SECTION - 8B

TECHNICAL SPECIFICATIONS

SECTION-8B
TECHNICAL SPECIFICATIONS

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SECTION - 01

GENERAL

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1. 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 submitted by the contractor and approved by the Employer / Engineer duly signed and stamped or issued to the Contractor by the Engineer duly signed and stamped by him as the case may be. 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 Employer / 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).

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.

1.1.5 The specifications have been divided into different sections / sub-heads for convenience only. They do not restrict any cross-references. The Contractor shall take into account inter-relations 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 purposes of measurements and payments shall be as per Price Schedule. Except where distinguished by Price Schedule, the Lumpsum Price apply to all heights, depths, leads, lifts, sizes, shapes and locations. They also cater for all cuts and wastes. No height wise / floor wise separation. Likewise, all heights of centering, shuttering, staging, formwork and scaffolding, launching trusses and other launching methods are covered by the quoted Lumpsum Price including multi stage propping for heights greater than one lift / 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 Institut für Normung e.V.
IRC	Indian Road Congress
IRS	Indian Railway Standards
IS	Indian Standards
JIS	Japanese Industrial Standard
MORTH	Ministry of Road Transport and Highways

1.1.8 OTHER PUBLICATIONS:

1. American Petroleum Industry (API) Standard 1104
2. RDSO Guidelines for certification of metro 2015 with amendment upto date.
3. 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 manuals etc.
4. KRIDE DBR
5. MoHUA Guidelines

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6. Indian Standard Hand Book on steel sections Part-I
7. Indian Railway Manual on Design and Construction of well and pile foundations
8. UIC/772-R The International Union of Railways Publication
9. CIRIA Report 80 A review of instruments for gas and dust monitoring underground
10. CIRIA Report 81 Tunnel Water proofing
11. CIRIA Report 44 model code of practice for work in compressed air
12. CIRIA Report C660 Early age thermal crack control in concrete
13. CIRIA Report 91 Early age thermal crack control in concrete
14. Swedish standard 05 59 00
15. PCI STD-112-84
16. CRRI and IOC, New Delhi Bituminous Road Construction Hand Book
17. Indian Railways Construction Hand Book

Alternative or additional codes and standards proposed by the contractor shall be internationally recognised codes and shall be equivalent to or better than, Indian Standards issued by the Bureau of Indian Standards or any other Indian professional body or organisation, subject to being, in the opinion of the Employer's Representative, suitable for incorporation or reference into the specifications

1.1.9 Items / Facilities to be provided by the Contractor

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 Price Schedule the cost being held to be included in the Contract Lumpsum 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 completing and maintaining the works to the satisfaction of the Employer / Engineer.

3. Adequate lighting for night works, and also at other times whenever and wherever required by the Employer / Engineer.

4. 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.

All fences, barricade shall be painted with colour shades as specified by the Employer / Engineer. The barricading should be of adequate height to ensure visual obstruction of work from public view.

5. All equipment, instruments, labour and materials required by the Engineer for checking alignment, levels, slopes and evenness of surfaces measurements and quality etc.

6. 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 shall be submitted to the Engineer for his approval before adoption on works.

7. Cost of Preparation and compliance with provision of a quality assurance control program.

8. Cost of safe guarding the environment as per SCC.

9. Contractor has to provide Method statements i.e., detailed work procedure for all the works

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10. A testing laboratory as specified by the Engineer equipped with not limited to the following apparatus, materials and competent trained staff required for carrying out tests, as specified in the relevant sections of the specifications in adequate quantity.

(i) 1 Set of standard sieves for testing grading of sand with mechanical sieve shaker.
(ii) Sieves with openings respectively of 4.75mm, 10mm, 20mm, 25mm, and 30mm for testing and grading of aggregates.
(iii) Digital Weighing Balance of capacity up to 10 Kg. reading up to 1 gm.
(iv) Electric controlled oven and pans for drying of sand and aggregates.
(v) Glass measuring flasks /2, 1 liter & 2-liter capacities.
(vi) Flask for determining moisture content of sand.
(vii) Slump cone with rod and V B Apparatus, flow table to measure slump or DIN Specifications (separate sets for laboratory and at Site).
(viii) Apparatus to measure permeability of concrete as per Appendix 1700/II of MORTH Specifications.
(ix) Sufficient Nos. steel moulds for 150mm x 150mm x 150mm concrete test cubes. It may be necessary to provide more steel cube moulds depending upon concreting programme.
(x) Sufficient number of 25mm dia vibrator for compaction of concrete in test cubes, vibrating table.
(xi) Digital Concrete cube testing machine of 200 tones Minimum capacity with direct print out facility.
(xii) Work benches, shelves, desks, sinks and any other furniture and lighting as required by the Engineer.
(xiii) Abrasion, Flakiness & Impact testing Equipment for testing coarse aggregates.
(xiv) Silt Testing Equipment.
(xv) Any other equipment specified by Engineer.
(xvi) Permeability Testing Apparatus.

Note: All the above equipment and apparatus shall be calibrated at the time of setting up and at specified intervals by NABL accredited agency.

1.1.10 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 and Quality Control system.

2. At the site, the Contractor shall arrange the materials, their stacking/storage in as per MORTH standards 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 tests shall be conducted at specified intervals and the results of tests properly documented. The cost of all such testing shall be included in the quoted Lumpsum Price and nothing extra shall be paid for in this regard. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surfaces.

3.

a. 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 as per provisions of General Conditions of Contract. The Contractor shall 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. The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory having NABL certification.

b. The test shall be conducted at the Site laboratory that may (to) be established by the Contractor at his cost or at any other NABL accredited Laboratory selected by the Engineer.

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c. 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 from the Contractor's bills.

d. All testing shall be performed in the presence of Engineer or his authorized representative. 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.

4. The Engineer shall have the right at all times to inspect all operations including the sources of materials, procurement, its transportation, 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.

5. All materials which do not conform to these specifications shall be rejected. In the event of contractor not being able to arrange the material conforming to these specifications or in the event of failure of the contractor to get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such materials from any particular source, as may, in the Engineer's opinion, be necessary for the proper execution of work.

1.1.11 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.

1.1.12 Setting out of Works

The Contractor shall set out the Works indicated in the Conditions of Contract. 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, as 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 and maintain overall layout of complete work and get it checked from engineer periodically. The cost of all operations of setting out including construction of bench marks is deemed to be included in the quoted Lumpsum Price as per Bill of Quantities.

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

(b) The triangulation points given by Employer/Engineer before start of work shall be maintained during execution and handed over back to Employer / Engineer after completion of work.

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1.1.13 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 get it approved from the Engineer 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.

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 & other Standards.

3. Sampling and Testing

   All materials used in the works shall be subjected to inspection and test in addition to 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 labeled in boxes suitable for storage. A sample room will be made at casting yard and maintained at no cost. Materials or workmanship not corresponding in character and quality with approved samples will be rejected by the Engineer. If the material's testing conducted at third party laboratory, it shall be communicated directly to Engineer's office for obtaining the approval and the same.

   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 source, Materials shall also be tested at 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, at site or at any testing laboratory or institution as directed by the Engineer subject to the provisions of 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 these specifications and of the appropriate Indian Standards are to be supplied free of charge to the Engineer.

6. Rejection

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Any materials that have not been found to conform to the specifications or otherwise not acceptable to the Engineer 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.

1.1.14 Storing of Materials at site

All materials used in the works shall be stored on racks, supports, in bins, silos, go-downs, 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 or 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 within the time as communicated by the Engineer and at no extra cost to the Employer.

1.1.15 Water

1. Water from approved source:

   Potable water only shall be used for the works. Contractor shall have his own source of water duly tested and 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 all such Tests shall be borne by the contractor.

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1.1.16 Workmanship

1. All works shall be true to level, plumb and square and the corners, edges and rises 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.

1.1.17 Load Testing On Completed Structures

1.1.17.1 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 or otherwise:

(i) Results of compressive strength on concrete test cubes falling below the specified strength.

(ii) Premature removal of formwork.

(iii) Inadequate curing of concrete.

(iv) Over loading during the construction of the structure or part thereof.

(v) Carrying out concreting of any portion without prior approval of the Engineer.

(vi) 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.

(vii) 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.

1.1.17.2 All the loading tests shall be carried out by the contractor strictly in accordance with the instructions of the Engineer, as per IRS: CBC;1997 clause 18, IRC: SP-51 IS: 456, and as indicated in the Price Schedule and as indicated hereunder. Such tests shall be carried out only after expiry of minimum 28 days or such longer period as directed by the Engineer.

1.1.17.3 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.

1.1.17.4 All costs involved in carrying out the test ordered on the grounds as mentioned in, (except load and integrity test for piles) and other incidental expense thereto shall be borne by the contractor regardless of the result of the test. In case of failure of the test the contractor shall take down or cut out and reconstruct the defective work or shall take the remedial measures, as instructed, at his own cost.

If the load testing is instructed on any ground other than mentioned in then the cost of the same shall be reimbursed if the test results are found to be satisfactory.

1.1.17.5 In addition to the above load tests, non-destructive tests on various elements such as core 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 practice and as approved by the Engineer.

1.2 STRUCTURAL WORK

(a) Unless otherwise specified, only controlled concrete with design mix and weigh batching is to be used for the work.

(b) Minimum cement content specified in IRS CBC latest/CPWD specification latest is purely from durability point of view. Larger content of cement shall have to be provided if demanded by mix design.

(c) Provision of cement slurry to create bond between plain / reinforced concrete surface and subsequent applied finishes shall not be paid extra.

(d) Mix design using smaller aggregates of 10mm down shall also be done in advance for the use in the junction having congested reinforcement.

(e) Procedure of mixing the admixtures shall be strictly as per the manufacturer's recommendations or as directed by the Engineer.

(f) All the water tanks and other liquid retaining concrete structures shall undergo hydro-testing.

(g) Special benches shall be provided at site for stacking reinforcement bars of different sizes.

(h) Formwork for beams of RCC works 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.

(i) Wherever there is tension or 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.

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(j) Formwork shall be provided for full height at all locations. Special precautions for such tall formwork shall be taken to ensure its safety. Extra costs for providing such formwork shall be deemed to have been included in the prices quoted in Lumpsum price schedule.

(k) In the mobilization period the contractor shall carry out expeditiously and without delay the following works

i. Material testing and mix designs of concrete as contemplated in the specifications.

ii. Setting up of fully fledged site laboratory as per the requirements of these specifications.

iii. Any other pre-requisite items required for final execution.

iv. Site office for the use of the Engineer staff

v. Casting yard with complete facilities

vi. Identify and get approved the source of various major construction materials.

vii. Setting up concrete batching and mixing plant.

viii. Construction of site office set up.

ix. Construction of labour houses etc.

(l) Casting yard shall have following minimum facilities:

i. Casting beds as required.

ii. All handling facilities for precast elements like over gantry, etc.

iii. Curing arrangements as required.

iv. Stacking arrangements for material and precast elements.

v. Storing arrangement of materials.

vi. Proper drainage and all weather approach roads.

vii. All handling elements of pre cast elements.

1.2.1 Supply of Monthly Progress Photographs and Album

a) The work covers the supply of digital color photographs (Hard copy duly annotated) along with soft copy in an album to serve as a permanent record of various stages/facets of work needed for an authentic documentation as approved by the Engineer.

b) 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 negative. The Digital camera, type and quality of photo paper shall be of standard make approved by the Engineer. Each photograph in the album shall be suitably captioned and dated.

c) The photographs and materials including soft copy shall form a part of the records of concerned organization and prints of the same cannot be supplied to anybody else or published without the written permission.

1.2.2 Supply of Monthly Progress Video CD's

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

1.2.3 Survey Work

The said work involves at the very start of work taking-over of reference point from the Engineer, establishment of control points by using DGPS double frequency and the accuracy of 1 in 50,000, triangulation points, bench marks, grid layout for all the piers and other structures maintaining horizontal and

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vertical control within the permissible limits, incorporating changes (if any), submission of full data in the tabulation form and survey drawings. The survey shall be 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).

1.2.4 Barricading

The work covers barricading for the work done along the Existing IR track, median and areas affecting road or rail traffic. Barricading for other areas like casting yard, batching plant, storage and other working area shall be done at own cost by the contractor. The detailed scope of work is:

(i) Providing and installing the barricade 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) Providing adequate road and IR track safety devices. A tentative list given hereunder identifies minimum items, which may be required. However, actual numbers required shall be as per plan approved by the Engineer and clearance obtained from traffic department , Bangalore and concerned division of Railway officials. During execution of works , if any additional cost to this list is required then the contractor shall not be paid any extra cost .

(iii) Dismantling of barricade, other temporary installation from the site and cleaning the site shall be as per direction of Engineer upon completion and acceptance of work.

Tentative Road or IR track Safety Devices are mentioned below or any other safety devices as per site requirement

1. Supply of Red portable traffic cones of 750mm height with white reflective tape bands on 100mm width all around.
2. Hazard warning light flashes with rechargeable. Maintenance free battery & charging system.
3. Safety light island post with 11 nos. parallel reflective.
4. Red reflective arrow fitted on enabled mild steel board of 360 x 220mm size.
5. Traffic Triangular Tripod made of fluorescent cloth fitted on steel frame.
6. Retro-reflective tape (I) 50mm 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 Tabular Delineator of 610mm height with reflective tapes.
10. Retro-reflective arrows diversion board 450 x 900mm with crystal clear protective transparent coat to avid damage on 14-gauge Mild Steel sheet with and without pole.
11. Retro-reflective “Men at Work” triangular board of size 900mm 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 750mm with crystal clear protective transparent coat to avoid damage to the Mild Steel board with and without pole.
13. Retro-reflective advance direction signs cum Diversion Boards of size 1200 x 900mm 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 600mm Diameter with crystal clear protective transparent coat to avoid damage on 14-gauge sheet (without pole).
15. ‘SORRY FOR INCONVENIENCE’ Retro-reflective Boards of size 900 x 300mm size with crystal clear protective transparent coat to avoid damage on 14 gauge Mild Steel sheet (without pole).

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16. HAZARD MARKERS (Yellow & Black) must be put all over the construction sites. This Retro-reflective board is of size 300 x 900mm with crystal clear protective coat to avoid damage and the 14-gauge Mild Steel with or without pole.
17. 'CAUTION' tape which is normally yellow tape of special Polyether Material having 75mm width 'CAUTION' is written all over with Black colour is rolls of 300 meters.
18. For running trains, Retro-reflective speed limit as per IR Specifications.

1.2.4.1 **Measurement**

The barricading including all the required safety devices as listed under the above table shall be measured as per relevant item in Price Schedule. (Payment of the item shall be made on monthly basis over contract period including extended period, if any. The availability of maximum road width is essential requirement for smooth flow of traffic on road. Therefore, contractor may be required to shift barricading from original location to alternate location to permit smooth & free flow of road traffic. It shall be incumbent on contractor to minimize the suburban rail corridor (barricading space) at any point of time to facilitate free movement of road traffic. For such alternation of barricading work no separate payment shall be admissible to contractor. Payment shall be deducted for the period during which the barricading and arrangements for traffic diversion are not satisfactory to the Engineer. The payment and deduction (if any) for the item shall be on pro-rata basis).

1.2.5 Transplantation of Trees

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.

1.2.5.1 **Measurement**

The item shall be measured in numbers according to size of the tree as specified in the item and the full payment shall be released only when the item is executed fully as per the Scope of Work detailed out in the approved plan for transplantation of trees.

The rate shall include all required operations during the transplantation and specified duration afterwards, clearances from the concerned authorities.

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.

i. Waterproofing
ii. Caulking & Sealants
iii. Seismic Joints
iv. Expansion joints
v. Application of Silicone water repellent solution where specified.
vi. Bearings
vii. Painting and polishing works.

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1.3 Guarantees and Maintenance:

(i) 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 in other documents. 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.

(ii) 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.

(iii) Waterproofing for the other areas such as toilets, kitchens, chajjas 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

1.3.1 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.

1.3.2 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.

1.3.3 Expansion bolts/ fasteners:

(a) 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.

(b) For steel backings the fasteners shall be prevented from contact with other metals, which would lead to bimetallic corrosion.

(c) 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.

(d) The holes drilled for the expansion fasteners shall be cleaned of all ground material, dust, etc. before inserting the expansion sleeves.

(e) All expansion bolts fixed into soffits shall be bonded to the backing with epoxy/ polyester resin of approved make.

(f) 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.

(g) 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.

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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.

1.4 Applicable Codes, Standards & Publications for Structural work

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

IS Code no.	Description of code
IS:875 (Part 3)	Code of practice for design loads (other than earthquake) for buildings and structures
IS:1322	Bitumen felts for water proofing and damp-proofing
IS:1893	Criteria for earthquake resistant design of structures
IS:2572	Code of Practice for construction of hollow concrete block masonry
IS:3414	Code of practice for design and installation of joints in buildings
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
CPWD	Specifications latest Vol 1 & Vol 2.
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
SP 7	National Building Code of India
SP 23 (S&T)	Hand Book on Concrete Mixes
B	**Bitumen**
IS:702	Industrial Bitumen
IS:3384	Specification for bitumen primer for use in waterproofing and damp-proofing
C	**Building Construction Practices**
IS:1838 Parts I and 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:6509	Code of Practice for installation of joints in concrete pavements.
IS:11134	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

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D	Cement
IS:269-2015	Ordinary Portland cement
IS:455	Portland Slag Cement
IS:650	Specification for standard sand for testing 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.
IS:6925	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.
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 (Parts I to III)	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 works (Parts 1 to 15)
IS:1343	Code of practice for prestressed concrete
IS:1607	Method of Test Sieving
IS:2386	Parts 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	Specifications for integral water proofing compounds for cement mortar and concrete
IS:2722	Specifications for portable swing weigh batchers for concrete (single and double bucket type)
IS:2770	Methods of testing bond in reinforced concrete part I pull out test
IS:3025	Methods of sampling and tests (physical and chemical) for water & waste water (Parts 1 to 14)
IS:3370	Code of practice for concrete structures for storage of liquids
IS:3935.	Code of practice for composite construction
IS:4326	Code of practice for earthquake resistant construction of building
IS:6925.	Methods of test for determination of water-soluble chlorides in concrete Admixtures
IS:7242	Specifications for concrete spreaders
IS:7251	Specifications 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

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IS:8989	Safety code for erection of concrete framed structures
IS:8142	Methods of test for determining setting time of concrete by penetration resistance
IS:9103	Specifications 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) latest
IRS	Concrete Bridge Codes
IRC -112-2011	Concrete Bridge Codes
ASTM - C - 94 IS 4926:2003	Ready Mix Concrete 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 board concrete vibrators.
IS:3558	Code of Practice for use of immersion vibrators for consolidating concrete.
IS:4925	Specification for concrete batching and mixing plant.
IS:11993	Code of Practice for use of screed board concrete vibrators.
IS-3366	Specification for Pan vibrations
IS-4656	Specification for form vibrations
G	**Formwork**
IS:4990	Specifications for plywood for concrete shuttering work.
IRC:87	Guidelines for the design and erection of false work for road bridges.
IS:806	Code of practice for use of steel tubes in general building construction.
IS:1161	Specification of steel tubes for structural purposes.
IS:1239	Specification for mild steel tubes. Tubulars 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 Stacking 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-Chaterlier test.
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 fiber
L	**Paints and Coatings**
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.
IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming
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
BS:EN:10152	Specification for electrolytically zinc coated cold rolled steel flat products. Technical delivery conditions
ASTM A 164-71	Specification for electrodeposited coatings of zinc on steel
IS 102	Ready mix paint, brushing red lead non sealing
M	**Pigment for Cement**
BS:1014	Specification for pigments for Portland cement and Portland cement products
N	**Re-inforcement & Structural Steel**
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:815	Parts I & II. Electrodes for metal arc welding of structural steel.
IS:816	Code of Practice for use of metal arc welding for general construction in mild steel.
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:5525	Recommendations for detailing of reinforcement in reinforced concrete works
IS:9417	Recommendations for welding cold-worked steel bars for reinforced concrete construction.
IS:14268	Uncoated stress relieved low relaxation steel class 2 for Pre-stressed 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:1024	Code of practice for use of welding in bridges and structures subject to dynamic loading.

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IS:1161	Steel tubes for structural purposes.
IS:1182	Recommended practice for radiographic examination of fusion welded butt joints in steel plates.
IS:2062	Structural steel
IS:3757	Specification for high strength structural bolts.
IS:5624	Specification for foundation bolts.
IS:3600	Code of practice for testing of fusion welded (Part I) joints and weld metal in steel.
IS:4923	Hollow steel sections for structural use.
IS:801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
IS:811 IS:8910 IS:9595 IS:7205	Specifications for cold formed light gauge structural steel sections. General requirements steel products Recommendations for metal arc welding of carbon &Carbon-Manganese steels Safety Code for erection of Structural Steel Works
O	**Aggregates**
IS:383	Coarse and fine aggregates from natural sources for concrete.
ASTM C117	ASTM C117 Standard test method for materials finer than 75µ (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
IS:4014 (Part 2) IRC:87	Code of practice for steel tubular scaffolding: Safety regulations for scaffolding Guidelines for the design and erection of falsework 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

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S IRC:83Part-II IRC:83 Part-III	**Bearings** Standard specifications and code of practice for road bridges Elastomeric Bearings Standard specifications and code of practice for road bridges Pot Bearings Standard specifications and code of practice Spherical Bearings for road bridges
T IS 4985	**UPVC Pipe for Drainage** Unplasticized PVC Pipes for portable water supplies
U IS :2911 PART-I IRC:78	**PILING** Bored Cast in-situ Concrete Piles 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	**Indian Railway and RDSO Guidelines**
W	**MORT&H Specifications for Road and Bridge works (latest Revision)**
X	**CPWD Specifications & KPWD Specifications (Latest Revisions)**

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SECTION – 02A

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

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SECTION – 02B

SPECIFICATION FOR SUPPLY, ERECTION AND LAUNCHING OF STEEL GIRDERS REFER: LATEST RDSO GUIDELINES

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SECTION – S.02 B

SPECIFICATIONS

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.

ADDITIONAL SPECIAL CONDITION & SPECIFICATION FOR SUPPLY, FABRICATION, ERECTION & LAUNCHING OF STEEL GIRDERS FOR RAILWAY AND ROAD OVER BRIDGES.

1. GENERAL

1.1. This specification covers **supply**, fabrication, assembling, erection and **launching** of **Steel superstructure (Girders) and bearings.**

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.

1.3. The scope of work shall include:

a. Supply, Fabrication, assembling and Erection of Open Web Steel Girders/Plate Girders and Composite Plate Girders for **Railway Bridges** (as per IR loading) and Bow String Steel Girders/ Composite Plate Girders (as per IRC loading) of specified span(s) as mentioned in GAD including erection and launching (with or without power and traffic power blocks, as applicable) for Rail/ **Road Over Bridges** (ROBs.)

b. Providing and fixing in position standard spherical bearing/fixed type POT bearing, free sliding type POT cum PTFE bearings, as per approved drawings including designs of bearings.

c. Preparation of temporary Arrangement Drawings (TAD), Launching Scheme, Fabrication/Detailed Shop Drawings including drawing office dispatch lists (DODL), and other documentation as required by K-RIDE.

d. Preparation of Quality Assurance Plan (QAP) for super-structure including bearings.

e. Other miscellaneous works as listed in Schedules / GCC/ SCC.

1.3.1. The contractors/agencies and officials associated with fabrication work should have thorough understanding of both the codes under para 1.2 (i & ii). However, the "GUIDELINES ON FABRICATION OF STEEL GIRDERS FOR CONSTRUCTION/FIELD ENGINEERS BS-110", help the field engineers associated with execution of the fabrication work through trade and cover various aspects which require close attention of the field engineers for ensuring quality of the fabrication work. These guidelines are just to facilitate and not to supersede the two codes specified in para 1.2((i) &(ii) above. All engineers associated with fabrication are advised to understand the provision of IRS B1-2001 and Welded Bridge Code and take help from guidelines specified in para 1.2 (iii) above.

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1.4. 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 equipment and the machinery that they intend to use for the execution of the work. The tenderer 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 trusses from the yard to the final site of placement etc.

2. FABRICATION

2.1. GENERAL

The fabrication of the girders and its accessories shall be carried out by the contractor in his factory premises or in a well-established fabrication workshop to be set up by the contractor at bridge site or any other location as approved by the Engineer. The workshop staff shall have requisite experience, proven skill and experience in the technique of fabricating large components.

2.1.1. For Steel Girders of all bridges, other than Important Bridges, (as defined in IRS Substructure Code) including ROBs, the tendering firm shall be from RDSO approved list of firms for Steel Bridge Girder; in case the tendering firm is not in the list of RDSO approved firms for Steel Bridge Girder, then he will have to get the Steel Girder manufactured through an RDSO firm in the RDSO approved premises only. Further subject to condition that tendering firm fulfills other Technical eligibility criteria, as prescribed by the Railways in the tender and the Steel Girder to be manufactured in the RDSO approved premises only.

2.1.2. For the Steel Girders of Important Bridges, (as defined in IRS Substructure Code) besides RDSO approved firms, the tendering firm will have to get the Steel Girder manufactured through an RDSO approved firm in the RDSO approved premises of firm. The agency will be permitted to set up a site fabrication workshop at site of work which meets the 'Standard Technical Requirements' (STR) for Steel Bridge Girder issued by RDSO which is appended in **Clause 31** of this Additional Special Condition and specification. The approval of the site fabrication workshop meeting with STR to be done by RDSO only and not by any other organization.

2.1.3. Accuracy of fabrication shall be realized through controlled high precision jigs, fixtures and templates, which shall be inspected and passed by Inspection Agencies as specified in Clause 9.4 of this 'Additional Special Condition and specification'. 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 riveting /welding, painting, handling etc. shall be monitored for quality. The quality parameters for monitoring shall be identified along with monitoring these identified quality parameters and 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.

2.1.4. The works of fabrication in contractor's fabrication shop will at all times be open for inspection by Engineer or any other 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 or any other authority/agency nominated by Engineer who will thereafter issue inspection certificate.

2.1.5. 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.

2.1.6. In the fabrication of girder, necessary arrangement and provision shall be kept for inspection facilities underneath the girder and also for carriage of service cables, pipe lines etc as per approved plans.

2.2. Fabrication Drawings

2.2.1. A set of latest approved drawings along with latest revisions should be available in the workshop/ with Agency. On the basis of standard drawings, Fabrication drawings shall be prepared by the fabricating Agency.

2.2.2. The contractor shall prepare detailed shop drawings including drawing office dispatch lists (DODLs) on the basis of design drawings supplied by Engineer in such size and in such details as may be specified by Engineer.

2.2.3. The shop drawings shall be submitted to Engineer in triplicate. One copy of which will be returned after flame cutting, machining to obtain correct length and shape, tolerance provisions. Welding sequence, type and size of welding. 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 will be borne by the contractor. Nomination of the Institution/Consultant for proof checking works will be decided by concerned Engineer/Con. 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.

2.2.4. 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.

2.3. Maintenance of records by Fabricators

The records of fabrication shall be maintained in the registers as per the formats given in Appendix I of IRS BI - 2001.

2.4. Tolerance in Fabrication

Fabrication tolerance for girders shall be as stipulated in Appendix II of IRS-BI-2001.

Permissible deviation for driven rivets shall be as stipulated in Appendix IV of IRS-BI-2001.

3. BRIEF DESIGN DATA

(i) Steel Girders of Track Carrying Bridges are designed for 25 T/32.5T axle loading as per Indian Railway Bridge Rules and Standard Specifications.

(ii) The composite girders of road carrying bridges are designed as per code of practice for Road bridges.

(iii) All panel joints are designed for vertical and transverse forces including secondary moments.

(iv) The structure shall be fabricated to camber as per Steel Bridge Code and as provided in the approved drawings.

(v) The deflection of girder is expected not to exceed the values as given in the approved drawing.

(vi) All members of the girder and joints are to be either riveted or welded or bolted as shown in the approved structural drawing.

(vii) No welding except where approved by the Engineer is to be carried out at site. All welding/riveting/bolting are to be carried out as per relevant IRS Specifications.

(viii) The materials as well as execution of works shall be confirming to the following specifications and codes of practice (Latest Revision of the Specification /Codes & up to date correction slips to be referred).

3.1. Indian Railway Standard Codes And Specifications:

(i) IR Specification for Fabrication of steel girder bridge & Locomotives turn tables (fabrication specification) - SERIAL NO.BI-2001 issued by RDSO, Reprint -2008 (Upto date)and BS-110 –**March 2016**.

(ii) IRS: Bridge Rules (2008)

(iii) IRS: Welded Bridge Code (1989)

(iv) IRS: Steel Bridge Code (2003)

(v) IRS: M-28 Specifications for electrodes.

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(vi) IRS: M-39 Specification for wire flux for SAW.

(vii) IRS: Specification for Erection and Riveting of Bridge Girders.

3.2. Indian standard specification

(i) IS: 2062-2011 Specification for structural steel.

(ii) IS: 813-1986 Scheme of symbols for welding.

(iii) IS: 800-2007.

(iv) IS: 9595-1996(R-2003) Manual for metal arc welding.

(v) IS: 818-R 2003 Code of Practice for safety and Health requirements in electric and gas welding operations.

(vi) IS: 2074, Ready mixed paints, Red Oxide Zinc chromate.

(vii) IS: 2339-1963: Aluminium paint

(viii) IS: 2004-1991 Carbon steel forgings for general engineering purposes.

(ix) IS: 1852-1985 Rolling and cutting tolerances for hot-rolled steel products.

(x) IS: 1148 Rivet bars for structural purposes.

(xi) IS: 1929-1982 Hot forged steel rivets for hot closing(12to36mm diameter)

(xii) IS: 4353-1995 Recommendations of Sub-merged Arc welding of mild steel and low alloy steel.

(xiii) IS: 3935 (shear connector)

3.3. Indian Road Congress Specification (Robs)

(i) IRC: 6 (loading & forces)

(ii) IRC: 22 (Composite construction)

(iii) IRC: 24 (Steel Road bridges)

(iv) IRC: 83(ii) (POT PTFE bearing)

Note: All the codes mentioned under para 3.1,3.2 & 3.3 shall be used / followed with latest updates.

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4. MATERIALS

4.1. Steel

4.1.1. Steel grade conforming to IS 2062-2011 (with latest amendment) shall be used for all components of steel girder for all spans with quality as specified in the approved structural drawings.

4.1.2. (i) Material for web, flange plate & end plate should be as per IS 2062 Quality.

(ii) No Re-rolled Steel should be used.

(iii) Steel should be procured only from approved manufacturers /venders by RDSO. The source of steel should be got approved by the Engineer / Employer. In support of purchase copy of vouchers are to be submitted.

4.1.3. It may be noted that quality of steel used for fabrication shall be the essence of the contract & shall be rigidly followed. Steel sections to be 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 carryout 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.

4.1.4. All rolled sections shall bear cast mark and shall be of such length as to avoid butt welded joints in components of truss. Such rolled sections shall be within rolling tolerances stipulated as per IS:1852 and shall be defects free.

4.1.5. The tenderer (s) shall supply information in the tender regarding source/manufacturers from where procurement of steel is proposed by him/them. However, the usage of type and grade of steel may vary during the execution of the work depending upon the design requirement and market availability. No claim shall be entertained from the contractor on this account and payment shall be as per relevant items as per Price schedule.

4.1.6. Steel for rivets shall conform to IS: 1148 for M.S and IS: 1149 for H.T.S. Welding consumables for Manual Metal Arc Welding (MMAW) shall conform to IRS-M-28, wire and flux combination for submerged arc welding to IRS M-3 and filler wires for CO2 welding to RDSO/M&C/Specification issued vide letter No. M & C/W/111/24 dated 1.1.1994/7.2.1994.

4.1.7. All welding consumables (electrodes, wire, flux etc.) shall be procured only from the manufacturers approved by RDSO subject to final approval by Engineer.

4.1.8. In an extreme eventuality of steel of particular section not being made available locally by Indian Steel manufactures, the tender/s may have to import steel. The imported steel shall be of equivalent specification. Use of built-up sections in place of rolled sections can be permitted. Working out the weight of steel for payment in such cases will be based on the actual sections used. Engineer will not take any responsibility of delays in importing the steel and no cognizance of the same will be given in the completion period.

4.1.9. Test Certificates

All materials for the work shall pass tests and/or analysis prescribed by the relevant IS specifications or such other equivalent specifications. For all materials including rivets and bolts, the Contractor shall furnish copies of test certificates from the manufacturers including proof sheets, mill sheets etc. showing that the materials have been tested in accordance with the requirements of various specifications and codal provisions.

4.1.10. In addition to the test certificate obtained from the steel producers/suppliers/dealers, for conformity sake, all materials/consumables, i.e. steel, rivets, welding electrodes, paints, etc. shall be got tested from the NABL approved labs/recognized labs. Proper record of all such test results shall be maintained. A copy of the same be given to client/K-RIDE as well. Test result of the supplier and that of the lab should match with each other. In case of major difference, mater has to be investigated. Decision of the K-RIDE shall be final in that regard.

