It is mandatory to establish a chiller plant near batching plant to cater to the needs of acceptable temperature of fresh concrete. Nothing extra shall be paid in this regard. Contractor is solemnly responsible for delivering concrete within restricted temperature at site.

3.11 Transporting, Placing, Compacting and Curing:

Transporting, placing, compacting and curing of concrete shall be in accordance with IS: 456.

a. Transporting:

The mix after discharging from the mixer shall be transported by transit mixers, buckets, pumps etc. or as approved by the engineer without causing segregation and loss of cement slurry and without altering its desired properties with regard to water cement ratio, slump, air content, cohesion and homogeneity. It should be ensured that the concrete is moved to its final destination before it attains an initial set.

The transportation is to be done by agitating transit mixers, pumps or other approved methods. During hot weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather such as covering/wrapping transit mixer's drum by hessian cloth may also be adopted.

b. Placing :

The method of placing shall be such as to prevent segregation by providing windows in the formwork for pouring concrete or by Tremie pipe. The thickness of horizontal layers shall not exceed 300mm. High velocity discharge of concrete causing segregation of mix shall be avoided. The concrete shall be placed in the forms gently and not dropped from a height exceeding 1.5m except in columns where the maximum allowed will be 2.0m. Each layer of concrete shall be compacted fully before the succeeding layer is placed and separate batches shall follow each other so closely that the succeeding layer shall be placed and fully compacted before the layer immediately below has taken initial set.

For piers, pier heads, portal columns and portal beams the concreting is to be carried out in single stage i.e. in first stage concreting will be from kicker to just below pier head bottom and second stage of concreting will be pier head including shear key and cross girder (in station zone stages as given in drawings for all heights by using tremie/ pumps at the rate not more than 1.5m / hr or as approved by the Engineer.

Concreting of any portion or section of the work shall be carried out in one continuous operation and no interruption of concreting work will be allowed without; approval of the

Engineer.

c. **Compaction:**

Internal (needle) and surface (screed board) vibrators of approved make shall be used for compaction of concrete.

Internal vibrators shall be used for compaction of concrete in foundations, columns, buttresses arch section, slabs etc., and if required surface vibrators shall also be used. Depending on the thickness of layer to be compacted, 25 mm, 40 mm, 60 mm and 75 mm dia internal vibrators will be used. The concrete shall be compacted by use of appropriate diameter vibrator by holding the vibrator in position until:

- i) Air bubbles cease to come to surface.
- ii) Resumption of steady frequency of vibrator after the initial short period of drop in the frequency, when the vibrator is first inserted.
- iii) The tone of the vibrated concrete becomes uniform.
- iv) Flattened, glistening surface, with coarse aggregates particles blended into it appears on the surface.
- v) Use of curing compounds may be permitted with specific approval of Engineer.

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

- vi) To secure even and dense surfaces free from aggregate pockets, vibration shall be supplemented by tamping or rodding by hand in the corners of forms and along the form surfaces while the concrete is plastic.
- vii) A sufficient number of spare vibrators shall be kept readily accessible to the place of deposition of concrete to assure adequate vibration in case of breakdown of those in use.

- viii) Form vibrators whenever used shall be clamped to the sides of formwork and shall not be fixed more than 450 mm above the base of the new form work and concrete shall be filled not higher than 230mm above the vibrator. The formwork must be made specially strong and watertight where this type of vibrator is used.

Care must be taken to guard against over vibration especially where the workability of the concrete mix is high since this will encourage segregation of the concrete.

- ix) Plain concrete in foundations shall be placed in direct contact with the bottom of the excavation, the concrete being deposited in such a manner as not to be mixed with the earth. Plain concrete also shall be vibrated to achieve full compaction.

- d. Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground and with water draining there from during placing and for a period of seven days or as otherwise instructed thereafter. Approved means shall be taken to protect immature concrete from damage by debris, excessive loading, abrasion,

vibrations, deleterious ground water, mixing with earth or other materials, and other influences that may impair the strength and durability of the concrete.

e. Field Control

Sampling at both, truck discharge and point of final placement shall be employed to determine the quality of concrete

f. Curing:

i. Curing of concrete shall be complete and continuous using potable water free from chlorides and sulphates. Water that is free of harmful amounts of deleterious materials that may attach stain or discolour the concrete as per IS 456. The concrete shall be kept constantly wet for a minimum period of 14 (fourteen) days by ponding or covering with a layer of wet (but not dripping) sacking, canvas, hessian or similar absorbent material.

ii. Method of curing and their duration shall be such that the concrete will have satisfactory durability and strength and members will suffer a minimum distortion, be free from excessive efflorescence and will not cause undue cracking in the works by shrinkage.

Steam curing with approved methodology can be adopted if required, for precast segments. No extra payment will be made for adopting steam curing. Before concrete products are subjected to any accelerated method of curing, the cement to be used shall be tested in accordance with accepted standards (relevant IS codes) especially for soundness, setting time and suitability for steam curing. In the case of elements manufactured by accelerated curing methods, concrete admixtures to reduce the water content may be allowed to be as permitted by applicable codes of practice subject to the approval of the Engineer. The normal aeration agents used to increase the workability of concrete shall not be allowed. The steam curing of concrete products shall take place under hoods, under chambers or in tunnels. Use of insulated tarpaulin may be permitted. The steam shall have a uniform quality throughout the length of the member. The precast elements shall be stacked with sufficient clearance between each other and the bounding enclosure, so as to allow proper circulation of steam. The surrounding walls, the top cover and the floor of steam curing chamber or tunnel or hood shall be so designed as not to allow more than 1 kcal/m²/h/ degC. The inside face of the steam curing chamber, tunnel or hood shall have a damp-proof layer to maintain the humidity of steam. Moreover, proper slope shall be given to the floor and the roof to allow the condensed water to be easily drained away. At first, when steam is let into the curing chambers, the air inside shall be allowed to go out through openings provided in the hoods or side walls which shall be closed soon after moist steam is seen jetting out. Preferably, steam should be let in at the top of the chamber through perforated pipelines to allow uniform entry of steam throughout the chamber. In no case shall steam impinge directly on concrete products. The fresh concrete in the moulds shall be allowed to get the initial set before allowing the concrete to come into contact with steam. The regular heating up of fresh concrete product from 20 °C to 35 °C shall start only after a waiting period ranging from 2 to 5 hours depending on the setting time of cement used. The second stage in steam curing process shall be to heat up the concrete elements, moulds and the surroundings in the chamber. The air-space around the member shall be heated up to a temperature of 75°C to 80°C at a gradual rate, not faster than 30° C per hour. This process shall continue 1 1/2 to 2 1/2 hours

depending upon the outside temperature. The third stage of steam curing shall be to maintain the uniform temperature and pressure for a duration depending upon thickness of the section. This may vary from 3 to 5 1/2 hours. The fourth stage of steam curing shall be the gradual cooling down of concrete products and surroundings in the chamber and normalization of the pressure to bring it at par with the outside air. The maximum cooling rate, which is dependent on the thickness of the member, shall not exceed 30° C per hour. In all these cases, the difference between the temperature of the concrete product and the outside temperature shall not be more than 60°C for concrete up to M 30 and 75°C for concrete greater than M 45. In the case of light weight concrete, the difference in temperature shall not be more than 60°C for concrete less than M 25. For concrete greater than M 50, the temperature differences may go up to 75°C. After the steam curing is completed, the elements shall be further water cured for about 3 to 7 days.

Curing Compound shall be used only after specific approval from Engineer-in-Charge. Clear, water based, non-toxic, non-film forming, reactive silicate treatment with indefinite shelf life suitable as a complete replacement to any water curing procedures such as water soak, ponding, blankets and plastic sheets for all horizontal and vertical surfaces. Manufacturer shall supply written proof of completed, successful projects for upto 30 years.

Approved curing compounds may be used in lieu of moist curing with the permission of the engineer. Such compounds shall be applied to all exposed surfaces of the concrete along with stripping of form work. Tests shall be done to ascertain:

- (i) Loss of moisture in concrete with and without curing compound.
- (ii) Cube strength of concrete with moist curing and curing compound.
- (iii) Permeability of concrete.

Application of curing compound shall be done after prior approval from the Engineer or his representative at site. Nothing extra will be paid for any related activity for supplying or applying the curing compound in lieu of moist curing or grinding it after the curing period for painting the structure if any.

- (iv) Curing compound should have been successfully tested by CRRI as a replacement for water curing and accredited by IRC also. Material test result should be in compliance with ASTM C 309 and ASTM 1315°.
No curing compound is allowed for superstructure members.

- (v) Water curing with sprinkler arrangement to be adopted for precast elements at Casting yard

3.12 Construction Joints:

Construction joints in all concrete work shall be made as directed by the Engineer. Where vertical joints are required, these shall be shuttered as directed and not allowed to take the natural slope of the concrete.

Before fresh concrete is placed against a vertical joint, the old concrete shall be chipped, cleaned and moistened.

No separate payment shall be allowed to the Contractor for forming joints or chipping and

cleaning them. When a horizontal construction joint is formed, provision shall be made for interlocking with the succeeding layer by the embedment of saturated wooden blocks or wooden strips bevelled on four sides to facilitate their removal. Prior to the next pour the wooden pieces shall be loosened and removed in such a manner as to avoid injury to the concrete.

Construction joints in concrete walls and slabs for liquid retaining structures shall be prepared in a similar manner to normal construction joints. If use of metal, rubber or plastic water stops is specified, this shall be cast in to joints. Measures shall be taken by the contractor to ensure that no displacement or distortion of water stops takes place during placing of concrete. The construction joints shall ensure proper bond and leak proof joint. Construction joint is not permitted in superstructure members.

(b) Expansion and Movement Joints

Expansion, contraction and other movement joints shall be incorporated in the works as shown on the Drawings.

Where shown on the Drawings approved, expansion joint fillers shall be supplied and installed. Filler material shall be stored flat on a dry surface adequately protected from rain or moisture in such a way that the material does not deteriorate. Filler material which has been damaged or has started to deteriorate shall not be incorporated in the works.

Movement joints shall be sealed with an approved sealant applied in strict accordance with the manufacturer's instructions to the dimensions shown on the Drawings. The surface of the concrete to which the sealant is to adhere shall be straight and cleaned of all filler material, dirt, oil, grease and other matter. The sealant shall be applied by methods recommended by the manufacturer so that the sealant is brought flush to the surface of structure and a smooth surface is achieved. Excess material and spillage shall be properly cleaned off and removed.

Dowel bars shall be installed and cast in across the movement joint where shown on the Drawings. The bars shall be straight with clean cut ends of the diameters and lengths as shown on the Drawings or in the Schedules. Cutting and cleaning of the dowel bars shall comply with the requirements of this Specification.

The bars shall be firmly supported in the positions shown on the Drawings so that they remain accurately parallel and are not displaced during the casting of the concrete in the first part of the structure. After the concrete has hardened and the formwork removed, the projecting ends shall be cleaned of all concrete spillage and painted with two coats of an approved bituminous paint and caps shall be fitted to the free ends of the bars. Dowel bar end caps shall be of cardboard or other material, of correct diameter for the dowel bar and of sufficient length to allow the specified movement of the two adjacent concrete structures. They shall be manufactured expressly for this purpose by an approved manufacturer.

The Contractor shall take care to protect the projecting ends of dowel bars from bending or other damage prior to concreting the succeeding bay. The bituminous paint shall be applied as soon as practicable, but end caps shall not be fitted until immediately prior to the succeeding concreting operations.

(c) Water-stops

The layout and installation of the water-stops shall be in accordance with the manufacturer's recommendation and shall be subject to the approval of Designer and consent of Engineer.

(d) Bolts, Inserts and Openings

All fixing blocks, brackets, built in bolts, holes, chases, etc., shall be accurately set out and formed and carefully sealed prior to the concrete being placed. No cutting away of concrete for any of these items shall be done without the permission of the Engineer.

Bolts and other inserts to be cast into the concrete shall be securely fixed to the formwork in such a way that they are not displaced during the concreting operations, and that there is no loss of materials from the wet concrete through holes in the formwork.

Unless shown otherwise on the Drawings or the Engineer has given consent reinforcement shall be locally moved so that the minimum specified cover is maintained at the locations of inserts, holes, chases, etc

Temporary plugs shall be removed and the threads of cast in bolts shall be proved to be free and shall be greased before handing over any part of the Works. Construction joints in all concrete work shall be made as directed by the Engineer. Where vertical joints are required, these shall be shuttered as directed and not allowed to take the natural slope of the concrete.

3.13 Cracks:

If cracks, which in the opinion of the Engineer may be detrimental to the strength of the construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in clause 1.1.16 of 'Load Testing' of these Specifications. If under such test loads the cracks develop further, the Contractor shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto. If any cracks develop in the concrete construction, which in the opinion of the Engineer, are not detrimental to the stability of the construction, the Contractor at his own expense shall grout the cracks with neat cement grout or with other composition as directed by Engineer (IRC:SP -40) and also at his own expense and risk shall make good to the satisfaction of the Engineer all other works such as plaster, moulding, surface finish, which in the opinion of the Engineer have suffered damage either in appearance or stability owing to such cracks. The Engineer's decision as to the extent of the liability of the Contractor in the above matter shall be final and binding.

External crack width shall be restricted to 0.2 mm on all viaduct structures, if cracks width is more than

0.2 mm or in the opinion of Engineer may be detrimental to concrete construction, the contractor at his own expenses should test the structure.

3.14 Defective Concrete:

Should any concrete be found honeycombed or in any way defective, such concrete shall be cut out partially or wholly by the Contractor and made good at his own expense. If Engineer feels that repaired structure will not be having same strength or shape or uniformity with other exposed surface as original desired structure / original structure, the same shall be rejected by Engineer and required to be dismantled and disposed by contractor at his own cost as instructed by Engineer. Decision of the Engineer shall be final and binding in this regard.

3.15 Exposed Faces, Holes and Fixtures:

On no account shall concrete surfaces be patched or covered up or damaged concrete rectified or replaced until the Engineer or his representative has inspected the works and issued written instructions for rectification. Failure to observe this procedure will render that portion of the works liable to rejection.

Holes for foundation or other bolts or for any other purposes shall be moulded and steel angles, holdfasts or other fixtures shall be embedded, according to the drawing or as instructed by the Engineer.

3.16 Finishes:

Unless otherwise instructed the face of exposed concrete placed against formwork shall be rubbed down immediately on removal of the formwork to remove irregularities. The face of concrete for which formwork is not provided other than slabs shall be smoothed with a float to give a finish equal to that of the rubbed down face, where formwork is provided. The top face of a slab which is not intended to be covered with other materials shall be levelled and floated to a smooth finish at the levels or falls shown on the drawings or as directed. The floating shall be done so as not to bring an excess of mortar to the surface of the concrete. The top face of a slab intended to be surfaced with other material shall be left with a spaded finish. Faces of concrete intended to be plastered shall be roughened by approved means to form key.

3.17 Concrete for flooring on grade:

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4m x 6m or as specified in the drawings including forming the joints or adjacent bays. The stiff mix shall be thoroughly vibrated and finished to receive the floor finish.

3.18 Grouting of base plates & bolt holes:**i. Mixing:**

Dry grout should be mixed in a mechanical mixer: the conventional 200/400-litre capacity concrete mixer can be used to mix four bags of dry grout; alternatively, paddle type mortar mixers can be used. The quantity of grout to be mixed at one time should not exceed that amount which can be placed in approximately 10 to 15 minutes.

ii. Batching :

Batching of grout by fraction of a bag is not allowed. The quantity of mixing water should be the minimum commensurate with workability, compaction, and filling of the grout in all corners and crevices. Mixing should be done for a minimum of three minutes to obtain a fluid grout of uniform consistency.

iii. Cleaning and preparation of the surface:

The base concrete should be clean and strong, and its surface should be properly hacked; all dust should be removed by suction or compressed air. The surface should be thoroughly wetted with water for several hours. Before the grout is poured, all free water should be removed and the flat surfaces coated with a thin cement slurry.

iv. Restraint:

Heavy back-up blocks of timber or concrete should be fixed on all sides of the base plate to prevent escape of the grout, when poured through the openings provided in the base plate. Adequate restraint must be ensured on all the sides for a period of 7 days to obtain effective expansion and shrinkage compensation.

v. Curing:

The grout should not dry out where external restraint is provided in the form of

formwork, the top opening and all stray openings should be covered with wet sack for at least 7 days.

vi. **Placing and Compaction:**

The grout should be placed quickly and continuously either through the holes in the base plates or from one side only to ensure complete filling without entrapment of air. Grout should be properly spread and compacted by rodding. Excessive vibration should be avoided. Below the bed plates the grout should be compacted using long pieces of doubled-over flexible steel strapping or chains. The forward and backward movement of the strap or chain will assist in the flow of the grout into place. Steps must be taken to keep the grout in full contact with the underside of the bedplate until the grout sets; maintaining a small head of fresh grout in the forms.

vii. **Shrinkage Compensated Grout:**

Shrinkage compensated grout or non-shrinkable grout of Associated Cement Companies Limited or any other approved manufacturer (Fosroc, Sika) should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

3.19

(a)

Precast Concrete:

The provision in this section shall be considered supplementary to general provisions for reinforced concrete works.

3.19.1 Manufacture off the Site

1. Casting of members shall not begin until consent to the shop drawings, required computation, prestressing system (if required) and method of manufacture has been given and is approved by Engineer.
2. When the drawings and method of manufacture have been approved, no changes shall be made without the approval of designer and consent of the Engineer
3. The Contractor shall inform the Engineer in advance of the date of commencement of manufacture and casting of each type of member Concrete reinforcement and workmanship shall be as per IS:456.
4. A copy of all cube test results to the work shall be sent to the Engineer as soon it become available.
5. Where the Engineer requires tests to be carried out, no members to which the tests relate shall be dispatched to the Site until the tests have been satisfactorily completed and accepted.
6. All members shall be indelibly marked to show the Member Mark as described in the Contract, the production line on which they were manufactured, the date on which the concrete was cast and, if they are of symmetrical section, the face that will be uppermost when the member is in its correct position in the works. The markings shall be so located that they are not exposed to view when the member is in its permanent position.

3.19.2 Forms

1. The design and engineering of the forms and false work as well as their construction shall be the responsibility of the Contractor. Design of the false work for all concrete shall be done under the direction of a registered engineer based in Bangalore. All exposed surfaces of each element of the structure shall be formed with similar material to produce similar concrete surface textures, colour, and appearance. Forms shall be inspected and approved by the Engineer prior to authorizing casting operations. Details shown on the Drawings shall be built into the forms. Worn, damaged, or otherwise unacceptable forms shall

- be repaired before casting of any member will be authorised.
2. The forms may be made either of steel or of plywood. If the Contractor selects to use plywood forms, it shall be a high quality plywood, 19mm minimum thickness, marine grade and it shall not be reused and shall be removed from site subject to the consent of the Engineer.
 3. Forms shall be structurally adequate to support the members within permissible tolerances. The form design shall incorporate the method and the necessary hardware to adjust and maintain grade and alignment. Details of the hardware and adjustment procedure shall be included in the required plans.
 4. Forms shall be coated with form release agent prior to use. Form release agent shall be a commercial quality form oil or other equivalent coating which will permit the ready release of forms and will not discolour the concrete. Excess form release agent shall not be allowed to stand in puddles in the forms nor shall coating be allowed to come in contact with reinforcing steel or hardened concrete.
 5. Anchor devices may be cast into the concrete for later use in supporting forms, provided the arrangement is approved by the designer and consented by Engineer. The use of driven or drilled types of anchorages for fastening forms or form supports to concrete will not be permitted.

3.19.3 Curing

The steam curing shall be at 100% relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient air temperature shall increase at a rate not to exceed 22oC per hour until the maximum temperature Curing shall comply with the requirements of specification.

Steam curing process may be used as an optional alternative to water curing at no extra cost to the employer. The casting bed for any unit cured with steam shall be completely enclosed to prevent steam escaping and exclude outside atmosphere. 2 to 4 hours after placing concrete and after the concrete has undergone initial set, the first application of steam shall be made, unless retarders are used, in which case the waiting period before application of the steam shall be increased to from 4 to 6 hours. Water curing methods shall be used from the time concrete is placed until steam is first applied.

Where the steam has been raised the maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 22oC per hour until a temperature has been reached 10oC above the temperature of the air to which the concrete shall be exposed. The maximum curing temperature shall be from 60oC to 67oC. If the Contractor elects to cure by any other special method, the method and its details shall be subject to the approval of the designer and consent by Engineer.

3.19.4 Storage

When members are stored, they shall be firmly supported only at the points specified by the Designer. The accumulation of trapped water and deleterious matter in the units shall be prevented. Care shall be taken to avoid rust staining and efflorescence.

3.19.5 Handling and Transport

1. Members shall be lifted or supported only at points specified by the Designer or otherwise agreed by the Engineer and shall be handled and placed without impact.
2. The method of lifting, the type of equipment and transport to be used, and the minimum age of the members to be handled shall be subject to the Designer's requirements.

3.19.6 Assembly and Erection

The method of assembly and erection described in the Contract shall be as practicable and be strictly adhered to on site. Immediately after a unit is in position, and before the lifting equipment is removed, temporary supports or connections between members, as necessary, shall be provided. The final structural connections shall be completed as soon as possible.

3.19.7 Forming Structural Connections

1. No structural connections shall be made until the Engineer's consent has been given.
2. Unless otherwise agreed by the Engineer, the composition and water/cement ratio of the in situ concrete or mortar used in any connection and the packing of joints shall be in accordance with the assembly instructions.
3. Levelling devices shall only be released or removed with the consent of Engineer.

3.19.8 Epoxy Grout for Structural Connections (if required)

1. Description

Epoxy shall be furnished as 2 components which shall be mixed together at the Site.

2. Sampling and Testing

All tests will be conducted in accordance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141 or equivalent British Standard.

3. Packaging, Labelling and Storing

Each component shall be packaged in steel containers not larger than 20 liters in volume. When the components are to be mixed at a ratio of 2 parts A to one part B, by volume, the container containing component B shall be one half the volume of the container containing component A. The containers shall have lug type crimp lids with ring seals, shall be new, not less than 0.6 mm nominal thickness, and shall be of such character as to resist any action by the components. Each container shall be clearly labeled with the designation (Component A or B), type (Standard or Rapid) if applicable, manufacturer's name, date of manufacture, batch number (a batch shall consist of a single charge of all components in a mixing chamber), lot number, all directions for use specified elsewhere and the following warning

"CAUTION"

"This material will cause severe dermatitis if it is allowed to come in contact with the skin or eyes. Use gloves and protective creams on the hands. Should this material contact the skin, wash thoroughly with soap and water. Backfill to Structures

Do not attempt to remove this material from the skin with solvents. If any gets in the eyes, flush

for 10 minutes with water and secure immediate medical attention." Attention is directed to the characteristic of some epoxy components to crystallize or thicken excessively prior to use when stored at temperatures below 2C. Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments which cannot be readily redispersed with a paddle shall not be used.

4. Directions for Use

At the time of mixing, components A and B shall be at a temperature between 16oC and 29oC, unless otherwise specified. Any heating of the adhesive components shall be done by application of indirect heat. Immediately prior to mixing, each component shall be thoroughly mixed with a paddle. Separate paddles shall be used to stir each component. Immediately prior to use, the 2 components shall be thoroughly mixed together in the specified ratios. When mixed, all adhesives shall have a uniformly gray colour without black or white streaks. No solvent shall be added to any epoxy. After mixing, all epoxies shall be placed in the work and any overlaying or inserted be cleaned and it shall have moisture content of not more than 0.50% when tested. The maximum size of the aggregate shall not exceed that of material which is to be bonded to the work by the epoxy. It shall also be placed before thickening of the epoxy has begun. Surfaces upon which epoxy is to be placed shall be free of rust, paint, grease, asphalt, moisture and loose and deleterious material. When epoxy is used as a binder to make epoxy concrete or grout, the 2 components of epoxy shall be thoroughly mixed together before the aggregate is added and, unless otherwise specified, the mix proportions shall consist of one part of binder to approximately 4 parts of aggregate, by volume. Aggregate for use in epoxy concrete and grout shall one-fourth of the thickness of the joint to be grouted. All surfaces against which epoxy concrete and grout are to be placed shall be primed with a coat of the epoxy used just prior to placing the grout. No more material shall be mixed than can be used within 20 minutes from the time mixing operations are started. Pot life of the epoxy mixture shall be 45 minutes.

5. Epoxy Grout Strength Requirements

The compressive strength of 38 mm cubes of epoxy grout tested in accordance with ASTM C39 after 10 hours of curing at 20oC shall be not less than the design strength of the precast number.

Handling and Storage:

The precast units shall be stored as directed by the Engineer. The area intended for the storage of precast units should be surfaced in such a way that no unequal settlement can occur.

To prevent deformation of slender units, they should be provided with supports at fairly close intervals and should also be safeguarded against tilting. Lifting and handling positions should conform to the Engineer's directions and drawings. In addition, location and orientation marks should be put on the members, as and where necessary. During erection the precast units should be protected against damage caused by local crushing and chafing effects of lifting and transport equipment.

Temporary Supports and Connections:

Temporary supports provided during erection should take into account all construction loads

likely to be encountered during the completion of joints between any combination of precast and in-situ concrete structural elements. The supports should be arranged in a manner that will permit the proper finishing and curing of any in-situ concreting and grouting associated with the precast member being supported when the gaps of joints have to be filled with concrete or mortar. They should first be cleaned and faces of the joints should be wetted. The mixing, placing and compacting of cement and mortar should be done with special care. Mortar of a dry consistency should be in the proportion of 1:1% (1 part of cement to VA parts of sand) and should be placed in stages and packed hard from both sides of the joint.

Tolerances:

The following tolerances apply to finished precast products at the time of placement in the structure. The forms must be constructed to give a casting well within these limits:

- i. Overall dimensions of members should not vary more than $\pm 6\text{mm}$ per 3m length with a maximum variation of $\pm 20\text{mm}$.
- ii. Cross-sectional dimensions should not vary more than the following:
 - $\pm 3\text{mm}$ for sections less than 150mm thick
 - $\pm 4\text{mm}$ for sections over 150mm & less than 450mm $\pm 6\text{mm}$ for sections over 450mm to 1000mm .
 - $\pm 10\text{mm}$ for sections over 1000mm
 Deviation from straight line in long sections should not be more than $\pm 5\text{mm}$ up to 3m, $\pm 10\text{mm}$ for 3m to 6m, $\pm 12\text{mm}$ for 6m to 12m.
 For tolerances on precast segments for girders please refer Section 11.2.

(a) **Structural steel inserts/bolts for connecting precast concrete elements**

GI Square rods with internal threading and GI base plate/stiffener, shall be firmly fixed in the mould to the true line, level and alignment as shown in drawings. If required by engineer MS template may use for above purpose. The threaded hole/pipe shall be properly protected so as to prevent ingress of mortar etc. (by providing dummy bolts, PVC cover, cotton waste etc.).

3.20 Ready Mix Concrete and Pumping:

- i. Ready-mixed concrete may be manufactured in a central automatic weigh Batching plant and transported to the place of work in agitating transit mixers shall conform to IS:4926.

The maximum size of coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe used for pumping. Provision shall be made for elimination of over-sized particles by screening or by careful selection of aggregates. To obtain proper gradation it may be necessary to combine and blend certain fractional sizes of aggregates. Uniformity of gradation throughout the entire job shall be maintained.

The quantity of coarse aggregate shall be such that the concrete can be pumped, compacted and finished without difficulty.

- ii. Fine aggregates:
 The gradation of fine aggregate shall be such that 15 to 30 percent should pass the 0.30 mm screen and 5 to 10 percent should pass 0.15 mm screen so as to obtain pump able concrete. Sands, which are deficient in either of these two sizes, should be blended with selected finer sands to produce these desired percentages. With this gradation, sands

having a fineness modulus between 2.4 and 2.8 are generally satisfactory. However, for uniformity, the fineness modulus of the sand should not vary more than 0.2 from the average value used in proportioning.

iii. Water, Admixtures and Slump:

The amount of water required for proper concrete consistency shall take into account the rate of mixing, length of haul, time of unloading, and ambient temperature conditions.

Additions of water to compensate for slump loss should not be resorted to nor should the design maximum water-cement ratio be exceeded. Additional dose of retarder be used to compensate the loss of slump at contractor's cost, when permitted by Engineer. Re-tempering water shall not be allowed to be added to mixed batches to obtain desired slump.

iv. Transportation:

The method of transportation used should efficiently deliver the concrete to the point of placement without significantly altering its desired properties with regard to water-cement ratio, slump, and homogeneity.

The revolving-drum truck bodies of approved make shall be used for transporting the concrete. The numbers of revolutions at mixing speed, during transportation, and prior to discharge shall be specified and agreed upon. Reliable counters shall be used on revolving drum truck units. Standard mixer uniformity tests, conforming to ASTM standards C 94-69 "Standard Specifications for Ready Mix Concrete", shall be carried out to determine whether mixing is being accomplished satisfactorily.

v. Pumping of concrete:

Only approved pumping equipment, in good working condition, shall be used for pumping of concrete. Concrete shall be pumped through a combination of rigid pipe and heavy duty flexible hose of approved size and make. The couplings used to connect both rigid and flexible pipe sections shall be adequate in strength to withstand handling loads during erection of pipe system, misalignment, and poor support along the lines. They should be nominally rated for at least 3.5 MPa pressure and greater for rising runs over 30 m. Couplings should be designed to allow replacement of any section without moving other pipe sections, and should provide full cross section with no construction or crevices to disrupt the smooth flow of concrete.

All necessary accessories such as curved sections of rigid pipe, swivel joints and rotary distributors, pin and gate valves to prevent backflow in the pipe line, switch valves to direct the flow into another pipe line, connection devices to fill forms from the bottom up, extra strong couplings for vertical runs, transitions for connecting different sizes of pipe, air vents for downhill pumping, clean-out equipment etc, shall be provided as and where required. Suitable power controlled booms or specialized crane shall be used for supporting the pipe line.

vi. Field control:

Sampling at both truck discharge and point of final placement shall be employed to determine if any changes in the slump and other significant mix characteristics occur. However, for determining strength of concrete, cubes shall be taken from the

placement end of line.

vii. Planning:

Proper planning of concrete supply, pump locations, line layout, placing sequence, and the entire pumping operation shall be made and got approved. The pump should be as near the placing area as practicable, and the entire surrounding area shall have adequate bearing strength to support concrete delivery pipes. Lines from pump to the placing area should be laid out with a minimum of bends. For large placing areas, alternate lines should be installed for rapid connection when required. Standby power and pumping equipment should be provided to replace initial equipment, should breakdown occur. The placing rate should be estimated so that concrete can be ordered at an appropriate delivery rate.

As a final check, the pump should be started and operated without concrete to be certain that all moving parts are operating properly. A grout mortar should be pumped into the lines to provide lubrication for the concrete, but this mortar shall not be used in the placement. When the form is nearly full, and there is enough concrete in the line to complete the placement the pump shall be stopped and a go-devil inserted and shall be forced through the line by water under pressure to clean it out. The go-devil should be stopped at a safe distance from the end of the line so that the water in the line will not spill into the placement area. At the end of placing operation, the line shall be cleaned in the reverse direction.

3.21 Additional Specifications for Concrete M60 and above

- (a) Mineral admixture in the form of micro silica or condensed silica fume shall be permitted in the design mix. It shall comply with IS 15388 (2003) and ASTM C 1240 "Specifications for Fume for use in Hydraulic Cement Concrete and Mortar". It shall be obtained from proven and reliable manufacturer/supplier to the satisfaction of the Engineer.
- (b) Adequate and complete dispersal of the micro silica during the concrete mixing shall be ensured.
- (c) When micro silica is used in powder form the contractor shall take all precautions against potential health hazards during handling of the material.
- (d) Chilled water and/ or ice shall be used in the concrete mix depending on the ambient temperature, dimensions of the concrete element, rate of pouring and design mix constituents.
- (e) Special profuse curing arrangements shall be made for dissipation of the heat of hydration. The water curing shall be continued for a period of 14 days.
- (f) The concrete design mix and arrangement for mixing, transportation, and curing of concrete shall be subject to the approval of the Engineer.

3.22 Testing Concrete Structures for Water Tightness & Acceptance Criteria

Underground Structures, Pump Rooms and Sumps

In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground structures, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hours over a period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface

level over a period for seven days shall be taken as an indication of the water tightness of the structure.

A structure shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Roofs

The roofs of liquid-retaining structures shall be water-tight and shall be tested on completion by flooding the roof with water to a minimum depth of 25 mm for 24 hrs. Where it is impracticable, because of roof falls or otherwise, to contain a 25 mm depth of water, the roof shall have water applied by a continuous hose or sprinkler system to provide a sheet flow of water over the entire area of the roof for not less than 6 hrs. In either case the roof shall be considered satisfactory if no leaks or damp patches show on the soffit. Should the structure not satisfy either of these tests, then after completion of the remedial work it should be retested in accordance with this clause. The roof insulation and covering should be completed as soon as possible after satisfactory testing. Contractor shall give warranty for leak tightness of joints for 10 years.

3.23 **Measurement (Not applicable for Viaduct Lumpsum portion (Schedule B)):**

Concrete and reinforcement shall be paid separately unless otherwise "specified. Measurement shall be made for the finished volume of reinforced cement concrete (excluding lean concrete) only. All linear dimensions shall be measured correct to 1cm & restricted to design dimensions, and the volume calculation will be correct to two decimal places in cubic metres. The volume of concrete measured shall include that occupied by:

1. Reinforcement and other metal sections.
2. Cast in components each less than 0.01 cum in volume.
3. Rebates fillets or internal splays each less than 0.005 Sq.m in cross sectional area.
4. Pockets and holes not exceeding 0.01 m³ in volume.

Rates for precast concrete shall include remoulding, handling, storing, transporting and erecting at site, including all clamping, bracing that may be required during erection including erection equipment.

3.24 **Inspection, Tests and Standards of Acceptance**

- a. The Contractor shall submit test certificates from the manufacturer or supplier of materials along with each batch of material(s) delivered to site.
- b. The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products to be used in the construction.
- c. The testing of all the materials shall be carried out by the Contractor at the field laboratory or from the laboratory approved by the Engineer and in the presence of the Engineer. The Contractor shall make all the necessary arrangements and bear the entire cost for the same.
- d. Tests which cannot be carried out in the field laboratory shall be done at the Contractor's cost at any recognised laboratory or testing establishments having NABL certification and duly approved by the Engineer.
- e. If materials are brought from abroad, the cost of sampling or testing, whether in India or abroad, shall be borne by the Contractor.
- f. The Contractor shall provide and maintain on site, until the works are completed, at all times the equipment and staff required for carrying out these tests. The Contractor shall grant the Engineer or his representative full access to his laboratory at all times and shall, on demand, produce complete records of all tests carried out on the Site.

3.25 Quality Control of Concrete

- a. The Contractor shall carry out the following tests for concrete, at his own cost, at the site of placing, and ensure that they comply with appropriate provisions of Indian and/or other standards, as may be applicable:
 - i. Slump test for concrete: The frequency of slump test shall be conducted once in each delivery of transit mixer as per IS: 1199 & IS: 7320. Tolerance for slump shall conform to IS 4926 (CL. 6.2.1).
 - ii. Compressive and Flexural strength of concrete: Sampling, Strength tests and Acceptance criteria of concrete shall conform to IS: 456 & IS 1199, according to the type of concrete grade. For the purpose of precast segment lifting and pre-stressing of segments, additional concrete cube samples shall be casted as directed by the Engineer-In-Charge.
 - iii. Chloride ion content test: It shall be conducted once a week. Test method shall be as per manufacturer's instructions and conforming to IS 456.
 - iv. Relative Density and pH value of plasticizer (if used): The test shall conform to IS 9103 and the tolerances shall be as specified in IS:9103.
 - v. Temperature of concrete shall be verified once in each slump test.
 - vi. The concrete shall be verified for permeability and the test procedure along with tolerances shall conform to the provisions given in these specifications. The frequency of test shall depend upon the change in design mix or change in source of material used in the work. However, the Engineer shall select random batches of concrete for examination at his discretion, and any time during concreting. Sampling shall generally be done at the point of discharge from the mixer at placing point. The concrete shall pass the permeability test if it is properly compacted and the water penetration depth in the broken core is less than 25 mm.
- b. It is the complete responsibility of the Contractor to redesign the concrete mixes as per the standard methods that have been approved and to produce the reinforced concrete conforming to the specifications. The Contractor shall have competent staff to carry out this work.
- c. After the completion of the quality control checks of concrete, the Contractor shall immediately report the test results to the Engineer by submitting quality control records of the concrete.

3.26 Failure to meet specified Requirements:

- i. If from the cube test results, it appears that some portion of the Works has not attained the required strength, the Engineer may order that portion of the structure be subjected to further testing of any kind whatsoever as desired by the Engineer, including, if so desired by him, full load testing of the suspected as well as adjacent portions of the structure as specified in the Conditions of Contract. Such testing shall be at the Contractor's own cost. The Engineer may also reject the work and order its demolition and reconstruction at the Contractor's cost.
- ii. If the strength of concrete in any portion of the structure is lower than the required strength, but is considered nevertheless adequate by the Engineer so that demolition is not necessary, the Contractor shall be paid a lower rate for such lower strength concrete as determined by the Engineer.

3.27 Inspection of Concrete

- a. Inspection shall be carried out by the Contractor, after the removal of formwork. Also, additional inspection shall be carried out if instructed by the Engineer.
- b. Inspection shall be carried out as per approval of the Engineer and in accordance with approved Method Statement.
- c. Additional non-destructive tests (NDT) on the hardened concrete in the structure as a whole or any finished part of the structure where necessary, or directed by the Engineer.
- d. The Contractor shall report the inspection results along with the location to the Engineer immediately after the inspection.
- e. If defects such as deleterious cracking, deformation, and finishing defects are noticed from the results of the inspection, no repair work shall be commenced without prior permission taken from the Engineer. Countermeasures against the defects shall be subjected to approval of the Engineer. In this case, "repair work" refers to all actions which make alterations to the surface of concrete after the removal of formwork (including plastering etc.). If repair work is required, the Contractor shall submit Method Statement on the repair work and shall obtain approval of the Engineer for the same, prior to the commencement of repair work. During the repair work, the Contractor shall record about the work, and shall report to the Engineer on the results of the work immediately after the repair work has finished.
- f. If cracks develop in concrete construction, provisions given elsewhere in these specifications shall be followed.

TECHNICAL SPECIFICATION

S-04: FORM WORK

S.04: FORM WORK

- 4.1 These specifications shall be read in conjunction with the CPWD specifications 2019 and latest with up-to-date correction slips, MOST/MORTH (5th Revision) Specifications and other relevant specifications described in the S.01 of Section-VII-F of these specifications.

Timber used for formwork shall be easily workable with nails without splitting. It shall be stable and not liable to warp when exposed to sun and rain or wetter during concreting.

4.2 **Materials:**

Formwork shall be of timber, plywood (including marine plywood), steel or any other suitable material capable of resisting damage to the contact faces under normal conditions of fixing steel, erecting forms and placing concrete. The selection of materials suitable for form work shall be made by the Contractor based on the quality consistent with the specified finishes and safety. **For designated areas prominently in public view like piers, pier caps, portals, pier arms and any precast members forming a part of viaduct etc., only steel shuttering shall be used.** Steel material shall be in good condition. It should not be corroded. Condition of material shall be decided by the Engineer and if found not complying as per relevant standards or requirements, it shall be replaced. Number of uses (repetitions) for steel shuttering shall be between 50 and 100. However, the no of uses shall be decided by Engineer as per the condition of steel shuttering. Special finishes like grooves, logos, floral designs to be incorporated in the steel shutter itself during its fabrication. The material shall be approved by the Engineer before being erected at site. However, the entire responsibility of planning, designing, erection, dismantling, shifting and safety of false work lies with the contractor.

All formwork and formwork supports (centering, props, scaffolds etc.) shall only be in structural steel and preferably of pipes conforming to IS:806, IS:1161, IS:1239, IS:2750. Wooden ballies shall not be permitted as props/formwork supports. All props shall be properly braced using x & k bracings. **Ladders to be used at site should have treads and shall be fabricated from structural steel. Wooden / bamboo / aluminium / pipe ladders shall not be permitted. No additional payment to be made for all types of formwork and formwork supports including ladders to the contractor.**

Plywood:

Plywood used for formwork shall be **minimum 12 mm** thick. Shuttering quality plywood complying with IS: 4990 and of make approved by the Engineer. Suitable stiffeners and wallers shall be provided depending on the shuttering design.

Steel:

Steel formwork shall be made of minimum 4 mm thick black sheets stiffened with angle iron frame made out of M.S. angles 40mmx 40 mm x 6 mm supported at suitable spacing.

4.3 **Design & Drawings:**

All temporary works such as formwork, false work, staging, launching girder, cantilever form traveller scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, false work, staging, launching girder & cantilever form traveller shall be limited as same as that for permanent structure. **All calculations and drawings of the same including construction sequence shall be checked and verified by independent agency appointed by contractor.** Only after the checking of the same, the calculations and drawings (along with soft copy in CD ROM) shall be submitted to Engineer for approval well in advance of work. All temporary works shall also be inspected by the independent agency and independent report shall be submitted to Engineer. All temporary works shall be robust, safe and constructed such a way that the concrete can be

properly placed and thoroughly compacted to obtain the required shape, position and level subject to specified tolerances. It is the responsibility of the Contractor to obtain the results required by the Engineer, whether or not some of the work is sub-contracted. Approval of the temporary works by the Engineer shall not diminish the Contractor's responsibility for the satisfactory performance of the same, nor for the safety and co- ordination of all operations.

For pier formwork, it shall be ensured that total deflection (taking account of combined deflection of plate, stiffeners, wallers or any other supporting arrangement) shall not be more than 3 mm. All the formwork, launching truss and cantilever form traveller and other selected temporary works shall be tested for the load including factor of safety for which the truss/formwork is designed before use in works **at no extra cost**.

The design of false work should be such as to facilitate easy and safe access to all parts for proper inspection. Methodology for removal of form should be planned as a part of total form work design.

In case of pre-stressing concrete, careful consideration shall be given to re-distribution of loads due to pre-stressing.

4.4 Formwork for Exposed Concrete Surfaces:

The facing formwork, unless indicated otherwise on drawings, or specifically approved by the Engineer in writing, shall generally be made with materials not less than the thickness mentioned below for different elements of the structure:

- i. Plain slab soffit and sides of beams, girders, joists and ribs and side of walls, fins, parapets, parrises, sun-breakers, etc. shall be made with:
 - a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane.
 - b. Timber planks of 20mm actual thickness and of specified surface finish, width and reasonable length.
 - c. Plywood not less than 12mm thick (IS:4990 - Specification for Plywood for Concrete Shuttering Work) stiffened with a suitable timber frame work or 3mm thick plywood with a 20mm timber plank backing, of specified sizes stiffened with a suitable timber framework and bracing. At joints 6mm/10mm sponge to be provided.
- ii. Bottoms of beams, girders and ribs, sides of columns shall be made with:
 - a. Steel plates not less than 5mm thick of specified sizes stiffened with a suitable structural framework, fabricated true to plane .
 - b. Timber planks of 35mm actual thickness and of specified surface finish width and reasonable length.
 - c. Plywood plates not less than 12mm thick (IS 4990), of specified sizes stiffened with a suitable timber framework as approved by Engineer.
- iii. For Precast segments, precast girders, piers, pier heads, portals etc. suitable steel form work is to be used unless otherwise specified by Engineer.
- iv. For station areas suitable steel form work is to be used unless as specified by Engineer.

4.5 Formwork for Sloped Surfaces:

- i Forms for sloped surfaces shall be built so that the formwork can be placed board-by-board immediately ahead of concrete placement so as to enable ready access for placement, vibration inspection and finishing of the concrete.
- ii The formwork shall also be built so that the boards can be removed one by one from the bottom up as soon as the concrete has attained sufficient stiffness to prevent sagging. Surfaces of construction joints and finished surfaces with slopes steeper than 2 horizontal: 1 vertical shall be formed as required herein.

4.6 Formwork for Curved Surfaces:

- i The contractor shall interpolate intermediate sections as necessary and shall construct the forms so that the curvature will be continuous between sections. Where necessary to meet requirements for curvature, the form lumber shall be built up of laminated splices cut to make tight, smooth form surfaces.
- ii After the forms have been constructed, all surface imperfections shall be corrected and all surface irregularities at matching faces of form material shall be dressed to the specified curvature.

4.7 Formwork for Waffle Slab:

DELETED

4.8 Erection of Formwork:

The following shall apply to all kinds of formwork:

- i To avoid delay and unnecessary rejection, the Contractor shall obtain the approval of the Engineer for the design of forms and the type of material used before fabricating the forms. (Ref. ACI 347 Formwork for Concrete or equivalent 1.3 Code).
- ii All shuttering planks and plates shall be adequately backed to the satisfaction of the Engineer by sufficient number and size of wallers 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 pouring rate and vibration.
- iii 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 level shall be placed directly over those in the level immediately below, and the lowest props shall bear on a sufficiently strong area. Care shall be taken that all formwork is set plumb and true to line and level or camber or better where required and as specified by the Engineer.
- iv Provision shall be made for adjustment of supporting struts where necessary. When reinforcement (dowel bars) passes through the formwork care should be taken to ensure close fitting joints against the steel bars so as to avoid loss of fines during the compaction of concrete.
- v If the formwork is held together by bolts, these shall be so fixed that no iron will be exposed on surfaces 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. These tie-bolts are not to be provided in structures with exposed surfaces.

- vi 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.
- vii Formwork shall be so arranged as to permit removal of forms without jarring the concrete. Wedges, clamps and bolts shall be used wherever practicable instead of nails. The formwork for beams and slabs shall be so erected so that forms on the sides of the beams and the soffit of slabs can be removed without disturbing the beam bottoms or props under beams.
- viii Surfaces of forms in contact with concrete shall be oiled with a mould oil of approved quality (form releasing agent). If required by the Engineer the contractor shall execute different parts of the work with different mould oils to enable the Engineer to select the most suitable. The use of oil which results in blemishes on the surface of the concrete **including Diesel oil, burnt oil or any other lubricating oil** shall not be allowed. Oil shall be applied 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 is left in place. Nothing extra shall be paid to contractor for oiling.
- ix Immediately before concreting is commenced, the formwork shall be carefully examined to ensure the following:
 - a) Removal of all dirt, sawdust and any other refuse by brushing and washing **and compressed air / vacuum cleaning.**
 - 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) Adequate cover blocks are in place.
 - e) Straightness and plumbness of form works.
 - f) Construction joint (wherever applicable) is properly prepared.
 - g) Side supports / restraints for the form work are enough and robust.
 - h) That all wedges are secured and firm in position.
 - i) That provision is made for traffic on formwork not to bear directly on reinforcing steel.
 - j) Pouring platform along with its approach from ground is robust and safe for workers movement
 - k) Arrangement for vibrators for compaction of concrete
 - l) Sequence of concrete pouring is well defined and is agreed upon by the Engineer and is explained to concrete pouring team m.
 - m) The Pouring area is well lit.
 - n) Curing arrangements are well planned and agreed upon by the Engineer.
 - o) The green concrete protection measures from sun & rain etc. are in place.

Note: Contractor shall make above arrangements at his own cost and no extra payment shall be made to contractor for the same.

- x The Contractor shall obtain the Engineer's approval for dimensional accuracies of the work and for the general arrangement of propping and bracing. (IS: 3696 -Safety Code of Scaffolds and Ladders, IS: 4014 Steel Tubular Scaffolding I & II). All scaffolding and staging shall be either of steel tubes or built up section of rolled steel with adequate bracing at several levels in each perpendicular direction connecting each prop. In addition to this diagonal bracing should be provided in elevation ideally at 45 degrees or between 30 and 60 degree. The Contractor shall be entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the decentring period. (IS: 8989 Safety code for erection of concrete framed structures) and **cost of the propping and staging shall be inclusive of the quoted cost for the RCC works in BOQ.**
- xi Formwork shall be continuously watched during the process of concreting. If during concreting any weakness develops and formwork shows any signs of distress, the work shall be

stopped and remedial action as directed by the engineer shall be taken.

- xii Staging for portal girder and cross girder (in station zone) shall be in the form of portal frame. It shall be ensured that minimum two lanes of traffic with a restricted height of 5.5m can ply underneath it with adequate protection to portal legs from moving traffic. All necessary permissions for the height restrictions on the existing highways, main road, etc., shall be taken by the contractor from the local authorities at his own peril.

For concourse floor (if any) over road, the contractor shall design and fabricate prefabricated type of staging and shuttering which can be erected in very short duration. Such erection will be only permitted in the night. In such case staging has to span the full width of the road in a portal shaped profile as shown in tender drawings. The portal frame shall have 5.5m (min) traffic clearance from the road for allowing safe movement of traffic below. In case no road runs beneath the concourse zone of station, the bidder may decide whether to use the above form of staging or any normal staging arrangement from the ground itself. All necessary permissions for the height restrictions on the existing highways, main road, etc., shall be taken by the contractor from the local authorities at his own peril.

4.9 Concrete Finishes:

This section deals with the surface of concrete on which forms had been fixed while concreting.

i. Formed Surface:

Allowable deviation from plumb or level and from the alignment profile, grades and dimensions shown on the drawings is defined as "tolerance" and is to be distinguished from irregularities in finishes as described herein. Tolerances in concrete construction are specified elsewhere.

The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawings or as hereinafter specified. In the event of finishing not being definitely specified herein or in the drawings, finishes to be adopted shall be as directed by the Engineer.

Completed concrete surface shall be tested, where necessary to determine whether surface irregularities are within the limits specified hereinafter.

Surface irregularities are classified as "Abrupt" or "Gradual". Offsets caused by displaced or misplaced form sheathing, or form sections or by loose knots or otherwise defective timber form will be considered as abrupt irregularities, and shall be tested by direct measurements. All other irregularities shall be considered as gradual irregularities and will be tested by use of template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template shall be 150 cm for testing of formed surfaces and 300 cm for testing of unformed surfaces.

The classes of finish for formed concrete surfaces are designated by one of the symbols F1, F2, F3 and F4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows:

Finish F1: This finish applies to surfaces where roughness is not objectionable, or surface that will otherwise be permanently concealed. Surface treatment shall be the repair of defective concrete, correction of surface depressions deeper than 25 mm and filling of tie rod holes. Form sheathing will not leak mortar when concrete is vibrated. Forms may be manufactured with a minimum of refinement.

Finish F2: This finish is required on surfaces permanent/ but not prominently exposed to public view for which other finishes are not specified except F1. Forms shall be manufactured in a workmanlike manner to the required offsets or bulges. Surface irregularities shall not exceed 5mm for abrupt and 8mm for gradual irregularities measured with a 1.5 m template.

Finish F3: This finish is required for coarse textured concrete surfaces intended to receive plaster, stucco or wainscoting. Surface irregularities shall not exceed 5mm for both abrupt and gradual (C2/ SET-YPR-HEB /Elevated & BYPL STN)

irregularities.

Finish F4: This finish is designated for surfaces prominently exposed to public view where appearance is also of special importance. This shall include piers of viaducts, beams, parapets, railings and decorative features on the structure and on the viaduct and stations. To meet with requirements for F4 finish, forms shall be manufactured in a skilful, workmanlike manner, accurately to dimensions. There should be no visible offsets, bulges or misalignment of concrete. At construction joints, the forms shall be rightly set and securely anchored close to the joint. Abrupt and gradual irregularities shall not exceed 3mm. Irregularities exceeding this limit shall be reduced by grinding to a level of 1:20 ratio of height to length. Jute bag subbing or sand blasting shall not be used.

ii. **Unformed Surfaces:**

The classes of finish for unformed surfaces are designated by symbols U1, U2, U3 and U4. Unless otherwise specified or indicated on drawings, these classes of finish shall apply as follows: **Finish U1:** This finish applies to unformed surfaces that will be concealed permanently or otherwise where a screeded surface finish meets the functional - requirements. Finish U1 is also used as the stage of finishes for U2 and U3. Finishing operations shall consist of sufficient levelling and screeding to produce an even uniform surface. Surface irregularities shall not exceed 10mm. **Finish U2:** This is floated finish and used on all outdoor, unformed surfaces. Finish U2 is also used as the second stage of finish for U3. Floating to be performed manually or mechanically on stiffened screed surface shall be minimum to produce textured surface so as to perform effective trowelling. If finish U3 is to be applied, floating shall be continued till a small amount of mortar without excess water is brought to the surfaces so as to be effective trowelling. Surface irregularities shall be removed as directed by the Engineer.

Finish U3: This is a trowelled finish and shall be used for tops of parapets etc. prominently exposed to view. When the floated surface has hardened sufficiently, steel trowelling shall be started. Steel trowelling on hardened, floated surface shall be performed with firm pressure to produce a dense uniform surface free from blemishes and trowel marks and having slightly glossy appearance. Surface irregularities shall not exceed 5mm.

Finish U4: This is a steel-trowelled finish, similar to finish U3, except that light surface pitting and light trowel marks such as obtained from the use of machine trowelling will be acceptable, provided that surface irregularities do not exceed the limits specified for finish U3.

Unformed surfaces which are nominally level shall be sloped for drainage as shown on drawings or as directed by Engineer unless the use of other slopes or level surface is indicated on drawings. Narrow surfaces such as tops of parapets, walls and kerbs shall be sloped approximately 1cm per 30cm of width. Broader surface such as roadways, platform and decks, shall be sloped approximately half centimetre per 30cm of width. Finishes of floor and roof slabs shall be sloped, if required, by the Engineer.

4.10 **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 including the surface defects in the concrete shall be removed by the Contractor without affecting the strength of adjoining concrete as directed by the Engineer and fresh concrete placed without extra cost, as instructed by the Engineer. Part of defective concrete thus removed shall be re-cast using fresh concrete of

same grade or approved quality concrete repair material depending upon the size, location, thickness of the defective concrete and structural behaviour of the member having defective concrete as instructed by the Engineer without extra cost. For the purpose the Contractor shall prepare a comprehensive work procedure and get it approved from the Engineer. Nothing extra shall be paid for repair of the concrete. Contractor shall ensure that no air bubbles are formed on the exposed surface. Concrete pouring sequence, vibration methodology etc. shall be planned to avoid air bubbles. All materials, sizes and layouts of formwork including the locations for their joints shall have prior approval of the Engineer.

4.11 Age of Concrete at Removal of Formwork:

Age of Concrete at the time of removal of formworks shall be in accordance with CPWD specifications 2019 or IS: 456. The Engineer may vary the periods specified if he considers it necessary. Immediately after the forms are removed, they shall be cleaned with a jet of water and a soft brush.

4.12 Stripping of Formwork:

The work of form work removal should be planned and a definite scheme of operation worked out. Formwork shall be removed carefully without jarring the concrete and curing of the concrete shall be commenced immediately. Concrete surfaces to be exposed shall, where required by the Engineer, be rubbed down with Carborundum stone or bush-hammer 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.

4.13 Reuse of Forms:

The Contractor shall not be permitted reuse of plywood formwork brought new on the works more than 5 times for exposed concrete formwork and 8 times for ordinary formwork. 5 or 8 uses shall be permitted only if forms are properly cared for, stored and repaired after each use. The Engineer may in his absolute discretion order rejection of any forms he considers unfit for use for a particular item irrespective of no of times the shuttering has been used and order removal from the site of any forms he considers unfit for use in the Works. Used forms brought on the site will be allowed proportionately fewer uses as decided by the Engineer. Use of different quality boards or the use of old and new boards in the same formwork shall not be allowed. If any other type of special or proprietary form work is used, the no. of times they can be used will be determined by the Engineer.

4.14 Formwork for Precast/ Prestressed Concrete:

The provisions in this section shall be considered supplementary to the general provisions stated above and additional Technical Specifications for pre cast segments. Precast concrete members and panels shall be made in accurately constructed moulds, on a properly prepared casting bed. All aspects of the making, curing and erection of precast units shall be subject to the approval of the Engineer. The contractor shall submit detailed drawings of formwork for the approval of the Engineer. Finishing with cement mortar shall not be allowed.

The formwork should be so designed that it does not restrain the shrinkage movements and possible shortening due to pre-stress of the concrete. The formwork shall be of sturdy construction with special considerations to shutter vibrators when used. All edges and joints of the formwork should be designed and sealed so that no cement grout can escape and there is no wedging or keying to the concrete. The effect of curing on the formwork should be given special consideration. Depending on care, curing erection and maintenance after stripping, the following number of/ uses can be made with different types of formwork.

Plywood with timber backed formwork - As per satisfaction of Engineer Steel moulds -do-

No of uses of shuttering shall be as per approval of the Engineer. In cases where concrete moulds can
(C2/ SET-YPR-HEB /Elevated & BYPL STN)

be satisfactorily provided by the contractor, the Engineer's approval shall be obtained before use on the works.

4.15 Stripping:

As soon as the precast units have attained sufficient strength, the formwork shall be stripped. The precast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects or any other stresses and as per the guidelines issued by Engineer or his authorised representative.

If proprietary system of form work is used, detailed information as given in Annexure 4.1 shall be furnished to Engineer for approval before use.

4.16 Measurements (Not applicable for Schedule B):

Unless stated otherwise, the rate for concrete in plain concrete, reinforced concrete or in pre-stressed concrete shall be deemed to include the cost of all formwork / shuttering, staging, launching etc.

4.17 Special Architectural Finishes

Special approved architectural finishes like grooves, logos, engravings/projections in inset and out set as per the approved design shall be provided by fixing monolithic rubber forms or any other approved material fixed on the entire surface of the form work. The shore hardness of the rubber shall be 600 ± 5 SA to ensure strength, flexibility and elasticity. The rubber shall be cold cured (preferably polyurethane based) and fixed to the formwork under controlled conditions in shade and air temperature.

The form liners should be shrinkage free, solvent free and should be impervious to abrasion by Concrete, resistant to concrete pressure and heat resistant upto 700 C dry heat. Formwork liner fixation should be factory made under close tolerances and stage inspections.

ANNEXURE 4.1

Information to be Supplied by Manufacturers of Proprietary Systems of Formwork

1. General

- 1.1 The information which the manufacturer is required to supply shall be in such detail as to obviate unsafe erection and use of equipment due to the intention of the manufacturer not having been made clear or due to wrong assumptions on the part of the user.
- 1.2 The user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

2. Information Required

- 2.1 The manufacturers of proprietary systems shall supply the following information;
- a. Description of basic functions of equipment.
 - b. List of items of equipment available, giving range of sizes, spans and such like, with manufacturer's identification number or other references.
 - c. The basis on which safe working loads have been determined and whether the factor of safety given applies to collapse or yield.
 - d. Whether the supplier's data are based on calculations or tests. This shall be clearly stated as there may be wide variations between results obtained by either method.
 - e. Instructions for use and maintenance, including any points which require special attention during erection, especially where safety is concerned.
 - f. Detailed dimensional information, as follows :
 - i. Overall dimensions, depths and widths of members.
 - ii. Line drawings including perspectives and photographs showing normal uses.
 - iii. Self-weight.
 - iv. Full dimensions of connections and any special positioning and supporting arrangements.
 - v. Sizes of members, including tube diameters and thicknesses of material.
 - vi. Any permanent camber built into the equipment.
 - vii. Sizes of holes and dimensions giving their positions.
 - viii. Manner of fixing including arrangements for sealing joints.
 - ix. Method of de-stripping, storing & shifting.
 - g. Data relating to strength of equipment as follows:
 - i. Average failure loads as determined by tests.
 - ii. Recommended maximum working loads for various conditions of use.
 - iii. Working resistance moments derived from tests.
 - iv. Working shear capacities derived from tests.
 - v. Recommended factor of safety used in assessing recommended loads and deflections based on test results.
 - vi. Deflections under load together with recommended pre-camber and limiting deflections.
 - vii. If working loads depend on calculations, working stresses should be tested. If deflections depend on theoretical moments of inertia or equivalent moments of inertia rather than tests, this should be noted.
 - viii. Information on the design of sway bracing against wind and other horizontal loadings.
 - ix. Allowable loading relating maximum extension of bases and/or heads.
- Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions.

TECHNICAL SPECIFICATION S-05: REINFORCEMENT

Bi-RIDE

S.05: REINFORCEMENT**5.1 General**

These specifications shall be read in conjunction with the CPWD specifications 2019 with upto date correction slips, MOST/MORTH Specifications and other relevant specifications described in the S.01 of Section-VII-F of these specifications.

High strength deformed steel bars for concrete reinforcement used in the works shall be Fe 500D TMT or higher grade, conforming to IS 1786. Steel specified for reinforcement shall conform in every respect to the latest relevant Indian Standard Specifications and shall be of tested quality under the ISI Certification Scheme.

All reinforcement work shall be executed in conformity with the drawings supplied and instructions given by the Engineer and shall generally be carried out in accordance with the relevant Indian Standard Specifications IS: 2502 Bending and Fixing of Bars for Concrete Reinforcement.

The reinforcement steel shall be from primary producers from the approved vendor list and no re-rolled steel shall be supplied/used. The Contractor shall produce copy of original challan or voucher as a proof of having purchased the steel reinforcement from manufacturers or their authorised distributors having approval of the Engineer.

Procurement of reinforcement steel shall be so phased by the Contractor that the storage period before its actual use in the works is limited to the bare minimum as directed by the Engineer.

5.2 Couplers Specifications

Only cold-forged, parallel threaded mechanical coupler system are recommended. All mechanical couplers shall be of Type 2 (or Class H as specified in IS-16172) and should be simple to install and which can be confirmed by quick visual inspection to have been correctly installed and to have achieved the required full strength connection.

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

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

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties. The coupler manufacturer shall operate at least an ISO 9000 approved quality assurance programme or equivalent for the manufacture of couplers.

Threading of ends of the reinforcing bars:

This threading activity shall preferably be done at Site. The various stages involved in threading are as given below:

a) Cutting (Rebar End Preparation):

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain and surface perpendicular to the axis of the bar.

b) Cold forging & threading:

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

c) Quality control in making of threads:

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

d) Qualification tests

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

i) Static tensile test

Mechanical connections shall be tested for all reinforcing rebar sizes. For each rebar size, a minimum of three connections (3 joints + 1 Parent bar) in each load direction shall be tested in accordance with ASTM A370 test method to meet code requirement. A tensile test on an unsliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength. The tensile strength of an individual splice system shall not be less than the 125% of the specified minimum yield strength (f_y of rebar) of the spliced bar.

ii) Cyclic tension and compression test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for cyclic tension & compression test. Each specimen shall withstand cycles of stress variation of the specified minimum yield strength of the reinforcing bar. The test should be carried out as per the table mentioned below:

Loading Stages and Cycles per stage for cyclic load test Stage	Tension	Compression	Cycles
1	0.95 f_y	0.5 f_y	20cycles
2	2 ϵ_y	0.5 f_y	4cycles
3	5 ϵ_y	0.5 f_y	4cycles

Note:

f_y is specified yield strength of the reinforcing bar.

ϵ_y is the strength of reinforcing bar at actual yield stress.

i) Cyclic tensile test

Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength (f_y) of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return.

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

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

iv) High cycle fatigue test (for 2,000,000 cycles)

In high cycle fatigue test, the test specimen is subjected to an axial tensile load which varies cyclically according to the sinusoidal wave form of constant frequency in the elastic range, as accordance with IS-16172. Past certificates for high cycle fatigue test shall be accepted, however these should not be more than 10 years old.

v) Slip test

Slip Test Shall be performed on each diameter coupler specimen as per ASTM A 370 section 10. Test shall be conducted confirming to IS 16172:2014 & Caltrans specifications. Total slip shall not exceed the max value of 0.1 mm. Refer table below for more details:

diameter	Total Slip (μ m)
8mm to 20 mm	250
25mm to 28 mm	350
32 mm to 40 mm	450
45 mm	600

vi) Proof loading test

Every cold-forged, threaded bar end shall undergo a proof load test prior to leaving system supplier's workshop. Every threaded bar must be subjected to proof load testing to a minimum test loading of 75% of the characteristic strength (theoretical f_y). The system supplier shall essentially install a proof load tester equipment within its threading workshop premises and ensure to test each and every threaded bar. A positive indication shall be marked on the rebar to indicate that this operation has been carried out.

5.3 Installation of Couplers in the Field:

The installation of couplers in the field, for joining reinforcing bars shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned just before installation. Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached, then the same to be cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative experienced in mechanically connecting reinforcement to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary. The threading workshop is to be fully supervised by the manufacturer's representative.

The contractor shall submit to the Engineer, for his acceptance a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

- a. Requirements for cleanliness
- b. Equipment for threading bars
- c. Method of flocking the connections on both rebars
- d. Method of verification of final rebars alignment and coupler integrity

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance shall be completely removed and the bars re-connected as required.

5.4 Reinforcement Coating

In order to offer adequate resistance against corrosion, reinforcement bars shall be provided with a coating of " Truncated Inhibited Cement Slurry (Patent No. 109784/67 of CECRI, Karaikudi)" for non-aggressive environments (Mild and Moderate). **No extra payment shall be made for the same.**

5.5 Inspection & Testing:

Manufacturer's test certificate steel shall be submitted for each lot of supply brought at Site of work by the Contractor. The reinforcement shall be tested as per IS 1786-2008. However, the sampling of the same shall be as laid down in the CPWD specification 2019 with latest correction slips. The cost of the same is deemed to be included in the contract price and nothing extra shall be payable to the contractor in this regard. Every bar shall be inspected before assembling on the works and any defective, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

Batches shall be rejected if the results of each batch are not in accordance with the specifications.

Every consignment of steel brought to the site of works for use in reinforced concrete work, shall be accompanied by a certificate from the manufacturer giving the following details:

- a) Place of manufacture of the reinforcing steel,
- b) Nominal diameter of the steel,
- c) Grade of the steel,
- d) Rolled-in marking on the steel,
- e) Cast/heat number,
- f) Date of testing,
- g) Mass of the tested lot, and
- h) Individual test results for all the properties,

All such certificates shall be deposited with the Engineer- in -Charge for his record and reference.

5.6 Bar bending and Bar Bending Schedule:

All bars will be carefully and accurately bent by approved means in accordance with IS: 2502, and relevant drawings. It shall be ensured that depth of crank is correct as per the bar cutting and bending schedule and bent bars are not straightened for use in any manner that will injure the material.

Prior to starting bar bending work, the Contractor shall prepare bar bending schedule from the structural drawings supplied to him and get the same approved by Engineer. No work shall commence before the approval of Engineer for the same. Any discrepancies and inaccuracies found by the Contractor in the drawings shall be immediately reported to the Engineer whose interpretation and decision there to, shall

be accepted.

5.7 **Lapping & Welding:/Mechanical Splicing**

As far as possible, bars of the maximum length available shall be used. Laps shown on drawings or otherwise specified by the Engineer will be based on the use by the Contractor of bars of maximum length. In case the Contractor wishes to use shorter bars, laps/couplers (approved make with permission of the Client) shall be provided in the manner and at the locations approved by the Engineer. **No extra payment shall be made for reinforcement lapping.** In case the Contractor wishes to use shorter bars, laps shall be provided at the Contractor's cost in the manner and at the locations approved by the Engineer. Use of Mechanical couplers for splicing is not permitted. However, under exceptional cases, it may be allowed with the prior approval of Engineer-in-Charge purely on case-to-case basis **and no extra payment shall be made for the same.**

Welding in lieu of lap is not permitted unless specified in the drawings or as instructed by the Engineer.