4.1.11. 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 judgment 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.

4.1.12. Rolled steel shall also be ultrasonically tested by the reputed firm. Only ultrasonically tested steel shall be used for fabrication work. Record of ultrasonically tested steel shall be maintained separately. All the testing work shall be done in accordance to the provisions of the relevant codes.

4.2. Regarding radiographic testing/x-ray testing of the welded joints, matter shall be finalized in consultation with the inspecting authority. Agreed to procedures shall be followed. Necessary arrangement for that has to be got done by the tenderer at their own cost. All testing work shall be got done by the contractor at their own cost. Nothing extra shall be paid. Tenderers should quote their rate accordingly.

4.3. Quality Assurance Plan (QAP), WPSS and WPQR

4.3.1. Before fabrication of girder, a Quality Assurance Plan (QAP) is prepared by the Contractor based on RDSO guidelines for fabrication of girders (as per sample given in Annexure-I of BS-110 issued by RDSO) and submitted to Inspection Agency as specified in **clause 9** of this specification for approval to ensure proper quality of fabrication. The QAP shall indicate stage wise manufacturing process covering various steps, test checks and their frequency, sampling plan, authority for grant of clearance etc. for all activities. The QAP submitted by fabricating agency is scrutinized by Inspecting Agency on visiting workshop/ site, inspection of the manufacturing process and the same is approved for the particular work during currency of the work/contract before the Agency proceeding with the work.

4.3.2. QAP is to be scrutinized and approved by the Inspection Agency. The QAP should be signed by Fabricator and The Engineer/K-RIDE Officials [Minimum JAG Level] before submission to Inspection Agency. Field

Engineer should ensure that work is carried out strictly as per the approved QAP and no deviation takes place from QAP. All the stages should be studied in detail, prior to start of work. (BS 110- issued by RDSO.)

4.3.3. Girders should be got fabricated by a firm who has full-fledged fabrication workshop and should have valid certification of RDSO for fabrication of girders. Any another procedure will require approval of Engineer.

4.3.4. Scrutiny & Approval of Welding Procedure Spec. Sheet (WPSS) (final approval to be done by Inspecting Agency as specified in clause 9.4 of this document): WPSS is process sheet indicating plate/section used, welding process, type of joint, welding consumables quality, welding parameters, acceptance standard, tests applicable etc. Field Engineer should ensure that welding is carried out as per approved WPSS. Performa for WPSS is given in Appendix-V of IRS B12001. WPSS should be signed by fabricator and K-RIDE Officials before sending for approval of Competent Authority (Annexure-II). It is to be ensured that welding consumables to be used are from approved source and a proper record of their consumption is maintained. A sample Performa for record keeping of consumables is enclosed as Annexure–III.

4.3.5. Welding Procedure Qualification Records (WPQR) (final approval to be done by K-RIDE): WPQR is the document indicating approval of various welders who are to be deployed for carrying out welding work for fabrication. It contains Name of the welder with photograph, qualification, experience, qualification tests and records for each welding process and joint, welding parameter. Tests are conducted by Inspecting Agency before qualifying the welders and then approval is granted through WPQR Proforma given in Appendix-V of IRS B1-2001. WPQR should be signed by fabricator and K-RIDE Officials before sending for approval of Competent Authority in the prescribed format (Appendix V of IRS B1-2001). Field engineer should ensure that welding is done only by approved welders and no deviation takes place.

4.4. Handling and Storing of Steel Sections

4.4.1. 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.

4.4.2. All threaded ends and machined surfaces are to be efficiently protected against damage in transit. The parts shall be transported in convenient lengths.

4.4.3. 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 rivets, bolts, nuts washers, plates under 300mm square and small articles generally are to be packed separately for each span in cases each weighing when full not more than 350 kg or in strong petroleum casks, or barrels as approved by Engineer. If not entirely filled by the contents the space left shall be closely packed with wood shaving or other suitable material. Bolts and rivets 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.

4.4.4. All rolled steel received from supplier shall be carefully unloaded to avoid twisting, bending and damage to mill scale, stacking area shall be covered and the materials placed on a raised platform above ground level and every care taken to avoid contact with water in order to prevent rusting and pitting.

4.4.5. All sections damaged transit or handling shall be stacked separately and damaged portions shall be indicated by paint of distinct colour. Such materials shall be dealt with as per instructions of the Engineer. Badly damaged portions may require replacement. Slightly distorted parts or broken parts must be dealt with as the case demands and as directed by Engineer. The rectified sections shall be used for fabrication only after approval of Engineer.

4.4.6. Where the work has been passed in the manufacturers factory premises as strictly interchangeable. All members bearing the same marks can be stacked together without reference to any particular position. Care must be taken by the contractor that the parts at site are available in proper sequence. Every portion of work shall be distinctly stenciled with paint and marked with the punch not less than 15mm dia for guidance in erection in the field, and stamped with the letters specified in the drawings. In the case of non-interchangeable work, the system of marking shall be as shown in drawing. All field rivets for site riveting, service bolts and drift for assembly of girder, shall be stored under cover.

4.4.7. The contractor shall supply without charge, three complete lists of the rivets, bolts, service bolts, washers and drifts required for erecting the work at site, showing the parts of the work to which the various rivets and bolts belong and having each item marked so as to indicate the particular case in which it will be found. List of total rivets required for one girder stating length, numbers, and wastage allowance of 12.5% shall be prepared and supplied along with the span components, the requirements for service bolts = 45% and drifts = 15% covering 60% of field holes in one span plus wastage allowance of 12.5%. Actual requirement for the work shall be assessed by the contractor who shall arrange accordingly.

4.5. Steel Tape

4.5.1. Contractor shall use steel tape conforming to IS: 1269(Part 2:1997) duly tested and issued with certificate of accuracy by an accredited National testing house for templating, fabrication of drilling jig etc. The tape shall be calibrated under a tension of 1.8 kg at 16.7 degree C. All marking and checking of master gussets, camber layout, etc shall preferably be at the mean temperature of the fabrication zone.

4.6. Straightening

4.6.1. All rolled sections and plates shall be straight and free from defects like twists and bends before they are used for marking and cutting. If any rolled section of plate has minor defects, it shall with the approval of the Engineer, be cold straightened by pressure with the help of plate and section straightening machine. Pressure applied for straightening shall be such a not to damage the surface or microstructure of grains in the steel member. Flattening, straightening and bending in hot condition shall not be carried out unless specified on drawings or approved by Engineer.

4.7. Cutting of Material

4.7.1. All edges shall be machined mechanically (by a sawing machine) or controlled torch oxy-acetylene flame cut after. All flame cut edges shall be ground to secure clean and square edges.

4.7.2. No shearing of section or plates is permitted. When flame cutting is deployed on a plate of long length, flame cutting shall be done by multi-torch mechanically controlled equipment to ensure a straight clean cut and prevent lateral distortion due to heat application. All flame cut edges shall be ground or machined to obtain reasonably clean square and true edges. Drag lines formed during flame cutting shall be removed.

4.7.3. While chalk marking for flame cutting, following cutting allowance shall be added to the prescribed dimensions:

Thickness	Cutting allowance
Up to 12 mm	+3mm
Above 12 and up to 25 mm	+5mm
Above 25mm	+7mm

4.7.4. Templates made from 3 to 4 mm thick steel plate shall be used for cutting Gussets. Long length cutting by marking with white chalk and string may be followed.

4.7.5. Minimum edge distance while preparing profile for gussets, cleats and edges of components from center of rivet hole to a flame cut edge shall be 1.75 times the diameter of hole, and for machined edge or rolled edge shall be 1.5 times the diameter of rivet holes, (machined edge means first edge distance kept 1.75 times diameter of hole for flame cutting and reduced to 1.5 times diameter of hold by removal of material by machining).

5. METHOD OF FABRICATION

Fabrication, Workmanship shall generally comply with current IRS specification No.B1-2001 and GUIDELINES ON FABRICATION OF STEEL GIRDERS FOR CONSTRUCTION/FIELD ENGINEERS BS – 110 (R) with latest correction/amendments thereof unless otherwise specified in special conditions of this contract or as specially directed by the Engineer in writing.

5.1. The fabrication of the girders and its accessories shall be carried out by the Contractor in his factory premises or in a well-established fabrication workshop to be set up by the Contractor at bridge site or any other location as approved by the Engineer as shown below.

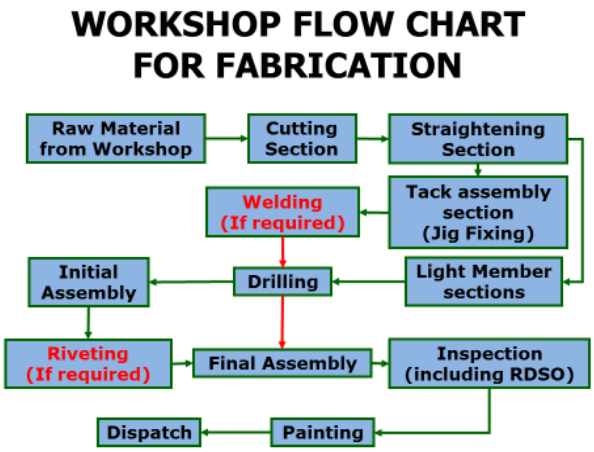
WELL EQUIPPED WORKSHOP

WORKSHOP MAINLY CONSIST OF –

1.Template/jig section
2.Cutting section
3.Tack assembly fit-up section
4.Welding section
5.Drilling section
6.Initial assembly section
7.Riveting section
8.Final assembly section
9.Inspection
10.Painting section
11.Dispatch section

5.2. 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 / any other inspection agency as nominated by Engineer.

5.3. The following is a typical "Workshop Flow Chart for Fabrication.



5.4. Considering the length and height of span, jigs and fixtures shall be used to guide and support drilling of holes and fixtures during entire fabrication work assembly of components, before riveting / welding of components.

5.5. Drilling jigs shall be fabricated with the help of Master gussets fabricated as templates for all panel joints of truss. Jigs after manufacture shall be checked and approved by Engineer or any other Inspecting agency as nominated by Engineer/ Con. Only approved and stamped jigs shall be used for fabrication. First component after drilling of holes through approved jig for each specific component of truss, shall be checked with the help of Master gusset by the Inspecting Officer before further fabrication.

5.6. Tack Assembly

5.6.1. For fabrication of riveted construction, top and bottom chords of members shall be tack assembled for drilling of holes through jig. Tack assembly of members shall be done by stitch rivets after positioning the drilling jig in true position.

5.6.2. Drilling jig and tacked members shall be clamped to a fixture to avoid shifting of jig during handling and drilling.

5.6.3. Tack welding may be permitted only at ends or locations, which will eventually be cut and removed. No active part of the component shall be tack welded as this would initiate crack formation in service.

5.7. Template

The contractor shall supply and provide templates at his own cost. No separate payment shall be made for this and accepted Lumpsum Price shall be deemed to include this aspect. The templates used for the work shall be of steel of similar category as the member and shall be of tested quality. In case where actual materials from a bridge have been used as templates for drilling similar pieces the inspecting officer will decide whether these are fit to be used as part of finished structure.

5.7.1. **Template Shop**

Fully covered template shop consisting of uninterrupted steel or concrete floor as approved having true and correct level covering adequate area shall be provided by the contractor. Camber layouts shall be drawn to full scale from end of girder to half span. This camber layout once approved shall be used for fabrication of master gusset profiles and end profile of each member. It shall be used for working out the actual lengths of each member and checked to conform to the calculated length. Master gussets at every panel joint of top chord, bottom chord and middle web panel shall be marked accurately on camber layout drawn of template floor.

5.7.2. All precautions shall be taken while drawing camber layout for correct setting of angle of intersection of chord and web member and great accuracy shall be ensured while transferring the same on master gusset.

While marking centre point of field rivet holes on master gusset, if there is symmetry of holes on vertical axis, marking shall be made only on half the master gusset across vertical axis, and holes drilled by inscribing each hole. Subsequently remaining half portion shall be drilled through gusset using the same half portion master gusset. This will help realize symmetry of holes in gusset and fairing of field rivet hole during girder assembly.

5.7.3. Camber layout and fabrication of Master gusset at every panel joint requires highly skilled and trained staff experienced in accurate fabrication of large girders, drilling jigs and fixtures. At least one jig shall be required for each component. Each jig shall be numbered and a record kept in register for identification.

5.8. Drilling of Holes

5.8.1. Holes for riveting / bolting in members shall be carried out by drilling through jig only. No punching or hand drilling of holes is permitted. Sub-punching to a diameter 6mm less than that of finished holes may be permitted by Inspecting Officer except in the main truss members of open web girders.

5.8.2. When the holes are to be sub-punched they shall be marked off with a centre punch and made with a nipple punch or preferably, shall be punched in a machine in which the position of the hole is automatically regulated. The punching shall be so accurate that when the work has been put together before drilling, a gauge 1.5mm less in diameter than the size of the punched holes can be passed easily through all the holes.

5.8.3. Drilling jig should be provided with an internal turned and case hardened bush at all holes in jig, for retaining accuracy of all similar units fabricated. Bushes will have a tolerance of - 0.0/+0.1 mm for shop riveting. The tolerance shall be periodically checked & replaced when the tolerance exceeds - 0.00/+0.4 mm (for hardening). Before fixing to jig, bushes shall be checked with a plug gauge to ensure these tolerances.

5.8.4. Drilling of all holes through jig by radial drilling machine for fabrication of top and bottom chords of all members will be allowed. Web members and floor system having welded construction, field holes for riveting shall be drilled through jig.

5.8.5. Holes for countersunk heads of rivets, bolts or screws shall be drilled to the correct profile so as to keep the heads flush with the surface.

5.8.6. Holes for rivets shall be 1.5 mm greater than the diameter of rivet bars for rivets less than or equal to 25 mm and 2 mm greater than the diameter of rivet bars for rivets greater than 25 mm. Holes for turned bolts, for field connection, where specified on drawing shall be drilled in the shop 1 mm less than diameter of holes shown on the drawing and should be reamed at site to suit diameter of turned bolt.

5.8.7. Drilling to enlarge un-faired holes is prohibited. The holes required to be enlarged shall be reamed provided the Engineer permits such reaming after satisfying himself about the extent of inaccuracy and the effect of

reaming on the soundness of the structure. The Engineer reserves the right to reject all steel work if the holes are not properly matched.

5.8.8. On completion of drilling of holes in each component and before shifting the jig, it shall be ensured that all holes are drilled to their correct diameter to reconfirm quality of work.

5.9. Rivets & Riveting of Components

5.9.1. The work shall include supply of all rivets, bolts, nuts, washers etc. required for complete erection at site with allowance for wastage. The contractor shall be responsible for supplying site rivets of correct length. The length of such rivets shall be verified in the presence of Engineers representative by snapping a few rivets of each length to check whether the holes have been completely filled in by rivet material. Particularly in case of rivets with long grips (with grip exceeding 6 times the diameter), specimen rivets shall be cut to see if the holes are totally filled even though the rivets are tight under the usual hammer tests.

5.9.2. All rivets to be used shall be checked with profile gauge for its true shape, contours of head, concentricity of head, diameter as well as correct length to match the thickness of joint. Calibrated gauges for rivet dimensions and contours shall be provided by the contractor for use of the Inspecting Officer and the Engineer.

5.9.3. Service bolts and nuts, ordinary plates, washers and drifts for use in the erection of the work shall also be supplied by the contractor at his own cost. On completion of the work these materials may be taken back by the contractor.

5.9.4. The dimension on the drawings refer to the diameters of finished rivets and not the diameter of rivet holes. The rivets shall be made to relevant IS specification. The clearance i.e. the difference in diameter of rivet measured under head (before heating) and rivet hole shall not be less than 0.75 mm. The shanks shall be made of length sufficient to fill the holes thoroughly and to form the head.

5.9.5. Riveting shall not be started until such time as Engineer or his authorized representative has personally satisfied himself that the alignment of the girders is correct, the vertical members plumb correctly, all the mating surfaces are secure and in full contact with service bolts and field rivet holes in alignment.

5.9.6. All rivets shall be properly heated to straw heat for the full length of the shank, firmly backed and closed. The head of the rivet, particularly in long rivets, shall be heated more than the point and in no case shall the point be heated more than the head. Before placing the rivet in drilled holes the rivets shall be smartly jerked to shake off oxide scale. Where it is impossible to back up by normal method of holding up, double gunning may be resorted to. Alternatively pneumatic holding device may be used.

5.9.7. Unless permitted by Engineer, all riveting shall be done by machine riveting using hydraulic riveters for sound & perfect riveting. Fabrication workshop should have Hydraulic Riveting facilities for fabrication of heavy duty bridge girders as per IRS/IRC specifications. Pneumatic riveters may be used subject to approval of Inspecting Officer/Engineer. The working pressure to be employed when using pneumatic or hydraulic tools shall be as per manufacturers specifications and approved by the Engineer. Hand riveting shall only be done when specifically allowed by the Engineer. In such cases means shall be adopted to ensure the rivets are sued for their entire length and fill rivet holes completely, the snap being used only to give the correct form of head.

5.9.8. All rivets when driven shall completely fill the holes, have the heads concentric with the shanks and shall be in full contact with the surface. Driven rivets when struck sharply on the dolly side head with a 110 gm rivet-testing hammer shall be free from movement and vibration. While riveting built up members, great care shall be exercised to ensure that the set of holes for field rivets in each flange of the built up member is aligned, dead square in relation to that in the other flange and not aborted. Use of special jigs shall be made to ensure this fit.

5.9.9. All sparking, loose and burnt rivets, and rivets with cracks, badly formed eccentric or deficient heads shall be cut out and replaced by others. Permissible deviation of driven rivets shall be as per IRS BI-2001. Rivets shall also be cut out when required for the examination of the work. The Engineer shall approve actual method of cutting out. Recouping and caulking shall in no circumstances be resorted to.

5.9.10. Service bolts shall be frequently retightened as the riveting proceeds, the number and position of the drifts used in the joints permitting this. All field rivets shall be tested as directed by the Engineer.

5.9.11. Care must be taken to use rivets of correct dimensions but burrs or lips around the rivet heads shall not be removed.

5.9.12. Rivets less than 10 mm diameter may be driven cold subject to approval of Engineer. Flattened rivet head may be used in certain places where clearance demands so.

5.9.13. When all the rivets at a joint have been finally passed they shall be painted as per specification.

5.10. Welding of Components

5.10.1. All welding work shall be as per IRS/IRC Standard and by such process that the workmanship is flawless. ALL welding shall be by automatic and semi-automatic submerged arc welding process, except where inaccessible. Site welding shall be avoided, but if necessary, shall be carried out only on secondary members having low stresses to transmit across the joint for which approval of the Engineer shall be required.

5.10.2. Welded construction shall be carried out generally in accordance with provisions of the Welded Bridge Code and IS:9595 (Metal Arc Welding) and further subject to specifications as under:

a. Welding shall be done only by qualified and approved welding operators, whose competency has been verified and certified by Engineer/Inspecting Officer. Routine re-testing of welding operators may be required every six months if deemed necessary by the Engineer who also reserves the right to retest any welding operator at any time during the contract.

b. All long and continuous welds shall be carried out by automatic Submerged Arc Welding (SAW) process only, in order to obtain sound and uniform shape and cross section CO2 or Manual Metal Arc Welding (MMAW) may be done for short lengths of for secondary connections where access to the location of the weld does not permit Submerged Arc Welding (SAW), subject to approval of Engineer.

   Except for special types of edge preparation, such as single and double U, single and double J, the fusion edges of the plates which are to be joined by welding may be prepared by using mechanically controlled automatic flame cutting equipment and then ground to smooth finish. Special edge preparation should be made by machining or gouging.

c. The contractor shall appoint welding supervisors whose competence and qualification shall be subject to approval of TPIA (Third Party Inspecting Agency) like WRI-BHEL/Trichy or any other firms specifically approved in prior by Engineer/Con. All welds shall be carried out under their direction & supervision.

   Welding position for fabrication of components shall be Flat or Horizontal position for SAW (flat position preferred) and Flat or Horizontal position for CO2 or manual metal arc welding. To ensure above position for welding, component shall be placed in a manipulator, tack assembled and rotated in the manipulator to assist welding sequence and prevent distortion of member. In absence of manipulator, special jig and fixtures shall be provided for positioning and careful handling by crane.

5.10.3. Welding Procedure

The welding procedure shall be such as to avoid distortion and minimize residual shrinkage stresses. Properly designed jigs should be used for assembly. The welding techniques and sequences, quality, size of electrodes, voltage and current required shall be as prescribed by relevant codes. The contractor should submit full details of welding procedure in proforma given at Appendix-V of IRS BI-2001 (with latest correction slip).

5.10.4. Sequence of welding and welding pass

The sequence of welding and welding pass shall be done as per IRS BI-2001.

5.10.5. Procedure Trials

5.10.5.1. Where required by the Engineer/Inspecting Officer, welding and flame cutting trials as per following shall be carried out and completed before fabrication on representative samples of materials to be used in the work.

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i) The samples of material shall be selected and marked by the ENGINEER when the materials for the work are inspected at the mills.

ii) The trials of flame cutting shall be carried out in material representative of all thicknesses to be used in the work.

iii) The welding & flame cutting trials shall be commensurate to the satisfaction of Engineer/Inspecting Officer and the procedures to be adopted in the fabrication of work which shall include:

a) Welding procedure in accordance with relevant specification.

b) Heat control techniques required to ensure that the flame cut surface of steel are suitable for inclusion in welds.

iv) The trials shall include specimen weld details from the actual construction which shall be welded in a manner simulating the most un-favourable instances of fit-up and preparation. After welding the specimens shall be held as long as possible at room temperature but in any case not less than 72 hours, and then shall be sectioned and examined for cracking. Six representative samples of each weld joint similar to joint used in fabrication of all components shall be prepared by qualified and certified welding operators.

v) Following groups of tests shall be carried out:

(a) Butt welds: Transverse tensile test, transverse & longitudinal bend test with the root of weld in tension and compression respectively, Charpy V-notch impact test.

(b) Fillet welds: Fillet weld fracture test.

(c) Track welds: Inspection for cracking.

(d) All welds: Macro examination.

Additional tests may also be carried out as per requirement and instruction of Engineer/Inspecting Officer, the cost of which shall be borne by the contractor.

Following tests are normally performed on welds.

(a) **Non Destructive Tests (NDT):**

- Visual inspection/profile gauge for dimensional check of size and throat thickness of weld.
- Etching test for penetration of joint.
- Magnetic particle or Ultra Sonic Pulse Velocity (USPV)
- Gamma Radiography & x-ray (only for butt welds)
- Dye penetration of all welds joints.

(b) **Destructive Test :**

-Tensile test

- Bend test
- Impact test
- Load test.

5.10.5.2. Once samples representing the weld joint used in fabrication of all components are tested and test results are found satisfactory, then approval shall be taken from the Engineer/Inspecting Officer for the welding of built up components by approved welding operators. Welding Procedure Qualification Records (WPQRS) shall include joint details, welding consumables (i.e. electrode/wire & flux combination), weld parameters (i.e. welding current, wire feed speed), welding position, welding equipment carriage speed (for SAW process), are Length, arc voltage etc.

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5.10.6 **Precautions during welding**

5.10.6.1. The Contractor shall submit list of weld joints of different combined thickness for approval of welding procedure for all members.

5.10.6.2. The welding of built up component shall be carried out only by approved welding operators and in accordance with Welding Procedure Qualification Records. WPQRs shall be prepared in advance and approved by the Engineer. Proper welding sequence shall be followed to avoid distortion and minimize residual shrinkage stress, and surface defects, within acceptable tolerance limits.

5.10.6.3. To ensure sound and defect free welding of built up members, record of welding adopted as per approved qualifying procedure shall be maintained in Performa prescribed in guidelines for welded fabrication issued by TPIA (Third Party Inspecting Agency) like WRI-BHEL/Trichy or any other firms specifically approved in prior by Engineer/Con.

5.10.6.4. Any change during welding for fabrication of built up member, such as welding sequence, welding process, positioning, wire and flux combination joint details, increase or decrease in combined thickness of joint by 5 mm etc. shall be carried out only after representative samples test and procedure qualification, is accepted. In no case deviation from WPQRs without approval of Engineer shall be adopted.

5.11 Preparation of Faces

5.11.1. Preparation of joint face: Except for special types of edge preparation such as single or double 'U' & 'J' joints, the fusion edges of all plates which are to be joined by welding shall be prepared by using mechanically controlled automatic flame cutting equipment with the cutting allowance as per clause 4.7 and the extra length machined to obtain correct length.

5.11.2. It shall be ensured by Non-destructive tests that the fusion face and adjacent surface are free from cracks, notches or other irregularities that are likely to cause defects during service or interfere with deposition of the weld.

5.11.3. Fusion faces and the surrounding surface up to 50 mm shall be free from mill scale, moisture, oil, paint dirt or any other substance which may affect the quality of the weld, and same shall be removed by grinding or flame cleaning/grit blasting.

5.11.4. Details of joint, fusion faces, root face and gap shall be as per details given in fabrication drawing or as stipulated in IS:9595.

5.12 Welding Operation

5.12.1. Parts to be welded shall be assembled such that the joints to be welded are accessible and visible to the operator. Assembly jig and fixture shall be used for accuracy.

5.12.2. Manipulators should preferably be used to execute the sequence of welding without disturbance, in the most suitable position. Fixture shall maintain the alignment with minimum restraint in order to reduce the possibility of locked up stresses.

5.12.3. Run in and run out plate shall be provided for fabrication of built up members or truss to ensure that weld will start on run in plate and weld will stop on run out plate and thus avoid crater defects on the components.

5.12.4. The size and length of weld shall not be less than those specified in the drawing nor shall they be in excess of the requirement without prior approval of the Inspecting Officer. The location of weld shall not be changed without prior approval of the Engineer.

5.12.5. During design and detailing of component lengths, care is to be taken to avoid butt weld in built up members of truss. Therefore it is essential to use only nearest size and length or rolled sections that have been procured to scheduled sizes and lengths by proper planning. No butt weld shall be carried out without approval of Engineer.

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5.12.6 Fabrication of components subject to dynamic loading in the structure need careful inspection during fabrication by qualified, experienced and certified Engineer from contractors side and final approval by Inspecting Officer. This inspection shall be carried out as stipulated in Indian Railway Welded Bridge Code before, during and after welding.

5.13 Additional Precautions During Welding

5.13.1. Following precautions shall further be observed during fabrication.

a. All equipments shall be provided with calibrated gauges to observe limits of variation for parameters prescribed in WPQR'S for welding current, arc voltage, speed of travel of equipment etc.

b. Covered shed for environmental control (particularly against dust, moisture and initiation in weld or under bed of weld (i.e. Heat Affected Zone HAZ). Also baking of flux use for submerged arc welding in oven for an hour at 200 degree C shall be carried out to ensure that no moisture is contained in flux during welding.

c. All tack weld shall be carried out by qualified and approved welder only. As tack weld will become part of the final weld, it shall be free from all cracks and other welding defects.

d. If multiple runs are used for fabrication of built up member, inter run cleaning shall be carried out and subsequent weld bed made only after approval of inspecting officer or his authorized representative. This is to check free defects in the weld. Also visible defects such as cracks, cavities, if any, shall be removed by grinding. It shall be ensured during welding that craters are avoided.

e. Stray arcing of components, which cause local hard spots or cracking of parent metal, shall be avoided.

f. Flux of approved quality will be permitted for use.

g. The Auto melt grade wire spools of wires for Submerged Arc Welding and Carbon Dioxide (CO2) consumables of only the approved quality will be permitted.

h. Pre Heat Treatment will be given to the consumables to remove the moisture if any.

i. No violation of welding procedure will be permitted on any account.

6. GENERAL : RIVETING , WELDING & JOINTING WITH HSFG BOLTS

6.1. Qualified trained, and experienced supervision is essential at all times during fabrication, and for maintenance of records.

6.2. After riveting of riveted components or welding of welded components, they shall be finished finally by grinding or matching with the help of a profile template. All the butting ends of components shall be faced in milling machine after members haven completely fabricated. In the case of compression members, the face shall be machined so that the faces are of proper angle as shown in drawing and the joint when made will be in close contact throughout within a gap tolerance of less than 0.15 mm. The Inspecting officer may permit a tolerance of (-) 0.4 mm at isolated points in butting line.

6.3. **Jointing with HSFG Bolts** shall be as per Para 28.9 to 30.1 of IRS:B1-2001.

7. PAINTING

Specification for metallising and painting of bridge girders shall be as per IRS:B1-2001.

7.1 **Surface Preparation**

7.1.1 This is the most important factor in ensuring good performance of the steel girder. The surface should be clean, dry and free from contaminants and it should be rough enough to ensure adhesion of the paint film. However it should not be so rough that the film cannot cover the surface peaks.

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7.1.2 The cleaning of the surface shall be done initially with the use of emery paper, wire brushes, scrapers etc. for spot cleaning to remove rust, scale etc. Subsequently, sand blasting of the surface shall be done to remove rust, mill scale along with some of the base metal. This will be achieved by high velocity impact of abrasive material against the surface in accordance with the provisions of IS:6586, which will also create a base for good adhesion. The abrasive material once used for cleaning heavily contaminated surface should not be reused even though re-screened. Washed salt free angular silica sand of mesh size 12 to 30 with a minimum of 40% retained on a 20 mesh screen shall be used for blasting. The material specifications and other requirements shall be as provided in Indian Railways Bridge Manual, 1998.

7.1.3 All site rivets, bolts, nuts and washers shall be thoroughly cleaned and dipped in boiled linseed oil. All machined surfaces are to be well coated with a mixture of white lead conforming to IS:34 and Mutton tallow conforming to IS:887 as per specifications before dispatch to site. Nothing extra shall be payable to contractor on this account.

7.1.4 All the components in the floor and deck system in open web girders and all members in plate & composite girders shall be metalized as IRS specifications.

7.2 Metal Spraying

7.2.1 The sprayed coating shall be applied as soon as possible after surface preparation.

7.2.2 The wire method shall be used for the purpose of metallising, the diameter of the wire being 3mm or 5mm. Specified thickness of coating shall be applied in multiple layers and in no case less than 2 passes or the metal spraying unit shall be made over every part of the surface. The surface after spraying shall be free from uncoated parts of lumps of loosely spattered metal.

7.2.3 The composition of the aluminium to be sprayed shall be in accordance with BS 1475 Material 1-B(99.5%) aluminium otherwise as per IS:739 and IS:2590. However the selection of metal for spraying, i.e. Zinc or Aluminium shall be subject to final approval by the Engineer.

7.2.4 At least one layer of the coating must be applied within four hours of blasting and the surface must be completely coated to the specified thickness within 8 hours of blasting.

7.2.5 Minimum thickness of metal coating applied shall be 165 microns and average thickness shall be 200 microns. The specified thickness of coating shall be applied in multiple layers, not less than three. The metal coating shall be checked for thickness by approved magnetic thickness measuring gauge. At least one reading for each sqm of area painted shall be taken. The calibration of the gauge shall be checked against a standard of similar thickness within an accuracy of 10%.

7.2.6 For measurement of dry film thickness, following instruments may be used by the contractor:

(i) Electronic coating thickness gauge,

(ii) Elcometer (magnetic thickness gauge) Dial type.

(iii) Surface profile gauge.

7.2.7 After metallising any oil, grease etc. shall be removed by thorough wash with a suitable thinner as approved by the Engineer and shall be allowed to dry for 15 minutes. The first coat shall be applied by brush/airless spray-one coat of epoxy micaceous Iron Oxide to RDSO specification No. M & C/ PCN-103/86 to 100 microns minimum DFT and allowing it to hard dry.

7.2.8 The finishing coat shall be applied with two coats of ploy urethane aluminium finishing to RDSO specification No. M& C/PCN-110/88 to 40 microns minimum DFT giving sufficient time gap between two coats to enable the first coat to hard dry. The finishing coats to be applied in shop and touched after erection if necessary.

7.2.9 The Engineer however reserves the right to select the scheme of painting of the girders and channel sleepers.

7.2.10 The Engineer also reserves the right to select the colour scheme for the third and fourth coats.

7.3 Miscellaneous

7.3.1 Final dry film thickness in case of metallising shall be average 150 microns and shall be measure before application of final finishing two coats.

7.3.2 Surface preparation shall not be done unless approved paints of sufficient quantity (both primer and finishing) are available in stock.

7.3.3 Special care should be taken in preparing corners, junctions of members, head and nuts of bolts, rivets, holes, areas less accessible, hidden pockets etc. Surface preparation at such locations shall not be inferior to that attained over the rest of the area.

7.3.4 Surface preparation shall not be carried out in the following conditions:

-In rainy season from June to September and from December to January.

-In extremely windy/misty/dust blowing conditions.

-At night.

-In winter before 8 A.M.

-In summer between 11 and 15 hrs, in areas, which are likely to be exposed to direct sunlight.

7.4 Inspection

7.4.1 Adhesion: The sprayed metal coating shall be subjected to an adhesion test using the method described in IRS BI-2001. If any part of the coating between the lines breaks away from the base metal, it shall be deemed to have failed the test.