5.8 **Spacing, Supporting and Cleaning:**

- i. All reinforcement shall be placed and maintained in the positions shown on the drawings to be prepared by contractor.
- ii. The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape and size, chairs and spacer bars shall be used to ensure accurate positioning of reinforcement. Cover blocks shall be cast well in advance and shall consist of approved proprietary pre-packaged free flowing mortars (Conbextra HF of Fosroc or equivalent). They shall be circular in shape for side cover and square for bottom cover. The cost of **cover blocks and Chairs / spacer bars** shall be deemed to have been included in the rates/contract price.
- iii. Bars must be cleaned, before concreting commences, of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete. Any reinforcement which is certified as corroded by the Engineer shall be removed from the site.
- iv. 18 gauge G.I. wire shall be used for binding reinforcement as well as for tying cover blocks with reinforcement. **The cost of gauge wire is deemed to have been included in the rate quoted by the contractor.**

5.9 **Welding (If specific approval from Engineer is granted):**

- i. Wherever specified all lap and butt welding of bars shall be carried in accordance with IS: 2751. Only qualified welders duly tested and certified shall be permitted to carry out such welding.
- ii. For cold twisted reinforcement, welding operations must be controlled to prevent a supply of large amounts of heat larger than that can be dissipated. The extreme non-twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used.
- iii. Bars shall be free from rust at the joints to be welded.
- iv. Slag produced in welding after alternative run should be chipped and removed by brush.
- v. Electrode should not be lighted by touching the hot bar.
- vi. The welding procedure shall be approved by the Engineer and tests shall be made to prove the soundness of the welded connection.
- vii. E7018 electrode shall be used for Fe415 grade and E8018 electrode shall be used for Fe500D and above as per AWS (American Welding Society) standards.

5.10 **Measurement:**

- i. The measurement shall be done by weight in MT based on bar bending schedule. Payment of

reinforcement steel shall be made for the length of the reinforcement bars of different diameter as per approved bending schedule (to be prepared by the contractor on the basis of approved drawing). In case the actual reinforcement provided in any member is less than the quantity calculated based on drawings/ bar bending schedule (with the approval of engineer), the same shall be adjusted for the purpose of payment.

- ii. No additional payment will be made for any welding operations carried out on reinforcement bars and providing mechanical couplers. Laps of all types, chairs, spacers, bend correction deduction as per SP 34 etc., as required are deemed to be included in the quoted rate and nothing extra is payable on this account. **Payments shall not be made for lapping/welding and reinforcement bars used for lifting, hooks, handling, etc., as cost towards these is deemed to be included in the accepted rate of the item.**

5.11 Protective Coating of Reinforcement bars using Truncated Inhibited Cement Slurry:

The protective coating of reinforcement bars shall conform to IS 9077 and it shall be approved by the Engineer in Charge.

The reinforcement bars should be dipped in the derusting solution of approved quality and the bars removed as soon as the rust is satisfactorily removed and a bright surface is obtained. This should be immediately followed by cleaning the bars with wet waste cloth and alkaline cleaning powder.

The bars should then be brushed with the phosphate jelly of approved quality by means of fibre brush. The jelly should be left on the surface for a period of 45- 60 minutes and then removed by means of wet waste cloth. This should be followed by brushing the inhibitor solution of approved quality and the first coat of cement slurry, prepared by mixing 500 cc of inhibitor for each 1000 gm of Portland cement. All the above steps should be applied in the same day and after 12-24 hours of air-drying, the sealing solution of approved quality should be brushed followed by the second coat of cement slurry.

It should then be dried for 12-24 hours followed by a brush coat of the sealing solution which should be applied again after 4 hours of air-drying.

Briefly following steps are involved in this process:

- a) Derusting by dipping the rebars in pickling solution (patent no.465/CAL/75) for 30 minutes (pH of the solution is 1.04)
- b) Removal from acid tank and dipping in alkaline tank to neutralize and cleaning with potable water for 2 minutes.
- c) Application of phosphate jelly coat (Patent no. 109897) and drying for 45-60 minutes (pH of the jelly is 2.5).
- d) Application of inhibitor solution A (patent no. 109784/67) for 2 minutes.
- e) Application of first coat of cement slurry coating with inhibitor solution A
- f) Air drying for 24 hours.
- g) Application of first coat of sealing solution B (Patent no. 112440/67) for 2 minutes.
- h) Application of 2nd coat of cement slurry solution A for 2 minutes.
- i) Air drying for 24 hours
- j) Another coat of sealing solution B and drying for 4 hours.
- k) Application of 3rd coat of sealing solution B for 2 minutes
- l) Air drying for 4 hours.

Detailed specification regarding quality control aspects and chemicals/solutions used in the process may be

obtained from Central Electro Chemical Research Institute (CECRI) Karaikudi- 623 006 (Tamandu).

No extra payment shall be made for the protective coating procedure mentioned above and cost of the same shall be deemed to be included in the contract price.

5.12 Splicing (Laps, couplers, welds, etc) Couplers:

These specifications cover threaded couplers to be used for joining reinforcement bars, in lieu of laps/welding/mechanical splicing.

SPECIFICATIONS - GENERAL

The couplers shall be of standard parallel square thread type. Ends of the reinforcement bars, which are to be joined, shall be enlarged by cold forging, threaded in such a way that thread diameter is not lesser than the parent bar to be joined. The material of the coupler shall be of same quality or of superior quality than the quality of material of the parent bars (i.e. reinforcement bars to be joined). The joint shall have guaranteed bar break i.e. when the joint is tested in universal tensile testing machine, the bar shall fail away from the coupler i.e. not within the coupler as well as within 2 times the diameter of bar from the ends of the coupler, which can be considered as affected zone. The Guaranteed Bar break condition is not mandatory, if the failure load of coupled specimen is higher than 1.15 times of its minimum specified yield stress. The coupler shall be qualified as per ASME, Section III, and Div.2. Additionally, it shall meet all the requirements of "Class H" coupler as specified in IS 16172. The safety margin in coupler design shall be such that guaranteed bar break is ensured even if 15% of the total threads length are out of coupler during installation.

The hand tightening of coupler shall be sufficient in the field and no mechanical means shall be essential for tightening. During testing, the coupler should only be hand tightened.

The process of manufacturing of the coupler, cold forging and threading including testing shall be carried out as per ASME approved quality assurance programme. The manufacturer of coupler shall hold a valid Quality System Certificate (QSC) from ASME. Installation of the coupler and supervision shall be done by the qualified personnel.

MANUFACTURING OF COUPLERS

All the couplers shall undergo quality checks on uniformity of threads, dimensional accuracy etc. Each coupler shall be clearly stamped indicating batch number, heat number and diameter. This number shall be traceable to the original cast. The relevant material mill certificate shall be submitted with supply of a particular lot. The certificate shall give salient material properties.

THREADING OF ENDS OF THE REINFORCING BARS

This threading activity shall preferably be done at site. The various stages involved in threading are as given below

CUTTING

The ends of reinforcement bars shall be cut by mechanical means to get a perfect plain end surface, perpendicular to the axis of the bar.

COLD FORGING & THREADING

After cutting, the ends of the bar shall be enlarged by cold forging such that the area of cross section after threading shall not be less than the area of cross section of the parent bar. The length of cold forging shall be adequate for proposed on lathe machine. The thread shall be square parallel type, to suit the couplers.

- (a) requirements for cleanliness

- (b) equipment for threading bars
- (c) method of locking the connections on both rebars
- (d) method of verification of final rebar alignment and coupler integrity.

thread length and depth shall as per manufacturer's design. After threading is completed, the threaded length of the bars shall be protected by providing plastic caps, before taking the bars out of the shop.

QUALITY CONTROL IN MAKING OF THREADS

The work in shop shall be fully supervised by the Manufacturer representative. Double forging of bars is not permitted. In case of improper cold forging, the forged end of the bar shall be square cut and fresh cold forging shall be undertaken. The threading shall be checked with 'go' and 'no go' gauges.

For threaded coupler systems, every prepared bar end shall undergo a load test prior to actual use. The minimum test loading shall be equivalent to 80% of specified yield strength of bar. For this purpose contractor shall deploy the machine having facility of integrated load testing. The "Integrated" means the testing operation is performed automatically by the same machine used to prepare the bar ends. A positive indication shall be punched on the rebar to indicate that this operation has been carried out and bar end has qualified for specified strength.

INSTALLATION OF COUPLERS IN THE FIELD

The installation of couplers in the field, for joining reinforcing bars, shall be undertaken by trained manpower and as per manufacturer's instructions. Threads of both the couplers and the bars shall be thoroughly cleaned with acetone or any other solvent, just before installation.

Where couplers are cast-in the concrete, but connection is not to be completed immediately, the couplers shall be internally greased and plastic capped to a protection detail acceptable to the engineer. This cap shall be removed only when next bar is to be attached & then cleaned before joining the next bar.

The contractor shall arrange for a suitably qualified manufacturer's representative, experienced in mechanically connecting reinforcement, to be present at site before the start of work for initial training of personnel, and also to demonstrate the equipment and techniques as necessary.

The contractor shall submit to the Engineer, for his acceptance, a method statement for mechanically connecting the reinforcement and for the installation and verification in the field. This shall take into account any special requirements for horizontal, vertical and inclined couplers and shall include a rectification procedure, if the connection is incorrectly made. It shall also cover the correct methodology for handling of tools and equipment for mechanical connection on site. The following information shall also be included:

Each coupler shall be visually examined prior to use to ensure the absence of rust and of any foreign material on the inside surface. All completed couplers shall be inspected and verified in accordance with the approved QAP. The Contractor shall ensure the acceptance of the Engineer for a procedure for documenting the inspection of the couplers. The contractor shall retain inspection records and shall submit copies to the engineer within 7 days. The Couplers that do not meet the acceptance standards shall be completely removed and the bars re-connected, as required.

QUALIFICATION TESTS

The splices shall be qualified as per ASME Section III Div-2, IS 16172 and by conducting following tests:

STATIC TENSILE TEST

Mechanical connections shall be tested in all reinforcing rebar sizes. All rebar transition connectors shall also be tested. For each rebar size, a minimum of six connections in each load direction shall be tested in accordance with ASTM A370. A tensile test on an unspliced specimen from the same bar used for the spliced specimens shall be performed to establish actual tensile strength.

The average tensile strength of the splices shall not be less than the followings:

- (a) 90% of the actual tensile strength of the reinforcing bar being tested.
- (b) 100% of the specified minimum tensile strength

The tensile strength of an individual splice system shall not be less than the 115% of the specified minimum yield strength of the spliced bar.

CYCLIC TENSILE AND COMPRESSIVE TEST

Cyclic tensile and compressive test: Mechanical connections shall be tested in all reinforcing rebar sizes. For each rebar size, a minimum of three connections shall be tested for low cyclic tensile test. Each specimen shall withstand 100 cycles of stress variation from 5% to 90% of the specified minimum yield strength of the reinforcing bar. One cycle is defined as an increase from the lower load to the higher load & return. The test shall be performed as per Annexure D of IS 16172.

PERCENTAGE ELONGATION

The minimum uniform elongation (Elongation at maximum force) in the reinforcement bar outside the length of mechanical splice as measured as per Annexure B of IS 16172 shall be 3 % before failure of test piece.

SLIP TEST

The total slip value when measured in accordance to test procedure described in Annexure C of IS 16172 shall not exceed 0.10 mm.

TEST FOR AVOIDANCE OF STAGERRING

The strain measured over the full length of the splice at 90% of the specified minimum yield strength of the bar shall not exceed that of a bar that is not mechanically-spliced by more than 50%. The test shall be performed for all diameter of couplers.

LOW CYCLE FATIGUE TEST

The mechanical splice shall withstand 10000 cycles of alternating tension & compression load, when tested as per Annexure E of IS 16172.

HIGH CYCLE FATIGUE TEST

The mechanical splice when tested accordance to Annexure E of IS 16172 shall withstand 2 million cycles (2000000 Nos) of varying axial tensile load with a stress range of 60 MPa with upper stress in the test equal to $0.6f_y$.

PRODUCTION TESTS & ACCEPTANCE CRITERIA FOR A LOT

Static Tensile tests, as per ASTM A370, shall be conducted on each bar size & grade for each lot as follows. The criteria mentioned below are in variance with the above referred codes

Sl. No.	No of Coupler in the Lot	No of Sample to be Tested	Acceptable Defective Couplers
1	Upto 500	14	NIL
2	501 - 1200	20	NIL
3	1201-3200	32	1
4	3201-10000	50	2
5	10001 and above	50+ 2 for each 1000 Nos beyond 10000	Not more than 4% of the samples tested

The lot is defined as the group of couplers which are of same size, type, class, material traceable to same cast and manufactured under similar conditions of production. All the tests shall ensure guaranteed bar break at a load not lower than the specified tensile strength of the bar. The quoted rate shall be inclusive of carrying out above tests and no separate payment shall be made for these tests.

The Contractor shall submit to the engineer for acceptance a report on these Proving Tests, within seven working days of the tests. The report shall provide full details including:

- (a) Results of all tests
- (b) Details of dimensions, geometry.
- (c) Details of test procedures
- (d) Description of test rig/load cell
- (e) Description of load monitoring, strain measurements
- (f) Calibration certificates.

From each test on the coupler and control bar specimens, the following information shall be provided:

- (a) Stress-Strain (or Load Displacement) curves
- (b) Yield Load & Yield Strength
- (c) Elongation of the mechanical connection
- (d) Ultimate load & Ultimate Tensile Strength
- (e) Mode of failure
- (e) Gauge length used for strain measurement and statement of how gauge length was determined.
- (f) Lapping will not be permitted anywhere other than piles for bar dia of 20 mm and above.

5.13 Spacing, Supporting and Cleaning

All reinforcement shall be placed and maintained in the positions shown on the drawings. The Contractor shall provide approved types of supports for maintaining the bars in position and ensuring required spacing and correct cover of concrete to the reinforcement as specified on the drawings. Cover blocks of required shape, size and strength M.S. Chairs and spacer bars shall be used to ensure accurate positioning of

reinforcement. Cover blocks shall be cast well in advance and shall consist of approved proprietary pre-packaged free flowing mortars having the strength same as that of concrete for the member for which they are to be used. They shall be circular in shape for side cover and square for bottom cover. Cover blocks shall be cast and compacted using plate vibrator or any other approved method and shall be cured so as to achieve the desired strength. The cost of cover blocks and chairs/spacers shall be deemed to have been included in the Lumpsum Price.

Bars must be cleaned, before concreting commences, of all scale, rust or partially set concrete which may have been deposited there during placing of previous lift of concrete.

Cleaning of HYSD Bars

Only TMT bars complying to IS:1786 shall be provided

18 gauge 2 ply G.I. wire shall be used for binding reinforcement and as well as for typing cover blocks.

5.14 Welding

1. Wherever specified all lap and butt welding of bars shall be carried in accordance with IS: 2571. Only qualified welders duly tested and certified by the contractor shall be permitted to carry out such welding.
2. For cold twisted reinforcement welding operations must be controlled to prevent supply of large amounts of heat larger than that can be dissipated. The extreme non twisted end portion shall be cut off before welding. Electrodes with rutile coating should be used.
3. Bars shall be free from rust at the joints to be welded.
4. Slag produced in welding after each run should be chipped and removed by brush.
5. Electrode should not be lighted by touching the hot bar.
6. The welding procedure shall be approved by the Engineer and tests shall be conducted to prove the soundness of the welded connection.
7. E7018 electrode shall be used for Fe415 grade and E8018 electrode shall be used for Fe500 above as per AWS (American Welding Society) standards.

Sl. No.	Bar Dia (mm)	Standard sectional weight in Kg./ m
1	6	0.222
2	8	0.395
3	10	0.617
4	12	0.888
5	16	1.578
6	18	2.000
7	20	2.466
8	22	2.980
9	25	3.854
10	28	4.830
11	32	6.313
12	36	7.990
13	40	9.864
14	45	12.490

5.15 Measurement

The Payment of reinforcement steel is included in the lumpsum price of price schedule.

The cost quoted should cover all welding, providing mechanical couplers, all types of laps, stiffeners, hooks, spacer bars, U-bars, standard laps, chair, bend deduction as per IS code, as required and nothing extra is payable on this account and also in case if it is recorded in bar bending schedule, payment will not be made for these bars. Payments shall not be made for butt welding and reinforcement bars used for lifting, hooks, handling, etc., as cost towards these is deemed to be included in the lumpsum price schedule.

1. APPROVED MANUFACTURERS / SUPPLIERS FOR CIVIL WORKS

All materials and products shall conform to the relevant standards/specifications of IS code, BS Code etc. and shall be of approved make and design. A list of manufacturers / vendors is given herein below for guidance. The approval of a manufacturer/vendor shall be given only after review of the sample / specimen by the Employer. The complete system and installation shall also be in conformity with the – “Applicable Codes, Standards and Publications”. **The Contractor shall submit the proposal for the approval of the Employer.**

List of approved makes for products and materials is given below. The Employer reserves the right to adhere any of the vendor against each of the item.

No.	Details of Materials/Products	Manufacturer's Name
1.	Cement	<ul style="list-style-type: none"> ➤ <u>Viaduct Work & Station</u> • ACC, Ultratech, ➤ <u>Other works:</u> • Gujarat-Ambuja, Grasim, JK Lakshmi, Birla. Dalmia, JSW, Bharati Cement, RAMCO
2.	Reinforcement Bars (TMT Bars)	• SAIL, Rastriya Ispat Nigam Ltd, Tata Tiscon, JSW Steel, VIZAG STEEL
3.	Epoxy	• FOSROC, SIKKA QUALCRETE, Araldite, BASF, Fairmate.
4.	Expansion Joints	<ul style="list-style-type: none"> • Prequalified Manufacturers as per RDSO's latest approved list or as approved by the Employer. • Fair Mate Chemical Pvt. Ltd • Chembond Chemical Ltd. • Kantaflex (India) Pvt Ltd.
5.	Admixtures	<ul style="list-style-type: none"> • FOSROC, MBT. MC Baucheme, Sika, • Pidilite, BASF • Fairmate • ADO Additives Technologies Ltd. • Concrete Additives & Chemicals Pvt Ltd. (CAC Admixture).
6.	Pile Integrity Testing Agency	• CBRI. Pile Dynamic. AIMIL, Geo dynamic or NABL Accredited Agency
7.	Anchor Fastener	<ul style="list-style-type: none"> • HILTI. FISHER, BAUCH • Canon Fasteners
8.	Structural Steel	• TATA, SAIL, ESSAR, Jindal Steel & Power Ltd, JSW
9.	Stainless Steel	<ul style="list-style-type: none"> • Jindal. • JSW.
10.	Pre-stressing Strand (LRPC)	• TATA SSL Ltd, USHA Martin
11.	Welding Electrodes	• ESAB. Advani - Orlikon Weld Alloy. Modi L&T Eutectic. (RDSO approved manufactures.)
12.	Pot/Elastomeric Bearings	• Prequalified Manufacturers as per RDSO's latest approved list
13.	Horizontal Tie Bars/Shear Bars	• BB Bars System, BBV Systems, Dextra
14.	HDPE Sheathing	• Rex Polyextrusion, Gwalior Polypipes Ltd, M/s Dynamic Prestress

No.	Details of Materials/Products	Manufacturer's Name
15.	Formwork Release Agent	<ul style="list-style-type: none"> • FOSROC, MBT, MC Baucheme, Ado Conmat, • CICO, SWC, Choksey, BASF, Adoadditives, STP • Fair Mate Chemical Pvt Ltd. • Chembond Chemical Ltd.
16.	Prestressing System	<ul style="list-style-type: none"> • Freyssinet, BBR, VSL, Dynamic, Killick Nixon, Tensacciai (India Ltd.), Usha Martin, Posten, VSIL
17.	Reinforcement Couplers	<ul style="list-style-type: none"> • Dextra, Moment • SANFIELD India Pvt Ltd.
18.	Drainage Pipes	<ul style="list-style-type: none"> • Tirupati Plastomatics, Duraline, REX, STIPL • Ashirvad pipes Pvt Ltd. • Prakash Surya • Prince
19.	Acrylic Textured Coatings	<ul style="list-style-type: none"> • Spectrum, Renova, Wallz, Surfa Nova, Jotun, Asian Paints
20.	Non shrink Grout	<ul style="list-style-type: none"> • Fosroc Chemical (India). Sika BASF, ELCHEM, • MBT. Sika. • Chryso India Pvt Ltd. • Hindcon Chemicals Limited • APPLE CHEMIE INDIA PVT. LTD • Flaminco Refractories Pvt Ltd. • Ultratech. • BASF • Fairmate
21.	Bonding Coat	<ul style="list-style-type: none"> • CICO, FOSROC, Sunanda specialty coating Pvt. Ltd., BASF, SWC. TAM, Fairmate
22.	Polysuphide Sealant	<ul style="list-style-type: none"> • CICO. Pidilite. BASF. FOSROC. SWC, STP, • Sika, Fairmate
23.	Steel Structural Fasteners	<ul style="list-style-type: none"> • Pooja Forge, Sundram Fasteners, Unbrako, Nelson, Panchsheel, karamtara.
24.	Micro Silica	<ul style="list-style-type: none"> • Sika, Elkem, FOSROC. MAPEI. Comiche, Star Silica, TAM, CICO, CAC, BASF, Buildetech, Ashtech, Alcofine.
25.	Fire Resistant Paints	<ul style="list-style-type: none"> • Akzo Noble, PPG or equivalent, Jotun
26.	Integral Crystalline Waterproofing Method	<ul style="list-style-type: none"> • APPLE CHEMIE INDIA PVT. LTD • Fosroc • Perma • Cryton • Sika • Fairmate • TREMCO (Vandex)
27.	Water stopper/Bar	<ul style="list-style-type: none"> • Kanta Rubber. Greenstreak, Maruti, Duron • Fair Mate Chemical Pvt Ltd. • Supreme • Fairmate
28.	Liquid polymer membrane waterproofing	<ul style="list-style-type: none"> • INTEGRITANK, BASF. MAPEI, PIDILITE. DAVCO, CICO • APPLE CHEMIE India Pvt. Ltd, FOSROC, Asian Paints, MC-Bauchemie, Fairmate

No.	Details of Materials/Products	Manufacturer's Name
29	Curing Compound	<ul style="list-style-type: none"> • Clean tech concure, SINAK, FOSROC, ATPL • TAM, STP SWC.CICO • SUPREME BITUCHEM INDIA PVT. LTD. • Fair Mate Chemical Pvt Ltd. • Chembond Chemical Ltd. • Chryso India Pvt Ltd. • Rheoplast Technology Pvt Ltd. • Polygon Chemicals Pvt Ltd. • BASF • Pidilite • FOSROC • Sika • BASF • ATPL • Asian Paints • Fairmate • MC-Bauchemie
12.	Fly ash	<ul style="list-style-type: none"> • Thermal plant. Ashcrete, Ultra pozz, star pozz, (the fly ash shall be as per our specifications)
13.	False Ceiling	<ul style="list-style-type: none"> • Hunter Douglas • Fundermax • Armstrong
14.	Aluminum Louvers	<ul style="list-style-type: none"> • Hunter Douglas-LUXALON H-3 , CS-RS-1605 • Jindal • Hindalco
15.	Barbed Wire / Chain-link fencing	<ul style="list-style-type: none"> • Krishna Industries Bhilwara, / Concertina Coils New Delhi,
16.	PEB/Steel Structures/Pipe Structure	<ul style="list-style-type: none"> • Fabtech • Fabrimax • Framecad, • Voltagreen, • Everest, • ZAMIL • Renuka Equipments Pvt Ltd • Bajaj steels industries Ltd. • MetalFAB
17.	Cement (For Brick Works, & General Work, Wall/Boundary Wall only)	<ul style="list-style-type: none"> • Birla Gold (Manikgarh Cements) • Chettinad Cement Corporation Pvt Ltd. • JSW Cement Limited. • Dalmia Cement (Bharat) Limited. • Ultratech • Ambuja
18.	MS Angles & Flats	<ul style="list-style-type: none"> • Ramson Steel (For general purpose only, not for dynamic & heavy loading structures)

No.	Details of Materials/Products	Manufacturer's Name
19.	Corrosion inhibiting admixture	<ul style="list-style-type: none"> • EPCO-KP 200 from Krishna Conchem Product Pvt. Ltd. • SUPREME BITUCHEM INDIA PVT. LTD. • ADO Additives Technologies Ltd. • BASF India Limited. (Construction Chemical Division). • Silka • Pidilite
20.	Coal tar epoxy for sub-structure protection.	<ul style="list-style-type: none"> • Krishna Conchem Product Pvt. Ltd.
21.	Coating of PSC Girders and RCC Substructures	<ul style="list-style-type: none"> • IPNet from Krishna Conchem Product Pvt. Ltd. • Nerolac • Berger
22.	Solid Concrete Blocks	<ul style="list-style-type: none"> • Punjab Bricks • Apex • Grams

The above list is not exhaustive. Contractor may propose similar product of other reputed vendor too for the works. However, the approval /acceptance / rejection of proposed vendor rest with the Employer.

TECHNICAL SPECIFICATION S-06: PRESTRESSED CONCRETE

S.06: PRESTRESSED CONCRETE

Structural concrete containing prestressed steel reinforcement to introduce pre-compression is termed as prestressed concrete.

6.1 General

The work shall be carried out in accordance with the drawings and these specifications or as approved by the Engineer.

Concrete and un-tensioned steel for the construction of pre-stressed concrete members shall conform to the requirements of sections respectively in so far as the requirements of these Sections apply and are not specifically modified by requirements set forth herein.

Contractor shall ensure that different components of pre-stressing system such as jacks, bearing plates, wedges, anchorages, strands and HDPE ducts are compatible to each other and the data regarding the same shall be exchanged in between all the suppliers **to ensure the same**.

6.2 Scope of Work:

The general scope of work will include:

- i. Providing and placing cement concrete with all ingredients and admixtures if and as required.
- ii. All arrangements needed to keep the reinforcement bars, pre-tensioned strands and sheathing in position with due spacing & cover blocks
- iii. Providing steel shuttering, staging, scaffolding, erection & eventual removal.
- iv. Providing and placing in position and fixing permanent specialized bearings with the super structure, with their anchor bolts as per detailed specifications/instructions as stipulated, supplemented by manufacturer's specifications and directions of Engineer including grouting of holes etc. if any, with suitable grouts as approved by the Engineer.
- v. Installation of expansion joints in stages over the viaduct deck as per approved drawings and as per manufacturer's specifications/directions of Engineer.
- vi. Contractor to furnish facility for fixing/embedding all necessary electrical or other fixtures by the designated contractors at site.
- vii. Providing and mixing cement concrete with all ingredients and admixtures if and as required.
- viii. Casting, curing, with steam/water as adopted, stacking at casting yard including all handling, re-handling and interim storage operations as required for precast girders.
- ix. Loading at casting yard, transportation to site in accordance with the prevailing traffic rules and regulations, unloading and stacking at site for precast girders.
- x. Provision of necessary & suitable packing to maintain the required gap between precast girders.
- xi. Protection of reinforcement, required to be left for Integration of the precast unit with top deck slab cast in place and bending the reinforcement to required shape after precasting & till their embedment in concrete.
- xii. Transporting precast segment to the location of placement, hoisting & placing in correct position, including all handling operations.
- xiii. The operation of placing precast segment over brackets/pier arms on Teflon/neoprene pads/tar paper including the cost of all operations involved, appropriate setting of superstructure.
- xiv. Fixing/embedding any fixture supplied by the Employer.

The handling, carriage and storage of HT strands as per manufacturers' specification.

- xv. The H.T. strands will be procured by the Contractor. The extra pieces of HT strands cut after the stressing of the cable will be the liability/property of the Contractor.
- xvi. Cost of all other items of materials, plants and equipment and works (not specifically excluded above) for proper prestressing operation of the strands in accordance with the provisions contained elsewhere in the tender documents will be included in the cost of this item.
- xvii. Providing/supplying and operating etc. of jacks and power pumps for prestressing, recording of data, tabulating the same in necessary formats for submission. The item will also include corrective measures that may be necessary and required by the Engineer.

6.3 Materials

A. Sheathing

Material for all pre-stressing sheathing duct shall be HDPE in the form of corrugated. The thickness of the HDPE sheathing ducts shall conform to IRS Concrete Bridge Code-1997 & IRC -112:2020).

- i. The minimum wall thickness of the duct as manufactured shall be 2.0 mm, 2.5 mm, 3.0 mm and 4.0 mm for ducts of internal diameter upto 50 mm, 85 mm, 100 mm and 125 mm respectively. Linear interpolation may be done for any intermediate values.
- ii. Tolerance for duct diameter is $\pm 1\%$ or ± 1 mm, whichever is greater. Tolerance for wall thickness shall be $-0/+0.5$ mm.
- iii. The minimum residual wall thickness after loss in the compression test as per clause B1-2 at Appendix B1 of IRS CBC-1997 with latest correction slips, shall not be less than 1.5 mm for ducts upto 160 mm outer Diameter.
- iv. The material for the ducts shall be high-density polyethylene with more than 2 percent carbon black to provide resistance to ultra-violet degradation and shall have the following properties as mentioned in table below unless otherwise specified:

Property	Unit	Applicable Standard	Temperature	Acceptance Values	
				Min	Max
Carbon content	%			e	
Density	gm/cc	IS2530	23 ° C	0.94	0.96
Tensile strength at Yield	MPa	BS EN ISO 527-3		20	
Shore 'D' Hardness		IS 13360 (Part 5 /Section 11)		a. 3 Sec b. 15 Sec	: 60 : 58
Elongation at Yield	%	BS EN ISO 527-3		7	
Melt Flow Index (MFI)	g/10 minutes	IS:2530	190 ° C under a mass of 5 kg	0.5	1.2
Environmental Stress Crack Resistance	Hrs	ASTMD-1693	70 ° C	192	
Coefficient of Thermal Expansion for 20 ° C - 80 ° C	/ ° C	DIN 53 752		1.50x10 ⁻⁴	

Charpy impact strength of notched specimen (i) at 23 °C	kJ/m ²	BS EN ISO 179		1.0kJ/m ² 4 kJ/m ²	
(ii) at -40 °C					

- v. The ducts shall be corrugated on both sides. The duct shall transmit full tendon strength from the tendon to the surrounding concrete over a length not greater than 40 duct diameters. Material and formulation of sheathing ducts shall conform to test and acceptance criteria of IRC-112:2011.
- vi. The sheaths shall be sufficiently watertight to prevent concrete laitance penetrating in them in quantities likely to increase friction. Special care shall be taken to ensure water-tightness at the joints
- vii. The alignment of all sheaths and extractable cores shall be correct to the requirements of the drawings and maintained securely to prevent displacement during placement and compaction of concrete. The permissible tolerance in the location of the sheaths and extractable cores shall be 5 mm. Any distortion of the sheath during concreting may lead to additional friction.
- viii. Sheathing ducts shall be joined by adopting any one or more of the following methods, as convenient to suit the individual requirements of the location, subject to satisfactory pressure tests before adoption and approval of Engineer.
 - Using Corrugated threaded sleeved couplers which can be tightly screwed together with male and female threads
 - Jointing with thick walled HDPE shrink couplers with glue. This can also be used for connection with trumpet etc.
 - Welding with electro fusion couplers/Heat Shrink Couplers.
- ix. The joints shall be able to withstand an internal pressure of 0.5 bar(0.05 Mpa) for 5 minutes as per **water loss test procedure** given in Clause-B-7 at Appendix-B of IRS Concrete Bridge Code- 1997
- x. The initial acceptance tests such as bond test, compression test for loss of wall thickness are required to be performed as part of acceptance criteria for system.
- xi. In addition to above, the HDPE ducts supplier must have conducted friction test at least once as given in FIP bulletin No-7 to establish/confirm the friction values (K & u) using the HDPE ducts produced by them, submit the test details and obtain approval prior to commencing supplies .
- xii. The routine test such as workability test, transverse load rating test, tension load test and water loss test shall be applicable for both post threading and pre - threading system of cables.
- xiii. Loads to be imparted on the 107mm ID sheathing during transverse load rating test and tension load test shall be extrapolated from values given for smaller dia sheathing as per IRC 112:2020 with latest amendments. At least 3 samples for one lot of supply (not exceeding 7000 meter length) shall be tested.
- xiv. In viaduct constructed by precast segmental construction, cables shall be threaded after application of temporary prestressing.
- xv. In such cases a temporary flexible PVC/HDPE tube of suitable O.D shall be homed through sheathing which will provide adequate stiffness to sheathing during concreting and also prevent blockage of sheathing in case of possibility of leakage. The temporary PVC/HDPE tube shall be pulled out before threading of the permanent cables.

B. Anchorages

- I. Anchorages shall be procured from authorized manufacturers only. Anchorages shall conform to BS: 4447.

Load transfer test and anchorage efficiency shall be conducted as defined in FIP-1993. Engineer-in-charge shall select at random, the required anchorages / wedges sample from completed lots for testing by the manufacturer.

The concrete unit of required size/R/F will be made by contractor using same design mix of concrete which will be required for the load transfer test.

The load transfer test shall be conducted only when the concrete unit attains sufficient strength required for stressing activity as proposed in the drawings.

No damaged anchorages shall be used. Steel parts shall be protected from corrosion at all times. Threaded parts shall be protected by greased wrappings and tapped holes shall be protected by suitable plugs until used. The anchorage components shall be kept free from mortar, loose rust and any other deleterious coating.

After completion of pre-stressing and grouting of cables in PSC members, the extra length of stressed strands projecting outside the anchorage are required to be cut as per approved methodology and the anchorage ends are to be sealed as per the relevant specifications approved by Engineer-in-Charge.

- II. Swages of prestressing strand shall develop strength of at least 95 per cent of the **specified** breaking load of the strand.
- III. Untensioned steel reinforcements, around anchorages shall be furnished by prestressing system supplier. Requirement of the same should be job specific and based on edge distance of anchorage and strength of concrete at the time of stressing of cables as defined in drawings. The same R/F shall be provided in unit required for load transfer test.

Minimum 3 tests each are required to be conducted for load transfer test and anchorage efficiency test. The manufacturer shall complete the required testing and determine compliance of the obtained results with FIP-1993 recommendations before transporting the lot to site.

C. Prestressing Steel

- i. Uncoated, stress relieved, low relaxation steel conforming to IS: 14268:2017, class - 2 shall be used. Nominal dia shall be 15.2 mm with minimum breaking strength of 260.7 KN and minimum 0.2 % proof load of 234.6 KN.
- ii. Various test as recommended in IS: 14268 shall be conducted before transporting the lot to site. Apart from 1000 hrs relaxation test conducted by manufacturer, at least two such tests are required to be conducted by approved independent (third party) agency in the beginning of project.
- iii. All strands to be transported to the site shall be assigned a lot number and tagged for identification purposes.

D. Prestressing Strands/Wires Storage

All high tensile steel for prestressing work shall be stored about 30 cm above the ground in a suitably covered and closed space to protect it from dampness. It shall also be invariably wrapped in gunny cloth or tar paper or any other suitable material, as per approval of Engineer. Even if it is to be stored in an area at the site for short time during transit it shall be suitably covered. Protection during storage and repacking or application of washable protective coating to the H.T. steel shall be given by the contractor at no extra cost, if the packing of H. T. Strands/wires during unloading and storage / handling in the stores gets damaged.

Stock piling of HTS wires on the work site shall not be allowed any time, especially before and during the monsoon.

Engineer-in-Charge or his authorized representative shall always have an easy access to the store-yard for inspecting the H. T. Wires/strands/Bars and satisfying themselves regarding the condition thereof. Any modifications regarding storage suggested by Engineer shall scrupulously be followed by the contractor. During monsoon days, H.T wires/strands shall be kept in a reasonably air tight store, if required by the Engineer, at no extra cost.

6.4 **Testing of Prestressing Steel and Anchorages**

All strand from each manufactured reel and all bars of each size from each mill heat to be shipped to the site shall be assigned a lot number and shall be tagged in such a manner that each lot can be positively identified at the job site. Each reel of prestressing reinforcement shall be accompanied by a manufacturer's certificate of compliance, a mill certificate, and a test report. Samples from each size and each heat of prestressing bars and from each manufactured reel of prestressing steel strand shall be furnished to the Engineer for testing.

Samples shall be submitted in ample time to allow for testing, for tabulating results and, if necessary, in case of unsatisfactory finds, to call for and retest substitute samples. The Contractor shall have no claim for additional compensation because of delay while awaiting approval of the materials furnished for testing.

- i. Testing of Prestressing Steel as per IS 14268:2017 is included in the scope of work. Nothing Extra shall be payable in this regard.
- ii. All materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.
- iii. Anchorage assemblies to be transported shall be like-wise identified.
- iv. All samples submitted shall be representative of the lot to be furnished and in the case of strands, samples shall be taken from the same master roll. The Contractor shall furnish samples of at least 5.0m length selected from each lot for testing. Also, two anchorage assemblies, complete with distribution plates of each size or types to be used, shall be furnished along with short lengths of strands as required.

6.5 **Workmanship**

A. Cleaning

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious substance. Cleaning of the high tensile steel wires may be carried out by immersion in suitable solvent solutions, wire brushing or passing through a pressure box containing Carborundum powder. However, the tendons shall not be brought to a polished condition.

B. Straightening

High tensile strands shall be supplied in coils of sufficiently large diameter such that tendons shall retain their physical properties and shall be straight as it unwinds from the coil. Tendons of any type that are damaged, kinked or bent shall not be used.

The packing of prestressing strands shall be removed only just prior to making of cable for placement. Suitable stands shall be provided to facilitate uncoiling of strands without damage to steel. Care shall be

taken to avoid the possibility of steel coming into contact with the ground.

C. Positioning

I. Post-Tensioning

- i. Prestressing tendons shall be accurately located and maintained in position, both vertically and horizontally, as per drawings.
 - ii. Tendons shall be so arranged that they have a smooth profile without sudden bends or kinks. The location of prestressed cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons.
 - iii. Sheathing shall be placed in correct position and profile by providing suitable ladders and spacers. Such ladders may be provided at intervals of approximately 1.0 m. Sheathing shall be tied rigidly with such ladders/spacer bars so that they do not get disturbed during concreting.
 - iv. The method of supporting and fixing shall be such that profile of cables is not disturbed during vibrations, by pressure of wet concrete, by workmen or by construction traffic.
- II.** Each anchorage device shall be set square to the line of action of the corresponding prestressing tendon and shall be positioned securely to prevent movement during concreting.
- III.** The anchorage devices shall be cleaned to the satisfaction of the Engineer prior to the placing of concrete. After concreting, any mortar or concrete which adheres to bearing or wedging surfaces shall be removed immediately.
- IV.** Tendons shall be placed only prior to stressing. Tendons shall be handled with care to avoid damage or contamination, to either the tendon or the sheathing. Any tendons which are damaged or contaminated shall be cleaned or replaced as directed by the Engineer.

D. Cutting

Cutting and trimming of H.T.S wires or strands shall be done by suitable mechanical cutters. In post-tensioning, the ends of prestressing steel projecting beyond the anchorages, shall be cut by suitable means Before grouting operation.

E. Protection of Pre-stressing Steel

Pre-stressing steel shall be continuously protected against corrosion, until grouted. The corrosion protector shall have no deleterious effect on the steel or concrete or on the bond strength of steel to concrete. Grouting shall conform to these specifications or as directed by the Engineer.

F. Sheathing

The joints of sheathing pipes shall be water-tight. Special attention shall be paid to the junction at the anchorage end, where the sheathing must tightly fit on the protruding trumpet end of anchorage and thereafter sealed preferably with adhesive water proof tape as per approved manufacturer's specifications.

The sheathing and all joints shall be water tight. Any temporary opening in the sheathing shall be satisfactorily plugged and all joints between sheathing and any other part of the prestressing system shall be effectively sealed to prevent entry of mortar, dust, water or other deleterious matter. Sheathing shall be neatly fitted at joints without internal projection or reduction of diameter.

Sheathing shall be firmly tied so that while concreting they should not float up. Sheathing shall be aligned accurately with respect to vertical and horizontal coordinates (profile).

Enlarged portions of the sheathing at couplings or anchorages shall be of sufficient length to provide for the extension of the tendons.

G. Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both ends of the sheathing.

H. Anchorages

All bearing surfaces of the anchorages shall be cleaned prior to concreting and tensioning.

Anchor cones, blocks and plates shall be securely positioned and maintained during concreting such that the centre line of the duct passes axially through the anchorage assembly.

The anchorages shall be recessed from the concrete surface as per drawings.

After the prestressing operations are completed and pre-stressing strands are cut, **the surface shall be painted with two coats of epoxy of suitable formulation having a dry film thickness of 80 microns per coat and entire recess shall be filled with concrete or non-shrink/pre-packaged mortar or epoxy concrete as approved by Engineer-in-Charge.**

6.6 Supervision

All pre-stressing and grouting operations shall be undertaken by trained and qualified personnel only.

All prestressing accessories shall be procured from authorized manufacturers with in-house testing facilities. The Contractor shall be required to engage specialized agencies who should also be entrusted with the total service contract for fabrication of cables to required Length, protection of cables during concreting, prestressing and grouting.

Necessary certificates shall be accorded by such specialized agencies that the work has been carried out in accordance with prescribed specifications.

A representative of supplier of the pre-stressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

6.7 Post-Tensioning

Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the prestressing system supplier, whichever is more. After prestressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily as to avoid shock to the prestressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel for the particular lot as given by the manufacturer.

Parallel measurement of prestressing force by load cell in combination with direct reading of pressure gauge shall be preferred. In any case such parallel measurements by load cell shall be made for at least 10% of the

cables stressed during any tensioning operation

The difference between calculated and observed tension and elongation during prestressing operations shall be regulated as follows:

- a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer.
- b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5kg/sq.cm until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure.
- c) If the elongation at 1.05 times the Specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this discrepancy:
 - i Check the correct functioning of the jack, pump and leads.
 - ii Detention the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Retension the cable if free.
 - iii Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory. Contractor may suggest other remedial measure for approval of the Engineer.

If the required elongation is still not obtained, further finishing operations as cutting or sealing, should not be undertaken without the approval of the Engineer.

- d) When stressing from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/II of MORT&H Specification.

- e) Any breakage of individual strand / groups of strands during tensioning shall require immediate destressing of all strands and replacement of the all the strands by fresh strands.

6.8 Grouting of Prestressed Tendons

Prior to grouting, all cables shall be tested with water pressure of 0.5 Bar (0.05 MPa) for approximately 5 minutes, to investigate leakages and connectivity of ducts. Where directed by the Engineer, the Contractor shall perform full scale site test to determine the adequacy of grout mix, equipment and grouting method. The Contractor shall submit a method statement detailing the test procedure.

All other aspects of grouting of cables shall be governed by. MORTH Specifications. A record of grouting operations shall be maintained in the format as given in Appendix 1800/IV of MORTH Specifications.

Handling and Storage

Care shall be taken to avoid mechanically damaging, work-hardening or heating prestressing tendons while handling. All prestressing tendons shall be stored clear of the ground and protected from the weather, from splashes from any other materials, and from splashes from the cutting operation of an oxy-acetylene torch, or arc-welding processes in the vicinity.

In no circumstances shall prestressing tendons after manufacture be subjected to any welding operation, or

'on-site' heat treatment or metallic coating such as galvanising. This does not preclude cutting as specified.

All wires, strands or bars stressed in one operation shall be taken, where possible, from the same parcel. Each cable shall be tagged with its number from which the coil numbers of the steel used can be identified. Cables shall not be kinked or twisted. Individual wires and strands for which extensions are to be measured shall be readily identifiable at each end of the member. No strand that has become unraveled shall be used.

All prestressing and grouting operations shall be undertaken by trained personnel only. A representative of supplier of the prestressing system shall be present during all tensioning and grouting operations and shall ensure, monitor and certify their correctness.

6.9 **Tensioning Equipment**

All tensioning equipment shall be procured from authorised manufacturers only and shall be approved by the Engineer prior to use. Where hydraulic jacks are used, they shall be power-driven unless otherwise approved by the Engineer. The tensioning equipment shall satisfy the following requirements:

- (i) The means of attachments of the pre-stressing steel to the jack or any other tensioning apparatus shall be safe and secure.
- (ii) Where two or more wires/strands constitute a tendon, a single multi pull stressing jack shall be used, which is capable of tensioning simultaneously all the wires/strands of the tendon. Suitable facilities for handling and attaching the multi-pull jack to the tendons shall be provided.
- (iii) In special cases where usage of multistrand jack is not feasible, Contractor may use mono strand jack on specific approval of Engineer.
- (iv) The tensioning equipment shall be such that it can apply controlled total force gradually on the concrete without inducing dangerous secondary stresses in steel, anchorage or concrete;
- (v) Means shall be provided for direct measurement of the force by use of dynamometers or pressure gauges fitted in the hydraulic system itself to determine the pressure in the jacks. Facilities shall also be provided for the linear measurement of the extension of prestressing steel to the nearest mm and of any slip of the gripping devices at transfer.
- (vi) The tensioning equipment shall be calibrated before the tensioning operation and at intervals of the months or as approved by the Engineer. Any indication in the loss of strength in tendons during the tensioning operation shall be brought to the attention of the Engineer. Any corrective measures which may be required in procedures and/or material shall be approved by the Engineer.

When friction must be reduced, water soluble oil may be used subject to the approval of the Engineer. This oil may be flushed from the duct as soon as possible after stressing is completed by use of water pressure. These ducts shall be flushed again just prior to the grouting operations. Each time the ducts are flushed, they shall be immediately blown dry with oil-free air.

All dynamo meters and pressure gauges including a master gauge shall be calibrated by approved laboratory immediately prior to use and then at intervals not exceeding 3 months and the true force determined from the calibration curve.

Pressure gauges shall be concentric scale type gauges accurate to within two per cent of their full capacity. The minimum nominal size of gauge shall be 100 mm. The gauge shall be so selected that when the tendon is stressed to 75 per cent of its breaking load, the gauge is reading between 50 percent and 80 percent of its full capacity. Suitable safety devices shall be fitted to protect pressure gauges against sudden release of pressure.

Provision shall be made for the attachment of the master gauge to be used as a check whenever requested for

by the Engineer.

Jack efficiency test shall be conducted at suppliers factory as well as at site prior to first use at site and then at intervals not exceeding three months

pump shall be calibrated from an approved laboratory prior to use and then at intervals not exceeding three months.

6.10 Testing by Contractor

For the purpose of accurately determining the tendon elongations while stressing, the Contractor shall bench test two samples of each size and type of strand tendon to determine the modulus of elasticity prior to stressing the initial tendon. The bench should be at least 6 meters long, with concrete anchorage blocks having a constant area end section of at least four times that of the anchorage assembly area. The tendon shall be straight and centered on the cross-sectional area of the bench. The test procedure shall consist of stressing the tendon at an anchor assembly with the dead end consisting of a load cell. The test specimen shall be tensioned to 80 percent of ultimate to 0 in 10 increments. For each increment, the gauge pressure, elongation and load cell force shall be recorded. The data shall be furnished to the Engineer. The theoretical elongations shown on the post-tensioning working drawings shall be reevaluated by the Contractor using the results of the tests and corrected as necessary. Revisions to the theoretical elongations shall be submitted to the Engineer for approval. Apparatus and methods used to perform the tests shall be proposed by the Contractor and be subject to the approval of the Engineer. After the initial testing, five (5) more tests shall be performed. These tests shall be spaced evenly throughout the duration of the Contract.

6.11 Prestressing Where pretensioning methods are used, the tension shall be fully maintained by some positive means during the period between tensioning and transfer. The transfer of stress shall take place slowly to minimize shock.

- i. **Straight Tendons** In the long line method of pretensioning, sufficient locator plates shall be distributed throughout the length of the bed to ensure that the wires or strands are maintained in their proper position during concreting. Where a number of units are made in the line, they shall be free to slide in the direction of their length and thus permit transfer of the prestressing force to the concrete along the whole line.

In the individual mould system, the moulds shall be sufficiently rigid to provide the reaction to the prestressing force without distortion.

- ii. **Deflection Tendons**

Where possible the mechanisms for holding down or holding up tendons shall ensure that the part in contact with the tendon is free to move in the line of the tendon so that frictional losses are nullified. If, however, a system is used that develops a frictional force, this force shall be determined by test and due allowance made as agreed by the Engineer.

For single tendons the deflector in contact with the tendon shall have a radius of not less than 5 times the tendon diameter for wire or 10 times the tendon diameter for a strand, and the total angle of deflection shall not exceed 150. Where the radius is less than 5 times the diameter of the tendon and the angle of deflection exceeds 150, the loss of strength of the tendon shall be determined by test and due allowance made.

The transfer of the prestressing force to the concrete shall be effected in conjunction with the release of hold-down and hold-up forces as approved by the Engineer

6.12 **Pre- tensioning**

- a) Pre-stressing strands shall be of diameter as per drawing, uncoated stress relieved low relaxation steel & from approved source
- b) Stock piling of HT Strands at site shall not be done especially during before & after monsoon season.
- c) HT Strands shall be stored about 30cm above the ground in a suitably covered & closed space to protect it from dampness.
- d) It shall also be wrapped with any suitable material for its protection against moisture & unwanted materials.
- e) The number of uncoated strands shall be placed in the reinforcement cage as per the span length mentioned in the approved drawings.
- f) In a number of strands, the number of fully bonded and partially bonded strands shall be identified as per the drawings.
- g) The partially bonded strands shall be a set of strands having a de-bonded length that shall be measured from the face of recess at the end of the pre cast element.
- h) The length of de-bonded strands from recess face shall be as per approved drawings.
- i) Strands shall be initially stressed with small pre-stressing force to remove slackness of the strands.
- j) After removal of slackness, strands & de-bonding tubes shall be thoroughly examined to ensure correct alignment.
- k) The strands shall be stressed at the stressing force as approved.
- l) Stressing shall be done with Stressing jacks by approved stressing agency.
- m) Stressing of strands shall be done either by single pull or multi pull jack, in case of single pull jack it shall be ensured that the strands shall be stressed symmetrically with respect to the centre line of the pre cast element.
- n) Stressing with multi pull jack shall also be done in proper sequence so that the transfer of stresses to concrete portion shall be uniform.
- o) A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in MORTH Specification

6.13 **Post Tensioning**

Tensioning force shall be applied in gradual and steady steps and carried out in such a manner that the applied tensions and elongations can be measured at all times. The sequence of stressing, applied tensions and elongations shall be in accordance with the approved drawing or as directed by the Engineer.

It shall be ensured that in no case, the load is applied to the concrete before it attains the strength specified on the drawing or as stipulated by the pre-stressing system supplier, whichever is more.

After pre-stressing steel has been anchored, the force exerted by the tensioning equipment shall be decreased gradually and steadily as to avoid shock to the pre-stressing steel or anchorage.

The tensioning force applied to any tendon shall be determined by direct reading of the pressure gauges or dynamo-meters and by comparison of the measured elongation with the calculated elongation. The calculated elongation shall be invariably adjusted with respect to the modulus of elasticity of steel and area of strand for the particular lot as given by the manufacturer.

The difference between calculated and observed tension and elongation during prestressing operations

shall be regulated as follows:

- a) If the calculated elongation is reached before the specified gauge pressure is obtained, continue tensioning till attaining the specified gauge pressure, provided the elongation does not exceed 1.05 times the calculated elongation. If 1.05 times the calculated elongation is reached before the specified gauge pressure is attained, stop stressing and inform the Engineer for proper remedial measure.
- b) If the calculated elongation has not been reached at the specified gauge pressure, continue tensioning by intervals of 5kg/sq. cm until the calculated elongation is reached provided the gauge pressure does not exceed 1.05 times the specified gauge pressure. If the elongation at 1.05 times the Specified gauge pressure is less than 0.95 times the calculated elongation, the following measures must be taken, in succession, to determine the cause of this lack of discrepancy:
 - I. Check the correct functioning of the jack, pump and leads.
 - II. De-tension the cable. Slide it in its duct to check that it is not blocked by mortar which has entered through holes in the sheath. Re-tension the cable if free.
 - III. Re-establish the modulus of elasticity of steel for the particular lot from an approved laboratory. Contractor may suggest other remedial measure for approval of the Engineer.

If the required elongation is still not obtained, further finishing operations such as cutting or sealing, should not be undertaken without the approval of the Engineer.

When stressing is taken up from one end only, the slip at the end remote from the jack shall be accurately measured and an appropriate allowance made in the measured extension at the jacking end.

A complete record of prestressing operations along with elongation and jack pressure data shall be maintained in the format given in Appendix 1800/II of MOST Specification or as per format approved by Engineer.

Any breakage of individual strand / groups of strands during tensioning shall require immediate de-stressing of all strands and replacement of the all the strands by fresh strands.

6.14 **Grouting of Pre-stressed Tendons**

Post tensioned tendons shall be bonded to concrete of the prestressed member as well as protected from corrosion by cement grout which shall fill the ducts fully, without leaving any entrapped air or water pockets, voids created by evaporation of excess water in the grout and bleeding.

Prior to grouting, all cables shall be tested with water pressure of 0.3 MPa for approximately 3 minutes, to investigate leakages and connectivity of ducts.

Since the epoxied joint (in precast segmental construction) is of paramount importance to ensure long-term durability of prestressing cables, this field test shall be taken as an indication of the Contractor's quality of work in general and effectiveness of the epoxy joint executed by him. The approval / rejection of such span shall depend on the decision of Grouting of pre stressed tendons should be carried out as early as possible but not later than 2 weeks from the date of prestressing. Whenever this stipulation cannot be complied with for unavoidable reason, adequate temporary protection of the steel against corrosion by methods or products which will not impair the ultimate adherence of the injected grout should be ensured till grouting.

All other aspects of grouting of cables shall be governed by latest MORTH- Specification and IRC-112:2020. If there is any discrepancy of clauses between them, IRC 112:2020 shall prevail. A record of grouting operations shall be maintained in the format as given in Appendix 1800/III of MORTH Specifications.

6.15 Ducts for Unbonded Tendons

Unless shown otherwise on the Drawings, ducts and injection tubes in the superstructure and substructure shall be formed from high density polyethylene (HDPE) which shall incorporate a stabilizing agent to prevent Ultra Violet Light (UVL) degradation.

The minimum wall thickness of the ducts shall be such that the ducts are capable of resisting the pressures developed during installation of the protection compound. The ducts shall be smooth bore.

Ducts with external diameters greater than 70 mm shall be transported and stored in straight lengths. The distance between supports shall be limited to 3m and the height of storage to 1.5 m. Alternatively, ducts may be transported and stored in coils provided that they are fixed to the tolerances required by the Designer.

Damaged ducts shall not be used in the Works.

No boring of any No boring holes in the ducts shall be permitted once the tendons are installed.

U-bend anchorages shall be formed from smooth-bore unwelded steel tubes and shall comply with the requirements of BS 4360.

Joints between ducts, ducts and anchorages and ducts and U-bend anchorages shall be formed by a coupling device using thermo-fusion techniques which shall provide a watertight seal to the ducts and shall be capable of resisting the pressure developed during installation of the tendon protection compound. The inner surfaces of the joints shall form a smooth transition between ducts and U-bend anchorages to allow satisfactory installation of the tendons. All coupling devices shall be approved by the Engineer.

Injection tubes shall be provided at the U-bend anchorages, the stressing anchorages and at any other positions on the length of the ducts which are required to achieve satisfactory installation of the tendon protection compound. The injection tubes at the U-bend anchorages shall also be used as drainage points for the U-bend. The connection between the ducts and the injection tubes shall be watertight and capable of resisting the pressure developed during installation of the tendon protection compound.

All injection tubes shall be sealed after use to prevent the ingress of water to the satisfaction of the Engineer.

After completion of all duct joints and before completion of the insitu joints between precast segments and before installation of the tendons, all ducts shall be air tested to an equivalent 100 mm water gauge unless otherwise directed by the Engineer. The test shall be performed in accordance with BS 8301 Section 5.

Any ducts which do not contain tendons shall remain empty and shall be sealed at each end to prevent the ingress of water.

6.16 Prestressing Tendons - Trial Construction-Unbonded Tendons

Engineer. However, no extra payment shall be made to the contractor for such epoxy injection.

Before commencing construction of the precast segments a trial shall be carried out which shall demonstrate the satisfactory installation, removal and replacement of a prestressing strand together with the proposed techniques for duct jointing, duct testing and installation of the tendon protection compound.

- i. The tendons shall be stressed in accordance with this Specification.
- ii. The ducts shall be filled with a tendon protection compound in accordance with the specification as detailed in relevant subsections and the tendon extension and anchorage shall be protected as if they were to be included in the permanent works.
- iii. The trial shall demonstrate that any one strand may be destressed, removed, inspected, replaced and re-stressed and that no voids are created within the tendon protection compound, all to the satisfaction of the Engineer.
- iv. The trial shall also demonstrate that all of the strands in a duct may be removed and that the tendon protection compound can be removed from the ducts and U-bend anchorage to the satisfaction of the Engineer.
- v. The trial shall be undertaken using the prestressing system to be used in the permanent works and shall be approved by the Engineer.

6.17 **Prestressing Tendons - Temporary Tendons**

Temporary tendons may be re-used as temporary tendons elsewhere provided special precautions are incorporated at the anchorages to ensure tendons are not damaged. These precautions shall be approved by the Engineer

The tendons shall be enclosed within a duct throughout their length.

The tendons shall be pre-treated in accordance with the specifications as detailed in relevant subsections and the protection compound shall be applied to the outer surfaces of the tendon after each use.

The maximum jacking force for the re-usable temporary tendons shall not exceed 70 percent of their guaranteed minimum breaking load.

After removal of the tendons the ducts shall be sealed at each end to prevent the ingress of water.

6.18 **Preparation for Casting**

- a) The Contractor shall submit for approval, in accordance with the provisions of the Employer's Requirements, working drawings of the prestressing system proposed for use. For initial review, 3 sets of such drawings shall be submitted.
- b) After review, between 6 and 12 sets, as requested by the Engineer, shall be submitted for final approval and for use during construction.
- c) The working drawings of the prestressing system shall show complete details and be accompanied by substantiating calculations of the method and materials the Contractor proposes to use in the prestressing operations, including any additions or rearrangement of reinforcing steel from that shown on the Drawings. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, working stresses, anchoring stresses, type of ducts, and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members.
- d) Working drawings shall be A1 size and each drawing and calculation sheet shall include the job site, name of the structure as shown on the Contract Drawings and Contract name.
- e) Working drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the work. Such time shall be proportional to the complexity of the work but in no case shall such time be less than eight (8) weeks.
- f) At the completion of each structure, one set of reproducible mylars of the corrected original tracing of all working drawings for said structure shall be furnished to the Engineer. Drawings which are

common to more than one structure shall be provided for each structure. An index prepared specifically for the drawings for each structure containing sheet numbers and titles shall be included.

- g) Reinforcing steel shall be fabricated and placed in accordance with the Drawings. and as required herein. No reinforcing steel shall be cut and removed to permit proper alignment of stressing ducts. Any bar that cannot be fabricated to clear the conduits shall be replaced by additional bars with adequate lap lengths and shall be submitted to the Engineer for approval. In the plane of the steel parallel to the nearest surface of concrete, bars shall not vary from plan placement by more than 12 mm or one-tenth (1/10) of the spacing between bars, whichever is less.
- h) All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Prestressing steel that has sustained physical damage at any time shall be rejected. The development of visible rust or other results of corrosion shall be cause for rejection, when ordered by the Engineer.
- i) Prestressing steel shall be packaged in containers or shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor which prevents rust or other results of corrosion shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.
- j) The shipping package or form shall be clearly marked with a statement that the package contains high-strength prestressing steel, and the care to be used in handling; and the type, kind and amount of corrosion inhibitor used, including the date when placed, safety orders and instructions for use.
- k) Prestressing steel for post-tensioning which is installed in members prior to placing and curing of the concrete, shall be continuously protected against rust or other corrosion, until grouted, by means of a corrosion inhibitor placed in the ducts or applied to the steel in the duct. The corrosion inhibitor shall conform to the requirements specified herein.
- l) When steam curing is used, prestressing steel for post-tensioning shall not be installed until the steam curing is completed.
- m) All water used for flushing ducts shall contain either quick lime (calcium oxide) or slaked lime (calcium hydroxide) in the amount of 13g. per litre. All compressed air used to blow out ducts shall be oil free.
- n) When acceptable prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within 10 calendar days after the installation of the prestressing steel, rust which may form during said 10 days will not be cause for rejection of the steel. Prestressing steel installed, tensioned and grouted in this manner, all within 10 calendar days, will not require the use of a corrosion inhibitor in the duct following installation of the prestressing steel. Prestressing steel installed as above but not grouted within 10 calendar days shall be subject to all the requirements in this section pertaining to corrosion protection and rejection because of rust. Any time acceptable prestressing steel for pretensioning is placed in the stressing bed and is exposed to the elements for more than 36 hours prior to encasement in concrete, adequate measures shall be taken by the Contractor, as approved by the Engineer, to protect said steel from contamination or corrosion
- o) All ducts shall be located within 5 mm of the locations given on approved fabrication plans. Method and spacing of supports for ducts shall be shown on the working drawings. After installation in the forms, the end of the ducts shall at all times be sealed to prevent entry of water and debris. Following each pour of concrete, the Contractor will be required to demonstrate that all empty ducts are free of water and

are unobstructed and undamaged. Immediately prior to installation of the prestressing steel, the Contractor shall again demonstrate to the satisfaction of the Engineer that all ducts are unobstructed and that they are free of water and debris.

Where tendons are described in the Contract as debonded from the concrete they shall be covered with sleeves approved by the Engineer. The ends of the sleeves shall be taped to the tendon to prevent the ingress of grout.

- p) Concrete shall not be deposited into forms until the entire set-up of the forms, reinforcement, ducts, and anchorage has been thoroughly inspected and checked. The placing of concrete will not be permitted until the Engineer is satisfied that the rate of producing and placing concrete will be sufficient to complete the proposed pour and finishing operations within the scheduled time, that experienced concrete finishers are available where required for finish work and all necessary finishing tools and equipment are on hand at the site of the work and are in satisfactory condition for use.
- q) Conveying equipment shall be of a size and design that will permit the placing of concrete within the time limits specified. Conveying equipment shall be cleaned at the end of each operation or work day and just prior to reuse shall again be checked and cleaned of hardened concrete and foreign materials. Belt conveyors shall be horizontal or at a slope which will not cause excessive segregation or loss of ingredients. Concrete shall be protected against undue drying or rise in temperature. An approved arrangement shall be used at the discharge end to prevent aggregate segregation. Mortar shall not be allowed to adhere to the return length of the belt. Concrete shall be discharged into a hopper or through a baffle.
- r) The concrete shall be first placed in the web forms followed by placement at the bottom slab and then in the top form. Any alternate sequence shall be submitted to the Engineer for approval.

All concrete shall be consolidated by means of approved vibrators together with any other equipment necessary to perform the work as specified. Internal vibrators shall have a minimum frequency of 8,000 vibrations per minute and sufficient amplitude to consolidate the concrete effectively. At least two (2) standby vibrators in working condition shall be provided for emergency use in case of malfunction. The use of external vibrators for consolidating concrete will be permitted and may be required when the concrete is inaccessible for adequate consolidation. When external vibration is used, the forms shall be constructed sufficiently rigid to resist displacement or damage. Vibrating of concrete shall be done with care and in such a manner as to avoid displacement of reinforcing, conduits, and other items to be fixed in place.

6.19 **Safety Precautions during Tensioning**

Care shall be taken during tensioning to ensure the safety of all persons in the vicinity.

Jacks shall be secured in such a manner that they will be held in position, should they lose their grip on the tendons.

No person shall be allowed to stand behind the jacks or close to the line of the tendons while tensioning is in progress.

The operations of the jacks and the measurement of the elongation shall be carried out in such a manner and such a position that the safety of all concerned is ensured.

A safety barrier shall be provided at both ends to prevent any tendon, which might become loose from recoiling unchecked.

Safety net shall be placed below the End segment during prestressing to avoid any falling of any broken concrete pieces of segment on the road in case of any cracks in End segment during prestressing.

During actual Prestressing operation, warning signs shall be displayed at both ends of tendon and below the jack location at ground level.

After pre-stressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without approval of the Engineer.

No welding shall be permitted on or near tendons nor shall any heat be applied to tendons. Any tendon which has been affected by welding, weld spatter or heat shall be rejected.

6.20 **Tolerances**

Permissible tolerances for positional deviation of Pre-stressing tendons in cast-in-situ construction shall be limited to the following

Variation from the specified horizontal profile	:	5 mm
Variation from the specified vertical profile	:	5 mm
Variation from the specified position in member	:	3 mm

6.21 **Transportation and Storage of Unit:**

Precast girders shall be transported in an upright position. Points of support and the direction of reactions with respect to the girder shall approximately be the same during transportation and storage as when the girder is placed in final position.

When members are to be stacked, they shall be firmly supported at such bearing positions as it will ensure that the stresses induced in them are always less than the permissible design stresses. Further, inclined side supports shall be provided at the ends and along the length of a precast girder to prevent lateral movements or instability.

Care shall be taken during storage, hoisting and handling of the precast units to prevent their cracking or being damaged. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense.

6.22 **Tests and Standards of Acceptance**

The materials shall be tested in accordance with these Specifications and shall meet the prescribed criteria. The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

6.23 **DELETED**

6.24 **Pre-cast Pre-tensioned Girders General**

This section generally applicable to precast pre-tensioned girder.

a. **Construction sequences**

Sequence of Operations for pre-tensioned girders.

For pre tensioned girders of standard length, the sequence of operation, starting from erection of formwork, shall be as follows:

- (i) Erection of formwork
- (ii) Placement of reinforcement cage
- (iii) Threading of HT strands from movable bulkhead to fixed anchor through individual casting beds, end

shuttering and reinforcement cages. De-bonding tubes are to be placed in position for strands to pass through. The de-bonding tubes shall be 25mm internal dia, hollow, rigid HDPE pipes and the same shall be provided as per detailed drawing/approval of engineer without any extra cost.

- (iv) Removal of initial slackness in the strands by using J-20 mono-strand jack or equivalent up to 20KN force.
- (v) Complete the balance pre-stressing by using mono-strand jacks of desired capacity and lock individual strands. Locking plate to be inserted between the movable bulkhead and fixed bulkhead. Mark individual strands for checking the slip of strands.
- (vi) Seal the ends of de-bonding tubes and close the formwork to correct dimension.
- (vii) Pour concrete. Keep test cubes in the same environment as that of the girder concrete.
- (viii) Allow concrete to set for 3-4 hours before steam curing if required is started.
- (ix) Once steam curing (if required) is over as per direction of the Engineer, remove covers and allow the girders to cool to ambient temperature. Test the cubes for determining compressive strength of concrete in girders.
- (x) If adequate compressive strength is obtained, release the strands and check the slip of strands. Releasing shall be done by displacement of one side of the anchor supports, or both supports alternatively. Releasing shall be done on every strands simultaneously. Releasing shall be smooth and progressive. Sudden releasing by rupture is prohibited.
- (xi) Cut the strands, remove the formwork and lift the girders to inspection bay for removal of end plate and bending of projected bars.
- (xii) Cut the projected strands from girder ends and apply epoxy coating to strands. Mark the girders.
- (xiii) Wet curing.
- (xiv) Arrange for stacking, lock handling and transportation to site.

b. Concreting for Precast Girders

Unless otherwise mentioned hereunder, the concrete shall be prepared, mixed and placed in position in accordance with the particular specifications given earlier. The Contractor shall maintain a record of the proportions of mix at the batching plant and produce the same for checking by the Engineer whenever required. Casting of girder shall be done in a single pour.

The contractor shall take care in placing reinforcement cage so that cables/strands are not disturbed and the minimum cover as recommended in the drawing is available. The girder shall be cast with specified camber and curvature.

c. Forms for Precast Pre-stressed Girders

The pre-tensioned girders shall be cast at casting yard. The contractor shall clean, thoroughly, the steel forms of all dirt, mortar and other matter such as chips, blocks etc. prior to using them. The contractor shall check the accuracy of alignment and rectify the inconsistencies, if any, of the forms and steel casting bed. Contractor shall also take care of bulkheads including positioning of jacks who may become necessary to suit the design requirement of the precast girders or as instructed by the Engineer. Forms shall be specifically suited to external form vibrators.

Some of the precast pre-tensioned girders are curved. The moulds in the precast yard shall be adjustable to construct these curved beams as per the Construction drawings.

d. Permissible tolerances

The formwork for precast girder shall be so made that it produces a finished concrete true to shape, lines, levels, plumb and dimension shown on the drawings subject to the following tolerance unless otherwise specified in these documents or directed by Engineer.

Length of Girder

Per 3 m length	-	±3 mm
Maximum for entire length	-	±10 mm

Cross-sectional Dimension

Web	-	±3mm
Flange/Slab	-	± 3 mm
Depth	-	± 3 mm
Plumb	-	1 in 1000
Location of Strand	-	± 3 mm

e. Quality Control and Testing Materials

The contractor shall carry out all tests of materials in order to guarantee the specified quality in accordance with the relevant clauses of this specification.

f. Steam Curing of Precast girders**g. Marking of Precast Elements**

Precast Elements shall be marked immediately after removing the side forms with paint of approved quality. The elements shall be marked at minimum four places on outer faces of webs and at the ends with the following details:

a) Girder Number. Date of casting the girder.

h. Tests of Precast Pre-tensioned Elements

Precast units shall be load tested at service load after erection on site and up to failure at precast yard, as approved by the Engineer.

Prior to carrying out load tests, if required, the contractor shall submit arrangement of testing, loading etc. and shall carry out any modifications, if needed, on the existing testing arrangement to the satisfaction of the Engineer at no extra cost. The contractor shall submit a report containing test results and observations etc. to the department.

i. Handling, Stacking, Transportation and Placing of Precast Element

All aspects of casting, pre-tensioning, handling, transportation and erection shall be proposed by contractor in detailed method of statements along with calculations and submitted for approval of the Engineer. Detailed fabrication drawings of each element to be submitted by contractor for approval of the Engineer.

All handling, lifting and erection equipment shall be load-tested prior to their use and also when ordered by the Engineer.

Handling of precast members shall be allowed only after the same have attained the specified strength.

The members shall be lifted only from the positions specified for this purpose. Precast members are to be lifted, stacked and/or handle such that self-weight is mobilized and supports are located as per their final bearing conditions.

Lifting inserts are to be proposed by the contractor for approval of the Engineer.

For precast pre-tensioned members arrangements would be required for de bonding of strands for part length towards end of members. All exposed edges of precast elements should have chamfers of 10mm x 10mm. All necessary safety precautions will be taken to avoid any accident and damage during handling of the precast

units. Special precautions shall be taken during and after erection for stability of the precast elements.

The contractor shall submit detailed plan showing stacking of precast elements at casting yard and at site and shall obtain approval of the Engineer.

The precast girders shall be stacked on timber or any other suitable supports provided over the firm ground/base. The girders shall be placed side by side on these supports. Care shall be taken to avoid any undue loading of girders during stacking.

The girders shall be transported in an upright position and points of support and the direction of reaction with respect to the girders shall approximately be the same during storage as when the girder is placed in final position. The transportation of precast units to position or to lifting position (to the deck) shall be done during night unless otherwise permitted by the Engineer.

The contractor shall obtain necessary permission from the concerned departments for transporting the precast girders. The contractor should study the problems likely to arise in the transportation of long girders on heavy traffic road. The road movements shall be possible only from 12.00 midnight to 6.00 AM. Mode of transportation, proposed by Contractor, shall be approved by the Engineer before commencing the transportation operation. Proper precautions should be taken during handling of precast units during transportation and all traffic safety measures taken.

The contractor shall be required to execute all handling and re handling of girders including interim storages etc., till these are finally erected, within his quoted rate. Contractor can plan the activities in advance to reduce such handling if practicable. The contractor should plan for emergencies in case of failure of a trailer. Adequate standby arrangements will have to be made. Transport, handling and storage operations must:

- Ensure the security of all personnel by avoiding any risk of instability of the members or of the lifting or handling equipment,
- Avoid any unexpected stress and excessive deformation,
- Eliminate every risk of deterioration capable to alter the aspect or the durability of the structure.
- Avoid any thermal shock during storage.

When placing the precast units in position, care should be taken to place the right unit in the right position with minimum handling of units. Care should also be taken to prevent any damage to the precast units. Units damaged by improper storing or handling/rehandling shall be replaced by the contractor at his own expense. The methodology proposed by the Contractor for placing these units, shall be approved by the Engineer, before commencement of the work. The rate for the reinforcement in the girders shall also include cutting of temporary handles (rebar), if required. The contractor shall prepare and submit a form for each span indicating the location and girder number of each girder.

j. **Shop Drawings and Design Calculations for Construction Procedures General**

The Contractor shall submit according to a schedule, complete details and information concerning the method, materials, equipment and procedures he proposes to use. These shall be called "Method Statements". Method Statements shall be submitted sufficiently in advance of the start of superstructure field construction operations, so as to allow the Engineer adequate review period, which shall not be less than 30 days. The submittals shall invariably include step-by-step casting, lifting, curing, stacking, transportation and erection procedure. The Contractor's Method Statements shall also include all calculations, drawings and information as may be relevant. The following points are specifically highlighted:

- Accommodating block-outs, openings and protrusions. Protruding re-bars may be needed (track starter rebar, for example). Anchorages and inserts for OHE poles, signalling equipment and cable routing supports shall also be included where needed in precast beams.
- Adjusting to changes in girder length, curve, inclination and camber as shown in Detailed Design Drawings.
- Adjusting the profile to take into account design camber values
- Stripping without damage to the concrete.
- The form design shall provide a tapered portion at both end for bearing of elastomeric bearing.
- Forms shall not be removed until the concrete has attained adequate strength. Care should be exercised in removing the forms to prevent spalling and chipping of the concrete.
- All side, bottom and end forms for precast beams shall be constructed of steel.
- Forms shall be of sufficient thickness, with an adequate external bracing and stiffeners, and shall be sufficiently anchored to withstand the forces due to placement and vibration of concrete. No tie bolt is permitted for casting of precast beam. Joints in the forms shall be designed and maintained for mortar tightness. The grade and alignment of forms shall be checked each time they are set and shall be maintained during the casting of concrete.

k. **Design Calculations for Construction Procedures**

Design assumptions and calculations shall be submitted for temporary pre-stressing, false work, erection devices, formwork or other temporary construction which may be required to complete the work.

- 1) Assumptions and Calculations shall also be submitted to substantiate the system and method of permanent and temporary pre-stressing proposed by the Contractor.
- 2) In the sections that follow, specific recommendations for precast full span construction for superstructure are given apart from certain special aspects of construction.
- 3) Shop Drawings for Precast Full Span Construction
- 4) The Contractor shall submit detailed shop drawings for approval. The shop drawings shall be based on Final Design Drawings issued by the Client to the Contractor and shall include:
- 5) Fully and accurately dimensioned views showing the geometry of precast units including all projections, recesses, notches, openings, block-outs, blister if any and where acceptable, as well as other pertinent details.
- 6) Details of any special reinforcing required for handling of precast units or for other purposes. Also all bar bending schedules shall be presented based on reinforcement schedules given in Final Drawings issued by the Client.
- 7) Details and locations of all other items to be embedded in the precast units such as inserts, lifting devices shall be shown.
- 8) Pre-stressing system details shall include sizes and properties of strands, assemblies and stressing procedure, Graphs, charts or tables showing the theoretical location of each precast units, as erected or placed shall be furnished to the Engineer for his use in checking the erection of the superstructure. Detailed procedures for making geometry correction shall be designed.
- 9) Details of sealing of de bonding tubes and protection of strands.
- 10) Method of installing bearings and expansion joints shall be given including approved manufacturer's recommendations.
- 11) Forms For Precast Full Span Construction
- 12) Forms for precast units construction shall be metal form work only. Shop drawings shall be submitted for all formwork. The precast units during storing /curing shall always be supported as shown in tender drawings or as approved by Engineer only.
- 13) In addition to the requirements of the Standard Specifications, the forms used for precasting shall be capable of:
- 14) Producing the precast units within the tolerances permitted in this section.

- 15) Accommodating block-outs, openings and protrusions. Protruding re-bars will be needed at least for second-pour plinths. Anchorages and inserts for OHE poles, signaling equipment and cable routing supports shall also be included where needed in precast units.
- 16) Adjusting to changes in precast units geometry as shown in Final Design Drawings issued by the Client, or for correcting previous minor casting errors to prevent accumulation.
- 17) Adjusting the profile to take into account design camber values
- 18) Stripping without damage to the concrete.
- 19) Joints in external formwork shall be avoided as far as possible. Where sections of forms are for some reason to be joined on the exterior face of the precast units, an offset in excess of
- 20) 0.5mm for flat surfaces and 1 mm for comers and bends will not be permitted.
- 21) Forms shall not be removed until the concrete has attained adequate strength Care should be exercised in removing the forms to prevent spading and chipping of the concrete.
- 22) All side, bottom, inside and header forms for precast units construction shall be constructed of steel.
- 23) Forms shall be of sufficient thickness, with an adequate external bracing and stiffeners, and shall be sufficiently anchored to withstand the forces due to placement and vibration of concrete. Internal bracing and holding devices in forms shall be limited to stay bolts in webs, which can be removed from the concrete surface to permit patching following form removal. Joints in the forms shall be designed and maintained for mortar tightness. The grade and alignment of forms shall be checked each time they are set and shall be maintained during the casting of concrete.
- 24) Metal forms shall be reasonably free from rust, grease or other foreign materials. All forms shall be cleaned thoroughly prior to each casting operation. End headers shall be maintained to smooth casting surface.
- 25) All formed surfaces for casting members shall be constructed and maintained to provide precast units tolerances.
- 26) The faces of all forms, other than end headers, shall be properly cleaned and treated with form oil or other bond breaking coating prior to placing concrete. The oil or other materials used shall be of a consistency and composition to facilitate form removal. Materials, which stain or react with concrete, shall not be used. Care shall be exercised to facilitate formwork and precast units removals without damage to the concrete.
- 27) de bonding tubes and locations of additional reinforcement necessary to resist pre- stressing stresses.

6.25 **Measurements for Payment:**

Prestressed Concrete shall be measured in -cubic metres based on theoretical cross- sectional area and length. The volume occupied by mild steel reinforcement / HYSD bars; high tensile steel, sheathing and anchorages shall not be deducted. Measurement for transportation of precast member/segment shall be measured in metric tonnes based on standard density of concrete equivalent to 2.5 t/cum including the weight of rebars, sheathing ducts, embedment's etc.

Supplying, fixing and tensioning steel HT wires/strands/cables (measured between anchorages) shall be measured in metric tonnes on theoretical basis based on the standard weight per metre length. Each size shall be measured separately. No allowance shall be made for extra lengths in anchorages or elsewhere.

HDPE sheathing, grouting operations, couplers for sheathing, anchorages, epoxy protection of anchorages, stressing using Multi strand stressing jacks, samples for testing including testing, sealing of anchorage recess with concrete (same grade as structure) and all related operations to complete the work shall all be deemed to be included in the main item of HT strand and shall not be paid for separately. The rate shall also include payments, if any to be made to the supplier of the prestressing system who has to monitor,

ensure and certify the correctness of all the arrangements/operations.

Bi-RIDE

TECHNICAL SPECIFICATION S-07: STRUCTURAL STEEL WORK

S.07: STRUCTURAL STEEL WORKS**7.1 STRUCTURAL STEELWORK SPECIFICATIONS- GENERAL****7.1.1 Scope of Specification**

This specification covers the scope of work of structural steel works, submittals by the contractor, applicable codes of practice for structural steel work and the specifications for the materials to be used, including steel, bolts & nuts, washers etc. and the storage thereof. These specifications shall be read in conjunction with the CPWD specifications 2019, MORTH specifications and other relevant reference specifications described in the S.01 of Section-VII-F of these specifications.

7.1.2 Scope of Work

The scope of work for the contractor in respect of structural steel work shall cover, but shall not be limited to the following:

- A. Submittal of detailed design drawings, preparation of complete detailed fabrication drawings and erection marking drawing based on the design drawings, required for all the permanent and temporary structures
- B. Submittal of revised design with calculations and detailed fabrication drawings, in case any substitution of the designed sections is required.
- C. Submittal of design calculations for joints and connections to be developed by the contractor along with detailed fabrication drawings.
- D. Supply of all raw steel materials for fabrication, taking into account wastage margin, including storage and upkeep of the materials.
- E. Furnishing of all materials, labour, tools and plant and all consumables required for fabrication and supply of all necessary bolts, nuts, washers, tie rods and welding electrodes for field connections, with necessary wastage margins.
- F. Fabrication of the steel works in accordance with the approved fabrication drawings including all shop assembling, matching and marking. Design, manufacture / fabrication and provision of all jigs, fixings, manipulators etc. required for the fabrication.
- G. Provision of shop painting and requisite site painting to all fabricated steelwork, as per requirements of the related specification of the painting.
- H. Suitability marking, bundling and packing for transport of all fabricated materials. Preparing and furnishing detailed bill of materials, drawing office dispatch lists, bolts lists and any other lists of bought out items required in connection with the fabrication and erection of the structural steelwork.
- J. Loading, Transportation and unloading of all fabricated structural steel materials from site storage yard to erection site, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and/or as directed by the Engineer.
- K. The contractor shall submit, for examination by the Engineer, detailed particulars of his proposed methods of erection of the superstructure steelwork, together with complete calculations relating to strength and deflection. If the erection scheme necessitates the attachment of strength steelwork (temporary work) to the permanent steel work, the contractor shall submit, for approval of the Engineer, the methods he proposes for making good the permanent steelwork after removing the temporary work. The contractor shall also submit the design and fabrication drawings of all temporary supports, staging, braces etc. required for safe erection, for approval of the Engineer.
- L. The contractor shall provide all construction and transport equipment, tools, tackles, consumables, materials, labour and supervision required for the erection of the structural steelwork.

- M. Receiving, unloading, checking and moving to storage yard, storage, guarding and upkeep of fabricated steelwork and other consumable materials and fasteners at site.
- N. Transportation of all fabricated structural steel materials from site storage yard, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and/or as directed by the Engineer.
- O. Setting out, aligning, ensuring verticality (proper plumb), levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the erection scheme, or as directed by the Engineer.
- P. Provision of requisite site painting to all fabricated steelwork, as per requirements of related specifications of the painting.
- Q. Providing protective treatment to the erected steel structures, as per Specification.
- R. All major modifications of the fabricated steel structures, as directed by the Engineer, including but not limited to the following:
 - i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
 - ii) Cutting, chipping, filling, grinding etc. if required or preparation and finishing of site connections.
 - iii) Reaming of holes for use of higher size bolt if required.
 - iv) Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
 - v) Fabrication of parts omitted during fabrication by error, or subsequently found necessary
 - vi) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
 - vii) Carry out tests in accordance with the related specification.
- S. Preparing and furnishing detailed bill of materials of fabricated parts received from the Client or its authorized fabricator.
- T. The Contractor shall observe all safety requirements for erection of structural steelwork as covered in IS: 7205.

7.1.3

Submittals

- A. On commencement of the Project, the Contractor shall submit the following:
Prior to the technical submittals, the contractor shall submit the proposed overall schedule for documentation such as calculations, shop/ working drawings, plan/ procedures and records. Submission of samples, process of fabrication / delivery/ erection for the approval of the Engineer.

Complete fabrication drawings, material lists, cutting lists, bolt lists, welding schedules and QC schedules, based on the design drawings furnished to him and in accordance with the approved schedule. It is highlighted that structural steel members dimensions indicated in tender drawings are tentative only, and may be modified during final design stage.

Results of any tests, as and when conducted and as required by the Engineer.

Manufacturer's test reports in respect of steel materials, bolts, nuts and electrodes, as may be applicable.

A detailed list of all constructional plant & equipment, such as cranes, derricks, winches, welding sets, erection tools etc. their make, model, present condition and location, readily available with the contractor and the ones he will employ on the job to maintain the progress of work in accordance with the contract.

The total number of experienced personnel of each category, like fitters, welders, riggers etc., which he intends to deploy on the project.

- B. The contractor shall submit a detailed erection programme for completion of the work in accordance with contract. This will show, in a proforma approved by the Engineer, the target programme, with details of erection proposed to be carried out in each week, details of major equipment required and an assessment of required strength of various categories of workers.
- C. The contractor shall submit complete design calculations for any alternative sections proposed by him, for approval of the Engineer. Use of any alternative section shall be subject to approval of the Engineer. However, no escalation in unit rates of work shall be allowed for such cases.

7.1.4 Drawings:

7.1.4.1 The Engineer will supply to the Contractor profile drawings showing sizes of all structural members and typical connection details.

7.1.4.2 Should there be any discrepancy in the drawings the Contractor is to refer the matter to the Engineer. The Contractor shall further provide a drawing showing the accurate setting out to line and level of all the anchor bolts intended for the work in sufficient time for their inclusion in the work so as to maintain the building program.

7.1.4.3 The Contractor is to prepare all the necessary fabrication shop drawings and these shall be submitted to the Engineer in duplicate and be approved by him before fabrication is commenced. All such drawings shall show the dimensions of all parts, method of construction, welding and bolting. A further set of all approved fabrication drawings shall be supplied by the Contractor for use of the Engineer as required.

7.1.4.4 Approval by the Engineer of drawings or any other particulars submitted by the Contractor shall not relieve the Contractor of full responsibility for any discrepancies, errors or omissions therein. The Contractor shall at his own expense supply such additional copies of his working drawings as are required for the use of the interested parties.

7.1.5 Furnishing of Information

- A. Design drawings shall be furnished by the contractor and all such drawings shall form part of these specifications.
- B. The Engineer reserves the right to make changes in the design drawings even after release for preparation of shop drawings to reflect addition, omission & modifications in data/details and requirements. Contractor shall consider such changes as part of these specifications and the contract, and no extra claims shall be entertained on this account.
- C. Design drawings, approved by the Engineer, will show as appropriate the salient dimensions, design loads, sizes of members, location of openings at various levels and other necessary information required for the preparation of fabrication drawings, designs and erection details.
- D. It shall be clearly understood that the drawings of the Engineer are design drawings. The typical details of connections, cuts, notches, bend, etc. were shown in the design drawings are only for general guidance of the contractor. The contractor shall design and develop all such details based on the design forces and functional requirements.
- E. In case of variations in design drawings and specifications, the decision of the Engineer shall be final. Should the contractor, find any discrepancy in the information furnished by the Engineer, same shall be immediately brought to the notice of Engineer for resolution. The contractor shall obtain clarifications on discrepancies from Engineer before proceeding with the work.

- F. No detailed shop drawings will be accepted for examination by the Engineer unless the same, have first been completely checked by the contractor's qualified structural engineer (independent agency to be appointed by contractor) and are accompanied by an erection plan showing the location of all pieces detailed. The contractor shall check and ensure that detailing of connections is carefully planned to obtain ease in erection of structures, including field-welded connections and/or bolting.
- G. No fabrication work shall be started by the contractor without having obtained approval of Engineer on the relevant drawings. Approval by the Engineer of any of the drawings shall not relieve the contractor of his responsibility to provide correct design of connections, workmanship, fit of parts, details, materials and errors or omissions of all work shown thereon. The approval of Engineer shall constitute approval of the size of members, dimensions and general arrangement, but shall not constitute approval of the connections between members and other details.
- H. Drawings, for approval, shall be submitted by the contractor in an orderly manner commensurate with erection sequence and approved construction programme.
- I. The contractor shall furnish ten prints of all approved final drawings for field use and record purpose.
- J. The drawings prepared by the Contractor, and all subsequent revisions thereof shall be at the cost of the Contractor, and no separate payments shall be made for the same. Revisions shall incorporate all modifications, field changes, substitutions etc. effected. The rates/prices quoted for fabrication work shall be deemed to include the cost of such drawing work.
- K. The Contractor shall give due consideration to the need of trial assemblage at shop, weight and size limitation of elements for transportation from shop to construction site, temperature variation of 25 degree centigrade between the fabrication shop and site, site measurements or the as- built dimensions and avoidance of site welding except for fixtures. All the drawings shall be prepared in metric units. The drawings should preferably be of A-1 standard size, and the details shown therein shall be clear /and legible. These drawings shall include but shall not be limited to the following:
 - i) Assembly drawings, giving exact sizes of the sections to be used and identification marks of the various sections.
 - ii) Dimensional drawings of base plans (plates), anchorages detail in foundation, foundation bolts location etc.
 - iii) Complete bills of materials and detailed drawings of all sections including their billing weights.
 - iv) Shop details of temporary structures together with detailed calculations.
 - v) Detailed shop drawings for proper co-ordination with the concrete components to which the steel members shall be connected, as required.
 - vi) Any other drawings or calculations that may be required for proper completion of the works and clarification of the works or substituted parts thereof.
 - vii) All 'as-built' drawings.

7.1.6

Applicable Codes of Practice

The following specifications, standards and codes are included as part of this Specification. All standards, specifications, codes of practice current on the date of signing of agreement and referred to herein shall be applicable

- | | |
|-------------------|---|
| 1. IS: 800 (2007) | Code of Practice for General Construction in Steel. |
| 2. IS: 808 (1989) | Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections. |

3. IS: 814 (1991)	Covered Electrodes for Manual Metal Arc Welding of Carbon & Carbon - Manganese Steel
4. IS: 816 (1969)	Code of Practice for Use of Metal Arc Welding for General Construction / Mild Steel
5. IS: 817(1969)	Code of Practice for Training and Testing of Metal Arc Welders.
6. IS: 919 (1993)	ISO System of Limits & Fits (Part 1 & Part 2)
7. IS: 1148 (1982)	Hot Rolled Rivet Bars (upto 40mm) for Structural Purposes.
8. IS: 1182 (1983)	Recommended Practice for Radio Graphic Examination of Fusion Welded Butt Joints in Steel Plates.
9. IS: 1363 (1992)	Hexagon Head Bolts, Screws and Nuts of Product grade C.
10. IS: 1364 (1992)	Hexagon Head Bolts, Screws and Nuts of Product Grades A & B (Part 1 to 5)
11. IS: 1367(1991)	Technical Supply Conditions for Threaded Steel Fasteners.
12. IS: 1821 (1987)	Dimensions for Clearance Holes for Bolts and Screws.
13. IS: 4206 (1987)	Dimensions for Nominal Lengths and Thread Lengths for Bolts, Screws and Studs.
14. IS: 1852 (1985)	Rolling & Cutting Tolerances for Hot-Rolled Steel Product.
15. IS: 1977 (1975)	Structural Steel (Ordinary Quality).
16. IS: 2016(1967)	Plain Washers.
17. IS: 2062 (1992)	Steel for General Structural Purposes
18. IS: 2595 (1978)	Code of Practice for Radio Graphic Testing.
19. IS: 3600 (1985)	Methods of Testing Fusion Welding Joints.
20. IS: 3613 (1974)	Acceptance Tests for Wire Flux Combinations for Submerged Arc Welding.
21. IS: 3658 (1981)	Code of Practice for Liquid Penetrant Flow, Detection.
22. IS: 3757 (1985)	High Strength Structural Bolts
23. IS: 4000 (1992)	High Strength Bolts In Steel Structures-Code of Practice
24. IS: 4353 (1967)	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steel
25. IS: 4943 (1968)	Assessment of Butt and Fillet Fusion Welds in Steel Sheet, Plate and Pipe
26. IS: 5334 (1981)	Code of Practice for Magnetic Particle Flow Detection of Welds
27. IS: 5369 (1975)	General Requirements for Plain Washers and Lock Washers.
28. IS: 5372 (1975)	Taper Washers for Channels
29. IS: 5374 (1975)	Taper Washers for I Beams.
30. IS: 6623 (1985)	Specification for High Strength Structural nuts
31. IS:6649 (1985)	Specifications for hardening and tempering washers for high strength structural nuts
32. IS: 6755 (1980)	Double Coil Helical Spring Washers.
33. IS: 7215 (1974)	Tolerances for Fabrication of Steel Structure.
34. IS:7318 (1974) (Part I)	Approval Tests for Welders When Welding Procedure Approval is not required -fusion Welding of Steel
35. IS:8500 (1991)	Structural steel -Micro alloyed (Medium and High Strength Qualities)
36. IS:8910(1978)	General requirements of Supply of Weldable Structural Steel
37. IS: 9595 (1980)	Recommendations for Metal Arc Welding of Carbon & Carbon- Manganese Steels

7.1.7

Product

7.1.7.1

Materials

- A. All materials to be supplied by the Contractor shall conform to relevant Indian, Standards or equivalent, as approved by the Engineer.
- B. Steel materials required for the work shall be free from imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair strength, durability and appearance. All materials shall be of tested quality only. If desired by the Engineer, test certificates in respect of each consignment shall be submitted in triplicate. Whenever the materials are permitted for procurement from identified stocks, a random sample shall be tested at an approved laboratory, as directed by the Engineer.

7.1.7.2 **Structural Steel**

All structural steel shall be of tested quality and shall conform to one of the following standards:

IS: 226 Structural steel (Standard Quality)

IS: 2062 Grade -B Structural steel (Fusion welding quality) IS:

961 High Tensile Structural Steel (Ordinary)

IS: 1161 Steel Tubes for Structural purposes IS:8500

- Grade Fe 540 HT(High Tensile) IS:4923 Hollow

Steel Sections for Structural use

IS 3757& IS 4000 for high strength bolts in steel structures.

IS 816for use of metal arc welding for general construction in mild steel IS 9595

for Metal arc welding of carbon and carbon manganese steels IS 811for Cold

Formed Light Gauge Structural Steel Sections -

The Contractor shall supply to the Engineer, copies of the manufacturer's test certificate that the steel brought to the site for incorporation in the works is of a quality fully complying with the specifications. If required by the Engineer, the Contractor shall arrange for testing of the steel samples as per IS: 1608 – 1599, Welding electrode shall conform to IS:814

7.1.7.3 **Bolts and Nuts**

For splicing of any structural member wherever required HSFG bolts and nuts of property class-8.8 conforming to IS:3757 and IS:6623 (1985) respectively shall be used. Unless specified otherwise, the bolts shall be hexagonal. All anchor bolts shall be of property class of 8.8 and nuts shall conform to IS: 1363 (1992), IS:1364 (1992) and IS:1367, as applicable, and unless specified otherwise, shall be hexagonal. All nuts shall conform to property class compatible with the property class of the bolts used.

7.1.7.4 **Washers**

For HSFG bolts, washers shall be conforming to IS:6649 (1985). Plain washers shall be conforming to IS:5369 (1975), unless otherwise specified. One washer shall be supplied with each bolt and in case of special types of bolts, more than one washer as needed for the purpose shall be supplied. An additional double coil helical spring washer, conforming to IS:6755 (1980), shall be provided for bolts carrying dynamic or fluctuating loads and those in direct tension. Tapered washers, conforming to IS:5372 (1975) and IS:5374 (1975), shall be used for channels and beams respectively wherever required.

7.1.8 **Storage of Materials**

7.1.8.1 **General**

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. If required by the Engineer, the materials shall be stored under cover and suitably painted for the protection against weather. Any material, which has deteriorated or has

been damaged shall be removed from site and replaced by new members as directed by the Engineer at no extra cost and time.

- A. The steel to be used in fabrication shall be stored in a separate stack clear off the ground section wise and lengthwise.
- B. The storage area shall be kept clean and properly drained. Structural steel shall be so stored and handled in such a manner that members are not subjected to excessive stresses and damage. Girders and beams shall be placed in upright position. Long members shall be supported on closely spaced skids/runners to avoid unacceptable deflection.

7.1.8.2 **Yard**

- A. The Contractor shall be required to establish a suitable yard, in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to site. The yard shall have proper facilities such as drainage and lighting including access for cranes, trailers and other heavy equipment.
- B. The Contractor shall have been deemed to have visited the site, prior to submission of his tender, to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc., all of which shall be carried out by the Contractor at his own cost and as directed by the Engineer.

7.1.8.3 **Covered Store**

All field connection materials, paints etc. shall be stored on racks and platforms, off the ground, in a properly covered building by the contractor.

7.2 **STRUCTURAL STEELWORK SPECIFICATION –WELDED STRUCTURE**

7.2.1 **General**

Scope of Specification

This Specification covers the supply, fabrication and delivery to Site of welded structural Steelwork, including the supply of all consumables, electrodes and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the Specification.

7.2.2 **Products**

Ref. Specification 7.1.6 for Structural Steel

7.2.3 **Execution**

7.2.3.1 **Workmanship**

7.2.3.1.1 **General**

All workmanship shall be in accordance with the best practices in modern structural shops. Greatest accuracy shall be maintained in the manufacture of every part of the work and similar parts shall be strictly interchangeable. The contractor shall not proceed with any welding until the Engineer has approved his welding plan, which shall include.

- All information on welding procedures, equipment, additives and preheating during welding operation.
- Details of non- destructive testing methods.
- Precautions with regard to welding shrinkage.
- Possible treatment of completed welds by grinding.
- Procedure and programme of welding sequence.

7.2.3.1.2 Templates

Templates used throughout the work shall be of steel. In cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether such materials are fit to be used as parts of the finished structure.

7.2.3.1.3 Straightening

All materials shall be straight and free from twists, and if necessary, before being worked, shall be straightened and/or flattened by pressure, unless required to be of curvilinear form.

7.2.3.1.4 Clearance

The clearance between faying surfaces of bolted connections shall not be greater than 1mm for each end. If separation is between 1 to 3mm, the surface should be tapered to eliminate the separation. Over 3mm separation shall be filled with filler plates.

7.2.3.1.5 Shearing, Cutting and Planning

Cutting shall be done automatically. Cutting by shearing machine may be used for plates not exceeding 10 mm in thickness provided that the plate edges be fully enclosed in a weld. Oxygen cutting may be used provided a smooth and regular surface free from cracks and notches is secured.

1. Chipping of angle flanges and edges of plates, wherever necessary, shall be done without damaging the parent metal. Chipped edges shall be ground to a neat finish and sharp corners and hammered rough faces shall be rounded off.
2. The edges and ends of all cut/sheared plate members, flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground. Edge preparation for welding may be done by machine controlled flame cutting, with edges free from burrs should be clean and straight.
3. The butting surfaces at all joints of girders shall be planed so as to butt in close contact throughout the finished joint.
4. All flame cut surfaces shall be ground to remove the burned/ hardened portion of the material for flame cut surfaces.

7.2.3.1.6 Assembly

1. All parts assembled for welding shall be in as close contact as practicable over the whole surface.
2. The component parts shall be so assembled that they are neither twisted nor otherwise damaged. Specified cambers, if any, shall be provided.
3. All parts of bolted and welded members shall be held firmly in position by means of jigs or clamps while bolting or welding. No drifting of holes shall be permitted, except to draw the parts together and no drift used shall be larger than the nominal diameter of the bolt. Drifting done during assembling shall not distort the metal or enlarge the holes.
4. Trial assemblies shall be carried out at the fabrication stage to ensure accuracy of workmanship. These checks shall be witnessed by the Engineer-in-Charge and such trial assemblies shall be at the cost of the Contractor.

7.2.3.2 Welding**7.2.3.2.1 General**

The welding and the welded work shall conform to welded bridge code, IS:816 (1969) and IS:9595 (1980), unless otherwise specified. As much work as possible shall be welded in shops and the layout and sequence of operations shall be so arranged as to eliminate distortion and shrinkage stresses.

7.2.3.2.2 Electrodes

All electrodes shall be kept under dry conditions. Any electrode damaged by moisture shall not be used unless it is guaranteed by the manufacturer that, when it is properly dried, there will be no detrimental effect. Any electrode, which has part of its flux coating broken away or is otherwise damaged, shall be rejected. Any electrode older than six (6) months from the date of manufacture shall not be used. Batch certificates for electrodes shall be submitted by the Contractor.

Manual Metal Arc Welding electrodes shall be adopted as per following details:

S. No.	Classification	Brand Name	Manufacturer	Remarks
1	E-6013	Overcord Steelon Standard Excel-123 S Ferro-speed Plus	M/s Advani Oerlikon (P) Ltd. Modi Arc Electrodes Co. Weld Excel India Ltd. (Modi Group Co.) ESAB India Ltd.	For Structural Steel members having thickness up to 15mm
2	E-7018	Super Cito Modi-7018 Excel-18 S ESAB 36H	Advani Oerlikon Modi Arc Electrodes. Weld Excel India Ltd. (Modi Group Co.) ESAB India Ltd	For Structural Steel members having thickness more than 15mm

For MIG and SAW welding the suitable product/brand of above mentioned manufacturer shall be used.

7.2.3.2.3 Preparation of Joints

- The edges shall be prepared, with an automatically controlled flame cutting torch, correctly to the shape, size and dimensions of the groove, prescribed in the design and fabrication drawings. In case of U-groove joints, the edges shall be prepared with an automatic false cutting torch in two phases, following a bevel out with a gouging pass, or by machining.
- The welding surfaces shall be smooth, uniform and free from fins, tears, notches or any other defects, which may adversely affect welding, and shall be free of loose scale, slag, rust, grease, paint, moisture or any other foreign material.

7.2.3.2.4 Welding Procedure

- All welding procedures shall be submitted to the Engineer for approval, well before starting fabrication.
- The welding procedures shall be arranged by the Contractor to suit the details of the joints, as indicated in the drawings and the position at which welding has to be carried out. Welding procedure shall cover the following:
 - Type and size of electrodes
 - Current and (for automatic welding) arc voltage
 - Length of run per electrode; or (for automatic welding) speed of travel
 - Number and arrangement of runs in multi run welds
 - Position of welding
 - Preparation and set-up of parts
 - Welding sequence
 - Pre or post heating
 - Any other relevant information.

3. The welding procedures shall be so arranged that distortion and shrinkage stresses are reduced to the minimum, and that the welds meet the requirement of quality specified.
4. Any weld found defective shall be removed, by using either chipping hammer or gouging torch, in such a manner that parent material is not injured in any way.

7.2.3.2.5 **Fusion Faces and Surrounding Surfaces**

1. Fusion faces and the surrounding surfaces within 50mm of the welds shall be free from all mill scale and free from oil, paint or any substance which might affect the quality of the welds or impede the quality/progress of welding. These shall be free from irregularities, which would interfere with the deposition of the specified size of weld or be the cause of defects.
2. All mill scale within 50mm of welds shall be removed prior to welding, either by pickling followed by thorough power wire brushing, or by other approved methods.
3. If preparation or cutting of the fusion faces is necessary, the same shall be carried out by shearing, chipping, gas cutting or flame gouging.
4. Where hand gas cutting or hand gouging is employed, the blowpipe or gouging blowpipe shall be properly guided.

7.2.3.2.6 **Assembly for Welding**

Parts to be welded shall be properly assembled and held firmly in position by means of jigs and clamps prior to and during welding.

7.2.3.2.7 **Welded Girders and Other Plate Construction**

Automatic submerged arc welding shall be employed for fabrication of welded girders and other plate construction, wherever specified. Metal Inert Gas (MIG) welding (C0₂) may be done for short length where access to the location of the weld does not permit submerged arc welding subject to approval of Engineer.

7.2.3.2.8 **Accuracy of Fit-Up**

Parts to be fillet welded shall be brought into as close contact as practicable, and the gap due to faulty workmanship or incorrect fit-up shall not exceed 1.5mm. If greater separation occurs at any position, the size of fillet weld shall be increased at such positions by the amount of the gap.

7.2.3.2.9 **Jigs and Manipulators**

Jigs and manipulators shall be used, where practicable, and shall be designed to facilitate welding and to ensure that all welds are easily accessible to the operators.

7.2.3.2.10 **Ends of Butt Welded Joints**

The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by the use of extension pieces, cross-runs or other approved means.

7.2.3.2.11 **Weld Face and Reinforcement of Butt welds**

The weld face shall, at all places, be deposited projecting the surface of the parent metal. Where a flush surface is required, the surplus metal shall be dressed off.

7.2.3.2.12 **Testing of Butt Welds**

25% of the Butt-welded joints are to be radio graphically tested by the Contractor at his own cost. If such tests indicate the joints to be defective, the cost of rectification of defective welds shall also be borne by the Contractor.

7.2.3.2.13 Minimum Leg Length & Throat Thickness in Fillet Welds

The minimum leg length of a fillet weld as deposited shall be not less than the specified size. In no case shall a concave weld be deposited, unless specifically permitted. Where permitted, the leg length shall be increased above that specified length, so that the resultant throat thickness is as great as would have been obtained by the deposition of a flat-faced weld of the specified leg length.

7.2.3.2.14 Dislodging

After making each run of welding, all slag shall be thoroughly removed and the surface cleaned.

7.2.3.2.15 Quality of Welds

The weld metal, as deposited (including tack welds), shall be free from-cracks, slag inclusions, porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without under cutting or overlapping at the toes of the weld. The surface of the weld shall have a uniform consistent contour and regular appearance.

7.2.3.2.16 Weather Conditions

Welding shall not be done under weather conditions, which might adversely affect the efficiency of welding.

7.2.3.2.17 Qualification and Testing of Welders

The Contractor shall satisfy the department that the welders are suitable for the work for which they will be employed, and shall produce evidence to the effect that welders, have satisfactorily completed appropriate tests, as described in IS:817 Part I (1992). The Engineer may, at his own discretion, order periodic tests of the welders and/or of the welds produced by them. Such tests shall be at the expense of the Contractor.

7.2.3.2.18 Supervision

The Contractor shall employ competent welding supervisors to ensure that the standard of workmanship and the quality of the materials comply with the requirements laid down in this Specification.

7.2.3.2.19 Machining of Butts and Bases

Splices and butt joints of compression members, depending on contact for stress transmission, shall be accurately machined over the whole section. In column bases, the ends of shafts together with the attached gussets, angles. Channels etc., after bolting and/or welding together as the case may be, shall be accurately machined so that the parts connected butt over the entire surface of contact. Care shall be taken that connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 0.8mm.

7.2.3.2.20 Requirement of Welded Joints

Apart from the requirements of welding specified under the above sub clauses, sections above, the Contractor shall ensure the following requirements in the welded joints.

- i) Strength-quality with parent metal.
- ii) Absence of defects.
- iii) Corrosion resistance of the weld shall not be less than that of parent metal in an aggressive environment

7.2.3.3 Shop Assembly

1. The steelwork shall be temporarily shop assembled, as necessary, so that the accuracy of fit may be checked before dispatch. The parts shall be shop assembled with a sufficient number of parallel drifts to bring and keep the parts in place.

2. Since parts drilled or punched, with templates having steel bushes shall be similar and, as such, interchangeable, such steelwork may be shop erected in part only, as agreed by the Engineer.

7.2.3.4 **Erection Marking**

1. Each fabricated member, whether assembled prior to dispatch or not so assembled, shall bear an erection mark, which will help to identify the member and its position in respect of the whole structure, to facilitate re-erection at site.
2. These erection marks shall be suitably incorporated in the shop detail and erection drawings.

7.3

STRUCTURAL STEELWORK SPECIFICATION : BOLTED STRUCTURE

7.3.1

General

7.3.1.1

Scope of Specifications

These specifications cover the supply, fabrication and delivery to site of bolted structural steelwork, including the supply of all consumables and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the specification.

7.3.2

Products

Ref. Specification 7.1.6 for Structural Steelwork -General

7.3.3

Execution

7.3.3.1

Workmanship

7.3.3.1.1

General

All workmanship shall be in accordance with the best practice in modern structural shops. Greatest accuracy shall be maintained in the manufacture of every part of the work and all similar parts shall be strictly interchangeable.

7.3.3.1.2

Templates

Templates used throughout the work shall be of steel, in cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether such materials are fit to be used as parts of the finished structure.

7.3.3.1.3

Straightening

All materials shall be straight and free from twists, and if necessary, before being worked shall be straightened and/or flattened by pressure, unless required to be of curvilinear form.

7.3.3.1.4

Clearance

The clearance between faying surfaces of bolted connections shall not be greater than 1 mm at each end. If the separation is between 1 to 3 mm the surface should be tapered to eliminate the separation. Over 3mm separation shall be filled with filler plates.

7.3.3.1.5

Shearing, Cutting and planning

1. Cutting shall be done automatically. Cutting by shearing machine may be used for plates not exceeding 10mm in thickness provided that the plate edges be fully enclosed in a weld. Oxygen cutting may be used provided a smooth and regular surface free from cracks and notches is secured.
2. Chipping of angle flanges and edges of plates, wherever necessary, shall be done without damaging the parent metal. Chipped edges shall be ground to a neat finish and sharp and sharp corners and hammered rough faces shall be rounded off.
3. The edges and ends of all cut/sheared flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall

be planed/ground.

4. The butting surfaces at all joints of girders shall be planed so as to butt in close contact throughout the finished joint.
5. The ends of all built up girders and of all columns shall be faced in an end- milling machine after the members have been completely assembled. Bearing edges for girder bearing stiffeners and column bases shall be machined.
6. Unless clean, square and true to sharp, all flame-cut edges shall be planed. Cold sawn ends, if reasonably clean and flame-cut ends of sections not inferior to sawn ends in appearance need not be planned, except for butting ends.

7.3.3.1.6 **Drilling**

1. Holes for bolts shall be drilled to conform to Clause 10 of IS:7215-1974. Punching of holes shall not be permitted. All holes, except as stated hereunder, shall be drilled to the required size, 3mm less in diameter and reamed thereafter to the required size. All matching holes for bolts shall register with each other so that a gauge of 0.8mm less in diameter than the hole can pass freely through the members assembled for bolting, in the direction at right angle to such members.
2. All drilling shall be free of burrs.
3. No holes shall be made by gas cutting process.

7.3.3.1.7 **Assembly**

1. All parts assembled for bolting shall be in close contact over the whole surface
2. The component parts shall be so assembled that they are neither twisted nor otherwise damaged. Specified cambers, if any, shall be provided.
3. All parts of bolted and welded members shall be held firmly in position by means of jigs or clamps while bolting or welding. No drifting of holes shall be permitted, except to draw the parts together and no drift used shall be larger than the nominal diameter of the bolt.
4. Drifting done during assembling shall not distort the metal or enlarge the holes.
5. Trial assemblies shall be carried out at the fabrication stage to ensure accuracy of workmanship, and these checks shall be witnessed by the Engineer. Such trial assemblies shall be at the cost of the contractor.

7.3.3.1.8 **Field Bolts**

1. Requirements stipulated under bolting shall apply for field bolts. Field bolts nuts and washers shall be furnished by the Contractor in excess of the nominal numbers required. He shall supply the full number of bolts, nuts and washers and other necessary fittings required for completing the work, together with the additional bolts, nuts and washers totalling to 10% of the requirement subject to minimum of 10 Nos. Only HSFG bolts of class 8.8 shall be used.
2. At the time of assembly, the surfaces in contact shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interfere with the development of friction between them.
3. If any other surface condition, including a machined surface, is specified, it shall be the responsibility of the Contractor to work within the slip factor specified for the particular case.
4. Each bolt and nut shall be assembled with washers of appropriate shape, quality and number in cases where plane parallel surfaces are involved. Such washers shall be placed under the bolt head or the nut, whichever is to be rotated during the tightening operation. The rotated nut or bolt head shall be tightened against a surface normal to the bolt axis, and the appropriate tapered washer shall be, used when the surfaces are not parallel. The angle between the bolt axis and the surface under the non-rotating component (i.e. the bolt head or the nut) shall be 90 ± 3 degree. For angles outside these limits, a tapered washer shall be placed under the non- rotating component. Tapered washers shall be correctly positioned.

5. No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nut and bolts shall always be tightened in a staggered pattern and where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.
6. If, after final tightening, a nut or bolt is slackened off for any reason, the bolt, nut and washer or washers shall be discarded and not used again.

7.3.3.2 **Shop Assembly**

1. The steelwork shall be temporarily shop assembled, as necessary, so that the accuracy of fit may be checked before dispatch. The parts shall be shop assembled with a sufficient number of parallel drifts to bring and keep the parts in place.

7.3.3.3 **Erection Marking**

1. Each fabricated member, whether assembled prior to dispatch or not so assembled, shall bear an erection mark, which will help to identify the member and its position in respect of the whole structure, to facilitate re-erection at site.
2. This erection mark shall be suitably incorporated in the shop detail and erection drawings.

7.4 **STRUCTURAL STEEL SPECIFICATIONS PAINTING WORKS**

7.4.1 **General**

7.4.1.1 **Scope of Specification**

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding tools, equipment and everything that is necessary for the job completion on schedule.

7.4.1.2 **Applicable Codes**

The following Specifications, Standards and Codes are included as part of this Specification. All standards and codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions. In case of discrepancy between this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

- a) IS: 102 (1962) : Ready Mixed Paint, Brushing, Red lead, Non Setting, Priming.
- b) IS: 159 (1981) : Ready Mixed Paint, Brushing, Acid Resisting for Protection against Acid Fumes, Colour as Required.
- c) IS: 341 (1973) : Black Japan, Types A, B & C.
- d) IS: 384 (1979) : Brushes, Paints and Varnishes, Flat.
- e) IS: 487 (1985) : Brush, Paint and Varnish i) Oval Ferrule Bound ii) Round Ferrule Bound.
- f) IS: 958 (1975) : Temporary Corrosion Preventive Grease, Soft Film, Cold Application.
- g) IS: 1153(1975) : Temporary Corrosion Preventive, Fluid, Hard Film, Solvent Deposited.
- h) IS: 1477(1971) : Code of Practice for Painting of Ferrous Metals in Building. Part I –Pre-treatment Part II -Painting
- i) IS: 1674(1960) : Temporary Corrosion Preventive Fluid, Soft Film, Solvent Deposited.
- j) IS: 2074(1992) : Ready Mixed Paints, Red Oxide -Zinc Chrome, Priming.
- k) IS-5666: Etch (Pretreatment) Primer
- l) IS-104: Ready mixed paint, brushing, zinc chrome, priming
- m) IS-2339: ALUMINIUM PAINTS FOR GENERAL PURPOSES OF SPECIFICATION

7.4.2 Products**7.4.2.1 Materials****7.4.2.1.1 Paint**

1. All paint delivered to the fabrication shop/Site shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
2. Paint shall be stirred frequently to keep the pigment in suspension

7.4.2.1.2 Storage of Paints

1. All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks, flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.
2. All paint containers shall be clearly labelled to show paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage shall not be used. Paints for which the shelf life specified by the supplier has expired shall not be used without inspection and approval by the Engineer.

7.4.3 Execution**7.4.3.1 Paint System**

1. Sand blasting where specified shall be carried out in accordance with IS:1477.
2. Painting work shall be carried out as follows:

Painting Specifications

DESCRIPTION	GENERAL SURFACE	
FABRICATION SHOP	EXTERNAL SURFACES	INTERNAL SURFACES
Surface Treatment	Abrasive blast cleaning to minimum SA-2.5 (ISO 8501-1:1988) SIS-055900 near - white blast cleaning	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning
1 st Under - Coat	Inorganic zinc silicate primer (self-curing solvent type) DFT – 75 m shall be Berger Zinc Anode 11 or approved equivalent. The primer should be applied by spray only.	Epoxy Zinc phosphate primer polyamide cured DFT-35 m
2 nd Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT - 35 m shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Epoxy zinc phosphate primer polyamide cured DFT-35 m shall be Berger Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.
3 rd Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT-35 m shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Polyamide cured coal tar epoxy coating DFT 100 m
4 th Under Coat	Epoxy high build micaceous iron oxide coating polyamide cured DFT-90 m shall be Berger Epilux 4 High Build MIO. The primer should be applied by spray or brush only.	Polyamide cured coal tar epoxy coating DFT 100 m

ERECTION SITE	EXTERNAL SURFACES	INTERNAL SURFACES
Intermediate Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT- 30 m shall be Bergerthane or approved equivalent applied by spray or brush in approved colour.	NA
Finishing Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT- 30 m shall be Bergerthane or approved equivalent applied by spray or brush in approved colour.	NA

INTERNAL SURFACE = Internal surfaces are those which will become inaccessible after fabrication.

EXTERNAL SURFACE = All other surfaces which are prone to humidity and moisture from the Atmosphere.

The following precautions must be taken:

- After abrasive blast cleaning, the first undercoat (primer coat) should be applied well before surface deterioration.
- Over coating intervals, application parameters shall conform to manufacturer's instruction manual.
- The DFT (Dry film thickness) shall be measured after completion of each coat.

7.4.3.2 Surface Preparation

7.4.3.2.1 General

All surfaces shall be cleaned of loose substances and foreign materials, e. g. dirt, rust, scale, oil, grease, welding flux etc. so that the prime coat adheres to the original metal surface. The work shall be carried out in accordance with IS: 1477 (1971) (Part I). Any oil, grease, dust or foreign matter deposited on the surface after preparation shall be removed and care shall be taken to ensure that the surface is not contaminated with acids, alkalis or other corrosive chemicals. The primer coat shall be applied immediately after the surface preparation is completed.

Before the application of any paint, the surfaces to be treated shall be thoroughly cleaned freed from all scale, loose paint, rust and other deleterious materials. Oil and grease shall be removed from the surface by washing with solvents or with a detergent solution before blast cleaning operation of metal polish with metal pellets. If any traces of oil or grease remain after blasting they shall be removed by solvent cleaning and the area will be re-blasted thereafter.

All welded areas/joints shall be given special attention for removal of weld flux slag, weld metal splatter, weld head oxides; weld flux fumes, silvers and other foreign objects before blasting. If deemed necessary by the Engineer, acid washing and subsequent washing with clean water shall be used.

Any rough seams will have to be ground and must be inspected and approved by the Engineer-in- Charge before application of the coatings.

All structural steel to be painted shall be cleaned blast cleaning in accordance with SA 2 1/2 Near- White Blast cleaning (equivalent Swedish Standard SIS 055900). For SA 2 1/2 the profile should be in the range of 40-70 microns and shall be measured with comparator. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are light stains in the form of spots or stripes. Finally the surface shall be cleaned with a vacuum cleaner or clean dry compressed air.

The blast cleaning shall produce a surface roughness complying with the one specified by the paint manufacturer for the primer concerned. If cleaned surfaces are rusted or are contaminated with foreign material before painting is accomplished they shall be re-cleaned by the Contractor at his expenses.

The surface shall be cleaned by impingement of abrasive materials, such as grit of cast iron, malleable iron, steel or synthetic material, at high velocity created by clean and dry compressed air blast. Prior to application of the blast, heavy deposits of oil and grease shall be removed by solvent cleaning and excessive surface scale removed by hand tool or power tool cleaning.

The last finish paint shall be applied after structural steel erection and slab construction.

7.4.3.3 **Mixing and Thinning**

1. All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments, before use and during application, to maintain homogeneity. All pigmented paints shall be strained after mixing to remove skins and other undesirable matters.
2. Dry pigments, pastes, tinting pastes and colours shall be mixed and/or made into paint so that all dry powders get wetted by vehicles and lumps and particles are uniformly dispersed.
3. Additives that are received separate such as curing agents, catalysts, hardeners etc. shall be added to the paint as per the manufacturer's instructions. These shall be promptly used within the pot life specified by the manufacturers and unused paint h thereafter shall be discarded.
4. Thinners shall not be used unless essential for proper application of the paint. Where thinners are used, they shall be added during the mixing process and the type and quantity of thinner shall be in accordance with the instructions of paint manufacturer.

7.4.3.4 **Paint Application**

7.4.3.4.1 **General**

1. Paint shall be applied in accordance with the manufacturer recommendations, as supplemented by these Specifications. The work shall generally follow IS: 1477 (1971) (Part II). Prior approval of the Engineer shall be taken in respect of all primers and/or paints, before their use in the works.
2. Paint shall generally be applied by brushing except that spraying may be use for finish coats only when brushing may damage the prime coats. Roller coat or other method of paint application shall not be used unless specifically authorized.
4. Spraying paint shall not be adopted on red lead or zinc rich paints. Daubers may be used only when no other method is practicable for proper application in difficult accessible areas.
5. Paint shall not be applied when the ambient temperature is 10°C and below. For paints which dry by chemical reaction the temperature requirements specified by the manufacturer shall be met with. Also, paint shall not be applied in rain, wind, fog or at relative humidity of 80% and above or when the surface temperature is below dew point, resulting in condensation of moisture. Any wet paint exposed to damaging weather conditions shall be inspected after drying and the damaged area repainted after removal of the paint.
6. Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots. The film thickness shall not be so great as to detrimentally affect either, the appearance or the service life of the paint.
7. Each coat of paint shall be allowed to dry sufficiently before application of the next coat, to avoid damages such as lifting or loss of adhesion. Undercoats having glossy surface shall be roughened by mild sand papering to improve adhesion of subsequent coats. Successive coats of same colour shall be tinted whenever practical, to produce contrasts and help in identifying the progress of the work.

7.4.3.4.2 Brush Application

1. Proper brushes shall be selected for a specific work piece. Round or oval brushes which conform to IS:487(1985) are better suited for irregular surfaces, whereas flat brushes which conform to IS:384(1979) are convenient for large flat areas. The width of flat brushes shall not generally exceed 1.25mm.
2. Paint shall be applied in short strokes depositing a uniform amount of paint in each stroke followed by brushing the paint into all surface irregularities, crevices and corners and finally smoothening or leveling the paint film with long and light strokes at about right angles to the first short strokes. All runs and sags shall be brushed out. The brush marks left in the applied paint shall be as few as practicable.

7.4.3.4.3 Spray Application

1. The spraying equipment shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned of dirt, dried paint, foreign matter and solvent before use.
2. The paint shall be applied by holding the gun perpendicular to the surface at a suitable distance and moved in a pattern so as to ensure deposition of a uniform wet layer of paint. All runs and sags shall be brushed out immediately. Areas not accessible to spray shall be painted by brush or dauber.
3. Water trap acceptable to Engineer shall be furnished and installed on all equipment used in spray painting.

7.4.3.5 Shop Painting

1. The painting system specified in Table shall be followed.
2. Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted but require protection shall be given a rust inhibitive grease conforming to IS.958-1975 or solvent deposited compound conforming to IS: 1153 (1975) or IS. 1674 (1960) or treated as specified in the drawing.
3. Surface to be in contact with concrete shall not be painted.
4. The shop coats shall be continuous over all edges, including ends meant for jointing at site by bolting, except where the paint could be detrimental to bolting. In such cases, no paint shall be applied within 50mm, and the unprotected surface shall be given a coat of corrosion inhibitive compound.
5. The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and de-slagged, and immediately after covered by the same paint as has been used for the remaining surface.

7.4.3.6 Painting at Site

Surfaces which will be inaccessible after site assembly shall receive the full specified protective treatment before assembly. Surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Damaged or deteriorated paint surfaces shall be first made good with the same type of coat as the shop coat. Where steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds, bolts and site rivets. Specified protective treatment shall be completed after erection.

7.4.3.7 Protection of Paintwork

1. The Contractor shall provide measures as necessary to prevent damage to the work and to other

property or persons from all cleaning and painting operations. Paint or paint stains which result in other unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the contractor at his cost.

2. All painted surfaces that in the opinion of the Engineer are damaged in anyway, shall be repaired by the contractor at his cost with materials and to a condition equal to that of the requirements specified in these specifications.
3. Upon painted surfaces that in the opinion of any other work that would cause dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned. At the time of opening the flyovers to public traffic, the painting shall be completed and the surfaces shall be undamaged and clean.
4. The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.

7.4.3.8 **Site Painting**

1. After the erection of structures at the site, the contractor shall provide the necessary treatment as specified in Table "PAINTING SPECIFICATIONS".
2. Surface which has not been shop coated, but require surface treatment shall be given necessary surface preparation and coats at site as specified in Table.

7.5 **STRUCTURAL STEEL WORK QUALITY CONTROL & TESTING REQUIREMENTS**

7.5.1 **General**

7.5.1.1 **Scope of Specification**

The scope of work of these specifications is to establish the norms for ensuring the required Quality Control through established testing norms of the welded structural steelwork.

7.5.1.2 **Codes / Standards**

Relevant IS codes for tolerance and tests of welding procedures as specified in the specification for Structural Steelwork -General.

7.5.1.3 **Submittals**

The Contractor shall submit the following:

- Proposed overall schedule for documentation of calculations, shop drawings, plan/procedures and records, submission of procedure of fabrication.
- The contractor shall himself inspect all materials, shop work and field work to satisfy the specified tolerance limits and Quality norms before the same are inspected by Engineer or his authorized representative.

7.5.2 **Products**

Not Applicable

7.5.3 **Execution**

7.5.3.1 **Tolerances**

The contractor shall through appropriate planning and continuous measurements in the workshop and the erection at site, ensure that the tolerance specified below are strictly adhered to.

7.5.3.1.1 **Dimensional & Weight Tolerance**

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852. The acceptable limits of straightness for rolled or fabricated members as per IS: 7215 are:

Struts and columns: $1/1000$ or 10 mm whichever is smaller Where L is the length of finished member

A limit for distortion in transverse direction 5 from the true axis of plate and box girder shall not be more than $L/1000$ where L is the length of diagonal of profile.

Tolerance in specified camber of members shall be 3mm in 12m length Tolerance in specified lengths shall be as follows:

Column finished for contact bearing	± 1 mm
Other members (cols.) upto and over	10 m ± 5 mm
Including 10 m $L/2000$ sub to max of	± 8 mm
Other members (beams) upto 12m	± 3 mm
Over 12m $L/4000$ sub max. of	± 5 mm

7.5.3.1.2 End of Members

Beam Jo beam and beam to column connection -Where the abutting parts are to be jointed by butt welds, permissible deviation from the squareness of the end is

Beam upto 600 mm in depth : 1.5 mm

Beam over 600 mm in depth: 1.5 mm for increase in depth of every 600 mm subjected to max of 3 mm.

Where abutting parts are to be joined by bolting through cleats or end plates, the connections require closer tolerance, permissible deviation from the squareness of the end is:

Beams up to 600 mm in depth 1 mm per 600mm of depth subject to a max of 1.5 mm.

For full bearing, two abutting ends of columns shall first be aligned to within 1 in 1000 of their combined length and then the following conditions shall be met:

- Over at least 80% of the bearing surface the clearance between the surfaces does not exceed 0.1mm.
- Over the remainder of the surfaces the clearance between the surfaces does not exceed 0.3 mm.

Where web stiffeners are designed for full bearing on either the top flange or the bottom flange or both, at least half the stiffener shall be in positive contact with the flange. The remainder of the contact face could have a max. gap of 0.25 mm.

7.5.3.1.3 Depth of Members

Acceptable deviation from the specified overall depth as per IS:7215 (1974) is: Upto and including 1000mm : 1.0mm

Over 1000 mm : 2.0mm

7.5.3.1.4 Web Plates

An acceptable deviation from flatness in girder webs in the length between the stiffeners or in a length equal to the girder depth shall be:

Upto 500 mm depth	0.5 mm
Over 500 mm & including 1000 mm	1.0 mm
Over 1000 mm	2.0 mm

7.5.3.1.5 Flange Plates

A reasonable limit for combined warpage and tilt on the flanges of a built-up member is $1/200$ of the total

width of flange or 2 mm whichever is smaller measured with respect to centreline of flange.

Lateral deviation between centre line of web plate and centre line of flange plate at contact surfaces measured as the difference δ between diagonals of nominal length L shall not be greater than $L/1000$.

7.5.3.1.6 End Milling

Column ends bearing on each other or resting on base plates and compression joints designed for bearing shall be milled true and square to ensure proper bearing and alignment. Base plates shall also have their surfaces milled true and square.

7.5.3.2 Quality Control

In order to exercise proper control of the quality of the welding, Contractor shall enforce methods of control as tabulated below:

Purpose	Control subjects	Methods of Control
Control of welding Materials basic and metal quality	Quality control of electrodes, welding wire, flux and protective gases Checking of quality and Weldability of the basic metal and welded members.	Weldability test to determine the technological properties if materials, Mechanical test of weld metal. Metalographical investigations of welds macro-structure and microstructure Checking of weld metal resistance for intercrystalline corrosion. Study if weld metal solidity by physical control methods.
Checking of welders qualifications	Welding of specimens for quality determination	Mechanical tests, metalo-graphical investigation & checking of welded joints by physical control methods
Control of welded joint quality	Control of assembly accuracy and technological welding process.	Checking of assembly quality and centering of welded members. Checking of welding equipment conditions. Checking correctness of welding procedure. Visual examination of welds.

7.5.3.3 Tests & Testing Procedures

Agency for testing of weld shall be approved by the Engineer prior to testing.

7.5.3.3.1 Visual Examination

The contractor shall conduct visual examination and measurement of the external dimensions of the weld for all joints. Before examining the welded joints, areas close to it on both sides of the weld for a width not less than 20 mm shall be cleaned of slag and other impurities. Examination shall be done by a magnifying glass which has a magnification power of ten (10) and measuring instrument which has an accuracy of ± 0.1 mm or by weld gauges. Welded joints shall be examined from both sides. The contractor shall examine the following during the visual checks.

- i) Correctness and shape of the welded joints
- ii) Incomplete penetration of weld metal.
- iii) Influx
- iv) Burns
- v) Unwelded craters
- vi) Undercuts
- vii) Cracks in welded spots and heat affected zones
- viii) Porosity in welds and spot welds
- ix) Compression in welded joints as a result of electrode impact while carrying out contact welding
- x) Displacement of welded element

The contractor shall, document all data as per sound practices.

7.5.3.3.2 Mechanical Test

The Contractor shall carry out various mechanical tests to determine weldability, metal alloyability, and nature of break, correct size and type of electrodes, degree of pre-heat and post-heat treatment. The type, scope and sample of various mechanical tests shall be determined in agreement with the purchaser. The number of tests conducted shall depend on the result obtained to satisfy the Engineer that the correct type and size of electrode, degree of preheating and post-heating and weldability of metal are being followed.

7.5.3.3.3 Dye Penetration Test

All welds shall be tested by "Dye Penetration test" as per current practices.

7.5.3.3.4 Radiography Test

Radiography test shall be conducted by the contractor to determine gas inclusion (blow holes, hollows) slag inclusion, shallow welds and cracks for 25% lengths all butt joints.

Before conducting the examination, the welded joints shall be cleaned of slag and scales and visually examined. The welds shall be marked into separate portions depending on the length of photograph. The length of photograph shall be such as to ensure that there are no distortions and shall reveal the defect correctly. The length shall not be more than 0.75 of the focal distance and the width of the photograph would depend on the width of the welded joint plus 20mm on either side of the weld. The cassette with film shall be protected by sheet of lead or equivalent of proper thickness against incidental, diffused and secondary radiation.

The direction of the ray with relation to the film shall be as specified hereunder.

Welds of butt joints without edge slopes with edge processing shall be examined by central ray directed at right angles to the weld.

In special cases examination of welds with inclined rays directed along edge slopes may be permitted by the Engineer.

Lap joints shall be examined by directing rays at 45 degree to the bottom plate. Welds in T-joints without any edge preparation shall be examined by rays directed at 45 degree to the weld. Angle welds in lap and tee-joints shall be examined by the rays in opposite direction i.e. the film will be on the side of the weld. Weld in angle joints shall be checked by directing ray along the bisector of the angle between the welded elements. Opposite direction of the ray and location of the film may also be permitted by the Employer.

7.5.3.3.5 Ultrasonic Test

Ultrasonic test shall be conducted by the contractor to detect gas inclusion (pores), slag inclusion, shallow welds, cracks, lamination and friability etc. Prior to starting of ultrasonic test the welded joint shall be thoroughly cleaned of slag and other material. Surface of the basic metal adjacent to welded joint on both sides shall be mechanically cleaned by the grinder or a metal brush to provide the contact of the whole ultrasonic probe surface with surface of basic metal. The width of the clean

surface shall be as directed by the Engineer. The welded joint then shall be covered with a thin coat of transformer oil, turbine or machine oil to ensure acoustic contact. The joints so treated shall be marked and the marks shall be entered into the documentation, subsequent to this, ultrasonic test shall be carried out as directed by the Engineer. At least 50% of weld shall be tested by ultrasonic testing.

7.6 STRUCTURAL STEEL SPECIFICATIONS -ERECTION**7.6.1 General****7.6.1.1 Scope of Specification**

This Specification covers the delivery to site, storage and erection of structural steelwork at site. This includes plant and equipment requirements, installation of fabricated steel work position and grouting all complete as per drawings, specifications and other provisions of the Contract.

7.6.1.2 Submittals

- A. Ref. Specification for Structural Steelwork -General
- B. The contractor shall submit for approval a full description of his proposed erection method including sequence of erection, use of temporary supports, connection details and erection camber diagram and design calculations covering various stages of erection process.

7.6.2 Products

Not applicable

7.6.3 Execution**7.6.3.1 Delivery, Storage & Handling**

- A. Before the shop assembling is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identification numbers as detailed in shop drawings.
- B. The Contractor shall deliver the fabricated structural steel materials to site, with all necessary field connection materials, in such sequence as will permit the most efficient and economical performance of the erection work. As per scheduled programme, the Engineer may, at his discretion prescribe or control the sequence of delivery of materials.
- C. Fabricated parts shall be handled and stacked in such a way-that no damage is caused to the components. Measures shall be taken to minimize damage to the protective treatment on the steelwork. All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion and adequately protect all machined surfaces. All bolts, nuts, washers, screws, small plates and articles generally shall be suitably packed and identified. Plant and Equipment

7.6.3.2 Plant and equipment

All erection tools and plant & equipment proposed to be used shall be efficient, dependable and in good working condition, and the suitability and adequacy of such shall be determined by the Engineer. The Contractor shall, in his technical proposal submittal, specify the plant and equipment proposed by him for erection of structural steelwork at Site.

7.6.3.3 Storage

Materials to be stored shall be placed on skids above the ground and shall be kept clean and Properly drained.

7.6.3.4 Method and Sequence of Erection

The method and sequence of erection shall have the prior approval of the Engineer. The contractor shall arrange for the most economic method and sequence consistent with the drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract. The erection of steelwork shall be planned so as to ensure safe- working conditions at all times. The Contractor

shall be solely responsible for enhancing the safety of his construction activities at Site.

7.6.3.5 **Assembly & Erection**

- A. During erection, the members and sections shall be accurately assembled as shown on the approved shop drawings and any match marks shall be followed. The material shall be carefully handled so that no sections will be bent, broken or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have one half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before bolting with high-strength bolts. Fitting-up bolts shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 1 mm or larger.
- B. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.
- C. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other damages. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, each application subject to the approval of the Engineer.
- D. The responsibility in respect of temporary bracing and guys shall rest with the Contractor until the structural steel is located, plumbed, levelled, aligned and grouted within the tolerances permitted under the Specification, and the permanent bracing/framing system has been installed.
- E. The temporary guys, braces, false work and cribbing shall not be the property of the department and may be removed by the Contractor, with the approval of the Engineer, without any charge, once the permanent framing system has been installed -to the satisfaction of the Engineer and when the temporary bracing, guys etc. can be removed without any potential danger/damage to the erected structure.

7.6.3.6 **Setting Out**

- A. Positioning and levelling of all steelwork, plumbing and placing of every part of the structure with accuracy shall be in accordance with the approved drawings and to the satisfaction of the Engineer. The Contractor shall check the positions and levels of the anchor bolts etc. before concreting and ensure that they are properly secured against disturbance during pouring operations. The Contractor shall remain responsible for correct positioning and shall set proper screed bars to maintain proper level. No extra payment shall be made on this account.
- B. No permanent field connections by bolting shall be carried out until proper alignment and plumbing guides have been attached.

7.6.3.7 **Field Bolting**

- A. Bolts shall be inserted in such a way that they remain in position under gravity, even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled all joint surfaces including those adjacent to the washers shall be free of scales. They shall be free of dirt, loose scales, burns and other defects that would prevent solid seating of the parts.
- B. Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming

for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications.

- C. All high tensile bolts shall be tightened to provide when all fasteners in the joint are tight, the required minimum bolt tension as per relevant Indian Standard/Specification.
- D. The manufacturing and use of high strength friction grip (HSFG) bolts shall comply with the requirements of IS:3757 (1985).
- E. Load indicating bolts or washers may be used, subject to the approval of the Engineer.

7.6.3.8 Holes, Cutting and Fitting

- A. No cutting of sections, flanges, webs, and cleats, rivets, bolts, welds etc. shall be done unless specifically approved and / or instructed by the Engineer.
- B. The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract, or directed by the Engineer. Wherever such work is specified, the Contractor shall obtain complete information as to size, location and number of alterations, prior to carrying out any work.

7.6.3.9 Drifting

- A. Correction of minor misfits will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes, as necessary, to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.
- B. Any error in shop work which prevents proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be brought to the attention of the Engineer, and approval of the method of correction obtained. The use of gas cutting torches at the erection site is prohibited.