Articles that have been rejected, shall have the defective sections blasted to clean off all sprayed material prior to re-spraying. Where the rejection has been solely due to too thin a coating, sprayed metal of the same quality may be added provided that the surface has been kept dry and is free from visible contamination.

7.5 Paints : Source & Quality

7.5.1 Paint and other accessories including those for metallising work will be supplied by the contractor. Paints manufactured by the following firms (or more) may be used subject to their being in the approved list of RDSO and final approval by the Engineer.

M/s. Jenson Nicholson. Paints

M/s. British / Barger paints.

M/s. Shalimar Paints

M/s. I.C.I. .paints

M/s. Nerolac. Paints

7.5.2 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.

7.5.3 The Engineer reserves the right to get the paint tested at contractor's expenses as considered necessary by the Engineer. It the test results do not conform to relevant IS specifications fully, then the lost of paint shall be rejected and got removed from the contractor(s) storage. If the paint has already been applied it shall be removed.

7.5.4 In addition to above, the following tests are required to be carried out in the field.

- Weight per litre
- Consistency test
- Scratch test.

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- Flexibility and adhesive test.

7.5.5 The Engineer reserves the right to reject the lot of paint even on the basis of field results.

7.6 Painting - General Instructions

7.6.1 Painting shall not be commenced till the surface preparation has been approved by the Engineer or his representative or inspecting officer.

7.6.2 Sealed containers of paint of approved brand shall be used. The paint drums must be rolled, turned upside down and shaken before opening. The paint must be stirred well before use. Over stirring which results in invisible air bubbles etc, shall be avoided.

7.6.3 Where brush painting is accepted, the paint must be applied by means of flat brushes not more than 75 mm in width having soft flexible bristles conforming to IS:384.

7.6.4 Round and oval brushes of approved quality conforming IS: 487 may also be used as per the instructions of the Engineer or his representative or inspecting officer.

7.6.5 All new brushes should be soaked in raw linseed oil conforming to IS:77 for at least 24 hours before use.

7.6.6 A little blue paint shall be added, in the first coat of aluminium paint to distinguish it from second coat. For paints of other colours for final and finishing two coats, suitable pigment shall be used as per instruction of the Engineer, to distinguish the first coat from the second coat.

7.6.7 The date of painting shall be marked with paint on the member.

7.7 Cares during Painting

7.7.1 Paint should be mixed in small quantities sufficient to be consumed within one hour in the case of red lead paint.

7.7.2 The applied coat of paint shall be uniform, and free from brush marks, sack marks, blemishes, scratching, non-uniform thickness, holes, log marks, fuel staining, cracking, scaling, and other defects.

7.7.3 Paint shall be applied only on dry and clean surface free from moisture or dust (including scrapping dust).

7.7.4 Paint should be used within the prescribed shelf life from the date of manufacture.

7.8 Each coat of paint shall be left dry till it sufficiently hardens before the subsequent coat is applied. Each coat of paint shall be inspected by the Engineer or inspecting officer and certified as satisfactory before applying subsequent coat.

7.9 Payment

The payment for complete painting of all components of girders including all accessories, painting of contact surface etc including all labour and material, is included in the accepted Lumpsum Price in the Price Schedule.

8. ASSEMBLEY & ERECTION

8.1 General

8.1.1 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.

8.1.2 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 he proposes to use for carrying our work in full accordance with drawings and specifications.

8.1.3 All temporary works shall be properly designed and fabricated & erected with great care for the loads, which they will be called upon to support. Adequate allowance and provision for the effect of lateral forces and wind loads shall be made to meet unforeseen conditions.

8.1.4 When chains are used for lashing care must be taken to protect the edges of members from twisting and distortion, damage to paint and similar effects.

8.1.5 Temporary bracing shall be provided to take care of stresses caused by erection equipment or other incidental loads during erection.

8.1.6 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.

8.1.7 The contractor shall observe sufficient accuracy in the assembly of every part of the work to ensure that all parts fit accurately together.

8.1.8 For erection of Open web Girder span, Appendix III of IRS B1- 2001 shall be followed. The launching of girders will be done very near to the existing bridge. Contractor shall take all necessary precautions for the safety of the substructure and superstructure of existing bridge, during assembling & launching works of the girders and nothing extra will be paid, owing to this. In addition, the contractor shall adopt all precautionary measures for safe plying of inland vessels, boats, crafts etc. and nothing extra will be paid, owing to this.

8.2 Procedure for Assembly in Workshop & Site

8.2.1 The contractor is required to undertake test assembly of the girders in his fabrication workshop to prove accuracy of templates and jigs. This assembly can be done in horizontal position. In case the fabrication workshop is set up by the contractor at bridge site itself the test assembly may be done at assembly platform and after testing of accuracy of jigs, fixtures & templates and the same assembly can be launched after riveting. The test assembly shall be certified by Inspecting agency of the Engineer.

8.2.2 Following procedure may be used by contractor subject to checking of design by contractors consultant and final approval by the Engineer.

i. The joints at the end of each top & bottom chord shall be drifted, bolted and preferably stitch riveted to their Geometrical outline.

ii. The procedure during assembly shall consist of placing camber jacks in position to support the structure. The camber jacks shall be set such that they provide sufficient height to allow for lowering of panel points to obtain and maintain the required camber. Throughout the process of assembly, tilt, shift, twisting etc. shall be repeatedly checked. The jacks shall be spaced so that they will support the ends of the main girders and the panel points.

iii. The bottom chord members shall then be placed on the camber jacks, carefully leveled and checked for straightness and the joints completed by riveting.

iv. The vertical and diagonal web members, except the end verticals shall then be erected with gusset connection outward from centre in their proper position on the bottom chords. Temporary gussets with correct whole position as on master gusset shall be fixed to connect the top end of diagonals. Strainers shall be used to realize matching of holes in the gussets at top & bottom of the diagonals & verticals, to ensure that the angles between the members at the bottom joints are as given by the nominal outline of the girders. The verticals and diagonals shall then be riveted to the lower chord.

v. All panel points, except the central one shall now be lowered by an amount sufficient to produce the correct camber on the main girders as shown on the camber diagram.

vi. The top chord shall thereafter be erected piece by piece, working symmetrically outwards from the centre without loss of camber profile.

vii. Temporary top gussets, if use, shall be replaced by permanent gussets outwards from the centre.

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viii. The ends posts shall be erected last. The upper end connection should preferably be made first and if there is not splicing in the end vertical, the final closure be made at the bottom connection. If there is splicing, it shall be made at the splicing.

ix. Frequent checks shall be made of the camber of girders during erection and care taken that the correct camber is obtained when the camber is obtained when the girder is completely assembled.

8.3 Care during Assembly

8.3.1 Drilling & Drifting of Holes

8.3.2 Drilling of joints shall be avoided as far as possible and when necessary should be done with great care and under expert supervision. Hammers not exceeding 1kg (2 lbs.) in weight may be used with turned barrel drifts and a number of holes drifted simultaneously, the effect of drifting shall be checked by observation of adjacent unfilled hole.

8.3.3 Any apparent error in shop work which prevents the assembling and fitting of the mating parts by the proper use of drifts, shall be investigated immediately.

8.3.4 As all work is rigidly inspected at the fabrication shop before dispatch, these difficulties should not arise and the cause could possibly be due to the use of incorrect components. It is usually important that parts be correctly handed. Should errors still persist, the matter shall be immediately reported to the Engineer who will decide what action is to be taken.

8.3.5 **Reaming:** No reaming shall be undertaken without the written authority of Engineer or his authorized representative or Inspecting Officer except for under drilled holes meant for turned bolts. If approved by Engineer, the contractor shall supply at his own expense, special rivets as may be required. Records of all actions relative to the recourse to reaming and the use of oversize rivets shall be reported to the Engineer.

8.4 Service Bolts & Drifts

Joint shall normally be made by filling not less than 50 to 60 percent of the holes with service blots and barrel drifts in the ration of four to one. The service bolts are to be fully tightened up as soon as the joint is assembled to secure full contact of the mating parts.

9. Inspection, Testing & Marking

9.1. 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.

9.2 On final finishing of each component, it shall be marked distinctly with paint with shipping mark for guidance, during assembly of component.

9.3 Stud shear connectors shall **conform to the standards specified in Clause 30 of this ' Additional Special Condition and Specification'** and the studs whose weld have failed the tests specified shall be replaced. All other aspects not stated above shall comply with IRS-BI-2001 and Welded Bridge Code.

9.4 Inspection of new Steel Bridge Girders

(a) Inspection of new Steel Bridge Girders including Composite Plate Girders for ROBs :

K-RIDE shall carry out inspection (including M&C)on its own by open line line/bridge organization or RDSO or may engage specialized third party like RITES,WRI or any other expert public sector undertaking e.g. CEIL etc. for fabrication inspection of girders to ensure the quality of fabrication.

(b) Inspection of Steel Bow String Girders for ROBs : shall only be done by RDSO (both at workshop and site).

(c) Inspection of Non-standard Girders for ROBs: shall be done by RDSO only.

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(d) The K-RIDE shall be responsible for nominating/selecting third party to ensure quality.

(e) The various stages and corresponding Inspection/Approval agency for Rail & Rail-cum-Road Bridge are as shown in Annexure-VII of BS 110 (R) are indicated below:

	Prefabrication stage	**Inspection/ Approval**
1	Approval of Quality Assurance Plan (QAP) QAP is to be scrutinized and approved by the inspection agency.	K-RIDE/Railway/ RDSO / Third party engaged by Railway for inspection.
2	Scrutiny of Welding Procedure Specifications Sheets (WPSS)	
3	Welders Qualification Test i.e. Welding Procedure Qualification Records (WPQR)	
4	Inspection and clearance of raw material	
5	Inspection of layout on template floor (Nominal Camber)	
6	Inspection of jigs and fixtures with master plates	
	During Fabrication:	
1	Use of approved raw material	
2	Use of approved welding consumables	
3	Use of approved welders	
4	Use of approved welding procedures and parameters (WPDS) Welding Procedure Data Sheet to be maintained for all welds.	
5	Fabrication with approved set of jigs	
	After Fabrication:	
1	Inspection of welds	
2	Structural and dimensional inspection	
3	Trial assembly (First Girder)- Camber Values, Dimensions, Fairness of Holes by Go-No-Go Gauge, Butting of Flange in Top Chord.	
4	Inspection of Dismantled Components of 1st Trial Assembly – Check for elongation of Holes/Abnormal stress marks/cuts etc. & Removal of shortcomings noted during Trial Assembly.	
5	Inspect of only components for further spans- welding inspection & Dimensional checks.	
6	Metalizing/ Painting	

Note: During fabrication, internal inspection to be done by K-RIDE to ensure that only RDSO approved welders carry out welding as per approved WPSS, work is as per dimensional tolerances and other quality aspects and should satisfy itself before sending Inspection call to inspection agency for Trial Assembly or components Inspection.

10. Transports from Workshop & Stacking at Site

10.1 loading of various Components and parts of Girders shall be done at the fabrication workshop by the contractor. The contractor/s are required to take following precautions as well due care in the entire process of transportation including loading, carriage and unloading at work site etc.

10.1.1 It should be ensured that while loading of various girder components / parts, the heavier material are loaded first followed by lighter material on the top so as to avoid any damage to lighter sections by heavy load or weight. All safety precaution is necessarily to be adhere-to as per extent instructions.

10.1.2 The contractor should provide all dunnage, rope and lashing in order to secure proper holding of material, for which no extra amount will be paid.

10.1.3 Proper wooden blocks, rubber pads shall be provided by the contractor/s so as to avoid direct contact of materials with trailer part which can cause damage to girder component.

10.1.4 All threaded ends and machine surfaces are to be efficiently protected against damage in transit.

10.1.5 Bolts, rivet, washer of different stages shall be separately packed in bag with label indicating its contents.

10.1.6 The payment will be made as per the relevant item of the works as per mode of payment specified in tender schedule after unloading and stacking the Girder components / parts at the site.

10.1.7 Utmost care should be taken during the transportation, loading / unloading etc. of the material viz. Girder components / parts. In case of any minor paint damage, proper patch painting should be done, according to relevant standard code, and for which no extra amount will be paid for any such rectification works.

10.1.8 The payment will be made as per the relevant item of the work in T/schedule after unloading and stacking at the site i.e. as per method of payment already prescribed in tender schedule.

10.2 INSURANCE:

10.2.1 Insurance:- Before commencing of works, it shall be obligatory for the contractor to obtain, at his own cost, insurance cover in the joint name of the contractor and employer from reputed companies under the following requirements:

10.2.2 **Insurance against Injury to Persons and Damage to Property:**

The Contractor, as insuring Party, shall insure against each Party's liability for any loss, damage, death or bodily injury which may occur to any physical property (except things insured under Sub-Clause 1.5.12 (b) [Insurance for Works and Contractor's Equipment]) or to any person / animal (except persons insured under Sub-Clause 1.5.12 (c) [Insurance for Contractor's Personnel]), which may arise out of the Contractor's performance of the Contract and occurring before the issue of the Performance Certificate.

10.2.3 This insurance shall be for a limit per occurrence of not less than the Rs. 50 Lakh (Rs Fifty Lakh), with no limit on the number of occurrences. The insurances specified in this Sub-Clause: a. shall be effected and maintained by the Contractor as insuring Party, b. shall be in the joint names of the Contractor and Employer, c. shall be extended to cover liability for all loss and damage to the Employer's property (except things insured under Sub-Clause 1.5.12 (b)) arising out of the Contractor's performance of the Contract

10.2.4 The insurance policy shall include a cross liability clause such that the insurance shall apply to the Employer, the Contractor and Subcontractors (wherever applicable) as separately insured.

10.2.5 The Employer shall not be liable for or in respect of any damages or compensation payable to any workman or other person in the employment of the Contractor or any Sub-Contractor (whether applicable), other than death or injury resulting from any act or default of the Employer, his agents or employees. The Contractor shall indemnify and keep indemnified the Employer against all such damages and compensation, other than those for which the Employer is liable as aforesaid, and against all claims, proceedings, damages, costs, charges and against all claims, proceedings, damages, costs, charges, and expenses whatsoever in respect thereof or in relation thereto.

10.2.7 **Insurance for Works and Contractor's Equipment:** The Contractor, as insuring Party, shall insure the Works, Plant, Materials and Contractor's Documents for not less than the full reinstatement cost including the costs of demolition, removal of debris and professional fees and profit. This insurance shall be effective from the Date of Commencement, until the date of issue of the Taking-Over Certificate for the Works.

10.2.8 The Contractor shall maintain this insurance to provide cover until the date of issue of the Performance Certificate, for loss or damage for which the Contractor is liable arising from a cause occurring prior to the issue of the Taking-Over Certificate, and for loss or damage caused by the Contractor in the course of any other operations. The Contractor shall insure the Contractor's Equipment for not less than the full

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replacement value, including delivery to Site plus 15% of replacement cost. For each item of Contractor's Equipment, the insurance shall be effective while it is being transported to the Site and until it is no longer required as Contractor's Equipment.

10.2.9 The insurances specified in this Sub-Clause:

(a) shall be effected and maintained by the Contractor as insuring Party,

(b) shall be in the joint names of the Parties, who shall be jointly entitled to receive payments from the insurers, payments being held or allocated between the Parties for the sole purpose of rectifying the loss or damage,

(c) shall cover all loss and damage from any cause not listed as Employer's Risks,

(d) shall also cover loss or damage to a part of the Works which is attributable to the use or occupation by the Employer of another part of the Works, and loss or damage from the Employer's Risks, excluding (in each case) risks which are not insurable at commercially reasonable terms.

(e) may however exclude loss of, damage to, and reinstatement of:

(i) a part of the Works which is in a defective condition due to a defect in its design, Materials or workmanship (but cover shall include any other parts which are lost or damaged as a direct result of this defective condition and not as described in subparagraph (ii) below),

(ii) a part of the Works which is lost or damaged in order to reinstate any other part of the Works if this other part is in a defective condition due to a defect in its design, Materials or workmanship

(iii) a part of the Works which has been taken over by the Employer, except to the extent that the Contractor is liable for the loss or damage.

10.2.10 **Insurance for Contractor's Personnel:** The Contractor shall effect and maintain insurance against liability for claims, damages, losses and expenses (including legal fees and expenses) arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel.

10.2.11 The Employer and the Engineer shall also be indemnified under the policy of insurance, except that this insurance may exclude losses and claims to the extent that they arise from any act or neglect of the Employer or of the Employer's Personnel.

10.2.12 The insurance shall be maintained in full force and effect during the whole time that these personnel are assisting in the execution of the Works. For a Subcontractor's employees, the insurance may be effected by the Subcontractor, but the Contractor shall be responsible for compliance with this Clause.

10.2.13 **Automobile Liability Insurance**

The contractor shall effect and maintain an insurance covering use of all vehicle used by the contractor or its sub-contractors (whether or not owned by them) in connection with the design, construction, testing and commissioning of the facilities under the contract in accordance with statutory requirements.

10.2.14 **Professional Indemnity Insurance**

(a) The Contractor shall provide evidence of professional indemnity insurance carried by its Designer for the Works. The professional indemnity insurance shall cover the risk of professional negligence in the design of the Works. This insurance shall be for a limit of not less than Rs. 50 Lakh and shall be maintained in full force and effect from the Commencement Date of the Works until 03 years after the date of completion of the Defect Notification period.

(b) The Engineer will not issue any payment certificate until the Contractor has provided evidence of this insurance and its period of effectiveness. The contractor shall provide evidence to the Employer / Engineer before commencement of work at site that the insurances required under the contract have been effected and shall within 60 days of the commencement date, provide the insurance policies to the

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Employer/Engineer, the contractor shall, whenever, called upon, produce to the engineer or his representative the evidence of payment of premiums paid by him to ensure that the policies indeed continue to be in force.

(c) The Contractor shall also obtain any additional insurance cover as per the requirements of the Contract or Law of the Country.

The Employer/Engineer shall not be liable for or in respect of any damages or compensation payable to any workman or other person in the employment of the Contractor or his subcontractor or petty contractor / other contractor working there. The Contractor shall indemnify and keep indemnified the employer / Engineer against all such damages and compensation for which the contractor is liable.

(d) The Policies of the contractor shall remain in force throughout the period of execution of the works and till the expiry of the defect liability period except for any specific insurance covers necessary for shorter period.

(e) If the Contractor fails to effect or keep in force or provide adequate cover as acceptable to the engineer in the insurance policies mentioned above, then in such cases, the engineer may effect and keep in force any such insurance or further insurance on behalf of the Contactor. The recovery shall be made at the rate of 1.5 times the premium/premiums paid by the engineer in this regard from the payment due to the Contractor or from the contractor's Performance security. However, the Contractor shall not be absolved from his responsibility and /or liability in this regard.

10.2.15 **Accident:-**

(a) The contractor shall, in respect of all staff engaged by him or by his sub-contractor, indemnify and keep the employer at all times indemnified and protected against all claims made and liabilities incurred under Workman's Compensation Act, the Factories Act and the Payment of Wages Act, and rules made there under from time to time or under any other labour and Industrial Legislation made from time to time.

(b) The contractor shall indemnify and keep the employer indemnified and harmless against all actions, suits, claim demands, costs, charges or expenses arising in connection with any death or injury sustained by any person or persons sustained due to the acts or omission of the contractor, his sub-contractors, his agents or his staff during the executions of this contract irrespective of whether such liability arises under the Workman's Compensation Act, or Fatal Accident Act or any other statute in force for the time being.

(c) The contractor's liability to meet third party claims of the type outlined above will be applicable only in cases where accidents have been caused by workmanship, material, execution or negligence on the part of the contractor and further the liability of the contractor will be limited to Rs.50 lakh for any one accident without any limit on the number of accidents.

(d) The contractor shall be responsible for all repairs and rectification of damages to completed works or works under execution due to DFCCIL accidents, thefts, pilferage or any other cause, without delay to minimize or to avoid traffic detentions, in a section until the installation are provisionally handed over to the employer.

11. Assembly and Launching :

11.1. Assembly work:

(i) After completion of fabrication, the girder components will be transported to the site and assembled on the specifically made assembly platform. Care must be taken by the contractor while transporting the materials to see that the parts at site are available in proper sequence.

(ii) All girders will be launched using suitable capacity cranes.

(iii) All temporary work shall be properly designed and substantial 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.

(iv) Temporary bracing shall be provided to take care of stress from erection equipment or other loads carried during erection.

(v) The blocks shall be arranged by K-RIDE. The contractor shall have to launch the girders within the block period.

11.1.1 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 in-charge 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 /Con may determine.

(a) The assembling of components at site to required camber and grade along bridge axis, preceding additional temporary structures and accessories for launching of girders and all related matters shall be full responsibility of the contractor.

(b) No pre-camber to be provided at the time of fabrication.

(c) All members of the girder and joints are to be either riveted or welded or bolted with HSFG bolts 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 riveting are to be carried out as per relevant IRS Specifications.

11.1.2 The launching 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 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.

11.1.3 For the Engineer's use and record, the contractor shall supply free of charge, four sets of prints on strong paper and one set of neatly executed tracings on linen of approved detailed drawings for assembly and launching schemes for use at site.

11.1.4 The launching system & procedure shown on enclosed drawings are purely indicative of the method proposed for launching for which the permanent members of the girders are designed. 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 members sizes but also for the entire launching system adopted. Contractor shall provide full structural details of the temporary member and their connections to the girder, along with necessary design calculations not only justifying members sizes but also of the entire launching system adopted. Contractor will be responsible for getting approval of launching scheme submitted by him from the Engineer.

11.1.5 In order to ensure perfect fit of the temporary components, holes may be carefully drilled for the connecting members in between the girders in situ and T & F High tension grip bolts used.

11.1.6 The launching system shall be test tried if directed by the Engineer and no separate payment for this shall be made.

11.1.7 Nothing extra will be paid to the contractor for adopting any scheme for launching and the costs are to be covered in the relevant item in the Price Schedule. All temporary members shall be removed after launching and may be taken back by the contractor. Erection gussets provided for connecting the members may be cut and edges ground as required by the Engineer.

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11.2 Temporary Strengthening

11.2.1 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.

11.2.2 The contractor has to make arrangements at his own cost for the steel for temporary arrangements including 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.

11.2.3 Crane working:

(a) The Contractor shall follow and comply with all prevailing Safety Rules of crane working, relevant provisions of applicable laws pertaining to the safety of workmen, employees, plant and equipment as may be prescribed from time to time without any demur, protest or contest or reservation. In case of any conflict between statutory requirement and Safety Rules prescribed by the crane manufacturer, the former shall be binding on the Contractor unless the statutory provisions are more stringent.

(b) Any loss or damage to property due to negligence of the crew employed by the contractor is attributable to the Contractor. K-RIDE shall not be responsible for any accident/injury to the Contractor's Crew/staff during operation or otherwise. Contractor has to assume full responsibility of the safety of their crew/staff and to comply with the prescribed security/safety regulations at site.

(c) The contractor shall inspect the Site for space for crane working, it is the responsibility of the contractor to ensure that no existing structure is damaged. In case any structure like boundary wall, footpath etc. is damaged, it should be repaired by the contractor at his own cost to the satisfaction of the owner/K-RIDE.

Some issues that need to be addressed during the inspection/preplanning stage are:

1. The type of crane that can safely perform the lift;
2. Access to the areas, staging areas, and the amount of space that is required to maneuver the equipment and materials;
3. The proximity of overhead power lines near the work;
4. A firm and adequate foundation for the crane;
5. Proper use and extension of the outriggers;
6. Guarding of the machine and all pinch points, especially the swing radius; and
7. Congestion in the work areas.

(d) The Contractor has to make their own arrangement for Accommodation, Transport and other amenities like Medical etc. for their crew/staff at Site at their own cost.

(e) All the statutory requirements as called for by the Labour Laws and other statutory authorities are to be met by contractor and proof of compliance should be made available to K-RIDE.

(f) Electrical Power/Illumination for Crane Operation/Maintenance works at Site shall be provided by the contractor at his own cost basis. However, the Crane should also have its own lights for movement/working in the working area at Site.

(g) The crane shall be operated by the certified trained operator only under the supervision of the qualified supervisor. The Contractor/crane supervisor shall ensure the cranes are set up and used properly on the construction site. He shall ensure right crane for the job, firm foundation, adequate clearances to handle the materials, guarding of moving parts, proper set up of the outriggers and basic crane operations such as two block, level, load charts, and load moment. The operator/supervisor must calculate loads to ensure they do not exceed the limitations of the equipment and satisfy MRVC engineer before deploying and actually operating the crane.

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11.3 Inspection and Rectification

11.3.1. During erection of girders, the contractor shall provide all facilities and permit the Engineer to inspect the field assembly, site riveting and erection of spans.

11.3.2 After inspection by the Engineer / Inspecting agency, 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 of 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.

11.3.3 A neat casting bearing the name of the contractor, the place and date of manufacture, the contact number and the standard of loading to be specified by the Engineer shall be bolted conspicuously on all girders. The drawing of the name plate shall be approved by the Engineer.

12. METHOD OF MEASUREMENT FOR PAYMENT

12.1 Measurement

12.1.1 For the purpose of payment, quoted Lumpsum Price apply to the weights of steel work calculated from final working drawings based on theoretical weights given in the producers hand books and using minimum square overall dimensions, 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 wastage of steel in the form of skew cuts etc. shall be the property of the contractor.

12.1.2 The drawing office dispatch lists (D.O.D.Ls) when prepared according to procedure shall be submitted by the contractor to the Engineer for approval.

12.1.3 The payment for steel work as per item in the Price Schedule shall be released in stages as per Schedules and 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 suppliers 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 in charge.

13. CONTRACTOR'(S) LIABILITY

13.1 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.

13.2 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 listed standards and in absence of any IRS & IS specifications.

14. TECHNICAL ORGANISATION/TOOLS, EQUIPMENT AND PLANTS.

(A) Contractor should have qualified and trained manpower suitable to do the work in terms of technical specifications and contract conditions.

(B) Contractor should have suitable and adequate plants, machinery and equipments required to execute the work like:

I. Cutting machine

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II. Radial drilling machine.
III. Edge milling machine, end milling machines.
IV. Plate/structural steel straightening machine.
V. Pneumatic grinding machine, drilling machines, chipping machines and wrenches etc..
VI. Sand blasting equipment and metalizing equipments.
VII. Welding machines.
   a. SAW
   b. MIG/MAG
VIII. Welding transformers
IX. Cranes of adequate capacity.
X. Suitable digs and fixtures.
XI. To test the raw material and girders to conform to relevant specification, testing facilities, for the following should be available either in house or through outsourcing.
   a. Elcometer for measurement of thickness of paints.
   b. Steel measuring taps duly calibrated.
   c. Ultrasonic flow detection testing facilities for checking internal flaws.
XII. Suitable Welding manipulator.
XIII. Macro etching/DP or MP testing facilities.
XIV. Tongue tester for measuring current and voltage.
XV. Gauges for checking weld size throat thickness and edge preparation etc..
XVI. All equipment must meet the requirements of corresponding IS, IRS or other international specifications.

(C) Manpower: Adequate No. of trained qualified welders shall be available with the tenderer. The welder must be trained in accordance with the provision of IS: 817. They must be trained either from recognized welding institutes or by in house training, where proper training facilities exist. The welder must be tested as per requirements of IS: 7310 and proper records maintained.

List of equipments mentioned above is only indicated and not exhaustive. The firm shall be required to deploy all other machineries, tools & plants etc. required for successful completion of the work of fabrication, assembly and launching of the girders.

15. Contractor shall establish (at his own cost) the fabrication workshop near the site only for close monitoring of all the quality aspects of this contract work. Contractors request for establishing workshop/using workshop proposed/located away from the bridge site shall require prior approval.

16. Contractor shall establish fully equipped laboratory for all the tests required on materials/processes/products as per provisions of the contract, Specifications and the direction/approval of the Engineer. Costs of these are deemed to be included in the quoted Lumpsum Price. Prior approval of the engineer shall be obtained for non-installation of such testing equipment which cannot be installed in normal course due to any reason. However, Engineer's decision (for installation non-installation) in this regard shall be final binding and conclusive.

17.0 SITE FACILITIES BY THE CONTRACTOR:

17.1. Contractor shall provide following office/site facilities at locations approved by K-RIDE for ensuring smooth and efficient communication and work execution. Cost of these facilities deemed to be included in the quoted Lumpsum Price and nothing extra shall be paid for this item.

(i) Contractor shall supply round the clock electricity in Project / Site Offices at locations approved by K-RIDE during the entire contract work. Contractor shall also maintain the electric fittings/writings/plants of both the offices in the good condition.

(ii) To provide proper communication, the contractor shall (at his own cost) establish inter office communication system between K-RIDE offices, Project / Site Offices provided to Employer and Engineer by the contractor, fabrication workshops and contractor's offices at site. Adequate number of intercom/

telephone/mobile sets or are similar suitable equipments as decided/approved by Employer fully communicable shall be established in each of the above fabrication shops & at site. The entire expenditure incidental to running and maintenance of above shall be borne by the contractor within quoted rates.

(iii) Contractor shall (at his own cost) depute/nominate safety officers(s) for supervising safety aspects of all works/process including enabling arrangements for execution and inspection of the work. Safety systems/arrangements should be made for each activity of fabrication/erection and its inspection and same should be certified by nominated safety officer. Special care/arrangements are required to be made for supervising the erection/launching process of such high girders and concreting in road deck: arrangements should facilitate satisfactory and fearless inspection of each activity of launching/erection.

18. COMPUTERIZED NUMERICAL CONTROL(CNC)MACHINE:

A machine based on advanced technology in the fields of fabrication of steel members known as Computerized Numerical Control (CNC) Machine is preferably be used. By this machine, cutting, drilling can be done at required distance and in required patterns. This machine is guided by a computer programme and drawings of the joints and components to be fabricated are prepared in AUTOCAD and fed in the computer programme. This machine is capable of reading the drawings in 3D image and after giving command, this machine cuts the steel plates, angles, channels etc. in desired length and pattern duly measuring very accurately in parts of mm. Drilling of holes are also done at required pitch and pattern as per drawing and hence the use of Jigs are done away with; thus eliminating the human error in measuring and marking etc. and further to enhance production.

19. CONTRACTOR TO STUDY DRAWING & SPECIFICATION etc. AND HIS LIABILITY:

The contractor shall be responsible for close scrutiny of the approved drawings supplied by the K-RIDE, for any discrepancies, error or omission in the drawings or other particulars indicated therein, the contractor shall approach the K-RIDE immediately for rectification of such discrepancies, errors and omission. If any dimension/figure/features etc. on approved drawings or plans differ from those drawings or plans issued to the tenderers at the time of calling the tender, the dimensions as figured upon the approved drawings or plans shall be taken as correct.

20. FURTHER DRAWING AND INSTRUCTIONS:

(i) Employer / Engineer shall have full power to make and issue further drawings or instructions or direction from time to time as may appear necessary and proper to the contractor for efficient construction, completion and maintenance of the works. The contractor shall be bound by the same as fully as if they had been mentioned or referred to in the contract, and the contractor shall not be entitled to any extra payment in respect of any work or materials shown or directed to be done supplied by such further drawings or instructions required for completion of unless the Engineer shall have given an extra order for the same in writing.

(ii) The tenderer's rate should provide for cutting M. S. Plates for making out M. S. Flats from plates, in case M. S. Flats are not available, No extra payment for such cutting and rinding that may be necessary for converting M. S. Plates to Flats will be admissible.

(iii) If the works are required to be done in by Rly. Yards and Tracks are to be crossed, the tenderer shall inspect the site and make himself thoroughly acquainted with site condition and quote proper rate including provision for making suitable facilities at site for the work.

(iv) The work shall have to be done in such a manner that the normal working of the Railway within the railway yard does not get disturbed. Proper protection is not to be ensured by the contractor for allowing their labourers to cross the Railway lines with head-leads. No material/temporary structures should be kept adjacent to the running track within 3M from the centre line of track which may infringe rail traffic. The contractor shall take necessary precaution to prevent/cause damage to the Railway property & K-RIDE staff during the execution of the work.

21. CONTRACTOR TO SUBMIT HIS TIME TABLE:

The contractor shall submit a monthly progress of work done during the month by the 4th day of the following month. He will also give the programme of coming month by 25th of each month. The programme will be subject to alteration at the discretion of the K-RIDE officials.

22. ANY DOUBTED POINTS TO BE REFERRED TO THE EMPLOYER :

Should there be any doubt or obscurity as to anything to be done or not to be done by the contractor or as to these instructions or as to any matter or thing, the contractor must set forth such doubt or obscurity in writing and submit the same to Employer. Only such reply as the Employer may be giving in writing given shall be taken as the authoritative interpretation of the point in doubt or obscurity. The Engineer does not have any authority to give any interpretation / explanation to the contractor with regard to the meaning of any provision of contract.