7.6.3.10 Grouting

- A. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water, and any accumulated water shall be removed. Grouting shall be carried out under expert supervision taking care to avoid air locks. Edges shall be finished properly.
- B. Whatever method of grouting is employed the operation shall not be carried out until the steelwork has been finally levelled. Immediately before grouting, the space under steel is thoroughly cleaned. Where packing is to be left in place, they shall be placed such that they are completely covered with grout.
- C. The grout to be used shall be Non-shrink grout Conbextra GP-2 of M/S Fosroc or equivalent.
- D. All steel in foundations shall be solidly encased in Portland Cement Concrete of minimum characteristic strength at 28 days as specified in the drawings, subject to a minimum of 35 N/mm². A minimum cover of 100mm shall be provided to all steelwork where surrounding concrete is in contact with soil.

7.6.3.11 Inserts and Embedment

Various steel inserts and embedment are required under the contract to be fabricated, positioned and secured firmly into place inside the formwork prior to concrete being poured. There are also requirements of jointing, threading, bolting and welding inserts and embedment of different concrete and structural steel elements in order to establish structural continuity and connection. Great care

shall be exercised by the contractor in executing all aspects of the work related to inserts and embedment, including tolerances, so that the final assembly of the concrete elements can meet satisfactorily the continuity requirements intended in the structure.

7.6.3.12 Painting after Erection

- A. Steelwork coated with rust inhibitor shall not be left exposed for a period exceeding 15 days. Otherwise, such steelwork shall be re-cleaned and re-coated with such finish until encased in concrete.
- B. No steelwork with shop paint shall be left exposed at site for a period exceeding that approved by the Engineer.
- C. The surfaces required to remain unpainted at shop, shall be given a protective coating after the structure is erected, levelled, plumbed, aligned in its final position, and accepted by the Engineer. However, touch up painting, making good any damaged shop painting and completion of any unfinished portion of the shop coat shall be progressively carried out by the Contractor.
- D. Painting shall not be done in frost or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted. Before commencing painting of steel, which is delivered unpainted, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.
- E. All field bolts, welds and abrasions to the shop coat, and surfaces delivered unpainted from fabrication shop, shall receive the full protective treatment as specified in Table defined in painting specifications before delivery to Site.
- F. Surfaces, which will be inaccessible after field assembly, shall receive the full specified protective treatment before assembly. Bolts and fabricated steel members, which are galvanized or otherwise treated, shall not be painted.
- G. The contractor shall be responsible for any damage caused to other components of the structure including the substructure. In particular, he shall take all necessary precautions to minimize concrete splash onto completed steelwork or rust staining of concrete due to erected steel work and clean and/or repair all stains and other damages to completed work prior to tests on completion.

7.6.3.13 Final Cleaning up

Upon completion of erection, and before final acceptance of the work by the Engineer, the Contractor shall remove, free of cost, all false work, rubbish and all temporary works, resulting from or in connection with the performance of his work.

TECHNICAL SPECIFICATION S08: PILE FOUNDATIONS

S.08: PILE FOUNDATIONS**8.1 General:****A. Piling plant and Methods:**

Suggested method for piling is bored cast in-situ piles with hydraulic drilling rigs using partial depth casing with Polymer slurry and oscillator arrangement.

- i. Not less than 2 weeks before any piling work is commenced, the Contractor shall submit to the Engineer for approval, full details of his proposed piling plant and detailed method statements for carrying out the Works. Details of casings and concreting methods in respect of bored cast in-situ concrete piles are to be provided.
- ii. The Contractor shall not commence any piling until the plant and methods which he proposes to use have been approved by the Engineer but such approval shall not relieve the Contractor from any of his obligations and responsibilities under the Contract. If for any reason the Contractor wishes to make any change in the plant and methods of working which have been approved by the Engineer, he shall not make any such change without having first obtained the Engineer approval thereof.
- iii. List and nos. of equipments, accessories proposed to be used for the present job shall be submitted along with the technical bid.

B. Records:

The Contractor shall keep complete records of all data required by the Engineer covering the boring operations, reinforcement cage lowering and concreting procedure of each pile and shall submit two signed copies of these records to the Engineer, in the format given in the specification or as approved by the Engineer, within two days of completion of concreting of the pile.

C. Programme and Progress Report:

- i. The Contractor shall inform the Engineer each day about the programme of piling for the following day and shall give adequate notice of his intention to work outside normal hours and at weekends, where approved.
- ii. The Contractor shall submit to the Engineer on the first day of each week, or on such other date as the Engineer may decide, a progress report showing the rate of progress to that date and progress during the previous week or period of all main items of piling works, as required by the Engineer.

D. Setting Out:

The Contractor shall establish and maintain permanent datum level points, base lines and grid lines to the satisfaction of the Engineer and shall set out with a suitable identifiable pin or marker, the position of each pile. The setting out of each pile shall be agreed with the Engineer at least 8 working hours prior to commencing work on a pile and adequate notice for checking shall be given by the Contractor.

Notwithstanding such checking and agreement, the Contractor shall be responsible for the correct and proper setting out of the piles and for the correctness of the positions, levels, dimensions and alignment of the piles.

- E. After all piles are cast and weak concrete is chipped out, the Contractor shall submit the drawing showing the exact location of piles with respect to the Pier/column centre line.

F. Disturbances and Noise:

- i. The Contractor shall carry out the piling work in such a manner and at such times as to minimize noise and disturbance. The pile driving operation can produce noise levels upto 100 dB(A) at a distance of 25m from the site. Using a sound absorbent could reduce the noise levels. This can reduce the noise levels to 70dB(A) at a distance of 15m from the piles. The safety and precautions as stipulated in IS:5121 (1969) "Safety Code for Piling and other Deep Foundation" need to be adopted.
- ii. The Contractor shall take precautions adequate enough to avoid damage to existing services and adjacent structures. IS: 2974 (Part 1) - 1982 may be used as a guide for studying qualitatively the effect of vibration on persons and structures. In case of deep excavation adjacent to piles, proper shoring or other suitable arrangement shall be done to guard against the lateral movement of soil stratum or releasing the confining soil stress. Any such damage shall be repaired by the contractor to the satisfaction of the Engineer.
- iii. The Contractor shall ensure that damage does not occur to completed piling works and shall submit to the Engineer for approval, his proposed sequence and timing for driving or boring piles having regard to the avoidance of damage to adjacent piles.

G. Obstructions:

If during the execution of the Works the Contractor encounters obstructions in the ground, he shall forthwith notify the Engineer accordingly, submit to him details of proposed methods for overcoming the obstruction and proceed according to the Engineer's instructions.

8.2 Scope of Work:

- a) These specifications cover the works of providing pile foundations. Work included consists of all necessary services and furnishing of all labour, material, tools, equipment and related items for the full and satisfactory performance of the contract, conforming to these specifications and as shown in the Contract Drawings or reasonably implied therein or any authorised conditions or alterations thereof.
- b) The tenderer is advised to visit the site and familiarise himself with the conditions at site. The Engineer shall not be held responsible for the accuracy of the soil data, furnished in good faith with the tender.
- c) The construction of piles shall be in accordance with the following Indian Standard Codes of Practice for Design and Construction of Pile Foundations:
IS: 2911-2010 Part I Section 2 Bored Cast in-situ Concrete Piles Or IRC:78 Standard specifications and code of practice for road bridges Foundation And Substructure
- d) With the tender the Contractor shall submit the detailed method of construction to be used. For cast-in-situ concrete piles the Contractor shall indicate the methods he proposes to concrete the piles in order to prevent necking of piles.
- e) The items of work will generally be as follows:
 - i. Boring/drilling including provision of temporary casing/permanent casing
 - ii. Supplying, fabrication, and placement of all reinforcing bars.
 - iii. Casting of concrete piles as per specifications.
 - iv. Load testing of piles.

8.3 Materials:

a. General:

Unless otherwise specified in this section all materials shall conform to the requirements specified in separate sections for Concrete, Formwork and Reinforcement.

b. Cement:

The cement to be used for piling and all foundation work shall be conforming to following Indian

Standard Specifications:

- i. 53 grade Ordinary Portland Cement conforming to IS:269 – 2015
- ii. IS:16714:2018 Specification of GGBS for Use in Portland cement by blending process, and for making concrete by direct addition.
- iii. IS: 455 Specification for Portland slag cement. Cement shall be free from lumps and caking.

c. Concrete Mix Design:

The concrete shall be M35 or as specified in the approved drawings. The maximum size of coarse aggregate shall not exceed 20mm. For sub aqueous concrete, the requirements specified in IS 456 shall be followed. For cast-in-situ piles, concrete with a slump of 150 to 180mm (consistent with the method of concreting) will be required. For slumps more than 150mm the workability should be tested by "determination of flow" as per IS: 9103. **Minimum cementitious content for design mix shall not be less than 400 kg/m³** of concrete in piling. For piling, quantity of cement shall be as per the design mix or the minimum cement content whichever is greater shall be used. For improving resistance against chlorides and sulphates form surrounding soils or water, mineral admixture such as GGBS is preferred to be used.

Chemical Admixture used in the Mix Design shall conform to specification mentioned in S.03 of Section-VII-F.

The contractor shall submit mix design calculations and get the same approved by the engineer well before the starting of installation of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings.

The concrete shall be properly graded, shall be self-compacting and shall not get mixed with soil, excess water, or other extraneous matter.

d. Concrete cube tests:

Concrete cubes shall be cast, tested and evaluated as specified in S.03 of Section-VII-F.

e. Reinforcement:

The reinforcement shall conform to the requirements specified in S.05 of Section-VII-F along with IS 2911 (Part 1/ Sec 2) and used as per the drawings, extending for the full length of the pile and shall project minimum 60 times the bar diameters above the cut off level or as specified in the drawing. Only circular concrete cover blocks threaded on to the helix shall be used for ensuring the specified cover. Minimum clear cover to the reinforcement shall be 75 mm, unless otherwise mentioned.

f. Temporary Casings and Tremie Pipes:

Temporary casings, as approved by the Engineer, shall be used to maintain the stability of pile bore hole. The casings and tremie pipes shall be in mild steel. The temporary casing plates shall have adequate wall thickness and strength to withstand driving stresses, stresses due to soil pressure, etc. without damage or distortion all joints shall be watertight. The internal diameter of the casing shall not be less than the nominal diameter of pile. Temporary casings and tremie pipe shall be free of distortion and shall be of uniform cross-section throughout each continuous length. During concreting, they shall be free of internal projections and encrusted concrete which may prevent proper formation of the pile. The tremie shall be water-tight throughout its length and have a hopper attached at its head by a water-tight connection.

g. Stabilizing Material:

The stabilizing material (Polymer slurry used & quality control) to maintain the sides of pile bores shall have the properties as per requirement given below. Polymer slurry is obtained by mixing polymer powder with water in suitable proportion (1kg powder in 1000 litres of water) and the solution is thoroughly agitated so as to ensure uniform mixing of the polymer powder and water. The capacity of the mixing tank shall be more than 1.5 times of the volume of the bore hole for which the Polymer is to be used.

For mixing of polymer powder with water and the subsequent pumping of slurry into bore, suitable capacity mixing tank (M.S tank) equipped with agitator & pumping arrangement shall be used.

However, Use of Bentonite as stabilizing material is not permitted. Polymer slurry shall satisfy the desired properties at all times:

- a) Marsh cone viscosity 60-70 seconds/qt (900 ml-One cone volume)
- b) Specific gravity 1.05 to 1.07
- c) PH value 8 to 10
- d) Sand Content by mud balance method - 0.25 % to 2%

8.4 Test Bores (150mm Dia)

- a. Bore hole shall be made as per IS 1892 for determining (which is one of the criteria of establishing) start of socketing horizon and termination level of piles. Standard Penetration Test (SPT), as per IS 2131, in a bore hole shall be conducted at 1.0 m intervals in the overburden soil and rock portion having core recovery $\leq 30\%$.
- b) Number of bore holes for determining termination shall vary depending on the site condition and as decided by the Engineer. Generally, one borehole shall be done at each Pier location.

8.5 Cast In-Situ Bored Piles:

A. General:

- i Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.
- ii Bore hole data provided by the Employer for construction are only indicative in this regard and it is the contractors' responsibility to make correct assessment of ground conditions before starting the piling operation. Depth of piles is likely to vary, and contractor shall have no claim whatsoever irrespective of the depth of piles provided at any and all locations.
- iii These shall be formed by boring to the founding strata specified in the drawings or as directed at site. The sides of the boring shall be prevented from collapsing by one of the following means
 - Permanent mild steel liner (cased pile)
 - Removable/temporary mild steel casing (uncased pile).
- iv Bored cast-in-situ piles shall conform to IS 2911 (Part 1/ Section 2) and IS 14593, where not contravening to the following provisions. Based on borehole reports and drawings, Method Statement for the piles shall be established by the Contractor before commencement of the work and the same shall be submitted to the Engineer for obtaining his approval. Installation of piles shall be carried out as per pile layout drawings, installation criteria, approved Method Statement and instructions of the Engineer Any changes to the pile design, based on test-piles results, bore-hole data or soil conditions encountered during boring, shall be as instructed by the Engineer.
- v During boring, the Contractor shall, where required by the Engineer, take soil, rock or ground water samples and transport them to an approved testing laboratory to carry out soil tests as directed.
- vi The method adopted shall be chosen giving due consideration to the subsoil data, ground water

- conditions and to the other relevant conditions at site as well as to the presence of adjacent structures.
- vii Before installing the initial test pile, the Contractor shall finalise the pile testing arrangement and obtain approval of the Engineer. It is envisaged that the working piles shall be installed after the successful completion of the initial pile load test.
 - viii The bottom of the steel lining shall be sufficiently deep in advance of the boring tool so as to prevent settlement of outside soil and formation of cavities.
 - ix Removable mild steel casings shall be used only with extreme caution. Individual casings shall be joined together by screwing or any other approved method and not by direct butting with external lug connections. The inner surface of casings shall be smooth and free of all internal projections.
 - x The Contractor shall record all the information during installation of piles, including pile-bore observations before concreting each pile. The data sheet for recording pile data shall be as approved by the Engineer. On completion of each pile installation, pile record shall be submitted to the Engineer within two days of completion of concreting of the pile.
 - xi The contractor shall set out piles with precision survey duly erecting permanent benchmarks and other references. He shall be responsible for correct maintenance of position and plumb thereafter and these shall be checked periodically.
 - xii **Control of Position & Alignment:** Piles shall be installed as accurately as possible according to the drawings either vertically or to the specified batter. All deviations will be measured at the cut off level of the piles. The deviation from the true axis shall not be more than 1.5% for vertical piles and 4% for rake piles. Piles should not deviate in location by more than 75mm when used in groups. For single or 2 piles used under columns, deviation shall not be more than 50mm. The Contractor shall maintain a record of actual pile locations in the form of drawing and submit the information to the Engineer at suitable intervals.

B. Boring:

- i Boring shall be done using hydraulic drilling rigs with oscillator arrangement suiting to different kinds of strata encountered.
- ii The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm. However, the size of cutting tool shall be chosen by contractor depending on the type of substrata and equipment employed by contractor so that executable pile shall not have diameter less than nominal diameter of pile as specified in drawing.
- iii The boring centre shall be aligned with the pile centre and the boring machine shall be installed so as not to move or incline. The sides of the borehole shall be stable throughout.
- iv Working level shall be above the Cut-off-Level. After the initial boring of about 1.0 m, temporary guide casing of suitable length shall be lowered in the pile bore for vertical pile. The diameter of guide casing shall be such as to give the necessary finished diameter of the concrete pile. The centre line of the guide casing shall be checked before continuing further boring. Guide casing shall be minimum of 1.0 m length. Additional length of casing may be used depending on the condition of the strata, ground water level etc.
- v The temporary guide casing (if provided) shall be withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing, concrete shall not be disturbed.
- vi For providing permanent MS liner, Clause 709.1.4 of IRC: 78 shall be complied. Wherever stricter provision has been given in the drawings, the same shall be followed. The Contractor shall fabricate MS liners from MS sheets to suit to the diameter of the pile. The required length of the liners will be made up by welding each unit at site. The thickness of the liners shall not be less than 6 mm and for the bottom length of 1.2 m or such increased length as decided by the Engineer, the thickness can be increased suitably. The bottom end of the MS liners shall be stiffened by welding additional plates to withstand the impact during driving.

- vii The piles shall be founded on hard rock or other suitable strata as approved by the Engineer.
- viii Piling shall be done by using hydraulic rig with temporary liner. Use of liner (for the top 4 to 6 metres from ground level or more depth, to protect loose soil falling in bore hole) as directed by engineer, is essential. **No extra payment shall be made to the contractor for using temporary liner over the item of piling as in BOQ/Design and build contract.**
- ix Use of drilling mud in stabilizing sides of the pile borehole may also be necessary together with temporary or permanent casing wherever sub soil and ground water conditions are likely to cause mud flows or instability of pile bore or sand boiling. However, this will be permitted only when deemed necessary by the Engineer.
- x Consistency of the stabilizing material suspension shall be controlled throughout concreting operations in order to keep the bore stabilized, as well as to prevent concrete getting mixed up with the thicker suspension of the mud.
- xi After the installation of temporary casing, the drilling operation will continuously proceed together with the application of the Polymer slurry.
- xii Boring operation shall be carried out further by using the shaft stabilization slurry (Polymer Slurry). The drilling operation shall proceed together with the mixing of the Polymer Slurry. Once the pumping of polymer slurry into the bore is initiated, the bucket or auger is then rotated to mix the Polymer slurry along the Pile shaft.
- xiii Prior to preparation of the bore stabilising slurry, cleanliness and water tightness of storage tank shall be ensured. pH value of fresh water shall be between 7 to 9.
- xiv The site conditions and drilling diameter of bore holes may affect the usage ratio of polymer in the mixture and as well as it's viscosity.
- xv During concreting activity, the flushed-out Polymer fluid will be collected in storage tanks by pumping back. There is no hazardous effect of this bore stabilising fluid on environment. The Polymer slurry level shall not be kept below the bottom level of Steel Casing. The slurry shall be tested periodically, and the results will be submitted to the Engineer. Prior to placing of concrete in the borehole, make sure that heavily contaminated slurry, which could impair the free flow of concrete from the tremie pipe, has not accumulated in the bottom of the borehole. For this, the borehole shall be kept untouched after reaching the desired depth for 1 to 2 hours so as to allow the suspended particles of the polymer to settle down. Then the bore hole shall be cleaned by cleaning bucket before pouring the concrete.
- xvi When borehole is stabilised by casing and drilling mud or by maintaining water head using temporary/permanent casing, the bottom of the hole shall be cleaned very carefully before concreting work is taken up. Cleaning / flushing methodology shall be submitted for the approved of the Engineer prior to commencement of piling.
- xvii Where mud flow conditions exist or the aggressive action of ground water is to be avoided, or in the case of piles built in water or in cases where significant length of piles could be exposed due to scour - the casing should be left permanently in the ground with 8 mm thick permanent liners as directed by Engineer-in-charge.
The quantum of steel required in liners up to depth of cut off level shall be measured as per drawing though the liner might have been provided right from the level of the working platform on practical considerations, since the length of the permanent liner above the cut-off level has to be necessarily removed by gas-cutting for facilitating peeling of the top portion of the pile and for interlacing its reinforcement bars into the capping slab. There is however, no objection if the surplus pieces (if cut and removed carefully and then found reusable) are joined and are re-welded to required length for reuse in the same contract on some of the other piles. No claim shall be entertained for such pieces if the cut pieces cannot be reused by the Contractor in the aforesaid manner.
- xviii Pumping from bore hole shall not be permitted unless a casing has been driven into a stable stratum

which prevents flow of external ground water from other strata in significant quantities.

- xix **In case of end bearing piles founded on hard rock, cutting of rock by hydraulic rig using diamond bits will be resorted to.** Scheme adopted shall be such that the noise and vibration parameters specified in tender documents /Environment manual are not violated. Drilling in rock shall be carried out by hydraulic rig using diamond bits. Hydraulics rigs of suitable capacity (in terms of rpm and torque) to be able to bore in hard rock strata shall be deployed.
- xx In case of dry bores, inspection shall be carried out from the ground surface for bores having diameter less than 750mm. For larger diameter bores equipment shall be provided to enable the Contractor and the Engineer or their representatives to descend into the boring for the purpose of inspection with all necessary safety precautions.
- xxi Care shall be taken not to harm a recently concreted pile due to driving the casing nearby before the concrete has sufficiently set in that pile. The danger of doing harm is greater in compact soils than in loose soils.

Penalty on mishandling of Polymer slurry

Mishandling of Polymer slurry (like splashing of Polymer slurry outside specified width of barricading or non-cleaning of tyres of dumpers and transit mixers before leaving the piling site thereby making the road dirty etc.) is strictly prohibited. Noncompliance of same shall attract a penalty as follows:

- I On first observation - Rs. one lakh
- I On Second observation - Rs. two lakhs
- II On third and each subsequent observation - Rs. three lakhs

8.6 Termination of Pile:

- a) The boring depth shall be measured at two or more places to the bottom of the Hole immediately after completion of boring operations. The results shall be reported promptly.
- b) Pile shall be terminated at a design depth with a minimum socket length as mentioned in design document/drawing, or as directed by the Engineer-In-Charge.
- c) Approval of the termination depth of the pile by the Engineer shall, in no way, absolve the contractor on the integrity of the pile.
- d) For the purpose of socketing of end bearing pile in hard rock, the following criterion shall be satisfied:
 - When the crushing strength of the rock is more than characteristic strength of pile concrete, the rock encountered should be deemed as hard rock as per clause No. B7 of Annex-B, IS 2911-Part1/ Sec-2).
 - Rock will classify as hard rock if RQD > 75%.
 - Minimum Socketing depth in hard rock shall be as per approved drawing or as directed by the Engineer-In-Charge.
- e) For establishing the similarity of soil/rock strata actually met while advancing the pile-bore with the strata selected for terminating the pile, Pile Penetration Ratio (PPR) shall be used in this method as per clause No.10 of IRC-78:2014.
- f) Pile Penetration Ratio (PPR) of rock strata encountered, used for termination of pile shall be confirmed by Initial Pile Load tests, Routine pile Load tests and also co-related with the Unconfined Compressive strength of rock strata and also RQD values.
- g) As the resistance to rock cutting increases, RPM decreases, and Kelly bar pressure is required to be increased, i.e., increasing the torque. This is reflected in the torque- RPM curve.

8.7 Cleaning of borehole:

- a) After completion of borehole upto the required depth, the borehole shall be cleaned as per clause 8.3 of IS : 2911 (Part 1/Section 2).

- b) When the boring is done by rotary drilling rigs, cleaning-bucket attached to the Kelly shall be used for cleaning the bore. Wherever stabilizing material is used, after using the cleaning-bucket, the bore shall be flushed with fresh slurry.
- c) Pile bore shall be cleaned by fresh stabilizing material through tremie pipe or as specified in the Method Statement, before (in case delay in concreting after the completion of bore) and after placing the reinforcement cage and just before the start of concreting. Pile boring shall be inspected and approved by the Engineer, in accordance with approved Method Statement, before concreting.
- d) The Contractor shall measure the final depth after this cleaning, when there is a delay in concreting after completion of the bore, for knowing the casting pile length, and confirm its effect by comparing with the depth at the end of boring.

8.8 Reinforcement Steel:

- a) The reinforcement shall be assembled before placing in the moulds and all hoops and links shall be of uniform length firmly wired into position. Ends of helical reinforcement, if used, shall be firmly secured. Diagonal for spacers shall be of a pattern that has been approved by the Engineer.
- b) Joints in main longitudinal bars will be permitted only where, in the opinion of the Engineer, each bar cannot be supplied in one complete length. Where permitted, joints shall be provided in staggered manner at agreed locations, designed to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups and staggered in position from those of adjacent longitudinal bars, all to the approval of the Engineer.
- c) All joints/laps in the longitudinal bars will be held in position by means of binding wire and tack welding. Nothing extra shall be paid for the welding of lap joints. The last one circle of helical stirrups at each end shall be welded to main longitudinal bars.
- d) **Lowering of the reinforcement cage:**
The reinforcement cage shall be properly aligned with the pile core and kept vertical without collapsing the hole wall. In lowering of the reinforcement cage, it shall avoid deformations, damages, etc. by using reinforcing material as necessary. In the lap joint part of the reinforcement cage, the upper and lower cages shall be in a straight line, with the joints tightly bound.

Proper cover to reinforcement and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers. cast specifically for the purpose, as directed by the Engineer. **The longitudinal reinforcement shall project, minimum 60 times the dia. of reinforcement bar or as indicated in the drawing, above Cut-off-Level.**

After lowering of the reinforcement cage, the height of the top end of the reinforcement shall be measured and reported. The axes of the reinforcement cage and the pile core shall be matched, checked and reported.

8.9 Concreting:

- i Concreting shall not be done until the Engineer is satisfied that the termination level of pile, is as per the installation criteria and the Method Statement that has been approved by the Engineer.
- ii Prolonged delays in the commencement of concreting after the completion of the boring shall not be permitted. The time interval between the completion of boring and placing of concrete shall not exceed 6 hours.
- iii Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part 1/ Sec 2).
- iv The concrete shall have a minimum slump of 150mm in case of concreting in a water free bore. Suitable precautions shall be taken for prevention of segregation. Internal vibrators shall not be used unless the Contractor is satisfied that segregation will not result because of vibration and unless the

method of use has been approved by the Engineer. It is essential that the water level within the pile bore be in equilibrium before commencement of concreting.

- v The concrete for piles underwater or in drilling mud shall be placed with a tremie pipe. The tremie pipe shall not be less than 200mm diameter for 20mm aggregate. The joint between the hopper and tremie pipe as well as the joints in the tremie pipe shall be watertight and the tremie pipes shall be thoroughly cleaned after each use.
- vi Concreting by tremie shall continue to allow the initial pours of concrete, mixed with stabilizing fluid, sludge and cut spoils from the bore to overflow and the consistency and quality of the overflowing concrete is comparable to that of design mix. The length of overflow shall be decided by the Engineer.
- vii The contractor shall also ensure that there is no reduction in poured concrete quantities. These calculations shall be based on consumption of concrete poured in bore (as recorded in bore log) and actual concrete required in bore on theoretical basis i.e. based on nominal diameter of pile and actual bore hole length (based on actual sounding of founding level). Above 5% reduction in consumption of poured concrete quantities in pile may be rejected.
- viii While concreting the tremie shall be withdrawn slowly ensuring adequate height of concrete outside the tremie pipe at all stages of withdrawal.
- ix The Contractor shall ensure that heavily contaminated drilling mud has not accumulated at the base of boring since this could impair free flow of concrete from the tremie pipe.
- x If the specific gravity of the drilling mud at the base of the bore exceeds 1.20 the placing of concrete shall not proceed.
- xi The first charge of concrete shall be placed in the hopper over a sliding plate of the bottom of the hopper. The charge should be adequate in volume to ensure flushing action to prevent mixing of water or drilling mud and concrete. Alternatively, floating plugs of approved specification may be used before the first charge of concrete.
- xii The tremie pipe shall at all times penetrate the previously placed concrete with adequate margin against accidental withdrawal. The tremie pipe shall not be withdrawn until the completion of concreting. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the seepage water.
- xiii Spot measurements shall be taken at suitable intervals to check that the tremie pipe has an adequate penetration into previous concrete.
- xiv Concreting of the pile shall be in one single and continuous operation. In case of long piles of large diameter, large size mixers or more mixers shall be used so that the entire concreting operation is completed in not more than two hours.
- xv Temporary casings, when used, shall be extracted carefully to the satisfaction of the Engineer, whilst the concrete is sufficiently workable to ensure it is not disturbed or lifted, and the reinforcement cage does not get disturbed. During extraction, a sufficient quantity of concrete shall be maintained inside the casing to overcome the pressure from external water, soil or stabilizing material and to ensure that no reduction in section by way of necking or shearing of concrete and contamination of the pile takes place.
- xvi When a casing is being extracted a sufficient quantity of concrete shall be maintained within the bore to ensure the pressure from external ground water and soil is adequately exceeded by the pressure of concrete. Otherwise necking of the pile may result. A minimum embedment of 1.5 to 1.8 m is required.
- xvii Grouting at base of pile shall be done wherever the results of proof coring (in case of rock), sonic logging and/or loading test etc. confirm that there is a void/sludge at the pile base. The grouting shall be done with cement slurry under suitable pressure after concrete in the pile attains the desired strength. For this purpose, conduit pipes with easily removable plugs at the bottom end shall be placed in the bore along with reinforcement cage before concreting.

- xviii No concreting shall be placed in the bore once the bottom of the casing has been lifted above the top of concrete.
- xix The top of concrete in a pile shall be brought above the cut-off level since the top concrete is loose and is weak because of contamination with water/drilling mud. This ensures good concrete at the cut-off level.
- xx After each pile has been cast, any empty bore shall be protected and carefully backfilled as soon as possible with approved materials.
- xxi Complete boring and concreting records shall be submitted to the Engineer for each pile. The records shall include the duration of concreting, tremie lengths (individual and cumulative), tremie pipe lengths removed, theoretical sounding, actual sounding, actual lengths of pile concreted and the volume of concrete placed, cut off level, founding levels etc. For piles with temporary casings records of sequence of casing withdrawal and levels of concrete before and after withdrawal shall also be included in the reports.

8.10 **Cut-off-level (COL)**

- a) Cut off level of piles shall be as indicated in working drawings or as directed by Engineer.
- b) The top of concrete in pile cast shall be above the Cut-off-Level by 1.0 m (minimum) and as per the Method Statement, to remove all laitance and weak concrete and to ensure good concrete at Cut- off-Level, for the proper embedment into the pile cap. Any exceptions, due to contingent situation, will be subject to the approval of the Engineer.
- c) **Preparation of pile head:** The area surrounding the piles shall be excavated up to the bottom of the pile caps. After seven days of concreting of pile, the exposed part of concrete above the COL shall be removed or chipped off and made rough at COL. In case a part of extra-pile concrete before curing is handled, the Contractor shall obtain prior approval from the Engineer. The projected reinforcement above COL shall be properly cleaned and bent carefully, only where required, to the required shape and level to be anchored into the pile cap as per the drawing. While finishing the pile head, care shall be taken to ensure no harmful damage, such as cracks, occurs in the concrete. The pile top shall be embedded into the pile cap by 150 mm or clear cover to reinforcement, as per the drawing and as agreed by the Engineer. All loose material on the top of pile head after chipping to the desired level shall be removed and disposed as per contractual procedure and as directed by the Engineer.
- d) In case of concrete being placed by tremie method and pile cut off level less than 1.0 meter below the ground level, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to a minimum of one meter above COL. Before concreting, contractor shall obtain the approval of the Engineer of the height above COL up to which the concrete is to cast.
- e) Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete.

8.11 **Alignment of Piles**

8.11.1 Piles shall be installed as accurately as possible according to the drawings either vertically or to the specified batter. All deviations will be measured at the cut off level of the piles. The deviation from the true axis shall not be more than 1.5% for vertical piles and 4% for raker piles. Piles should not deviate in location by more than 75mm when used in groups. For single or two piles used under piers / columns, deviation shall not be more than 50mm.

8.11.2 The Contractor shall maintain a record of actual pile locations in the form of a drawing and submit the information to the Engineer at suitable intervals.

8.12 **Pile Cap:**

Pile caps shall be of reinforced concrete. A minimum offset of 150 mm shall be provided beyond the outer faces of the outer most piles in the group. If the pile cap is in contact with earth at the bottom, a levelling course of minimum 75 mm thickness of PCC of grade M15 shall be provided or as shown in the drawings. The ground shall be excavated, levelled, prepared and then layers of coarse aggregate and blinding concrete shall be constructed below pile cap, conforming to Clause 2.0 of this Specifications and as per the drawings. The pile cap shall then be cast as per the drawings and conforming to specifications mentioned in S.03 & S.05 of Section-VII-F of this Technical Specifications, subject to tolerances mentioned therein.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. The top of pile after stripping shall project at least 150mm or clear cover to reinforcement or as per given in the drawing, into the pile cap. Concreting of the pile cap shall be carried out in dry conditions. All the operations and tools required for making the pile in dry condition is included in the item.

8.13 **Testing of Piles:**

- i The Contractor shall conduct Load tests/Integrity Tests on Pile as described below in accordance with these specification and approved method statement. **Cost of the same is deemed to be included in the contract price and nothing extra shall be payable to the contractor on this account.**
- ii When preparing for conducting a pile test, the Contractor shall follow the requirements of the various acts, orders, regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.
- iii Full details of the equipment proposed to be used, the test setup and pile testing scheme along with detailed design, drawings shall be submitted to the Engineer, before making arrangements to carry out the tests, for obtaining his approval. Approval of the Engineer shall also be obtained after the test setup is complete, prior to commencement of loading.
- iv The work shall include mobilization of all necessary equipment, anchor piles and rock anchors and anchor piles and rock anchors, providing necessary engineering supervision and technical personnel, skilled and unskilled labour as required, to carry out the complete pile testing and submission of test reports.
- v It is essential that all the equipment and instruments are properly calibrated both at the commencement and immediately after the completion of tests, so that they represent true values. If the Engineer desires, the Contractor at his own cost shall arrange for calibration of the instruments in presence of the Engineer, at a laboratory having Engineer's approval, and the test report and calibration certificate shall be submitted to the Engineer.
- vi The load tests shall be in accordance with the Indian Standard Code of Practice for Design and Construction of Pile Foundations IS 2911 (Part IV) Load Tests on Piles. For initial load test, test load will be 2.5 times the theoretical designed capacity of pile. For initial load, test arrangement to be designed shall also cater for additional 25% above test load and nothing extra will be paid on this account. Permissible stresses in test arrangement (steel truss or plate girder) to cater for test load plus additional 25% load shall be within permissible stresses as per IS: 800 (as for permanent structure). For test frame, steel of Grade -B conforming to IS: 2062 shall be used.
- vii Engineer will decide the locations of initial and routine (both lateral and vertical load tests). The Frequency or number of the Initial/Routine pile load test shall be as per IS: 2911 (Part IV). Notwithstanding to the above, the number of Routine Load test shall be 2 percent of the total number of piles required. **Nothing Extra shall be payable to the contractor on this regard.** The contractor shall undertake test piles required for initial pile load test (both lateral and vertical) in the initial stages

of work using the same methodology and equipment's which will be subsequently used for working piles. These tests shall be undertaken well in advance of taking up working piles. No working pile would be allowed to be undertaken till satisfactory initial pile load tests have been completed. Non-granting of permission for pile/ pile cap by Engineer in such respect will not be considered as reason for delay or any claim thereof. The test arrangement to be employed shall be of nature which is quick to install and remove and easily transferable. However, for stations initial load tests for all pile types have to be performed. Routine pile testing has to be as per IS 2911-Part 4

- viii The Contractor shall give the Engineer at least 48 hours' notice of the commencement of construction of these piles which are to be subjected to Initial Tests.
- ix The load tests shall not normally be conducted unless the concrete is at least 28 days old. However, in special circumstances, permission can be given by Engineer for prior testing.
- x All testing shall be done under the direction of experienced personnel conversant with the equipment and the testing procedure.
- xi Before the commencement of the tests all the particulars regarding the test pile including boring data and concrete cube strengths shall be made available at site and shall form a part of the test report.
- xii On completion of each load test the Contractor shall submit a report of the load test which shall include the following information.
 - a. Description of soil conditions, ground water table, actual boring and installation records, concrete cube test results.
 - b. Method of load application
 - c. Load settlement readings during loading and unloading
 - d. Time load-settlement curve
 - e. All other observation relevant to the test being conducted.

8.14 Integrity test

Two types of pile integrity tests will be performed:

a. **Dynamic Integrity Test:**

The Dynamic Integrity test using pile driving analyser or approved equivalent for pile integrity shall be performed on all the piles as specified below. The top of the pile shall be made accessible, chipped off up to hard concrete, levelled by trimming it back as far as practicable. The reinforcing bars of the piles tested shall be bent sideways. The test shall be performed after removal of bad/ weak concrete at top so that the wave propagation is steady through hard concrete. The test shall be carried out at minimum 3 locations on each pile in such a way that the entire cross section of the pile is evenly covered. The test shall be conducted with a minimum age of concrete of 15 days. A specialist approved agency shall be employed for the test and the tests shall generally be as per recommendations of the agency unless directed by the Engineer. A complete report indicating the graphical display of wave propagation under each hammer blow shall be submitted along with interpretation of results showing discontinuities, cross-sectional changes or material changes if any are to be co-related with Site data. **75% of total working piles shall be tested by dynamic integrity test.**

b. **Cross hole Ultra-Sonic Integrity Test**

The bored piles shall be tested to determine integrity of the pile by the above method.

The tests shall be carried out with consented method and consented specialist firm. **25% of total working piles shall be tested for integrity by Cross hole ultra-sonic method**

c. **General**

- i. The integrity of each pile shall be examined prior to acceptance of the pile into the Permanent Works.
- ii. At least 30 days prior to the commencement of integrity test, the Contractor shall submit the testing method, equipment, and testing company (specialised firm) to the Employer's

- Representative for his consent.
- iii. The Contractor shall demonstrate how the results obtained from the tests are to be interpreted in order that irregularities can be identified.
 - iv. The equipment of tests shall be certified with recent calibration/set up of the instrument and with curriculum vitae of those using the instrument and interpreting the result.
- d. **Criteria for acceptance**
- i. Criteria for acceptance or non-acceptance of the piles shall be established before starting the test in agreement between the Employer's Representative and the Contractor, based on specifications and experience records from the equipment supplier and the specialized company performing the testing, and other available information.
 - ii. In cases where there is doubt if the pile can be accepted based on the test results, an impartial expert appointed by the Employer's Representative shall decide.
- e. **Installation of pipes for integrity testing Cross hole Ultra-sonic method**
- i. 4 nos. of 50 mm (OD) Mild Steel pipes shall be fastened to the inner side of the reinforcement cage of all piles with diameter 1200mm or below. Installation of these pipes shall be carried out for the entire length of the pile. All the joints (if any) in the pipes shall be properly sealed by suitable means so as to make them water tight. The bottom and top of these pipes shall be plugged to prevent entry of mud, slush, polymer slurry, concrete etc.. Spacing of these pipes shall be at 90° in piles with diameter of 1200mm or below. For 1500 mm and 2000 mm diameter piles, 6 nos. of 50 mm (OD) pipes spaced at 60° shall be used.
 - ii. The mild steel pipes shall be supported and braced securely so that they maintain their position during cage lowering and subsequent concreting operations.
- f. **Testing**
- i. The Contractor shall carry out the tests by a specialized experienced agency consented by the Employer's Representative for all bored piles or as directed by the Employer's Representative.
 - ii. Unless otherwise directed or consented by the Employer's representative, integrity tests shall not be carried out until 7 days or more have elapsed since pile casting. Testing shall be undertaken on pile heads before steel reinforcement for pile caps is placed.
 - iii. Once the testing is completed, the pipes shall be filled with standard cement non-shrink mortar/grout before taking up the pile cap works.
 - iv. The testing shall be carried out in the presence of the Employer's Representative.
- g. **Reporting**
- i. The Contractor shall submit to the Employer's Representative the test results, associated interpretive report and certificate for each tested pile within 10 days of the completion of each test.
 - ii. The interpretation of test results shall be carried out by competent specialist engineers.
- h. **Anomalies**
- i. If any anomalies, which indicate unacceptable weaknesses in the concrete, are reported as a result of integrity testing, the Contractor shall perform core drilling for sampling and laboratory testing to prove whether the quality and bearing capacity of the concrete are adequate. The program for necessary core drilling and testing shall be consented by the

Employer's Representative.

- ii. If such anomalies are shown to be detrimental to the performance of the pile, remedial measures shall be consented by the Employer's Representative and undertaken by the Contractor to rectify this.
- iii. No covering over of the piles shall occur until the Employer's Representative is satisfied with the results of the testing and any remedial works.

The contractor shall conduct trial probes and trial pits down to depths decided by the Engineer with the objective of locating underground utilities well in advance of the piling. The locations shall be decided by the Engineer after consultation with the contractor.

8.15 Defective Piles:

- i. The Engineer reserves the right to reject any pile which in his opinion has not been constructed in accordance with the specifications.
- ii. The Contractor will not be paid for rejected piles. The increase in cost of the pile caps, tie beams and other measures adopted for strengthening as a result of rejection of defective piles shall be borne by the Contractor.

8.16 As-Built Drawings:

On completion of the work, the Contractor will submit a plan showing the exact location and length of each pile as constructed at site, as well as dates of concreting, cube test results etc. The original tracing of this drawing shall be submitted to the Engineer.

8.17 Pile Data:

The contractor shall submit data in the following proforma for each pile indicating all technical details along with date and time of various operations in adequate permanent forms/copies for record.

Proforma:

- i) Reference No. Location (Co-ordinates) ____ area.
- ii) Sequence of installation of piles in group
- iii) Pile diameter & type
- iv) Working level (Platform level)
- v) Cut off level (COL)
- vi) Actual length below COL
- vii) Pile termination level
 - (a) Start of socket (Level)
 - (b) Termination of pile (Level):
- viii) Top of finished concrete level
- ix) Date and time of start and completion of boring
- x) Depth of ground water table in the vicinity.
- xi) Type of rock at pile tip
- xii) Method of boring operation
- xiii) Details of stabilizing material as used:
- xiv) (a) Unconfined Compression Strength (UCS) Value in rock (from the nearest bore hole): Core recovery (from the nearest bore hole):
- (b) Rate of drilling in mm / hr:
 - (1) At start of socketing horizon
 - (2) At termination level
- xv) Date and time of start and completion of concreting.
- xvi) Concrete quantity Actual:
 - Theoretical:
- xvii) Grade and slump of concrete

xviii) Results of test cubes

8.18 Measurement for Payment (Not applicable for Schedule B):

The Contractor shall be paid for the length of each pile as measured from the theoretical founding level (as per drawing) or as per actual whichever is less to the point of the vertical cut-off level. The Contractor's rate shall include all items of work including all temporary/permanent arrangements for boring including usage of polymer slurry, concreting, handling, form-work, including chipping of top weak concrete, cutting off the MS liner / casing as necessary, removal of excavated earth, chipped concrete, casing / liners and polymer slurry away from site including its treatment & final disposal, and all other items of work for the satisfactory completion of the pile foundations. Reinforcement shall be measured and paid separately.

The quantity of permanent steel liners required for the job shall be measured in Metric tonnes and paid for separately as per the relevant item of BOQ.

The boring/drilling and socketing through hard rock strata shall be measured extra over and paid for separately as per the relevant item of BOQ.

TECHNICAL SPECIFICATION S-09: SHALLOW FOUNDATIONS

Bi-RIDE

S .09: SHALLOW FOUNDATIONS**9.1. General**

The work shall cover furnishing and providing plain or reinforced concrete foundation placed in open excavation, in accordance with the drawings and these Specifications or as directed by the Engineer.

Shallow foundations shall be used where a suitable bearing stratum is found near the surface without any highly compressible layers below and calculated settlements are within acceptable limits.

A method statement indicating the following shall be submitted by the Contractor for approval of the Engineer, well in advance of the commencement of construction of open foundation:

- i) Sources of materials
- ii) Design, erection and removal of formwork
- iii) Production, transportation, laying and curing of concrete
- iv) Personnel employed for execution and supervision
- v) Tests and sampling procedures
- vi) Equipment details
- vii) Quality Management System to be adopted including Quality Manual
- viii) Any other relevant information

Details of necessary arrangements for execution under water wherever necessary, shall be included in the method statement.

Dimensions, lines and levels shall be set out and checked with respect to permanent reference lines and permanent benchmark so that the foundations are located correctly and in accordance with the drawings.

Formwork, steel reinforcement and structural concrete for open foundations shall conform to S.02, S.05 and S.03 of Section-VII-F respectively of these Specifications.

9.2. Workmanship**Preparation of Foundations**

Excavation for laying the foundation shall be carried out in accordance with S.02 of Section-VII-F of these Specifications. The last 300 mm of excavation shall be done just before laying of lean concrete below foundation. Excavation shall be made only to the exact depth as shown on the drawing or as approved by the Engineer.

Open foundations shall be constructed in dry conditions and the Contractor shall provide for adequate dewatering arrangements, wherever required, to the satisfaction of the Engineer.

Open foundations should be located on the firm ground having stable strata of having SBC as per drawing or as specified by the Engineer. The strata shall be well compacted before levelling course and foundations are laid on the levelling. In case foundations resting on rock, no foundation shall be laid on sloping rock. The rock shall be made level for the width of the foundation before levelling course is laid. Before seating on the rock, bearing capacity of the rock shall be assessed properly, and safe bearing capacity assessed in the designs is to be confirmed.

In case of Open foundation resting on rock, seating of the rock shall be achieved by providing adequate no. of anchorage bars drilled to the required depth in the rock or as directed by Engineer-In-Charge.

Cost of the same is deemed to be included in the contract price and nothing extra shall be payable to the contractor in this regard.

Setting Out

The plan dimensions of the foundation shall be set out at the bottom of foundation trench and checked with respect to original reference line and axis.

9.3. Construction

- i. For foundation resting on soil, a layer of M15 concrete of minimum thickness 100 mm shall be provided above the natural ground to provide an even surface to support the foundation concrete. Before laying of lean concrete layer, the earth surface shall be cleaned of all loose material and wetted. Care shall be taken to avoid muddy surface. If any part of the surface has become muddy due to over-wetting, the same shall be removed. If required, the M15 concrete may be laid to a thickness of more than 100 mm, as per the direction of the Engineer. For foundations resting on rock, the rock surface shall be cleaned of any loose material and then levelled with a layer of concrete of the same grade as that of the foundation, so as to provide an even surface.
- ii. No point of the surface of the lean concrete, in the case of foundation on soil or the surface of hard rock, in the case of foundation on hard rock, shall be higher than the founding level shown on the drawing or as ordered by the Engineer. Levels of the surface shall be taken at intervals of not more than 3 metres centre-to-centre in each direction, subject to a minimum of nine levels on the surface.
- iii. Foundation Concreting to be done as per specified in the S.03 of Section-VII-F of these specifications. The concrete surface shall be finished smooth with a trowel.
- iv. Open foundations shall be laid dry. Where dewatering is necessary for laying of concrete, it shall be carried out adopting any one of the following methods or any other method, approved by the Engineer.
- v. All spaces excavated and not occupied by the foundations or other permanent works shall be refilled with sand or approved suitable material up to surface. surrounding ground with sufficient allowance for settlement. All backfill shall be thoroughly compacted and in general, its top surface shall be neatly graded. Backfilling shall be in accordance with S.02 of Section-VII-F of these Specifications.

9.4. Tests and Standards of Acceptance

The materials shall be tested in accordance with these Specifications and shall meet prescribed criteria.

The work shall conform to these Specifications and shall meet the prescribed standards of acceptance.

Test Bore shall be done at each Pier Location, or as approved by the Engineer-In-Charge, as per IS 1892 for determining strata of the sub-soil for Open Foundation. Standard Penetration Test (SPT), as per IS 2131, in a bore hole shall be conducted at 1.0 m intervals in the overburden soil and rock portion having core recovery $\leq 30\%$.

Contractor shall conform bearing capacity and settlement for shallow foundation at each foundation location via SPT/Plate Load Test. Contractor shall conduct at-least one Plate Load Test for each type of shallow Foundation. Nothing extra shall be payable to the contractor on this regard.

9.5. Tolerances

- a) Variation in dimensions : +50mm, -10mm
- b) Misplacement from specified position in plan : 15mm

- c) Surface unevenness measured with 3 m straight edge: 5mm
- d) Variation of levels at the top : $\pm 25\text{mm}$

9.6. Measurement (applicable to the BOQ schedules)

Excavation in foundation shall not be payable, rates of the same is deemed to be included in the rate of Concrete works.

Lean concrete shall be measured in cubic metres in accordance with S.03 of Section-VII-F of these Specifications, based on the as shown on the drawing.

Concrete in foundation shall be measured in cubic metres in accordance with S.03 of Section-VII-F of these Specifications, based on the as shown on the drawing.

Reinforcement steel shall be measured in tonnes in accordance with S.05 of Section-VII-F of these Specifications, based on the as shown on the drawing.

The contract unit rates for excavation in foundation, lean concrete, including dewatering and blasting where required, concrete in foundation and reinforcement steel shall include all works as given in respective Sections of these Specifications and cover all incidental items for furnishing and providing open foundation as mentioned in this Section and as show on the drawings.

TECHNICAL SPECIFICATION S-10: MISCELLANEOUS

S.10: MISCELLANEOUS**10 BEARINGS, SHEAR KEY DEVICES, EXPANSION JOINTS.****10.1 BEARINGS, SHEAR & EXPANSION JOINTS****i. GENERAL**

This work shall consist of design, supply and fixing in position of bearings for bridge girders in accordance with details shown in drawings and to the requirements of these specifications, codes and standards quoted therein and as directed by Engineer.

Expansion or fixed devices shall be constructed in accordance with details shown on drawings.

It shall be ensured that the bearings are set truly in level and in exact position as indicated on drawings so as to have full and even bearing on the seats. This shall be checked with spirit level in both directions. Thin epoxy mortar pads may be made to meet with this requirement.

It shall be ensured that the bottoms of girders that form a receiving surface for the bearings are plane at the location of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

When elastomeric bearing pads are to be provided, the concrete surfaces on which pads are to be placed shall be wood float finished to a level plane, which shall not vary by more than 1.5 mm from a straight edge placed in any direction across the area by maintaining sufficient roughness.

ii. Scope of work

Rendering necessary assistance/coordinate with the manufacturer with regard to placement/fixing of said bearings. The contractor shall ensure that these bearings are installed in accordance with the specification of the manufacturers so that the bearings perform in the desired manner, in accordance with the forces/ displacements/ rotations for which these bearings have been designed.

The contractor shall liaise with the agency and will be responsible for design etc. The contractor shall furnish adequate and proper installation details for these bearings while submitting his design and detailed Engineering Drawings. The design criteria, specifications etc. as mentioned in tender documents are mandatory and no deviation to the same shall be permitted unless otherwise directed by the Engineer.

The contractor shall supply all the bearings in suitable packed condition (for its proper transportation and storage before placement in position) at project site to be identified by the Engineer. The price for such bearings (quoted in Schedule of Quantities) shall include all the accessories/holding down bolts/fixing arrangements (excepting reinforced concrete work in piers and girders, and finishing the surfaces of the pedestal) including grouting of holes with epoxy etc., as required.

SPHERICAL BEARINGS

Spherical bearings consisting of a metal piston supported by a disc, sealing rings, dust seals, steel

mating surface, Complete as per IRC83-2014 Part (IV) and as per drawing and approved Technical Specifications The design of the bearings shall be submitted by the manufacturers/contractor and got approved from BI-RIDE before fixing. Test report of the bearings should be got approved before the materials are lifted from the manufacturer premises.

Spherical bearings

Stipulations of this clause regarding the Acceptance Testing, Certification and Marking shall be strictly adhered which forming the basis of Product conformance and acceptance for the Spherical and Cylindrical Bearings.

System of Attestation and Conformity Following will form the basis of acceptance of the Spherical and Cylindrical Bearings:

a) Tasks of the manufacturer:

- 1) Raw Material Acceptance/Testing
- 2) Factory production control/in-process testing
- 3) In-house Test on Finished Bearing

b) Tasks of the accepting/inspection authority:

- 1) Initial inspection of factory and of factory production control
- 2) Surprise/audit inspection on process of production and conformance test on raw materials and production in-process, if deemed necessary
- 3) Witness of final acceptance testing of finished product.

Lot Classification For the purpose of Lot classification, following definitions shall be applicable

- A lot shall comprise of the total number of Bearings manufactured together, of the type and load capacity as defined below, and offered for the Inspection at a time to the Inspecting/Accepting Authority. However, the maximum number of Bearings in one lot shall be limited to 24. Bearings in excess of 24 Nos. shall be treated as separate lot.
- The fixed and movable Bearings shall be classified as separate lots. However, the movable bearings irrespective of uni-directional and bi-directional movement abilities shall be placed under the same lot.
- In terms of Load capacity. Bearings with max. design vertical load less than 500 MT shall be considered as one lot and Bearings with more than 500 MT vertical load capacity shall be considered as separate lot.

Manufacturer Internal Testing

Apart from the Raw material and In-process Inspection to be carried out and documented for all Bearings and their Components. The Bearings thus manufactured shall be subjected to rigorous In-house Testing by the manufacturer prior to offering for the Acceptance Testing. Following In-house/internal testing on the finished Bearings shall be performed by the Manufacturer:

- i) All Bearings shall be checked for surface finish or any other discernible superficial defects.
- ii) All the Bearings shall be checked for overall dimensions as per the manufacturing tolerances

specified in this code and the relevant contract Specifications.

- iii) At least 20 percent Bearings subject to a minimum of 04 and maximum of 20 numbers selected randomly out of the entire production quantity to be offered for acceptance shall be subjected to vertical test load at 1.10 times the maximum design vertical load in SLS condition as shown in the drawings and simultaneously the rotation of 0.02 radians or design rotation whichever is higher.
- iv) From the entire production quantity to be offered for acceptance. One Bearing each selected at random shall be tested for Co-efficient of Friction at maximum design vertical load in SLS condition and Combined Vertical and Horizontal Load test (at 1.10 times the maximum SLS design loads), as the case applicable.

Acceptance Test by Inspecting Authority

Bearings passing the In-house Test requirements are then offered to the Accepting/Inspection Authority for Acceptance Testing. Following Acceptance tests in presence of the Inspection authority shall be performed on the components of the bearings or the bearing as a whole, as applicable.

Tests for conformance of raw materials and its processing

- i) In addition to the certificates of Raw materials from the supplier/manufacturer forming the initial basis of acceptance. Random sampling and testing at Independent NABL accredited lab for the material used in the production of the Bearings like steel, sliding surface, stainless steel. Bolts etc. shall be done. The inspection/accepting authority at his discretion shall relax and not insist on conducting the above test subject to availability of the satisfactory test data for the similar test conducted on materials of bearings recently manufactured and supplied for other projects within a period of six months preceding the date of Testing.
 - ii) Ultrasonic inspection of the steel components
 - iii) Test on welding e. g. Dye Penetration Test
 - iv) Test on hard chromium plating e. g. Ferroxy Test
 - v) Surface finish of the stainless-steel sheet
 - vi) Thickness of the anti-corrosive treatment etc Acceptance test on finished bearings
- i) Surface Finish Bearings shall be randomly checked for surface finish or any other discernible superficial defects.
 - ii) Dimension Bearings shall be randomly checked for overall dimensions as per the Manufacturing tolerances specified in this code and the relevant contract Specifications.
 - iii) Compression (Vertical Load) Test One Bearing selected at random from the lot under acceptance shall be simultaneously subjected to vertical test load of 1.10 times the maximum design vertical load in serviceability condition as shown in the drawings and rotation of 0.02 radians or design rotation, whichever is higher.

Friction Test

For movable Bearings (Free Float and Slide Guide Types), One Bearing selected at random per lot shall be tested in order to determine the co-efficient of friction at maximum design Vertical Load in serviceability condition, the value of friction shall not exceed 0.03 under lubricated condition

Combined Vertical and Horizontal Load Test

For Bearings required to resist Horizontal Forces (Fixed and Slide Guide Types), One Bearing selected at random from each lot shall be subjected to combined Vertical and Horizontal Load Test to 1.10 times of the respective maximum design loads and forces in serviceability condition Note: Installation procedure as per the IRC 83(Part-IV).

(Shear key devices)

Fabrication Details

The Contractor shall provide the Engineer with written notification thirty (30) days prior to the start of bearing fabrication. This notification shall include all the information shown on the shop drawings which are required as explained in subsequent section.

The finish of the mold used to produce the elastomeric rotational element shall conform to good machine shop practice.

All steel surfaces exposed to the atmosphere, except stainless steel surfaces and metal surfaces to be welded, shall be shop painted in accordance with the Contract Plans. Prior to painting, the exposed steel surfaces shall be cleaned in accordance with the recommendations of the coating's manufacturer. Metal surfaces to be welded shall be given a coat of clear lacquer, or other protective coating approved by the Engineer, if the time of exposure before welding takes place is to exceed three months, the coating shall be removed at the time of welding. No painting will be done to these surfaces prior to the completion of welding.

Stainless steel sheet shall be attached to its steel substrate with an approved epoxy to ensure complete contact and then sealed with a continuous seal weld.

The steel piston and the steel pot shall each be machined from a solid piece of cast steel.

The outside diameter of the piston shall be no more than 1mm less than the inside diameter of the pot at the interface level of the piston and elastomeric rotational element. The sides of the piston shall be bevelled to facilitate rotation. Except as noted all bearing surfaces of steel plates shall be finished or machined flat in accordance with tolerance given below:

iii. POT-PTFE BEARING

a. General

- i. The design, drawings and detailed method statements for installation and replaceability of the **bearings shall be got checked and certified by approved independent agency before submitting** to the Engineer for approval.
- ii. **Criteria for Selection of bearing manufacturer shall conform to the RDSO's list of approved manufacturers for Pot-PTFE bearings.**
- iii. Pot bearings shall be measured in numbers, Fixed Pot Bearing, Longitudinal guide pot bearing, transverse guide bearing & free pot bearing shall be counted separately, according to their capacities. The rate shall include the cost of supplying and fixing the bearing in position. **The cost shall also include the cost of samples and their testing as required and conforming to specification.**
- iv. The contractor shall furnish along with tender documents in technical bid, the name of

the manufacturer of bearings, his qualifications with all details including proof of

satisfactory performance, certification and testing facilities of the bearing he proposes to use.

b. Material specifications of Pot bearing

- i. All the materials to be used in POT Bearings shall confirm to clause No. 4 Materials of IRC 83: Part-III 2018.
- ii. Chloroprene (CR) only shall be used as raw polymer in the manufacture of Confined elastomer for the components of Pot Bearings.
- iii. The Pot Base, saddle, Piston & top plate shall be of cast steel only of Grade 340-570W of IS 1030 or equivalent, confirming to clause No. 4.1.2 of IRC 83: Part-III 2018.
- iv. The steel piston and the steel pot shall each be machined from a solid piece of cast steel.
- v. Guides shall be monolithic to the component to which it is connected.
- vi. **Anchor sleeve**

All the part of bearing such as anchor sleeves embedded in concrete shall be hot dip galvanized @ 300gm/ Sq.m. The anchor sleeves have to be designed taking account of difference in elasticity of steel of sleeve and concrete. The effect of shifting of center of rotation of sleeve should be also taken into account.

c. DESIGN

Design of the bearing and all accessories shall be the responsibility of the Contractor and got approved from the Employer's Representative.

Design of the POT Bearings shall confirm to clause no. 5, Design Section of IRC:83 (Part III)-2018.

The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.

d. Permissible stresses in steel component of Pot bearing

All the design requirements for Pot bearing as specified in IRC: 83 Part-III has to be fulfilled with following modifications.

No increase in permissible stresses in any material of bearing or bearing stress between concrete and bearing is permitted in seismic condition.

Permissible bearing stresses in concrete

The allowable bearing stresses in concrete as defined in IRC: 83 Part-III has to be followed with following modifications.

e. Warranty of POT-PTFE Bearings.

All bearings shall carry a warrantee of not less than 15 years in a format as approved by the Employer. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the Employer at no extra cost to the Employer within the warrantee period.

The following undertaking shall also be taken by the contractor from Manufacturer of Pot-PTFE Bearing for submission to the Employer:

- i. "We undertake to use -----(Name of Chloroprene) in the manufacturing of the Elastomeric bearings and the same shall be imported by us directly from (name of Manufacturer)/purchased from (Name of Agent) who is the authorized Indian agent of M/s (Name of the Manufacture)."
- ii. "We hereby guarantee against defective materials manufactured workmanship as well as certify quality assurance at every step of manufacturing of bearings. Pot-PTFE bearings that may be supplied by us as per this office and which shall be installed at the - (Name of the Bridge) shall have life of 15 years under normal loading, normal

traffic and routine maintenance. We also stand guarantee for free repair and replacement (including the cost of placing the new bearings in position) in part or full, if any, defect is found, in the bearings or part thereof within the period 36 months from the date of supply or 24 months from the date of installation whichever is earlier, except for defects arising out of theft pilferage, floods, earthquake or any other natural calamity etc, over which we have no control, shall be replaced free of cost."

- iii. "We also give an undertaking that the entire manufacturing and testing process shall be open to inspection for the client or their authorized representatives and that all possible help shall be extended in conducting the relevant tests required as per IRC 83 (Part-II) 2018 and other instructions issued by Ministry of Road Transport & Highways from time to time."

f. Manufacturing and Tolerances:

- i. The Contractor shall submit the Design & Fabrication drawings for the approval of Engineer at least 30 days prior to the start of bearing fabrication.
- ii. Manufacturing of Bearing shall be commenced only after the approval of Design and Fabrication drawings by the Engineer.
- iii. The bearings shall be manufactured in accordance with the clause 6.2 of IRC:83-2018 (Part-III) with the tolerances as specified in Clause 6.1 of IRC:83-2018 (Part-III).
- iv. For the measurements to be taken using dial height gauges, vernier calliper, surface finish measurement instrument etc., the measuring instruments shall be arranged by manufacturer at the workshop.
- v. Appropriate silicon grease shall be applied at the sliding material – stainless steel interface of bearing.
- vi. **Movement indicators shall be provided for bearing with sliding assembly to facilitate routine inspection during service period.**

g. Testing of Pot Bearing

i) Proof Load Test

A test bearing shall be loaded to 150% of the bearing's rated design capacity and simultaneously subjected to a rotational range of 0.02 radians or design rotation, whichever is greater, for a period of one hour.

The bearing will be visually examined both during the test and upon disassembly after the test. Any resultant visual defects, such as extruded or deformed elastomer or PTFE, damaged seals, or cracked steel, shall be cause for rejection.

During the test, the steel bearing plate and steel piston shall maintain continuous and uniform contact for the duration of the test. Any observed lift-off will be cause for rejection.

All bearings will be applied with a vertical load perpendicular to the plan area of the bearings and on approved system duly approved by Engineer, to subject the bearings to rotation. The minimum load at which the required rotation is achieved is to be determined and this value should be less than the minimum design vertical load as tabulated in the drawing.

For guide-stopper bearing, test on specially molded test pieces shall be conducted as per clause 918.4.1.2. of IRC : 83 (Part – II) – 1987 which shall be compared with Test pieces from test bearings. The variation shall be within limits specified herein.

ii) **Sliding Coefficient of Friction**

For all guided and non-guided expansion type bearing, the sliding coefficients of friction shall be measured at the bearing's design capacity.

The sliding coefficient of friction shall be calculated as the horizontal load required to maintain continuous sliding of one bearing, divided by the bearing's vertical design capacity.

The test result will be evaluated as follows: -

- (a) The measured sliding coefficients of friction shall not exceed 3%.
- (b) The bearing will be visually examined both during and after the test. Any resultant visual defects, such as bond failure, physical destruction, cold flow of PTFE to the point of debonding, or damaged components shall be cause for rejection.

h. **Sampling and Testing**

i. **Lot Size**

Sampling, testing and acceptance consideration will be made on a lot basis. A lot shall be defined as those bearings presented for inspection at a specific time or date. A lot shall be further defined as the smallest number of bearings as determined by the following criteria.

A lot shall not exceed a single contract or project quantity; A lot shall not exceed 25 bearings;

A lot shall consist of bearings of the same type regardless of load capacity. Bearing types shall be fixed or expansion bearings types. Guided and non-guided expansion bearing shall be considered a single type.

iii) **Sampling and testing requirements**

The manufacture shall furnish the required number of samples to perform testing in accordance with Table Given below:-

Sampling and Testing Requirement

Test	Sample Required
Proof load	One production bearing per lot
Coefficient of Friction	One production bearing per lot
Physical Properties of elastomeric rotational elements	One elastomeric element per lot
Physical properties of PTFE sheet	One 10" x 15" sheet of PTFE material per project

A minimum of thirty (30) days shall be allowed for inspection, sampling and testing of production bearings and component materials.

All exterior surfaces of sampled production bearings shall be smooth and free from irregularities or protrusions that might interfere with testing procedures.

The manufacturer shall select, at random, the required sample bearing(s) from completed lots of bearings for testing by the manufacturer. He shall complete the required testing and determine compliance with this specification before submitting the lot(s) for inspection, sampling, and

acceptance consideration.

The Engineer shall select, at random, the required sample bearing(s) from completed lots of bearings.

Necessary test certificates for all raw material shall be furnished by manufacturer. Test specified in IS:1030 for cast steel shall be performed. Casting shall be ultrasonically got tested by approved testing agency.

j. **PAINTING/CORROSION PROTECTION:**

All non-working exposed surfaces, including 50 mm (min.) return on surfaces to be in contact with concrete / steel shall be treated with full corrosion protection system conforming to the requirements of Clause 6.3.1 of IRC:83-2018 (Part-III).

k. **SHOP DRAWINGS**

The Shop drawings to be submitted for Engineer's approval should contain the following necessary information, but not limited to:

- i. Quantity, type (fixed, guided expansion, non-guided expansion), and location of all bearing units.
- ii. A table containing maximum and minimum vertical and horizontal loads, design rotation requirements, and magnitudes and directions of movements.
- iii. Allowable contact stresses, maximum dimensions, and anchorage requirements at the bearing interfaces; grades, bevels, and slopes at all bearings; and allowable coefficients or friction of all sliding surfaces.
- iv. Any special consideration such as earthquake requirements, uplift details, or temporary attachments.
- v. Installation scheme of pot bearing.

l. **INSPECTION AND ACCEPTANCE SPECIFICATION:**

- i. Bearings shall be manufactured to high standards both in terms of material quality and workmanship. The manufacturer shall have requisite load test and NDT facilities required for process and acceptance control tests installed at his plant. The test facilities and their operation shall be open for inspection. For confirmatory tests on raw materials, tests shall be conducted at in-house facility of the manufacturer or at NABL accredited laboratory.
- ii. All tests on raw materials and finished bearings shall be carried out as per procedures described in this section. All the test reports duly certified by the Engineer shall be furnished by the manufacturer at the time of despatch of the bearing.
- iii. Acceptance testing shall commence with the prior submittal of testing program in form of Inspection and Test Plan (ITP) prepared by the manufacturer and approved by concerned authority, to the Engineer.
- iv. Lot by lot inspection, testing and acceptance shall be made in accordance with the clause 7 of IRC:83-2018 (Part-III).

m. **STORAGE, TRANSPORTATION AND HANDLING:**

- i. Bearings should be transported to bridge site after final acceptance by the Engineer/ inspection agency appointed by the concerned authority and shall be accompanied by an authenticated copy of the certificate to that effect.
- ii. All bearings shall have suitable index markings made of indelible ink or flexible paint, which if practicable shall be visible after installation, identifying the information like Name of manufacturer, Month and year of manufacture, bearing designation, Type of bearing, Load and movement capacity, Centreline markings to facilitate installation, Direction of major and minor movement, if any, Pre-set, if any.

- iii **Movement indicators shall be provided for bearing with sliding assembly to facilitate routine inspection during service period.**
- iv After assembly bearing components shall be held together with steel strapping, or other means, to prevent disassembly until the time of installation.
- v Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during transportation and storage.
- vi "Provision against contamination of the sliding surface shall be made by suitable devices. Such protection devices shall be easily removable for the purpose of inspection". This may be achieved by the provision of a simple removable rubber apron around the bearing. This apron is connected by a Velcro-type fastener, allowing it to be easily removed without tools for inspections etc.

n. Installation of POT Bearing: -

A detailed method statement shall be submitted considering the points mentioned below for the approval of Engineer. Installation work of POT Bearings shall be commenced only after approval of method statement by the Engineer.