23. LAND:

DELETED

24. TRANSPORTATION AND HANDLING OF MATERIAL & PLANT:

The contractor shall be responsible to arrange at his own cost wagons (if required) for transportation of materials and stores (other than those which are being arranged by the K-RIDE) required for the works. The Railway / Client undertakes no responsibility for delay in its supply. The contractor shall be responsible for all handling and timely loading and unloading as per Railway commercial rule for public.

25. LOADING OF MATERIALS: REFER CLAUSE 44.1 TO 44.3 OF IR FABRICATION SPECIFICATION SERIAL BI-2001 ISSUED BY RDSO.

26. GUARANTEE AGAINST DEFECT:

(a) The Contractor shall guarantee that all the works executed under this contract shall be free from all defects and faults in material, workmanship and manufacture and shall be of acceptable standards for the contracted work and in full conformity with the technical specifications, drawings and other contract stipulations, for a period of 24 months from the date of taking over by the Employer.

(b) During the period of guarantee the Contractor shall keep available an experienced engineer /manpower to attend to any defective works / installations resulting from defective erection and/or defect in the installation supplied by the Contractor. This engineer shall not attend to rectification of defects which arise out of normal wear and tear and come within the purview of routine maintenance work. The contractor shall bear the cost of modifications, additions or substitutions that may be considered necessary due to faulty materials or workmanship for the satisfactory working of the equipment. The final decision shall rest with the Engineer his successor(s)/Nominee.

During the period of Guarantee the Contractor shall be liable for the replacement at site of any parts which may be found defective in the executed work whether such parts / structural elements of his own manufacture or those of his sub-contractor / supplier whether arising from faulty materials, workmanship or negligence in any manner on the part of the Contractor provided always that such defective parts as are not repairable at site are promptly returned to the Contractor if so required by him at his (Contractor's) own expenses. In case of parts of executed work detected during guarantee period, contractor should replace all such items irrespective of the fact whether all such items have failed or not. The Contractor shall bear the cost of repairs carried out on his behalf by the Employer at site. In such a case, the contractor shall be informed in advance of the works proposed to be carried out by the Employer.

(c) If it becomes necessary for the Contractor to replace or renew any defective portion of the structural elements until the expiration of six month from the date of such replacement or renewal or until the end of the above-mentioned period whichever is later. Such extension shall not apply in case of defects of a minor nature, the decision of the General Manager/ROB or CPM or his successor/nominee being final in the matter. If any defect be not remedied within a reasonable time during the aforesaid period the Employer may proceed to do work at the Contractor's risk and expense, but without prejudice to any other rights and remedies which the Employer may have against the Contractor in respect of such defects or faults.

(d) The repaired or renewal parts structure shall be delivered / supplied and erected / executed on site free of charge to the employer.

(e) Any materials, fittings, components or equipment / structure supplied under items for supplying / providing and fixing in schedule shall also be covered by the provisions of this paragraph. The liability of the Contractor under the guarantee will be limited to re-supply of components / structure installation and fittings.

27. INCLUSIVE PRICE:

(i) The cost of all painting, temporary erection and testing at the Tenderer's workshop, Packing and delivery at the site of work as specified in the schedule, is to be included in the price quoted on the tender.

(ii) Any fittings, accessories or apparatus which may not have been mentioned in the specification, but which are considered necessary for the execution of this work, are to be provided by the contractor without any extra payment .The work must be completed in all details.

28. Traffic Blocks / Power Blocks / Shut Down:

28.1. The Engineer shall obtain Power / Traffic / Shut down as per the readiness and request of the contractor. Engineer/Engineer's representative 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. Contractor will arrange minimum two gangs of labours i.e. expert of TR line fitters, Semi-skilled fitters, labour, etc. with super visors and sufficient tools and tackles required as per site conditions. Work will be done day & night with war foot level with the approval of the Engineer/Engineer's representative. Block will be provided for each ROB individually.

28.2 Blocks will be granted during day & night hours continuous. 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.

28.3 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.

28.4 Blocks will be subject to normal operating conditions and rules of the Railway. All formalities of exchanging private number etc. with the traffic control/traction power controller will be carried out by the Engineer staff and for this purpose the Engineer will depute a representative for each ROB, who will be responsible for imposing power blocks/shut down and also removing the same after men, material and equipment have been cleared by the Contractor from running tracks and the same declared safe for traffic by Engineer/Engineer's representative in case of works involving safety of running tracks.

28.5 The works required to be done under traffic block shall be carried out only in the presence of Engineer/Engineer's representative . The Engineer/Engineer's supervisor shall certify safe conditions for passage of trains before resumption of traffic. The works to be done under traffic block shall be carried out under the provision of banner flag and protection of engineering flagman.

28.6 Any charges which may be levied by IR on account of "Possessions" shall be payable by the contractor but shall be reimbursed 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.

29. DECLARATION OF DESIGNED FABRICATION/ASSEMBLY YARD AS A PART OF SITE:

29.1. K-RIDE may issue necessary declaration on specific request of the contractor subject in the condition that the workshop area is earmarked exclusively for fabrication of girder components for this bridge with separate entry/exit arrangements. This is with further stipulation that such an arrangement should be acceptable to excise department by way of a no objection certificate. Necessary follow up with Excise Department will be solely the contractors responsibility. In the event of excise department not agreeing to such an arrangement ,

the contractor shall not have any claims whatsoever, and shall pay excise tax and other extant taxes as per extant rules within quoted Lumpsum Price and nothing extra would be payable to them on this account

30. STUD SHEAR CONNECTOR:

In the case of Composite Girders wherein the steel structure of a bridge is fixed to the concrete structure of the deck so that the steel and concrete act together, so reducing deflections and increasing strength. This is done using 'shear connectors' fixed to the steel beams and then embedded in the concrete. Shear connectors can be welded on, perhaps using a 'stud welder', or better still on export work, by fixing nuts and bolts.

30.1 Material: The stud shear connector and ceramic ferrules shall conform to type SD1/UF as per BS EN ISO 13918-2008. The diameter of ceramic ferrule D 7 as per Figure 13/Table 18 of BS EN ISO 13918 shall be 26. Mechanical properties of stud shear connectors shall be as per ISO 6892/BS EN ISO 13918–2008. Shape of tip of stud shear connectors may be chosen by manufacturer. The stud tip shall be supplied with flux in the form of press fitted aluminum ball or Aluminum spray coating.

30.2 Welding: The welding of stud shear connectors shall be done by “Drawn arc stud welding with ceramic ferrule” Technique. The stud and the surface to which studs are welded shall be free from scale, moisture, rust and other foreign material. The stud base shall not be painted, galvanized or cadmium plated prior to welding. Welding shall not be carried out when temperature is below 10 degrees Celsius or surface is wet or during periods of strong winds unless the work and the welder are adequately protected. The welds shall be visually free from cracks and shall be capable of developing at least the nominal ultimate strength of studs. The procedural trial for welding the stud shall be carried out when specified by the Engineer.

30.3 Testing:-

(a) Appearance test

1. The weld to a stud shear connector should form a complete collar around the shank and free from cracks, excessive splashes of weld material, free from injurious laps fins, seams, twist, bends or other injurious defects.
2. Weld material should have a `Steel Blue‟ appearance.

(b) Test to check the fixing of shear studs. All studs need to be checked by a ring test.

1. Ring Test: Involves striking the side of the head of the stud with a 2 kg hammer. A Ringing tone achieved after striking indicates good fusion whereas dull tone indicates a lack of fusion (BS 115).
2. Bend Test: Test requires the head of a stud to be displaced laterally by approximate 25% of its height using a 6 kg hammer.

- The weld should then be checked for signs of cracking or lack of fusion
- Stud should not be bent back as this is likely to damage the weld
- The testing rate should be 1 in 50 (BS 115).

30.4 Measurements: The work shall be enumerated. It's unit is "each".

30.5 Lumpsum Price :- The Lumpsum Price shall include the cost of material, labour, equipment, tools and plants, etc. complete required for all operations described above. The rate for Stud Shear Connected is also included so no separate payment for this item will be made.

31. SCHEDULE OF TECHNICAL REQUIREMENTS (STR)) FOR FABRICATION OF STEEL GIRDERS. (LATEST VERSION TO BE FOLLOWED)

A. Procedure for supply of steel girder:

1. For the steel girders of all bridges other than important bridges (as defined in IRS Sub Structure Code), the tendering firm shall be from RDSO approved list of firms for Steel Bridge Girders only further subject to the condition that the tendering firm fulfils other technical and financial eligibility criteria as prescribed by the K-RIDE in the tender and the steel girders to be manufactured by the tendering firm in RDSO approved premises only.

2. For Steel Girders of important bridges (as defined in IRS Sub Structure Code), besides RDSO approved firms, the tendering firm can also be other than RDSO approved firm for Steel Bridge Girders subject to the firm fulfilling technical and financial eligibility criteria as prescribed by the K-RIDE in the tender and the site fabrication workshop of the firm shall be set up at site of work which meet with the Schedule of Technical Requirement (STR) for Steel Bridge Girders issued by RDSO time to time. The approval of the site fabrication workshop meeting with the STR to be done by RDSO only and not by any other organization. The existing system of approval by K-RIDE officer not below JA Grade is discontinued.

The tenderers besides satisfying similar work eligibility criteria and financial eligibility criteria have also to fulfill the following technical requirements.

B. The firm will ensure availability of

i) The required infrastructure, machinery & plant.

ii) Testing and measuring equipment duly calibrated.

iii) Trained technical manpower and quality assurance programme.

iv) Equipment meeting the requirements of relevant specifications.

v) Space required for manufacturing, testing and storage viz. manufacturing floor, godown, store, office and test lab also.

C. General and Infrastructural Requirements for Steel Girders.

i. The fabricator must have adequate organization including supervisors, skilled workers and adequate manpower to execute the fabrication work in competent manner.

ii. A proper organization must exist to perform the functions of purchasing of various raw materials and consumables etc. and maintaining related inspection certificates, test certificates etc.

iii. Previous experience of fabricating steel structures capable of withstanding dynamic loads such as bridge girders, microwave towers, heavy industrial steel structures etc. is essential.

iv. A proper procedure for maintenance of records for receipt and consumption of raw material should be in vogue or developed so as to permit verification by K-RIDE representative.

v. Adequate power supply should be available through distribution agencies and adequate backup shall be available through captive generation.

vi. Covered pay area served by EOT cranes or by mechanically operated machines should be provided to handle day to day fabrication of girder components.

vii. Enough area to store raw material, subassemblies and finished product should be available. The area provided should be enough to store raw material to execute the work order for requirement of steel. Suitable material handling facilities in form of EOT/mobile cranes should be available.

viii. A separate line for inspection and testing of girders should be provided for final inspection and testing of bridge girders by K-RIDE inspecting engineers.

ix. Covered shed area protected from rain, dust etc. should be provided for surface preparation/painting/metalizing of steel girders. As no part of the work shall be painted unless it has been finally passed and cleared by inspecting officer, adequate space for storing fabricated component awaiting painting shall be available.

x. For full scale layout of drawings to which girders are to be manufactured, template shop with steel/concrete floor should be available. For symmetrical girders, central half of the layout may be done and for non-symmetrical girders full-length layout shall be required. Further, for development of jigs and fixtures this shop should have in – house jigs manufacturing facilities.

xi. Sufficient space for trial erection of the girder after manufacture shall be available. For this purpose, proper handling equipment, stacking space and other facility shall be available.

xii. An adequately equipped and staffed drawing office is required for preparation of fabrication drawings.

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D. Machinery & Plants.

Following machinery and plants shall be available with the fabricator.

(i) EOT/Portal/mobile crane of min.10t capacity or suitable material handling facility to serve the handling of material for fabrication of girders, unloading of raw material and loading of finished product.

(ii) Compressors of adequate capacity suitable for riveting and for other simultaneous applications.

(iii) Oxy – Acetylene gas cutting equipment.

a) Profile cutting equipment of adequate size.
b) Self-propelled straight cutting equipment preferably consisting of multiple torches.

(iv) Radial drilling machines of adequate capacity to drill holes of 12 to 50 mm diameter.

(v) End milling machine.

(vi) Plate & structural sections straightening machine.

(vii) Pneumatic/hydraulic yoke riveting machine.

(viii) Adequate number of portable pneumatic tools such as grinders, drilling machines chipping machines, wrenches etc.

(ix) Dumpy level or theodolite instrument for recording of camber/deflection of trial erected girder.

(x) Facility for surface preparation/painting/metalizing as per IRS B-1 specification.

(A) To test the raw material and girders to conform it for relevant specification, testing facilities for the following must be provided:

a. Elcometer for measuring thickness of paint.
b. Steel measuring tape duly calibrated.

(B) Following facilities for testing of material can be in house or may be arranged from external agencies:

a. Equipment required for testing of mechanical properties, chemical composition and microstructure etc.
b. Ultrasonic flaw detection testing facilities for checking internal flaws and thickness of section.

(xi) System of periodical maintenance of M& P must be in vogue and proper records maintained.

E. Quality Infrastructure.

i. Fabricator shall have proper quality infrastructure to ensure the quality product as required under latest issue of IRS B1 specification and IRS Welded Bridge Code as applicable.

ii. A system should be in force for analysis of defects noticed during internal and external inspections of the final product and sub-assemblies. A dynamic arrangement for a feed back to the source of defects and for rectification should be in vogue.

iii. The fabricator should have adequate infrastructure and facilities like checking gauges, templates etc. during fabrication required from time to time so as to ensure that the finished product is as per requirement of IRS : B1 and Welded Bridge code.

iv. Following specifications/codes commonly referred in connection with fabrication or riveted steel girders must be available with fabricator.

IRS B -1	Fabrication and erection of steel girder bridges
IRS	Steel bridge code
IS : 1148	Hot rolled steel rivet bars (up to 40 mm dia) for structural purpose.
IS: 1149	High tensile steel rivet bars for structural purpose

K-RIDE

IS : 1852	Rolling and cutting tolerance for Hot Rolled Steel Products
IS : 2062	Hot rolled low, medium and high tensile structural steel.

The latest version of BIS Codes/Specifications referred herein including their amendments issued from time to time are to be followed:

v. All equipment must meet the requirements of corresponding BIS or other international specifications.

F. Additional general and infrastructural requirements for fabrication of welded girders.

i) The following facilities should be available for fabrication of welded girders.

a. Welding transformers/rectifier for Manual Metal Arc Welding(MMAW)
b. Inert gas (Carbon Dioxide) welding equipment sets.
c. Automatic sub – merged arc welding equipment.
d. Suitable welding manipulators.
e. Macro-etching/ Dye Penetrant or Magnetic Particle testing facilities.
f. Arrangement for radiographic test either in house or from external agency.
g. Tongue tester for measuring current and voltage.
h. Gauges for checking weld size, throat thickness and edge preparation etc.

ii) Machine for edge preparation before welding.

iii) Fabricators must ensure that welding and gas cutting equipment/accessories meet BIS or other international standard requirements. It will be fabricators responsibility to satisfy the inspecting engineer that all the welding equipment/accessories conform to the BIS standard or any other standard in the absence of proper marking on such equipment/accessories.

iv) Only trained and qualified Welders shall be deployed for welding. The welders must be trained in accordance with the provisions of IS:817. They must be trained either from recognized welding institutes or by in – house training, if proper facilities exist. The welders must be treated as per requirements of IS: 7310 and proper records maintained.

v) All welding shall be carried out under the overall supervision of a qualified welding supervisor who has been trained in 'Welding Technology from any recognized welding institute.

vi) Welding instructions shall be prominently displayed on the shop floor. Requirement of the job in hand must be clearly explained to the welder before he is permitted to work.

vii) Following specifications/codes commonly referred in connection with fabrication of welded steel girders must be available with fabricator.

IRS WBC	IRS Welded Bridge Code
IS: 817	Code of practice for training and testing of metal arc welders.
IS : 818	Code of Practice for Safety and health requirements in electric and gas welding operations.
IS : 822	Code of Procedure for inspection of welds
IS : 4353	Recommendations for sub-merged arc welding of mild steel and low alloy steels.
IS : 7307 (Pt.I)	Approval tests for welding procedure.
IS : 7310 (Pt.I)	Approval tests for welders working to approved welding procedure – fusion welding of steel.
IS : 9595	Recommendations for metal arc welding of carbon and carbon manganese steel.

The latest version of BIS Code/Specifications referred herein including their amendments issued from time to time are to be followed. Wherever to the standards mentioned above appears in the specification it shall be taken as a reference to the latest version of the standard.

SECTION – 02C

SPECIAL CONDITIONS & SPECIFICATION FOR BOX PUSHING TECHNIQUE

SECTION- S.02 C

SPECIFICATIONS

SPECIAL CONDITIONS & SPECIFICATION FOR BOX PUSHING TECHNIQUE

a. **SUBMISSION OF PRELIMNIARY 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/K-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.

b. **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/K-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/ K-RIDE/ Bangalore.

After the approval of designs and drawings by Railways/K-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.

c. **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/ K-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 / K-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 GM/K-RIDE/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/K-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 / K-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 / K-RIDE.

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 benetonite 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 theoritical 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 K-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/K-RIDE.

Construction of footpaths, wheel guards boxes and parapet wall as per design to be submitted by the Tenderer for approval of the K-RIDE.

K-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.

d. **GENERAL RESPONSIBILITY OF CONTRACTOR**:

Contractor shall be responsible for all the damages caused to the property, by his labour, public or animanls caused during the execution of the work by him and shall indemnify the K-RIDE for such damanges 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.

e. **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.

1. STAGE PAYMENT FOR RCC BOX BY JACKING/PUSHING TECHNIQUE: TERMS OF PAYMENT

(1) On completion of thrust bed, payment equivalnt 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, prograssive 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.

K-RIDE

SECTION - 03

STRUCTURAL CONCRETE

SECTION- S.03

1. STRUCTURAL CONCRETE:

2. PLAIN, REINFORCED & PRESTRESSED

These specifications shall be read in conjunction with the IRS Concrete Bridge Code, IS 456, MORTH and CPWD specifications 2013/2009 with correction slips / amendments upto date, and other relevant specifications described in the Section 1 of these Specifications.

3.0 MATERIALS

Before bringing to the site, all materials for concrete including their source 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 on to the works shall conform in every respect to the 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 at any time to find out 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 material which has 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. In the event of contractor not being able to arrange the material conforming to specifications or in the event of failure of the contractor to get the sources approved within the agreed schedule submitted by contractor, the Engineer shall have the powers to cause the Contractors to purchase and use such 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.

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

3.1.1 CEMENT

3.1.1.1 The cement used shall be of the following types

43 grade Ordinary Portland Cement conforming to IS:-269 for RCC & PCC works.

53 grade Ordinary Portland Cement conforming to IS: 269 for RCC & PSC works.

IRST-40 Indian Railway standard specifications for special grade cement for use in concrete sleepers

For piling and foundation work, type of cement shall be as mentioned in section S-08 on Pile Foundations herein.

‘Cement’ means Ordinary Portland Cement conforming to IS 269 or slag cement conforming to IS 455 excluding mineral admixture/ additions as mentioned in para 5.2 of IS 456

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 labeled with the weight, name of manufacturer, brand, date of Manufacture and type. Cement received in tor 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 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.

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 a single consignment. 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 consignment, 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.

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.

3.1.2 AGGREGATES

Aggregates from natural sources shall be in accordance with IS: 383. 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 AGGREGATES

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, stone dust or other approved 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, III.

Water absorption shall be less than 3% by weight (ASTM C 117)

The contractor shall provide complete facilities at site for carrying out the following tests:

A) Proportion of clay, silt and fine dust by sedimentation method as per IS:2386 part II.

B) Moisture content in fine aggregate as per IS: 2386 Part III.

C) Bulk density/ Bulkage

3.1.2.2 Coarse Aggregates

The coarse aggregate shall be crushed stone. Coarse aggregate obtained from crushed or broken stone shall be angular, hard, strong, dense, non-porous, durable, clean and free from soft, friable, thin plate, elongated or flaky pieces and any deleterious material.

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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 aggregates of uniform quality can be maintained over the said period of the works, the grading of aggregates shall be controlled by obtaining the coarse aggregates in different sizes and blending them in correct proportions as and when required.

All coarse aggregates 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 aggregates shall be such that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of formwork. Unless otherwise permitted by the Engineer the nominal maximum size shall not exceed 20 mm.

Water absorption shall be less than 3% by weight (ASTM C 117)

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.

3.1.3 **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, clean and free from injurious amounts of oil, salts, acids, alkali, 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/liter.

Before starting any concreting work and wherever the source of water changes, the water shall be tested in accordance with IS: 3025 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 in aggregates will be a smooth curve from size 0.15 mm to 20 mm falling within the established envelope grading curve. Contractor shall establish envelope grading curve for each grade of concrete for given maximum size of aggregates and get it approved by Engineer before finalizing the mix design.

3.3 Admixtures

3.3.1 Chemical admixtures are not to be used until permitted by the Engineer. In case their use is permitted, the type, quantity/dosage and method of use of any admixture 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 the Admixtures.

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3.3.2 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.
d. Whether or not the admixture leads to the entrainment of air when used 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

3.3.3 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.

3.3.4 The admixtures when used shall conform to IS:9103. The suitability of all admixtures shall be verified by trial mixes.

3.3.5 The addition of calcium chloride to concrete containing embedded metal will not be permitted under any circumstances.

3.3.6 Retarding admixtures when used shall be based on ligneous-Phonates with due consideration to clause 5.2 and 5.3 of IS: 7861.

3.3.7 Fibre reinforcement will be Propex (Fibermesh 300-e3 / Fibermesh 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. 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 jobsite provided that fibers are evenly distributed mix.

3.3.8 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.

3.3.9 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/m^3 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:-

% equivalent Na2O = % acid soluble Na2O + 0.658 x (% acid soluble K2O)

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 Subsections14 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:

    Portland cement

$$A = \frac{C \times a}{100},$$

    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 = 0.76x {(NFxMF)+(NCxMC)} (kg/m3)

    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.

K-RIDE

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

3.5.1 Unless otherwise 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.

3.5.2 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 supplied by recognized 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's: 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 coarse aggregates in mm.

3.7 Mix Design

It is the complete responsibility of the Contractor to design the concrete mixes by approved standard methods as per IS 10262 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. However, should the contractor anticipate any change in quality and/or change in source 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.

Notwithstanding to the stipulations in any code, limits of Cement content, Water/Cement ratio & mineral admixture shall be followed as per the Table 3.7.1.

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

Sl. No.	Description of Structural items/ elements		Applicable code	Grade of Concrete	Max. W/C ration	Min. cement content (kg/m^3)	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)	RCC 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		
		Pier and pier cap		RCC M50	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.
		Slab & beams		RCC M50	0.45	340		
		Superstructure and PSC pier arms etc..		PSC M55	0.40	400	OPC 53 grade conforming to IS 12269	Not permitted
	Other than track supporting structures	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	In case slag cement not used, GGBS is permitted to be used for

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Sl. No.	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
	Pile cap/ footing/ raft foundation/ underground structures	IS 456	RCC M35	0.45	340	or site blending OPC53+GGBS	part replacement of OPC to max. 50% by weight.
	RCC Columns		M35	0.45	340	OPC 53 grade conforming to IS:12269	Permitted to use micro silica/ silica fumes or Flyash as per IS 456 over and above minimum cement content as per mix design requirement.
	Slabs & beams		M35	0.45	340		

Maximum cementitious content in a mix which includes cement and mineral admixtures shall not exceed 500 Kg/m³. Where ever code/standards permits, the micro silica, fly ash and GGBS shall be allowed.

Limits of Water and Cement Contents

Maximum water/cement ratio

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

3.8 Cement Content

Ordinary Portland cement (OPC) of 53 grade conforming to IS: 269 shall be used. For pre-stressed concrete, cement conforming to codal specifications for OPC 53 grade cement shall be used.

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.

3.9 Additional Tests for Concrete

As frequently as the Engineer may require, additional tests shall be carried out of concrete in addition to mandatory test specified in MORTH Specifications-2013(fifth revision), CPWD specifications -2009 and relevant IS Code.

3.9.1 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 1716.5 of MORTH Specifications and DIN 1048.

1. 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.
2. From the batches thus selected two concrete cylinders shall be made in accordance DIN 1048.
3. 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.
4. All cylinders shall be made, cured, stored, transported and tested in accordance with clause 1716.5 of MORTH Specifications. The tests shall be carried out in a laboratory having NABL certification.
5. Test Procedure

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

   (i) Prepare a cylindrical test specimen 150 mm dia and 160mm high.

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(ii) After 28 days of curing, test specimen will 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/II of MORTH.

(iii) At first a pressure of one bar is applied for 48 hours, followed by 3 bars for 24 hours and 7 bars for next 24 hours.

(iv) After the passage of the above period, the specimen is taken out and 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).

6. 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 as tested above.

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

3.10 Batching of Concrete Ingredients

Unless permitted by the Engineer, all concreting shall be produced in computerized automatic weigh batching plant having printing facilities to print out records of each batch and installed at site. Under exceptional circumstances Ready Mixed Concrete (RMC) manufactured in computerized automatic weigh batching plant (as per specifications described above) by the approved agencies using the constituent materials from approved sources and approved mix design may also be used with prior approval from Engineer. Nothing extra shall be paid for such RMC used in the work including transportation, placing in position etc. However, in such cases the RMC production & transportation will have to be directly supervised by the qualified personnel of the contractor. (Contractor has to setup his own batching plant(s). RMC from market will be permitted only in exceptional circumstances and to be decided by the Engineer.)

3.11 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 C, 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 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.

3.12 Transporting, Placing, Compacting and Curing

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

3.12.1 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.

3.12.2 **Placing:**

(i) **Placing General**

Concrete shall be placed in the position and sequence indicated on the Drawings, or as directed. Placing shall not be commenced until the fixing and condition of reinforcement and items to be embedded and the condition of the containing surfaces or formwork has been approved. 24 hours written notification shall be given of the intention to place concrete.

Concrete shall be transported by means which prevent contamination (by dust, rain etc.) segregation or loss of ingredients, and shall be transported and placed without delay.

Concrete shall be placed directly in its final position without segregation or displacement of the reinforcement, embedded items and formwork. Concrete shall not be placed in water, except as specified. Concrete shall not be dropped through a height greater than 1.5 meters.

(ii) **Extent of Pours**

The limit of individual pours and the height of lifts shall be as approved.

For walls, the length of panel placed at one time shall not exceed 6m; adjacent panels shall not be placed within 2 days, but shall be placed as soon as practicable thereafter. Subsequent vertical lifts shall not be poured within 2 days.

For piers and pier heads, portal columns 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.

Floors, roofs and ground slabs shall be placed in a sequence of pours to the approval of the Designer and the consent of the Engineer's Representative.

If the use of slip-forms or paving trains is permitted, these limits may be revised. The sequence of pours shall be arranged to minimise thermal and shrinkage strains.

(iii) **Placing Equipment**

Concrete shall generally be placed without segregation by pumping or bottom-opening skips. If chutes are used their slopes shall not cause segregation and spouts or baffles shall be provided.

(iv) **Time for Placing**

Concrete and mortar must be placed and compacted within 30 minutes of water being added to the mix or otherwise included via damp aggregates, unless admixtures are in use. Partially-set concrete shall not be used in the Works.

(v) **Continuity of Placing**

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

(vi) **Placing in Inclement Weather**

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

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(vii) **Placing in High Temperature and Low Temperature**

The temperature of concrete shall not exceed 32° nor below 50°C or the temperature stated in the table of Mixes whichever is the lower at the time of placing concrete. Also the maximum concrete temperature after placing shall not exceed temperature 50 ° C or 30 ° C above the concrete temperature at the time of placing whichever is the lower.

"Concrete in hot countries" published by FIP congress at New Delhi 1986 shall be complied with. The procedures the Contractor wishes to employ shall be subject to the Engineer consent

The Contractor shall supply suitable maximum/minimum thermometers and record the shade and sun temperatures at locations where concrete is being placed. Recommendations for cold weather concrete can be had from IS: 7861 (Part 2).

(viii) **Placing at Night**

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

(ix) **Placing Under Water**

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

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

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

The tremie pipe shall be buried in the concrete for at least 1.5m and the pipe must not be emptied until the pour is complete. If a bottom-dump skip is used, the contents shall be covered by canvas or similar before lowering into the water. The doors shall be opened when the skip is resting on the bottom with no tension in the support cable, and the skip shall be lifted gradually so that the concrete flows out steadily.

(x) **Preparation Before Placing**

Before placing concrete for reinforced work on the ground, the formation shall be compacted as specified and a screed of blinding concrete shall be applied to form a surface for construction.

Before placing concrete on or against rock, masonry, brickwork or old concrete, loose material shall be removed and the surface washed down; water seepage shall be stopped or channeled away from the work.

For mass concrete placed against masonry or brickwork the following shall apply:-

a. The mortar joints in the facework shall have fully hardened.
b. The water-cement ratio of the concrete shall be increased to compensate for the absorption of moisture by the existing work.
c. The surface shall be soaked prior to placing.
d. The concrete shall be worked around ties and bond stones and into open joints.

3.12.3 **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

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

vii. 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.

viii. A sufficient number of standby 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.

ix. 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 formwork 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.

x. 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.

xi. 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.

xii. Concrete placed below the ground shall be protected from falling earth during and after placing. Concrete placed on 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.

3.12.4 Field Control

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

3.12.5 Curing

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 discolor the concrete as per IS 456. Minimum wet curing will be for seven days by ponding water followed by moist curing by spraying water which shall be maintained up to a total period of at-least 14 days from the date of casting.

Immediately after compaction and completion of any surface finishes the concrete shall be protected from the evaporation of moisture by means of polythene sheathing, wet hessian or other material kept soaked by spraying. As soon as the concrete has attained a degree of hardening sufficient to withstand surface damage moist curing shall be implemented and maintained for a period of at least 14 days after casting.

i. 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.

ii. Steam curing with approved methodology can be adopted if required, for precast components. No extra payment will be made for adopting steam curing. Before concrete products are subjected to any

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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/ deg C. 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 airspace around the member shall be heated up to a temperature of 75°C to 80°C at a gradual rate, not faster than 30° 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° 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

iii. Curing Compound shall be used with prior approval of Engineer. Clear, water based, nontoxic, non-film forming, reactive silicate treatment with indefinite shelf life suitable as 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. After completion of curing process, there should not be a requirement of removal or special preparation for surface applied adhesives flooring, coatings, patching, concrete stains, etc. Curing compound should have been successfully tested by CRRI as a replacement for water curing an accredited by IRC also. Material test result should be in compliance with ASTM C 309 and ASTM 1315". No curing compound is allowed for segmental box superstructure.

iv. Water curing with sprinkler arrangement to be adopted for precast elements at Casting yard.

3.13 Joints

I. Construction Joints

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

Concrete placing shall not be interrupted except where joints occur, and shall continue

after normal hours if necessary to achieve this.

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

Before placing is resumed at a joint the set surface shall be roughened to remove laitance and expose the aggregate; the aggregate shall not be damaged. If damaging materials have come into contact with the surface of the joint the concrete shall be cut back and the roughened surface cleaned by compressed air or water jets and brushed and watered immediately before placing. If required the surface shall be coated with a layer of stiff cement-grout prior to placing the new concrete.

Chemical surface-retarders shall not be used.

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

Construction joints in water-retaining structures shall incorporate an approved water stop with approved methodology.

II. **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.

III. **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.

IV. **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

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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.

3.14 Cracks

If cracks, which in the opinion of the Engineer may be detrimental to the strength construction, develop in concrete construction, the Contractor at his own expense shall test the structure as specified in "Loading Tests" 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

External Shrinkage crack width shall be restricted to 0.25mm on all viaduct structures and 0.30 mm on Station structures. If it is more than the above and in the opinion of Engineer may be detrimental to concrete construction, the contractor should test and make good the structure at his own expense with prior approval.

3.15 Defective Concrete

Should any concrete be found honeycombed or in any way defective, such concrete shall be rectified as per approved methodology by the contractor at his 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 off by contractor at his own cost, as instructed by Engineer. Decision of the Engineer shall be final binding in this regard.

3.16 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.

3.17 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 leveled 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 of a key.

3.18 Concrete for Flooring on Grade

Concrete for flooring on grade shall be placed in alternate bays not exceeding more than 4 m x 4m 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.

3.19 Grouting of Base Plates & Bolt Holes

3.19.1 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.

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3.19.2 **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.

3.19.3 **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.

3.19.4 **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.

3.19.5 **Curing**

The grout should not dry out where external restraint is provided in the form of form-work, the top opening and all stray openings should be covered with wet sack for at least 7 days.

3.19.6 **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.

3.19.7 **Shrinkage Compensated Grout**

Shrinkage compensated grout or non-shrinkable grout of approved manufacturer should be used. The batching shall be as per the manufacturer's specifications, other procedures being as above.

3.20 Pre-Cast Concrete

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

3.20.1 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.

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3.20.2 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.3.18.3

3.20.3 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 22^{o}C 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 22^{o}C per hour until a temperature has been reached 10^{o}C above the temperature of the air to which the concrete shall be exposed. The maximum curing temperature shall be from 60^{o}C to 67^{o}C. 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.