- i. Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure. Bearings shall be so located as to avoid accumulation of dirt and debris likely to interfere with their performance and the structure so detailed that water is prevented from reaching the bearings. Proper installation of bearing is of utmost importance to ensure proper functioning of bearing and its durability. Poor installation may not only damage a high-quality bearing but also may cause damage, instability and collapse of structures.
- ii. In order that moving surfaces are not contaminated, bearings should not normally be dismantled after leaving the manufacture's workshop but if for any reason they are, then this should only be done after Engineer's approval and under expert supervision and the manufacturer's assistance should be sought.
- iii. Transfer of superstructure weight on to bearings should not be allowed until sufficient strength has developed in the bedding material to resist the applied load. Temporary clamping devices should be removed at an appropriate time before the bearings are required to accommodate movement. Consideration should be given to any treatment required to holes exposed on the removal of temporary transit clamps. Where reuse of these fixing holes may be required, the material selected to fill them should not only give protection against deterioration but also should be easily removable without damaging the threads.
- iv. Correct location and orientation of the bearing with respect to the structures is of immense importance. Mixing up in location or orientation may cause severe structural instability during construction and service.

o. Bedding

- i. Bearing shall not be placed directly on matured concrete surface without use of appropriate bedding material.
- ii. The choice of bedding materials is influenced by the method of installation of the bearings, the size of the gap to be filled, the strength required and the required setting time. When selecting the bedding material, consideration should therefore be given to various factors like type of bearing, size of bearing, loading on bearing, construction sequence and timing, early loading, friction requirements, access around the bearing, thickness of material required, design and condition of surface in the bearing area, shrinkage of the bedding material etc. as appropriate.
- iii. The thickness of the bedding material should be made as less as possible maintaining the requirement of workability and strength.

- iv. It is essential that the composition and workability of the bedding material be specified with the above factors in mind. In some cases, it may be necessary to carry out trials to ascertain the most suitable material.
- i. Bedding Material shall be High Strength Non Shrink Epoxy Grout. Cost of this Grout material is included in the scope of work and nothing Extra is payable in this regard.
- ii. Bedding Material shall be got approved by Engineer before commencement of Work.
- iii. To ensure even loading on bearings and the supporting structures, it is essential that any bedding material whether above and below the bearing, extend over the whole area of the bearing. Improper application of bedding material, below and above the bearing, i.e. voids, gaps, impurity etc. may attribute to failure of the bearing irrespective of the quality of the product.
Bearings shall be bedded over their whole area. After installation there shall be no voids or hard spots. The bedding material shall be capable of transmitting the applied load to the structure without damage. Surfaces to receive bedding mortar shall be suitably prepared to a state compatible with the mortar chosen. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.

p. Fixing of Bearing:

- i. To cater for vibration and accidental impact, some anchorage should be provided. Anchorage should be accurately set into recesses cast into the structure using templates and the remaining voids in the recesses should be filled with material capable of withstanding the loads involved i.e. High Strength Epoxy Grout.
- ii. Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Finally voids beneath the bearings should be completely filled with bedding material using the appropriate method.
- iii. Bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure or bottom of superstructure to the correct level and location. Generally, recess are provided in the substructure for the anchorages.
- iv. If the structure is of steel, the bearings may be bolted or welded directly to it. Proper care shall be taken to ensure that there are no mismatch in the bolt holes of the structure and the bearing. In case of welding care should be taken to assess and avoid damage of bearing or its components due to heat or distortion.
Threaded fasteners shall be tightened uniformly to avoid overstressing of any part of the bearing.
- v. For bearings supporting precast concrete elements a thin layer of synthetic resin High Strength Non -shrinkage Epoxy mortar should be used between bearings and precast concrete beams. Bearings shall be bolted to anchor plates or metal bedding plates embedded in precast elements.
- vi. For bearing supporting steel elements a machined sole plate shall be used to ensure proper contact.

q. Installation Tolerance

- i. The tolerances given below shall be strictly adhered to unless otherwise specified.
- ii. Bearings shall be located so that their centrelines are within ± 3 mm of their correct position.
- iii. The level of a bearing or the mean levels of more than one bearing at any support shall be within a tolerance of ± 0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding ± 5 mm.
- iv. Bearings shall be placed in a horizontal plane within a tolerance of 1 in 200 in any direction unless otherwise specified, even under superstructure in gradient

a ELASTOMERIC BEARINGS

The terms "bearing" in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomer bonded to internal steel laminates by the process of vulcanization. The bearing shall cater for translation and/or rotation of the superstructure by elastic deformation.

i. Raw Material

- a. Chloroprene (CR) only shall be used as raw polymer in the manufacture of Elastomeric Bearing. Blending with up to 5% of another polymer, which may be added to aid processing, is permitted.
- b. For Chloroprene Rubber Compound, grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110, Skyprene B-5 and Denka S-40V) shall be used.
- c. No reclaimed rubber or vulcanized wastes or natural rubber shall be used. The raw elastomer /polymer content of the bearing shall not be lower than 50 per cent by its weight. The ash content shall not exceed 5 percent (Polymer content shall be determined in accordance with ASTM D- 297, subsection 10 and ash content as per IS 3400 Part-XXII).
- d. EPDM and other similar candidate elastomer for bridge bearing use shall not be permitted.
- e. Tests for polymer identification through Pyrolysis test and confirmation about percentage of polymer content shall be carried out as per IS: 3400 (Part XXII).

ii. Properties

- a. The elastomer (CR) shall conform to the properties specified in Clause 4.2.1 of the IRC:83-2018 (Part-II).
- b. The adhesion strength of elastomer to steel plate, determined according to IS: 3400 Part XIV method A, shall not be lesser than 7kN/m.
- c. Ozone resistance test shall be conducted in all cases of use of elastomeric bearings.
- d. Laminates of mild steel conforming to IS: 2062/ IS: 1079 or equivalent international grade shall be used. The yield stress of the material shall not be lesser than 250 MPa. Uses of any other materials like fibreglass or similar fabric as laminates are not permitted.

iii. Manufacturing and Tolerances

The Contractor shall submit the Design & Fabrication drawings for the approval of Engineer. Manufacturing of Bearing shall be commenced only after the approval of Design and Fabrication drawings by the Engineer. The bearings shall be manufactured in accordance with the clause 6 of IRC:83-2018 (Part-II) with the tolerances as specified in Table 5 of IRC:83-2018 (Part-II).

iv. Acceptance Specifications

- a. The manufacturer shall have all test facilities required for process and acceptance control tests installed at his plant to the complete satisfaction of the engineer. The test facilities and their operation shall be open to inspection by the engineer on demand.
- b. All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the Contractor.
- c. Acceptance testing shall be commenced with the prior submittal of testing programme by the Contractor to the engineer and after obtaining his approval.
- d. All acceptance testing shall be conducted by the Engineer with aid of the personnel having adequate expertise and experience in rubber testing provided by the Contractor, working under the supervision of Engineer and to his complete satisfaction.

- e. Lot by lot inspection, testing and acceptance shall be made in accordance with the clause 7 of IRC:83-2018 (Part-II).
 - f. A lot under acceptance shall comprise of all bearings, including the extra test bearings of equal size produced under identical conditions of manufacture to be supplied by the contractor. The level of acceptance testing shall be '**Level 1**' as per the clause 7.8 of IRC:83-2018 (Part-II). **The cost of extra test bearings shall be borne by the contractor irrespective of the Lot size.**
 - g. Bearings tested at ULS condition, i.e. destructive testing, cannot be used in the structure since its performance at SLS cannot be guaranteed after such treatment.
 - h. If any further testing of materials is required by Engineer, such as polymer identification, Accelerated Ageing, Ozone Resistance etc., in accordance with the clause 7.9 of IRC:83-2018 (Part-II) , it shall be arranged for by the contractor at NABL accredited laboratory as approved by Engineer. For this, nothing extra shall be payable to the contractor.
 - i. In addition to tests mentioned above, all bearings shall be also weighed actually and compared with the theoretical weight.
 - j. Criteria for Selection of bearing manufacturer shall conform to the **RDSO's list of approved manufacturers for Elastomeric bearings.**
- v. **Warranty of Elastomeric bearings.**
All bearings shall carry a warranty of not less than 15 years in a format as approved by the Employer. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the Employer at no extra cost to the Employer within the warrantee period.
- The following undertaking shall be taken by the contractor from the Manufacturer of Elastomeric Bearing for submission to the Employer:
- a. "We undertake to use -----(Name of Chloroprene) in the manufacturing of the Elastomeric bearings and the same shall be imported by us directly from (name of Manufacturer)/purchased from (Name of Agent) who is the authorized Indian agent of M/s (Name of the Manufacture)."
 - b. "We hereby guarantee against defective materials manufactured workmanship as well as certify quality assurance at every step of manufacturing of bearings. Elastomeric bearings that may be supplied by us as per this office and which shall be installed at the - (Name of the Bridge) shall have life of 15 years under normal loading, normal traffic and routine maintenance. We also stand guarantee for free repair and replacement (including the cost of placing the new bearings in position) in part or full, if any, defect is found, in the bearings or part thereof within the period 36 months from the date of supply or 24 months from the date of installation whichever is earlier, except for defects arising out of theft pilferage, floods, earthquake or any other natural calamity etc, over which we have no control, shall be replaced free of cost."
 - c. "We also give an undertaking that the entire manufacturing and testing process shall be open to inspection for the client or their authorized representatives and that all possible help shall be extended in conducting the relevant tests required as per IRC 83 (Part-II) 2018 and other instructions issued by Ministry of Road Transport & Highways from time to time."

vi. **Design**

The design of elastomeric bearings shall conform to the provisions of the DBR of BSTP and Design criteria specified in the Employer's requirement of the tender document.

The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.

vii. Storage, Transportation and Handling

Each bearing shall be uniquely and individually numbered for identification on its external faces. The identification number shall be unique and such as to enable other bearings manufactured at the same time to be traced through the production control records should the need arise. Where practicable the identification number shall also be visible after installation of the bearing in the structure. The top of each bearing shall be clearly marked and the size and direction of preset, if any, and the direction of installation shall be indicated.

During transport and handling prior to and during installation, bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect columns and edges. Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearings during transport and handling prior to and during installation.

viii. Installation

- i. Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure and shall be installed in the structure as specified or approved by the engineer to ensure that right bearing is being installed at the right location.
 - ii. Transfer of superstructure weight on to bearings should not be allowed until sufficient strength has developed in the bedding to resist the applied load.
 - iii. For precast concrete or steel superstructure elements, fixing of bearing to them may be done by application of epoxy resin adhesive to interface, after specified surface preparation. The specification for adhesive material, workmanship and control shall be approved by the engineer. Care shall be taken to guard against faulty application and consequent behaviour of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearing against displacement for purpose of design.
 - iv. Bearings must be placed between true horizontal surfaces (maximum tolerance 0.2 per cent perpendicular to load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance ± 3 mm). Concrete surfaces shall be free from local irregularities (maximum tolerance ± 1 mm in height).
 - v. After installation, bearing and their surrounding areas shall be left clean.
 - vi. The contractor shall submit the detailed procedure for installation of bearing, including the type of non-shrink epoxy grout material to be used for filling the top / bottom gap of the bearing, for the approval of Engineer. Cost of Non-shrink epoxy grout above / below the bearing is included in the cost of bearing and nothing extra shall be payable on this account.
- r. **SHEAR KEY DEVICE**
- a. **GENERAL DESCRIPTION OF THE SYSTEM**
 - i. **General**

The shear key is made of concrete cast in place in second pour before concrete decks are assembled.

The shear keys shall take all horizontal loads (longitudinal and transverse). It is equipped with vertical bearings as per approved drawings.
 - ii. **Vertical/Lateral Elastomeric bearings system**

On the movable side of deck, one sliding elastomeric bearing shall be installed longitudinally on each side of the shear key.

On the fixed side of deck, one laminated elastomeric bearing shall be installed longitudinally on each side of the shear key. In addition, at the interface between the shear key, one laminated elastomeric bearing with adequate recesses to allow for replacement without taking out the high tensile bars shall be installed transversally.

These elastomeric bearings shall be made of polychloroprene, and manufactured according to Euro norm EN 1337-3 or equivalent.

All the Technical specifications mentioned for Horizontal Elastomeric bearings shall be valid for Vertical/lateral Elastomeric Bearings also except the following tests Shear Deformation and Shear Bond tests.

iii. INSTALLATION PROCEDURE

The installation procedure is proposed as follows. Alternate methods can be submitted by the contractor, subject to the Client approval.

1. Shear Key is poured before precast concrete deck segments are installed. The span must be assembled on higher level to avoid conflicts with already built concrete key.
2. Superstructure should have recess of 20mm for grouting by non-shrinkage grout at later stage
3. Erect the superstructure on temporary bearings/jacks with sliding surface at top at both ends
4. Provide some arrangement to prevent deck sliding (e.g. under seismic load).
5. Move the girder by nearly 20mm
6. At this stage vertical faced elastomeric pad is placed in position
7. Replace the temporary bearing with the permanent elastomeric bearing
8. Grout the gap between the girder (with hacked surface at grouting location) and the elastomeric bearing

Notes:

iv. MAINTENANCE PROCEDURE

The system shall be such that any device can be replaced without any destruction of concrete part of the structure.

The system shall be such that the maintenance procedures described below can be undertaken.

a) Vertical/lateral elastomeric bearings

For the lateral vertical bearings, a theoretical gap of 2mm shall be provided on each side of the shear key. If it is needed to change one or all of these lateral bearings, then, as the deck will not be in contact on each side at a time, the lateral bearings on the non-compressed side are taken out first. First the sliding plate is taken out, then the elastomeric bearing. Then the deck may need to be translated laterally to take out the elastomeric bearings on the compressed side. For this, steel angles can be split in the concrete on each side of the elastomeric bearings to provide support for jacks or threaded bars. The needed force to distort the neoprene bearings supporting the deck will be calculated.

s. HOLD-DOWN DEVICES

1 GENERAL DESCRIPTION OF THE SYSTEM

i. General

The holds down devices are designed to take the lifting loads between the pier caps and the girders that may occur mainly during earthquakes in curved sections. The system of hold down device must take relative horizontal movements between the pier and the girder without

any significant tensile stresses in the bars due to these movements.

ii. Description of the proposed system

(a) Movable end of the deck On the movable end, the system shall be composed of the 3 following devices:

1- A lower high tensile bar embedded in the pier cap concrete.

The bar is smooth and it is threaded only at its two ends. The bars are only threaded at their ends and they are smooth on the full length in order to increase the fatigue performances. The bar is equipped with a repartition plate and a nut.

2- A system of spherical articulation allowing the relative angular rotation between the lower and the upper bar. This device shall be composed with:

- A washer with adequate thickness to permit a good setting of the articulation device. Between the washer and the concrete shall be installed an elastomeric membrane to provide the waterproofing of the device.
- A lower nut with an internal threading to be assembled with the lower bar and an external threading to be assembled with the spherical room. - An articulation room equipped with a spherical contact surface.
- A spherical nut in contact with the spherical surface of the articulation room.
- A rubber protection skirt installed between the articulation room and the upper bar to avoid any dust in the upper opening of the articulation.
- A rectangular repartition plate to take into account the oblong recess.
- A protection cap that shall be equipped such as to avoid the rotation of the nut and to adjust precisely the gap between the nut and the repartition plate.

3- A high tensile upper bar installed in an oblong recess provided in the girder.

As for the lower bar, the upper bar shall be smooth and threaded at the two ends. The threading shall be made by rolling method. The corrosion protection of the bar shall be done by a heat shrinkable sleeve. In order to ensure that the lower bar will never break because this lower bar will not be replaceable, the diameter of the lower bar shall be always greater than the upper bar diameter, so that the upper bar shall always break (fuse principle) before the lower bar.

The upper threading shall be longer in order to take the variation of distance between the girder and the pier cap, and the variation of height of the lower part of the girder. It shall also take into account the construction tolerance. Important:

- a) The articulation system will be designed in order to permit a rotation of at least 8° in all the directions without any tensile stress in the bar.
- b) The articulation system will be designed in order to avoid any rotation of any component under the vibrations.
- c) Fixed end of the deck In that case, the articulation device can be simplified and replaced by a coupler having two different threading diameters. The other devices are the same as for the movable end.

Nevertheless, attention is brought to the fact that the design of the articulations and of the couplers shall be such that there is the possibility to replace a coupler by an articulation in case of non-verticity of the lower bar. Therefore the "fixed end" device may need to be replaced with the more complex "movable end" device if construction tolerances are not met.

2 MATERIALS CHARACTERISTICS

i) High tensile bars

Quality of steel: the quality of the raw material steel shall be according to the DIN EN 10083- 1 or equivalent. The chemical composition shall be such as to guarantee the following mechanical characteristics: - Yield stress $F_y > 1050$ MPa

-Tensile stress $F_u > 1200$ MPa

-Elongation at breaking $> 10\%$

-Resilience at $20^\circ\text{C} > 50$ Joules;

The threading of the bars shall be made by rolling method (cold plastic deformation of the metal between two dies) in order to give a good resistance to the fatigue. The threads shall have a rectangular profile H7 according to ISO 262 - NFE 03014 and 03053. The tolerance of the length of the bars is ± 5 mm Foreseen Diameters of bars:

The stress in the bar will not exceed $0.85 F_u$. The lower bar shall not reach the yield strength before upper bar is broken. The following upper/lower U.T.S bars are contemplated, but may be adjusted (+/-) during detailed design phase:

upper diameter (U.T.S)	lower diameter (U.T.S)
500kN	700kN

ii) CORROSION PROTECTION D.3.1 High tensile bars

The protection against corrosion of the high tensile bars shall be performed by using a heat shrinkable sleeve in order to give a very good protection against corrosion due to humidity, ozone, UV rays and shocks.

iii) other materials

The upper repartition plate and the protection cap shall be sandblasted and shall receive 3 layers of coating.

The articulation room, the Coupler and the lower ring shall be sandblasted and shall receive 3 layers of coating and a petrolatum tape.

The articulation room and the upper protection cap shall be filled up with grease.

iv) TRANSPORTATION & STORAGE

The bars and the accessories shall be transported in wooden cases and in containers, or equivalent.

The bar threading shall be temporarily protected against shocks by a greased tape and a steel ring or equivalent. The protection of the threads shall be taken off only right before the installation of the bars.

The bars and accessories shall be carefully stored in the jobsite in the following conditions:

- They shall be protected from rain, and the storage room shall have ventilation.
 - If the bars have to be kept stored for a long time, it will be necessary to protect them with a layer of solvable oil or equivalent in order to protect them against corrosion.
 - Before installation of the bars, if there is some corrosion, they shall be cleaned up.
- Acceptance of the bars shall be subject to the client approval.

v) INSTALLATION PROCEDURE

The installation procedure is proposed as follows. Alternate methods can be submitted by the contractor, subject to the client approval.

a) Installation of the lower bars

- Place the bar with the repartition plate and the nut into the reinforcement of the pier cap.
- Check that the length out of the concrete pier cap concrete is sufficient to install the articulation or the coupler.
- Check that the bar is installed vertically.
- Pour the pier cap concrete.

b) Installation of the articulation (or the coupler) and the upper bar

- Install the lower washer and the elastomeric pad on a plane and horizontal layer of mortar.
- Install the lower ring with the external and internal threading around the lower bar.
- Bring the upper bar equipped with the articulation room and the spherical nut and put in position the nut and the upper bar; the length of the pins installed between the nut and the ring shall be such to avoid any gap between the lower nut and the spherical articulation.
- Screw the articulation room until it is in contact with the lower washer.
- Apply a closing tape or equivalent between the bar end and the spherical nut.
- Fill the upper hole of the articulation room with grease or equivalent.
- Install the upper repartition plate on a plane and horizontal mortar.
- Apply a dosing tape or equivalent between the end of the bar and the spherical nut.
- Install the upper spherical nut around the bar in order to be in contact with the spherical surface of the repartition plate. At this stage, there shall be no gap between the two spherical nuts, the articulation room and the repartition plate.

The installation of the protection cap will allow to give a 2mm gap necessary to let the system free of rotation when there is any horizontal movement.

- Install a tape around the articulation room and the lower ring.
- Install the rubber protection skirt between the articulation room and the upper bar (the rubber skirt shall be filled up with grease).

NOTE: the same procedure can be applied for the fixed end, where the articulation room is replaced by a coupler.

vi) MAINTENANCE PROCEDURE

The system shall be such that the maintenance procedures described below can be undertaken.

a. Periodical inspection

- Every 5 years or after an earthquake, a visual inspection of the articulation room and the rubber protection skirt will have to be made to check the corrosion protection.
- At the same time, the upper protection cap will be taken off to check if the 2mm gap is still there and to adjust again this gap if necessary.
- The protection against corrosion of the upper bar will also be checked.

b. Maintenance

The system does not need any maintenance if it works in normal conditions. Nevertheless, if there is an earthquake, a special inspection will be carried out. If it is necessary to change the upper bar. The articulation device or the coupler, it will be necessary to take off the upper bar first, and to change the damaged devices

according to the installation procedure.

t. **EXPANSION JOINTS**

a. **Scope of Work**

The scope of work will include:

- i) Preparation of detailed engineering and installation drawings, supply and supervision during fixing of strip seal/compression seal expansion joints conforming to specifications. The expected expansion/contraction of the superstructure at the location of expansion joints are shown in relevant drawings.
- ii) Design, manufacture, providing and seating of expansion joints by the specialized agency and approved by the Engineer.
- iii) Necessary technical supervision for installation of each and every expansion joint during different stages of installation including rectification of any deficiency or defect attributable to fixing and installation will be provided by the manufacturer / supplier.
- iv) The expansion joint shall be provided for the full width of viaduct including the railing.
- v) Leak tightness of all joints shall be ensured which shall also carry a warranty of 10 years from the contractor.
- vi) Criteria for Selection of Expansion Joint manufacturer shall conform to the RDSO's list of approved manufacturers for Elastomeric bearings. All bearings shall carry a warrantee of not less than 10 years in a format as approved by the Employer. The contractor shall be responsible for immediate repair or replacement of the Expansion joints in case of failure / distress to the satisfaction of the Employer at no extra cost to the Employer within the warrantee period.
- vii) The expansion joints provided over elevated structure decks should be so designed as to be compatible with the bearings.
- viii) The expansion joint system of W-seal or equivalent shall be comprised of EPDM flexible Seal and work on Arch Principals fixed by Epoxy adhesive, the seal must confirm to BS-4225 and epoxy adhesive confirm to ASTM C—881 specification. The EPDM moisture barrier must be provided underneath of each joint fixing by binding wire with deck reinforcement. EPDM moisture barrier having predetermined holes and must be imported and confirm to ASTM 2240 & ASTM - G53 & 84 all complete as per manufacturer drawing.
- ix) The contractor shall submit design and drawing of expansion joints based on design criteria mentioned under "scope of Work" to the Engineer for approval. The design of expansion joint shall be done as per IS and International codes as applicable and Sound Engineering practices.
- x) Any modification to the design and drawings submitted by the Contractor, if suggested by the Engineer, shall be incorporated without any reservations. The design and drawings including changes approved by the Engineer shall form basis of execution and that Contractor shall undertake all necessary action for ensuring execution of work on that basis. For design, manufacture, testing and supply of W-seal expansion joints, following will be followed in order of preferences.
 - (a) Details in this chapter and elsewhere in tender documents.
 - (b) IRC Codes and MORTH specifications for Roads and bridges published by Indian Road Congress.
 - (c) Sound Engineering Practice (Decision of Engineer will be final in this case) which shall include specialized literature as decided by Engineer-in-Charge.

b. **Building Expansion Joints:** Specialised expansion joints consisting of extruded

aluminium frame assemblies of suitable profile to receive free floating cover plate of required shape and profile / or elastomer suited to building applications shall be used. These will be provided for covering the structural gap at expansion joints along the horizontal faces of slabs and beams, vertical faces of retaining walls, etc. Necessary block-outs as per the manufacturer's recommendations shall be provided in the structure which shall be filled in the approved manner after placing the expansion joints. The base of the expansion joint assembly shall be fixed onto the concrete base using anchor fasteners (not exposed to top surface) as per manufacturer's specifications. The joint shall have, and anti-skid serrated top plate with a free-floating central plate. All aluminium in contact with concrete shall have zinc chromate finish. The joint assembly shall be capable of accommodating the specified movement without loss of cover and shall include all the necessary accessories, sealant etc as per manufacturer's drawings. The joint fixing shall be carried out by the main contractor under the supervision of supplier/manufacturing agency of approved expansion joint. The expansion joint cover assemblies shall withstand a minimum 500lb point load without damage or permanent deformation. The joint should be watertight and test on same if required on direction of Engineer shall be conducted without any extra payment for same.

c. SPECIFICATION FOR STRIP SEAL EXPANSION JOINT:

Expansion joint type described here-after is the "strip seal" type, but alternate designs can be proposed for concerned organisation approval (e.g., elastomeric omega- shape cover joint, or any other suitable joint type)

1) Components:

Strip seal expansion joint shall comprise the following items:

i. Edge beam:

This shall be either extruded or hot rolled steel section or cold rolled cellular steel section with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further the configuration shall be such that the section has a minimum thickness of 10mm all along its cross section (flanges and web). The minimum height of the edge beam section shall be 80mm. The minimum cross-sectional area of the edge beam shall be 1500mm².

ii. Anchorage:

Edge beams shall be anchored to the deck by reinforcing bars or bolts or anchor plates cast in concrete or a combination of anchor plate and reinforcing bars. Anchor bars studs or bolts shall engage the main structural reinforcement of the deck and in case of anchor plates or loops, this shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plate shall be 12mm. Total cross-sectional area of bar on each side of the joint shall not be less than 1600mm² per meter length of the joint and the centre to centre spacing shall not exceed 250mm. The ultimate resistance of anchorage shall not be less than 600 kN/m in any direction.

2) Material

- i. The steel for edge beams shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 (DIN), ASTM A36 or A588, CAN/CSA Standard G40.21 Grade 300W or equivalent.

- ii. Anchorage steel shall conform to IS:2062 or equivalent.
- iii. All steel sections shall be protected against corrosion by hot dip galvanizing or any other approved anticorrosive coating with a minimum thickness of 100 micron.
- iv. Chloroprene of strip seal element shall conform to Clause 915.1 of IRC:83 (Part- II).
The properties of chloroprene shall be as specified in Table-1.

3) Fabrication (Pre-installation)

- i. The strip seal joint system and all its component parts including anchorages shall be supplied by the manufacturer /system supplier.
- ii. The width of the gap to cater for movement due to thermal effect, prestress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is to be installed, the gap dimension shall be pre-set.
- iii. Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Pre-setting shall be done in accordance with the joint opening indicated on the drawing.
- iv. The finally assembled joint shall then be clamped and transported to the work site.

TABLE-1 STRIP SEAL ELEMENT SPECIFICATION

Sealing element is made of chloroprene and must be extruded section. The working movement range of the sealing element shall be at 70mm.

Property	Specified Value
Hardness*	63+ /-5 Shore A
DIN 53505	55 +/- 5 Shore A
ASTM D 2240 (Modified)	
Tensile Strength*	Min 11 MPa
DIN 53504	Min 13 .8Mpa
ASTM D 412	
Elongation at fracture*	Min 350 per cent
DIN 53504	Min 250 per cent
ASTM D 412	
Tear Propagation Strength	Min 10 N/mm
Longitudinal	Min 10 N/mm
Transverse	Min 25 per cent
Shock elasticity	Min 220 Cu.mm
Abrasion	
Residual Compressive Strain	Max 28 per cent
(22h/70 deg C/30 per cent Strain))	
Aging in hot air	
(14days/70 deg C)	Max + 7 Shore A
Change in hardness	
Change in tensile strength	Max -20 per cent

Change in elongation at fracture	-20 per cent
Ageing in Ozone (24 h/50 pphm/25 deg C/20 per cent elongation)	No cracks
Swelling behaviour in Oil (168h/25 deg. C)	
ASTM Oil No. 1 Volume Change	Max + 5 per cent
Change in hardness	Max -10 Shore A
ASTM Oil No. 3 Volume Change	Max + 25 per cent
Change in hardness	Max -20 Shore A
Cold Hardening Point	Max -35 deg C

Only one set of specification viz. ASTM or DIN shall be followed depending on the source of supply.

- v. Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Pre-setting shall be done in accordance with the joint opening indicated on the drawing.
- vi. The finally assembled joint shall then be clamped and transported to the work site.

4) Handling and Storage

- i. For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.
- ii. The manufacturer/supplier shall supply either directly to the Engineer or to the Bridge Contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the jointing.
- iii. Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

5) Supply/Installation:

Components of expansion joint such as edge beam and strip seal shall be imported from the specified foreign manufacturer / collaborator to ensure quality and performance. The joint shall be supplied and installed only by the MOST approved manufacturer. Contractor shall furnish a warranty of trouble-free performance for at least ten years and free rectification of defects / replacement, if any, during this period.

The joints shall be installed by the manufacturer/supplier (only MOST Approved) or their authorised representative who will ensure compliance to the manufacturer's instructions for installation.

Taking the width of gap for movement of the joint into account, the dimensions of the recess in the decking shall be established in accordance with the drawings or design data of the manufacturer. The surfaces of the recess shall be thoroughly cleaned, and all dirt and debris removed. The exposed reinforcement shall be suitably adjusted to permit unobstructed lowering of the joint into the recess.

The recess shall be shuttered in such a way that dimensions in the joint drawing are maintained. The formwork shall be rigid and firm.

Immediately prior to placing the joint, the pre-setting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for pre-setting, correction of the pre-setting shall be done. After adjustment, the brackets shall be tightened again.

The joint shall be lowered in a pre-determined position. Following placement of the joint in the prepared recess, the joint shall be levelled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side of the joint. With the expansion joint finally held at both sides, the auxiliary brackets shall be released, allowing the joint to take up the movement of the structure.

High quality concrete shall then be filled into the recess. The packing concrete must feature low shrinkage and have the same strength as that of the superstructure, but in any case, not less than M40 grade. Good compaction and careful curing of concrete is particularly important. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

The neoprene seal shall be field installed in continuous length spanning the entire roadway width. To ensure proper fit of seal and enhance the ease of installation dirt, spatter or standing water shall be removed from the steel cavity using a brush, scrapper or compressed air. The seal shall be installed without any damage to the seal by suitable hand method or machine tools.

The deck surfacing shall be finished flush with the top of the steel sections. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

6) Acceptance Criteria:

- i. All steel elements shall be finished with corrosion protection system.
- ii. For neoprene seal, the acceptance test shall conform to the requirements stipulated in Table-1. The manufacturer/supplier shall produce a test certificate, accordingly, conducted in a recognized laboratory, in India or abroad.
- iii. The manufacturer shall produce test certificates indicating that anchorage system had been tested in recognized laboratory to determine optimum configuration of anchorage assembly under dynamic loading.
- iv. Prior to acceptance 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously pounded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.
- v. As strip seal type of joint is specialized in nature, generally of the proprietary type, the manufacturer shall be required to produce evidence of satisfactory performance of this type of joint.

7) Test and Standards of Acceptance:

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognized testing laboratory of India or abroad.

8) Water bars / Water stops

Where waterbars are required, the joints shall incorporate PVC water bar such as "Fixostop" or approved equivalent (conforming to IS: 12200). The water bars shall be complete with all the necessary moulded or prefabricated intersection pieces assembled with bends and butt joints in running lengths made by welding in an electrically heated jig. The fabrication drawing made by the manufacturer shall be submitted by the Contractor for approval of the Engineer

Jointing and fixing of waterbars shall be carried out strictly in accordance with the manufacturer's instructions which should be enumerated in a detailed method statement and submitted for approval / comments of the Engineer-in-Charge. The following types of waterstops are proposed to be used in the Work.

- i. 'FIXOSTOP' Type 230 KD or equivalent – To be used at construction joint in base slab
- ii. 'FIXOSTOP' Type 230 KV or equivalent – To be used at expansion joint in base slab
- iii. 'FIXOSTOP' Type 240 RS or equivalent – To be used at construction joint in between wall and base slab
- iv. 'FIXOSTOP' Type 240 H or equivalent – To be used at expansion joint in base slab

Waterbars shall be of approved and appropriate type obtained from approved manufacturers.

The waterbars shall be installed so that they are securely held in their correct position during the placing and compacting of the concrete. Necessary supporting devices to prevent sagging of the water bars shall be provided.

Where reinforcement is present adjacent to waterbars, adequate clearance shall be left between the reinforcement and waterbars to facilitate compaction of the concrete.

Double headed nails maybe used in the edge of the waterbar outside the line of the external grooves for fixing purposes, but no other holes shall be permitted through the waterbar.

A representative of the manufacturer shall be present at site during the operations of installing, jointing and embedment of waterstop. He shall monitor and certify that the work is being carried out strictly as per specifications and recommended practices.

d. SPECIFICATION FOR OMEGA TYPE EXPANSION JOINT

1. Expansion joint type described here-after is the "OMEGA TYPE EXPANSION JOINT".
As per IRC 83 part II 2018
 - i. Deleted.
 - ii. Material.
 - iii. Deleted.

2. **Anchorage:**

The steel plate shall conform to IS: 2062 or equivalent. The bolt and nut shall be anchored to the deck by welding to the main reinforcement. Steel plate used for shall be 8 mm thick hot dip galvanized. The center-to-center spacing of bolts shall not exceed 400 mm.

3. **Corrosion Protection:**

All steel section shall be protected against corrosion by hot dip galvanizing or any other approved anticorrosive coating with a minimum thickness of 100 micron.

4. **Joint Seal:**

5. **G. 2.4.1** The sealing element shall be a preformed chloroprene with high tear strength. Insensitive to soil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be vulcanized in a single operation for the full length of the joint. The seal shall cater for a horizontal movement up to 100mm and vertical movement of 3mm. **G. 2.4.2** the physical properties of chloroprene sealing element shall conform to the following:

(a) Deleted – Chloroprene Seal

(b) **Elastomeric seal**

It shall be performed extruded Omega type section of Elastomeric Seal of such a shape as to promote self-removal of foreign material during normal service operations. Elastomer of joint seal shall conform to clause 915.1 of IRC:83 (Part-II) and satisfy the properties stipulated in Table 2 strip seal element specifications of these specifications given in MORTH Circular no. RW/NH-34059/96-5 & R dated 30 Nov 02 on the subject except in respect of the working movement range of the sealing element which shall be as specified in CI G.2.4.1 above.

9. Deleted.

9.1 **Handling and Storage:**

- (i) The expansion joint material shall be handled with care and stored under cover.
- (ii) All joint material and assemblies shall be protected from damage and assemblies shall be supported to maintain true shape and alignment during transportation and storage.

9.2 **Installation:**

- i. The expansion joint shall be installed by the manufacturer/supplier or their authority's representative, who will ensure compliance of installation procedure and instructions.
- ii. The dimension of the joint recess edge beam above deck slab and the width of the gap shall conform to the approved drawing.
- iii. Bolts shall be welded to the main reinforcement in the edge beam deck maintaining the level and alignment of the joint.
- iv. Concreting of edge beam shall be done with great care using proper mix conforming to same grade as that of the deck concrete but no less than M30 grade in any case. The water cement ratio shall not be more than 0.40. If needed, suitable admixtures may be used to achieve the workability. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess edge beam.

- v. At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.
- vi. Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.
- vii. Deleted.
- viii. The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation, which shall be between +05 to +35 degree C. the joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.

F.5. Acceptance Criteria:

- F.5.1. All steel elements shall be furnished with corrosion protection system.
- F.5.2. For the joint seal the acceptance test shall conform to the requirements stipulated in para-G.2.4 above. The manufacturer/supplier of this type of joint shall produce a test certificate to this effect conducted in a recognized laboratory in India or abroad.
- F.5.3. Prior to acceptance 25% of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at-least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm any time during the test. A close inspection of the underside of the joint shall not reveal any leakage.

F.6. Tests and Standards of Acceptance:

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite from the recognized testing laboratory of India or abroad.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

F.7. Rates:

The contract unit rate shall include the cost of all materials, labour, equipment, cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications.

10.3 RAILINGS

10.3.1 General

Prefabricated railing as per approved design and drawing shall be provided and erected at site. Fixing arrangements on segment parapet shall be carefully designed and incorporated.

Railing shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. All edges and corners shall be straight and finished to true line and level.

Contractor should prepare and submit his own drawings and Method Statement as per best industrial practises for approval of Engineer before commencement of work. The work shall be commenced only after approval of the Method statement by Engineer.

10.3.2 Metal Railings

10.3.2.1 General

- i. MS Hand Railings shall be provided as per tender drawings attached.
- ii. All complete steel railing elements, terminal sections, posts, and other fittings shall be of shape, size and designation of approved material and make as given in the item of work or as directed by Engineer.
- iii. All these elements shall be painted with an approved paint. Primer coat (zinc epilux or equivalent) & three coats of PU paint as per specification and drawing. with all lead and lifts and as per the directions of engineer If straightening is necessary, it shall be done by methods approved by Engineer.
- iv. The Contractor shall take every precaution against damage of the components during fixing in position.
- v. Damaged painted surfaces shall be cleaned and repainted. Special care shall be taken to prevent staining of all products, rust, mortar, etc. before it is put into use.
- vi. The Contractor shall take every precaution against damage of the components during fixing in position.

10.3.2.2 Fixing

- i. The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints, correct alignment and camber throughout their length. Fixing shall be strictly as per fixing details shown on approved drawing or as directed by engineer.
- ii. All necessary holes, anchor bolts etc., required in fixing shall be made by the contractor and made good after installation, without any extra charge
- iii. Any damages done to the parapet while installing MS Railing shall be rectified by the contractor at his own cost. As per method statement approved by Engineer Nothing extra is payable in this regard.
- iv. Maximum continuous length at topmost pipe shall be restricted to 15.5m.
- v. Where the span length is less than 31m, 50mm gap shall be provided between continuous railing at Mid span Location(L/2)
- vi. Where the span length is greater than 31m, 50mm gap shall be provided between continuous railing at Location(L/3).

10.4 DRAINAGE SPOUTS AND DRAINAGE PIPE**10.4.1 GENERAL**

- i. This work shall consist of supply and fixing in position of drainage spouts and drainage pipes for bridge decks and piers true to lines, levels and position in accordance with details shown on drawings and to the requirements of these specifications and drainage plan for structure.
- ii. Where details are not given on drawings, contractor should prepare and submit his own drawings and Method Statement as per best industrial practises for approval of Engineer before commencement of work The work shall be commenced only after approval of the Method statement by Engineer.
- iii. Underground / Surface drainage works are to be designed by Contractor and carried as per CPWD specifications 2019 and paid for separately under DSR items.
- iv. Drainage pipe (Down take Pipe) to be embedded in pier and seismic Arrestor shall be of HDPE corrugated double wall and drainage pipe(Runner pipe) from Drainage spout outlet till Seismic Arrestor including bends shall be made of UPVC
- v. UPVC pipes shall be fixed to deck slab using adequate clamping, details of clamping shall be mentioned in the Method Statement and drawings submitted for approval of Engineer.
- vi. Minimum Working Pressure of UPVC pipes shall be 4Kg per Sq.cm and minimum diameter of UPVC Runner pipe shall be 160mm.Minimum diameter of HDPE down take pipe shall be 200mm.
- vii. UPVC pipes Specifications and fixing, including jointing of pipes using suitable approved solvents at

connections. shall Confirm to IS 4985 latest revision, Drainage spouts shall be as per MOST Type design No.SD/303. The waterspouts shall be provided at locations shown as per relevant layout drawing, and with a spacing not exceeding 5m.

- viii. Door bends i.e. (opening with a door/cap) shall be provided at all U-PVC pipe bend locations, to access and remove any debris choked at bend locations.
- ix. UPVC pipe shall be temporarily placed in the HDPE Pipe fixed in the pier during concreting and shall be moved up and down to avoid any ingress of slurry and avoid choking of HDPE Pipe due to damage of HDPE Pipe during needle vibrator compaction of pier concrete.

DESIGN:

Drainage:

The drainage of deck shall be designed to cater the maximum envisaged rainfall intensity and suitable longitudinal and transverse slope should be provided. Moreover, the provisions of Clauses-10.4.1.1 & 15.2.2 of IRS-CBC shall be followed.

Solid Pier

The drainpipe of double wall HDPE corrugated pipes will be located within solid pier to avoid unpleasant aesthetics.

10.4.2 FABRICATION

- i. Drainage assembly including drainage-spouts, gully-gratings and clean-out fixtures, shall be fabricated to dimensions shown in the drawings, and adequately fixed to the deck.
- ii. All materials shall be corrosion resistant; steel components shall be of mild steel conforming to IS 2062. The drainage assembly shall be seam welded for water tightness and then hot dip galvanised @ 650g/m² and further painted with anti-corrosion powder coated paint.
- iii. Drainage outlets shall be so provided that the discharge of the rainwater drained by them is not directed towards any part of the superstructure or substructure component.

10.4.3 PLACEMENT

The galvanised assembly of drainage spout shall be placed in true position, lines and level as shown in drawing with necessary cut-out in the shuttering for deck slab and held in position firmly. Where reinforcement of the deck is required to be cut, equivalent reinforcement shall be placed at the corners of the assembly.

10.4.4 FINISHING

After setting of deck slab concrete, shrinkage cracks around the assembly shall be totally sealed with polysulphide sealant or bituminous sealant as per IS: 1834 and excess sealant trimmed.

10.5 Manhole Cover

- A. The covers and frames shall conform to IS 1726 for cast Iron shall be of the following grades and types. Grade of Manhole Cover shall be either Medium, MD - 10 Rectangular/Circular or as decided by Engineer.
- B. The size of man hole cover shall be minimum of 900mm.
- C. The following specifications for Cast Iron Manhole Covers and Frames shall be followed:-
 - (i) Manhole covers and frame shall be manufactured from appropriate grade of grey cast iron not inferior than FG150 grade of IS 210.
 - (ii) They shall be cleanly cast and shall be free from air and sand holes, cold shuts and warping.
 - (iii) Covers shall have on its operative top a raised chequered design to provide for an adequate no-slip grip. The rise of chequers shall be not less than 4mm.
 - (iv) Key holes, keys and lifting devices shall be provided in the manhole covered to facilitate their placement in the frames and their operative maintenance.
 - (v) Manhole covers and frames shall be coated with materials having base with a black bituminous composition. The coating shall be smooth and tenacious. It shall not flow when exposed to temperature of 63°C

and shall not be so brittle as to chip off at temperature of 0°C.

- (vi) Size and shape and performance requirement of manhole covers, and frames shall conform to IS 1726.
- (vii) Each manhole covers and frame shall have cast on them the following information:
 - (a) Manufacturer's name or trademark
 - (b) Grade designation
 - (c) Date of manufacturer
 - (d) The words SWD or 'Sewer' to denote 'storm water drain' or 'sewer' respectively
 - (e) Identification marks as required by Engineer-in-Charge.
- (viii) The cover shall be gas tight and watertight.
- (ix) The sizes of covers specified shall be taken as the clear internal dimensions of the frame.
- (x) The approximate weight of the various type of manhole covers and frames shall be as per IS 1726.
- (xi) The cover shall be capable of easy opening and closing and it shall be fitted in the frame in workmanship like manner

10.6 CINDER

10.6.1 General

Cinder to be used for filling in floors shall be obtained from furnace of steam boilers using coal fuel only. It shall be clean and free from clay dirt, wood ashes or other deleterious matter. It shall pass through IS Sieve designation 3.35 mm with at least 50% of it passing through IS Sieve designation 1.70 mm. Cinder obtained from brick kilns shall not be used. At site of work, the cinder shall be protected from dirt collecting on it and could be used for filling in drops only.

10.7 SEALANTS

10.7.1 General

- i. Joint sealing compounds shall seal joints in concrete against the passage of water, prevent the ingress of grit or other foreign material and protect the joint filler. The compound shall have good extensibility and adhesion to concrete surfaces and shall be resistant to flow and weathering.
- ii. Approved Sealant where specified on the drawings shall be provided strictly in accordance with the manufacturer's written instructions, such joints shall be formed to the correct dimensions, thoroughly cleaned and treated with recommended primer strictly in accordance with the manufacturer's written instructions prior to sealing. Wherever width of gap to be sealed is wide enough to necessitate the use of backer rod, the same shall be provided at no extra cost. The contractor shall use only competent personnel experienced in the application of sealant for such work.
- iii. Where specified in the drawings, silicon/polyurethane/ polysulphide-based sealants shall be of an approved manufacture. The treatment of the joint and the use of sealing compound shall be strictly in accordance with the manufacturer's written instructions. The entire work shall be carried out as per IS:3414, IS.6509, IS:11433.
- iv. Sealants shall be as follows:
Silicon sealant shall be one part gun grade type with minimum movement capability of $\pm 25\%$ and elongation at break of 450% conforming to BS 5889 or TTS 001543A. This Sealant shall be of approved colour and shall be non-staining to the parent concrete surface.

10.7.2 Ancillary Materials

The Contractor shall provide all ancillary materials such as cleaning solutions epoxy mortar, primer, tool cleaner, bond breaker type, filler boards, back up material, backing rods, polyethylene foam, masking tapes, sealant slot former etc.

10.7.3 Primer

Primer for sealants shall only be as recommended by the sealant manufacturer, Primer shall have been

tested for compatibility and durability with the sealant to be used and on samples of the surfaces to be selected.

10.7.4 Backdrop Material

Backdrop material shall be an expanded polyethylene of nominal density 35 kg/cum as recommended by the sealant manufacturer. It shall be of non-absorbent and non-staining material compatible with the sealant used. Tube or rod stock shall be rolled into the joint cavity.

10.7.5 Bond-preventive Materials

Bond-preventive materials shall be pressure-sensitive adhesive polyethylene tape or aluminum foil.

10.7.6 Equipment

The Contractor shall inter alia provide the following plant and equipment for the work. T-paddle, follower plate, solid barrel gun, plastic nozzle, wire brush, heavy duty 500 rpm electric drill, palette knife, masking tape and paint brush for priming etc.

10.7.7 Working Life

Care shall be taken to ensure that material with adequate shelf life is provided. Material whose shelf life is over shall not be used in the works and shall be removed from the site forthwith. Depending on the storage, temperature and humidity, only one unit shall be drawn from the storage.

10.7.8 Curing Period

No portion of the work where sealant has been applied shall be allowed to be submerged or be wetted by any liquid for a period of 7 days after application of the sealant. This period may be modified depending on the temperature and humidity prevalent at the time.

10.7.9 Environmental Requirements

The ambient temperature shall be within the limits as given by the manufacturer, when the sealants are applied. The work shall not be carried out in a dusty atmosphere or when it is raining or when the humidity is high. Sealants shall not be applied when the ambient temperature is below 4-degree C. When the ambient temperature is below 10 degree C but greater than 4 degree C, the sealant containers shall be stored for some hours at 21 degree C, to ease mixing and application

10.7.10 Delivery and Storage

Materials shall be delivered to the job site in the manufacturer's original unopened containers. The containers shall include the following information on the label.: a) Name of supplier,

- b) Name of material,
- c) Formula,
- d) Lot number,
- e) Colour
- f) Date of manufacture,
- g) Mixing instructions
- h) Shelf life and
- i) Curing time

Materials shall be carefully handled and stored to prevent contamination of foreign materials to exposure to temperatures exceeding 35-degree C.

10.7.11 Joints

The effective width to depth ratio shall be as per the table given below unless directed otherwise by the Engineer.

Surfaces	Joint Width	Joint Depth	
		Minimum	Maximum
For concrete masonry or stone:	6 mm	6 mm	6 mm
	Over 6 mm up to 12 mm	6 mm	Equal to width
	Over 12 mm	½ width	½ width

10.3.1 Surface Preparation**General**

The surface of joints to be sealed shall be clean, dry, sound and free of all release agents, water repellents, laitance, oil, grease, dirt, chalk, particles of mortar, dust, loose rust, loose mill scale and other foreign substances. Oil and grease shall be removed with solvent and the surfaces shall be wiped with clean clothes

10.7.12 Concrete and Masonry Surfaces

Where surfaces have been treated with curing compounds, oil or other such materials, the materials shall be removed by sandblasting or wire brushing, Laitance, efflorescence and loose mortar shall be removed from the joint cavity. The surfaces/edges shall be repaired with epoxy mortar to give smooth and even surfaces to correct lines and levels with a uniform gap for the length to be sealed.

10.7.13 Application Masking Tape

Masking tape shall be placed on the finished surface on one or both sides of a joint cavity to protect adjacent finished surfaces from primer or compound smears. The masking tape shall be removed within 10 minutes after the joint shall be filled and tolled.

10.7.14 Bond-preventive materials

Bond-preventive materials shall be installed on the bottom of the joint cavity and other surfaces to prevent the sealant from adhering to the surfaces covered by the bond- preventive materials. The materials shall be carefully applied to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those covered by the bond- preventive materials.

10.7.15 Backstops

The back or bottom of joints constructed deeper than specified shall be packed tightly with an approved backstop material to provide a joint of the depth specified.

10.7.16 Primer

The primer shall be used in accordance with the manufacturer's instructions. The primer shall be applied to the joint surfaces to be sealed only and not spill over or be applied to surfaces adjacent to the joints.

10.7.17 Application of Sealant

The sealant shall be gun-applied with a nozzle of proper size to fit the width of the joint indicated and shall be forced into grooves with sufficient pressure to expel air and fill the groove solidly. The sealant shall be uniformly smooth and free of wrinkles.

The plastic nozzles shall be inserted on the gun and cut to appropriate size. The sealant shall be gunned into joints using an even trigger pressure. The nozzle shall be cleaned occasionally. The sealant shall be pressed into joints with a wet spatula and tooled within five minutes of application. The jointly shall be tooled slightly concave after the sealant is installed. The tolled joint shall present a smooth and professional joint giving the desired finish and shape. The masking tape shall be removed immediately after tooling.

Application equipment shall be cleaned with a tool cleaner, recommended by the % manufacturer, after wearing PVC or rubber gloves and whilst the sealant is still in an uncured state.

10.7.18 Cleaning

The surfaces adjoining the sealed joints shall be cleaned of smears and other soiling resulting from the sealing application as the work progresses. Sealant adhering to, porous surfaces shall be left until is just

cured and then removed by abrasion or other mechanical means.

10.8 FIREPROOFING OF STEEL STRUCTURES

10.8.1 DELETED.

10.8.2 SCOPE

This specification covers the general requirements of materials and the method of application for internal protection of platform structural steel girder (in a limited length) and steel door where high voltage cable are crossing from track girder to off- road station building, against fire by vermiculite cementitious coating.

10.8.2.1 Materials

All materials to be used shall conform to the requirements of respective UL codes / IS codes. Sample and test results for all the materials shall be submitted to the Engineer and got approved by him in writing before execution of work. Acceptance criteria of commonly used materials is given below.

10.8.2.2 Vermiculite Cementitious Coating

Branded product with base as Vermiculite mixed with ordinary portland cement shall have a max loose dry density of 400kg/m³ while in moulded condition, density shall not exceed 800kg/m³. Sulphate content in the branded product shall not exceed 1%, when the sulphate content is expressed as sulphur trioxide.

10.8.2.3 Reinforcement

Welded wire fabric to be used as reinforcement shall conform to IS:1566 and shall be of approved type. Mesh size shall be 50mm x 50mm and thickness of wire shall be 3mm.

Attachments

(a) Tie wire

Tie wire shall be of mild steel not thinner than 16SWG.

(b) Nuts

Nuts shall be made of mild steel and shall conform to IS:1367 and IS:2585 of required size as recommended by manufacturer.

10.8.2.4 Surface Preparation

Surface cleaning, Welding nuts and application of primer

All steel surface to be in contact with the fire proofing coating materials shall be cleaned of all oil/grease, loose rust/scales/dust by using detergent and wire brushing. M-16 or of required size as recommended by manufacturer nuts shall be welded with all the steel members to be fire proofed. Maximum spacing of nuts shall be 400mm centre to centre in both directions. Nuts shall be welded to the steel surface in shop. Epoxy zinc phosphate primer polyamid as specified in table of painting specification or as recommended by manufacturer's shall be also applied to the MS nuts and effected surfaces of the members due to welding after cleaning.

10.8.2.5 Placement of reinforcement

Reinforcement shall be placed in the middle of coated material thickness. It shall be bent confirming with outlines of finished encasement and rigidly secured in place by tie wire with all the nuts. Minimum lap at ends and sides shall be 100mm and lapped wire fabric shall be tied firmly.

10.8.2.6 Application

Application of fire proofing material coating shall be carried out by skilled and experienced operators.

Before start of application, zone which is not to be fireproofed shall be covered with polythene/ tarpaulin to protect them against damage.

For vertical webs of steel girder, the coating materials shall be applied in horizontal bands working upwards from the bottom. All outside edges of the fire proofing shall be chamfered by 20mm.

Thickness of fire proof coating shall be established by measuring it with electrometer.

The fire proofing material, after application shall be cured by keeping it in moist condition for a period of at least 14 days or else the surface shall be coated with a membrane of approved curing compound. Brand name, name of manufacturers, test results and method of application shall be submitted to and got approved from the Engineer prior to procurement of curing compound.

10.8.2.7 Approach Working Platform & Scaffolding

The contractor shall arrange all approaches, scaffoldings, stairways, ladder, working platform etc. for carrying out the entire works safely. The working area shall be neatly maintained and all the facilities required by Engineer for proper supervision of the work shall be provided. In case, any special precaution is needed for the safety of the structure till the completion of application, the contractor shall make and provide all such arrangement to the complete satisfaction of the Engineer and shall remove the same after completion of works.

10.8.2.8 Specific Requirement**10.8.2.8.1 Vermiculite Cementitious Coating****Design Requirement**

- (a) Vermiculite cementitious coating shall restrict the temperature of structure, below the maximum permissible temperature of 538 C for structural steel members, for a minimum time period of 2 hours and also it shall not fail till the end of the specified period.
- (b) The coating shall be non corrosive to the steel members & shall not be affected by environmental conditions. It shall also be asbestos free.
- (c) The coating materials shall be durable and easily repairable
- (d) Application procedure of the coating shall be easy, non hazardous and also shall not interfere with working of the adjoining areas.
- (e) The contractor shall submit coating thickness based on test results for structural steel sections to be fire proofed for review/approval of the Engineer for the offered branded product as per UL-1709 when tested on W10 x 49 steel I-beam.

Application

- (a) Vermiculite cementitious coating shall be mixed with water on a clean platform or in a clean mixing box or in a suitable mixer as per manufacturer's specifications. Water cement shall be adjusted so that vermiculite cementitious coating adheres properly to steel surface and does not sag or slide upon application.
- (b) Primer compatible with the vermiculite cement coating as recommended by the manufacturer's shall be applied over the steel surface after cleaning the shop primer if required as per the manufacturer's specifications.
- (c) Mixed vermiculite cementitious coating shall generally be applied, over the steel surface with the help of spray gun except for small area and inaccessible location, where application with conventional hand tools shall be permitted. Mixed vermiculite shall be used within the pot life specified by the manufacturer. Under no circumstances rebound material shall be used.
- (d) The full specified thickness shall be developed in three successive coats. rendering coat, floating coat, finishing coat and thickness of each coat shall be as manufacture's requirement.
Each successive layer shall only be applied after the preceding layer has developed its initial set and is also properly scratched with steel brush to developed proper bond. If the application is interrupted and does not satisfy successive layers criteria, the coating shall be cut back to the steel surface/preceding layer with a trowel at an inclined angle. Exposed surface of this coating shall be thoroughly wetted before resuming the work.
- (e) Application of mixed vermiculite shall not be carried out if the air temperature or the temperature of the surface to be fire proofed 4 C or less. Provision shall be made for adequate ventilation during and after application, until the coating is dry.

10.9 FINISHING AND JOINT SEALING

Fire proof coating shall be finished with 2 coats of microporous exterior top coat as recommended by manufacturer, compatible to cement surfaces of approved make colour conforming to IS: specifications.

10.10 TEST

The contractor shall submit the certificate of test results for the vermiculite cementitious coating over structural member from a laboratory, approved by the Engineer. Test shall be performed as per the requirements laid down in UL-1709 for 2 hours duration when tested on W10 x 49 I-beam.

10.11 MEASUREMENT

Measurement for fire proofing coating of 2hrs shall be in Sqm based on the net surface of structural steel on which it is applied.

10.12 APPROVED MANUFACTURERS/ SUPPLIER

All materials and products shall conform to the relevant standard specification, IS codes and other relevant codes etc. and shall be of approved makes and design.

10.12.1 Polycarbonate Roof/Wall Panels

The multi-cell polycarbonate panel to be used for Roofing/Wall Panels should have the following specifications:

- i. Two side Co-extrusion for UV rays protection Panels have to be joined together by protected

- polycarbonate connector/aluminum connector/any other mechanism that makes joint perfectly water tight.
- ii. year warranty
- iii. Thermal Insulation $\geq 1.50 \text{ W/m}^2\cdot\text{K}$ Acoustic Insulation $\geq 20\text{dB}$
- iv. Linear Thermal Expansion $= .065\text{mm/m degree C}$ Temperature Range (-20 degree C to 120 degree C)
Fire Reaction BS1d0 or better as per EN 13501:2002.

10.12.2 Epoxy

Epoxy bonding agents for match cast joints shall be thermosetting 100 percent compositions that do not contain solvent or any non-reactive organic ingredient or pigments required for coloring. Epoxy bonding agents shall be of two components i.e., a resin and a hardener. The two components shall be distinctly pigmented. So mixing produces a third color similar to the concrete in the segments to be joined, shall be packaged in proportioned, labeled, ready-to-use containers. Epoxy bonding agents shall be formulated to provide application temperature range that will permit erection of match cast segments at substrate temperature from 5°C to 40°C . depending upon the ambient temperature range, the following types of epoxy are recommended for use:

5° to 20°C : Fast reacting

15° to 30°C : Medium fast reacting 25° to

40°C : Slow reacting

If two surfaces to be bonded have different substrate temperatures, the adhesive applicable at the lower temperature shall be used.

Epoxy bonding agents shall be insensitive to damp conditions during application. After curing, shall exhibit high bonding strength to cured concrete, good water resistivity, low creep characteristics and tensile strength greater than concrete. In addition, the epoxy bonding agents shall function as a lubricant during the joining of match cast segments, as a filler to accurately match the surface of the segments and act as a durable water tight bond at the joint.

Epoxy bonding agents shall be tested to determine their workability get time, open time, bond and compressive strength and working temperature range. The frequency of the tests shall be as stated in the Special Specifications of the Contract.

The contractor shall furnish the Engineer with samples of the material for quality assurance testing and a certification from a reputed independent laboratory having NABL. Certification indicating that the material has passes the required tests. Specific properties of epoxy and the test procedures to be used to measure these properties shall conform to FIP requirement.

10.12.3 Mixing and Installation of Epoxy

Instructions furnished by the supplier for the safe storage, mixing and handling of the epoxy bonding agent shall be followed. The epoxy shall be thoroughly mixed until it is of uniform color. Use of a proper sized mechanical mixer operating at no more than 600 RPM will be required. Contents of damaged or previously opened containers shall not be used. Surfaces to which the epoxy material is to be applied

shall be at least at 40°F and shall be free from oil, laitance form, release agent or any other material that would prevent epoxy from bonding to the concrete surface. All laitance and other contaminants shall be preferably removed by water rinsing, or, alternatively, by light sand-blasting. Wet surfaces shall be dried before applying epoxy bonding agents. The surface shall be at least the equivalent of saturated surface dry (no visible water).

Mixing shall not start until the segment is prepared for installation. Application of the epoxy bonding agent shall be according to the manufacturer's instructions using trowel rubber glove or brush on one or both surfaces to be joined. The coating shall be smooth and uniform and shall cover the entire surface with a minimum thickness of 1.5 mm applied on both surfaces and 3 mm if applied on one surface. Epoxy should not be placed within 10 mm of prestressing ducts to minimize flow into ducts. A discernible bead line must be observed in all exposed contact areas after temporary post-tensioning. Erection operations shall be coordinated and conducted so as to complete the operations of applying the epoxy bonding agent to the segments, erection, assembling and temporary post-tensioning of the newly joined segment within 70% of the open time period of the bonding agent.

The epoxy material shall be applied to all surfaces to be joined within first half of the get time as shown on the containers. The segments shall be joined within 45 minutes after the application of the first epoxy material placed and a minimum required temporary prestress over the cross section should be applied within 70 percent of the open time of epoxy material. The joint shall be checked immediately after the erection to verify uniform joint width and proper fit. Excess epoxy from the joint shall be removed where accessible. All tendon ducts shall be swabbed immediately after stressing while the epoxy is still in the non-gelled condition to remove or smooth out any epoxy in the conduit and to seal any pockets or air bubble holes that have formed that joint. If jointing is not completed with 70 percent of the open time, the operation shall be terminated and the epoxy bonding agent shall be completely removed to the maximum possible extent from the surfaces. The surface must be prepared again and fresh epoxy shall be applied to the surface before resuming joining operations. As general instructions cannot cover all situations, specific recommendations and instructions shall be obtained in each case from the Engineer.

10.7 SPECIFICATION FOR COATING OF PSC GIRDERS AND RCC SUBSTRUCTURES:

1.1 MATERIALS:

- 1.1.1 The coating materials shall meet the standards specified by various codes and formulation set forth by the patentor.
- 1.1.2 A written certification shall be furnished to the Engineer that properly identifies the number of each batch of coating material used in the work, material, quantity represented, date of manufacture, name and address of manufacture and a statement that the coating material used must meet the requirements specified by CBRI/Roorkee. Also proof of purchase from CBRI's approved manufacture shall be submitted.
- 1.1.3 The coating material shall be stored in the manner as per recommendations of the manufacturer until ready for use. The coating material shall be used within the manufacture's written recommended shelf life.
- 1.1.4 When a representative sample of the material is to be sent to CBRL, Roorkee laboratory, then the sample shall be packaged in an airtight container and identified by batch number. The cost of testing will be borne by the Contractor.

1.2 SPECIFICATION OF COATING MATERIAL

Sr.No.	Description	Primer coat	Middle Coat	Top Coat
1.	Base	Interpenetrating Polymer (Epoxy phenolic)	Interpenetrating Polymer (Epoxy phenolic)	Interpenetrating Polymer (Aliphatic Polyurethane)
2.	Pot life	1 Hour for 2 lt. mix	1 Hour for 2 lt. mix	1 Hour for 2 lt. mix
3.	Curing	Air Curing	Air Curing	Air Curing

4.	Colour	Clear or as specified by the Engineer in charge	Yellow/Grey or as specified by the Engineer in charge	Yellow/Grey or as specified by the Engineer in charge
5.	Shelf Life	One year in tightly sealed container.	One year in tightly sealed container	One year in tightly sealed container
6.	Dry film thickness	55- 65 microns	90-100 microns per coat	40-50 microns per coat
7.	Coverage	5-6 sq.mt/lit(5.5 sq.mt Average)	4-5 sq.mt/lit(4.5 sq.mt Average)	6-7 sq.mt/lit(6.5 sq.mt Average)
8.	Recommended No. of coats	One	One	One
9.	Recoatibility	Subsequent coat shall be applied after 6 hours to 7 days	4 hours to 7 days. Ensure the surface is dust and deposit free prior to application	N.A
10.	Mix proportion	Base:1 PBV*/Curing Agent: 1 PBV*-Parts by volume	Base:1 PBV*/Curing Agent: 1 PBV*- Parts by volume	Base:1 PBV*/Curing Agent: 1 PBV*- Parts by volume

- 1.2.1 Tensile strength: Minimum tensile strength of the coating must be 15 N/mm² and it should be determined as per ASTM-2370.
- 1.2.2 Elongation: Minimum elongation of the coating must be 15% and it should be determined as per ASTM D-2370-73.
- 1.2.3 Specific permeability: The maximum value must be 0.15 mg/cm²/mm/24hr and it should be determined as per ASTM d-1653-74.
- 1.2.4 Adhesion with concrete: The minimum adhesion with concrete by pullout method must be 2.5n/mm² and it should be determined as per BS-3900-E-270.
- 1.2.5 For consumption calculation of various coats (primer, middle and top), average values of the specified coverage shall be adopted.

1.3 **SURFACE PREPARATIONS:**

- 1.3.1 In order to have better bonding, the concrete surface should be clean, dry and mechanically sound. The surface of the concrete structure to be coated shall be cleaned of all traces of mould oil, laitance, salt deposits by mechanised means. Finally, the surface should be washed with clean water jet to remove any salt deposits. The surface should be dried. All the protrusions should be removed and cracks, joints should be sealed with IPNet putty as per Central Building Research Institute (CBRI), Roorkee's recommendation.

1.4 **APPLICATION OF COATING:**

- 1.4.1 Mix the base and curing agent in prescribed proportion by volume thoroughly for 5-10 minutes and allow it to remain in a container for five minutes.
- 1.4.2 A primer coating of IPN polymer (transparent) shall be applied to the cleaned surface after surface preparation within the pot life.

- 1.4.3 After air curing, Intermediate and top coating should be applied with time lag as per manufacturer's specification. 1.4.4 The coating shall be applied by airless spray or other approved means.
- 1.4.4 The coating shall be applied by airless spray or other approved means.

1.5 COATING THICKNESS:

- 1.5.1 **Superstructure and Sub structures-** The minimum total thickness of all coats (primer coat +middle coat + top coat) must be 200+15 microns.

1.6 MEASUREMENT OF COATING THICKNESS

- 1.6.1 During the application of IPNET system clean abraded steel plates of approximately 10cm x 8cm shall be adhered to the concrete surface by means of putty /adhesive in such a way that these can be detached. IPNet system can be applied over the plates in the course of application over the concrete surface. Dry film thickness (DFT) can be measured using magnetic electrometer. DFT measurement should be done every 500 to 600 sqm area or as per the direction of engineer-in-charge.

1.7 COATING CONTINUITY:

- 1.7.1 The coating shall be visually inspected after curing for continuity of the coating and shall be free from holes, voids, contamination, cracks and damaged areas discernible to the unaided eye

1.8 PERMISSIBLE COATING DAMAGE AND REPAIR OF DAMAGED COATING:

- 1.8.1 All coating damage shall be repaired with patching material by the contractor at his own cost.
- 1.8.2 Repaired areas shall have a minimum coating thickness of 200+ 15 microns for Superstructure and sub structures.
- 1.8.3 Repair of damaged coating shall be done in accordance with the patching material manufacturer's written recommendations within the accepted rates.

1.9 INSPECTIONS:

The Engineer shall have free entry at all times to the parts of the contractor's works. The contractor shall afford the Engineer's representative all reasonable facilities to satisfy that the material is being furnished in accordance with this specification.

1.10 TESTING OF MATERIALS:

Following tests may be performed on the coating materials at CBRL, Roorkee testing laboratory by the contractor and testing report should be furnished to the Engineer

- Tensile strength, N/mm²
- Elongation, %
- Specific permeability, mg/cm²/mm/24hrs
- Adhesion with concrete, N/mm²

1.11 CERTIFICATION AND TEST REPORT:

Engineer shall be furnished with, at the time of completion, written certification that samples representing each lot have been tested as directed in this specification and the requirement have been met. A report of the test results shall be furnished to the Engineer.

TECHNICAL SPECIFICATION S-11: ADDITIONAL SPECIFICATIONS PRECAST SEGMENTAL CONSTRUCTIONS

11.1 TYPE OF CONSTRUCTION

The box girder superstructure for almost the entire length shall be constructed by precast segmental construction with epoxy bonded joints. The pre-stressing cables will be internal to the concrete. The methodology of construction will be "span by span". Only one end prestressing of permanent cables is contemplated, the other end of the cable being pre- blocked.

The standard spans c/c of piers have been envisaged as 31.0m, 28.0m, 25.0m, 22.0m & 18 - 15.0m (station spans). The spans may have curved alignment in plan. 34.0m or longer spans shall be adopted under special conditions, viz. site constraints or any obligatory location.

The usual segments shall be 3.0m in length except the pier segments which shall be 1.975/1.95m each. Standard spans shall be made to either add or subtract usual segments of 3.0m each. Where this is not possible or advisable for some reason, the segments will be of length between 1.5m and 3.0m. Hence the mould / casting bed shall be adaptable to cast non- standard length of segment.

The governing weight of the segments will be of the order of 45t. The maximum span length contemplated for precast segmental construction will be of the order of 31m. In exceptional circumstances, 34m span may be adopted with the approval of the Engineer-In-Charge.

Multiple Shear keys shall be provided at match casted joints at the webs as well as at top flange and soffit slab of the box girder as per IRC: SP-65.

Box girder segments shall be match cast at the casting yard and later transported to location and erected in position. Post-tensioned cables shall be threaded-in-situ and tensioned from one end. Box girder shall cater to two tracks.

11.2 MATERIAL SPECIFICATIONS**11.2.1 Cement**

Ordinary Portland Cement of 53 grade conforming to IS: 269 shall be used. All other specification will remain same as indicated in S.03 of Section-VII-F of these specifications.

11.2.2 Reinforcement

Only Fe500D TMT bars shall be used. All other specification will remain same as indicated in S.05 of Section-VII-F of these specifications.

11.2.3 Pre-stressing Steel

Uncoated stress relieved Low Relaxation Steel conforming to IS: 14268, Class 2, shall be used. The nominal diameter shall be 15.2mm with minimum breaking strength of 260.7 kN and minimum 0.2% proof load of 234.6 kN.

The pre-stressing steel accessories shall be subjected to an acceptance test prior to their actual use on the works. (Guidance may be taken from BS: 4447). Only multi-strand jacks shall be used for tensioning of cables. Single strand jack shall only be permitted in special cases with specific approval of Engineer-In-Charge. Direct and indirect force measurement device like Pressure Gauge) shall be attached in consultation with system manufacturer.

11.2.4 Concrete

Use of Fly Ash in Concrete as a part replacement of Cement is not permitted in precast prestressed segmental superstructure. All other specification will remain same as indicated in S.03 of Section-VII- F of these specifications.

Fibre reinforcement will be Propex (Fiber mesh 300-e3 / Fiber mesh 150-e3) or equivalent make polypropylene fibres, shall be added to ready-mixed concrete. Bar reinforcement is still considered primary reinforcement. Under normal condition, add to the ready-mix at the plant in the quantity recommended by the manufacturer subjected to the approval of engineer-in-charge. If job conditions warrant fibre reinforcement may be added at the job site provided that fibres are evenly distributed in the mix. Notwithstanding the same, Fibre reinforcement shall conform to IRC:SP:46 (2013).

The physical and chemical properties of the constituents of concrete and so also of the green and hardened concrete shall meet the requirements of provisions of section S.03 and MORTH Specifications for Road and Bridge Works, where relevant or where the standard specifications referred to in the Technical Specifications are silent.

11.2.5 Permanent Pre-stressing

The permanent pre-stressing cables shall generally be of the type 19K15 and 12K15, as suited to 19 nos. and 12nos. strands of 15.2mm nominal dia. intermediate numbers of strands may also be specified in the design, for which suitable anchorage heads shall be used. All aspects of pre-stressing including the system proper shall be subject to the approval of the Engineer.

The ducts shall be corrugated for internal prestressing and Material specifications of corrugated HDPE ducts used for internal prestressing shall be as specified in S.06 of Section-VII-F of these specifications. Adequate precaution shall be taken to ensure that epoxy material does not leak into joints of the ducts.

Maximum anchorage set- in shall be 6mm. Maximum wobble coefficient and friction ratios shall be 0.0020/metre and 0.17/radian respectively.

11.2.6 Epoxy Bonded Joints

In case of epoxy jointed superstructure, mating surfaces of both adjoining segments shall be effectively prepared by wire brushing, water jetting and /or any other approved means to ensure that the bond breaking material is completely removed. Epoxy of about 1mm thickness on each of the mating surfaces shall be applied (usually by hand application) within 70% of its pot life. Subsequently, the segment shall be brought closer to hug each other and an axial temporary compression of at least 0.3 MPa shall be applied by approved means for a minimum of 24 hrs. The uniform compressive stress may be applied by approved external temporary bar pre-stressing (such as Macalloy or Dywidag bar systems). This shall be accomplished using short HTS bar connecting the adjoining segments. The bars shall be anchored on temporary steel frame, passing through dedicated holes within the girder through. No passing-through holes shall be used in soffit slab or web. Passing-through holes used in soffit slab should be filled with free flow, high strength, non-shrink cement-grout.

The Epoxy shall essentially have properties as indicated below. The contractor shall plan his erection system in such a way that the time elapsed between mixing of components of epoxy applied to the mating surfaces of precast concrete segments and application of temporary axial force does not exceed 60 minutes. No epoxy from a batch for which the time since combining the components has exceeded 20 minutes shall be used.

The broad sequence of operations shall generally comprise placing of all segments of a portion intended to be assembled and prestressed in one stage, touching each other and then visually examining the matching of mating surfaces. Subsequently each segment shall be separated from adjoining segment by a distance just sufficient to apply the epoxy. After applying epoxy, temporary axial compression shall be imparted and maintained for minimum 24 h. Thereafter intended permanent

prestress shall be imparted prior to demobilising the temporary axial prestress.

In order to prevent intrusion of epoxy in sheathing, an O-ring with diameter compatible with the size of HDPE sheathing (10-20mm wide and 4mm thick) of polypropylene shall be provided on both mating surfaces. Nothing extra shall be payable for such temporary stress application including all related works.

The purpose of the epoxy joint shall be to serve as lubricant during segment positioning, to provide water proofing of the joints for durability in service conditions and to provide a seal to avoid cross-over of grout during grouting cable into other ducts.

11.2.7 EPOXY

Depending upon the ambient temperature range, following types of epoxies are recommended for use:

5 to 20° Celsius : Fast reacting

15 to 30° Celsius : Medium fast reacting 25 to 40° Celsius : Slow reacting

Epoxy comprises two components, namely resin and hardener. Resin must be stirred by a mixer in its container for about 10 seconds or until homogeneity is reached. Thereafter hardener must be added and mixing continued. For a mix of 5 kg batch, a mixing rotor attached to a 350 W, 400 rpm electric machine is recommended or as specified by the manufacturer. The speed of 400 rpm should not be exceeded because higher revolutions will entrap air in the mix, cause excessive frictional heat and therefore shorten the pot life. The mixing time should not exceed 3 minutes and the temperature not allowed to rise above 40°C for fast reacting and medium fast reacting formulations and 60°C for slow reacting formulations. It must be ensured that mixing paddles scrape the bottom and sides of the container, so as to ensure complete mixing of the two components. The mixing should be carried out as close as possible to the place where the epoxy will be applied, so as to avoid loss of time, and therefore wasting of pot life in transport.

The epoxy shall be special purpose proprietary material for the proposed usage with proven past record. Selection shall be subject to the approval of the Engineer. Epoxy shall be tested for its conformance to the FIP-1978 "Proposal for Standard Tests and Verification of Epoxy Bonding Agents for Segmental Construction". Some of the important properties (minimum values) of epoxy are as follows:

Pot-life	:	20 minutes (at 40°C for fast and medium reacting epoxies and at 60°C for slow reacting epoxy)
Open time	:	60 minutes (at upper temperature limit)
Compressive strength	:	60 MPa at 24 hrs and 75 MPa at 168 hrs on 50x50x50 mm cube (at lower temperature limit)
Tensile bonding strength:		after 24 hrs at 100% humidity, should have concrete failure, no joint failure with M40 concrete (at lower temperature limit) Shear
strength	:	12 MPa (at lower temperature limit)
Curing rate	:	compressive strength on 50x50x50 mm cube shall be 20 MPa at 12 hrs, 40 MPa at 24 hrs and 75 MPa at 168 hrs (at lower temperature limit)

After receiving every batch, all tests (except shear modulus, instantaneous and deferred modulus in compression and water absorption, heat resistance, shear strength and solubility in water) are required to be done at the site laboratory at prevailing ambient temperature to conform to the uniformity of standard of supplied product. In case the received batch is kept at site for a period of more than three months all tests are required to be re-done.

With every erection, tests for pot life and open time are required to be done at site at prevailing ambient temperature.

Nothing extra shall be payable for providing epoxy and all related operations.

11.3 SHOP DRAWINGS AND DESIGN CALCULATIONS FOR CONSTRUCTION PROCEDURES

11.3.1 General

The Contractor shall submit according to a schedule, complete details and information concerning the method, materials, equipment and procedures the contractor proposes to use. These shall be called "Method Statements". Method Statements shall be submitted sufficiently in advance of the start of superstructure field construction operations, so as to allow the Engineer adequate review period, which shall not be less than 30 days. The submittals shall invariably include step-by-step erection procedure. The Contractor's Method Statements shall also include all calculations, drawings and information as may be relevant. Two sets of all required drawings and calculations shall be submitted and resubmitted if and as necessary until approved by the Engineer. The specified number of distribution copies shall be furnished after approval.

11.3.2 Design Calculations for Construction Procedures

Design assumptions and calculations shall be submitted for temporary pre-stressing, false work, erection devices, formwork or other temporary construction which may be required to complete the work, and which will be subject to calculated stresses.

Design of the falsework or erection devices for all superstructure concrete shall be done under the direction of, and sealed by, a registered professional engineer. Calculations shall also be submitted to substantiate the system and method of stressing proposed by the Contractor.

Also, Assumptions and Calculations shall also be submitted to substantiate the system and method of permanent and temporary pre-stressing proposed by the Contractor.

In the sections that follow, specific recommendations for precast segmental construction for superstructure are given apart from certain special aspects of construction.

11.3.3 Shop Drawings for Precast Segmental Construction

The Contractor shall submit detailed shop drawings for approval. The shop drawings shall be based on Execution Drawings issued by the Client to the Contractor and shall include but not necessarily be limited to the following information:

- a) Fully and accurately dimensioned views showing the geometry of segments including all projections, recesses, notches, openings, block-outs, blister if any and where acceptable, as well as other pertinent details.
- b) Details of any special reinforcing required for handling of segments or for other purposes. Also, all bar bending schedules shall be presented based on reinforcement schedules given in Execution Drawings issued by the Client.
- c) Size and type of ducts for all post-tensioning tendons and their horizontal and vertical profiles shall be clearly detailed. Sheathing supports, grout tubes, vents and drains shall be shown including size, type and locations.
- d) Details and locations of all other items to be embedded in the segments such as inserts, lifting devices and post-tensioning hardware shall be shown.
- e) Pre-stressing system details shall include sizes and properties of tendons, anchorages, plates, assemblies and stressing procedure, and details and locations of additional reinforcement necessary to resist anchor block stresses.
- f) Graphs, charts or tables showing the theoretical location of each segment, as erected or placed shall be furnished to the Engineer for his use in checking the erection of the superstructure. Detailed procedures for making geometry corrections shall be described.
- g) Details of grouting equipment, grout mix design and method of mixing and placing grout shall be provided.

- h) Method of installing bearings and expansion joints shall be given including approved manufacturer's recommendations.

11.3.4 Forms for Precast Segmental Construction

All side, bottom, inside, and header forms for precast segmental construction shall be constructed of steel unless use of other materials is approved by the Engineer. Shop drawings shall be submitted for all formwork.

In addition to the requirements of the Standard Specifications, the forms used for pre-casting the concrete segments shall be capable of:

- Match casting for precast segmental construction.
- Producing the segments within the tolerance permitted in the specification.
- Accommodating block-outs, opening and protrusions. Protruding re-bars will be needed at least for diaphragm segments and for second-pour plinths. Anchorages, signalling equipment, OHE Pedestals and cable routing supports shall also be included where needed in precast segments.
- Adjusting to changes in segment geometry as shown in Execution Drawings issued by the client or for correcting previous minor casting errors to prevent accumulation.
- Adjusting to accommodate BI-RIDE logo at the parapet as shown in the tender drawings.
- Adjusting the profile to take into account design camber values.
- Stripping without damage to the concrete.
- The form design shall provide a tight leak-proof jointing to the previous segment. The bulkhead must be capable of connecting the sheathing in a manner to hold their position and prevent intrusion of grout.

Joints in external formwork shall be avoided as far as possible. Where sections of forms are for some reason to be joined on the exterior face of the segment, an offset in excess of 0.5mm for flat surfaces and 1mm for corners and bends will not be permitted.

Forms shall not be removed until the concrete has attained adequate strength as specified elsewhere in the specification. Care should be exercised in removing the forms to prevent spalling and chipping of the concrete.

Forms shall be of sufficient thickness, with adequate external bracing and stiffeners and shall be sufficiently anchored to withstand the forces due to placement and vibration of concrete. Internal bracing and holding devices in forms shall be limited to stay bolts in webs which can be removed from the concrete surface to permit patching following form removal. Joints in the forms shall be designed and maintained for mortar tightness. The grade and alignment of forms shall be checked each time they are set and shall be maintained during the casting of concrete.

Metal forms shall be reasonably free from rust, Grease or other foreign materials. All forms shall be cleaned thoroughly prior to each casting operation. End headers shall be maintained to provide a smooth casting surface.

All formed surfaces for casting members shall be constructed and maintained to provide segment tolerances as specified elsewhere in the specification.

The faces of all forms, other than end headers, shall be properly cleaned and treated with form oil or other bond breaking coating prior to placing concrete. Between adjacent match cast segments and headers bond breaking materials shall be provided as indicated elsewhere in these Additional Specifications. The oil or other materials used shall be of a consistency and composition to facilitate form removal. Materials which appreciably stain or react with concrete shall not be used. Care shall be exercised to facilitate formwork

and segment removals without damage to the concrete.

11.4 CASTING, HANDLING, TRANSPORTATION AND ERECTION OF PRECAST SEGMENTS

11.4.1 General

The Contractor shall submit detailed Method Statements for casting, handling, transportation and erection of precast segments. The superstructure shall be erected by the method indicated in the tender or by alternate method submitted by the Contractor, subject to the approval of the Engineer. The stressing system, Cage of reinforcement and lifting details shall be successfully demonstrated on sample segment for prior to casting any permanent segments.

All handling and erection plant and equipment shall be load tested prior to their use at site or when specifically asked for by the Engineer. Any additional material required to cater to any temporary condition including temporary pre-stressing shall be borne by contractor and nothing extra will be paid in this account.

11.4.2 Casting of Segments

Casting bed and forms shall be structurally adequate to support the segment without settlement or distortion. The casting bed shall be designed for the hardware needed to adjust and maintain grade and alignment. Special consideration shall be given to those parts of the forms that have to change in dimensions. To facilitate alignment or adjustment, special equipment such as wedges, screws, or hydraulic jacks shall be provided. Fittings shall not interfere with stripping of forms. Grading of the forms and the deck of each segment shall take into consideration the relative position of the member in the structure.

- i Details for casting bed and hardware for adjustment shall be submitted by the Contractor for the Engineer's approval. Casting of segments shall be done in a single pour. Construction joint is not permitted in segment. Compaction of concrete shall be achieved through form vibrators along with needle vibrators.
- ii The Top surface of the segments shall be finished smooth. Necessary drainage spouts, manhole openings etc. shall be provided as per drawings. These drainage openings shall be kept atleast 3mm and max. 5mm below the top surface as to ensure unobstructed drainage flow through these openings.
- iii After the first segment/pier segment of each unit/span is cast, all succeeding segments shall be match cast against previously cast segments to ensure complete bearing and proper alignment on all mating surfaces and shall be given a unique identification mark so as to be placed at the intended location in the superstructure. A bond breaking material such as flax soap, talc, wax or any other approved material shall be used between previously cast segment and newly cast segment, as well as the end headers when required.
- iv Segments shall not be moved from the casting yard until stipulated strength requirements have been attained and shall be supported in a manner that will minimize warping. Under any circumstances the concrete shall have attained a minimum compressive strength of 20MPa at the time of removal of forms. At the time of lifting and assembly of precast segments into the structure, the concrete shall have attained sufficient strength to withstand the handling stresses. Curing of segments may be achieved through water or steam followed by water curing as decided by the Engineer-In-Charge.
- v A full-scale mock-up of the lifting and holding equipment (including assembly truss, cantilevering formwork etc) shall be performed to demonstrate their adequacy and efficacy prior to beginning any erection/assembly of the segments.
- vi **Tolerances in Precasting:**

Finished segment tolerances should not exceed the following:

Length of match-cast segment (not cumulative)	± 5 mm
Overall span length between bearings	±10 mm

Web thickness, depths of top and bottom flanges, Width of top and bottom flanges, overall depth of segment, thickness of diaphragm	± 5 mm
Grade of form edge and soffit	±1.0mm/m
Tendon hole location	±3.0mm
Position of shear keys	± 5 mm
Tolerance for erection of the span: Horizontal and vertical position of the at-pier-segment shall be within 15mm of the longitudinal alignment and grade.	

Positioning and arrangement of pre-stressing tendons in the segmental structure shall be as per IS 1343:2012. The permissible tolerance in the location of pre-stressing tendons shall be ±5mm.

vii **Casting of Pier Segment:**

Pier segments transfer the load from the superstructure to the substructure of the bridge. They contain some component of a diaphragm or heavily reinforced concrete wall to transfer the load.

Pier segments have critical structural components that must be planned during the design, shop drawing, formwork design and purchasing phases. These might include an increased number of post-tensioning anchorages and ducts, heavier reinforcing densities, sleeves for temporary and future post-tensioning, personnel access, accommodations such as sleeves or block-outs for bearings and seismic restraining units, accommodations for drainage and utilities. Extensive conflict resolution for permanent materials and sleeves should be performed during design.

Accordingly, Each Pier segments are mandated to be tested for Ultrasonic Pulse Velocity (UPV) test. UPV test to be conducted before using the same in match casting of typical span segment. No additional payment shall be payable to the contractor on this account.

viii In span-by-span erection, pier segments are typically cast in a casting cell that operates in short- line fashion. Pier Segments are cast "square," with both bulkheads perpendicular, to reduce geometry requirements and form adjustments, processes better handled in casting the adjacent typical segments. A custom bed can be designed to mass-produce a pier segment type, similar to typical segment casting.

ix **Shear Keys**

Precast segments shall be provided with shear keys at match cast joints conforming to IRC:SP-65. These shear keys shall cover as much area of the cross section as possible. Shear keys in the webs shall be smaller in size and more in number whereas those in top flange and bottom flange may have larger sizes with lesser number. Shear keys shall be dimensioned in the form of trapezium. Shear keys shall be avoided at the tendon hole locations.

x **Segment Dimensioning**

The segment lengths must be dimensioned keeping adequate allowance of the epoxy thickness applicable after the imparting temporary prestressing. This is to ensure correct placement / alignment of bearings.

xi **Deviator Blocks**

Sufficient number of Deviator blocks to be provided inside the box-girder in order to pass the prestressing ducts for future prestressing as the case may be.

xii The anchorage system shall permit tendons to be inserted in the member after erection of segments and tensioned from one end only. Use of prestressing couplers are not permitted.

xiii Care shall be taken to ensure that deformations of match cast segments due to thermal gradients caused by the heat of hydration of the new cast concrete are negligible. These deformations shall be prevented

by properly protecting both the match cast and new cast segments with curing blankets and plastic sheeting. Both the previous segment and the new segment will be maintained at the same temperature.

Reinforcing steel shall be fabricated in cages/jigs and placed according to the Execution Drawing issued/approved by the Client. Any conflict or interference with the proper location of sheathing and / or reinforcement or block-outs shall be promptly resolved, and corrections made as directed by the Engineer. No reinforcing steel shall be cut and removed to permit proper alignment of stressing conduits. Any bar that cannot be fabricated to clear the post-tensioning ducts shall be replaced by additional bars with adequate lap lengths and shall be submitted to the Engineer for approval.

- xiv Concrete down-stands/Niches in pier segment –The segmental girders follows the longitudinal designed profile of the viaduct, so also the bottom of the girder. Since the pier segment (which is about 2.0m long) has to rest on the bearings over the whole area for the proper transmission of the load and as the segment bottom follows the gradient of the line, it becomes necessary to provide concrete 'down stands' (in the shape of trapezium like a wedge) integrally cast with the pier segment for normal transmission of load to the bearings. Alternatively, 'niches' (again in the shape of the trapezium) can be provided in the pier segment to serve the same purpose. However, the niches have the disadvantage that the bearings cannot be inspected thoroughly but by the jacking up the girder. However, if down stands are provided, then bearings are easily available for visual inspection. Hence down stands are the desirable alternatives. This applies in cases of all girders viz. Box girders, 'U' girders or 'I' girders.
- xv Positive means of holding the sheathing in its correct position shall be provided in all cases and shall be indicated on the GFC/working drawings submitted for approval. During the concreting, sheathing shall be stiffened from the inside by rubber or plastic hoses or by inflatable rubber tubes.

11.4.2.1 Casting Methods

For precast segmental construction using match-cast segments, careful checks of both measurements and computations of geometry shall be made by the Contractor before moving segments from their casting position. Computed coordinates of all sections cast shall be completed before casting a new segment. For casting of precast segmental superstructure, there are two commonly known techniques of precasting (i) Long Line method and (ii) Short Line method. The Contractor has to select the option carefully and provide appropriate type of formwork as well as casting and handling operations. The "short line" method requires much greater precision in the work as compared to the "long line" method. Therefore, Long Line Method is preferred and recommended for implementation.

A. The "Long Line" Method

The principle of the long line method is the casting of the segments, in their correct relative position, on a long line casting bed which exactly reproduces the profile of the structure. One or more formwork units move along this line. The formwork units are guided by a preadjusted soffit. A long line is easy to set up and to maintain control over the production as well as the geometry of the segments. The segments shall be cast by long line method for spans curved in plan.

After stripping the forms, it is not necessary to take away the segments immediately. Substantial space may be required for the long line. The theoretical length for casting alone is normally slightly more than the length of the longest span of the structure. It must be constructed on a firm foundation which will not settle or deflect under the weight of the segments. In case the structure is curved, the long line must be designed to accommodate horizontal and vertical curvatures as well as twists, if any. Because the forms are mobile, equipment for casting, curing, etc. has to move from place to place.

B. The “Short Line” Method

The short line method is mentioned here as a possible alternate.

The segments are cast at the same place in stationary forms and against a neighbouring element. After casting, the neighbouring element is taken away and the last element is shifted to the place of the neighbouring element, clearing the space to cast the next element.

The space needed for the short line method is small in comparison to the long line method, approximately three times the length of a segment for one short line. The entire process is centralised. Horizontal and vertical curves and twisting of the structure are obtained by adjusting the position of the neighbouring segment and through specified formwork.

To obtain the desired structural configuration, the neighbouring segments must be accurately positioned and requires very precise workmanship, quality control procedures, and geometry control. Care must be taken that the formwork be sufficiently flexible to allow for adaptation at the joint with the accurately positioned matching segment.

If short line method is adopted, the deck segments should follow profile as given below:-

Suggested Deck Alignment on Vertical Curves

- a) On Vertical Summit Curves
On vertical summit curves, deck will follow the path of straight line joining the two points on adjacent piers. These two points shall have the minimum offset from rail level to deck level as specified by Engineer at all points along the length of girder.
- b) Vertical Valley Curves
On vertical valley curves, deck will follow the path of straight line joining the two points on adjacent piers. The minimum offset from rail level to deck level as specified by Engineer shall be ensured at all points along the length of girder.
- c) Suggested Deck Alignment on Circular / Transition Horizontal Curves
On circular / transition horizontal curves, each segment of the deck will follow the profile of short chord line. The bottom and side form for segment to be cast are positioned to span between the stiff fixed end bulkhead and the previously match cast segment. The previously match cast segment shall be oriented w.r.t segment to be cast and it should be ensured that fixed bulkhead always remain perpendicular to end face of formwork.

Due to orientation of match cast segment, the length of segment towards inner side of curve will be less and towards outer side of curve will be more than segment length along centreline. The formwork to be used should have flexibility to adjust the segment length on both sides by adjusting the position of the match cast segment without any additional pieces and it shall be ensured that offset of match cast segment and segment to be cast is limited to value so calculated.

11.4.3 Separation of Match-Cast Segments

The Contractor shall provide equipment to be used for uniform separation of match cast segments without damage. The method as well as details of the equipment to be used for separating match cast segments shall be included in the shop drawings. A bond breaking material shall be used in the form of wax only on the webs and soffit slab of the previously cast segment and a newly cast segment, as well as the end headers when required. The material shall not be injurious to the concrete and shall permit removal of a segment without adhesion of the concrete. Any breakage in segment end face during separation / handling shall not be repaired, unless specifically accepted by the Engineer, in which case repairing at end face of segment

shall be done with epoxy at the time of epoxy application.

Segments with excessive breakage shall be rejected. Decision of the Engineer shall be final binding in this regard.

11.4.4 Handling, Stacking and Erection of Segments

The Contractor shall be responsible for the proper handling, lifting, storing, transporting and erection of all segments so that they may be placed in the structure without damage. Segments should be handled carefully, without impact, in a manner that limits stresses to values compatible with the strength and age of the concrete. Location of lifting holes and inserts should be determined carefully to prevent damage of segments during handling. Only HTS bar such as Macalloy or Dywidag shall be used for lifting/handling of segment at any stage of construction, with due care for fatigue considerations (multiple re-use). Transportation over uneven surfaces may produce static and dynamic stresses which need to be considered, especially at an early age of a segment. Special care should be exercised during handling and transportation to protect cantilevers or projections against damage or cracking.

The Contractor shall furnish calculations to establish that the stresses induced during any stages of construction shall not exceed 50% of the cube strength achieved at that stage, nor 40% of the specified 28 days cube strength. In addition, the following limitations shall be observed:

- a) The segment shall not be lifted from the casting bed till the concrete reaches a minimum of 25MPa Cube strength.
- b) The age of the concrete shall not be less than 14 days at the time of its erection provided it has achieved its specified 28-day strength.

Segments shall be maintained in an upright position at all times and shall be stored, lifted and/or moved in a manner to prevent torsion and differential deformation other undue stress. Stacking yard should be properly prepared to prevent any settlement under the segments. Members shall be lifted, hoisted or stored with lifting devices approved on the shop drawings. Stacking should be limited to 2-Levels to avoid excessive direct or eccentric forces.

Segment shall be stacked with three-point support in curing tank / stacking yard, or as approved by the Client. Curing shall be done using sprinkler system and it has to be ensured that all parts of segment are water cured during water curing period.

11.4.5 Cleaning, transportation and erection of Segments

A. Before transportation of segment, mating surface shall be cleaned by water rinsing and sand blasting as approved by the Engineer. When sand blasting is employed, surface shall be abraded to an extent that:

- Bond breaker such as wax applied during match casting is removed.
- Laitance is removed so that small aggregates are just exposed.
- Cleaned surface is neither polished nor excessively rough.

B. Transportation of Precast Segments from Stack Yard to the Erection Site:

Before the segments are transported to the erection site, it is important to verify that all quality control documents are properly completed, and that the segment has been accepted for incorporation in the bridge. As a minimum, the segment should be checked for the following:

- 1) Adequate Concrete strength is achieved as per the design requirements/approved drawings.
- 2) Specified curing duration is met.
- 3) All the patching and repairs are completed and accepted by the quality control inspectors.
- 4) All permanent and temporary post-tensioning ducts are checked for obstructions, correct layout, and placement.
- 5) All inserts are checked for correct placement.
- 6) Proper identification and orientation of the segment.

- 7) The segment match cast face has been pressure washed or sandblasted as specified above.

The Contractor shall submit to the Engineer-In-charge for approval of the precast segment/girder transportation plan identifying the loading and transportation procedures, including, but not limited to, the proposed route, schedule and traffic control procedures.

The Contractor shall be responsible for the design, supply, installation and removal of temporary bracing for girders as may be required during the Contractor's handling and transportation of the precast segment/girders. Should the Contractor choose to transport the precast segment/girders to a temporary storage location, he shall be responsible for additional loading, transporting, unloading and storage procedures. The submission of design calculations and Shop Drawings for the temporary bracing to the Engineer shall in no way relieve the Contractor of the full responsibility for the success or failure of the design.

In all traffic control situations, the flagman/traffic marshal must be trained and properly attired in flagman's vest and approved headgear with approved flagman's stop/slow paddle or fluorescent red flag. **No additional payment is to be made for Traffic Marshal/Flagman involved in the segment transportation.**

When transporting bridge girders, the Contractor shall be responsible for ensuring the following:

- Pilot vehicles to accompany the transporting vehicle/hauler.
- All of the required permits have been acquired and the conditions of all permits are met.
- Extreme care shall be exercised during the handling and transportation of the precast girders to avoid twisting, cracking or other distortion that may result in damage to the girder.

C. Launching:

There are broadly two ways of launching the segments. One using Underslung Launching system and the other using overhead Launching system. The former entails lesser height during construction and is comparatively slower. The later one is faster, has increased vertical clearance beneath the superstructure because of the load-carrying members are above the Viaduct slab level and hence offers better method of launching. It entails hanging of segments with wire ropes using electrically controlled pulleys mounted over the Overhead Launching Girder (LG). The Overhead Launching Girder (LG) method is preferred and suggested for implementation in this special specification. Further, Underslung Launching Girder Method may only be applied upon prior approval of the Engineer-In-Charge.

The superstructure shall be constructed by implementing sequential "span by span" construction method. The LG is to be supported either on the bridge piers, on the edge of the previously erected span and the next pier. The precast segments are to be placed and adjusted on a steel erection girder spanning from pier to pier, then post-tensioned together in one operation. The post-tensioning tendons are continuous from pier segment to pier segment.

The typical Overhead launching girder (LG) envisaged here is slightly longer than 2 spans. It must also be able to negotiate curves and accommodate for the gradients/camber if any of the structure as per the approved GAD. The launching girder should be capable of lifting the segments for the span to be erected from ground level and in case required, it should also be capable of feeding the segments from the rear end over the already erected span.

A suitable number of separate set of launching girders are essential in order to proceed at the contemplated pace for completion of project in time. However, Contractor shall furnish the construction scheme and nos. of launching girders, he proposes to deploy in order to ensure completion of project within scheduled time.

The Contractor shall submit the design notes & calculations, shop drawings and detailed method statement of precast segment/girder erection plan, proof checked by third party, for the approval of the Engineer-In-Charge which shall include but not necessarily be limited to the following:

- a) Type and capacity of equipment
- b) Sequence of operation, including position of cranes, trailers with girders, and traffic accommodation for all stages of unloading and erection.
- c) Risk, Safety and Hazard Plan
- d) Technical specification of LG including weight of LG, Length of LG, maximum working span, maximum working gradient, minimum working radius of curvature etc.
- e) Method of Erection of Launching girder.
- f) Method of Erection of First span.
- g) Method of Auto-Launching.
- h) Method of Disassembly/Dismantling of LG.

It is emphasized that for precast segmental construction only one-end pre-stressing shall be used.

11.5 DELETED

11.6 DEFLECTION AND CAMBER DATA

The Contractor shall submit deflection and/or camber data for each stage of construction as required to construct the structure to its final grade. The procedure used shall account for the effect of the time- dependent prestress losses and creep which will occur during the construction phase. The Contractor shall prepare and implement a camber control plan and submit the same as a part of Technical Design Submission to the Engineer for approval. The data for the entire bridge, based on the Contractor's proposed erection sequence, method and schedule, shall be submitted to the Engineer for review prior to commencing construction.

The camber of the structure will be monitored by the Contractor at each stage and corrective actions as approved by the Engineer shall be performed by the Contractor to assure proper erection of the structure to its final grade.

The camber control plan shall include, but not limited to, the following information:

- a. Camber calculation method (in consultation with the Engineer), and
- b. Calculated and actual camber (differential deformation between End-span and Mid-span) of each girder at each stage, such as:
 - at transfer of prestress;
 - after installation/construction of accessories;
 - at handover to the track contractor (at milestones);
 - at the Static Inspection (or at the Time of Completion); and
 - at any stage which the Engineer may require.

11.7 MISCELLANEOUS

The entire construction work shall be geared towards minimizing disruptions to road traffic. Also, the occupation of roads during all construction activities shall be reduced to a minimum and subject to the approval of the Engineer. Reinforcement shall be fabricated in cages in casting yard for piles, pile caps and piers before being brought into position for expediting the activities.

All elements of sub-structure below bearing pedestals viz piles, pile caps, piers and pier caps shall each be cast in single pour.

11.8 LOAD TESTING OF LAUNCHING GIRDER

Contractor shall conduct full scale load test of all launching girder prior to using it for execution purpose. Such tests are required to be done for all the launching girders engaged for project, even if the similar design of launching is adopted.

Nothing extra will be payable for conducting such test and the rate shall be included in respective item

Bi-RIDE

TECHNICAL SPECIFICATION S-12: ADDITIONAL SPECIFICATIONS FOR EARTHWORK IN RAILWAY FORMATION

S.12: ADDITIONAL SPECIFICATION FOR EARTHWORK IN RAILWAY FORMATION

12.1 General:

Earthwork for Metro Railway Formation (Embankment and Cutting) shall be as per RDSO's Comprehensive Guidelines and Specifications for Railway Formation, Specification No. RDSO/2020/GE: IRS-0004 (September 2020) and latest Guidelines for Earthwork in Railway Projects with latest correction slips, as applicable for suitability of soil, construction processes, sampling, testing and acceptance. This has been summarized hereunder for general guidelines and for details, aforesaid Guidelines may be referred to.

12.2 Site Clearance:

Before work is started, the site shall be properly and effectively cleared by the contractor of all small trees (of girth upto 30 cm), roots, bushes, heavy grass etc. The Contractor shall arrange removal of rubbish and other excavated material excluding earth from the periphery of the area under site clearance. High portions of the ground shall be cut down and hollow depressions filled upto the required level with the excavated earth so as to give an even neat and tidy look. The work of this nature will be covered by the initial rate for earth work, unless stated to the contrary in the agreement.

Trees of girth over 30 cm, measured at a height of 1m above ground level, shall be considered as large trees. Cutting down of large trees shall be paid extra at the rate specified when stumps are grubbed up in addition. Large trees shall not be cut without specific orders from the Engineer. As few trees shall be cut as is absolutely necessary for the execution of work. The roots of trees and saplings shall be removed to a depth of 60 cm below ground level or 30 cm below formation level or 15 cm below subgrade level, whichever is lower. All holes or hollows formed due to removal of roots shall be filled up with earth rammed and levelled. Trees, shrubs, poles, fences, signs, monuments, pipelines, cable, etc. adjacent to the area which are not required to be disturbed during site clearance shall be properly protected by the contractor at his own cost and nothing extra shall be payable. In case any damage to the pipelines, cables, etc. is done due to negligence on part of the contractor the necessary damage charges will be recovered accordingly.

Any trees cut down or building materials released from dismantling of structures shall be stacked by the contractor within a distance of 500 metres outside the periphery of the area under site clearance as per instructions of the Engineer. The contractor shall have no claim to the trees or other material removed during site clearance and the same shall be the property of the Client.

12.3 Demarcation and Profiles:

Centreline of the alignment with a (@ 20 m c/c or so) and full construction width should be demarcated with reference pegs/dug belling. This is to be considered as part of the setting out of work, and preliminary to contractor being allowed to start the work. The cost of this is included in the initial rate for earthwork.

The contractor before starting any work, shall take charge of all benchmarks, centre line, demarcation and other field stones and reference pegs and be responsible for their subsequent preservation, and should they disappear or be destroyed after he has taken them over, he shall pay the cost of their replacement or replace them at his own level in consultation with the department.

12.4 Measurements:

Cutting and banks are to be excavated and made up neatly to the lines shown in the cross section as per approved construction drawing. No payment will be made for excess work done outside these lines except when such work is so ordered in writing by the Engineer. However, if any bulges are left in the slopes of cuttings due to practical difficulties and are permitted, deduction as per actual measurements will be

made. Similar action will be taken in case of concave surfaces in the slopes of embankments, if permitted.

Should the Engineer so desire, he may, at any stage of the work, order the Contractor to increase or reduce the slopes of any cutting or bank or alter the formation level, in which case the amount of work actually done will be paid for in accordance with the specifications and the BOQ.

In computing the quantity of earth work in cuttings and side drains, no cognizance will be taken of the additional excavation, which may be necessitated during the progress of the work due to the presence of boulders or other material, and payment will only be made for the quantity as per cross sections required to be provided.

12.5 **Payment:**

It must be clearly understood that the Contract rates are intended to cover the full cost of finished work. Banks and cuttings are to be carefully dressed to formation with such slopes as may be specified in each case. The payment for the quantity of earth work in cutting / bank shall normally be made on cross sectional measurements. The existing ground / bank profile shall be taken and plotted by the Authorised representative of the Engineer in the presence of contractor or his authorized agent before commencement of the work. The profile of the bank or the cutting required to be provided including allowance of settlement in case of embankment, shall also be plotted on the same sheets. The levels and cross sections shall be signed by both the Authorised representative of the Engineer and the contractor / his authorized agent. (The profiles of the bank or cutting as required to be provided are for the guidance of the contractor and not for the purpose of measurements).

The profiles of the finished and plotted bank/ cutting shall like-wise be taken in the presence of the contractor or his authorised agent and super-imposed on the original ground profile. These profiles are to be taken at locations as directed by the Engineer, at least at 15m intervals on straight and at least at every 10m on Curves with radii sharper than 600m and at extra locations in special cases such as irregular or side long ground etc.. The gross volume of earth work shall be calculated from the original and finished profile of the bank/ cutting.

12.6 **Suitability of Sub-Soil:**

Field tests are required to be conducted on sub-soil strata, i.e. Plate load test for determination of Elastic Modulus in second cycle of loading (Ev2), Standard Penetration test to determine N-value, and Unconfined Compression Test or Vane Shear Test to determine unconfined compressive strength or undrained cohesion, cu. If any of these parameters, as specified in following para do not meet with specified requirement then ground improvement or removal/replacement of weak sub-soil needs to be undertaken.

Sub-Soil needs to conform to the following specification:

- (i) Ev2 value (PLT) \geq 20MPa, or
- (ii) Undrained cohesion of soil (C_u) \geq 25 kPa, only for soils having particles finer than 75 microns exceeding 12%, or
- (iii) N-value (SPT) < 5 ,

12.7 **Earth Work in Embankments:**

- i) **Formation Width:** The formation widths are to be as shown in the drawings.
- ii) **Side Slopes:** The side slopes will ordinarily be 2:1 or as specified in the drawing. The side slopes shall be carried up simultaneously with the rest of the work and not filled in afterwards.

This can only be ensured by insisting on the whole width of embankment from the toes of the slope coming up simultaneously.

- iii) **Dressing of earthwork:** After completion of earth work the slopes shall be neatly dressed to the correct profiles, and shall be made up where required during the maintenance period. The top should be neatly dressed off sloping at an inclination of 1 in 30 either side from the centre line unless otherwise specified in the drawings.

- iv) **Selection of Earth:** The disturbed / undisturbed soil samples along with the test results as per specifications will be submitted by the contractor for approval of the source from where the earth is proposed to be borrowed before the Earth work in embankment is started or in case of change in location of the source.
- v) **Specification of Subgrade:** The specifications prepared subgrade, subgrade should conform to the Soil Quality Class SQ1/SQ2/SQ3 as specified in the RDSO's Comprehensive Guidelines and Specifications for Railway Formation (RDSO/2020/GE: IRS-0004, September- 2020) and Latest Guidelines.

12.8 Blanketing:

The specification and work of blanketing material should conform to the specifications provided in RDSO's Comprehensive Guidelines and Specifications for Railway Formation (RDSO/2020/GE: IRS- 0004, September- 2020) and Latest Guidelines. Normally, the blanket material shall be produced mechanically by crushing the stones and/or by mixing, naturally available materials using suitable equipment/plants like pugmill, wet mix plant, crusher etc. as specified in the Appendix-A of RDSO's Comprehensive Guidelines and Specifications for Railway Formation (RDSO/2020/GE: IRS-0004, September- 2020) and Latest Guidelines. No extra payment shall be made in case of mechanical production of blanket material. However, if naturally available material conforms to the specifications, the same can also be used.

The parent material of the blanket material so chosen should be chemically inactive and sturdy in normal working environment. Brickbats, factory slag, weak dissolvable stones like lime, shale, laterite etc. need not be selected as blanket material.

The contractor should submit for approval by the Engineer samples of the Blanketing material. The material to be used by the contractor for blanketing should strictly adhere to the quality of material as approved by the Engineer.

12.9 Mechanical Compaction:

- i) The spreading of material in layers of 200 to 300 mm thickness over the entire width of embankment should be done by mechanical means and finished by a motor grader. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the slope and grade.
- ii) Compaction to specified levels of RD or percentage of MDD shall be carried out through a number of passes of vibratory rollers of 100-120 kN static weight or of equivalent capacity as approved by the Engineer. A combination of vibrating rolling initially, and static finishing rolling may be established through trials. Speed of roller shall not exceed 5 km/hr. However, the Contractor should get the Engineer's approval for the type of equipment to be deployed for compaction.
- iii) Density of soil will increase with the number of passes of roller but after optimum number of passes, further increase in density is insignificant for additional number of passes. For determination of optimum number of passes for given type or roller and optimum thickness of layer at a predetermined moisture content, a field trial for compaction is necessary which will be arranged by the Engineer for which the Contractor shall make all arrangements and bear the cost of test / tests as required.
- iv) If natural moisture content (NMC) of the soil is less than the OMC, calculated amount of water based on the difference between OMC and NMC and quantity of earthwork being done at a time, should be added with sprinkler attached to water tanker and mixed with soil by motor grader or by other means for obtaining uniform moisture content. When soil is too wet, it is required to be dried by aeration to reduce moisture content near to OMC. Efforts should be made to keep moisture content level of the soil in the range of OMC + 2% at the time of compaction.
- v) Fill shall be placed and compacted in layers of specified thickness. The rate of progress should be, as far as possible, uniform so that the work is completed to final level almost at the same time.

- vi) The rolling for compaction of fill material should commence from edges towards center with minimum overlap of 200mm between each run of the roller. In final pass, roller should simply move over the surface without vibration so that top surface is properly finished.
- vii) Extra bank width of 500mm on either side shall be rolled to ensure proper compaction at the edges. The extra soil would be cut and dressed to avoid any loose earth at the slopes. This should preferably be done with help of grade cutter. The earth so cut in final stages will not be paid but can be used at other places by the contractor.
- viii) At the end of the working day, fill material should not be left uncompacted. Care should be taken during rolling to provide suitable slope on toe of the bank to facilitate quick shedding of water and avoid ponding on formation.
- ix) Top of the formation should be finished to cross slope of 1 in 30 from one end to other towards cess / drain in multiple lines and from center of formation to both sides in single line or as indicated in the drawing.

12.10 Quality Control of Earthwork

Quality of execution of formation earthwork shall be controlled through exercise of checks on the fill material, blanket material, compaction process, drainage system, longitudinal & cross-sectional profiles of the finished embankment. The details of quality control procedure are as follows:

12.10.1 Suitability tests at source of Embankment fill/prepared subgrade/Blanket Material: Fill/Blanket material proposed to be used would have to be assessed for its suitability, as stipulated in this specification, after conducting soil classification and other relevant tests as per site requirement. Once the material has been found fit for use as fill material for Embankment, further lab tests, to assess OMC, MDD/ Relative Density, need to be conducted. The type and frequency of tests to be conducted will be as per table 7.2 of RDSO's Comprehensive Guidelines and Specifications for Railway Formation (RDSO/2020/GE: IRS-0004, September- 2020) and Latest Guidelines.

12.10.2 Quality Control Checks on Finished Earthwork

12.10.2.1 Compacted Earth: Degree of compaction of each layer of compacted soil/blanket should be ascertained by measurement of dry density/Relative Density of soil at locations selected in specified pattern. The method of sampling and method of tests to be conducted to be adopted are as stipulated in the RDSO's Comprehensive Guidelines and Specifications for Railway Formation (RDSO/2020/GE: IRS-0004, September- 2020) and Latest Guidelines unless otherwise approved by the engineer.

- a) **Frequency of Tests:** Density check would be done for every layer of compacted fill/blanket material as per following minimum frequency:
 - i. At least one density checks for every 30 m length for blanket layers and top one metre of prepared subgrade/subgrade along the alignment in a staggered pattern of each compacted layer.
 - ii. At least one density check for layers other than as specified in (i) above, every 500 m² or 75 m c/c whichever occurs earlier along the alignment in a staggered pattern of each compacted layer.

12.10.2.2 Acceptance Criteria

- i) The blanket material, which contains fines passing 75 micron IS Sieve, upto 5 percent should have the Density Index (Relative Density) a minimum of 70% as obtained in accordance with IS: 2720 (Part 14) – 1983(Reaffirmed 2015).
- ii) For other materials, field dry density should not be less than maximum attainable dry density obtained in field compaction trial. However, in field compaction trial, the maximum attainable dry density should not be less than 98% of MDD values as obtained by Heavy Compaction Test (IS: 2720 (part 8) – 1983) in the laboratory. In case, there are difficulties in achieving 98% of the MDD values as obtained by Laboratory test, in the field trials, the same may be relaxed upto 95% of MDD with the specific approval of Engineer, recording reasons of such relaxation.

- 12.10.2.3 Deformation Modulus (Ev2) measurement:** It is a parameter expressing the deformation characteristics of a soil. It is calculated taking values from the load settlement curve obtained from the second cycle of loading in the Plate Load Test. It is to be determined in the field on top of each formation layer i.e. at top of compacted Blanket layer/Prepared sub-grade/Subgrade- Top & Lower layer.
- 12.11 Formation Level:** Finished top of sub-grade level may have variation from design level by + 25 mm and finished top of blanket layer may also be permitted to have variation from design level by plus 25mm.
- 12.12 Cross Slope:** Cross slope should be within 1 in 28 to 1 in 30.
- 12.13 Side Slopes:** Side slope should be 2H: 1V or flatter as per design.
- 12.14 Formation Width:** Formation width should not be less than the specified width.
- 12.15 Quality Control Records:** At least, following records of quality control as per proforma approved by the Engineer-In-Charge needs to be maintained.
- a) Characteristics of fill/sub-grade materials.
 - b) Quality of blanket materials.
 - c) Field compaction trial computation sheet details.
 - d) Quality of compaction of earthwork including blanket material.
 - e) Quality of material and its compaction for backfill behind bridge.
 - f) Details of machineries engaged in execution of earth work including its output.

**TECHNICAL SPECIFICATION
S-13: ADDITIONAL SPECIFICATION
FOR
FABRICATION & ERECTION OF OPEN
WEB GIRDER**

S.13: ADDITIONAL SPECIFICATION FOR FABRICATION & ERECTION OF OPEN WEB GIRDER

13.1 General:

This chapter covers the supply of material, fabrication, assembly and erection of Open Web Girder (OWG) and bearings. The following are the brief specifications and general guidelines for fabricating and erecting the girders but not limited to and shall be read in conjunction with Indian Railway Specification for Fabrication and Erection of Steel Girder Bridges and Locomotive Turn-Tables (Serial No B1-2001).

High Strength Friction Grip Bolts (HSFGB) shall be used as per drawings.

Protection screen is to be provided portion as per RDSO Drawing No. RDSO/ETI/0068 (latest version).

All workshop fabrication shall be done using Automatic SAW (Submerged Arc Welding) process only. All welding, other than workshop welding, shall be done through Gas Shielded FCAW (Flux Core Arc Welding) process only. SMAW (Shielded Metal Arc Welding) also known as Manual Metal Arc Welding shall NOT be permitted anywhere in the structure. FCAW wire to be used shall be Flux Core Tubular consumable electrode to generate flux gas in addition to gas cover of CO₂, Argon or /CO 2- Argon mixture only. In FCAW process, wind screen and /or enclosures shall be providing around the welding location to prevent shielding gas from blown out. Welding shall be performed on prepared metal surfaces free from rust, dust, moisture etc. And before every new pass, slag must be carefully chipped off from weld surface. Radiography test shall be conducted to ensure weld quality. Method of launching shall be approved by Indian Railways for which no extra payment will be made to the Contractor.

13.2 Site Inspection:

Tenderers are requested to inspect the site and carry out careful examination to satisfy them as to the nature of work involved and facilities available at the site. They should note carefully all the existing structures and those under construction through other agencies. They should also study the suitability of utilizing the different equipments and the machinery that they intend to use for the execution of the work. The tenderers should also select suitable sites for the purpose of locating their store yard, laboratory, staff quarters etc., and satisfy themselves with regard to the feasibility of transporting the plate girders from the yard to the final site of placement etc.

13.3 Materials:

Steel (Plates and Rolled sections) should conform to IS: 2062-2011. It shall have Sub quality 'B0' & Grade E250 (Fe410) or E350 (Fe 490) as mentioned in the tender schedule/drawing and the requirements of IRS B1-2001 shall be fulfilled for all components for all spans.

Material supplied by the manufacturers shall be ultrasonically tested as per codal provisions at the manufacturer's premises before dispatch. The contractor on receipt of supply in his factory premises/fabrication workshop may have to carry out random USFD testing as per standards laid down in various codes and verify them with the list received from manufacturers, if instructed by the inspection agency/ Site Engineer. Only tested steel shall be used for fabrication. The steel shall comply in all respects with the requirements of approved drawings and relevant codes and specifications, and it may be noted that quality of steel used for fabrication shall be the essence of the contract & shall be rigidly followed.

Structural Steel shall be procured as per specification mentioned in BIS's documents – IS: 2062- 2011. Independent tests shall be conducted, wherever required, to ensure that the materials procured conform to the Specifications. These steel shall be procured only from manufacturer's in the approved vendor's list of The Client.

13.4 Test Certificates & Testing:

All materials for the work shall pass Mechanical test, Charpy test, Chemical Analysis, etc. prescribed by the relevant IS specifications or such other equivalent specifications. For all materials including HSFG bolts, the contractor shall furnish copies of test certificates from the manufacturers including proof sheets, mill test certificates, etc. showing that the materials have been tested in accordance with the requirements of various specifications and codal provisions. If any further testing of materials is required by Engineer in respect of these and other items, it shall be arranged for by the contractor at approved laboratory/NABL accredited Laboratory as approved by Engineer. For this, nothing extra shall be payable and accepted rates in the schedule of items shall be deemed to include this.

Even satisfactory outcome of such tests or analysis shall in no way limit, dilute or interfere with the absolute right of the Engineer to reject the whole or part of such materials supplied, which in the judgement of the inspecting authority does not comply with the conditions of the contract. The decision of the Engineer in this regard shall be final, binding and conclusive for all purposes.

The test shall be carried out by the Contractor, for which Contractor shall provide all facilities including supply of labour and plant. Engineer may at his/her discretion direct the Contractor to despatch such tests pieces as he/she may require to the National Test House or elsewhere as he/she may think fit for such testing purposes. The Engineer may at his/her discretion, check test results obtained at Contractor's work by independent tests at NABL accredited Laboratory.

13.5 Packing:

All projecting plates or bars shall be kept in shape by timber or angle bars spiked or bolted to them and the ends of chord lengths, end posts etc at their shipping joints shall be protected and stiffened so as to prevent damage or distortion in transit as the Engineer may direct. All threaded ends and machined surfaces are to be efficiently protected against damage in transit. The parts shall be transported in convenient lengths. All straight bars and plates except small pieces are to be transported in convenient bundles temporarily riveted or bolted together or bound with wrought iron or suitable wire as the Engineer may direct. All bolts, nuts, washers, plates under 300mm square and small articles generally are to be packed separately for each span. HSFG & other temporary Bolts of different sizes shall be separately packed in bags, each bag having a label indicating its contents. A list of contents shall be placed on top of each case or cask.

13.6 Fabrication:

13.6.1 General:

The fabrication of the girder and its accessories shall be carried out by the contractor in a workshop which is in the approved vendor list of RDSO for 'Steel Bridge Girder' or in a site workshop duly approved by RDSO. The workshop staff shall have requisite experience, proven skill and experience in the technique of fabricating large components. Accuracy of fabrication shall be realized through controlled high precision jigs, fixtures and templates, which shall be inspected and passed by Engineer specifically approved in prior by Engineer-In-Charge. The fabrication shall be preceded by Quality Assurance plans to be submitted by the contractor and every activity shall be documented in detail. The Quality Assurance Plans shall clearly indicate how individual processes such as cutting of raw steel, making, drilling, assembly bolting, welding, painting, handling etc. shall be monitored for quality.

The quality parameters for monitoring shall be identified. These identified quality parameters shall also be specified in these quality plans. The contractor shall get these quality plans approved from Engineer before start of fabrication work. The Engineer shall be empowered to check the manufacturing process from time to time to ensure that the work is executed as per approved quality plans. The quality records shall be submitted to Engineer for record, after completion of fabrication work. The works of fabrication in contractor's fabrication shop will at all times be open for inspection by Engineer / agency as nominated by Engineer. Before dispatch of fabricated steel work from the shops, the same will be inspected in the contractor's fabrication workshop by Engineer who will thereafter issue inspection certificate. Any defect noticed during inspection in the execution of work shall be rectified or replaced by the contractor at his own cost. The decision of Engineer or any other agency nominated for inspection as to be rectified or replaced, shall be final and conclusive.

13.6.2 Fabrication Drawings:

The contractor shall prepare detailed shop drawings including drawing office dispatch lists on the basis of design drawings approved by Engineer in such size and in such details as may be specified by Engineer. The shop drawings shall be submitted to Engineer in triplicate. No work of fabrication will be started without such approval being obtained. Contractor has to arrange the proof checking of the working fabrication drawings from the nominated Institution / Consultant. The cost of the same will be borne by the contractor. Nomination of the Institution/Consultant for proof checking works will be decided by the Client. Engineer will make all efforts to approve the drawings submitted by the contractor within reasonable time but no claim from contractor for any delay on this account shall be entertained by Engineer. For Engineer's use and record, the contractor shall supply free of charge, four sets of prints on string paper and one set of neatly executed tracings of all approved detailed drawings and fabrication drawings, soon after communication of approval for use at site.

13.6.6 Maintenance of records by Fabricators:

During fabrication as per approved QAP, stage wise records to be maintained by the fabricator which can ascertain the approved raw material and consumables, approved welding consumables, approved welders, approved set of jigs are being used. The Engineer or his nominated agency shall check all such records and necessary sign/certification should be done during fabrication at regular intervals. On completion of the work, fabricator should handover the original copy of such record to the Engineer.

The records of fabrication shall be maintained by the fabricator in the registers such as Jigs register, HSFG bolt checking register, Material offering and inspection register, RDSO / Inspecting Agency inspection notes and compliance register, Welding procedure data register, Radiographic inspection register and Statement of material test certificates, etc. The formats are given in Appendix I of IRS B1 – 2001. Inspections will be carried out by the agency/official nominated by The Client .

13.6.4 Tolerance in Fabrication:

Fabrication tolerance shall be as stipulated in Appendix II of IRS–B1– 2001. All members of the girder and joints are to be either welded or bolted as shown in the approved structural drawings. No welding except where approved by the Engineer is to be carried out at site. All welding and bolting are to be carried out as per relevant IRS Specifications.

13.6.5 Method of fabrication:

The Contractor shall submit the detailed method statement of fabrication, conforming to IRS: B1-2001 (with up-to-date correction slip) unless otherwise specified in these specification, for the approval of Engineer-In-Charge. The method statement of fabrication shall consist of but not limited to Flattening and Straightening, Planning and Shearing, Flame/CNC Plasma Cutting, Drilling and Sub-punching,

Tack Assembly, Temporary Bolts, Nuts & Washers, Welding operation, Sequence of welding and welding pass, **Welding Procedure Specification Sheet (WPSS)**, **Welding Procedure Qualification Records (WPQR)**, and Painting operation. No work of fabrication shall be started without such approval being obtained.

13.6.6 **Shear Studs/Shear Connectors:**

Shear Studs/Connectors specifications, Testing & Installations shall conform to Guidelines for Composite Construction Including Stud Shear Connectors Report No BS-115 (Revision 1) April 2016, unless otherwise specified in this specification.

The rate shall include the cost of material, labour, equipment's, tools and plants, etc. complete required for all operations described above. **The rate for Shear Stud/Connector is included in the respective item for girder fabrication, so no separate payment for this item will be made.**

13.6.7 **HSFG Bolts:**

HSFG bolts specifications, Testing & Installation shall conform to Guidelines for use of High Strength Friction Grip (HSFG) bolts on bridges on Indian Railways Report no BS-111 (Revision 5), unless otherwise specified in this specification. Contractor has to provide DTI washer in case HSFG bolts is specified to be used in the approved drawing.

The rate shall include the cost of material, labour, equipment's, tools and plants, etc. complete required for all operations described above. **The rate for HSFG Bolts is included in the respective item for girder fabrication, so no separate payment for this item will be made.**

13.6.8 **Camber:**

When supported on blocks or staging, the girders shall be erected to the camber specified in the fabrication drawings according to which the girders have been manufactured.

Camber shall be checked while the girder is supported on the nodal points on camber jacks and after releasing jacks i.e. for residual camber with girder resting on bearing ends. The camber measurements should be done with appropriate levelling instrument.

Frequent checks shall be made of the camber of girders during erection and care taken to see that the camber as per drawing is obtained when the girder is completely assembled. When span is supported on ends and intermediate supports are removed the dead load camber shall be recorded and entered in bridge register. This will provide the reference to compare the camber checked during technical inspection to ascertain the loss of camber.

13.6.9 **Care during Assembly at Workshop:**

All components shall be offered for inspection prior to painting. All approved components shall be stamped defect free, painted as per specifications prior to dispatch to bridge site. On final finishing of each component, it shall be marked distinctly with paint with shipping mark for guidance, during assembly of component.

The appearance test and test to check the fixing of shear studs shall be as per IRS BS-115.

13.6.10 **Trial Assembly:**

The contractor is required to undertake test assembly of the girders, before painting, in his fabrication workshop to prove accuracy of templates and Jigs. This assembly can be done in horizontal position. The test assembly shall be certified by the Inspecting agency of the Engineer. **Every span is to be temporarily erected complete in Fabricator's workshop for Engineer's Inspection before dispatch and all parts as marked to their place.** Any defect noticed during inspection in the execution of

work shall be rectified or replaced by the contractor at his own cost. The decision of Engineer or any other agency nominated for inspection as to be rectified or replaced, shall be final and conclusive.

13.6.11 Painting:

Specification for surface preparation, metalizing and painting shall be done as per Clause no. 39.2.1 of Indian Railway Specification for Fabrication and Erection of Steel Girder Bridges and Locomotive Turn- Tables (Serial No B1-2001). All approved components shall be stamped defect free, painted as per specifications prior to dispatch to bridge site. On final finishing of each component, it shall be marked distinctly with paint with shipping mark for guidance, during assembly of component.

13.6.11.1 Paints: Source & Quality:

Paint and other accessories including those for metallising work will be supplied by the contractor from the manufacturer's in the approved list of RDSO and final approval by the Engineer. The contractor shall furnish to the Engineer, the date of manufacture of paint as certified by the manufacturers with the necessary container marking and test certificate for paint conforming to relevant IS code. In addition to this, he shall also submit the necessary vouchers in respect of paint purchased by him. The Engineer reserves the right to get the paint tested at contractor's expenses as considered necessary by the Engineer. If the test results do not conform to relevant IS specifications fully, then the lot of paint shall be rejected and got removed from the contractor(s) storage. If the paint has already been applied it shall be removed.

In addition to above, the following tests are required to be carried out in the field.

- Weight per litre
- Consistency test - Scratch test.
- Flexibility and adhesive test.

The Engineer reserves the right to reject the lot of paint even on the basis of field results.

13.7 Transports from Workshop & Stacking at Site:

All items fabricated in the workshop shall be marked and packaged with accompanying package list. The items after fabrication shall be transported by contractor to site by Rail/Road in a manner as to cause no damage to the components. Contractor shall be liable for all losses and damages in transit for the materials consigned by him till materials are erected and work completed and taken over by the Engineer. Insurance against loss or damage in transit, if any, shall be the responsibility of the contractor.

After identification & correct marking, all components of each girder shall be dismantled & similar components shall be grouped together & labelled; bolts and plates of each size shall be packed separately, after approval by the Engineer. The packages shall be of such size by length & weight that they are safely transportable by Rail/Road. The components shall be provided with necessary packing to avoid damage to painting & members in transit. Dimensions for transport shall be as per standard schedules.

13.8 ASSEMBLY & ERECTION:

13.8.1 General:

The contractor shall provide at his own cost all tools, machinery, equipment and erection material, including all temporary works and shall assemble all components in every respect as stipulated in the contract and in accordance with approved drawings and specifications.

Before starting the work the contractor shall seek the Engineer's approval as to the method he proposes to follow and the type and suitability of equipment he proposes to use for assembly of girder components and launching of girder. The approval of the Engineer shall however not in any way relieve the

contractor of the responsibility for the adequacy and safety of methods and/or equipment's he proposes to use for carrying out work in full accordance with drawings and specifications.

All temporary work shall be properly designed and substantially constructed for the loads, which it will be called upon to support. Adequate allowance and provision of lateral forces and wind loads shall be made according to local conditions and ensure that support shall not settle during erection. Temporary bracing shall be provided to take care of stresses caused by erection equipment or other incidental loads during erection. The method used for lifting and slinging flexible members shall be brought to the notice of the Engineer and shall be subject to his approval. The contractor shall observe sufficient accuracy in the assembly of every part of the work to ensure that all parts fit accurately together.

13.8.2 **Assembly at site:**

Cleaning of permanent contact surfaces: - Surfaces which will have permanent contact shall be removed of paints and mill scale down to bare metal, clean and dried and immediately a coating of zinc chrome red oxide priming to IS:2074 shall be applied. Care shall be taken to see that all burrs are removed, and no surface defects exist before the parts are assembled. They shall be painted immediately before assembly with one coat of suitable primer and raw linseed oil freshly ground and the surface prepared for painting as per painting specification at Clause 2.5.38.

Reaming: - No reaming shall be undertaken without the written authority of Engineer or his authorized representative except for under drilled holes meant for turned bolts. The contractor shall supply special bolts to fill reamed hole, where reaming is approved. Record of all such variations shall be kept. However, these provisions should not apply for under drilled holes meant for turned bolts. Copies of all correspondence pertaining to the recourse of reaming and the use of oversize bolts shall be sent by the contractor for information to Engineer.

13.8.3 **Requirement of Traffic blocks/OHE Power Blocks for works adjacent to Live Railways:**

- i. The contractor shall obtain Power / Traffic / Shut down in the name of authorized representative of The Client. BI-RIDE/Engineer will facilitate to make arrangements to obtain power blocks / shutdown (hereinafter referred to as blocks) for works to be carried out along or adjacent to the track work. Works such as foundations of abutments/piers shall generally be done without blocks. However, if block is required due to safety considerations, the construction shall be done under block. The requirement of shut down, power blocks etc. shall be assessed by the contractor and will be submitted to the Engineer/Engineer's representative. All the erection of girders etc. shall be done under minimum power block/shut down.
- ii. The Contractor shall confirm that he will equip himself to carry out all construction during night blocks efficiently by suitable special lighting equipment without any extra cost.
- iii. Block period shall be counted from the time the TR-line is placed at the Contractors disposal at the work-spot till it is cleared by the Contractor.
- iv. **Any charges which may be levied by Indian Railway on account of "Possessions of Traffic/OHE Blocks" shall be payable by the Employer.** However, penalties, if any, levied by Indian Railways caused due to any careless working or otherwise of violation of the Terms and Conditions of the track block, shall be payable by the contractor.
- v. The contractor shall not be entitled to any extra payment due to hindrance resulting from normal Railway operations, such as delay on account of adequate number of, and duration of blocks not being granted.
- vi. **Additional 100% (or as directed by Indian Railways) reserve/standby cranes, machineries, tools and plants shall also be made available by the contractor in advance of work, to cater for any failure/ eventualities during the launching operation. The cost of the same is included in the respective item for girder fabrication, so no separate payment for this item will be made.**
- vii. **Safety Measures during Traffic/Power block:** Contractor shall conform that provision of IRPWM,

Railway Board Instructions and general instructions under Sub-Clause 37 of SHE manual related to block protection, safety precaution of work must be followed. The contractor shall abide by all Railway regulations in force for the time being and ensure that the same are followed by his representatives, Agents or sub-contractors or workmen. **Nothing extra shall be payable on this account.**

- viii. The employer shall remain indemnified by the contractor in the event of any accident occurring in the normal course of work, arising out of the failure of contractor or his men to exercise reasonable precaution at all places of work.

13.8.4 Erection of Open Web Girder Span:

13.8.4.1 General:

Once sufficient number of girders are assembled and the sub-structure has been certified to be ready, launching of girders shall be taken up. The launching/erection of girders shall be done as per approved drawings. For this purpose, the contractor shall submit in triplicate, detailed launching schemes of all the girders including design calculations, safety procedures and method statement with such plans, sketches and other details as may be necessary to determine the suitability and adequacy of the schemes proposed. The scheme will be checked by Engineer/Bi-RIDE. **After approval of Engineer-In-Charge, the contractor must also obtain the approval for Launching/Erection scheme by Indian Railways and any statutory clearances such as CRS sanction. The Client will only facilitate the contractor for getting the necessary approval from concerned regulatory authorities. Contractor will be responsible for getting approval of launching scheme submitted by him.** No work of Erection/Launching shall be started without such approval being obtained.

The contractor shall provide full structural details of the temporary members and their connections to the girder, along with necessary design calculations not only justifying member's sizes but also for the entire launching system adopted. The methods adopted shall not, under any circumstances, cause the stresses in various members of girder spans to exceed permissible and safe limits at any stage of launching. One copy duly approved by the Engineer shall be returned to the contractor.

The launching system shall be test tried, if directed by the Engineer, and no separate payment for this shall be made. Nothing extra will be paid to the contractor for adopting any scheme for launching. All temporary members shall be removed after launching and may be taken back by the contractor.

13.8.4.2 Temporary Strengthening:

The launching arrangement may include fabrication of launching nose or restraining girders, sway restraining devices such as sway ropes, restraining cables etc. the supply and fixing of members for temporary strengthening of girder members to take care of erection stresses and strains and other relevant components for satisfactory and successful completion of the defined scope of work. Erection stresses must be kept within safe and permissible limits at every stage of erection.

The contractor has to make arrangements at his own cost for the steel for temporary arrangements including fabrication of launching nose, sway restraining devices for launching and temporary strengthening of girder, as may be required for the launching operations. The rate quoted should take into account these factors as nothing extra shall be paid.

13.8.4.3 Inspection and Rectification:

During erection of girders, the contractor shall provide all facilities and permit the Engineer to inspect the field assembly, site bolting and erection of spans. After inspection by the Engineer, the contractor shall identify cause of any defect, imperfection and/or fault noticed during such inspection and initiate corrective action as per the direction of the Engineer. All defects, imperfections or faults for which the contractor is liable under the contract, shall be made good by the contractor to Engineer's satisfaction and the cost of identifying and rectifying such defects, imperfection or faults shall be borne by the contractor.

13.8.4.4 Commencement of the Erection Work at site:

The contractor shall commence the erection work when and as soon as, but not until, he receives instructions from Engineer to do so. On such order being given, possession of site/authority shall be given to the contractor of such portion or portions of the site as the Engineer may determine.

13.8.4.5 Contractor's Liability:

Any fitting, accessory or apparatus which may not have been mentioned in this specification or the drawings, but which are usual or necessary in the execution of such work, are to be provided by the Contractor without extra payment. The whole work must be completed in all details, whether mentioned in this specification or not, with the exception of such work as has been specified in the schedule of items to be separately provided for in the Contract.

Notwithstanding the specifications and conditions stated in the contract, the contractor shall keep the Engineer/ Employer authority fully indemnified and free from all liabilities and risks consequential to any lapse on his part in respect of material quality, standard of workmanship, accuracy of fabrication and the like. He shall provide all labour and material required for execution of the work as per all standards and specifications.

13.9 Quality Assurance:**13.9.1 Quality Assurance Plan (QAP):**

The Contractor has to submit the Quality Assurance Plan (QAP), in line with **Standard QAP for the Open Web Girder (OWG)** as per Annexure-I of RDSO's BS-125, for the scrutiny and approval of the Engineer-In-Charge. The contractor should ensure that work is carried out strictly as per the approved QAP and no deviation takes place from QAP.

13.9.2 Raw Material:

Passing of raw material is done on the basis of visual inspection and lab test, as per approved QAP, for mechanical properties, chemical composition, ultrasonic examination, Charpy Impact Test, lab test report etc. HSFG Bolts, Shear Studs and other consumables like paint, welding rods etc. should also be got tested from NABL Lab as per relevant codes/specification.

All the required test should be got done through independent NABL Labs and compared with the mill test results given by the supplier before passing the material for use. Material test certificate register must be maintained by fabricator as per Annexure available in IRS: B1-2001(appendix-I, Performa-7) and signed by Inspecting agency/Engineer as well as fabricator.