3.20.4 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.

3.20.5 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.

3.20.6 **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.

3.20.7 **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.

3.20.8 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 2□C. 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 16°C and 29°C, 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 an 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 20°C shall be not less than the design strength of the precast number.

3.20.9 **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 1:1½ (1 part of cement to 1½ parts of sand) and should be placed in stages and packed hard from both sides of the joint.

3.20.10 **Tolerances**

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

1. Overall dimensions of members should not vary by more than + 6 mm per 3 m length with a maximum variation of + 20 mm.
2. Cross-sectional dimensions should not vary by more than the following:

   + 3 mm for sections less than 150 mm thick

   + 4 mm for sections over 150 mm & less than 450 mm

   + 6 mm for sections over 450 mm to 1000 mm

   + 10 mm for sections over 1000 mm
3. Deviation from straight line in long sections should not be more than + 6 mm up to 3 m, + 10 mm for 3 m to 6 m, + 12 mm for 6 m to 12 m.

   (i) For tolerances on precast components, standard documents shall be followed

   (ii) Structural steel inserts/bolts for connecting precast concrete elements (Parapet to Box Girder) Connection of precast concrete parapet with segmental box girder:

Square rods with internal threading and 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). For connection of parapet with segmental box girder bolts of required length having threads at both ends shall be provided as shown in drawings. Grade of steel will be in accordance with the values specified in the drawing. Welding to bolts is not permitted. Grade of nuts will be same as grade of respective bolts. It is imperative to verify that that bolts can be threaded smoothly at all times. Dummy blots shall be used in the stacking yard as a protection measure to keep the threads clean free of dust / rust. Threading, bolts materials, tests etc shall be as per IS: 1367part 1 to 16,18, IS: 1821-1987, IS: 4206.

Levelling bolts as shown in tender drawings are for facilitating alignment of the precast parapet.

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3.21 Ready Mix Concrete and Pumping:

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

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.

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 pumpable 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.

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. Retempering water shall not be allowed to be added to mixed batches to obtain desired slump.

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.

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.

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.

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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.

3.22 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 ASTM C 1240 “Specifications for Silica 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 21 days.

(f) The concrete design mix and arrangement for mixing, transportation, and curing of concrete shall be subject to the approval of the Engineer

(g) IRC SP 47

3.23 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 of 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.

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Measurement:

Unless otherwise specified the cost of formwork deemed to be included in concrete cost.The reinforcement cost is included in the quoted lumpsum Price Schedule.

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 m^3 in volume.
3. Rebates fillets or internal splays each less than 0.005 m2 in cross sectional area.
4. Pockets and holes not exceeding 0.01 m3 in volume.
5. For M-10 concrete no payment shall be made for any shuttering used.
6. Lumpsum Price for precast concrete shall include demoulding, handling, storing, transporting and erecting at site, including all clamping, bracing that may be required during erection including erection equipment.

3.24 Concrete Cube Tests:

The quality of hardened concrete will be verified by the following procedure:

1. The Engineer shall select random batches of concrete for examination without warning the Contractor and sampling will generally be done at the point of discharge from the mixer.
2. From the batches thus selected 6 concrete cubes shall be made in accordance with Indian Standards. However not more than 2 cubes may be made from any single batch. Of these 6 cubes thus made 3 cubes (each cube representing concrete of different batches) shall be tested at 7 days and the remaining 3 cubes shall be tested at 28 days.
3. All cubes shall be made, cured, stored, transported and tested in accordance with Indian Standards. The tests shall be carried out in a laboratory approved by the Engineer.
4. At least 6 cubes shall be made on each day's concreting until 60 cubes have been made for each grade of concrete. This is the initial period.
5. After the initial period, subject to the acceptance of the Engineer, the frequency at which the cubes shall be made may be reduced as follows :

   (1 set = 6 cubes, each pair of cubes representing concrete from a different batch.) At least 1 set for each day's concreting consisting of :

   a) 1 set for every 10m3 or part thereof of concrete for critical structural elements like columns, parapet, segments, larger cantilever, plus .

   b) 1 set for every 40m3 or part thereof for all other elements.

   If concrete is batched at more than one point simultaneously the above frequency of making cubes shall be followed at each point of batching. 3 of the cubes of each set shall be tested at
6. 6 days and the remaining 3 cubes shall be tested at 28 days from the day of casting the cubes.

3.25 Failure to meet specified Requirements:

1. 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 cost. The Engineer may also reject the work and order its demolition and reconstruction at the Contractor's cost.
2. 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.

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SECTION - 04

FORM WORK

SECTION- S.04

4. FORM WORK

4.1 General

These specifications shall be read in conjunction with the MORTH specifications-2013 (fifth revision) and CPWD specifications - 2009 with correction slips / amendments upto date, and other relevant specifications described in the section 1 of these specifications.

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 erecting forms, fixing steel and placing concrete. The selection of materials suitable for formwork 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, piers caps, portals, viaduct (cast-in-situ or pre-cast), parapet 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 engineer and If find not as per Indian standards or not as per requirement it shall be replaced. Number of uses for steel shuttering shall be between 50 and 100. Uses shall be decided by engineer as per the condition of steel shuttering. Special finishes like grooves, logos, floral designs, engraving in inset and outset shall be provided by fixing monolithic rubber forms fixed on entire surface of the formwork. The minimum shore hardness of rubber shall be A-55 to ensure strength, flexibility & elasticity. The contours, design and edges of rubber form should be smooth to ensure minimal deposition of grime or dust. The material shall be approved by the Engineer before 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, ladders etc.) shall be in structural steel only 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 / aluminum / pipe ladders shall not be permitted.

4.2.1 Timber

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 wetted during concreting.

4.2.2 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 walers shall be provided depending on the shuttering design.

4.2.3 Steel

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

4.2.4 Design & Drawings

All temporary works such as formwork, false work, staging, launching girder, cantilever form traveler scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, false work, staging, launching girder& cantilever form traveler shall be same as 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 be also 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, walers or any other supporting arrangement) shall not be more than 3mm.All the formwork, launching truss and cantilever form traveler 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.

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

4.3 Formwork for Exposed Concrete Surfaces

The facing formwork, unless indicated otherwise in 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:

4.3.1 Plain slab soffit, and sides of beams, girders, joists and ribs and side of walls, fins, parapets, pardis, sun-breakers, etc shall be made with:

a. Steel plates not less than 4mm thick of specified sizes stiffened with a suitable structural framework and 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.

4.3.2 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, and fabricated true to plane

b. Timber planks of 35mm actual thickness and of specified surface finish, width and reasonable length,

c. Plywood not less than 12mm thick (IS: 4990), of specified sizes stiffened with a suitable timber framework.

4.3.3 For Precast segments, piers, pier heads, portals etc. suitable steel form work is to be used unless otherwise specified by Engineer.

4.4 Formwork for Sloped Surfaces

4.4.1 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.

4.4.2 The formwork shall be built in such a way 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.

4.5 Formwork for Curved Surfaces

4.5.1 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.

4.5.2 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.

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4.5.3 **Formwork for Waffle Slab**

4.5.4 Shuttering for Waffle Slab/ Coffered Slab shall be with Fibre Glass moulds of approved design. They can also be of Precast concrete unit as per design to form as part of structural concrete. The moulds shall be of uniform shape and dimension to give the desired shape of Coffered slab.

4.6 Erection of Formwork

The following shall apply to all formwork:

4.6.1 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 I.S. Code).

4.6.2 All shuttering planks and plates shall be adequately backed to the satisfaction of the Engineer by a sufficient number and size of walers or framework to ensure rigidity during concreting. All shutters shall be adequately strutted, braced and propped to the satisfaction of the Engineer to prevent deflection under deadweight of concrete and superimposed live load of workmen, materials and plant, and to withstand pouring rate and vibration.

4.6.3 Vertical props shall be supported on wedges or other measures shall be taken so that 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 batter where required and as specified by the Engineer.

4.6.4 Provision shall be made for adjustment of supporting struts where necessary. When reinforcement 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.

4.6.5 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 and within the concrete cover to the steel reinforcement. 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. The tie bolts shall be so designed that their removal on de-shuttering does not leave any embedment with in the concrete cover to steel reinforcement. Holes left in the concrete by these tie-bolts shall be filled by the concrete repair material and the methodology as approved by the Engineer at no extra cost.

4.6.6 Provision shall be made in the shuttering for beams, columns, and walls for a port hole of convenient size so that all extraneous materials that may be collected could be removed just prior to concreting.

4.6.7 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.

4.6.8 The formwork for beams and slabs shall be so erected 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.

4.6.9 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 MoRTH suitable. The use of mould oil which results in blemishes of the surface of the concrete including diesel, burnt oil and any other lubricating oil shall not be allowed. Mould 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 the moulds.

4.6.10 Immediately before concreting is commenced, the formwork and other related arrangements shall be carefully examined to ensure the following:

a. Removal of all dirt, shavings, sawdust and other refuse by brushing, washing and compressed air / vaccume 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 the form work
f. Side supports / restraints for the form work are enough and robust
g. Construction joint (wherever applicable) is properly prepared
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. 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.

4.6.11 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 degrees. The Contractor shall be entirely responsible for the adequacy of propping, and for keeping the wedges and other locking arrangements undisturbed through the de-centering period. (IS:8989 Safety code for erection of concrete framed structures).

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

4.6.13 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 4.5m can ply underneath it with adequate protection to portal legs from moving traffic.

4.6.14 For concourse floor 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 4.5m (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.

4.7 Concrete Finishes

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

4.7.1 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 permanently 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 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 bridges, viaducts, beams, parapets, railings and decorative features on the structure and on the bridges. To meet with requirements for F4 finish, forms shall be manufactured in a skillful, 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.

4.7.2 **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 leveling and screening 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. 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 permit 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 surface 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 centimeter per 30cm of width. Finishes of floor and roof slabs shall be sloped, if required, by the Engineer.

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4.8 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 other surface defects in the concrete shall be removed by the Contractor as per the methods, which do not affect the strength of adjoining Concrete and as approved 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 behavior 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.

4.9 Age of Concrete at Removal of Formwork

In accordance with CPWD Specifications 1996 / 2009 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.

4.10 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 using approved methods and as directed by the Engineer. No extra charge will be allowed to the Contractor for such work on concrete surfaces after removal of forms.

4.11 Reuse of Forms

The Contractor shall not be permitted reuse of timber facing formwork brought new on the works for 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 at 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 depending upon its condition and 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 number. of times they can be used will be determined by the Engineer.

4.12 Formwork for Precast/ Prestressed Concrete

1. 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.

2. 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

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effect of curing on the formwork should be given special consideration. Depending on care, curing, erection and maintenance of the formwork 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-

Number of uses of shuttering to be as per approval of the Engineer

In case concrete moulds can be satisfactorily provided by the contractor, the Engineer's approval shall be obtained before use on the works.

3. **Stripping**

As soon as the pre-cast units have attained sufficient strength, the formwork shall be stripped. The pre-cast unit shall be lifted uniformly out of the formwork without being subjected to tilting or restraint effects.

4.13 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 ± 5A 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.

If proprietary system of formwork is used, detailed information as given below herein shall be furnished to Engineer for approval before use.

1) General

i. 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.

ii. the user shall refer unusual problems of erection/assembly not in keeping with intended use of equipment, to the manufacturer of the equipment.

2) 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 factors 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.
x. Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions

4.14 Measurement

Unless otherwise specified, the cost of form work etc., is included under relevant Concrete items of Price Schedule.

4.15 Information to be supplied by manufacturers of proprietary systems of form work

1. General

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.

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

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

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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 factors 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.
X. Any restrictions regarding usage of any component or full assembly with regard to spans, heights and loading conditions.

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SECTION - 05

REINFORCEMENT

SECTION- S.05

5. REINFORCEMENT

5.1 General

These specifications shall be read in conjunction with the MORTH specifications -2013 (fifth revision) and CPWD specifications -2009 with correction slips / amendments upto date, and other relevant specifications described in the section 1 of these specifications.

Any 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 and no re-rolled steel shall be supplied and used.

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 (fy 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 fy	0.5 fy	20cycles
2	2 εy	0.5 fy	4cycles
3	5 εy	0.5 fy	4cycles

Note:

fy is specified yield strength of the reinforcing bar.

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

iii) Cyclic tensile test

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

iv) 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.

v) 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.

vi) 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:

Bar diameter	Total Slip (μ m)

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8 mm to 20 mm	250
25 mm to 28 mm	350
32 mm to 40 mm	450
45 mm	600

vii) 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 fy). 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.

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 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.

Reinforcement Coating

In order to offer adequate resistance against corrosion, reinforcement bars shall be provided with a coating of "Cement Polymer Composite Coating" OR "Fusion Bonded Epoxy Coating" as per IRS CBC clause 7.1.5 applicable for important and major bridges in aggressive environment (moderate, severe), ,which is the case for Bengaluru environment.

5.3 Inspection & Testing

Every bar shall be inspected before assembling on the works and any defective pitted, brittle, excessively rusted or burnt bars shall be removed. Cracked ends of bars shall be cut out.

No work shall be commenced without the Engineer's approval of the bar bending schedule.

Manufacturer's test Certificate shall be supplied for each lot of supply.

Specimens sufficient for three Tensile Tests for each different size of bar for each consignment delivered, or for 10 tonnes of supply of that size, whichever is less shall be sampled and tested by the Contractor. Batches shall be rejected if the average results of each batch are not in accordance with the specifications.

5.4 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. 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. 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 final.

5.5 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. The

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' guages.

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:

(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.

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.

QUALFICATION 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:

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(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 0.6fy.

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.

Lapping will not be permitted anywhere other than piles for bar dia of 20 mm and above.

5.6 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.

5.7 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.

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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

5.8 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, stiffners, 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.

List of Approved Make/ Likely Suppliers

All the materials and products shall conform to the relevant Standard Specifications, IS codes and other relevant codes etc. and shall be of approved make and design.

The list of approved makes for products and materials is given below. Other equivalent manufacturer can only be considered with prior approval of the Engineer subject to testing of the material for equivalent specification and properties.

1. Cement — Ultratech, ACC, Gujarat Ambuja, Shree Lakshmi, JK Cement and Grasim.
2. Reinforcement bars — Primary sources viz. TISCO, SAIL, JSW, RINL. In case of shortfall of above particular diameter, their approved conversion Agents viz. SRMB, Ramsarup Utpadak, Usha Rathi, Shyam steel. However the billet has to be procured from the primary producers on and proper quality control to be ensured.
3. Epoxy — FOSROCK, MBT, SIKA QUALCRETE, Araldite,CIBA,GEIGY.
4. Expansion Joints — Empanelled Suppliers as per Ministry of Road Transport & Highways letter no. RW/NH-34059/1/96-S&R dated 20 Feb 2001 & any amendments to the same.
5. Admixtures — FOSROCK, MBT, Asian Lab, MC Baucheme, Sika, BASF, Pidilite.

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6.	Waterproofing system	CICO, FOSROC, MBT, SIKA, SUPREME, SILTECH chemicals, Krypton Build mat Co., Pidilite.
7.	Pile Integrity Test	BRI, FUGRO-KND, Pile Dynamic, AIMIL, Geotech, Geo Dynamic Struct Geotech Research Laboratories Pvt Ltd., Bangalore.
8.	Anchor Fastener	HILTI, BOSCH, Tyrolite.
9.	Structural Steel	TATA, SAIL, JSW, Jindal, RINL.
10.	Pre- stressing Strand	TATA SSL Ltd, Indore Wire (LRPC), Usha Martin, Sumitomo Wire Corporation.
11.	Pot/Elastomeric Bearings	a) Prequalified Manufacturers as per Ministry of Road Transport & Highways Letter No. RW/NH-34057/1/95- S&R dated 2 Nov 2002 & any amendments to the same b) RDSO, Lucknow Prequalified/approved manufacturers.
12.	Horizontal Tie bars / Shear key system & Hold-down devices.	BB Bars System, ETIC system, Macalloy System
13.	Formwork Release Agent	FOSROC, MBT, MC Baucheme
14.	Prestressing System	Freyssinet, BBR, VSL, Dynamic, Killick, Nixon, Tensacciai (Italy), Macallloy, Dwyidag, Ushamartin.
15.	Reinforcement Couplers	Usha Ismal, Dextra, BBR, Moment.
16.	Form work suppliers	Pranav, L&T, Maruthy Fab (Pune), Dywidag (Grips India), Ideb India Ltd., Bangalore, Giri Engineering, (Yelahanka, Bangalore)
17.	Micro silica	Elkem, Fosroc, 20 Microns India Ltd.
18.	Non-Shrink Compound	Fosroc, Roff, Sika
19.	Testing labs	Civil AIDS, Karnataka test house and any other engineering College
20.	Pile Testing	Civil Aid, Geo Dynamics22. MS rounds/hollow sectors Bihar Fabs Ltd.
21.	Curing Compound	Fosroc, Sika.

Materials are to be supplied from Approved suppliers list only. In exceptional circumstances suitable alternatives can be permitted by K RIDE at its discretion on sufficient reason and details to be furnished by the contractor for such change. Engineer's decision is final in this regard and binding to the contractor.

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SECTION – 06

PRESTRESSED CONCRETE

SECTION- S.06

PRESTRESSED CONCRETE

6. 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 drawing and these specifications or as approved by the Engineer.

Concrete and un tensioned steel for the construction of prestressed 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 prestressing such as jacks, bearing plates, wedges, anchorages, strands and HDPE ducts are compatible to one another and 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.

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

xvi. 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.

xvii. 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.

xviii. 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

6.3.1 Sheathing

Material for all pre-stressing sheathing duct shall be HDPE in the form of corrugated.

The Thickness of the HDPE sheathing ducts shall be as per conforming to IRS Concrete

Bridge Code-1997 & IRC -112:2011 , with modifications as stated below).

For Anchorage system 19 K 15, HDPE ducts of 124mm OD/ 107mm ID (tolerance + 1mm) with minimum thickness of ducts 3.00 mm

For Anchorage system 12 K 15, HDPE ducts of 100 mm OD/ 85 mm ID (tolerance + 1mm) with minimum thickness of ducts 2.50 mm

For Anchorage system 7 K 15, HDPE ducts of 84 mm OD/ 69 mm ID (tolerance +

1mm) with minimum thickness of ducts 2.50 mm

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:

Density (IS 2530): 0.94 – 0.96 g/cm^3 at 230C

Tensile Strength at yield (BS EN ISO 527-3): 20-26 N/mm^2

Shore Hardness D (BS EN ISO 2039-1) : 3 sec – 60 min, 15sec – 58min

Elongation at Yield (BS EN ISO 527-3): 7 %(min)

Melt Flow Index (MFI) (IS: 2530) : 0.4 - 0.6 g /10 minutes (Temperature 190° C under a mass of 5 kg.)

Charpy Impact strength of notched specimen (BS EN ISO 179) At 23^{0}C: 10 kJ/m^2-40^{0}C: 4 kJ/m^2

Coefficient of Thermal Expansion for 20^{0}C – 80^{0}C (DIN 53 752): 1.50 x 10^{-4} / ^{o}C

Environmental Stress Crack Resistance (ASTM D-1693) at 70^{o}C: 192 Hrs

The residual wall thickness after loss (wear resistance) shall not be less than 1.5mm for ducts upto 85mm diameter and 2.mm for ducts diameter above 85mm as per IRC –112:2011.

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 Appendix 1B of IRC: 18-2000.

These 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.

(i) Screwed together with male and female threads

(ii) Joining with thick walled HDPE shrink couplers with glue. This can also be used for connection with trumpet, etc

(iii) Welding with electro-fusion couplers.

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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 Appendix-B of IRS Concrete Bridge Code-1997 (Addendum & corrigendum Slip No.5 Dated 19.11.2001).

The initial acceptance tests such as bond test; compression test are required to be performed as acceptance criteria for system. In addition to above, friction test as given in FIB bulletin.No-7 are also required to be performed as acceptance criteria. Test conducted by supplier in the past shall not be regarded as acceptance criteria.

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. 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. At least 3 samples for one lot of supply (not exceeding 3000 meter length) shall be tested.

In viaduct constructed by precast segmental construction, cables shall be threaded after application of temporary prestressing. In continuous unit, constructed by cantilever construction techniques the cantilever cables will be stressed as various segments are cast progressively. Such cables shall be threaded after concreting. In such cases a temporary flexible PVC tube of 90 mm 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 tube shall be pulled out before threading of the permanent cables.

6.4 Anchorages

6.4.1 Anchorages shall be procured from authorised 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 anchorage / 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 at the strength of concrete at which stressing are 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 and loose rust and any other deleterious coating.

After completion of pre-stressing and grouting of cable in PSC girders, the extra length pre-stressing strands projecting outside the anchorage are required to be cut at the anchor end and anchor end is to be sealed.

Swages of prestressing strand shall develop strength of at least 95 per cent of the specified breaking load of the strand.

Un- tensioned Steel reinforcement, 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 the result with FIP-1993 recommendations before transporting the lot to site.

6.5 Prestressing Steel

Uncoated stress relieved low relaxation steel conforming to IS: 14268, 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. various tests 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 independent agency in the beginning of the project.

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6.5.1 **Prestressing Strands/Wires Storage**

All high tensile steel for prestressing work shall be stored about 30cm 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 the short time during transportation 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. Strand/wire during unloading and storage / handling in the stores gets damaged.

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

Strand shall be stored in large diameter coils.

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

6.6 Testing of Prestressing Steel and Anchorages

Contractor should submit friction and wobble coefficient of prestressing system proposed to be used. GFC will be based on the above data

All materials specified for testing shall be furnished free of cost and shall be delivered in time for to be made well in advance of anticipated time of use.

All strands to be transported to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be transported shall be like-wise identified.

All samples submitted shall be representative of the lot to be furnished and in the case of strand, 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 type to be used, shall be furnished along with short lengths of strands as required.

6.7 Workmanship

6.7.1 **Cleaning**

Tendons shall be free from loose rust, oil, grease, tar, paint, mud or any other deleterious Substance.

Cleaning of the steel 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.

6.7.2 **Straightening**

High tensile strand 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 strand 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.

6.7.3 **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. Pull-in or push-in of the prestressing strands shall be mechanized,

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iii. The location of prestressing cables shall be such as to facilitate easy placement and vibration of concrete in between the tendons.

iv. 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.

v. 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.

vi. 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.

vii. 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.

6.7.4 Cutting

Cutting and trimming of wires or strands shall be done by suitable mechanical or flame cutters. When a flame cutter is used, care shall be taken to ensure that the flame does not come in contact with other stressed steel. The location of flame cutting of strand shall be kept beyond 75 mm of where the tendon will be gripped by the anchorage or jacks.

In post-tensioning, the ends of prestressing steel projecting beyond the anchorages shall be cut after the grout has set.

6.7.5 Protection of Prestressing Steel

Prestressing 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.

6.7.6 Sheathing

i. The joints of all sheathings 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.

ii. 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.

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

6.7.7 Grout Vents

Grout vents of at least 20 mm diameter shall be provided at both ends of the sheathing and at all valleys and crests along its length. Additional vents with plugs shall also be provided along the length of sheathing such that the spacing of consecutive vents do not exceed 20m. Each of the grout vents shall be provided with a plug or similar device capable of withstanding a pressure of 1.0 MPa without the loss of water, air pressure or grout

6.7.8 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.

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After the prestressing operations are completed and prestressing 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.

6.7.9 **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.

6.7.10 **Supervision**

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.

6.8 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:

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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.

6.9 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.

6.10 Tensioning Equipment

The tensioning apparatus shall meet the following general requirements:-

i. The means of attachment of the tendon to the jack or tensioning device shall be safe and secure.

ii. Where two or more wires or strands are stressed simultaneously, they shall be approximately of equal length between anchorage points at the datum of load and extension measurement. The degree of variation shall be small compared with the expected extension.

iii. The tensioning apparatus shall be such that a controlled total force is imposed gradually and not dangerous secondary stresses are induced in the tendons, anchorage or concrete.

iv. The force in the tendons during tensioning shall be measured by direct-reading load cells or obtained indirectly from gauges fitted in the hydraulic system to determine the pressure in the jacks. Facilities shall be provided for the measurement of the extension of the tendon and of any movement of the tendon

in the gripping devices. The load-measuring device shall be calibrated to an accuracy within ± 2% and checked at intervals to the approval of the Engineer. Elongation of the tendon shall be measured to an accuracy within 2% or 2 mm, whichever is the more accurate.

v. 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.

6.11 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.

6.12 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 15^0. Where the radius is less than 5 times the diameter of the tendon and the angle of deflection exceeds 15^0, 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.

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6.13 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

6.14 Post-tensioning

i) **Arrangement of Tendons**

Where wires, strands or bars in a tendon are not stressed simultaneously, the use of spacers shall be in accordance with the recommendations of the system manufacturer.

ii) **Anchorages**

(a) Anchorages shall be tested in accordance with the requirements of BS 4447.

(b) For each anchorage system used in the Works, the characteristic value for anchorage efficiency shall be not less than 90%.

(c) Proprietary anchorages shall be handled and used strictly in accordance with the manufacturer's instructions and recommendations.

iii) **Deflected Tendons**

The deflector in contact with the tendon shall, have a radius of not less than 50 times the diameter of the tendon, and the total angle of deflection shall not exceed 15 degrees unless otherwise agreed by the Engineer.

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iv) **Tensioning Procedure**

Before tensioning, the Contractor shall demonstrate that all tendons are free to move in the ducts unless the geometry of the ducts makes this impracticable as agreed by the Engineer. Tensioning shall be carried out in such a manner that the stress in the tendons increases at a gradual and steady rate.

Unless otherwise described in the Contract, concrete shall not be stressed until it has reached at least the age at which 2 test cubes taken from it attain the specified transfer strength. The test cubes shall be made and tested as described in BS 1881. They shall be cured in similar conditions to the concrete to which they relate in a manner approved by the Engineer.

The Contractor shall cast sufficient cubes to demonstrate that the required strength of the concrete at transfer has been reached.

The Contractor shall ensure that those carrying out the stressing are provided with particulars of the required tendon loads, order of stressing and extensions. Allowance shall be made during stressing for the friction in the jack and in the anchorage, although the former is not necessary when using load cells.

Any allowance for draw-in of the tendon during anchoring shall be in accordance with the Engineer's instructions.

Stressing shall continue until the required extension and tendon load are reached or are approved by the Engineer.

The extension shall allow for any draw-in of the tendon occurring at the non-jacking end, but measurement shall not commence until any slack in the tendon has been taken up.

Immediately after anchoring, the forces in the prestressing tendons shall not exceed 70% of their characteristic strength. During stressing the value may exceed 70% of their characteristic strength, with the approval of the Engineer, but shall not exceed 80%.

After the tendons have been anchored, the force exerted by the tensioning apparatus shall be decreased gradually and steadily so as to avoid shock to the tendon or the anchorage.

Full records shall be kept of all tensioning operations, including the measured extensions, pressure-gauge or load-cell readings, and the amount of draw-in at each anchorage. Copies of these records shall be supplied to the Engineer within 24 hours of each tensioning operation.

Unless otherwise agreed by the Engineer tendons shall not be cut less than 3 days after grouting.

6.15 Prestressing Tendons - Protection and Bond

The prestressing tendons shall be protected in their permanent positions from both mechanical damage shall be applied to all unbounded prestressing tendons within 28 days of installation of the tendon in the duct.

The tendon protection compound applied to the and corrosion as described in the Contract and the following sub-clauses.

The exposed tendons at the anchorages and the anchorages themselves shall be sealed within a closed box and protected from both mechanical damage and corrosion. Suitable access shall be left for jacking equipment for the later removal of the strands of unbounded tendons. The means of protection shall be designed by the prestress supplier and approved by the Engineer.

A tendon protection compound tendons shall be a micro-crystalline wax (petrolatum) base material containing additives to enhance the corrosion inhibiting, wetting, and moisture displacing properties, as well as the ability to form a polar bond with the tendon steel.

The compound Manufacturer shall provide test data verifying that the following properties are met for the service life of 120 years and temperature range of 0°C to 50°C evaluation and acceptance by the Engineers:

a. freedom from cracking and brittleness;
b. continuous self-healing film over the coated surfaces;
c. chemical and physical stability;
d. non reactivity with the surrounding and adjacent materials such as concrete, tendons, and ducts;

e. moisture displacing characteristics.

Additionally it shall remain flexible to allow removal and replacement of the tendons. The tendon protection compound and its method of installation shall be approved by the Engineer.

Provision shall be made for expansion of the tendon protection compound during the lifetime of the structure.

Before installing the tendon protection compound it shall be demonstrated that the ducts, U-bend anchorage and anchorages are clean and free of water and chlorides.

The tendons, internal face of the steel u-bend anchorage, stressing anchorages and any other metallic components of the prestressing system shall additionally be pre-treated with a protection compound before delivery to site. The protection compound shall be applied to each strand of the tendon and shall be compatible with the tendon protection compound injected into the ducts. The protection compound shall be approved by the Engineer.

The supplier of the tendon protection compound shall submit for the Engineer's approval proposals which shall describe how the tendon protection compound can be removed and re-injected into ducts, including buried ducts, within the permanent works.

All materials used in the prestressing systems shall not give off toxic fumes at temperatures below 50°C and shall not support combustion.

6.16 Ducts for Bonded Tendons

Ducts for longitudinal, transverse or vertical tendons embedded into the concrete may be of flexible, semi-rigid, or rigid galvanized, ferrous metal capable of withstanding concrete pressures without deforming or permitting the entrance of cement paste during casting of the member. They must retain their shape and be capable of transferring bond stresses. The semi-rigid duct must be rigid enough to remain straight when supported at 1200 mm maximum intervals but flexible enough to allow 3600 mm radius curves. Flexible duct shall be secured or supported at not more than 300 mm intervals.

6.17 Grouting of Prestressing Tendons

1. General

The Contractor shall undertake grouting trials when required by the Engineer

2. Materials

Unless otherwise directed or agreed by the Engineer as a result of grouting trials, the grout shall consist only of Ordinary Portland

Cement and water. The water/cement ratio shall be as low as possible consistent with the necessary workability, and under no circumstances shall the W/C ratio exceed 0.45 by weight.

The grout shall not be subject to bleeding in excess of 2% after 3h or 4% maximum when measured at 25°C or such other temperature as may be approved by the Engineer, in a covered cylinder approximately 10mm diameter with a height of grout of approximately 100 mm, and the water shall be reabsorbed by the grout during the 24h after mixing.

Admixtures may be used with the written permission of the Engineer and shall be applied strictly accordance with the manufacturer's instructions. Admixtures shall not contain chloride ions in excess of 0.25 percent by weight. Dry materials shall be measured by weight.

Dry materials shall be measured by weight.

3. Ducts

Air vents shall be provided at any crests in the duct profile and elsewhere as specified. All ducts shall be thoroughly clean before grouting. Ducts formed without metal sheathing shall be provided with effective drainage and, unless otherwise directed by the Engineer, shall be flushed with water before grouting. All surplus water shall be removed by compressed air injection. All anchorages shall be sealed or fitted with grouting connections.

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4. Grouting Equipment

The mixing equipment shall produce a grout of homogeneous consistency and shall be capable of providing a continuous supply to the injection equipment. The injection equipment shall be capable of continuous operation with little variation of pressure and shall include a system for recirculating the grout while actual grouting is not in progress. Compressed air shall not be used.

The equipment shall have a sensibly constant delivery pressure not exceeding 1 N/mm2. All piping to the grout pumps shall have a minimum of bends, valves and changes in diameter. All baffles to the pump shall be fitted with 1.18 mm sieve strainers. All equipment, especially piping, shall be thoroughly washed through with clean water after every series of operations and at the end of use for each day. The interval between washing shall not exceed 3h.

The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a valve that can be locked off without loss of pressure in the duct.

5. Mixing

Water shall be added to the mixer first, then the cement. When these are thoroughly mixed, the admixture, if any, shall be added. Mixing shall continue until a uniform consistency is obtained. Mixing shall not be by hand.

6. Injecting Grout

Grouting shall be carried out as soon as is practicable after the tendons in them have been stressed and anchors trimmed and the Engineer's permission to commence has been obtained. Injection shall be continuous, and it shall be slow enough to avoid producing segregation of the grout. The method of injecting grout shall ensure complete filling of the ducts and complete surrounding of the steel. Grout shall be allowed to flow from the free end of the duct until its consistency is equivalent to that of the grout injected. The opening shall then be firmly closed. Any vents shall be closed in a similar manner one after another in the direction of the flow. After an appropriate time, further injections shall be carried out to fill any possible cavities.

The injection tubes shall then be sealed off under pressure until the grout has set.

The filled ducts shall not be subjected to shock or vibration within 1 day of grouting.

Not less than 2 days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good as necessary.

The Contractor shall keep full records of grouting including the date each duct was grouted, the proportion of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be supplied to the Engineer within 3 days of grouting.

Where required by the Engineer, the Contractor shall provide facilities and attendance for the radiographic testing of duct.