In addition to above visual inspection shall be done to ensure that steel is free from surface defects like pitting, laminations, imperfect edges, twist, other harmful defects etc. and recorded in the register.

13.9.3 Inspection of Open Web Girders (OWG):

The standard stages of inspection for Open Web Girders (OWG) is detailed below:

(I)	Prefabrication stage :	Inspection/ Approval
	(1) Approval of Quality Assurance Plan (QAP)	Engineer/Bi-RIDE
	(2) Scrutiny of Welding Procedure Specifications Sheets (WPSS)	Engineer/Bi-RIDE
	(3) Welders Qualification Test i.e. Welding Procedure Qualification Records (WPQR)	Engineer/Bi-RIDE

	(4) Inspection and clearance of raw material	Engineer/Bi-RIDE
	(5) Inspection of layout on template floor (Nominal Camber)	Engineer/Bi-RIDE
	(6) Inspection of jigs and fixtures with master plates	Engineer/Bi-RIDE
(II)	During Fabrication :	
	(1) Use of approved raw material	Engineer/Bi-RIDE
	(2) Use of approved welding consumables	Engineer/Bi-RIDE
	(3) Use of approved welders	Engineer/Bi-RIDE
	(4) Use of approved welding procedures and parameters (WPDS) Welding Procedure Data Sheet to be maintained for all welds.	Engineer/Bi-RIDE
	(5) Fabrication with approved set of jigs	Engineer/Bi-RIDE
(III)	After Fabrication :	
	(1) Inspection of welds	Engineer/Bi-RIDE
	(2) Structural and dimensional inspection	Engineer/Bi-RIDE
	(3) Trial assembly (First Girder)- Camber Values, Dimensions, Fairness of Holes by Go-No-Go Gauge, Butting of Flange in Top Chord.	Engineer/Bi-RIDE
	(4) Inspection of Dismantled Components of 1 st Trial Assembly – Check for elongation of Holes/Abnormal stress marks/cuts etc. & Removal of shortcomings noted during Trial Assembly.	Engineer/Bi-RIDE
	(5) Inspect of only components for further spans- welding inspection & Dimensional checks.	Engineer/Bi-RIDE
	(6) Metalizing/ Painting	Engineer/Bi-RIDE

Note: The Contractor has to arrange all the facilities viz. transportation, lodging, assisting inspection etc. for the Engineer/Bi-RIDE to carry-out the inspections during all the stages mentioned above at his own cost. Nothing extra shall be payable regarding this.

13.10 Measurement for Payment:

For the purpose of payment, quoted rates apply to the weights of structural steel work calculated from final working drawings based on theoretical weights as specified on the approved drawings, no deductions being made for skew cuts, holes or notches. Each gusset shall be measured as equivalent to the dimension of the smallest enclosing rectangle. The rates items quoted by the tenderer shall include all wastage. The wastage of steel in the form of skew cuts etc shall be the property of the contractor.

The payment for steel work as per item in the schedule of items shall be released in stages of accepted item rates for quantities executed, as mentioned in the tender schedule. The payment after receipt of material in fabrication shop shall be made on the basis of measurements contained in the supplier's vouchers, if required, these measurements shall be further verified by the representative of Engineer in charge by measuring dimensions/sizes of the sections and multiplying the same by standard weight. Sampling for actual weight of the sections shall also be done by him as per procedure and frequency prescribed by Engineer.

No separate payment shall be made for the field bolts, nuts and service accessories for temporary works.

The cost of temporary erection and testing at the Contractor's workshop, marking, packing and delivery at the site of work is to be included in the price quoted on the tender. Rate include fabrication of all the types of battens, bracings, ties, stiffeners, packing, diaphragms, shop bolts / welding, T&F bolts, drifts, shop welds,

templates, jigs, fixtures, back up supports, accessories, transporting various components from fabrication shop to site including loading, unloading, lift and taxes complete including assembly of girders.

Rate of girder item includes assembling of temporary support for side slewing, raising of girders to the bed block level, providing sliding arrangements and slewing the girder in position and lowering of girder on bearings.

Grouting of holes with approved epoxy-based compounds in the bed block for fixing of HD bolts/anchor pins of bed plates as directed by Engineer are included in the bearing rates.

13.11 Bearing:

The detailed specification for bearing and its installation is provided in the section S.10. The bearing sets will be paid separately as per relevant item, but it includes the cost of H. D. Bolts also. (If required). Bearings shall be provided before concreting of deck slab is taken up.

Bearings shall be protected during concreting or providing holding down bolts operations. Any mortar or foreign material contaminating the bearing shall be completely removed.

13.12 Deflection Tests:

The deflection test shall be carried out as per relevant Indian standard or as specified in the specifications. Load testing will be paid separately as per relevant item.

TECHNICAL SPECIFICATION S-14: SPHERICAL BEARINGS

Bi-RIDE

S.14: SPHERICAL BEARINGS

The term “bearing” in this case refers to a spherical bearing consists of a pair of matching concave and convex steel spherical backing plates with a low friction sliding interface in between thereby permitting rotation by in-curve sliding. The bearing shall cater for translation and/or rotation of the superstructure.

14.1. Scope of Work

The scope of work will include:

- i) Rendering necessary assistance/coordinate with the manufacturer with regard to placement/fixing of said bearings. The contractor shall ensure that these bearings are installed in accordance with the specification mentioned in these documents and approved method statement, so that the bearings perform in the desired manner, in accordance with the forces/ displacements/ rotations for which these bearings have been designed.
- ii) The contractor shall liaise with the agency and will be responsible for design etc.
- iii) The contractor shall furnish adequate and proper installation details for these bearings while submitting his design and detailed Engineering Drawings.
- iv) The design criteria, specifications etc. as mentioned in tender documents are mandatory and no deviation to the same shall be permitted unless otherwise directed by the Engineer.
- v) The contractor shall supply all the bearings in suitable packed condition (for its proper transportation and storage before placement in position) at project site to be identified by the Engineer.
- vi) Scope for lifting the superstructure for future replacement of bearings shall be provided for in the design of bearing. The scheme of lifting shall be indicated on the drawing to be submitted at the time of approval.
- vii) When requested by the engineer, the Contractor shall submit test certificates from the approved, independent testing authority to show that the respective materials comply with the specified requirements, or a certificate from the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.
- viii) The bearings shall be fabricated from only new and unused materials. Reclaimed materials are not acceptable.

14.2. Design

Design of the bearing and all accessories shall be the responsibility of the Contractor and got approved from the Employer's Representative.

Design of the Spherical Bearings shall confirm to the provisions of the Employer's requirement – Design and General planning criteria of this tender document.

The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.

14.3. Material Specifications

- i. All the materials to be used in Spherical Bearings shall confirm to clause No. 4 Materials of IRC 83: Part-IV 2014.
- ii. Steel for bearing main components shall be cast steel in accordance with IS: 1030 Grade 340- 570W except for calotte which shall be only fine grain rolled steel conforming to IS:2062 Grade E 350 or above.

- iii. Equivalent or superior grades as per other national and international specification with proven performance and suitability to application requirements may also be acceptable, subject to the approval of Engineer-In-Charge.
- iv. Positive anchoring arrangement by way of Bolts passing through Bearing component and anchored to Dowels /Steel distribution plates shall be adopted for all Bearings. Bolts to be used for anchoring of the Bearings shall be of property class 8.8 or 10.9 in accordance with IS: 1367. Steel for Dowels shall be rolled steel in accordance with IS:2062 Grade E250 min. The anchor bolts and washers shall be galvanized.
- v. The corrosion protection of the exposed steel surfaces including backing, intermediate plates and welding zone etc. shall be achieved by a protective coating system in accordance with the Clause 4.10 of IRC-83-IV.
- vi. Low Friction Thermo-Plastic sliding material made of UHMWPE - Ultra high molecular weight polyethylene conforming to the provisions of IRC-83-IV, is only permitted for use as main sliding surface.
- vii. The entire curved surface of the convex steel plate mating with concave sliding surface shall be hard chromium plated only and conforming to the provisions of IRC-83-IV.
- viii. Silicone grease shall be used as lubricant for sliding surfaces. Physical and Chemical properties of silicon grease shall be as per Clause No.4.8 of IRC 83 Part-IV.
- ix. Care shall be taken to ensure that the adhesive is applied uniformly over the entire surface of the sliding material so as not to cause an uneven sliding surface that could lead to premature wear.

14.4. Manufacturing of Spherical Bearings

A. General

- i. Manufacturing of Spherical Bearings shall comply with Clause No.6 of IRC 83 Part-IV 2014.
- ii. The Contractor shall submit the Design & Fabrication drawings for the approval of Engineer at least 30 days prior to the start of bearing fabrication. This notification shall include all of the information shown on the shop drawings which are required as explained in subsequent section.
- iii. Protection Against Corrosion and Contamination: Shall conform to the provisions of Clause 6.9 of IRC-83-IV.
- iv. Manufacturing of Bearing shall be commenced only after the approval of Design and Fabrication drawings by the Engineer.
- v. **Movement indicators shall be provided for bearing with sliding assembly to facilitate routine inspection during service period.**

B. Shop Drawings

The Contractor shall submit shop drawings to the engineer for approval which shall include, but not limited to, the following information:

- i. Erection drawings, plan, elevations and complete details and sections showing all materials incorporated in the bearings.
- ii. Bearing pre-set details, if applicable.
- iii. Protective coating requirements.
- iv. A table containing maximum and minimum vertical and horizontal loads, design rotation requirements, and magnitudes and directions of movements.
- v. Bearing seat and all bearing connection and anchorage details.
- vi. Any special consideration such as earthquake requirements, uplift details, or temporary attachments.
- vii. The location of the top and bottom bearing adapter plates drawn in plan and in elevation on the deck soffit and on the support structures showing edge distances.
- viii. The bearing orientation (uni and multi directional bearings) with respect to the direction of Bridge / traffic movement.

- ix. The drawings and design calculations shall be duly signed & stamped by company seal.

C. Manufacturing Tolerances

- i. Manufacture tolerance shall conform to clause No.6 of IRC: 83 Part-IV.
- ii. All these measurements were taken using dial height gauges, vernier calliper, surface finish measurement instrument etc has to be arranged by manufacturer at the workshop.

14.5. Inspection and Acceptance Specification:

- i. Bearings shall be manufactured to high standards both in terms of material quality and workmanship. The manufacturer shall have requisite load test and NDT facilities required for process and acceptance control tests installed at his plant. The test facilities and their operation shall be open for inspection. For confirmatory tests on raw materials, tests shall be conducted at in-house facility of the manufacturer or at NABL accredited laboratory.
- ii. **Manufacturer's Internal Testing:** Shall comply with clause No. 7.3 of IRC 83-Part-IV 2014.
- iii. **Lot Classification:** Shall comply with clause No. 7.2 of IRC 83-Part-IV 2014.
- iv. **Acceptance Test by Inspecting Authority/Engineer:** Shall Comply with clause No 7.4 & 7.5 of IRC 83-Part-IV 2014. Acceptance testing shall commence with the prior submittal of testing program in form of Inspection and Test Plan (ITP) prepared by the manufacturer and approved by concerned authority, to the Engineer.
- v. **Inspection Report:** The details of the tests and inspection carried out both in house and in the presence of the Engineer shall be recorded in the standard testing formats along with their observations. These filled up formats along with the raw material test certificates, reports of the tests done in process e.g. welding (DPT), hard chromium plating (Ferroxyl Test), mating surface hardness test, ultrasonic test, S/S surface finish and Paint DPT etc. shall be compiled and submitted to the Inspecting/Acceptance Authority/Engineer as Test Reports.
- vi. **Certification:** The approving/accepting authority/Engineer after getting satisfied with the Quality of the Product manufactured shall issue Certificate of conformity of the product stating the conformity with the provisions of this Specification and clearance to the Manufacturer to effect the shipment of the Bearings to the job site.

14.6. Storage, Transportation and Handling:

A. Marking:

- a. Movement indicators shall be provided for bearing with sliding assembly to facilitate routine inspection during service period.
- b. All Bearings shall have suitable identification plates permanently affixed which shall be visible after installation, identifying the following information: -
 - i. Name of Manufacturer
 - ii. Month and Last two digits of the year in which the Bearing manufacturer(mm/yy)
 - iii. Serial Number of the Bearing
 - iv. Bearing Designation and Type
 - v. Design Performance parameters viz. Load, Movement etc.
- c. Besides this, the Bearing Top Surface shall also be marked with the following information to facilitate their correct installation at site:
 - i. Centerline Marking
 - ii. Bearing Designation and Type –
 - iii. Orientation Marking to facilitate correct placement on the Pedestal
 - iv. Direction of Major and Minor movement, as appropriate
 - v. Preset Marking, if applicable.
 - vi. -Location Number upon each support (If required)

- B. Packaging, Transport and Storage:** All the provisions of clause No.8 of IRC 83-Part-IV shall be complied.

14.7. Installation of Bearing:

- i. Install bearings in the structure as specified and shown on the drawings and directed by the bearing supplier. Installation procedure shall be subject to review and approval of the Method Statement by the engineer.
- ii. Bearing Installation Work shall be commenced only after the approval of Method Statement by the Engineer.
- iii. The manufacturer will have its technical representative present for the placement of the first few bearings unless the contractor gains confidence about the installation of the remaining Bearings.
- iv. At the instructions of the engineer, option of the manufacturer or the design engineer, the technical representative may be required to be present for the placement of any number of additional bearings.
- v. **Aspects Related to Bearing Performance and Installation:** Shall conform to the clause 9 of IRC:83-IV.
- vi. Bearings shall be set to the dimensions and offsets conforming to the requirements mentioned in the IRC:83-IV and the approved drawings.
- vii. When placed, bearings shall be dry, clean, and free from dirt, oil, grease, or other foreign substances.
- viii. They shall be adjusted as necessary to take into account the temperature at time of installation and future movements of the bridge due to temperature changes, release of false work and shortening due to prestressing.
- ix. Under no circumstances shall bearings be taken apart and reassembled on the site, except where it is an unavoidable feature, in which case the dismantling, installation and reassembly shall be under the supervision of the Manufacturer or his agent.
- x. Care shall be taken to ensure that no air pockets exist below the bearing bottom adapter plate after installation.
- xi. The bedding material i.e. High strength Non-Shrinkage Epoxy Mortar shall be capable of transmitting the applied load to the structure without damage. The cost of this epoxy mortar is included in the scope/BOQ Item and nothing extra is payable regarding this.
- xii. The bedding material thickness shall not be less than 20 mm.
- xiii. The bedding material shall extend beyond the bearing perimeter by at least 50 mm or twice the thickness of the bedding mortar; whichever is greater.
- xiv. Fall away (slope) the top surface of this bedding material extension from the bearing to prevent the collection of water around the bearing.
- xv. After installation leave bearings and their surrounding area clean. Remove temporary transit clamps at a time to be agreed upon by the supplier and the Consultant.
- xvi. Voids or hard spots after installation are not acceptable.
- xvii. Tighten threaded fixings uniformly to avoid overstressing any part of the bearing.
- xviii. Agree to the position of any temporary packing between the outer bearing plates and the structure with the Consultant.

14.8. Documentation to be Supplied with the Bearing:

The Contractor shall provide all necessary documentation for the long-term inspection, maintenance, and replacement of the bearings.

This shall include full documentation of the design, working drawings, a certificate of compliance from the supplier, third party testing certificates, welding certificates, documentation of the load tests, quality

records and as installed details, procedures for the inspection of the bearing, procedures for maintenance and a fully detailed method statement for the replacement of the bearings.

14.9. GUARANTEE

- i. The Contractor is to provide a written guarantee stating that the bearings have been fabricated such that they will perform satisfactorily within the design range of movement and under the design loads for a period of fifty years from the date of supply.
- ii. The Contractor shall indicate that they have reviewed the installation procedures and find it in accordance with the bearing recommendations.
- iii. Provide in the guarantee for the replacement (including supply and installation) of the bearing components or the bearing as a whole at no cost to the Owner in the event that the bearings do not perform satisfactorily within the design range of movement and under the design loads.
- iv. The Contractor shall submit from the bearings manufacturer the bearing technical approval document for Spherical Bearings with Special Sliding Material issued by MPA Stuttgart or equivalent approval bodies, which will indicate that the Manufacturer / their technology partner is allowed to design & produce the Bearings utilizing the special sliding material (MSM / UHMWPE) up to a diameter of 2500 mm and that the working / service life of the bearing shall not be not less than 50 years.
- v. Manufacturing or sourcing of the raw material or finished components of the Bearings or the Bearing as a whole from China is not permitted.

14.10. Measurement and Payment

- i. The bearings shall be measured and paid for per unit at the relevant price entered in the Bill of Quantities.
- ii. The tendered rate shall include full compensation for all engineering, labour, design, fabrication, installation and equipment necessary to complete the work, including all subsidiary and incidental items thereto for which separate payment is not elsewhere provided. Payment shall include supply of all materials, protection system, dust cover, all necessary bedding, anchor bolts, jacking plates (if required) and temporary works, etc., and shall include shop drawings, quality control, testing, supply and installation, storage, shipping and delivery.

TECHNICAL SPECIFICATION S-15: ADDITIONAL SPECIFICATION FOR BOX PUSHING

S.15: ADDITIONAL SPECIFICATIONS BOX PUSHING**1. SUBMISSION OF PRELIMINARY DESIGN ALONG WITH TENDER:**

The Tenderer/Contractor shall submit along with his tender a preliminary design and a sketch showing the details of RCC box of required inside dimensions to be cast and pushed below the formation by jacking technique, size of thrust bed required along with the other works associated with thrust bed, methodology of pushing the RCC Box by Jacking Technique and other important details and features proposed, along with the tender documents to check the general adequacy of the section proposed and also to evaluate his offer along with other tenderers, without which the offer is liable for rejection.

The successful Tenderer shall be required to submit in triplicate detailed calculations and drawings of the RCC Box by Jacking / Pushing Technique to the Engineer-in-Charge who will have the same scrutinized/checked. Comments on the design/drawing will be advised to the Contractor who shall there upon submit suitably corrected calculations/drawings for scrutiny and approval. Thereafter the Contractor shall supply to the Railway/Bi-RIDE free of charge one set of neatly executed approved drawing in reproduction film along with five sets of prints on strong paper done by an approved process and three neat copies of the calculations as finally accepted and approved.

Any further changes if still required due to site conditions shall also be done with the approval of Engineer-in-Charge. However, the ultimate responsibility of the safety of the design shall rest with the Tenderer / Contractor.

The Contractor shall also engage one consulting Engineer who shall be well conversant and have adequate field experience in executing the RCC Box by Jacking/Pushing Technique (in addition to the overseer/Engineer mentioned in the relevant clause above) at his own cost and who will be responsible for RCC Box by Jacking/Pushing Technique work.

2. BOX PUSHING WORK:**SUBMISSION OF DETAILED DESIGN AND DRAWINGS FOR APPROVAL**

After award of the tender the contractor shall submit the detailed design calculations in 3 copies along with the drawings for Railway/Bi-RIDE Administration approval within a period of 30 days after issue of the acceptance letter.

It shall be responsibility of the tenderer/s to ensure continued attendance and assistance of design Engineer's representative and get the design and drawings approved by the GM/ Bi-RIDE/ Bangalore.

After the approval of designs and drawings by Railways/Bi-RIDE, the contractor is required to submit 6 copies of approved design, the original being typed on electronic typewriting machine on bond paper, the report being bound suitably. The final design report shall be comprehensive giving all the detailed design calculations, brief theory for the basis of design etc. as directed by Engineer-in-charge. The tenderer/s shall also submit 8 (eight) copies of approved detail drawings including one reproducible (tracing) media to the full drawing sheet size 71 x 66 cm as well as 4 sets of drawings reduced to (A4) size using the standard reduction procedures.

3. DESIGN AND DRAWINGS FOR TEMPORARY ARRANGEMENTS

The successful tenderer is also required to submit a detailed drawing showing the method of construction and temporary arrangements he proposes to make for allowing the Rail traffic above during the construction

of Road Under Bridge. He shall be required to give detailed design, calculation for stresses and displacements etc., at various construction stages. These shall also be got approved from Railways/ BI-RIDE and shall form part of the report as above. Nothing extra is payable for above and the cost of the same shall be deemed to have been included in the Lumpsum Price quoted for the various items of works.

The design and drawings after approval shall be the property of the Railway and Railway / BI-RIDE shall have exclusive right to use and reuse it else-where. The contractor shall have no claim whatsoever in this regard.

In case computer programmes are used for analysis and design of the bridge structure, the same shall be used so as to give a format of output as would be for manual calculations. Copy of the computer programme shall be supplied. In such cases design calculations shall be validated by a sample manual calculation to the satisfaction of the Engineer / Employer, Bangalore. Otherwise the entire calculations shall have to be carried out by detailed manual calculations.

The tenderer shall specially note that while every effort shall be made to approve the design and drawings expeditiously, no claim shall be entertained on account of delays in approval of design and drawings for whatsoever reasons.

Railway/Bi-RIDE may decide to get the detailed design checked by any independent agency or at Research Designs and Standards organization, Lucknow of Ministry of Railway. The contractor shall ensure the regular presence and assistance of the consultants for the checking of the designs by the above agencies in their offices.

The item for construction of one RCC box by box pushing technique:

- The following works would form part of this item as per the approved General arrangement drawings. Procurement/fabrication of necessary plant and equipment like- jacking line jacks, pumps and other plants and equipment required for execution of this work.
- Earthwork in excavation for thrust bed and box pushing, including shoring / sheet piling or any other arrangement to the satisfaction of Railway / BI-RIDE required to protect the earth slopes / adjoining structures and disposal of the excavated earth as per the direction of Engineer-in-charge.
- Casting of thrust bed as per contractor's design duly approved by the Railway / Engineer / Employer.
- Drag sheet shall be provided by the contractor to minimize the friction and disturbance of the soil supporting the track during box pushing operations. Max. number of drag sheets as directed by Engineer-in-charge shall be provided based on actual requirement at site. All arrangements required in connection with drag sheet shall be provided free of cost and nothing extra will be paid. The contractor will be at liberty to utilize modern methods, of reducing skin friction etc. as approved by the Engineer-in-charge.
- Necessary provision of opening in the roof of boxes for bentonite pumping if required during the pushing operations.
- Manufacturing and fabrication of the front end frame/cutting shield and intermediate jacking stations etc.
Pre-casting and curing of RCC box units including fixing of front and frame/cutting shield, with all fabricated work should be done in casting yard. Jacking of precast boxes to form the opening under running railway traffic conditions. The maximum allowable deviation of the precast boxes at any time from the theoretical alignment will be limited to 200mm horizontal and 100mm in vertical direction. Box pushing work shall be done only in day-light hours and in the presence of BI-RIDE supervisor. The contractor will further ensure the rate of box pushing such that it will not disturb

the Railway tracks above and will be personally responsible for the safety of Railway traffic. However, maintenance of track if any required during box pushing operations will have to be done by contractor at no extra cost. The number of man power required as decided by Engineer-in-charge will have to be arranged by the contractor. Further the provision of Engineering indicators required for imposing caution order including caution watchman also will have to be supplied by contractor at no extra cost.

- Grouting of gaps with suitable material, having adequate structural strength at intermediate jacking stations after completion of pushing so that no leakage occurs from the joints at intermediate jacking station during the service of the bridge.
- Provision of M:30 PCC wearing coat on the floor of the box with design camber. Provision longitudinal drainage arrangements within the RCC boxes on either side of the box as approved by the Railway/Bi-RIDE.
- Construction of footpaths, wheel guard's boxes and parapet wall as per design to be submitted by the Tenderer for approval of the Bi-RIDE.

Electrical Fittings: Concealed conduit pipe shall be left on either side of the box during casting for laying of electrical cables/wires in it. Contractor shall provide 30 points for fittings lamps including provision for junction boxes. The scheme shall be got approved by the Department before construction of RCC box.

During the execution of work if any sub-soil water is met with, the contractor will make their own arrangements to bail out/pump out such water from the site, free of cost. Any un-foreseen accumulated rain water, during the progress of work, shall be bailed out/pumped out by the contractor free of cost and the Lumpsum Price quoted should include all these elements.

4. **GENERAL RESPONSIBILITY OF CONTRACTOR:**

Contractor shall be responsible for all the damages caused to the property, by his labour, public or animals caused during the execution of the work by him and shall indemnify the Bi-RIDE for such damages it is finally taken over by the Railways. He will be liable to be called upon to make good the damage or loss which may occur during such execution.

5. **RCC BOX BY JACKING/PUSHING TECHNIQUE:**

The rate to be quoted for the RCC BOX by JACKING/PUSHING TECHNIQUE shall be inclusive of cost of labour and materials (including ordinary Portland cement Grade 43/Grade 53 and MS/Tor Steel for Reinforcement), design and drawings as stated elsewhere. The rate quoted shall also be inclusive of all fares and charges of materials (either by road or rail), plant, equipment, Octroi, toll, taxes and other levies, royalties and patent rights, incidental charges etc. and must be consolidated one for all items of work. The Tenderer shall quote in the tender a lumpsum amount for which he will undertake to do the whole work as above and subject to the conditions of contract.

a. **STAGE PAYMENT FOR RCC BOX BY JACKING/PUSHING TECHNIQUE: TERMS OF PAYMENT**

- (1) On completion of thrust bed, payment equivalent to 10% of the Box pushing item value (of box pushing item).
- (2) On completion of casting of box for the complete length payment equivalent to 30% of the contract value of box pushing item will be payable.

However, progressive payments can be made for the length of the box cast which will be payable as per the following formula:

Payment due : { (length of the box cast) }

{ (Total length of box for jacking/pushing) x 30% of the
{ } contract value for box pushing item

- (3) On completion of jacking/pushing of 50% of contract RCC box to the full length value for box pushing item.

However, progressive payment can be made for the length of box and jacked / pushed based on the formula below:

Payment due= (Length of the RCC box jacked/pushed) x 50% of the (total length of the RCC box jacked / pushed contract value for box pushing item. The remaining 10% shall be paid after completion of finishing items for the correct corresponding alignment and level.

Bi-RIDE

**TECHNICAL SPECIFICATION
S-16: PRECAST 'U' GIRDER
&
RELATED ITEMS**

SECTION- S.16

Precast U-Girder and related items

16.1 PURPOSE

This Specification is Applicable for

- a. Precast Pier cap with cast-in-situ stitch concrete.
- b. U girder Type Superstructure.
- c. Deleted
- d. Launching of I Girder.

The specifications for the same are being provided herewith

16.2 U-GIRDER AND PRECAST PIER CAP

16.2.1 Pre-cast Pier cap

Construction Methods

STAGE-1

- Fabrication of Pier Cap at Casting Yard.
- Recess hole is provided at center of pier cap along with in-situ connection with pier.
- Reinforcement bars are folded around recess hole for future connection with pier.

STAGE-2

- Transport of Precast pier cap to site.
- Lifting of pier cap to top of pier by means of lifting cranes.
- Adjustment devices may be required for correct adjustment of pier cap on pier head. These steel devices are fixed to pier head and pier cap shaft.
- Adjustment the Line, Level and Align the Pier cap as per Drawings.

STAGE-3

- Installation of PT duct through hole and U-Bars inside hole and through Rebar cage.
- Pouring of concrete in recess hole for integral connection between pier and pier cap.

STAGE-4

- Removal of adjustment device.
- After in-situ concrete has reached sufficient strength, stressing of first Stage PT and grouting.
- Plugging of lifting holes before installation of u-girder

STAGE-5

- Installation of superstructure by crane or launcher and then
- Second stage of PT will be done and grouted.
- Concreting of PT anchorage recesses

16.2.2 U - Girder

STAGE-1

- Fabrication of U Girder at Casting Yard.

STAGE-2

- Transport of U Girder to site.

Lifting of U Girder to top of pier by means of lifting cranes I or by Launching Girder

- Placing of U Girder on the temporary supports and adjust the Line and Level.

STAGE-3

- Cast the Shear Key.

STAGE-4

- Place the Bearings both Horizontal and Vertical.
- Lower the U Girder and secure it.

STAGE-5

- Install all the Drainage accessories and waterproof Expansion joint.
- Hand over to Track People.

16.2.3 Shop Drawings and Design Calculations for Construction Procedures

16.2.3.1 General

The Contractor shall submit according to a schedule, complete details and information concerning the method, materials, equipment and procedures he proposes to use. These shall be called "Method Statements". Method Statements shall be submitted sufficiently in advance of the start of superstructure field construction operations, so as to allow the Engineer adequate review period. The submittals shall invariably include step-by-step erection procedure. The Contractor's Method Statements shall also include all calculations, drawings and information as may be relevant.

16.2.3.2 Design Calculations and Construction Procedures

Design assumptions and calculations shall be submitted for temporary prestressing, false work, erection devices, formwork or other temporary construction which may be required to complete the work. Assumptions and Calculations shall also be submitted to substantiate the system and method of permanent and temporary prestressing proposed by the Contractor.

16.2.4 Casting, Stacking, Handling, Transportation and Erection of Girder

16.2.4.1 General

The Contractor shall submit detailed Method Statements for casting, handling, transportation and erection of girder. The superstructure shall be erected by the method indicated in the tender or by alternate method submitted by the Contractor, subject to the approval of the Engineer. The stressing system, cage of reinforcement and lifting details shall be successfully demonstrated on sample segment prior to casting any permanent segments.

All handling and erection plant and equipment shall be load tested prior to their use at site or when specifically asked for by the Engineer. Any additional material required to cater to any temporary condition including temporary prestressing shall be borne by contractor and nothing extra will be paid in this account.

16.2.4.2 Casting

Casting bed and forms shall be structurally adequate to support the girders without settlement or distortion. The casting bed shall be designed for the hardware needed to adjust and maintain grade and

alignment. Special consideration shall be given to those parts of the forms that have to change in dimensions. To facilitate alignment or adjustment, special equipment such as wedges, screws or hydraulic jacks shall be provided. Fittings shall not interfere with stripping of forms. External vibrators shall supplement the internal vibration if necessary and be attached at locations that will ensure maximum consolidation. Details for casting bed and hardware for adjustment shall be submitted by the Contractor for the Engineer's approval. Casting of girders shall be done in a single pour. Construction joint is not permitted in girder.

Care shall be taken to ensure that deformations due to thermal gradients caused by the heat of hydration of the new cast concrete are negligible. These deformations shall be prevented by properly protecting with curing blankets and plastic sheeting. Reinforcing steel shall be fabricated in cages and placed according to the Execution Drawing issued by concerned organization. Any conflict or interference with the proper location of reinforcement or block-outs shall be promptly resolved and corrections made as directed by the Engineer/Engineer's Representative. All girders shall be marked on the inside with a unique identification at the time of form removal.

16.2.4.3 Stacking

Stacking of Girders or Precast Units shall be done as per Approved Drawing and as per Available Layout in the Casting Yard.

16.2.4.4 Handling | Erection of Girders

The Contractor shall be responsible for the proper handling, lifting, storing, transporting and erection of all girders so that they may be placed in the structure without damage. Only HTS bar shall be used for lifting/handling of girder at any stage of construction, with due care for fatigue considerations (multiple re-use).

Girders shall always be maintained in an upright position and shall be stored, lifted and/or moved in a manner to prevent torsion and differential deformation other undue stress. Members shall be lifted, hoisted or stored with lifting devices approved on the shop drawings.

The Contractor shall furnish calculations to establish that the stresses induced during any stages of construction shall not exceed 50% of the cube strength achieved at that stage, nor 40% of the specified 28 days cube strength. In addition, the following limitations shall be observed:

The girder shall not be lifted from the casting bed till the concrete reaches a minimum cylindrical strength of 25 MPa (or 30MPa Cube strength).

The age of the concrete shall not be less than 28 days at the time of its erection provided it has achieved its specified strength as per design requirements.

Girders shall be stacked with three-point support in curing tank / stacking yard as shown in tender drawing, or as approved by concerned organization. Curing shall be done using sprinkler system (assisted by steam curing in the initial stages if adopted) and it has to be ensured that all parts of girder are water cured during water curing period. Curing compound as per relevant specifications may be applied after approval of Engineer-In-Charge

16.2.4.5 Cleaning of Girders

Before transportation of girder, surface shall be cleaned by water rinsing or sand blasting as approved by the Engineer.

16.2.4.6 Miscellaneous

The entire construction work shall be geared towards minimizing disruptions to road traffic. Also, the occupation of roads during all construction activities shall be reduced to a minimum and subject to the approval of the Engineer. Reinforcement shall be fabricated in cages in casting yard for piles, pile caps and piers before being brought into position for expediting the activities.

All elements of sub-structure below bearing pedestals viz piles, pile caps, piers and pier caps shall each be cast in single pour.

16.2.4.7 Load Testing of Standard Span of Superstructure

The contractor shall conduct full scale load test for one Girder (simply supported span, erected in position, including arrangements for applications of serviceable vertical load for measuring deflections and rotations and submit the report).

The sequence of placement and position of loading on the girder shall be as directed by the engineer.

16.2.5 Overhead Gantry Specifications for U Girder

16.2.5.1 Nomenclature

The following terms and abbreviations are used in this report: LG Launching Gantry or Erection Gantry

MT	Main Truss
UCB	Upper Cross Beam
LB	Lifting Beam
CB	Connection Beam
(F/R)RS	(Front/Rear) Roller Support
(F/R)LCB	(Front/Rear) Lower Cross Beam
LSF	Lower Support Frame
F/RSL	Front/Rear Support Leg
Stress bar	Threaded stress bar
LSJ	Long Stroke Jack Long Longitudinal
Trans.	Transverse
Ecc.	Eccentricity
-NA-	Information Not Available
EJ	Expansion Joint
TBA	To Be Advised

16.2.5.2 Structural design codes & load factors

The design of the gantry shall be based on a limit state design approach. The design codes used for the structural design of steelwork include the following:

- (a) IS800 or any other suitable international code of practice.
- (b) The load combinations, load factors and material resistance factors will be appropriate for each of the design code(s).

16.2.5.3 Stability factors of safety

For all possible scenarios of operation, the factor of safety for stability shall be established. However, for certain controlled conditions, a reduction in the required factor of safety against instability can

be

considered, provided that the potential risks are assessed, and it is deemed sufficiently safe. However, the factor of safety against overturning should not be less than 1.2.

16.2.5.4 Friction Factors

The following friction factors shall be assumed:

- a) Crane wheels (adverse): 1.0%
- b) Lateral guide wheels and flanges of crane wheels (adverse): included above
- c) Crane wheels (beneficial): zero
- d) Lateral guide wheels (beneficial): zero
- e) Teflon/stainless steel (adverse): 5%
- f) Teflon/stainless steel (beneficial): zero
- g) Ecotex (Nylatron)/stainless steel (adverse): 10%
- h) Ecotex (Nylatron)/stainless steel (beneficial): 5%
- i) Brass (or bronze)/steel - greased (adverse): 20%
- j) Brass (or bronze)/steel - greased (beneficial): 5%
- k) Steel/steel - greased (adverse): 30
- l) Steel/steel - greased (beneficial): 5%

16.2.5.5 Dynamic factors & launching forces

a) Stationary MT

The following dynamic factors are to be used for consideration of moving loads when the MT is stationary:

- Vertical - 15% of moving loads
- Parallel to movement direction - 5% of moving load
- Perpendicular to movement direction - 3% of moving loads

b) Moving MT

i. Dynamic factors

The following dynamic factors are to be used for consideration of MT launching and movement:

- Vertical - 10% of moving loads
- Parallel to movement direction - 5% of moving loads
- Perpendicular to movement direction - 3% of moving loads

ii. Launching forces for equipment

For consideration of longitudinal forces on hydraulic jacks during launching of the MT, the force is derived considering longitudinal gradient and friction.

iii. Launching forces for structure

For consideration of longitudinal forces on the Roller support during launching of the MT, the force is derived considering longitudinal gradient and friction.

c) Moving UCB/FSL/RSL

i. Dynamic factors

The following dynamic factors are to be used for consideration of UCB/FSL/RSL movement:

- Vertical - 10% of moving loads
- Parallel to movement direction - 5% of moving loads
- Perpendicular to movement direction - 3% of moving loads

ii. Launching forces for equipment

For consideration of longitudinal forces on chain blocks or other moving devices during launching of the UCB/FSL/RSL, the force shall be calculated considering longitudinal gradient and friction.

iii. Launching forces for structure

For consideration of longitudinal forces on the MT/UCB/FSL/RSL during launching of the UCB / FSL / RSL, the force shall be calculated considering longitudinal gradient and friction.

iv. Longitudinal fixity

During span erection shall have a longitudinal fixity with Roller support and shall be considered in design and stability of system.

16.2.5.6 Wind loading

All wind speeds referred beneath are based on gust speed.

In service wind (with span erection) S 20 m/s Gantry launching wind load S 15m/s Tropical storm wind (with span erection) s 42m/s

Tropical storm is normally with advance warning and hence it is deemed to be possible that span under erection shall be completed and load transfer onto span jack prior to arrival of storm. Effect of gantry stability under self- weight only should be evaluated without any segment suspended and additional tie down system is to be provided if necessary. The Above Wind Speeds May be suitably modified for Site Specific Winds. Two types of wind loading shall be considered:

- In-service wind loading: wind while handling of span (lifting, lowering, etc.)
- Out-of-service wind loading: Typhoon wind loading

16.2.5.7 Height Restriction

The gantry must cross few exiting structures. The height of top of main truss above pier cap top shall be limited to 6500mm.

16.2.5.8 Minimum Horizontal Radius

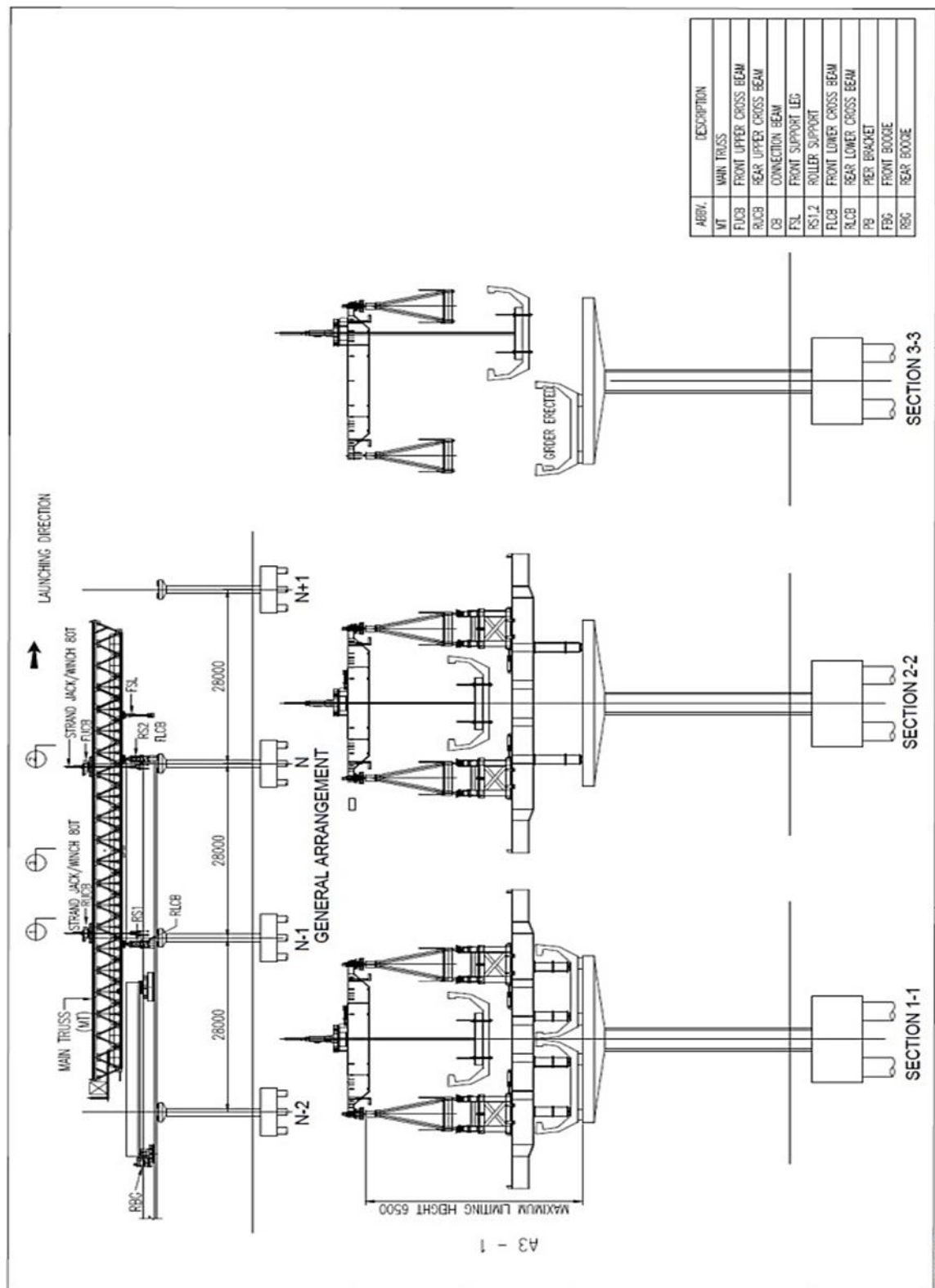
The gantry shall have adequate functional and structural provisions to launch over spans with 200m horizontal radius.

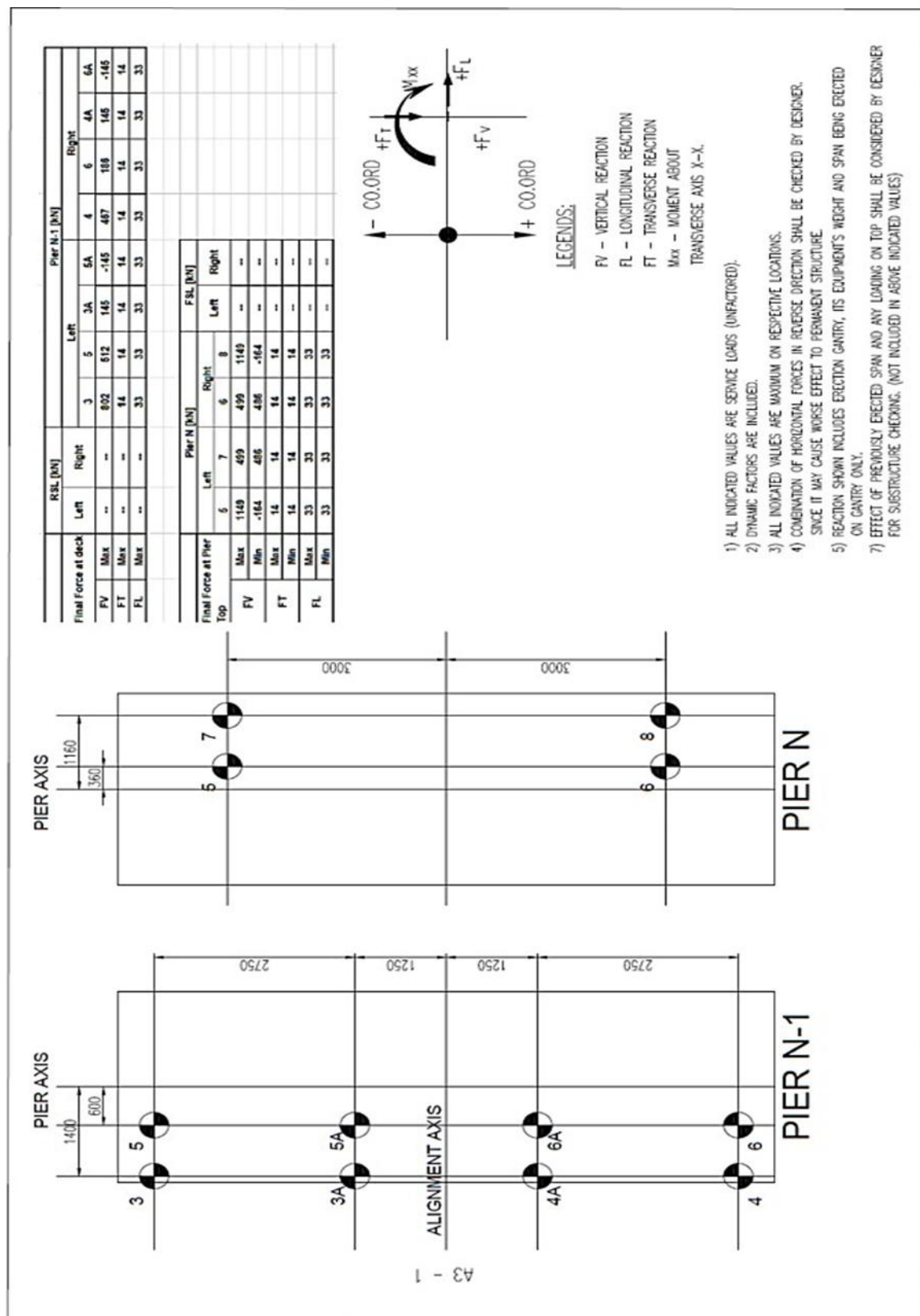
16.2.5.9 Reaction on Piers

The reaction on pier top due to operation of erection gantry, shall be limited to followings:

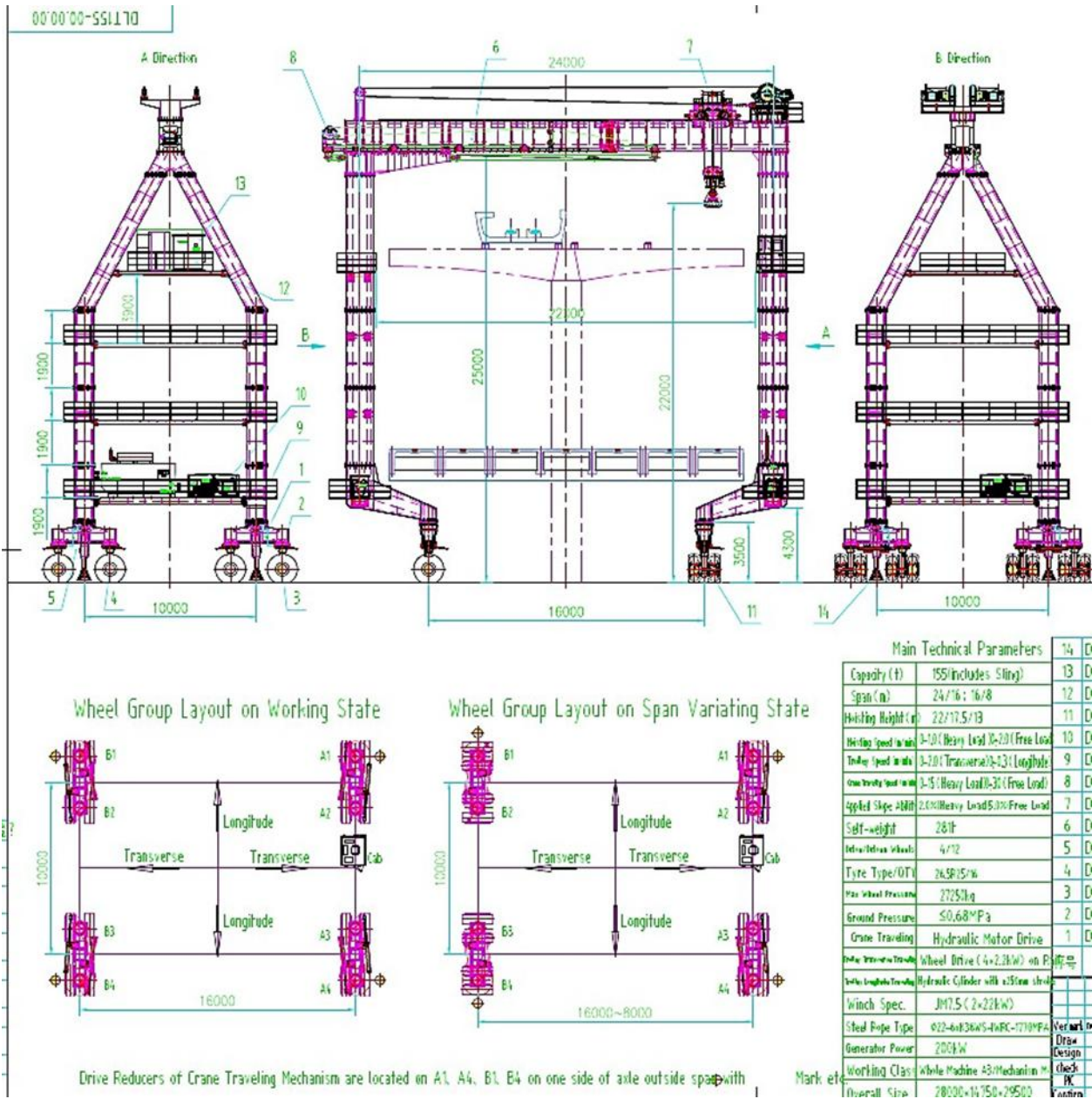
		RSL [kN]		Pier N-1 [kN]							
Final Force at deck		Left	Right	Left				Right			
				3	5	3A	5A	4	6	4A	6A
FV	Max	—	—	802	512	145	-145	467	186	145	-145
FT	Max	—	—	14	14	14	14	14	14	14	14
FL	Max	—	—	33	33	33	33	33	33	33	33
		Pier N [kN]				FSL [kN]					
Final Force at Pier Top		Left		Right		Left	Right				
		5	7	6	8						
FV	Max	1149	499	499	1149	—	—				
	Min	-164	486	486	-164	—	—				
FT	Max	14	14	14	14	—	—				
	Min	14	14	14	14	—	—				
FL	Max	33	33	33	33	—	—				
	Min	33	33	33	33	—	—				

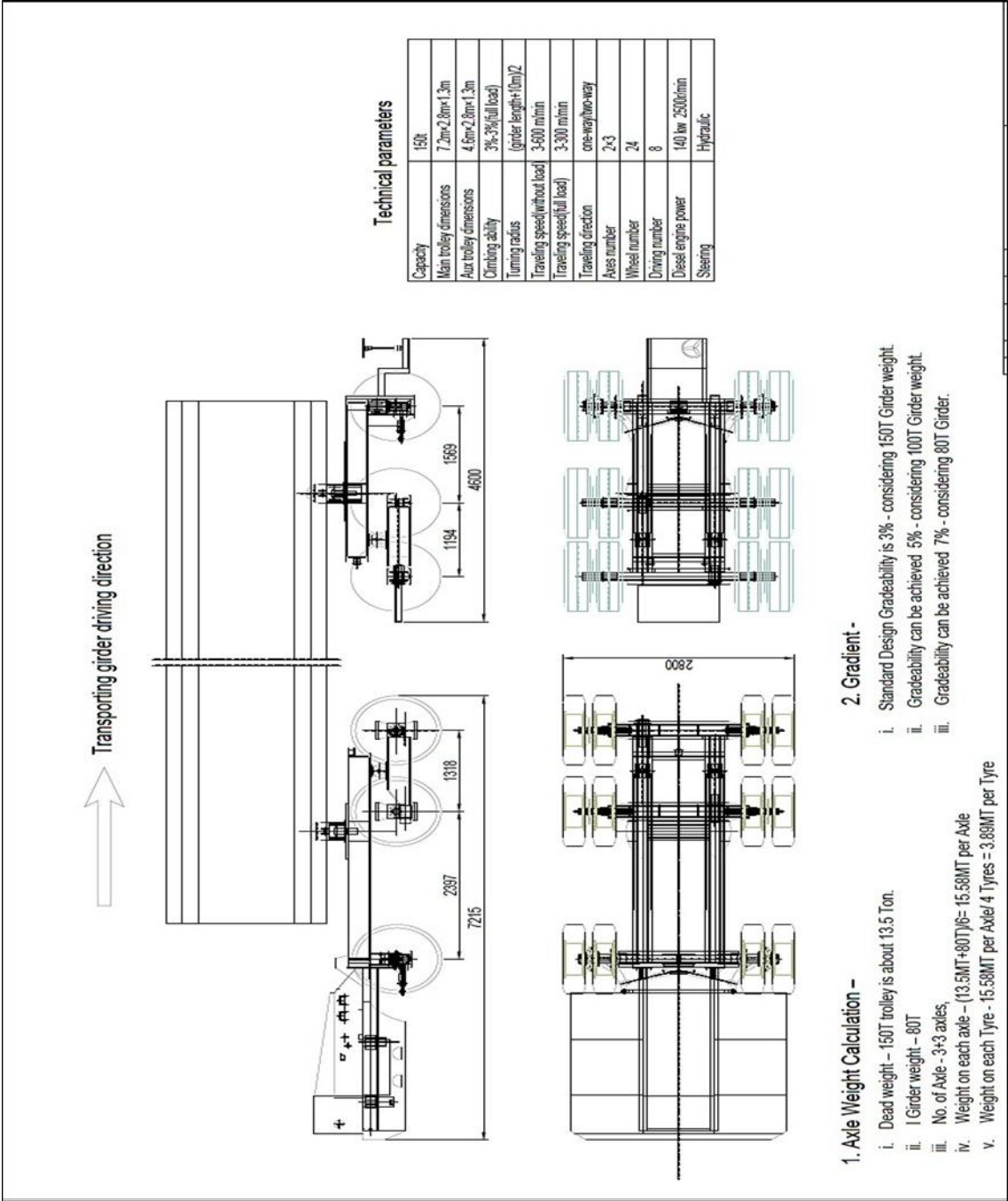
For nomenclature and location of reaction point definition refer to following drawings: -





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The U Girder shall be transported with two numbers of motorized bogies. The Weight of each bogey, inclusive of all equipment, shall be limited to 5.5 t.

S. Nr	Item	Specification
1	Max Weight of each boggy	5.5 t
2	Max Speed (Loaded condition)	2 Km/hr
3	Max Speed (Unloaded condition)	3 Km/hr
4	Maximum gradient	4%

16.5.2.11 Specification on Safety

a) Illumination

A lighting system for working area shall be provided to improve visibility in case of scarce daylight. Anyway, personnel responsible of safety must make sure that there is a good visibility of every point, not be create dangerous reflex and allow a clear reading of control boards and identification of emergency push buttons.

b) Controls

Operating any control that creates a sharp variation in drive direction, such as halting the winch by engaging the opposite movement, is forbidden. The stresses which may arise are uncontrollable and may seriously damage the equipment, causing personnel and material risk. Such controls may be operated in the event of an imminent danger to persons.

c) Safety devices

The GANTRY shall be provided with electrical and mechanical devices which reduce the danger that may occur during working phases. The safety devices are in various points of the launching machine and can be listed as follows:

➤ Protected walkways, ladders and platforms

Main walkways, placed inside the two trusses, allow safe access to working areas and all control units of supports, legs, winches, cranes. In order to reach walkways and platforms, protected ladders are mounted on both legs and supports.

➤ Limit switches

Electrical limit switches shall be installed on moving parts of the gantry. If actuated, they stop the related movement before mechanical stops are reached.

➤ Over speed detection system

A safety system that monitors operating speed and stops the machinery in case of over speed shall be installed on winch drums.

➤ Inclination detectors

Electrical inclination detectors shall be installed on the winch drums.

➤ Load cells

Gantry shall be equipped with load cells in order to constantly survey load conditions.

➤ **Emergency push buttons**

Emergency push buttons shall be installed in the gantry. If actuated by operators, they stop immediately all running movements.

➤ **Safety braking system**

Safety braking system shall be installed to stop the rope drum in case of failure of the control drive, motor, service brake or gearbox.

➤ **Encoders**

Lifting and lowering stroke shall be defined by an encoder mounted on each hoisting winch drum connected with a limit switch.

➤ **Digital speed gauges**

Speed gauge shall be mounted on each hoisting winch drum to continuously check for rope over speed.

➤ **Max relief hydraulic valve**

Each hydraulic motor shall be equipped with a hydraulic valve to limit oil pressure in the circuits.

➤ **Hydraulic pressure switch**

Winches hydraulic circuit shall be equipped with a hydraulic switch to control lifting pressure.

16.3 Technical Specification for Steel Plates (Placed in between in between bearing and bottom of girder).

16.3.1 General

- i. This specification covers requirement for Carbon Steel Plates of Structural Quality as per IS:2062 Gr. E 250-B (as a minimum requirement) intended primarily for steel plates in contact with bearing and bottom of girder.
- ii. Plates shall conform to IS: 2062 Grade E250-B-as a minimum requirement and to this technical specification. Reference shall be made to IS: 2062 wherever applicable.
- iii. Steel Plates manufactured by steel makers only will be accepted. Plates rolled from slabs that are sourced from Third parties will not be accepted. Plates supplied to this specification shall conform to IS:2062 with additional requirement mentioned herein.
- iv. The plate shall be free from surface flows, laminations and any other harmful defects.
- v. The tolerance for plate thickness, width and length shall be ZERO in negative side and the tolerance for plate thickness, width and length on the positive side shall be in line with the tolerance limit(s) specified in the latest issue of IS:2062 in accordance with IS 1852 - latest edition.
- vi. The plates shall be free from injuries and defect and shall have workmanlike finish.
- vii. Reconditioning/ repair of plates by welding is not permitted.

16.3.2 Plates shall comply with Chemical composition as per table 1 of IS:2062.

Plates shall have following Mechanical Properties. Plates conforming to all the specifications of E-250-B quality as per

a)	IS:2062. Yield Strength	250 MPa Minimum
b)	Tensile Strength	410 MPa
c)	Elongation	23% min.
d)	Bend Test	2t for less than or equal to 25mm thick product,

		3t for less than 25mm thick product.
e)	Charpy Test	applicable for E-250-B quality & thickness of 12mm & above. Table 2 of IS: 2062 may be referred for full details.

16.3.3 Supplementary Technical Requirements:

The contractor shall produce manufacture certificate of Chemical composition and Mechanical Properties in accordance with IS: 2062. Additionally, inspection reports for dimensional checks and surface conditions shall be furnished for confirmation that the plates are dimensionally acceptable and free from surface flows, laminations and any other harmful defects.

Measurement

Measurement shall be made for the finished volume of reinforced cement concrete (excluding lean concrete) only. All linear dimensions shall be measured correct to 1cm & restricted to design dimensions, and the volume calculation will be correct to two decimal places in cubic meters.

No deduction shall be made for volume of steel embedded in concrete or for voids not exceeding 0.03 cum in volume.

The measurement for prestressing steel wires shall be made on the actual length of wires from end to end of cut-face of anchorages for post tensioned concrete as per the profile drawing and shall not include the extra length of wires at both ends. For pretensioned concrete the measurements of high tensile steel wires shall be measured from end to end of concrete faces and shall not include extra length of wires at both ends. The quoted Lumpsum Price for high tensile steel work shall include formation of cables in position including cost of spacers, transporting, anchorages, sheathing, grouting, stressing and all other relevant work including staging etc.

**TECHNICAL SPECIFICATION
S-17: ADDITIONAL SPECIFICATION
FOR
STEEL BRIDGE GIRDER ERECTION**

S.17: ADDITIONAL SPECIFICATION FOR STEEL BRIDGE GIRDER ERECTION**17. STEEL BRIDGE GIRDER ERECTION**

(Fabrication and erection as per RDSO guidelines "IRS – Specification for Fabrication and Erection of Steel Girder Bridge and Locomotive Turn Table - SERIAL NO. B1-2001/2008) or latest.

Separate priced booklets containing Indian Railway/South Western Railway Standard Specifications for Materials and Works Civil, Electrical and Signalling and Telecommunication) are available in K RIDE office. These specifications shall be applicable for all works covered in this contract.

It is presumed that bidders have gone through the above (including latest correction slips issued up to the date 28 days prior to the deadline for submission of bids) before quoting the Lumpsum Price.

17.1 STRUCTURAL STEEL ERECTION WORK - GENERAL**17.1.1 Scope of Specification**

This specification covers the scope of work for structural steel erection works, submittals by the Contractor, applicable codes of practice and the specifications for the materials to be used, including steel, bolts and nuts, washers etc. and the storage thereof.

17.1.2 The fabrication of steel girder bridges is being done by various Railway Workshops as well as through trade. The fabrication is governed by the provisions of;

- i) Indian Railway Standard Specification for Fabrication and Erection of Steel Girder Bridges and Locomotive Turntables. (B1-2001).
- ii) Indian Railway Standard Code of Practices for Metal Arc Welding for Structural Steel Bridges carrying Rail cum Road or Pedestrian Traffic (Adopted 1972 Revised 2001).
- iii) Guidelines on Fabrication of Steel Girders for Construction / Field Engineers BS -110 (R)- Issued by RDSO.

17.1.3 Scope of Work

The scope of work for the contractor in respect of structural steel erection work shall cover, but shall not be limited to the following:

Preparation of complete erection sequence drawing based on the suggested erection scheme(s) as proposed by contractor, required for all the permanent and temporary structures including launching nose / truss.

Submission by the contractor, for examination by the Engineer, detailed particulars of the proposed method of erection of the superstructure steelwork, together with complete calculations relating to strength and deflection. If the erection scheme necessitates the strengthening of the permanent steel work, the contractor shall submit, for approval of the Engineer, the methods he proposes for making good the permanent steelwork after removing the temporary work. The contractor shall also submit the design and fabrication drawings incl. detailed calculations of launching nose I truss, counter weight, all temporary supports, staging, bracings etc. required for safe erection, for approval of the Engineer.

Providing all construction and transport equipment, tools, tackle and consumables, materials, labour and supervision required for the erection of the structural steelwork.

Receiving, unloading, checking and moving to storage yard / storage, guarding and upkeep of fabricated steelwork and other consumable materials and fasteners at site.

Compiling and furnishing detailed bill of materials of fabricated parts received from the fabricator.

Loading, Transportation and unloading of all fabricated structural steel materials from storage yard to erection site, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural

steel materials in proper location, according to approved erection drawings and I or as directed by the Engineer.

Setting out, aligning, keeping in plumb, bolting, welding and securely fixing the fabricated steel structures in accordance with the erection scheme, or as directed by the Engineer.

Requisite, site planning to all fabricated steelwork, as per requirements of related specification of the painting.

Carrying out all major modifications of the fabricated steel structures, as directed by the Engineer, including but not limited to the following:

- (a) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
- (b) Cutting, chipping, filing, grinding etc. as required or preparation and finishing of site connections.
- (c) Drilling of holes which are either not drilled at all or are wrongly drilled.

17.1.4 Submittals

- A. On commencement of the Project, the Contractor shall submit the following:
 - i) Prior to the technical submittals, the contractor shall submit the proposed overall schedule for documentation such as calculations, erection drawings, shop I working drawings for all temporary structures etc. It is highlighted that structural steel member dimensions indicated in tender drawings are tentative only, and may be modified during final design stage.
 - ii) A detailed list of all constructional Plant & Equipment, such as cranes, derricks, winches, welding sets, erection tools etc. their make, model, present condition and location, available to the contractor and the ones he will employ on the job to maintain the progress of work in accordance with the contract.
 - iii) The total number of experienced personnel of each category, like fillers, welders, riggers etc., which he intends to deploy on the work.
- B. The contractor shall submit a detailed erection programme for completion of the work in time and in accordance with contract. This will show, in a Proforma approved by the Engineer, the target programme, with details of erection proposed to be carried out in each week, details of major equipment required and an assessment of required strength of various categories of workers.
- C. The contractor shall submit complete design calculations for any alternative's sections (for permanent structure) proposed by him, for approval of the Engineer. Use of any alternative section shall be subjected to approval of the Engineer. However, no escalation in unit price of work shall be allowed for such cases.

17.1.5 Furnishing of information

- A. Design drawings shall be furnished to the contractor and all such drawings shall form part of these Specifications.
- B. The Engineer reserves the right to make changes in the design drawings even after release for preparation of shop drawings to reflect addition, omission & modifications in data I details and requirements. Contractor shall consider such changes as part of these Specifications and the contract, and no claims shall be entertained on this account.
- C. Design drawings, approved by the Engineer, will show as appropriate the salient dimensions, design loads, sizes of members, location of openings at various levels and other necessary information

required for the preparation of fabrication drawings, designs and erection details.

- D. It shall be clearly understood that the drawings of the Engineer are design drawings. The typical details of connection, cuts, notches, bend etc were shown in the design drawings are only for general guidance of the contractor. The contractor shall design and develop all such details based on the design forces and functional requirements.
- E. In case of variations between design drawings and specifications, the decision of the Engineer shall be final. Should the contractor, find any discrepancy in the information furnished by the Engineer, same shall be immediately brought to the notice of Engineer for resolution. The contractor shall obtain clarifications on discrepancies from Engineer before proceeding with the work.
- F. No detailed erection or shop drawings for temporary structures will be accepted for examination by the Engineer unless the same, have first been completely checked by the contractor's qualified structural engineer (independent agency to be appointed by contractor) and are accompanied by an erection plan showing the location of all pieces detailed. The contractor shall check and ensure that detailing of connections is carefully planned to obtain ease in erection of structures, including field-welded connections and l or bolting.
- G. No fabrication work shall be started by the contractor without prior approval of Engineer on the relevant drawings. Approval by the Engineer of any of the drawings shall not relieve the contractor of his responsibility to provide correct design of connections, workmanships, fit of parts, details, materials and errors or omissions of all work shown thereon. The approval of Engineer shall constitute approval of the size of members, dimensions and general arrangement, but shall not constitute approval of the connections between members and other details.
- H. Drawings, for approval, shall be submitted by the contractor in an orderly manner commensurate with erection sequence and approved construction programme.
- I. The contractor shall furnish ten prints of all approved final drawings including soft cop in CD ROM for interface l field use and record purpose.
- J. The drawings prepared by the Contractor, and all subsequent revisions thereof shall be at the cost of the Contractor, and no separate payments shall be made for the same. Revisions shall incorporate all modifications, field changes, substitutions etc. effected. The Lumpsum Price quoted for fabrication work shall be deemed to include the cost of such drawing work.
- K. All the drawings shall be prepared in metric units. The drawings should preferably be of A-1 standard size, and the details shown therein shall be clear and legible. These drawings shall include but shall not be limited to the following:
 - i) Assembly drawings, giving exact sizes of the sections to be used and identification marks of the various sections.
 - ii) Shop details of temporary structures together with detailed calculations.
 - iii) Detailed shop drawings for proper co-ordination with the concrete components to which the steel members shall be connected, as required.
 - iv) Any other drawings or calculations that may be required for proper completion of the works and clarification of the works of substituted parts thereof.
 - v) All 'as-built' drawings.

17.1.6 **Applicable Codes of Practice**

The following specifications, standards and codes are included as part of this Specification. All Standards, specifications, codes of practice current on the date of signing of agreement and referred to herein shall be

applicable.