7. Strength of Grout

The compressive strength of 100 mm cubes made of the grout shall exceed 27 N/mm2 at 7 days or 30 Mpa at 28 days. Cubes shall be cured in a moist atmosphere for the first 24h, and subsequently in water.

6.18 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.

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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.

6.19 Prestressing Tendons - Trial Construction-Unbonded Tendons

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.

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.

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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.

6.20 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.

o) 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.

p) 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.

q) 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.

r) 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 of 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.

s) 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.

t) 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.

6.21 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 associated operations 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.

During actual tensioning operation, warning sign shall be displayed at both ends of the tendon.

After prestressing, concrete shall neither be drilled nor any portion cut nor chipped away nor disturbed, without express 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.

6.22 Tolerances

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

a) Variation from the specified horizontal profile : 5 mm

b) Variation from the specified vertical profile : 5 mm

c) Variation from the specified position in member : 5 mm

6.23 Transportation and Storage of Unit:

Precast members 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 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

6.24 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. Shop drawings and design calculations for construction procedure needs to be submitted by the contractor

6.25 Measurement

The prestressing steel rates are included in the quoted lumpsum price of price schedule. The 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 extra length of wires and staging etc.

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SECTION – 07

STRUCTURAL STEELWORKS

SECTION- S.07

7. (A) STRUCTURAL STEEL WORKS

7.1 STRUCTURAL STEELWORK SPECIFICATIONS- GENERAL

(Viaduct Hand rails works only)

This section 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 1996 / 2002, MORTH Specifications and other relevant reference specifications.

7.2 Scope of Specification

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

(a) 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 consumable required for fabrication and supply of all necessary bolts, nuts, washers(All washers shall be DTI only), tie roads 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.

(i) 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 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 support, staging, braces etc. required for safe erection, for approval of the Engineer.

(l) The contractor shall provide all construction and transport equipment, tools, tackle, and consumables, materials, labour and supervision required for the erection of the structural steelwork.

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(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, plumbing, leveling, 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. iReaming of holes for use of higher size bolt if required.

iv. Re-fabrication of parts damaged beyond repair during transport and handling or refabrication of parts which are incorrectly fabricated.

v. Fabrication of parts omitted during fabrications 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 concerned organization or its authorized fabricator.

(t) The Contractor shall observe all safety requirements for erection of structural steelwork as covered in IS: 7205

The coated finish for flashing and roofing sheet shall have the following properties:

a) Humidity Residence Blistering tested accordance to ASTM D 2247 (3000 Hours) with no Blistering.
b) Acid salt spray tested accordance to ASTM B117 (3000 Hours) with no creepage sighted.
c) Formability of 0T to 2T, tested accordance to ASTM D4145.
d) Pencil hardness conforming to ASTM D2794, with no loss of adhesion.
e) Flame test tested to ASTM E84. Class A Coating.
f) Specular gloss of 20-35%, measure at 60◦ and tested in accordance to ASTM D523.

7.3 Submittals

On commencement of the Project, the Contractor shall submit the following:

(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, shop/ working drawings, plan/ procedures and records. Submission of samples, process of fabrication / delivery / erection for the approval of the Engineer.

ii) Complete fabrication drawings, materials lists, cutting lists, bolt lists, welding schedules and QC schedules, based on the design drawing 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.

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

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iv) Manufacturers mill test reports in respect of steel materials, bolts, nuts and electrodes, as may be applicable.

v) 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.

vi) 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 time and in accordance with contract. This will show, in a performa 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

7.4 Drawings:

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

7.4.2 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.

7.4.3 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.

7.4.4 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.

7.5 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/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 connection, cuts, notches, bends, 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 relive 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 Lumpsum Price 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 of 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, anchorages details 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.

Applicable Codes of Practice

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.

   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

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1. IS: 800 (1984) 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 in 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. (Part 1 to Part 3)
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. (Part 1 to Part 9)
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) .

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36. IS:891O (1978) General requirements of Supply of Weldable Structural Steel.
37. IS: 9595 (1980) Recommendations for Metal Arc Welding of Carbon & Carbon- Magnese Steels.

7.6 Products

7.6.1 Material:

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.

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 Structural steel (Fusion welding quality)

IS:961 High Tensile Structural Steel (Ordinary)

IS:1161 Steel Tubes for Structural purposes

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 certificate that the steel brought to the site for incorporation in the works is of a quality fully complying with the specification. 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

7.6.2 Bolts and Nuts:

For splicing of any structural member wherever required HSFG bolts and nuts of property class-8.8/10.9 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 8.8/10.9 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 bolt used.

7.6.3 Washers

For HSFG bolts , washer shall be conforming to IS:6649 (1985). DTI washers shall be conforming to ASTM F 959 . 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.

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7.6.4 **Storage of Materials**

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 a stored in separate stack 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 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 to avoid unacceptable deflection.

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 equipments.

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.

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 .

7.7 STRUCTURAL STEELWORK SPECIFICATION -WELDED STRUCTURE

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.

Products

Ref. Specification 7.1 for Structural Steel-General

Execution

Workmanship

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

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- Procedure and programme of welding sequence

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.

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.

Clearance

The clearance between fraying surface of bolted connections shall not be greater than 1mm at 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.

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 plates 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

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.

Welding

General

The welding and the welded work shall conform to welded bridge code, IS:816 (1969) and 1S: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.

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 :

Serial	Classification	Brand Name	Manufacturer	Remarks
1	E-6013	Over Steelon Standard Excel-123 S Ferrospeed Plus	M/s .Advani Orelikon (P) Ltd. Modi Arc Electrodes Co. Weld Excel India Ltd. (Modi Group Co) EsAB Indai Ltd	For structural steel having thickness upto 15mm
2	E-7018	Super Cito Modi-7018 Excel-18 S ESAB 36H	Advani Orelicon Modu Arc Electrodes. Weld Excel Indai Ltd . (Modi Gropu Co) Esab India Ltd	For structural steel having thickness more 15mm

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

Preparation of Joints

1. 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.
2. 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.

Welding Procedure

1. All welding procedures shall be submitted to the Engineer for approval, well before starting fabrication.
2. 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

    a. Type and size of electrodes
    b. Current and (for automatic welding) arc voltage
    c. Length of run per electrode; or (for automatic welding) speed of travel
    d. Number and arrangement of runs in multirun welds
    e. Position of welding
    f. Preparation and set-up of parts
    g. Welding sequence
    h. Pre or post heating
    i. Any other relevant information.

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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.

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.

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.

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 welding (CO_2) 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.

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.

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.

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.

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.

Testing of Butt Welds

Butt-welded joints are to be 25% radiographically 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 .

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.

Dislodging

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

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.

Weather Conditions

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

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.

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.

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.

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 material in an aggressive environment.

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.

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.

These erection marks shall be suitably incorporated in the shop detail and erection drawings.

STRUCTURAL STEELWORK SPECIFICATION BOLTED STRUCTURE

General

Scope of Specifications

This 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.

Products

Ref. Specification 7.17.1.6 for Structural Steelwork –General

Execution

Workmanship

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.

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.

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.

Clearance

The clearance between fraying surface 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.

Shearing, Cutting and planning

1. Cutting shall be done automatically. Cutting by sheathing 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 but in close contact throughout the finished joint.
5. The ends of all build 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.

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 cab pass freely through the members assembled for bolting, in the direction at tight angle to such members.
2. All drilling shall be free burrs.
3. No holes shall be made by gas cutting process.

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. 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, and these checks shall be witnessed by the Engineer. Such trial assemblies shall be at the cost of the contractor.

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(DTI) and other necessary fittings required completing the work, together with the additional bolts, nuts and washers totaling to 10% of the requirement subject to minimum of 10 Nos. 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 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 nonrotating 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.

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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.

Erection Marking

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.

This erection mark shall be suitably incorporated in the shop detail and erection drawings.

STRUCTURAL STEEL SPECIFICATIONS -PAINTING WORKS

7.8 General

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.

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: 384 (1979) : Brushes, Paints and Varnishes, Flat.
d). IS: 487 (1985) : Brush, Paint and Varnish i) Oval Ferrule Bound
ii) Round Ferrule Bound.
e). IS: 958 (1975) : Temporary Corrosion Preventive Grease, Soft Film, Cold Application.
f). IS: 1153(1975): Temporary Corrosion Preventive, Fluid, Hard Film, Solvent Deposited
g). IS: 1477(1971) : Code of Practice for Painting of Ferrous Metals in Building.
Part I –Pretreatment
Part II –Painting
h). IS: 1674(1960) : Temporary Corrosion Preventive Fluid, Soft Film, Solvent Deposited.
i). IS: 2074(1992) : Ready Mixed Paints, Red Oxide -Zinc Chromate.
j). IS-5666: Etch (Pretreatment) Primer
k). IS-104: Ready mixed paint, brushing, zinc chrome, priming
l). IS-2339: ALUMINIUM PAINTS FOR GENERAL PURPOSES OF SPECIFICATION

Products & Materials:

Paint:

All paint delivered to the fabrication shop shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.

Paint shall be stirred frequently to keep the pigment in suspension

Storage of Paints:

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.

All paint containers shall be clearly labeled 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-in-charge.

Execution:
Paint System (High Performance Polysiloxane System)
Sand blasting shall be carried out in accordance with IS: 1477.
Painting work shall be carried out as follows:

Description	**Surface**	
Fabrication Shop	External Surfaces	Internal Surfaces
Surface Treatment	Abrasive Blast to SA 2.5(ISO 8501-1:1988). If oxidation occurs between blasting and application of paint, the surface shall be re blasted to the specified standard.	Abrasive Blast to cleaning to minimum SA 2.5 (Swedish Standard SIS 055900), Near- White blast cleaning.
primer	Providing & applying two components high build Zinc Rich Epoxy Primer Poly amide cured with minimum volume Solids of approximately 60% and a product weight of 2.50 kg/liter, minimum recoat interval of not more three hours at 25 deg C. The primer can be like Interzinc 52 of International Paints or approved equivalents. DFT-75 microns The primer shall be applied by Conventional/Airless Spray only in Shop.	Surface Tolerant Epoxy with minimum Volume Solids of 80%, minimum overcoat interval of not more than 24 hours at 25 deg C and a product weight of 1.6kg/liter. The primer can be like Interseal 670 HS of international paints or approved equivalent DFT-150 microns
1st Coat	Providing and applying two components Hi Build Epoxy Intermediate Coat pigmented with Micaceous Iron oxide with approximate Volume Solids of 80%, minimum re-coat interval of 6 hours at 25 deg C and a product weight of approximately 2 kg/liter- like Intergard 475 HS of international paint or approved equivalent. DFT-150 microns The coat shall be applied by Conventional/Airless Spray only in Shop	
Erection Site		
Touch up Primer	Power Tool Cleaning to ST 2 standards followed by Surface Tolerant Epoxy with minimum Volume Solids of 80%,minimum overcoat interval of not more than 24 hours at 25 deg C and a product weight of approximately	

	1.6kg/liter like Interseal 670 HS of International Paints or approved equivalent. This primer shall be applied as touch up wherever damages have occurred on account of welding or Transportation &Erection.(Stripe Coat)-The DFT shall not be included in the Total DFT of System DFT-75 microns The primer shall be applied by Conventional/Airless Spray only at site	
2nd coat(Finish Paint)	Providing and applying two components Hi Gloss Acrylic Polysiloxane Finish Paint with approximate Volume solids of 70%, The product shall hard dry in not more than 5 hours at 25 deg C and 50% R.H. like Interfine 878 of International Paints or approved equivalent. This product should exhibit Gloss Retention following 3000 hours to U.V-A florescent lamp when checked as per ASTM-523 DFT-75 microns The paint shall be applied by Conventional/Airless Spray only at site.	

The total Average DFT of External Surface is 375 microns

The total Average DFT of Internal Surface is 150 microns

DFT measurements should be done in accordance with Specifications SSPC PA 2.

INTERNAL SURFACE =Internal surface are those which will become inaccessible after fabrication and are not prone to humidity and moisture from the atmosphere.

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.

Surface Preparation (sandblasting)

All surfaces shall be cleaned of loose substances and foreign materials. e.g. dirt, rust, scale, oil, grease, welding flux etc so that the primer 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 matters. 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 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 in Charge, 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 using 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 own expenses. Nothing extra shall be paid on this account.

Mixing of paint

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/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 manufacturers' 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. 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.

Paint Application

General

i. 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-in-charge shall be taken in respect of all primers and/or paints, before their use in the works.

ii. Paint shall generally be applied by brushing except that spraying may be used 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.

iii. 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.

iv. 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.

v. 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 color shall be tinted. Whenever practical, to produce contrasts and helps in identifying the progress of the work.

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Brush Application

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.

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.

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-in-charge shall he furnished and installed on all equipment used in spray painting.

Shop Painting

The painting system specified in Table shall be followed. Surfaces, which will be inaccessible after field assembly, shall receive the full-specified protective treatment before assembly.

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.

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.

The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and deslagged, and immediately after covered by the same paint as has been used for the remaining surface.

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.

Protection of Paint work

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.

All painted surfaces that in the opinion of the Engineer-in-charge 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.

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.

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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.

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 have not been shop coated, but require surface treatment shall be given necessary surface preparation and coats at site as specified in Table.

7.9 STRUCTURAL STEEL WORK -QUALITY CONTROL & TESTING REQUIREMENTS

General

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

Codes / Standards

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

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.

Products

Make of approved manufacturer

Execution

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.

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 δ 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 12 m + 3 mm
- Over 12m L/4000 sub max. of + 5 mm

End of Members

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Beam to 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 jointed by bolting through cleats or end plates, the connections require closer tolerance, permissible deviation from the squareness of the end is:

Beams upto 600 mm in depth 1mm 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 there combined length and then the following conditions shall be met :

a) Over atleast 80% of the bearing surface the clearance between the surfaces does not exceed 0.1mm.

b) 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, atleast 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

Depth of Members

Acceptable deviation from the specified overall depth as per 1S:7215 (1974) is:

Upto and including 1000mm : 1.0 mm

Over 1000 mm : 2.0mm

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

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 centerline of flange.

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

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.

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**	**Method of control**
	1	2	3
1.	Control of welding and basic metal quality	Quality control; of electrodes, welding wire, flux and protective gases	Welding test to determine the technological properties if materials

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		Checking of quality and weldability of the basic metal and welded members	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.
2.	Checking of welders qualifications	Welding of specimens for quality determination	Mechanical tests, metalographical investigation & checking of welded joints by physical control methods
3.	Control of welded joint quality	Control of assembly accuracy and technological welding process	Checking of assembly quality & centering of welded members Checking of welding equipment conditions. Checking correctness of welding procedure. Visual examination of welds

Tests & Testing Procedures

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

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.

Mechanical Test

The Contractor shall carry out various mechanical tests to determine weldability, metal alloyability, 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 pre-heating and post-heating and weldability of metal are being followed.

Dye Penetration Test

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

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 20 mm 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 examiner 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.

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

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.

Testing of welds

Butt Welds- Radiography test-5% IS:1182.

Fillet welds- Ultrasonic Test

All welded connections shall be inspected as per IS:822

All welds shall be tested by Dye Penetration test"

7.9.1 STRUCTURAL STEEL WORK ERECTION:

i) Scope of Specifications
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 in position and grouting all complete as per drawings, specifications and other provisions of the Contract.

ii) Submittals

A. Ref. Specification for Structural Steelwork Erection –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.

iii) Execution

Delivery, Storage & Handling

A. Before the shop assembly is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identification numbers as detailed in shop drawings. The Contractor's representative shall be present during all the shop assemblies (wherever fabrication will be done), it's dismantling and marking operations.

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 MoRTH 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 shall be suitably packed and identified.

iv) Plant and Equipment

All erection tools and plant & equipment proposed to be used shall be efficient, dependable duly certified by independent third party 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.

v) Storage

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

vi) 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 MoRTH 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.

vii) Assembly & Erection

A. During erection, the members and sections shall be accurately assembled as shown in the approved shop drawings and by following the match marks. The material shall be carefully handled so that no section 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 50% of the holes filled with bolts and balance 50% with cylindrical erection pins before bolting with high-strength bolts. Filling-up bolts shall be of the same nominal diameter as the high-strength bolts, whereas the cylindrical erection pins shall be 1 mm or larger in diameter.

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.

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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 carefully planned and well supervised application of a limited amount of localized heat. Each application will be 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, kept in plumb, leveled, aligned and grouted within the tolerances permitted under the Specifications, 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 Engineer/Employer and will 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.

viii) Setting Out

A. Positioning and leveling of all steelwork, keeping in plumb 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 guides for keeping in plumb have been attached.

ix) 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 the required minimum bolt tension as per relevant Indian Standards / Specifications when all fasteners in the joint are tight,

D. The manufacture and use of high strength friction grip 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.

x) 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.

xi) 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.

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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 the 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.

xii) 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; takings 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 aligned and leveled. Immediately before grouting, the space under steel is thoroughly cleaned. Where packings are 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/mm^2. A minimum cover of 100mm shall be provided to all steelwork where surrounding concrete is in contact with soil.

xiii) 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 and contiguity requirements intended in the structure.

xiv) Painting after Erection

A. The surfaces required to remain unpainted at shop, shall be given a protective coating after the structure is erected, leveled, kept in plumb, 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.

B. 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.

C. 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.

D. 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.

xv) 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.

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SECTION – 08

PILE FOUNDATIONS

SECTION- S.08

8. PILE FOUNDATIONS

8.1 General

8.1 PILE FOUNDATION

All piles shall be RCC bored cast in situ reinforced concrete piles.

8.1.1 Piling plant and Methods

Suggested method for piling is cast in situ-bored piles with hydraulic drilling rigs using 4.5m. Depth casing by oscillator or vibro hammer arrangement,

1. 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, polymer slurry mixing, handling, transporting and disposal scheme and detailed method statements for carrying out the Works.

   Details of casings and concreting methods in respect of bored cast in place concrete piles are to be provided.

2. The Contractor shall not commence any piling until the plant and methods which he proposes to use including polymer slurry mixing, handling, transporting and disposal scheme 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.

3. List and nos. of equipments & accessories proposed to be used for the present job shall be submitted along with the bid.

8.1.2 Records

The Contractor shall keep complete records of all data required by the Engineer covering the fabrication; driving and installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after installation of the piles.

8.1.3 Programme and Progress Report

1. The Contractor shall inform the Engineer each day of 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.

2. 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.

8.1.4 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.

8.1.5 After all piles are cast in a pile cap and weak concrete is chipped out, the Contractor shall submit the drawing showing the exact location of piles with respect to the column centre line.

8.1.6 Disturbances and Noise

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1. The Contractor shall carry out the piling work in such a manner and at such times as to minimise noise, vibrations and disturbance. Noise limit as prescribed in "Building and other Construction Workers Act-Schedule-VI" shall be referred
2. The Contractor shall take precautions adequate enough to avoid damage to existing services and adjacent structures. Fig.1 of IS:2974 (Part 1) - 1969 may be used as a guide for studying qualitatively the effect of vibration on persons and structures. In case of deep excavation adjacent to buildings/structures, 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 if caused shall be repaired by the contractor at his own cost to the entire satisfaction of the Engineer.
3. 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.

8.1.7 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 at no cost to the employer.

8.2 Scope of Work

8.2.1 These specifications cover the works of providing pile foundations. Work included consists of all necessary services and furnishing of all labour material, tools, plant, 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.

8.2.2 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.

8.2.3 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

8.2.4 With the tender, the Contractor shall submit the detailed method of construction to be adopted. 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.

8.2.5 The items of work to be carried out in piling will generally be:

(a) Boring/drilling including provision of temporary casing (including its withdrawal), empty boring, & polymer slurry,

(b) Supplying, fabrication, tying and placement of all reinforcement.

(c) Casting of concrete piles as per specifications.

(d) Integrity and Load testing of piles.

8.3 Materials

8.3.1 General

Unless otherwise specified in this section all materials shall conform to the requirements specified in separate sections for Concrete, Formwork and Reinforcement.

8.3.2 Cement

The cement to be used for piling and all foundation work shall be conforming to following Indian Standard Specifications:

IS: 455: Specification for Portland slag cement

However, if the soil and ground water conditions are found ok on chemical testing in labs, Ordinary Portland Cement of 53grade may also be used as per codal provisions.

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Cement shall be free from lumps and caking.

8.3.3 Concrete Mix Design

The concrete shall generally be of grade M35. The maximum size of coarse aggregate shall not exceed 20mm. For cast-in-situ piles concrete with a slump of 150 to 175mm (consistent with the method of concreting) will be required. Minimum cement content for design mix shall not be less than 400 kg/m3 of concrete in piling. For piling, qty of cement to be used shall be as per the design mix or the minimum cement content whichever is greater.

The contractor shall submit mix design calculations and get the same approved by the Engineer well before the starting of boring of piles and carry out adequate numbers of tests to ensure the minimum specified strength as indicated in drawings.

8.3.4 Concrete cube tests

Concrete cubes shall be cast, tested and evaluated as specified in Section 3.

8.3.5 Reinforcement

(a) The reinforcement shall conform to the requirements specified in Section 5 extending for the full length of the pile and shall project 60 times 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.

(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, laps with full welding shall be provided as per the design/ drawings to develop the full strength of the bar across the joint, provided with adequate extra links or stirrups in position from those of adjacent longitudinal bars, all to the approval of the Engineer. No extra payment on account of providing laps shall be paid. The cost towards steel consumed in laps shall be considered in the Lumpsum Price Schedule.

(c) All main longitudinal bars shall be welded at lapping and to the pile cap reinforcement. The last circle of helical stirrups at each end shall be welded to main longitudinal bars Nothing extra shall be payable on account of this. Any extra tack welding required for handling and lowering of cage in borehole shall also be done by the contractor at no extra cost.

8.3.6 Casings and Tremie Pipes

The casings and tremie pipes shall be in mild steel. The temporary casing plates of 4.5m. Length and permanent liners 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 water tight. The internal diameter of the casing shall not be less than the nominal diameter of pile.

8.4 Cast In-Situ Bored Piles

8.4.1 General

(a) Diameters of the piles shall be the concrete shaft diameters and shall not be less than the diameters specified in the drawing.

(b) These shall be formed by boring to the founding strata specified on the drawings or as directed at site. The sides of the boring shall be prevented from collapsing by one of the following

Providing permanent mild steel liner (cased pile)

Providing removable mild steel casing (uncased pile)

(c) Piles shall be constructed in a sequence approved by the Engineer. 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 or carry out soil tests as directed.

(d) 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.

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(e) The bottom of the steel lining shall be sufficiently in advance of the boring tool so as to prevent settlement of outside soil and formation of cavities.

(f) 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.

8.4.2 Boring

(i) Boring shall be done using Rotary hydraulic drilling rigs with oscillator arrangement / equipments and methodology suitable for different kinds of strata encountered.

(ii) As a general guideline, size of cutting tool shall in no case be less than the diameter of the pile minus 75mm. 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. 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 pour 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). More than 5% reduction in consumption of poured concrete quantities in pile may be rejected. In general, piling shall be done by using hydraulic rig with temporary liner. Use of liner for top 4.5 meters from ground level or upto depth having N. value (Minimum) 10 (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 Price Schedule.

(iii) Use of Polymer slurry 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. In such situations the properties of Polymer used & quality control shall be as per requirement given below.

Fresh polymer slurry shall satisfy the following properties at all times:

Mud density shall not exceed 1.05 g/cc

PH Value to be 9 to 11.5

Marsh Cone viscosity 30-40 seconds

The sand content of Size > 0.075mm shall not be more than 1 Percent.

Liquid limit of bentonite shall not be less than 400 percent.

(Geo Polymer slurry specification to be added)

When using bentonite mud, flushing shall be done after lowering of inserting reinforcement cage and tremie before starting of concreting with fresh bentonite slurry.

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 and got approved by the engineer prior to commencement of piling.

The quantum of steel required in permanent liners from the cut off level downwards shall be measured as per drawing. Though the liner might have been provided right from the level of the working platform on practical considerations, the length of the permanent liner above the cut-off level has to be necessarily removed for facilitating chipping 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 / compensation shall be entertained for such cut pieces if they cannot be reused by the Contractor in the aforesaid manner.

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(iv) Pumping from a 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.

(v) In case of end bearing piles founded on rock, cutting of rock by hydraulic rig using diamond bits will be resorted to. Scheme adopted shall be such that noise and vibration parameters specified in tender document /Environment manual are not violated. Drilling in rock shall be carried out by hydraulic rig using diamond bits.

(vi) On completion of boring, loose disturbed or remolded soil shall be removed from the base of bore.

(vii) 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

Penalty on mishandling of Polymer

Mishandling of Polymer (like splashing of Polymer 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
(ii) On Second observation –Rs. two lakhs
(iii) On third and each subsequent observation – Rs. three lakhs

8.4.3 Concreting

(a) 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.

(b) The concrete shall have a minimum slump of 150 mm. 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.

(c) 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 water tight and the tremie pipes shall be thoroughly cleaned after each use.

It is essential that the water level within the pile bore be in equilibrium before commencement of concreting.

(d) 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.

(e) If the specific gravity of the drilling mud at the base of the bore exceeds 1.20 the placing of concrete shall not proceed.

(f) 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.

(g) The tremie pipe shall at all times penetrate the previously placed concrete for minimum depth of 2 m as a precaution 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.

(h) Spot measurements shall be taken at suitable intervals to check that the tremie pipe has an adequate penetration into previously placed concrete.

(i) 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 number of mixers shall be used so that the entire concreting operation is completed in not more than two hours.

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(j) 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.

(k) Cut off level (COL)

Cut off level of piles (50mm inside the pile cap) shall be as indicated in working drawings or as indicated by Engineer.

The top of concrete in pile shall be brought above the cut off level to remove all laitance & weak concrete and to ensure good concrete at cut-off level.

In case of concrete being placed by tremie method and pile cut off level being less than 1.0meter 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 be cast.

In the circumstances where COL is below ground water level, the need to maintain a pressure should be observed & accordingly length of extra concrete above COL shall be determined by the Contractor and approval of Engineer obtained before concreting.

Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete.

(l) When a casing is being extracted, 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.

(m) No concreting shall be placed in the bore once the bottom of the casing has been lifted above the top of concrete.

(n) After each pile has been cast any empty bore shall be protected by putting steel cage/Jali over it and carefully backfilled as soon as possible with approved materials.

(o) 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.

Generally, the COL is 2.5 m below the exiting ground level however, if any utility has to be placed on top of the pile cap, the COL may vary according to the requirement at that specific location.

8.5 Alignment of Piles

8.5.1 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.

8.5.2 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.

8.6 Pile Cap

Pile caps shall be of reinforced concrete. A minimum offset of 200mm shall be provided beyond the outer faces of the outer MoRTH 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 M20 shall be provided or as shown in the drawings.

The attachment of the pile head to the cap shall be adequate for the transmission of loads and forces. A portion of pile top may be stripped of concrete and the reinforcement anchored into the cap. Manual chipping may be permitted after three days of pile casting while pneumatic tools for chipping shall not be used before seven days

after pile casting. The top of pile after stripping shall project at least 50mm into the pile cap. Concreting of the pile cap shall be carried out in dry conditions. Nothing extra will be paid for dewatering, etc. for carrying out pile cap excavation. Cost of all the operations and tools required for making the pile cap in dry condition is deemed to be included in the item.

The road surface after casting of pile cap should be repaired immediately. If the surface

is not repaired immediately, penalty will be imposed as decided by the Engineer.

8.7 Testing of Piles

8.7.1 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. The payment shall be made based on relevant item included in Price Schedule on test load only. 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.

8.7.2 Engineer will decide the locations and nos. of initial load tests to be performed in different zones depending on variation in substrata but minimum two initial load tests are required to be done for different types of strata. The contractor shall undertake test piles required for initial pile load test 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 working pile. No working pile would be allowed to be undertaken till initial pile load tests have been satisfactorily 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. Sufficient nos of test arrangement and resources will be required to be mobilized by contractor so as to conduct required nos of initial load tests simultaneously. Vertical cyclic loading tests shall be carried out where specially needed and specified for separation of skin friction and point bearing components of the load carrying capacity of the piles. **At every one KM initial load tests both vertical and horizontal is to be performed by the contractor during the mobilsation period. GFC design and drawings will be made as per the initial load test results.**

8.7.3 Routine tests are performed as a check on the load carrying capacity and settlements of the pile foundations. At least one routine test shall be performed for every 100 piles unless otherwise specified by the Engineer.

8.7.4 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.

8.7.5 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.

8.7.6 All testing shall be done under the direction of experienced personnel conversant with the equipment and the testing procedure.

8.7.7 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.

8.7.8 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 observations relevant to the test being conducted.

8.7.9 Integrity test

Two types of pile integrity tests will be performed

8.7.10 This Dynamic Integrity test using pile driving analyser or approved equivalent for pile integrity shall be performed on the sample of piles selected by the Engineer. 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 otherwise directed by the Engineer. A complete report indicating the graphical display of wave propagation under each flow shall be submitted along with interpretation of results showing discontinuities, cross-sectional changes or material changes if any. The results are to be co-related with Site data.

All the piles are to be tested with integrity and cross hole sonic tests. 75% integrity test and 25% cross hole sonic test (dynamic integrity test). Further details are in technical specification section 8B.

8.7.11 Cross Sonic Logging Test

'Cross Sonic Logging' test should be conducted to verify the structural integrity of piles by means of the measurement of the time travel of a sound waveform an emitter to a receiver through the concrete of a pile. The emitter and the receiver shall generally be at the same level. Cross-hole Sonic logging testing is compulsory for 25% of piles with 100% of piles installed with recess tubes and equipped for testing. The Engineer in Chief from client will randomly select and conduct tests of 25% of piles.

a. Sonic Logging Tubes

Material

Every pile must be provided with sonic logging tubes cast into it. The tubes shall be manufactured from steel of 50mm ID and 1mm thick. To form single tube the pipes to be connected with an enlarged end Bell Mouth – push fit arrangement provided with rubber gasket only. The bell mouth and rubber gasket should ensure a concrete-tight joint to maintain the tube integrity and prevent entry of foreign material. PVC or any kind of plastic material is strictly prohibited as it cannot resist great compression pressure. The expansion factor between PVC and concrete is not the same (unlike steel and concrete). When the concrete is setting, its temperature goes up and leads to the expansion of the PVC. Once the concrete has set and the temperature goes back to normal there will be a void between the tube and the concrete: this will lead to bad reading of the test and the rejection of the pile. One tube in each pile should be installed of internal diameter 100mm in order to allow for coring of the concrete at the base of the pile.

Tests to be conducted for Sonic Tubes assembly and desired results

The Sonic Tubes assembly should be tested for following tests –

1. External Pressure Test –

Description	Pressure in Mpa	Hold Time	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 5 Mpa	>= 60 Sec	No Leakages from Inner Surface of Tubes and No Distortion of Tubes

Minimum 3 test results should be obtained

2. Pull Out Test for Tubes-

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm X 1.0 mm Thick	>= 0.5 KN	No Distortion found and should withstand the test load of >=0.5 KN

3. Pull Out Test for tubes ' Fixing Ears'

Description	Tensile Force to be applied	Desired Results
Sonic Tubes Diameter 50 mm x 1.0 mm Thick	>= 0.5 KN	No Distortion found and should withstand the test load of >=0.5 KN

4. **Crush Test –**

Sl.No.	**Descriptions**	**Test**	**Desired Results**
1	Direction	1500 mm	1. No Cracks 2. After test 30 mm Steel ball can go through the tubes.
2	Drop Weight	4000 + 150/0g	
3	Diameter of Drop	50.03 mm	

Installation

The agency supplying sonic tubes should submit a detailed installation methodology and conduct a demo for one pile before being implemented for all piles.

Frequency

Four tubes shall be required for each pile, any other configuration is not allowed.

b. Sonic Coring

At least 7 days after the pile has been cast, but before carrying out any sonic logging test, a core of concrete and soil or rock from the founding material shall be taken. The core shall be taken from the base of the 100mm diameter sonic logging tube. The core shall be kept in a suitable wooden box with depths clearly recorded on rigid markers, shall be photographed along with a scale and colour chart. Thereafter, these shall be delivered to a core store designated by the Engineer. The scanning of the pile toe for its integrity by measuring the propagation time of transmitted waves between the vertical tubes and the pile toe/ founding strata shall also be carried out.

c. Sonic Logging Equipment

The equipment shall be properly maintained and calibrated. Where necessary, means shall be provided to centralise the probes within the tubes, so that variation in the separation of the emitter and receiver resulting from clearance between the probes and the tubes does not occur.

d. Test Procedure

The tubes shall be filled with water. The tests shall be repeated for each pair of tubes, i.e. three runs for a pile with three tubes and six runs for a pile with four tubes.

e. Analysis of Test Results

A report shall be prepared for each pile tested. The photographic record of the oscilloscope displays shall be analysed in detail. Any deviation from the record to be expected from a pile constructed entirely of sound concrete and without defect shall be reported. The report shall indicate the nature, location and severity of the defect and recommendations shall be made for further testing. The implication of the existence of the defect on the performance of the pile shall be evaluated.

f. Submission of Results

Immediately after testing, a signed copy of all the raw test data of a pile shall be given to the Engineer. A test report shall be submitted to the Engineer within 7 days after testing.

g. Anomalous Sonic Logging Test Results

The piles with anomalous sonic logging results shall be rejected at the Engineer discretion unless the Contractor is able to demonstrate that the pile integrity is acceptable through proof coring.

h. Grouting of Pile after Testing

Upon completion of sonic logging test, the access tubes and sonic coring holes, if any, shall be grouted up.

Defective piles

The engineer reserves the right to reject any pile which is in his opinion has not been contructed in accordance with the specifications.

The contractor will not be paid for rejected pile.

Mode of measurement

Piles with casing pipe / Temporary Liners

1. The length of each pile is 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, chiseling as specified / required, concreting, handling, form-work and grouting for precast piles, 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. The quoted price is also inclusive for permanent liners, temporary liners, socketing in weathered rock, soft rock and hard rock for all depths.
2. Pile load tests initial and routine load test.
3. Each pile integrity test and cross hole sonic test..
4. The quoted lumpsum price in price schedule is inclusive of all above items and the rates are including the costs of tools and plants, cutting, welding MS liner, cutting shoe etc. complete. Attention is also drawn to Para 8.4 2 (c) above.

Piles with Permanent Liners:

Liner is used to maintain the clear cover between the main reinforcement and concrete surface during the stages of construction. It is used for bored cast in situ pile that extends through very soft soils, such as marsh deposits, to reach an underlying stratum that is more stable.

The quantum of steel required in permanent liners from the cut off level downwards shall be measured as per drawing. Though the liner might have been provided right from the level of the working platform on practical considerations, the length of the permanent liner above the cut-off level has to be necessarily removed for facilitating chipping 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 / compensation shall be entertained for such cut pieces if they cannot be reused by the Contractor in the aforesaid manner.

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 tracings of these drawings along with soft copies shall be submitted to the Engineer.

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SECTION – 09

OTHER WORKS

SECTION- S.09

9. OTHER WORKS

9.1 Bearings

9.1.1 General

This work shall consist of design supply and fixing in position of bearings for bridge / viaduct girders in accordance with details shown on drawings and to the requirements of these Specifications, Codes and Standards quoted therein and as directed by Engineer.

Bearing plates, assemblies and other expansion or fixed devices shall be constructed in accordance with details shown on drawings.

When bearing assemblies or plates are shown on drawings to be placed (not embedded) directly on concrete, the concrete bearing area shall be constructed slightly above grade and shall be finished by grinding.

It shall be ensured that the bearings are set truly 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 (not exceeding 5 mm) may be made to meet with this requirement.

It shall be ensured that the bottoms of girders to be received on 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 or preformed fabric 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.

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 K-RIDE before fixing. Test report of the bearings should be got approved before the materials are lifted from the manufacturer premises.

A. ELASTOMERIC BEARINGS

The term “bearing” in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomeric 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.

A.1 Raw Material

Chloroprene (CR) only shall be used in the manufacture of bearing.

Grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110 Skyprene B- and Denka S-40V) shall be used. No reclaimed rubber or vulcanized wastes or natural rubber shall be used. The raw elastomer content of the compound shall not be lower than 60 per cent by its weight. The ash content shall not exceed 5 percent (as per tests conducted in accordance with ASTM D-297, sub-section 10).

EPDM and other similar candidate elastomer for bridge bearing use shall not be permitted.

A.2 Properties

The elastomer shall conform to the properties specified in Clause 4.3.1 of the IRICEN publication titled "Bearings for Railway Bridges" and those specified in Table 2000-1 of the publication titled "Specifications for Road and Bridge Works", published by IRC on behalf of MORTH (Roads Wing).

A.3 Fabrication and Tolerances

Fabrication and Dimensional tolerances shall be governed by the specifications laid down in Clause 4.3.2 of the IRICEN publication & Clause 2005.2 of the MORTH specifications mentioned above.

A.4 Acceptance Specifications

For inspection and testing requirement Clause 4.4 of the above mentioned IRICEN

publication shall be referred with modifications of lot size as mentioned below:-

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) A lot shall not exceed a single contract or project quantity;
(b) A lot shall not exceed 50 bearings;
(c) A lot shall consist of bearings of the same type regardless of load capacity.

Accepting and testing requirements shall also conform to the specifications laid down in Clause 2005.3 of the referred MORTH specifications/IRC 83(Part-2).

In addition to tests mentioned above, all bearings shall be also weight actually and compared with the theoretical weight.

All bearings shall carry a warrantee of not less than 15 years in an approved format. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the Owner at no extra cost to the Owner within the warrantee period.

Criteria for Selection of bearing manufacturer shall conform to requirement of MOST letter No- RW/NH-34057(1) / 95-(S & R) dated 2nd November,2000.

It is necessary that all manufacturers of all elastomeric bearings shall have in house facilities for carrying out Infrared Spectro-Photometry as per ASTM D-3677.

Polymer content and Ash content of Elastomeric bearing test to be done by third party (IRMRA) and reports to be submitted to the Engineer.

A.5 Design

The design of elastomeric bearings shall be in accordance with EN1337 Part 1 and Part III.

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.

A.6 Storage and Handling

Each elastomeric bearing shall be clearly labelled or marked. The bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect corners and edges.

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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.

A.7 Installation

Installation procedure shall conform to the guidelines listed in Clause 4.5 of the IRICEN publication and Clause 2005.6 of the MORTH specifications. Cost of Non shrink grout above and below the bearing is included in the cost of bearing.

B. POT BEARINGS

B.1 Material specifications of Pot bearing

The material such as PTFE lubrication, Confined elastomer, stainless steel & internal seal shall conform to requirement of IRC: 83 Part-III. The Pot base, saddle & top plate shall be of Cast steel conforming to IS: 1030 Gr 280-520 W. The anchor bolts shall conform to IS: 1364. All welding shall conform to IS: 816 & IS: 9595 with electrode as per IS: 814. Painting on non-working surface of bearing shall be as per IRC: 83 Part-III. The mating surface of Piston and cylinder shall be hardened to 350BHN (Min).

Guides of sliding pot bearing shall be monolithic to parent component

Design of the bearing and all accessories shall be the responsibility of the Contractor and got approved from the Employer's Representative.

B.2 Permissible stresses in steel component of POT bearing

All the design requirement for Pot bearing as specified in IRC: 83 Part-III has to be fulfilled with following modifications.

(a) No increase in permissible stresses in any material of bearing or bearing stress between concrete and bearing is permitted in seismic condition.

B.3 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.

No increase in permissible bearing stress between concrete and bearing is permitted in seismic condition.

B.4 Anchor sleeve

All the part of bearing such as anchor sleeves embedded in concrete shall be hot dip galvanized @ 300gm/ m². 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

B.5 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 be proposes to use. Products of reputed manufacturers shall only be used.

B.6 The Bearings shall be measured in numbers according to their capacities. For this purpose, Fixed type POT bearings, Free sliding type POT-cum-PTFE bearings, Guided sliding type POT-cum-PTFE bearings, Free or Guided PTFE Sliding Assembly, Pin Bearings or Metallic Guided bearings shall be counted separately. The rate shall include the cost of supplying, fixing, sampling and testing as required and confirming to the specifications

B.7 Testing of Pot Bearing

B.7.1 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.

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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.

B.7.2 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.

B.8 Sampling and Testing

B.8.1 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.

B.8.2 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.

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 than500 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 of20 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.

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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
ill) Test on welding e. g. Dye Penetration Test
iv) Test on hard chromium plating e. g. Ferroxyl 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)

B.9 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.

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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 beveled to facilitate rotation. Except as noted all bearing surfaces of steel plates shall be finished or machined flat in accordance with tolerance given below:

Tolerances

Manufacture tolerance shall be as per IRC:83 Part-III/Part IV.

All the measurements will be taken using dial / height gauges, vernier calipers, surface finish measurement instrument etc has to be arranged by manufacturer at the workshop.

Every bearing shall have the Project Identification Number, Lot Number, and individual bearing number indelibly marked with ink on a side that will be visible after erection.

After assembly, bearing components shall be held together with steel strapping, or other means, to prevent disassembly until the time of installation. Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during transportation and storage.

B.10 Shop Drawings

Along with detailed design of different types of bearing, shop drawings shall be submitted. The shop drawings shall contain the following information, which is necessary for proper design and detailing of the bearings.

Quantity, type (fixed, guided expansion, non-guided expansion), and location of all bearing units.

A table containing maximum and minimum vertical and horizontal loads, design rotation requirements, and magnitudes and directions of movements.

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.

The painting system to be used on the steel components to guard against corrosion.

Any special consideration such as earthquake requirements, uplift details, or temporary attachments.

Installation scheme of pot bearing/Spherical Bearing.

The Contractor shall submit detailed shop drawings in conformance with the applicable requirements.

SHEAR KEY DEVICES

General Description of the system

General

The shear Key is made of concrete cast in place in second pour after concrete decks are assembled.

The shear keys shall take all horizontal loads (longitudinal and transverse) It is equipped with a system of fixation with high strength bars to one end of the deck, and with five vertical bearing taking the transverse horizontal loads and rotations.

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Description of the proposed system

The system of fixation of the shear key to the deck is performed by high strength tensile bars installed on only one horizontal layer.

The system shall satisfy the following two main requirements.

- construction easiness

- maintenance easiness

The high strength tensile bars shall have good resilience and good resistance to fatigue as due to the rotation of the braking/acceleration loads, the bars are almost continuously loaded.

Material Characteristics

High tensile bars

Quality of steel: The quality of the raw material steel be according to the DIN EN 10083-1 equivalent.

The chemical composition shall be such as to guarantee the following mechanical characteristics:

- Yield stress Fy >1050 MPa

- Tensile stress Fu> 1200 MPa

- Elongation at breaking >10%

- Resilience at 20%C >50 Joules:

The threading of the bars shall be made by rolling method (cold plastic deformation of the metal between two dies). The threads shall have a triangular profile H7 according to ISO 262-NFE 03053.

The tolerance of the length of the bars is +/-5mm.

Due to the repetitive loading that will be applies to the bars, tests shall be carried out to demonstrate the fatigue resistance of the bars. The test criteria shall be as follows:_

- mean stress: 0.57Fy

- stress range: +/- 0.03

- 4million cycles

- after 4 million cycles, no breaking at less than 0.80Fy

Other materials

The repartition plates shall be of S355 JO steel quality or equivalent, and each shall include an injection pipe.

The ends of the bars shall be equipped with a protection cap filled up with grease and fixed on reparation plate by threading.

The nuts at the ends of the bars shall be spherical in order to ensure that the tensioning is axial.

The sheaths shall be made of a 2mm-thich steel.

The injection product shall be wax in order to provide a good time –resistance and to provide flexibility under the deck rotations. The product shall be equivalent as for use for protecting stay cables or tension rods.

9.2 EXPANSION JOINTS

9.2.1 Scope of Work

The scope of work will include :

1. Preparation of detailed engineering and installation drawings, supply and supervision during fixing of strip seal/compression seal expansion joints conforming to specifications. The expected

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expansion/contraction of the superstructure at the location of expansion joints are shown in relevant drawings.

2. Design, manufacture, providing and seating of expansion joints by the specialized agency and approved by the Engineer.
3. 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.
4. The expansion joint shall be provided for the full width of viaduct including the railing.
5. Leak tightness of all joints shall be ensured which shall also carry a warranty of 10 years from the contractor.

The expansion joints provided over elevated structure decks should be so designed as to be compatible with the bearings wherever provided where the structure passes through stations, specially designed completely waterproof expansion joints should be provided.

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 Revised Highways “Interim Specification for expansion joint” issued by MOST circular No. RW/NH – 34059/1/96 – S & R dated 30th

November 2000 and 20th february 2001, IRC Codes and MORTH Specification for Roads and Bridges and Sound Engineering practices.

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 the Contractor shall undertake all necessary action for ensuring execution of work on that basis.

For design, manufacture, testing and supply of strip seal/modular strip seal expansion joints, following will be followed in order of preferences.

a) Details in this chapter and elsewhere in tender documents.

b) “Revised Interim Specifications for expansion joints” issued by MOST circular v No. RW/NH – 34059/1/96/ S & R dated. 30.11.2000 and 20th february 2001

c) IRC Codes and MORTH specifications for Roads and bridges published by Indian Road Congress.

d) Sound Engineering Practice (Decision of Engineer will be final in this case) which shall include specialized literature as decided by Engineer-in-Charge.

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 manufacture’s drawings. The joint fixing shall be carried out either 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

water tight and test on same if required on direction of Engineer shall be conducted without any extra payment for same.

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.

1. **Components**:

Strip seal expansion joint shall comprise the following items:

(a) 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 1500mm ^2.

(b) 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 1600mm Sq. per meter length of the joint and the center to center spacing shall not exceed 250mm. The ultimate resistance of anchoress shall not be less than 600 kN/m in any direction.

Material

a) 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.

b) Anchorage steel shall conform to IS:2062 or equivalent.

c) 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.

d) 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.

Fabrication (Pre-installation)

a) The strip seal joint system and all its component parts including anchorages shall be supplied by the manufacturer /system supplier.

b) 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 preset.

c) 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. Presetting shall be done in accordance with the joint opening indicated on the drawing.

(Instead of expansion joint : strip seal , Compression seal expansion joint is to be used.)

Include vertical bearing including steel frame in Price Schedule. Also add in structural steel nomenclature and qty.

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	+/- 5 Shore A
ASTM D 2240 (Modified)	.
Tensile Strength*	Min 11 MPa Min 13 .8Mpa
DIN 53504	Min 350 per cent
ASTM D 412	Min 250 per cent
Elongation at fracture*	Min 10 N/mm
DIN 53504	Min 10 N/mm
ASTM D 412	Min 25 per cent
Tear Propagation Strength	Min 220 Cu.mm
Longitudinal	Max 28 per cent
Transverse	
Shock elasticity	
Abrasion	
Residual Compressive Strain (22h/70 deg C/30 per cent Strain)) Aging in hot air	
(14days/70 deg C) Change in hardness Change in tensile strength Change in elongation at fracture	
Ageing in Ozone	Max + 7 Shore A
(24 h/50 pphm/25 deg	
C/20 per cent elongation)	Max –20 per cent
Swelling behaviour in Oil (168h/25 deg. C)	-20 per cent
ASTM Oil No. 1	
Volume Change	No cracks
Change in hardness	Max + 5 per cent
ASTM Oil No. 3	Max –10 Shore A
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.

d) 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. Presetting shall be done in accordance with the joint opening indicated on the drawing.

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e) The finally assembled joint shall then be clamped and transported to the work site.

f) The finally assembled joint shall then be clamped and transported to the work site

Handling and Storage

(a) For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.

(b) 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.

(c) Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

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 presetting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for presetting, correction of the presetting 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 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.

Acceptance Criteria:

(i) All steel elements shall be finished with corrosion protection system

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(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

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.

9.3 **WATER BARS / WATERSTOPS**

Where water bars/ waterstops are shown on the drawings, the joints shall incorporate PVC waterbar/ waterstop such as "Fixostop" or approved equivalent (conforming to IS:12200). The waterbars/ waterstops 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 / waterstops 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. The following types of water bars / waterstops are proposed to be used in the Work.

Water bars / water stops shall be of approved and appropriate type obtained from approved manufacturers.

The water bars / water stops 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 / water stops shall be provided.

Where reinforcement is present adjacent to water bars / water stops, adequate clearance shall be left between the reinforcement and water bars / water stops to facilitate compaction of the concrete.

Double headed nails maybe used in the edge of the water bar / water stop outside the line of the external grooves for fixing purposes, but no other holes shall be permitted through the water bar / water stop.

A representative of the manufacturer shall be present at site during the operations of installing, jointing and embedment of water bar / water stop. He shall monitor and certify that the work is being carried out strictly as per specifications and recommended practices.

SPECIFICATION FOR OMEGA TYPE EXPANSION JOINT

Expansion joint type described here-after is the **"OMEGA TYPE EXPANSION JOINT" as per IRC 83 Part-II**

Material.

1.1 Anchorage: The steel plate shall conform to IS: 2062 or equivalent. The bolt and nutshall 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.

G.1.2 Corrosion Protection: All steel section shall be protected against corrosion by hot dip galvanising or any other approved anticorrosive coating with a minimum thickness of 100micron.

Joint Seal:

The sealing element shall be a preformed continuous chloroprene or closed cell foam seal 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 vulcanised in a single operation for the full length of the joint required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement up to 40mm and vertical movement of 3mm.

The physical properties of chloroprene/closed cell foam sealing element shall conform to the following:

Elastomeric Seal:

It shall be preformed 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.

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.

Installation

The expansion joint shall be installed by the manufacturer/supplier or their authority's representative, who will ensure compliance of installation procedure and instructions.

The dimension of the joint recess **edge beam above deck slab** and the width of the gap shall conform to the approved drawing.

Bolts shall be welded to the main reinforcement in the edge beam deck maintaining the level and alignment of the joint.

Concreting of pocket/recess **edge** 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.

The width of pocket shall not be less than 300mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess **edge beam**.

At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.

Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.

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.

Acceptance Criteria:

All steel elements shall be furnished with corrosion protection system.

For the joint seal the acceptance test shall conform to the requirements as stipulated. 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.

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.

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.

Lumpsum Price

The Lumpsum Price of Schedule shall include the cost of all materials, labour, equipments, cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications.

Specification for Compression Seal Expansion Joint

Expansion joint type described here-after is the “Compression seal” type, but alternate designs can be proposed for approval of the Engineer.

Compression seal joint shall consist of steel armoured nosing at two edges of the joint gap suitably anchored to the deck concrete and a preformed chloroprene elastomers or closed cell foam joint sealer compressed and fixed into the joint gap with special adhesive binder.

Material:

Steel Nosing:

The steel nosing shall be of angle section ISA 100 x 100 conforming to weldable structural steel as per IS:2062. The thickness of legs shall not be less than 12mm. The top face of the angle shall be provided with Bleeder holes of 12mm diameter spaced at maximum 100mm centre so as to ensure that there are no voids in the concrete beneath the angle.

Anchorage:

The anchorage steel shall conform to IS:2062 or equivalent. The steel nosing shall be anchored to the deck by reinforcing bars or anchor plates cast in concrete or a combination of anchor plates and reinforcing bars, anchor plates and anchor loops. This shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plates shall be 12mm. Total cross sectional area of bars on each side of the joint shall not be less than 1600sq mm per m length of the joint and the centre to centre spacing shall not exceed 250mm. The ultimate resistance of each anchorage shall not be less than 600 KN/m in any direction.

Corrosion Protection:

All steel section shall be protected against corrosion by hot dip galvanising or any other approved anticorrosive coating with a minimum thickness of 100 microns.

Joint Seal

The sealing element shall be a preformed continuous chloroprene or closed cell foam seal 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 required for carriageway, kerbs and footpaths, if any. The seal shall cater for a horizontal movement up to 40mm and vertical movement of 3mm.

The physical properties of chloroprene/closed cell foam sealing element shall conform to the following

(a) Chloroprene Seal

It shall be performed extruded multi-web cellular section of chloroprene of such a shape as to promote self-removal of foreign material during normal service operations. Chloroprene of joint seal shall conform to IRC:83 (Part-II) and satisfy the properties stipulated in Table 1 herein above strip seal element specifications of these specifications except in respect of the working movement range of the sealing element which shall be as specified above.

(b) Closed Cell Foam seal:

It shall be of preformed non-extruded non cellular section made from low density closed cell, cross linked ethylene vinyl acetate, polyethylene copolymer that is physically brown using nitrogen. The material shall possess properties as indicated in the Table 2 below.

Table-2

Properties of Closed Cell Foam Seal

Property	**Special Value**
Density	41.7 – 51.3 kg/cum (I)
(ii) Compression set on 25mm	50% compression samples (ASTM D 3575) for 22 hours at 23^0 C, 2 hour recovery; 13% set.
(iii) Working temperature	-70^0 to $+70^0$C.
(iv) Water Temperature absorptions (total Immersion for 3 months) (ASTM3575)	0.09766 kg/sqm
(vi) Tensile strength	0.8 Mpa
(vii) elongation at break (ASTM D 3575)	195 +/-20%

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Lubricant cum Adhesive: The type and application of material used in bonding the preformed joint seal to the steel nosing and concrete shall be as recommended by the manufacturer / supplier of the seal system.

Handling and Storage

The expansion joint material shall be handled with care and stored under cover.

All joint materials and assemblies shall be protected from damage and assemblies shall be supported to maintain true shape and alignment during transportation and storage.

Installation

a. The expansion joint shall be installed by the manufacturer / supplier or their authorised representative, who will ensure compliance of specified installation procedure and instructions.

b. The dimension of the joint recess and the width of the gap shall conform to the approved drawing.

c. Anchoring steel shall be welded to the main reinforcement in the deck maintaining the level and alignment of the joint.

d. Concreting of pocket/recess 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. The width of pocket shall not be less than 300mm on either side of the joint. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess.

e. At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.

f. Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.

g. The lubricant cum adhesive shall be applied to both faces of the joint and joint seal prior to installation in accordance with the manufacturer's instructions.

h. 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.

i. The joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.

Acceptance Criteria

(i) All steel elements shall be furnished with corrosion protection system.

(ii) For the joint seal the acceptance test shall conform to the requirements stipulated in para above. The manufacturer/supplier of this type of joint shall produce a test certificate to this effect conducted in a recognized laboratory in India having NABL certification or abroad.

(iii) 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.

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 certificates from the recognised testing laboratory of India having NABL certification or abroad.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

Mode of Measurement

The measurement for expansion joints as a finished work shall be in running meters nearest to a centimetre.

Lumpsum Price

The quoted Lumpsum Price shall include the cost of all materials (including cast–in-situ concrete), labour, equipments, cost of transportation (overseas as well as within country), cost of testing including cost of test samples and other incidental charges for fixing the joints, covering plates over shear keys etc., complete in all respects as per specifications.

9.4 WEARING COAT

9.4.1 ASPHALTIC WEARING COAT

Wearing coat shall be provided as indicated on drawings. It shall consist of the following:

A coat of mastic asphalt 6mm thick with prime coat over the top of deck before the wearing coat is laid. The prime coat of mastic asphalt shall be 30% straight run 30/40 penetration grade bitumen and 50% light solvent (benzol) to be laid over the deck slab. The insulation layer of 6 mm thick mastic asphalt with 75% limestone dust filler and 25% of 30/40 penetration grade bitumen shall be laid at 375 degree F with broom over the prime coat.

A layer of asphaltic concrete wearing coat of thickness varying from 25 mm to 60 mm to be laid in single layer.

9.4.2 **CONCRETE WEARING COAT**

Scope

The work shall consist of laying cement concrete layer of required thickness as indicated on the drawings, It shall not be laid monolithic with the slab

Materials

Materials shall conform to ISI and / or IRC specifications.

Construction Operation

i. For Weather and seasonal limitations shall be as per IRC Standards.

ii. All carriageway and footpath surfaces shall have non-skid characteristics

iii. The surface shall be thoroughly swept and scraped clean and made free of dust and other foreign matter. It shall be conditioned to the specified levels, grade and cross fall (camber) as directed by Engineer.

iv. Construction operations such as preparation of mix, laying of concrete, steel reinforcement shall conform to respective specifications in the relevant Chapters.

v. Curing of wearing coat earlier than what is generally specified may be resorted to, so as to avoid formation of shrinkage cracks in hot weather.

9.5 **Railings**

9.5.1 General

Railing are not contemplated for the project but these specifications are provisional in case railings are finally provided for the full length of viaduct or for small parts.

Prefabricated railing as per approved details shall be erected at site Fixing arrangements with deck shall be carefully designed and incorporated.

Railing on bridge shall not be constructed until the centering or form work for the span has been released and the span is self supporting. For concrete and steel, specifications of the items of controlled concrete and reinforcement mentioned under relevant specifications shall be applicable.

Railing shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. The pockets left for posts shall be filled up with non-shrinkable mortar

All edges and corners shall be straight and finished to true line and level. Forms shall either be of single width boards / plates or shall be lined with suitable materials duly approved by Engineer. Form joints in plain surface will not be permitted. All mouldings, panel work and level strips shall be constructed according to the details shown in the drawings.

9.5.2 **Metal Railings**

9.5.2.1 General

All complete steel / aluminium 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. In case of steel railing all these elements shall be galvanised or painted with an approved paint. If galvanised, all elements of the railings shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by Engineer.

Aluminium sections shall be of approved quality and make and free from scratches, stains and discoloration.

The Contractor shall take every precaution against damage of the components during fixing in position.

Damaged galvanized surfaces shall be cleaned and re galvanised. Special care shall be taken to prevent staining of all products, rust, mortar, etc. before it is put into use.

Prefabricated railing as per approved details shall be erected at site Fixing arrangements with deck shall be carefully designed and incorporated.

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9.5.2.2 Fixing

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 in the drawings or as directed by Engineer.

If sections are not galvanised, railing shall be given one shop coat of paint, and three coats of paint after erection.

All necessary holes, chases, etc., required in fixing shall be made by the contractor and made good after installation, without any extra charge.

9.6 DRAINAGE SPOUTS AND DRAINAGE PIPE

GENERAL

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. Where details are not given on drawings, contractor should prepare and submit his own drawings for approval of Engineer before commencement of work. Underground / Surface drainage works are to be designed by Contractor and carried as per CPWD specifications.

All drainage pipe to be embedded in superstructure diaphragm and pier shall be HDPE.corrugated double wall.

FABRICATION

Drainage assembly shall be fabricated to dimensions shown in drawings. All materials shall be corrosion resistant; steel components shall be of mild steel conforming to IS:226. The drainage assembly shall be seam welded for water tightness and then hot dip galvanised.

PLACEMENT

The galvanised assembly shall be given two coats of bituminous paint before placement. The whole assembly 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.

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 to receive the wearing coat. After the wearing coat is completed, similar sealant, finished to cover the wearing coat surface all-around the drainage assembly, shall be provided at least 50 mm.

9.7 CINDER

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.

9.8 SEALANTS

General

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.

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 manufacturers 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.

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.

Sealants shall be as follows:

Silicon sealant shall be one part gungrade type with minimum movement capability of 25% and elongation at break of 450% confirming to BS 5889 or TTS 001543A. This Sealant shall be of approved color and shall be nonstaining to the parent concrete surface

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.

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.

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.

Bond-preventive Materials

Bond-preventive materials shall be pressure-sensitive adhesive polyethylene tape or aluminum foil.

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.

Working Life

Care shall be taken to ensure that material with adequate shell life is provided. Material whose shell 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

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.

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.

Delivery and Storage

Materials shall be delivered to the job site in the manufacturer’s original unopened containers.

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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) Shell 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.

Joints

The effective width to depth ratio shall be as per the table given below unless directed otherwise by the Engineer.

Table Surfaces	Joint Width	Joint Depth	
		Maximum	Minimum
For concrete masonry	6 mm	6 mm	6 mm
Over 6 mm upto 12 mm	6 mm	-	equal to width
Over 12 mm	½ of width	-	½ of width

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.

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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, Litance, 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.

Application

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.

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.

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.

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.

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 whist the sealant is still in an uncured state.

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.

FIRE PROOFING OF STEEL STRUCTURES

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.

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.

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.

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 ahan 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.

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.

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.

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 champhered 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.

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.

Specific Requirement

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.

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(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.

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.

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.

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.

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.

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 >/=1.50 W/m^2.K Acoustic Insulation >/=20dB
iv. Linear Thermal Expansion=.065mm/m degree C Temperature Range (-20 degree to 120 degree C) Fire Reaction BS1d0 or better as per EN 13501:2002.

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 5^0 C to 40^0 C. depending upon the ambient temperature range, the following types of epoxy are recommended for use:

5^0 to 20^0C : Fast reacting

15^0 to 30^0 C : Medium fast reacting

25^0 to 40^0 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.

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.

SECTION -10

PRECAST U-GIRDER AND RELATED ITEMS

SECTION- S.10
PRECAST U-Girder and related items

10.1. **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

10.2. **U-GIRDER AND PRECAST PIER CAP**

10.2.1. 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

10.2.2. **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 / or by Launching Girder.
- Placing of U Girder on the temporary supports and adjust the Line and Level.

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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.

10.2.3. Shop Drawings and Design Calculations for Construction Procedures

10.2.3.1 *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.

10.2.3.2 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.

10.2.4. Casting, Stacking, Handling, Transportation and Erection of Girder

➢ **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.

➢ **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

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Engineer/Engineer's Representative. All girders shall be marked on the inside with a unique identification at the time of form removal.

➢ **Stacking**

Stacking of Girders or Precast Units shall be done as per Approved Drawing and as per Available Layout in the Casting Yard.

➢ **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 28days 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

➢ **Cleaning of Girders**

Before transportation of girder, surface shall be cleaned by water rinsing or sand blasting as approved by the Engineer.

➢ **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.

➢ **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.

10.2.5. Overhead Gantry Specifications for U Girder

10.2.5.1. *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

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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

10.2.5.2. **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).

10.2.5.3. **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.

10.2.5.4. **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%

10.2.5.5. **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

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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.

10.2.5.6. **Wind loading**

All wind speeds referred beneath are based on gust speed.

In service wind (with span erection) ≤ 20 m/s Gantry launching wind load ≤ 15m/s Tropical storm wind (with span erection) ≤ 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

10.2.5.7. **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.

10.2.5.8. **Minimum Horizontal Radius**

The gantry shall have adequate functional and structural provisions to launch over spans with 200m horizontal radius.