IS:800 (1984)	Code of Practice for General Construction in Steel
IS:808 (1989)	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle sections
IS:800 (1984)	Covered Electrodes for Manual Metal Arc Welding of Carbon & Carbon - Manganese Steel.
IS:816 (1969)	Code of Practice for Use of Metal Arc welding for General Construction in Mild Steel
IS:817 (1969)	Code of Practice for Training and Testing of Metal Arc Welders
IS:919 (1993)	ISO System of Limits & Fits (Part 1 & Part 2)
IS:1148 (1982)	Hot Rolled Rivet Bars (upto 40 mm) for Structural Purposes
IS:1182 (1983)	Recommended Practice for Radio Graphic Examination of Fusion Welded Butt joints in steel plates
IS:1363 (1992)	Hexagon Head Bolts, Screws and Nuts of Product Grade C (Part 1 to Part 3)
IS:1364 (1992)	Hexagon Head Bolts, Screws and Nuts of Product grade A & B.(Part 1 to Part 5)
IS:1367 (1991)	Technical Supply Conditions for Threaded Steel Fasteners
IS:1852 (1985)	Rolling & Cutting Tolerances for Hot-Rolled Steel Product
IS:1977 (1975)	Structural Steel (Ordinary Quality)
IS:2016 (1967)	Plain Washers
IS:2062 (1992)	Steel for General Structural Purposes.
IS:2595 (1978)	Code of Practice for Radio Graphic Testing.
IS:3600 (1985)	Methods of Testing Fusion Welding joints (Part 1 to Part 9)
IS:3613 (1974)	Acceptance Tests for Wire Flux Combinations for Submerged Arc
IS:3658 (1981)	Code of practice for Liquid Penetrant Flow, Detection
IS:3757 (1985)	High Strength Structural Bolts
IS:4000 (1992)	High Strength Bolts in Steel Structures Code of Practice
IS:4353 (1967)	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steel
IS:4943 (1968)	Assessment of Butt and Fillet Fusion Welds in Steel Sheet, Plate and Pipe
IS:5334 (1981)	Code of Practice for Magnetic Particle Flow Detection of Welds
IS:5369 (1975)	General requirements for Plain Washers and Lock Washers
IS:5372 (1975)	Taper Washers for Channels
IS:5374 (1975)	Taper Washers for I Beams
IS:6623 (1985)	Specifications for High Strength Structural nuts
IS:6649 (1985)	Specifications for hardening and tempering washers for high strength structural nuts
IS:6755 (1980)	Double Coil Helical Spring Washers
IS:7215 (1974)	Tolerances for Fabrication of Steel Structure
IS:7318 (1974) (Part I)	Approval Test for Welders when welding procedure approval is not required - fusion welding of steel
IS:8500 (1974)	Structural steel - Micro alloyed (Medium and high Strength Qualities)
IS:8910 (1978)	General requirements of Supply of Weldable Structural Steel
IS:9595 (1980)	Recommendations for Metal Arc Welding of Carbon & Carbon - Manganese Steels
RDSO Specifications and guide lines along with IR bridge manual to be referred for compliance	

17.1.7 Storage of Materials

17.1.7.1 General

All materials shall be so stored as to prevent deterioration, and to ensure the preservation of their quality and fitness for the work. If required by the Engineer, the materials shall be stored under cover the suitably painted for the projection against weather. Any material, which has deteriorated or has been damaged shall be removed form site and replaced by new members, as directed by the Engineer at no extra cost and time.

- A. Steel to be used in fabrication shall be stored in separate stacks clear of the ground, section wise and lengthwise.

- B. The storage area shall be kept clean and properly drained. Structural steel shall be so stored and handled to such a manner that members are not subjected to excessive stresses and damage. Girders and beams shall be placed in upright position. Long members shall be supported on closely spaced skids to avoid unacceptable deflection.

17.1.7.2 Storage Yard

- A. The Contractor shall be required to establish a suitable yard, at an approved location at site for storing the fabricated steel structures and other materials which will be delivered to site. The yard shall have proper facilities such as drainage and Lighting including access for cranes, trailers and other heavy equipment's.
- B. The Contractor shall have been deemed to have visited the site, prior to submission of his tender, to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc., all of which shall be carried out by the Contractor at his own cost and as directed by the Engineer.

17.1.7.3 Covered Store

All field connection materials, paints etc. shall be stored on racks and platforms, off the ground in a properly covered building by the Contractor.

17.2 Field Bolts

1. Requirements stipulated under bolting shall apply for field bolts. Field bolts, nuts and washers (DTI) shall be supplied by the authorized fabricators of the structural member in excess of the nominal numbers required. Only HSFG bolts of class 8.8/10.9 shall be used.
2. At the time of assembly, the surfaces in contact shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interface with the development of friction between them.
3. In any other surface condition, including a machined surface, is specified, it shall be the responsibility of the Contractor to work within the slip factor specified for the particular case.
4. Each bolt and nut shall be assembled with washers of appropriate shape, quality and number in cases where plane parallel surfaces are involved. Such washers shall be placed under the bolt head or the nut, whichever is to be rotated during the tightening operation. The rotated nut or bolt head shall be tightened against a surface normal to the bolt axis, and the appropriate tapered washer shall be used when the surfaces are not parallel. The angle between the bolt axis and the surface under the non-rotating component (i.e., the bolt head or the nut) shall be 90 ± 3 degree. For angles outside these limits, a tapered washer shall be placed under the non-rotating component. Tapered washers shall be correctly positioned.
5. No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening. Nuts and bolts shall always be tightened in a staggered pattern and where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.
6. If, after final tightening, a nut or bolt gets slackened off for any reason, the bolt, nut and washer or washers shall be discarded and not used again.

Structural Steel Work Painting Works

17.2.1 General

17.2.1.1 Scope of specification

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding, tools, equipment and everything that is necessary for the job completion on schedule.

17.2.1.2 Applicable Codes

The following Specifications, Standards and Codes are included as part of this Specification. All standards and Codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions.

In case of discrepancy between this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

IS: 102 (1962)	Ready Mixed Paint, Brushing, Red lead, Non Setting, Priming
IS: 159 (1981)	Ready Mixed Paint, Brushing, Acid Resisting for Protection against Acid Fumes, Colour as required
IS: 341 (1973)	Brushes, Paints and Varnishes, Flat
IS: 384 (1979)	Brush, paint and varnish i) Oval Ferrule Bound ii) Round Ferrule bound
IS: 487 (1985)	Temporary Corrosion Preventive Grease, Soft film, Cold Application
IS: 958 (1975)	Temporary Corrosion Preventive, Fluid, Hard film, solvent deposited
IS:1153 (1975)	Temporary Corrosion Preventive, fluid, hard film, solvent deposited
IS:1477 (1971)	Code of practice for painting of Ferrous metals in building Part I - Pretreatment Part II - Painting
IS:1674 (1960)	Temporary corrosion preventive fluid, soft film, solvent deposited
IS:2074 (1992)	Ready mixed paints, red oxide - Zinc Chrome, Priming

17.2.2 Products and Materials**17.2.2.1 Paint**

1. All paint delivered to the site shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
2. Paint shall be stirred frequently to keep the pigment in suspension.

17.2.2.2 Storage of Paints

1. All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks, flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.
2. All paint containers shall be clearly labelled to show, paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage, shall not be used. Paints for which the shelf life specified by the supplier has expired shall not be used.

17.2.3 Execution**17.2.3.1 Painting system**

Painting work shall be carried out as detailed in Table 12.1 follows:

TABLE 12.1
PAINTING SPECIFICATIONS

DESCRIPTION	GENERAL SURFACE	
FABRICATION SHOP	EXTERNAL SURFACES	INTERNAL SURFACES
Surface Treatment	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning
1 st Under - Coat	Inorganic zinc silicate primer (self- curing solvent type) DFT 75 cum shall be Berger Zinc Anode 11 or approved equivalent. The primer should be applied by spray only.	Epoxy Zinc phosphate primer polyamide cured DFT-35 m
2 nd Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT - 35µm shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Epoxy zinc phosphate primer polyamide cured DFT-35 µm shall be Berger Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.
3 rd Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT- 35 µm shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Polyamide cured coaltar epoxy coating DFT 100 µm
4 th Under Coat	Epoxy high build micaceous iron oxide coating polyamide cured DFT-90 µm shall be Berger Epilux 4 High Build MIO. The primer should be applied by spray or brush only.	Polyamide cured coal tar epoxy coating DFT 100 µm
ERECTION SITE	EXTERNAL SURFACES	INTERNAL SURFACES
Intermediate Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT-30 µm shall be Berger thane or approved equivalent applied by spray or brush in approved colour.	NA
Finishing Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT-30 µm shall be Berger thane or approved equivalent applied by spray or brush in approved colour.	NA

INTERNAL SURFACE = are those which will become inaccessible after fabrication.

EXTERNAL SURFACE = are those which are prone to humidity and moisture from the atmosphere. The DFT (dry film thickness) shall be measured after completion of each coat

17.2.3.2 Surface Preparation

17.2.3.2.1 General

1. The work shall be carried out in accordance with IS: 1477 (2008) (Part 1). Any oil, grease, dust or foreign matter deposited on the surface after preparation shall be removed and care shall be taken to ensure that the surface is not contaminated with acids, alkalis or other corrosive chemicals.
2. All welding areas shall be given special attention for removal of weld flux slag, weld metal splatter, weld head oxides, weld flux fumes silvers and other foreign objects before blasting. If deemed necessary by the Engineer, acid washing and subsequent washing with clean water shall be used.
3. Any rough seams will have to be ground and must be inspected and approved by the Engineer - before application of the coatings.
4. The last finish paint shall be applied after structural steel erection and slab construction.

17.2.3.2.2 Mixing and Thinning

All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments, before use and during application, to maintain homogeneity. All pigmented paints shall be strained after mixing to remove skins and other

undesirable matters.

1. Dry pigments, pastes, tinting pastes and colours shall be mixed and l or made into paint so that all dry powders get wetted by vehicles and lumps and particles are uniformly dispersed.
2. Additives that are received separate such as curing agents, catalysts, hardeners etc. shall be added to the paint as per the manufacturer's instructions. These shall be promptly used within the pot life specified by the manufacturers and unused paint thereafter shall be discarded.
3. Thinners shall not be used unless essential for proper application of the paint and approved by the Engineer. Where thinners are used, they shall be added during the mixing process and the type and quantity of thinner shall be in accordance with the instructions of paint manufacturer.

17.2.4 **Paint Application**

17.2.4.1 **General**

1. Paint shall be applied in accordance with the manufacturer recommendations and as supplemented by these specifications. The work shall generally follow IS:1477 (1971) (Part II). Prior approval of the Engineer shall be taken in respect of all primers and l or paints, before their use in the works.
2. Paint shall generally be applied by brushing except that spraying may be used where specified and for finish coats only when brushing may damage the prime coats. Roller coat or other method of paint application shall not be used unless specifically authorized.
3. Spraying paint shall not be adopted on red lead or zinc rich paints. Daubers may be used only when no other method is practicable for proper application in difficult accessible areas.
4. Paint shall not be applied when the ambient temperature is 10° C and below. For paints which dry by chemical reaction the temperature requirements specified by the manufacturer shall be met with. Also, paint shall not be applied in rain, wind fog or at relative humidity of 80% and above or when the surface temperature is below dew point, resulting in consideration of moisture. Any wet paint exposed to damaging weather conditions shall be inspected after drying and the damaged area repainted after removal of the paint.
5. Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots. The film thickness shall not be so great as to detrimentally affect either the appearance or the service life of the paint.
6. Each coat of paint shall be allowed to dry sufficiently before application of the next coat, to avoid damages such as lifting or loss of adhesion. Undercoats having glossy surface shall be roughened by mild sand papering to improve adhesion of subsequent coats. Successive coats of same colour shall be tinted, whenever practical, to produce contrasts and help in identifying the progress of the work.

17.2.4.2 **Brush Application**

1. Proper brushes shall be selected for a specific work piece. Round or oval brushes which conform to IS:487 (2012) are better suited for irregular surfaces, whereas flat brushes which conform to IS: 384 (2002) are convenient for large flat areas. The width of flat brushes shall not generally exceed 125 mm.
2. Paint shall be applied in short strokes depositing a uniform amount of paint in each stroke followed by brushing the paint into all surface irregularities, crevices and corners and finally smoothening or levelling the paint film with long and light strokes at about right angles to the first short strokes. All runs and sags shall be brushed out. The brush marks left in the applied paint shall be as few as practicable.

17.2.4.3 **Spray Application**

1. The spraying equipment shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned and free from dirt, dried paint, foreign matter and solvent before use.
2. The paint shall be applied by holding the gun perpendicular to the surface at a suitable distance and moved in a pattern so as to ensure deposition of a uniform wet layer of paint. All runs and sags shall be brushed out immediately. Areas not accessible to spray shall be painted by brush or dauber.
3. Water trap acceptable to Engineer shall be furnished and installed on all equipment used in spray

painting.

17.2.4.4 Shop Painting

1. The painting system specified in Table 11.1 above shall be followed.
2. Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted but require protection shall be given a rust inhibitive grease conforming to IS:958-2000 or solvent deposited compound conforming to IS: 1153 (2000)) or IS: 1674 (1960) or treated as specified in the drawing.
3. Surface to be in contact with concrete shall not be painted.
4. The shop coats shall be continuous over all edges, including ends meant for jointing at site by bolting, except where the paint could be detrimental to bolting. In such cases, no paint shall be applied within 50 mm, and the unprotected surface shall be given a coat of corrosion inhibitive compound.
5. The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and de-stages, and immediately after covered by the same paint as has been used for the remaining surface.

17.2.4.5 Protection of Paintwork

1. The Contractor shall provide measures as necessary to prevent damage to the work and to other property or persons through all cleaning and painting operations. Paint or paint stains which result in other unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the contractor at this cost.
2. All painted surfaces that in the opinion of the Engineer are damaged in anyway, shall be repaired by the contractor at his own cost with materials and to a condition equal to that of the requirements specified in these specifications.
3. If in the opinion of Engineer, any other work would have caused dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned. At the time of commissioning of the work, the painting shall be completed and the surfaces shall be undamaged and clean.
4. The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint shall be removed by power wire brushing to a standard equivalent to SA3.

17.2.4.6 Site painting

After the erection of structures at the site, the contractor shall provide the necessary treatment as specified in Table 11.1 "PAINTING SPECIFICATIONS".

Surface which have not been shop coated, but require surface treatment shall be given necessary surface preparation and coats at site as specified in the Table 11.1 above.

17.3 Additional Specifications for Launching

Truss launching for longer spans:

- a) Preferably no road traffic blocking will be used. Multiple day I night short blocks of 1h to 1h30 maximum are acceptable to ensure safety.
- b) Launching scheme shown in Tender drawings is suggestive only. Contractor has to provide his own proposed launching scheme and supporting calculations with the offer.
- c) Contractor has to provide principles of nose I truss connection details in tender.
- d) Truss design composite girder requirements will govern over nose I launching equipment requirements.
- e) Contactor will submit and get approval from Engineer of the detailed design of the full launching equipment and scheme before starting the launching.
- f) Contractor will coordinate with Bangalore Traffic Police and Engineer before and during the launching contractor to develop detailed traffic diversion scheme.
- g) Tentative allowable bearing pressure for temporary supports foundation concrete blocks shall be assumed at 10 tonnes I sqm.
- h) For location of storage and fabrication yard relevant clause of N.I.T shall be referred. Contractor shall indicate and justify in tender the proposed total needed yard area for the purpose.

- i) Any necessary precaution by proper and secure fixing shall be taken by the contractor to prevent the fall of any object onto the road below during the whole erection period.
- j) A minimum 15 m clear width (4 lanes) shall be kept during the whole construction period. These lanes can be obtained as 4 or 2+2.

17.4 **Mode of Measurement**

The cost of steel bridge girder is included in Lumpsum price of Price Schedule. The quoted lumpsum price shall also includes the following:

- a. Erection of fabricated parts (fabrication and transportation of various parts I components including HSFG bolts I nuts I washers from workshop to storage yard will be done by approved sub-contractors)
- b. Receiving, unloading and keeping in safe custody and upkeep of all fabricated parts including HSFG bolts I nuts I washers at storage yard.
- c. Loading, transportation and unloading of all fabricated structural steel materials including HSFG bolts I nuts I washers from site storage yard to erection site, handling, assembling, bolting, welding if necessary and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and I or as directed by the Engineer.
- d. Tightening of HSFG bolts for the field erection of fabricated parts. However, supply of HSFG bolts and its compatible nuts and washers will be arranged I supplied at the storage yard by approved sub- contractor.
- e. Preparation of complete detailed erection drawings and detailed calculation based on suggested erection sequence and design drawings as given by Engineer or alternative scheme proposed by contractor and approved by Engineer.
- f. Preparation of complete detailed fabrication drawings for all temporary structures such as temporary nose, staging, temporary support, bracing required for all permanent and temporary structures.
- g. All tools, plants and equipment's I machinery
- h. All other consumables including fuel and lubricants etc.

All safety and protection arrangements to be made at site I storage yards for road users, public and workmen.

TECHNICAL SPECIFICATION S-18: ROAD WORK

S18 – ROAD WORK

ADDITIONAL SPECIFICATION FOR ROAD WORK

1. ROADWORK

1.1 Control of Traffic

- 1.1.1 The Contractor shall take all necessary precautions in co-ordination with and to the requirements of all the competent authorities concerned to protect the work from damage until such time as the seal coat or surface treatment has developed sufficient strength to carry normal traffic without any damage to it.
- 1.1.2 The new work shall be opened to traffic only after it is authorised by the Engineer. The contractor shall submit a detailed traffic diversion/or control and regulation plan taking all safety measures during the course of work permitted by the concerned authorities to the Engineer for his consent before start of work.
- 1.1.3 The Contractor shall take all precautions to avoid or minimise delays and inconvenience to road users during the course of the work. Where adequate detours or side tracks are available, traffic shall be temporarily diverted while the work is in progress depending on volume of traffic and subject to approval by Traffic Police. Adequate signs, signals, barriers and lamps for the warning and guidance of traffic shall be provided at all times during the course of the work till it is opened to traffic.
- 1.1.4 The Contractor shall take all reasonable precautions to protect traffic against accident, damage or disfigurement by construction equipment, tools, and materials, splashes and smirches of bitumen/ bituminous material or any other construction materials and shall be responsible for any claims arising from such damage or disfigurement. Traffic signs erected shall be in accordance with the IRC Standards and/or as prescribed and approved by the Traffic Police Department.

1.2 Granular Sub-Base (Non-Bituminous)

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these specifications or as per MORTH standards, as acceptable to Highway authorities & road owing agency. The material shall be laid in one or more layers according to lines, grades and cross- sections shown on the Drawing.

1.2.1 Material

The Material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading specified in MORTH specifications for Roads and Bridges. The material shall be free from organic or other deleterious constituents.

1.2.2 Physical requirements

The material shall have a 10 percent fines value of 50 KN or more (for sample in soaked condition) when tested in compliance with BS:812 (Part III). The water absorption value of the coarse aggregate shall be determined by IS:2386 (Part 3); if this value is greater than 2 percent, the soundness test shall be carried out on

the material delivered to site as per IS: 383. CBR Value shall be determined at the density and moisture content likely to be developed in equilibrium conditions which shall be taken as being the density relating to a uniform air voids content of 5 percent.

1.2.3 **Strength of sub-base**

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

1.2.4 **Construction Operations**

1. **Preparation of sub-grade**

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

2. **Spreading and compacting**

The approved sub-base material shall be spread on the prepared sub-grade by a grader of suitable type and adequate capacity.

When the sub-base material consists of combination of materials, mixing shall be done mechanically by the mix-in-place method.

The equipment used for mix-in-place construction shall be approved equipment capable of mixing the material to the desired degree.

Moisture contents of the loose material at the time of compaction shall be checked in accordance with IS: 2720 (Part 7) and suitably adjusted. Rolling procedure shall be as described under relevant Subsection except stated herein.

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

1.2.5 **Control of Traffic**

Control of traffic shall be as described under Subsection 12.1.

1.3 **Water-bound Macadam Sub-base/ Base (Non-Bituminous)**

1.3.1 **Description**

The work shall consist of furnishing, placing, watering and compacting sub-base material mechanically interlocked by rolling and bounded together with screening and/ or binding material to the required degree on a prepared sub-grade/ sub-base or the existing surface as the case may be in accordance with these Specifications, and to the lines, levels, grades, dimensions and cross sections as shown on Drawings and/ or required by the Engineer.

1.3.2 **Materials**

1. **Coarse aggregate**

The coarse aggregates shall be hard and durable crushed stones, free from deleterious matter conforming to one of the gradings as set forth in Table 12.3.1, the physical requirements given in Table 12.3.2 subject to the Engineer's consent.

2. Screenings

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate or of gravel (other than round material) or moorum as approved by Engineer. However, where permitted non-plastic material such as moorum may be used for this purpose provided liquid limit and plasticity index of such material are below 20 and 6 respectively and fraction passing through 75 micron sieve does not exceed 10 percent.

3. Binding material

Binding material to be used for water-bound macadam as a filler material meant for preventing ravelling, shall be a suitable material and having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS: 2720 (Part-5).

Table 13.3.1
Grading requirements of coarse aggregates

Grading	Size Range	IS Sieve Designation	Percent Passing by weight
1	90 mm to 45 mm	125 mm	100
		90 mm	90-100
		63 mm	25-60
		45 mm	0-15
		22.4 mm	0-5
2	63 mm to 45 mm	90 mm	100
		63 mm	90-100
		53 mm	25-75
		45 mm	0-15
		22.4 mm	0-5
3	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

Note: The compacted thickness for a layer with Grade 1 shall be 100 mm while for a layer with Grade 2, it shall be 75 mm.

Table 12.3.2
Physical requirements of coarse aggregates or water-bound macadam sub-base and base courses

Sl. No.	Test	Test Method	Requirement (Maximum)
1.	*Los Angeles Abrasion value	IS :2386 (Part-4)	50 per cent
2.	* Aggregate Impact value	IS :2386 (Part-4)	40 per cent
3.	*Flakiness Index	IS :2386 (Part-1)	15 per cent

* Aggregate may satisfy requirements of either of the two tests

4. Construction Method

1. Preparation of Sub-grade/ sub-base

- a) The surface of the sub-grade/ sub-base or existing surface shall be shaped and prepared to the lines, levels, grades, dimensions and cross sections as shown on the Drawings. Damage to or deterioration of sub-grade/ sub-base shall be made good before sub-base/ base is overlaid.

b) Inverted Choke

If water bound macadam is to be laid directly over the sub grade, without any intervening pavement or soling course, a 25 mm course of screenings or coarse sand shall be spread and compacted on the prepared subgrade before application of the coarse aggregate. In case of fine sand or silty or clayey sub grade, a 100 mm insulating layer of screenings or coarse sand shall be laid, the gradation of which will depend on drainage requirements. Alternatively, appropriate geosynthetics performing functions of separation and drainage layer may be used over the prepared sub-grade subject to the satisfaction of the Engineer.

5. Spreading coarse aggregates

- a) The coarse aggregates of specified size and grading shall be spread uniformly in layers with each compacted layer thickness not more than 100mm for Grading 1 and 75 mm for Grading 2 and in a manner that prevents segregation into fine and coarse materials.
- b) Sub-base/ or base material shall contain moisture nearly equalising the optimum moisture content at the time of compaction.
- c) Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment. Rolling operations shall begin from the outer edge of roadbed towards the centre, gradually in a longitudinal direction; except on super-elevated curves, where rolling shall begin at the lower edge and progress towards the upper edge. The rolling shall be continued until the aggregates are thoroughly keyed, well-bounded and firmly set in its full depth.

6. Tolerance

The finished sub-base/ base at any point shall not vary more than 15mm below and 12mm above the planned grade or adjusted grade with 3m straight edge applied to the surface parallel to the centreline of the road. With the template laid transversely the maximum permissible variation from specified profile shall be 12mm and 8mm respectively.

The sub-base/ base course completed in each day's work shall have an average thickness not less than the required thickness. Sub-base/ base course which does not conform to the above requirements shall be reworked.

1.4 Bituminous Materials

1.4.1 Materials

Materials shall meet the requirements of the relevant IS Codes. These shall be of the following types.

1. **Cut back Bitumen**

Cut back bitumen shall be Rapid Curing (RC), Medium Curing (MC) or Slow Curing (SC) conforming to IS : 217.

2. **Cationic Emulsion**

Bitumen emulsions of the cationic type for roads shall conform to IS: 8887. Emulsified bitumen shall be Rapid Setting (RS), Medium Setting (MS), or Slow Setting (SS). The physical and chemical requirements of the three types emulsions shall comply with the requirements specified in Table 1 of IS: 8887.

3. **Paving Bitumen**

Paving bitumen shall be conforming to IS: 73 and of the following two types:

Type 1 Paving bitumen from non-waxy crude shall satisfy the requirements given in Table 1 of IS: 73.

Type 2 Paving bitumen from waxy crude shall satisfy the requirements given in Table 2 of IS: 73. The temperature at application of bituminous materials shall be maintained as per manufacturer's instructions and/or as directed by the Engineer's Representative.

An anti-stripping and Bonding agent should be used in all final restoration road works. It should conform to IS: 14982-2001 Specifications. The percentage can be from 0.5% to 1.25% by weight of bitumen content. The optimum dose can be ascertained using M.O.S.T. / BIS guidelines.;

1.4.2 **Methods of Storage and Handling**

Asphaltic material shall be handled and stored with due regard for safety and in such a way that at the time of use in the work the material conforms to the Specifications. Following precautions shall be taken while using these materials:

1. Work with these materials shall be carried out in good weather conditions and it shall be carried out in warm and dry weather, and not in wet or extremely cold weather.
2. Emulsified asphalt shall be handled with care and not subjected to mechanical shocks or extremes of temperature likely to cause separation of the asphalt. Emulsified asphalt showing sign of separation shall not be used.
3. During heating, no water or moisture shall be allowed to enter the boiler.
4. Heating of bitumen shall be done to the correct temperature range, as prescribed by the manufacturer for the grade used. The temperature shall be controlled with the use of a suitable thermometer, and the material shall be drawn and used while still at such temperature as is prescribed by manufacturer or in accordance with MOST specifications.
5. It shall be ensured that mixing of ingredients is thorough and all particles of aggregates are coated uniformly and fully.

1.5 **Prime Coat**

1.5.1 **Description**

This work shall consist of the cleaning and preparing of the surface to be primed to specified lines, grade, and cross-section, booming and clearing thoroughly and applying bituminous material in accordance with these Specifications

1.5.2 Materials

The choice of the primer shall depend upon the porosity characteristics of the surface to be primed. The primer shall be Medium Curing Cutback (MC) and the particular grade to be used for the work shall have the consent of the Engineer. Slow setting Cationic emulsion conforming to IS: 8887 may also be used. Sampling and testing of bituminous primer shall be as per IS: 217, IS : 454 and IS : 8887

1.5.3 Construction Methods**1. Weather Limitations**

Prime coat shall not be applied at a time when the surface is wet or when the weather is foggy, rainy or windy.

2. Equipment

The equipment used for the work shall include a power broom and primer material distributor spraying it uniformly at specified rates and temperatures. It shall be equipped with self-heating arrangement, suitable pump, adequate capacity compressor and spraying bar with nozzles having constant volume or pressure system. Spraying by manual methods may be allowed for inaccessible or small areas with the consent of the Engineer.

3. Cleaning Surface

Immediately prior to applying the prime coat the surface to be primed shall be swept clean from all loose dirt and other objectionable material and shall be shaped to the required lines, grades, cross section.

4. Application of bituminous primer

The primer material shall be applied by means of a distributor at rates usually from 0.8 to 1.4 liters per square meter and at a temperature within the allowable range corresponding to the material used and porosity condition of surface over which it is laid .The temperature of primer at time of application may vary from 400 C to 600 C for cutback bitumen and 400 C to 600 C for bitumen emulsion

Prime coat shall be allowed to penetrate for at least 48 hours to allow penetration into the base course and aeration of volatile from the primer material, then covered with clean dry sand or stone screening. Areas containing an excess or deficiency of priming material shall be corrected by the addition of sand or primer.

1.6 Tack Coat**1.6.1 Description**

This work shall consist of furnishing and applying bituminous material to an existing road surface or to an existing bituminous prime coat surface which has dried out or preparatory to laying another bituminous layer over it.

1.6.2 Materials

The material for tack coat shall be a bituminous or cut back emulsion of suitable type and grade.

1.6.3 Construction Methods**1. Cleaning Surface**

The whole surface on which the tack coat is to be applied shall be cleaned of dust and any extraneous material before the start of application of tack coat by using a power broom or any other equipment/ method.

2. Application of tack coat material

The tack coat material shall be applied uniformly by means of a distributor at controlled rates as per MORTH specifications and at the temperature within the allowable range corresponding to the material used. It shall be done with self-propelled or towelled bitumen. Surfaces of structures and trees adjacent to the areas being treated shall be protected in such a way as to prevent their being splattered or marred.

1.7 Bituminous Macadam

1.7.1 Description

The work shall consist of one or more applications of compacted crushed aggregates premixed with bituminous binder (suitable grade) to a primed non-bituminous surface or previously constructed bituminous surface and in conformity with the lines, grades, dimensions and cross-sections shown on the Drawings. This shall comprise of a single course of 50mm to 75mm thickness as specified in the approve or as Directed by Engineer.

1.7.2 Materials

1. Bitumen

The bitumen shall be paving bitumen of suitable grade approved by the Engineer and conforming to IS:73.

2. Additives

Adhesion and Ant-stripping agent shall be added to the bitumen subject to Engineer's consent at the required percentage of additive. The additive shall be thoroughly mixed with the bituminous material in accordance with the manufacturer's instructions.

3. Aggregates

Aggregates shall consist of clean and hard crushed stone free from dust, clay, dirt and any other deleterious matter. The physical requirements shall be as given in Table 12.7.1. 'Aggregates shall conform to one of the two gradings given in Table 12.7.2 depending on the compacted thickness; the actual grading shall have the consent of the Engineer.

Table 13.7.1

Physical requirements of aggregates for bituminous macadam

Test	Test Method	Requirement (maximum)
Los Angeles Abrasion value	IS :2386 (Part-4)	40 per cent
* Aggregate Impact value	IS :2386 (Part-4)	30 per cent
Flakiness Index and Elongation Indices (Total)	IS : 2386(Part-1)	30 per cent
Coating and Stripping of Bitumen aggregate mixtures	AASHTO T-182	Minimum retained coating 95%
Soundness : (i) Loss with Sodium Sulphate 5 cycles (ii) Loss with Magnesium Sulphate 5 cycles		12 percent 18 percent
Water absorption	IS : 2386 (Part-3)	2 per cent

* Aggregates may satisfy requirements for either of the two tests

IS Sieve Designation	Per cent by weight passing the sieve	
	Grading 1	Grading 2
45.0mm	100	-

26.5mm	75-100	100
22.4mm	60-95	75-100
11.2mm	30-55	50-85
5.6mm	15-35	20-40
2.8mm	5-20	5-20
90.0 micron		

Bitumen content for pre mixing shall be 4% by weight of total mix unless otherwise approved by Engineer.

1.7.3

Construction Method

1. Weather and Control of Work

The work of laying shall not be undertaken 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 15°C or less. The Engineer may order work to cease temporarily on account of adverse weather, unsatisfactory condition of materials, equipment or any conditions which he considers may affect the work adversely.

2. Cleaning and Preparation of Surface

Prior to the application of binder, loose dirt and other objectionable material shall be removed from the surface to be treated by means of the power broom or blower or both. If this does not provide a uniformly clean surface, additional sweeping shall be done by hand, using stiff brushes or similar brooms. The areas inaccessible to the cleaning means shall be cleaned manually. The sweeping shall extend 200mm beyond each edge of the area to be treated.

Adherent patches of objectionable material shall be removed from the surface by steel scraper or other approved method and where the Engineer so directs the scraped area shall be washed down with water and hand brooms. No application of bituminous material shall be undertaken until the surface has been cleaned to the satisfaction of the Engineer.

Before application of the bituminous material any necessary preliminary patching of the surface of the road (To fill in potholes.) shall be done to the complete satisfaction of the Engineer.

Tack coat shall be applied in accordance with these Specifications. Prime coat if required, shall conform to Subsection 12.5.

3. Plant and Equipment

All plant used by the Contractor for the preparation, hauling and placing of asphalt mixtures shall be subject to the consent of the Engineer and shall minimise smoke, dust and noxious emission and odours. These shall generally meet the following requirements:

- a. The mixing plant shall be a batching plant and shall have adequate capacity sufficient to supply the finisher on the road continuously when spreading the asphaltic mix at normal speed and required thickness.
- b. Scale for any weigh box shall be designed to be accurate to within 1% of the maximum load required and shall be fully automatically controlled. The Contractor shall provide and have at hand not less than ten 25 kilogram weights for frequent testing of all scales.
- c. Weigh box or hopper shall include a means for accurately weighing each bin size of aggregate in a weight

box or hopper, suspended on scales, ample in size to hold a full batch without running over.

- d. The asphaltic materials shall be stored in storage tanks designed to keep the temperature of the asphaltic material at maximum temperature of 1100 C. The properties of the asphaltic material kept in that storage tanks shall be in good condition before mixing. The plant shall be provided with a circulating system to ensure continuous circulation between the storage tank and the mixer.
- e. The plant shall be provided with a cold bin for feeding the aggregates. Bin shall have a calibration gate and a mechanical means to insure uniform feeding of the aggregates into the drier as required by the Engineer.
- f. The rotary drier shall be capable of drying and heating the aggregates to the specified temperature.
- g. The plant shall be provided with plant screens capable of screening all aggregates to the specified sizes.
- h. The plant shall include at least 3 hot bins for storing the aggregates fed from the drier after passing through the screen. Each bin shall be provided with an overflow pipe to prevent any backing up of material into other bins.
- i. The plant shall be provided with asphaltic control unit by weighing to obtain the proper amount of asphaltic material in the mix within the tolerance specified for the job-mix.
- j. The batch mixer shall be an approved twin pugmill type and capable of producing a continuous uniform mixture within the job-mix tolerances. The mixer capacity shall not be less than 1,000 kilogram batch.
- k. An armoured thermometer reading from 500 C to 2000 C shall be fixed in the asphaltic feed line at a suitable location near the discharge valve at the mixer unit. The plant shall be further equipped with an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregate.
- l. The plant shall be equipped with a dust collector.
- m. The plant shall be equipped with accurate positive means to govern the time of mixing and to maintain it constant. The time of mixing shall be divided into two steps, dry mixing and wet mixing. For dry mixing, the aggregate from hot bins shall be mixed for a period of 5-15 seconds. For wet mixing, the mixing time shall begin with the start of the asphalt spray after dry mixing. The wet mixing shall take about 30-45 seconds. The mixing time shall be extended if in the consideration of the Engineer the material obtained is not homogeneous.

4. Equipment for Hauling and placing

- a. Trucks for hauling asphaltic mixtures shall have tight, clean, and smooth metal beds that have been sprayed with soapy water, thinned fuel oil, or lime solution to prevent the mixing from adhering to the beds (The amount of sprayed fluid shall however be kept to the practical minimum. Each load shall be covered with a canvas or other suitable material of such size as to protect the mixture from the weather). Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall upon direction of the Engineer be removed from the work until such conditions are corrected.

- b. The equipment for spreading and finishing shall be mechanical, self-powered pavers, capable of spreading and finishing the mixture true to the lines, grades, dimensions and cross sections. The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly.
- c. The pavers shall maintain trueness of grade and confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to give the cross-section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of material required.
- d. Pavers shall be equipped with activated screeds and devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring.
- e. The term "screed" includes any cutting, crowing, or other practical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.
- f. If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities, the use of such equipment shall be discontinued and other satisfactory spreading and finishing shall be provided by the Contractor forthwith.

5. Preparation and transport of mix

Bituminous macadam mix shall be prepared in a hot-mix plant either owned by the Contractor or it may be taken from an approved hot mix plant before supply of mix for the work, consent for the use of the mix shall be taken from the Engineer. The hot-mix plant should be of adequate capacity of batch mix type with the features as described under Subsection 15.7.3(3) or otherwise approved by Engineer unless some work specific features are required and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. The plant shall meet the overall requirements through stringent quality control practices.

The mineral aggregates shall be dried and heated to a temperature between 1500 C and 1630 C. The contractor shall submit for consent the exact temperature to the Engineer. Surfaces of aggregates shall be clean and free of carbon and unburnt fuel oil. The aggregates, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for combining and mixing with asphaltic material.

The dried mineral aggregates prepared as prescribed above, shall be combined in the plant in the amount of each fraction of aggregate required to meet the job-mix formula for the particular mixture. The proper amount of asphaltic material shall be distributed over the mineral aggregate and the whole thoroughly mixed for a period of at least 30 seconds, or longer if necessary to produce a homogeneous mixture in which all particles of the mineral aggregates are coated uniformly. The total mixing time shall be regulated by a suitable locking means.

The mixture shall when emptied from the mixer be at a temperature between 1500 C and 1630 C even for tolerances.

The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Subsection 15.7.3 (4)(a) unless otherwise approved by the Engineer.

6. Application of the Pre-mix

The application of the mix shall proceed immediately after application of tack coat. The mix shall be spread immediately by means of self-propelled mechanical paver with suitable screeds capable of spreading, tamping, and finishing the mix true to lines, levels, dimensions and cross-sections specified. Any bare or insufficiently filled areas shall be re-treated by the mechanical spreader or covered by hand as necessary to give uniform and complete coverage. Any aggregate spread in excess of the agreed rate shall be scattered and evenly distributed on the road or otherwise removed and stockpiled. The temperature of the mix at the time of laying shall be in the range of 120 or 1600 C

7. Rolling

After the spreading of the mix, the rolling shall be done by road roller of suitable type and capacity. Rolling shall start as soon as possible after the material has been spread and it shall be completed within limited time frame, and to meet this, the Contractor shall deploy a set of rollers. Rolling shall be done with care to avoid unduly roughening of the pavement surface. It shall commence at the edges and progress towards the centre longitudinally except that on super-elevated and unidirectional cambered portions, it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The speed of the rollers shall not exceed 5 kilometre per hour for steel wheeled rollers and 7 kilometre per hour for pneumatic tired rollers and shall be at all times slow enough to avoid displacement of the hot mixture. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh mixture where required. Care shall be exercised in rolling not to displace the line and grade of the edges.

Rolling shall progress continuously as may be necessary to obtain uniform compaction while the mixture is in a workable condition and until all roller marks are eliminated.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until it has thoroughly cooled or set.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is cause for the removal and replacement of the contaminated pavement by the Contractor. 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 material. Rolling shall then be continued until the entire surface has been rolled to 95 % of the average laboratory density, and there is no crushing of aggregates. and all roller marks are eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3rd width. The roller wheels shall be kept damp to prevent premix from adhering to the wheels and being picked up. In no case shall fuel/ lubricating oil be used for this purpose.

Along kerbs, man-holes etc., and at any other locations where proper consolidation by rollers is not practicable, alternative means such as steel rammers shall simultaneously be used to secure adequate consolidation.

1.7.4 Surface Control**1. Surface Regularity**

Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 12mm. Maximum

permissible variation from specified cross profile under camber template shall be as 8mm. Surface evenness requirements in respect of both longitudinal and cross profiles should be simultaneously satisfied.

Tests for conformity with the specified crown and grade shall be made immediately after initial compaction, and variations shall be corrected by removing or adding materials as may be necessary. Rolling shall then be continued as specified. After final rolling, the smoothness of the course shall be checked again and any irregularity of the surface exceeding the permissible limits corrected as agreed by the Engineer's Representative, including removal and replacement

2. **Surface Finish**

The bituminous macadam shall be covered with either the next pavement courses or wearing course, as the case may be, without any delay. If there is to be any delay, the course shall be covered with the seal coat. The seal coat in such cases shall be considered incidental to the work and shall not be paid separately

1.7.5 **Control of Traffic**

This shall be as described under Subsection 12.1 above

1.8 **Open-graded Pre-mix Carpet**

1.8.1 **Description**

This work shall consist of laying and compacting an open-graded carpet generally of 20mm thickness or as otherwise specified in a single course composed of suitable small sized aggregates premixed with a bituminous binder on a previously prepared base to serve as a wearing course

1.8.2 **Materials**

1. **Binder**

Binder shall be bitumen of suitable grade meeting the requirements of the work and other environmental conditions. This shall be conforming to the requirements of IS : 73, IS : 217 and IS : 454 or other approved cut back bitumen as applicable.

2 **Coarse aggregates**

Coarse aggregates consist of crushed stones and shall be clean, strong, durable, and free from organic or other deleterious materials. The aggregates shall be hydrophobic and of low porosity. If hydrophilic aggregates are to be used, bitumen shall preferably be treated with anti-stripping agents of approved quality in suitable doses.

The aggregates shall meet the requirements given in Table 12.7.1 except that the water absorption shall be limited to 1 per cent. The Stone Polishing Value as measured by BS: 812-(Part-114) shall not be less than 55.

3. Proportioning of Materials They shall comprise of a mix of stone chipping 13.2mm size (passing 22.4 mm sieve and retained on 11.2 mm size) and 11.2 mm size (passing 13.2 mm sieve and retained on 5.6 mm sieve.)

The contractor shall propose material proportions to the Engineer for his consent.

1.8.3 **Construction Methods**

1. Weather and Control of Work This shall be as carried out per Subsection 12.7.3(1).
2. Cleaning and Preparation of Surface This shall be as carried out per Subsection 12.7.3(3).

3. **Tack Coat** This shall be applied as per Subsection 12.6.

4. **Preparation and transport of Premix** The binder shall be heated to a temperature appropriate to the grade of bitumen in boilers of suitable design avoiding local overheating and ensuring a continuous supply.

The aggregates shall be dry and suitably pre-heated to the required temperature before they are placed in a mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified. Mixing shall be continuous and thorough to ensure a homogeneous mixture in which all particles are coated uniformly and the discharge temperature shall be within the specified range.

The mixing of binder with chippings shall be continued until the chippings are thoroughly coated with binder. The mix shall be discharged and immediately transported from mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and the mix being transported should be covered in transit and protected from any kind of damage.

5. **Spreading and Rolling**

Immediately after the application of tack coat, premixed material shall be spread by means of mechanical paver finisher truly to lines, levels, dimensions and cross section as specified. The areas not covered by the mechanical means shall be treated with manual means for which the Engineer has given his consent.

6. **Rolling**

This shall be carried out as per Subsection 12.7.3(7)

1.8.4 **Control of Traffic**

Subsection 12.1 shall be followed

1.9 **Bituminous Concrete**

1.9.3 **Description**

This work shall consist of a surfacing of single-layer bituminous concrete of specified thickness on previously prepared bituminous surface to the lines, grades, dimensions and cross section as shown on Drawings. It shall be 25mm / 40mm thick as required by Engineer.

1.9.4 **Materials**

1. **Bitumen**

The bitumen shall be paving bitumen of suitable penetration grade within the range S 35 to S 90 or A 90 to IS: 73. The actual grade of bitumen to be used shall be appropriate to the requirements of the work and environmental conditions.

2. **Coarse aggregates**

The aggregates shall satisfy the physical requirements given in Table 15.7.1. Flakiness index shall not exceed 30% and water absorbed not more than 1%.

3. **Fine aggregates**

Fine aggregates shall be the fraction passing 2.36 mm sieve and retained on 75-micron sieve, consisting of crushed run screenings, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry and free from any injurious, soft or flaky pieces and organic or other deleterious substances.

4. **Filler**

Filter shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement. The filter shall be graded within following limits:

IS Sieve	Per cent passing by weight
600 micron	100
300 micron	95 - 100
75 micron	85 - 100

The filter shall be free from organic impurities and have a Plasticity Index not greater than 4. The Plasticity Index requirement shall not apply if filter is cement or lime. When coarse aggregate is gravel, 2 per cent of mass of total aggregate of Portland cement or hydrated lime shall be added and percentage of fine aggregate reduced accordingly. Cement or lime is not required when the gravel is lime stone.

5. Aggregate gradation

Mineral aggregates, including filler shall be so graded or combined as to conform to grading set forth in Table 15.9.1 below

Table 13.9.1

Sieve Designation	Per cent by weight passing through sieve for		
	25mm thick Grade 1	25-40mm thick Grade 2	>40mm thick Grade 1
26.5mm			100
22.4mm		100	75-100
13.2mm	100	80-100	--
11.2mm	90-100	75-95	50-85
5.6mm	60-80	55-75	20-40
2.8mm	40-55	40-55	5-20
710micron	20-30	20-30	--
300micron	15-25	15-25	--
180micron	10-20	10-20	--
90micron	5-11	5-11	0.5

1.9.5 Mix Design

1. Requirement of Mix

Apart from conformity with grading and quality requirements of individual ingredients, the mix shall also meet the requirements set forth in Table 15.9.2.

Table 13.9.2

Sl.No.	Description	Requirements
1.	Marshall stability (ASTM Designation : D-1559) determined on Marshall specimens compacted by 75 compaction blows on each	820 Kg (1800 pounds)
2.	Marshall flow (mm)	Minimum 2-4
3.	Per cent air voids in mix	3-5
4.	Per cent voids in mineral aggregate (VMA)	Minimum 11-13
5.	Percent voids in mineral aggregates filled by bitumen (VFB)	65-75
6.	Binder content, per cent by weight of mix	Minimum 4.5
7.	Water sensitivity (ASTM : D-1075) loss of Stability on immersion in water at 60 deg. C	Minimum 75% Retained strength
8.	Swell Test (Asphalt Instt. MS-2, No.2)	Maximum 1.5%

1. Binder content

Binder content shall be so determined as to achieve the requirements of the mix set forth in Table 12.9.2. Marshall method for arriving at binder content shall be adopted

2. Job Mix Formula

Before starting work the Contractor shall submit to the Engineer for his consent. The job mix formula for the mixture shall fix a single percentage of aggregate passing each required sieve size, a single percentage of asphalt to be added to the aggregate, and a single temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the composition and the temperature limits. The formula shall give the following details:

- i. Source and location of all materials
- ii. Proportions of all materials as described under: Binder - as percentage by weight of total mix Coarse aggregate/ Fine aggregate/ Mineral Filler - as percentage by weight of total aggregate including Minerva Filler
- iii. A single definite percentage passing each sieve for the mixed aggregate (Vide Table 12.9.1)
- iv. The results of test as per specifications obtained by the contractor
- v. Test results of physical characteristics of aggregates to be used
- vi. Mixing temperature and compacting temperature

3. Application of job-mix formula and Allowable Tolerances

The approved job mix formula shall remain effective unless and until modified. Each day as many samples of the materials and mixtures shall be taken and tested considers necessary for checking the required uniformity of the mixture.

All mixture furnished shall conform to the job-mix formula within the range of tolerances set in forth in Table 12.9.3.

Table 13.9.3
Permissible variations from the job-mix formula

Sl. No.	Description of Ingredients	Permissible Variation by Weight of Total mix in Percentage
1	Aggregate passing 13.2mm sieve and larger	+/- 8
2	Aggregate passing 9.5mm sieve and 4.75mm sieve	+/- 7
3	Aggregate passing 2.36mm sieve & 1.18mm sieve	+/- 6
4	Aggregate passing 600 micron sieve & 300 micron sieve	+/- 5
5	Aggregate passing 150 micron sieve	+/- 4
6	Aggregate passing 75 micron sieve	+/- 3
7	Binder	+/- 0.3
8	Mixing Temperature (Centigrade)	+/- 10

When unsatisfactory results or changed conditions make it necessary, a new job mix shall be submitted to the Engineer.

Should a change in a material be encountered or should a change in a source of material be made, a new job mix formula shall be submitted before the mixture containing the new material is delivered

1.9.6 Construction Methods

1. Weather Limitation

The control over the weather conditions shall be as described under Subsection 12.7.3 (1) above

2. Progress of Work

No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or labour to ensure progress at a rate not less than 75% of the capacity of the mixing plant

3. Preparation of Existing Surface

The surface on which the mix is to be laid shall be swept thoroughly and cleaned of all loose dirt and other objectionable material using mechanical broom immediately before start of work. In portions where mechanical means cannot reach, the surface shall be prepared, shaped and conditioned to specified levels, grade and cross-fall (camber).

4. Preparation of Mix

A Hot-mix plant of adequate capacity and capable of producing a proper and uniform quality mix shall be used for preparing the mix. The plant may be either a weigh batch type or volumetric proportioning continuous or drum mix type. The plant shall have co-ordinated set of essential units capable of producing uniform mix as per the job-mix formula.

The temperature of the binder at the time of mixing shall be in the range of 150 to 163 degree C and of aggregates in the range of 155 to 163 degree C, provided also that at no time shall the difference in

temperature between the aggregates and binder exceed 14 degree C. The Contractor shall submit the exact temperatures and total mixing time for the consent of the Engineer. Mixing shall be thorough to ensure that a homogeneous mixture is obtained in which all particle of mineral aggregates are coated uniformly

5. **Transportation and Delivery of Mix.**

The mix shall be transported from the mixing plant to the point of use in suitable tipper vehicles. The vehicles employed for the transport shall be clean and be covered in transit.

6. **Spreading and Finishing**

The mix transported from the hot mix plant to the site and shall be spread by means of a self-propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to specified grade, elevation, and cross-section. However, in restricted locations and narrow widths, where available equipment cannot be operated, other suitable means shall be employed subject to the consent of the Engineer. The mixture shall be laid upon an approved surface and only when weather conditions are considered suitable. The temperature of the mix, at the time of laying, shall be in the range of 120-degree C to 160 degree C.

The prime coat and tack coat to be applied shall be as per Subsections 12.5 and 12.6 respectively. Spreading, finishing and compacting of the mix shall be carried out during daylight hours only, unless satisfactory illumination is provided by the Contractor

7. **Compaction of Mixture**

Immediately after spreading of mix by paver, it shall be thoroughly and uniformly compacted by rolling with a set of self-propelled rollers moving at a speed not more than 5 km per hour, **immediately** following close to the paver. Generally, with each paver, two steel wheeled tandem rollers and one pneumatic tired roller will be required. The initial or breakdown rolling shall be with 8 to 10-ton static weight smooth three wheeled steel roller and finish rolling with 6 to 8 ton tandem roller. The breakdown rolling shall preferably be followed by an intermediate rolling with a smooth wheel pneumatic roller of 10 to 25 ton having a tire pressure of 7kg/sq.cm moving with a speed not more than 7 km per hour and shall be at all times slow enough to avoid displacement of the hot mixture. Means shall be provided for checking and adjusting the tire pressure on the job at all times. All compaction operations, i.e., breakdown rolling can be accomplished by using vibratory roller of 8 to 10-ton static weight. During initial or breakdown rolling and finished rolling, the vibratory shall be switched off. The joints and edges shall be rolled with an 8 to 10 ton three wheeled static roller. No delays in rolling the paved surface shall be tolerated, the breakdown roller must be right up to the paver at all times and the intermediate pneumatic roller right up to the breakdown roller. The compaction of the asphaltic concrete shall be controlled by temperature as follows:

Roller	Temperature
Breakdown	120° C - 135° C
Pneumatic	95° C - 115° C
Finishing	< 65° C

Rolling procedure shall be as specified under Subsection 12.7.3 (7).

Rolling shall be continued till the density achieved is at least 98% of that of laboratory Marshall specimen. Rolling operations shall be completed in all respects before the temperature of the mix falls below 100-degree C.

8. **Joints**

Both longitudinal and lateral joints in successive courses shall be staggered so as not to be one above the other. Longitudinal joints and edges shall be constructed true to delineating lines parallel to the centre line of the road.

Longitudinal joints shall be offset by at least 150mm from those in the lower course.

Longitudinal and transverse joints shall be made in a careful manner so that well bonded and sealed joints are provided for the full depth of the course.

Surface regularity

Surface shall be tested for undulations in longitudinal and cross profiles with 3 m straight edge and crown template respectively. Crown template shall conform to the typical cross section.

Maximum permissible undulation in longitudinal profile with 3m straight edge shall be as 8mm.

Maximum permissible variation from specified cross profile under camber template shall be as 4mm.

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

Protection of the pavement from traffic

Subsection 12.7.5 shall apply except as stated below.

Section of the newly finished works shall be protected from traffic of any kind until the mixture has cooled to approximately ambient air temperature and well set.

1.10 Seal Coat

1.10.3 Description

This work shall consist of application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade, and cross fall. Seal coat used shall be of premix type unless otherwise approved by the Engineer.

1.10.4 Materials

1. Binder

The binder shall be bitumen of a suitable grade appropriate to the requirements of the work and other environmental conditions as directed by the Engineer and satisfying the requirements of IS: 73, 217, 454 or other cut back as applicable.

2. Aggregates

The aggregates shall be sand or grit and shall consist of clean, hard, durable, dry particles and shall be free from dust, soft or flaky/ elongated material, organic matter or other deleterious substances. The aggregates shall pass 2.36mm sieve and be retained on 180-micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sq m area

1.10.5 Construction Methods

1. Preparation of base

The seal coat shall be applied immediately after laying of bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other objectionable matter.

2. Preparation and Application of Mix

Mixtures of approved type shall be employed for mixing aggregates with suitable bituminous binder. The binder shall be heated in boilers of suitable design, to a temperature appropriate to the grade of bitumen. The aggregates shall be clean, dry and suitably heated to a temperature before the same are placed in the mixture. Mixing of binder with aggregates to specified proportions shall be continued till the latter are thoroughly coated with the former.

The mix shall be immediately transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed.

3. Rolling

As soon as sufficient length has been covered with pre-mixed material, the surface shall be rolled with 8-10-ton smooth wheeled steel, suitable vibratory or other equipment. As regards procedure for rolling it shall be as specified under Subsection 12.7.3 (7).

4. Control of Traffic

Subsection 12.1 shall apply.

1.11 Cement Concrete Pavements**1.11.3 General**

This work shall consist of constructing Plain/ or Reinforced Cement Concrete Pavements as required in accordance with these Specification and in conformity with the lines, levels, grades and dimension in accordance with the design

1.11.4 Materials**1. General**

The concrete materials viz. cement, aggregates, water, steel reinforcement, admixtures shall be in accordance with Section 5 on concrete except as specified herein

2. Dowel and Tie Bars Dowel bars shall be plain round bars

They shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the Works, one half of the length of each dowel bar shall be painted with one coat of bituminous material.

Tie bars shall be deformed bars free from oil, dirt, loose rust and scale.

These shall conform to the requirements of IS: 432, IS: 1139 and IS: 1786 as relevant.

3. Sleeves

The sleeves for dowel bars of expansion joints shall be of plastic material. This shall be designed to cover the dowels specified by the Designer, with a closed end, and with a suitable stop to hold the end of the sleeve a distance equal to the thickness of joint filler or at least 30mm from the end of the dowel bar. These shall be of such design that they do not deflect or collapse during construction, and the arrangement of sleeves shall be in accordance with these Specifications.

5. Waterproof Membrane

Where Waterproof membrane is to be provided, it shall be an impermeable polythene plastic sheeting. Where an overlap of underlay material is necessary this shall be at least 300mm. Water shall not be allowed to pond on the membrane which shall be completely dry when the concrete is laid.

6. Jointing Materials**a. Joint Filler**

The expansion joint fillers shall conform to the requirements of IS: 1838. They shall be punched to admit the dowels where called for as specified by the Designer. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened closely together securely and accurately to shape by stapling or other satisfactory positive fastening.

b. Joint Primer

Joint primer shall be fully compatible with the joint sealant and shall be applied strictly in accordance with the manufacturer's instructions

c. Joint Sealing Compound

The Sealing Compound of hot poured, elastomeric type shall conform to AASHTO M282 and cold applied sealant shall be in accordance with BS 5212 (Part 2).

1.12 Equipment and Tools**1.12.1 General**

The concrete paving shall be carried out by use of mechanised method. Equipment and tools necessary for handling materials and performing the work shall have the consent of the Engineer as to design, type, capacity and mechanical, condition shall be at the site of the work before work is started. In special cases like a very short length of road to be laid at a location, other methods may be approved by Engineer

1.12.2 Batching and Mixing Plant

This shall be of suitable type, capacity and make meeting the requirements of work

1.12.3 Paving Equipment

The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i)spread, (ii)consolidate, screed and float finish, (iii)texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications.

Vibrators for full width vibration of concrete paving slabs may be either the surface pan type or the internal type. They may be attached to the spread finisher. They shall not come in contact with the joint, sub base or side forms.

The frequency of the surface vibrators shall not be less than 3500 impulses per minute and for the internal type not less than 5000 impulses per minute. The variable vibration setting shall be provided in the machine.

At least two spare vibrators and one generating unit shall be on hand in case of any breakdown of the vibrating equipment being used.

1.12.4 Concrete Saw for joint cutting

The mechanical saw for cutting concrete shall be adequately powered to cut rapidly with a water-cooled diamond edge saw blade to the depth required. A water tank with flexible hoses and pump shall be made available in this activity on priority basis. The Contractor shall have at least one standby saw in good working condition.

1.12.5 Forms

Straight side forms shall be metal forms having a thickness of at least 5mm and have a depth equal to the prescribed edge thickness of the pavement slab.

Curved forms shall be of the radius called for as specified by the Designer and acceptable flexible forms shall be installed with that radius. Built-up forms with horizontal joints shall not be used. Forms shall be free from kinks, bend or wraps. Forms shall not deflect more than 6 mm when tested as a simple beam with a span of three metres under a load equal to that which the finishers or other construction equipment will exert on them. The top of the form shall not vary from a three metre straight edge by more than 3mm at any point and the side by more than 6mm at any point.

The forms shall contain provision for locking together tightly the ends of abutting form sections and for secure setting.

1.13 Construction Methods**1.13.1 Preparation of Sub-base**

The sub-base, which shall generally be of water-bound macadam (WBM) conforming to Subsection 3.3.

The sub base shall be wetted adequately or provided with a water proof membrane so that it does not absorb any water from the concrete to be laid over it. Concrete shall not be placed on any portion of the sub-base until the consent of the Engineer is given.

1.13.2 **Setting Forms**

The sub-base under the forms shall be compacted and cut to grade so that forms, when set to the position are within + 3mm of a straight line formed by the top of the forms. If the sub-base is found to be below the required grade at the form line, the grade line shall be lifted by placing lean concrete mix 1:4:8 beneath the form and setting the form when it is set. Imperfections and variations above grade shall be corrected by tamping or cutting to the degree required.

The alignment and grade elevations of the forms shall be checked and the necessary corrections made by the Contractor immediately before and after placing the concrete. When any form has been disturbed or any roadbed has become unstable, the form shall be reset and rechecked. On final setting of the forms, these shall be checked for at least half the length of pavement to be concreted in a particular day before concreting commences on that day. While concreting long lengths, the setting up of forms to the exact grade and alignment shall be in advance of the concreting operation by at least 60 m.

Forms shall be cleaned and oiled prior to the placing of concrete. The forms shall be removed not earlier than 24 hours after the concrete has been laid.

1.13.3 **Preparation of Concrete**

a. Trial Mix I Mix Design

Subsection 12.2.1 shall be followed Minimum grade of concrete to be used is M25.

b. Batching, Mixing and Transporting

Materials Subsection 12.2.4 shall apply.

c. The Ready-Mixed Concrete (RMC) shall conform to Subsection 12.2.4 (5).

1.13.4 **Placing Concrete**

Concrete shall be placed only on a prepared sub-base as specified in Subsection 3.12.2. No concrete shall be placed around structures until they have been brought to the required grade and alignment nor until expansion joint material has been placed around them.

The concrete shall be spread, compacted and finished by a mechanical paver and in accordance with Subsection 12.11.3 (3). The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the pavement.

The truck mixers, truck agitators and other approved hauling equipment shall be equipped with means for discharge of concrete into the hopper of the paver without segregation of the materials. In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength of concrete and all other quality control measures for hand laid concrete shall be the same as in the case of machine laid work.

The concrete shall be thoroughly consolidated against and along the faces of all forms by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the sub-base or a side form. In no case shall the vibrator be operated longer than 30 seconds in any location. The vibrator shall be inserted in the concrete and worked along the full length and both sides of a joint.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket on to a joint assembly.

Except at construction joints, concrete shall be shovelled against both sides of the joint simultaneously, maintaining equal pressure on both sides. It shall be deposited to a height of approximately 5 cm more than the depth of the joint, and shall be vibrated avoiding honeycombing voids. The vibrator shall be inserted in the concrete and worked along the full length and both sides of the joints. Subsection 12.2.6 shall also apply.

1.13.5 Initial strike-off and Placement of Reinforcement

Where the concrete is laid in two layers, the bottom layer of concrete shall be struck off for the full width between longitudinal construction joint true to crown at the required distance below the finished surface elevation, for placement of reinforcement or for placement of a top layer of the required thickness.

The striking-off shall be accomplished by use of the finishing machine, unless some other approved device is allowed. The reinforcement shall be placed as called for by the Designer and pouring of concrete over it shall only be allowed after placement of reinforcement is proper in all respects and approved by the Engineer.

1.13.6 Joints

(a) General

Joints shall comply with the design approved for the construction. A strip of the preformed expansion joint filler shall be placed around each structure which extends into or through the pavement before concrete is placed.

(b) Transverse Expansion Joints

These shall be formed at the design spacing. The material for a transverse joint shall be assembled at the roadbed, and placed into position as a unit.

(c) Transverse Contraction Joints

Transverse Contraction joints shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement. Transverse contraction joints shall also include load transfer dowel- bars where these are specified by the Designer.

The contraction joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take up the load of joint sawing machine without causing damage to the slab.

Grooves shall be at right angles to the centreline of the pavement and shall be true to line, subject to a tolerance of 5 mm in the width of the slab.

Any procedure for sawing joints that results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete and cutting of the joints.

Load transfer assemblies for transverse contraction joints shall consist of dowel bars without sleeves and an approved auxiliary spacing and supporting element.

The assembly shall be placed into position so that the dowels are parallel to the centreline and shall be staked into position in such a way as to hold the assembly securely in position throughout construction.

(d) Longitudinal Joints

Longitudinal joints shall be constructed in conformity with the design. Planes of weakness shall be created by forming or cutting grooves in the surface of the pavement in accordance with the applicable provisions of this Section. When adjacent lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. The bars may be bent at angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is poured.

(e) Transverse Construction Joint

Transverse construction joints shall be placed whenever concreting is completed after a day's work or is suspended for more than duration permissible for continuous pouring of concrete. Joints shall be formed by placing installing bars or suitable bulkhead material so that a vertical face with approved key is formed or shall be butt joints formed with suitable material so that a vertical face is formed with no key. No tie bars shall be necessary when key joints are formed but dowel bars of the same dimensions and at the same spacing as for contraction joints shall be necessary at all butt joints.

1.13.7 Finishing

(a) Machine Finishing

As soon as the concrete has been placed, it shall be struck off and screeded by an approved finishing machine or tools to the grades and cross sections specified by the Designer and to a level slightly above grade so that when properly consolidated and finished the surface of the pavement will be at the exact level and grade. The machine or tool shall go over each area of pavement as many times and at such intervals as necessary to give the proper compaction and to leave a surface of uniform texture, true to grade and cross section.

Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machine on the forms shall be maintained true without lift, wobble or other variation tending to effect the precision finish.

After concrete has been placed on both sides of the joint and struck off, the installing bar or channel cap shall be slowly and carefully withdrawn, the concrete shall be carefully spaded and additional freshly mixed concrete worked into any depression left by the removal of the installing bar. A diagonal finishing machine shall be used if available.

(b) Hand Finishing

A portable screed shall be provided for use. The screed shall be at least 60 cm longer than the width of the slab to be struck off and consolidated. It shall be of approved shape, sufficiently rigid to retain its shape and constructed either of metal or of other material shod with metal. (If necessary, a second screed shall be provided for striking off the bottom layer of concrete).

The screed shall then be placed on the forms and slip along them, without lifting, in a combined longitudinal and transverse shearing motion moving always in the direction in which the work is progressing. If necessary this shall be repeated until the surface is of uniform texture, true to grade and contour, and free from porous areas

(c) Edging at Forms and Joints.

After the concrete's initial set, the edges of the pavement along each side of each slab, and on each side of transverse expansion joints, planes of weakness except when sawed transverse construction joints, and emergency construction joints shall be worked with an approved tool and rounded to a radius of 5 mm. A well-defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting of the tool during use.

All joints shall be tested with a straight edge before the concrete has set, and correction shall be made if one side of the joint is higher than the other or if they are higher or lower than the adjacent slabs.

1.13.8 **Surface Texture**

The surface of the carriage-way shall be textured by wire brushing in a direction at right angles to the longitudinal axis of the carriage-way. The pavement shall be given this broomed texturing as soon as surplus water has risen to the surface.

The wire brushes shall be either mechanically operated or manual methods may be allowed depending upon the type of paver being used on the Work. In either case the wire broom shall be not less than 450 mm wide with two rows of spring steel. At least two brooms in working order shall be on the site at all times.

The surface texturing shall be completed before the concrete is in such condition that the surface is torn or unduly roughened by the brooming. The broomed surface shall be free from rough areas, porous areas, irregularities, or depressions

1.13.9 **Surface Requirements**

After the concrete has hardened sufficiently, the surface shall be given a further test for trueens, using an approved 3 m straight edge laid on the surface. Any portion of the surface, when tested in the longitudinal direction, which shows a variation or departure from the testing edge of more than 3.5mm but not exceeding 7mm shall be marked and immediately ground down with an approved grinding tool until the variation does not exceed 3.5mm.

Whenever the variation or departure from the testing edge is more than 7.0mm the pavement shall be removed and replaced. Such removal shall be of the full depth and width of the slab and at least 3m long.

1.13.10 **Curing**

Immediately after the surface texturing, the surface and sides of the slab shall be cured by approved curing method for not less than 7 days. During this period measures shall be taken to prevent the loss of moisture.

The concrete shall not be left exposed between stages of curing.

The surface shall be inspected regularly to ascertain the earliest time at which it is able to withstand the spreading of moisture retaining material. This shall be by ponding of water or spreading and wetting either two layers of burlap or two mats of cotton l jute or a layer of sand or other approved highly absorbent material. Whatever material is used it shall be kept continuously moist for not less than 7 days and to a degree which will ensure that 100% humidity is maintained adjacent to the concrete surface. A membrane curing compound meeting the requirements of BS 7542 may be used subject to the consent of the Engineer.

Concrete surfaces which are subjected to heavy rainfall within three hours after the curing compound has been applied shall be resprayed by the method and the coverage specified above.

Concrete surfaces to which membrane curing compounds have been applied shall be adequately protected for the duration of the entire curing period from the pedestrian and vehicular traffic, except as required for joint sawing operations and surfaces tests, and from any other cause which will disrupt the continuity of the membrane. The curing membrane so formed shall be maintained intact for a period of not less than 14 days. The entire surface shall be protected from the effects of solar radiation and in addition by the use of frames covered with material with heat and light reflecting properties.

Concrete liable to be affected by running water shall be adequately protected from the damage during

the setting period

1.13.11 Removing Forms

Forms shall be removed only after stipulated period and carefully so as to avoid damage to the pavement

1.13.12 Protection of Pavement

The Contractor shall erect and maintain suitable barricades and shall employ watchmen to exclude public traffic and that of his employees and agents from the newly constructed pavement until opened for use. These barriers shall be arranged as not to interfere with public traffic on any lane intended to be kept open and necessary signs and lights shall be maintained by the Contractor clearly indicating any lanes open to the public. Where any stipulated public traffic lane is contiguous to the slab or lane being placed, the Contractor shall provide, erect, and subsequently remove a substantial temporary guard fence along the prescribed dividing line, which shall be maintained there and protected by signages until the slab is opened to traffic. The Contractor's plan of operation shall be such as to obviate any need for encroachment on the public traffic lane or lanes under use.

The same shall be approved by the local competent authority.

Any part of the pavement damaged by traffic or other cause prior to its final acceptance shall be repaired or replaced by the Contractor.

1.13.13 Sealing Joints

Before the pavement is opened to traffic, and as soon after the curing period as is feasible, all joints both longitudinal and transverse, shall be filled with the material approved for use as seal.

Both primer and sealing compound shall be treated and applied strictly in accordance with the manufacturer's specifications/ instruction and by use of approved equipment.

The sealing material shall be poured into each joint opening as directed by the Engineer. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned.

TECHNICAL SPECIFICATION S-19: REINFORCED EARTH

S19 - REINFORCED EARTH ADDITIONAL SPECIFICATION FOR REINFORCED EARTH**1. REINFORCED EARTH**

The work shall be carried out as per the Cl. 3100 of latest edition of (MORTH) as published by Indian Roads Congress.

1.1 MEASUREMENT:

The measurement for reinforced soil wall shall be in Square metres of finished work of each face and shall be measured in the plane of final inclination specified in the drawings. The measurement of length shall be the finished work along the length of the road. The measurement of height along the slope shall be done from the top level of the footing on which the fascia element is placed to the top of the capping beam.

The rates shall include cost of material, labour, plant, royalties, handling, storage and transportation expenses, cost of bed block, levelling pads, fascia elements, capping beam, connectors, reinforcing elements, scaffolding, supply of the specified filter media materials including drainage arrangement, supply of soil fill for the reinforced as well as unreinforced zone of the quality specified in the design/ drawings, placing, spreading and compaction through mechanical means.

The rate shall include full compensation for design, drawings and testing of materials.

The rate shall include the cost of investigations, design and construction of ground improvement measures. Measurement for friction slab and crash barriers is included in the lumpsum price quoted in the price schedule.

The rates of above items of work are included in the lumpsum price of price schedule.