10.2.5.9. **Reaction on Piers**

The reaction on pier top due to operation of erection gantry, shall be limited to followings: -

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		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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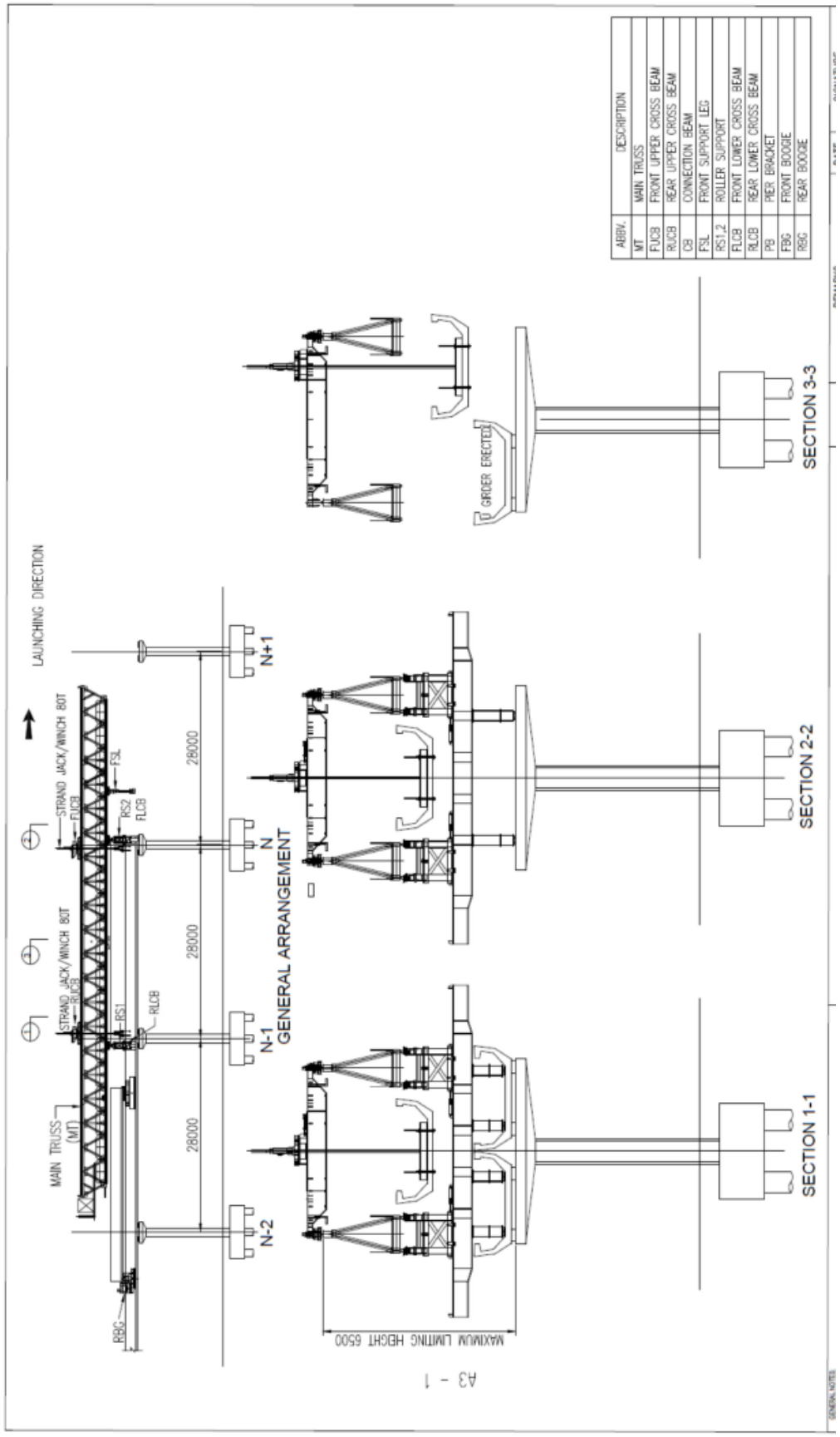
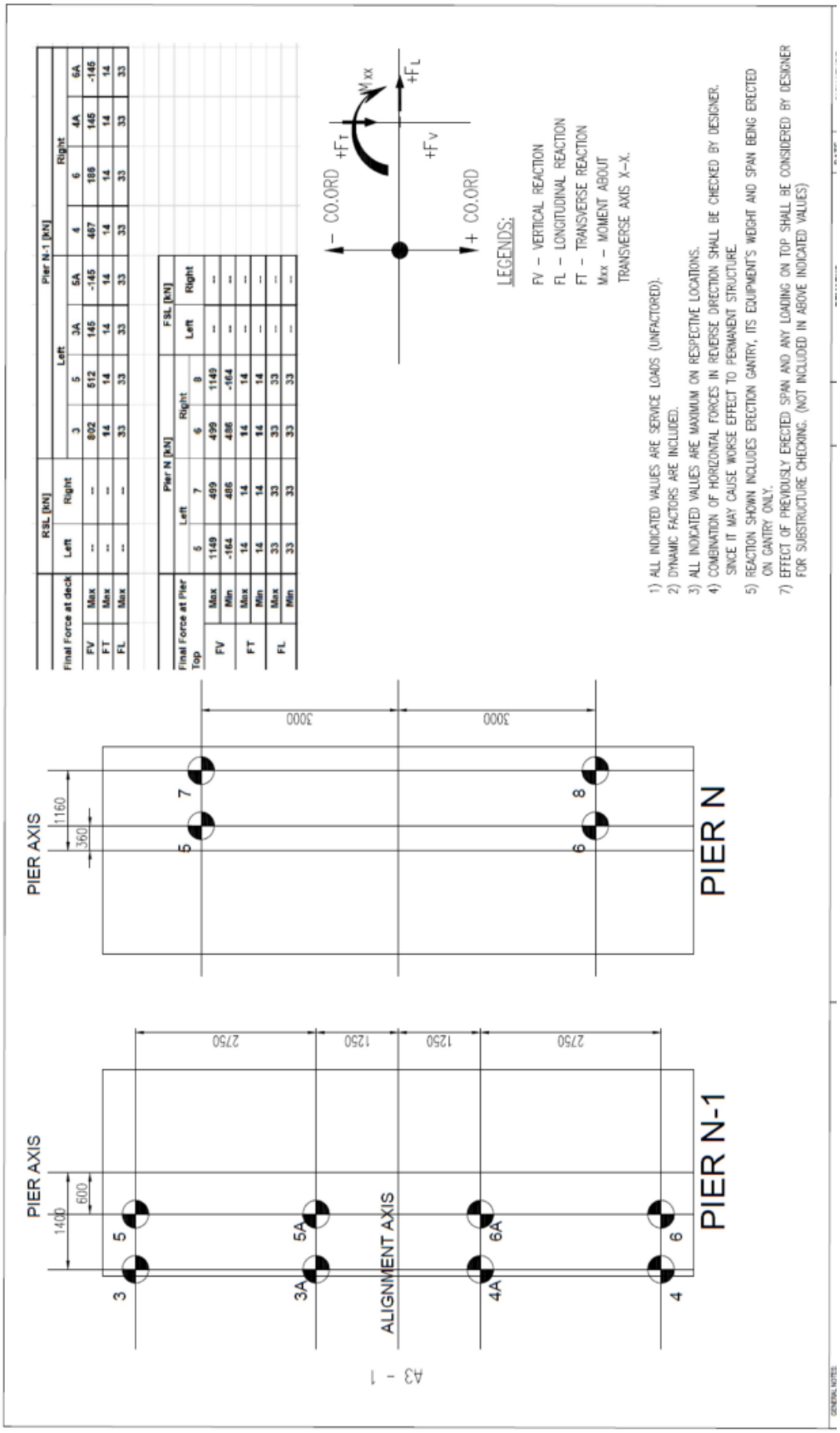
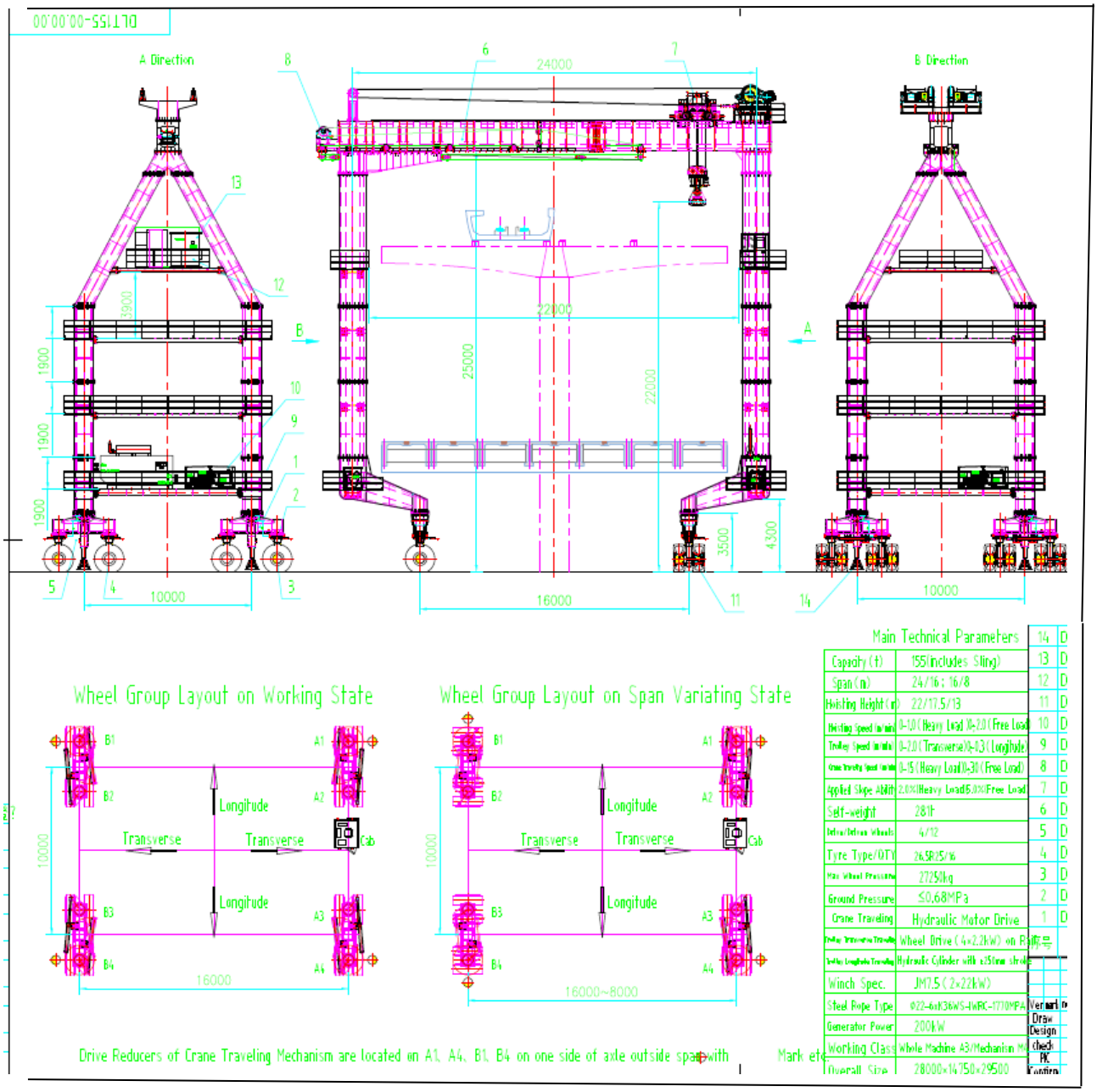

GENERAL ARRANGEMENT
LAUNCHING DIRECTION
STRAND JACK/WINCH 80T
MAIN TRUSS (MT)
FUCB
RUCB
RLCB
RBG
FSL
RS1
RS2
28000
N+1
N
N-1
N-2
SECTION 1-1
SECTION 2-2
SECTION 3-3
GIRDER ERECTED
MAXIMUM LIMITING HEIGHT 6500
A3 - 1
ABBV. DESCRIPTION
MT MAIN TRUSS
FUCB FRONT UPPER CROSS BEAM
RUCB REAR UPPER CROSS BEAM
CB CONNECTION BEAM
FSL FRONT SUPPORT LEG
RS1,2 ROLLER SUPPORT
FLCB FRONT LOWER CROSS BEAM
RLCB REAR LOWER CROSS BEAM
PB PIER BRACKET
FBG FRONT BOGGIE
RBG REAR BOGGIE

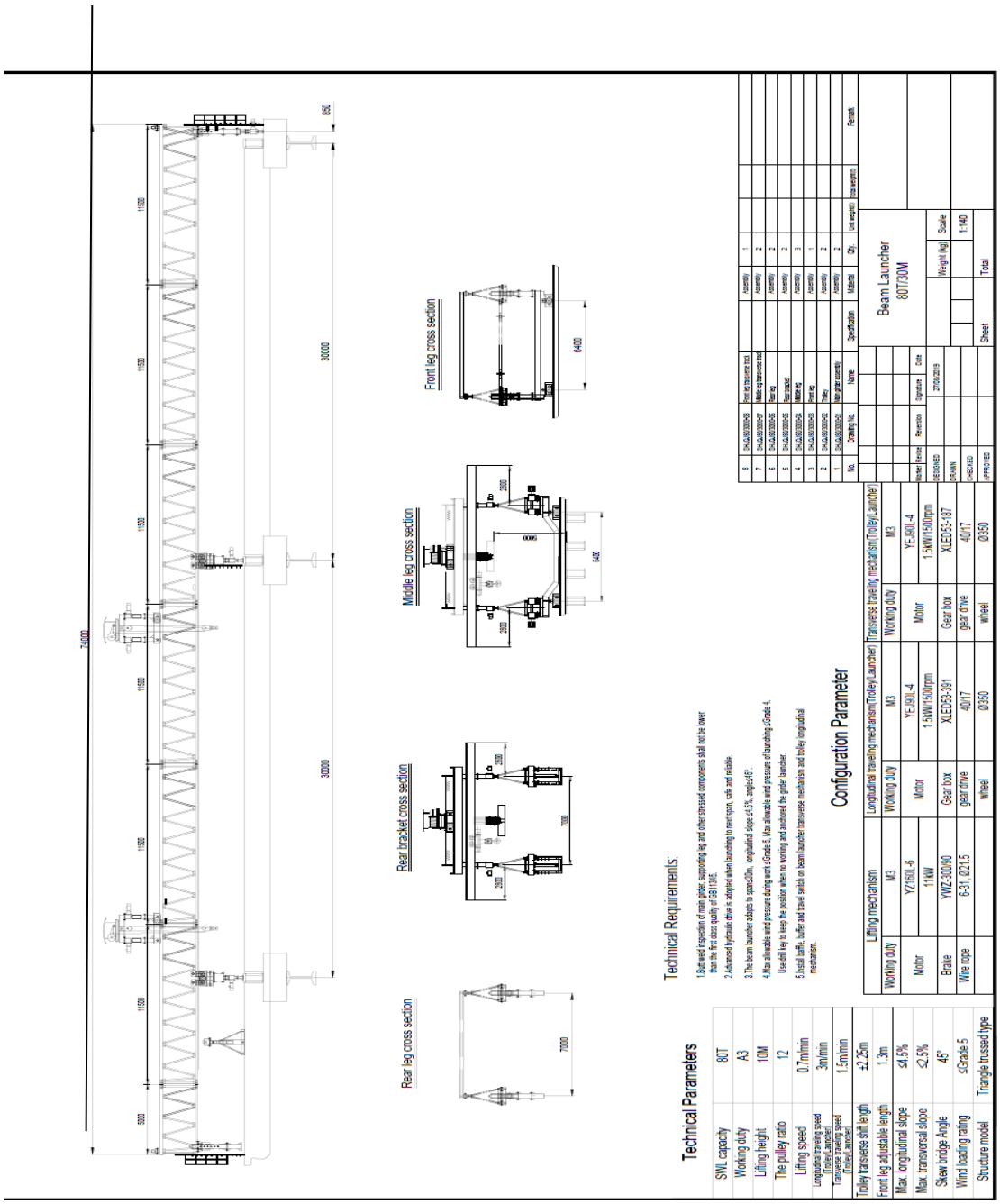


	RSL [kN]	Pier N-1 [kN]											
		Left						Right					
Final Force at deck	Left	Right	3	5	3A	5A	4	6	4A	6A
FV	Max	--	--	802	612	145	-145	467	168	145	-145
FT	Max	--	--	14	14	14	14	14	14	14	14
FL	Max	--	--	33	33	33	33	33	33	33	33

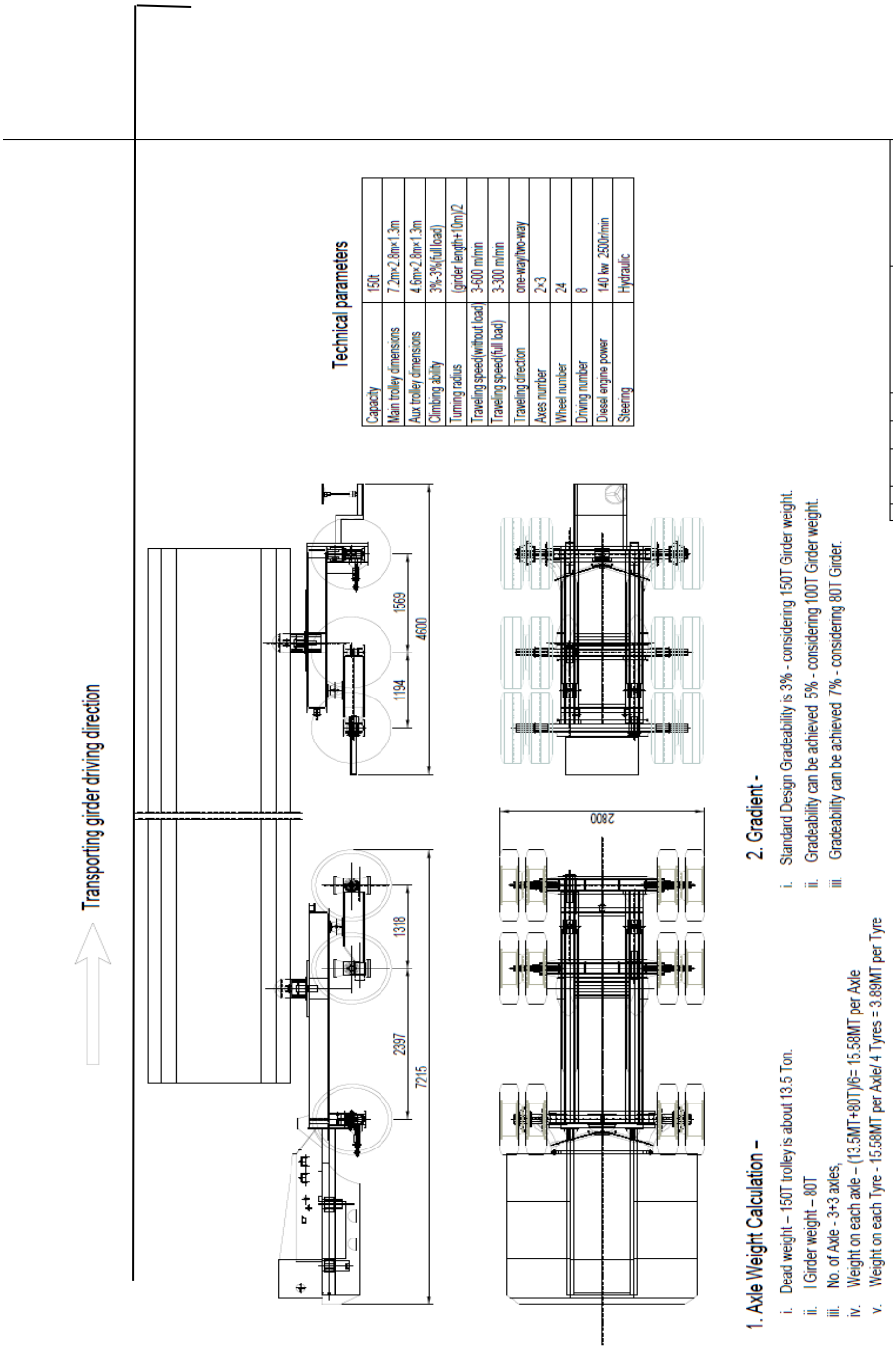
		Pier N [kN]				FSL [kN]	
		Left		Right			
Final Force at Pier Top		5	7	6	8	Left	Right
FV	Max	1149	499	499	1149	--	--
	Min	-164	486	486	-164	--	--
FT	Max	14	14	14	14	--	--
	Min	14	14	14	14	--	--
FL	Max	33	33	33	33	--	--
	Min	33	33	33	33	--	--



SKETCH SHOWING DETAILS OF STRADLE CARRIER SUITABLE FOR STATION GIRDER LAUNCHING.



Indicative Sketch-1 for Launching Arrangements for I Girders , Feeding of girder from back side.



Indicative Sketch-2 for Launching Arrangements for I Girders , feeding of girder from back side

10.2.5.10. **Transfer Boogie**

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%

10.2.5.11. **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.

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- **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 overspeed.

- **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.

10.3. Technical Specification for Steel Plates (Placed in between bearing and bottom of girder)

10.3.1. 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 form 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.

10.3.2. 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.

10.3.3. 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 form 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.

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SECTION – 11

SPECIFICATIONS FOR PRECAST SEGMENTAL CONSTRUCTION

SECTION- S.11

SPECIFICATIONS FOR PRECAST SEGMENTAL CONSTRUCTION

11. 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 pre - stressing 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 & 18.0 m. spans may have curved alignment in plan. Longer spans 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 1.975m and 3.745m each for Metro viaduct and NHAI Flyover respectively. 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 55 t. The maximum span length contemplated for precast segmental construction will be of the order of 31.0m. Multiple Shear keys shall be provided at segmental joints at the webs as well as at top flange and soffit slab of the box girder.

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.

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11.1. MATERIALSPECIFICATIONS

11.1.1. Cement

Ordinary Portland Cement of 53 grade conforming to IS: 269 (2015) shall be used. For prestressed concrete, cement conforming to IRS T-40 specification or OPC-53 Grade shall be used. All other specification will remain same as indicated in sectionS.03.

11.1.2. Reinforcement

Only TMT bars shall be used. All other specification will remain same as indicated in section S.05

11.1.3. Pre-stressing Steel

Uncoated stress relieved Low Relaxation Steel conforming to IS: 14268 (2017), Class 2, shall be used. The nominal dia shall be 15.2mm with minimum breaking strength of 260.7 kN and minimum 0.2% proof load of 234.6kN.

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. Direct and indirect force measurement device like Pressure Gauge shall be attached in consultation with system manufacturer.

11.1.4. Concrete

The 28-day concrete strengths measured on 150mm cubes to be adopted for various structural elements have been indicated in the Bill of Quantities. The physical and chemical properties of the constituents of concrete

and so also of the green and hardened concrete shall meet the requirements of MORTH Specifications for Road and Bridge Works, where relevant or where the standard specifications referred to in the Technical Specifications are silent.

11.1.5. 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 corrugated sheathing shall be of HDPE. Maximum anchorage set- in shall be 6mm. Maximum friction ratios shall be 0.0020m-1 and 0.17rad-1.

11.1.6. Epoxy Bonded Joints

A minimum compressive stress of 3 kg / sq. cm shall be provided uniformly over the cross section for the closure stress on the epoxied joint until the epoxy has set.

This temporary compressive stress can be applied by temporary pre-stressing bars.

The curing period for application of the compressive stress, method of mixing and application of epoxy and all related aspects including surface preparation shall be as per approved manufacturer's specifications.

The Epoxy shall be spread with the help of a stubby brush to a thickness of about 1 mm each on both the joining surfaces.

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.

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 is of paramount importance to ensure long-term durability of pre-stressing cables, this field test shall be taken as indication of the Contractor's quality of work in general and effectiveness of the epoxy joint executed by him. All other aspects of grouting of cables shall be governed by MORTH Specifications.

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. It shall meet the requirements of relevant provision of FIB (International Federation of Concrete, previously "FIP - International Federation of Pre-stressed Concrete'). For selection of epoxy, all tests which govern the properties of epoxy for its application and subsequently determine the durability of joint are required to be done in laboratory temperature controlled condition. Some tests for evaluating properties of epoxy are critical in the upper limit of specified application temperature range while other tests are critical for evaluating the properties in the lower limit of specified application temperature range. The tests shall be conducted in laboratories equipped to handle controlled temperature conditions. All tests shall conform to FIB requirements.

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.

The uniform compressive stress during the curing period 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. 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.

11.2. SHOP DRAWINGS AND DESIGN CALCULATIONS FOR CONSTRUCTION PROCEDURES

11.2.1. 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, 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.

11.2.2. 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. 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.

11.2.3. 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 KRIDE/Engineer to the Contractor and shall include:

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 KRIDE/ Engineer.

c. 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.

11.2.4. Forms for Precast Segmental Construction

Forms for precast segmental construction shall be metal form work only. Shop drawings shall be submitted for all formwork. The segments during storing /curing shall always be supported as shown in tender drawings or as approved by Engineer only. 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 Annexure11.2.

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- Accommodating block-outs, opening sand protrusions. Protruding re-bars will be needed at least for diaphragm segments and for second-pour plinths. Anchorages, signaling equipment 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 KRIDE/Engineer or for correcting previous minor casting errors to prevent accumulation.
- 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 bulk head 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 1 mm for corners and bends will not be permitted.

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, inside and header forms for precast segmental construction 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. Internal bracing and holding devices in forms shall be limited to stay bolts in webs. This 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. AII 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 in accordance with Annexure11.2.

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 segment sand 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 stain or react with concrete shall not be used. Care shall be exercised to facilitate formwork and segment removals without damage to the concrete.

11.3. CASTING, HANDLING, TRANSPORTATION AND ERECTION OF PRECAST SEGMENTS

11.3.1. 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.

11.3.2. 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 hard ware 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. 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 segments shall be done in a single pour. Construction joint is not permitted in segment.

After the first segment of each unit is cast, all succeeding segments shall be cast against previously cast segments to ensure complete bearing and proper alignment on all mating surfaces.

The anchorage system shall permit tendons to be inserted in the member after erection of segments and tensioned from one end only.

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 and placed according to the Execution Drawing issued by K-RIDE. 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.

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.

All segments shall be marked on the inside with a unique identification at the time of form removal. This identification shall be used to identify each segment on shop plans, post tensioning details and calculations and any other document pertaining to the fabrication and erection of precast concrete segments.

Positive means of holding the sheathing in its correct position shall be provided in all cases and shall be indicated on the shop drawings submitted for approval. The sheathing shall be stiffened from the inside by rubber or plastic hoses or by inflatable rubber tubes.

11.3.2.1. **Casting Methods**

Match cast segments may be cast by the "long line" or "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.

11.3.2.2. **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. A long line is easy to set up, whilst the geometry of the segments is easily controlled. 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 curvature as well as twists, if any, because the forms are mobile, equipment for casting, curing, etc., has to move from place to place.

11.3.2.3. **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 neighboring element. After casting, the neighboring element is taken away and the last element is shifted to the place of the neighboring 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 centralized. Horizontal and vertical curves and twisting of the structure are obtained by adjusting the position of the neighboring segment and through specified formwork.

To obtain the desired structural configuration, the neighboring segments must be accurately positioned. 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 centerline. 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.

11.3.3. **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.

11.3.4. **Handling / 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. 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).

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. 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:

(a) The segment shall not be lifted from the casting bed till the concrete reaches a minimum cylindrical strength of 20 MPa (or 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 days strength.

Segment shall be stacked with three-point support in curing tank / stacking yard, or as approved by KRIDE/the Engineer, 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 segment are water cured during water curing period.

11.3.5. **Cleaning, transportation and erection of Segments**

Before transportation of segment, mating surface shall be cleaned by water rinsing or 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.

Two methods of erection have been suggested: Side beams method, and as an allowed alternate, the top beams method. Only the side -beams method is referred to in these special specifications. The launching girder (or more accurately, the "assembly truss") is capable of supporting all the loads with in permissible limits as stipulated in codes and transferring it to the temporary cross girder, which transfer the loads directly on pile cap using trestles. The launching girder envisaged is slightly greater than 2 spans. It must also be able to negotiate curves and accommodate for the camber if any of the structure. As far as practical, '"* the movement of segments shall be done at the deck level of the already constructed portion of the continuous length so that the disturbance to traffic at the ground level is minimized. Mobile crane of adequate capacity and boom length shall be mobilized by the Contractor for transferring the segment from ground level to deck level for the purpose. The launching girder should be capable of lifting the segments for the span to be erected from below 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 sets 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.

It is emphasized that for precast segmental construction only one-end pre-stressing shall be used. The superstructure shall be constructed "span by span“ sequentially.

The diaphragm segments shall need specific additional temporary supports under the webs during those various stressing operations. Those temporary supports shall be flexible enough in rotation. The precise load transfer during the stressing operations between the various supports shall be monitored at least once with adequate jacks during the destructive testing of one span in precast yard. It is emphasized that

- The spans must be assembled on a higher level to avoid conflicts with already built concrete shear key.

- The launching truss supports must be at same location than temporary bearings.

11.4. **MISCELLANEOUS**

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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.

Design & Drawings of LG and temporary works:

All temporary works such as formwork, false work, staging, launching girder, cantilever form traveler scheme etc. shall be designed by the Contractor. The permissible stresses in materials of formwork, false work, staging, launching girder & cantilever form traveler shall be same as 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 be also 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, stiffness, walers or any other supporting arrangement) shall not be more than 3mm.

All the formwork, launching truss and cantilever form traveler 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 process.

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

Shop drawings and design calculations for construction procedures

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 filed 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, curing, lifting, and stacking, transportation and erection procedure. The contractor’s Method Statements shall also include all calculations, drawings and information as may be relevant

11.5. LOAD TESTING OF LAUNCHING GIRDER

Contractor shall conduct full scale load traveler 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 lumpsum price of price schedule.

NOTE: The above instructions are applicable for segmental construction. In case contractor proposes single or twin U girder, he should submit detailed method statement showing casting, stacking, handling, transporting and launching scheme for the prior approval of engineer.

SECTION – 12

STEEL BRIDGE GIRDER ERECTION

SECTION- S.12

12. STEEL BRIDGE GIRDER ERECTION

(Fabrication and erection as per RDSO guidelines to be incorporated)

12.1. STRUCTURAL STEEL ERECTION WORK - GENERAL

12.1.1. 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.

12.1.2. 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 / 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 / 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.

12.1.3. 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 / 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 alternatives 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.

12.1.4. 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 / 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 where 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 / 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.

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I. The contractor shall furnish ten prints of all approved final drawings including soft cop in CD ROM for interface / 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.

12.1.5. 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

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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 Welding
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.

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12.1.6. Storage of Materials

12.1.6.1. 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.

12.1.6.2. **Storage Yard**

A. The Contractor shall be required to establish to 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.

12.1.6.3. **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.

12.2 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 bolts 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

12.2.1 General

12.2.1.1 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.

12.2.1.2 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

12.2.2 Products and Materials

12.2.2.2 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.

12.2.2.3 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 labeled 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.

12.2.3 Execution

12.2.3.2 Painting system

Painting work shall be carried out as detailed in Table 12.1 follows:

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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
1st Under - Coat	Inorganic zinc silicate primer (self-curing solvent type) DFT – 75 μm shall be Berger Zinc Anode 11 or approved equivalent. The primer should be applied by spray only.	Epoxy Zinc phosphate primer polyamide cured DFT-35μm
2nd 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.
3rd 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
4th 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.

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12.2.3.3 Surface Preparation

12.2.3.3.1 General

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.

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.

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

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

12.2.3.3.2 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 thereafter shall be discarded.
4. 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.

12.2.4 Paint Application

12.2.4.2 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 / 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 color shall be tinted, whenever practical, to produce contrasts and help in identifying the progress of the work.

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12.2.4.3 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.

12.2.4.4 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.

12.2.4.5 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.

12.2.4.6 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.

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12.2.4.7 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.

12.3 Additional Specifications for Launching

Truss launching for longer spans:

a) Preferably no road traffic blocking will be used. Multiple day / 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 / truss connection details in tender.

d) Truss design composite girder requirements will govern over nose / 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 / 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.

12.4 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 / components including HSFG bolts / nuts / 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 / nuts / washers at storage yard.

c. Loading, transportation and unloading of all fabricated structural steel materials including HSFG bolts / nuts / 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 / 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 / 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.

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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 / machinery

h. All other consumables including fuel and lubricants etc.

i. All safety and protection arrangements to be made at site / storage yards for road users, public and workmen.

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SECTION – 13

ROADWORK

SECTION – S.13

13 ROADWORK

13.1 Control of Traffic

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.

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.

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.

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.

13.2 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 drawings.

13.2.1 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.

13.2.2 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.

13.2.3 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.

13.2.4 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.

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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).

13.2.5 **Control of Traffic**

Control of traffic shall be as described under Subsection 12.1.

13.3 Water-bound Macadam Sub-base/ Base (Non-Bituminous)

13.3.1 **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.

13.3.2 **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).

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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 90 mm 63 mm 45 mm 22.4 mm	100 90-100 25-60 0-15 0-5
2	63 mm to 45 mm	90 mm 63 mm 53 mm 45 mm 22.4 mm	100 90-100 25-75 0-15 0-5
3	53 mm to 22.4 mm	63 mm 53 mm 45 mm 22.4 mm 11.2 mm	100 95-100 65-90 0-10 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

Construction Method

1. Preparation of Sub-grade/ sub-base

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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.

2. 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.

3. 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.

13.4 Bituminous Materials

13.4.1 Materials

Materials shall meet the requirements of the relevant IS Codes. These shall be of the following types.

1. Cut back Bitumen

1.1 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.

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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 confirm 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.;

13.4.2 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 through and all particles of aggregates are coated uniformly and fully.

13.5 **Prime Coat**

13.5.1 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.

13.5.2 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.

13.5.3 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.

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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.

13.6 Tack Coat

13.6.1 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.

13.6.2 Materials

The material for tack coat shall be a bituminous or cut back emulsion of suitable type and grade.

13.6.3 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 spattered or marred

13.7 Bituminous Macadam

13.7.1 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.

13.7.2 Materials

1. **Bitumen**

The bitumen shall be paving bitumen of suitable grade approved by the Engineer and conforming to IS :73.

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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.

13.7.3 **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 150C 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 smock, 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 kilograms 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

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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.

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 leveling 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.

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.

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.

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.

13.7.4 **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 course 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.

13.7.5 **Control of Traffic**

This shall be as described under Subsection 12.1 above.

13.8 **Open-graded Pre-mix Carpet**

13.8.1 **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.

13.8.2 **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.

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13.8.3 **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 Subsection12.6.
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)

13.8.4 **Control of Traffic**

Subsection 12.1 shall be followed.

13.9 **Bituminous Concrete**

13.9.1 **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.

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.Flankiness 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**

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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 15.9.1below

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

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13.9.2 **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	820 Kg (1800 pounds)

	blows on each end	
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%

2. 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.

3. 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 Minera Filler

III. A single definite percentage passing each sieve for the mixed aggregate (VideTable 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

4. 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.

13.9.3 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.

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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 mrolling 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/sqcm 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.

13.10 Seal Coat

13.10.1 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.

13.10.2 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.

13.10.3 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.

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13.11 Cement Concrete Pavements

13.11.1 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.

13.11.2 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.

4. 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.

5. 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).

13.11.3 Equipment and Tools

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.

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2. Batching and Mixing Plant

This shall be of suitable type, capacity and make meeting the requirements of work.

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.

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.

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 from sections and for secure setting.

13.11.4 **Construction Methods**

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.

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.

3. Preparation of Concrete

a. Trial Mix / 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.

The Ready-Mixed Concrete (RMC) shall conform to Subsection12.2.4 (5).

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.

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.

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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 spacings. 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.

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

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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.

8. 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.

9. 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.

10. Surface Requirements

After the concrete has hardened sufficiently, the surface shall be given a further test for tureens, 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.

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11. 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 / 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 only 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.

12. Removing Forms

Forms shall be removed only after stipulated period and carefully so as to avoid damage to the pavement.

13. 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.

14. 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.

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SECTION – 14

REINFORCED EARTH

SECTION- S.14

14 REINFORCED EARTH

The work shall be carried out as per the Cl. 3100 of latest edition of (MORTH) as published by Indian Roads Congress.

14.0 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 facia 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, facia 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.

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