

S.10: MISCELLANEOUS**10 BEARINGS, SHEAR KEY DEVICES, EXPANSION JOINTS.****10.1 BEARINGS, SHEAR & EXPANSION JOINTS****i. GENERAL**

This work shall consist of design, supply and fixing in position of bearings for bridge girders in accordance with details shown in drawings and to the requirements of these specifications, codes and standards quoted therein and as directed by Engineer.

Expansion or fixed devices shall be constructed in accordance with details shown on drawings.

It shall be ensured that the bearings are set truly in level and in exact position as indicated on drawings so as to have full and even bearing on the seats. This shall be checked with spirit level in both directions. Thin epoxy mortar pads may be made to meet with this requirement.

It shall be ensured that the bottoms of girders that form a receiving surface for the bearings are plane at the location of these bearings and care shall be taken that the bearings are not displaced while placing the girders.

When elastomeric bearing pads are to be provided, the concrete surfaces on which pads are to be placed shall be wood float finished to a level plane, which shall not vary by more than 1.5 mm from a straight edge placed in any direction across the area by maintaining sufficient roughness.

ii. POT-PTFE BEARING**a. General**

- i. The design, drawings and detailed method statements for installation and replaceability of the **bearings shall be got checked and certified by approved independent agency before submitting** to the Engineer for approval.
- ii. **Criteria for Selection of bearing manufacturer shall conform to the RDSO's list of approved manufacturers for Pot-PTFE bearings.**
- iii. Pot bearings shall be measured in numbers, Fixed Pot Bearing, Longitudinal guide pot bearing, transverse guide bearing & free pot bearing shall be counted separately, according to their capacities. The rate shall include the cost of supplying and fixing the bearing in position. **The cost shall also include the cost of samples and their testing as required and conforming to specification.**
- iv. The contractor shall furnish along with tender documents in technical bid, the name of the manufacturer of bearings, his qualifications with all details including proof of satisfactory performance, certification and testing facilities of the bearing he proposes to use

b. Material specifications of Pot bearing

- i. All the materials to be used in POT Bearings shall confirm to clause No. 4 Materials of IRC 83: Part-III 2018.
- ii. Chloroprene (CR) only shall be used as raw polymer in the manufacture of Confined elastomer for the components of Pot Bearings.
- iii. The Pot Base, saddle, Piston & top plate shall be of cast steel only of Grade 340-570W of IS 1030 or equivalent, confirming to clause No. 4.1.2 of IRC 83: Part-III 2018.
- iv. The steel piston and the steel pot shall each be machined from a solid piece of cast steel.

- v. Guides shall be monolithic to the component to which it is connected.
- vi. **Anchor sleeve**
All the part of bearing such as anchor sleeves embedded in concrete shall be hot dip galvanized @ 300gm/ Sq.m . The anchor sleeves have to be designed taking account of difference in elasticity of steel of sleeve and concrete. The effect of shifting of center of rotation of sleeve should be also taken into account.
- c. **DESIGN**
Design of the bearing and all accessories shall be the responsibility of the Contractor and got approved from the Employer's Representative.
Design of the POT Bearings shall confirm to clause no. 5, Design Section of IRC:83 (Part III)-2018.
The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.
- d. **Permissible stresses in steel component of Pot bearing**
All the design requirements for Pot bearing as specified in IRC: 83 Part-III has to be fulfilled with following modifications.
No increase in permissible stresses in any material of bearing or bearing stress between concrete and bearing is permitted in seismic condition.
Permissible bearing stresses in concrete
The allowable bearing stresses in concrete as defined in IRC: 83 Part-III has to be followed with following modifications.
- e. **Warranty of POT-PTFE Bearings.**
All bearings shall carry a warrantee of not less than 15 years in a format as approved by the Employer. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the Employer at no extra cost to the Employer within the warrantee period.
The following undertaking shall also be taken by the contractor from Manufacturer of Pot-PTFE Bearing for submission to the Employer:
 - i. "We undertake to use -----(Name of Chloroprene) in the manufacturing of the Elastomeric bearings and the same shall be imported by us directly from ----- (name of Manufacturer)/purchased from ----- (Name of Agent) who is the authorized Indian agent of M/s----(Name of the Manufacture)."
 - ii. "We hereby guarantee against defective materials manufactured workmanship as well as certify quality assurance at every step of manufacturing of bearings. Pot-PTFE bearings that may be supplied by us as per this office and which shall be installed at the -----(Name of the Bridge) shall have life of 15 years under normal loading, normal traffic and routine maintenance. We also stand guarantee for free repair and replacement (including the cost of placing the new bearings in position) in part or full, if any, defect is found, in the bearings or part thereof within the period 36 months from the date of supply or 24 months from the date of installation whichever is earlier, except for defects arising out of theft pilferage, floods, earthquake or any other natural calamity etc, over which we have no control, shall be replaced free of cost."
 - iii. "We also give an undertaking that the entire manufacturing and testing process shall be open to inspection for the client or their authorized representatives and that all possible help shall be extended in conducting the relevant tests required as per IRC 83 (Part-II) 2018 and other instructions issued by Ministry of Road Transport & Highways from time to time."

f. **Manufacturing and Tolerances:**

- i. The Contractor shall submit the Design & Fabrication drawings for the approval of Engineer at least 30 days prior to the start of bearing fabrication.
- ii. Manufacturing of Bearing shall be commenced only after the approval of Design and Fabrication drawings by the Engineer.
- iii. The bearings shall be manufactured in accordance with the clause 6.2 of IRC:83-2018 (Part-III) with the tolerances as specified in Clause 6.1 of IRC:83-2018 (Part-III).
- iv. For the measurements to be taken using dial height gauges, vernier calliper, surface finish measurement instrument etc., the measuring instruments shall be arranged by manufacturer at the workshop.
- v. Appropriate silicon grease shall be applied at the sliding material – stainless steel interface of bearing.

vi. **Movement indicators shall be provided for bearing with sliding assembly to facilitate routine inspection during service period.**g. **PAINTING/CORROSION PROTECTION:**

All non-working exposed surfaces, including 50 mm (min.) return on surfaces to be in contact with concrete / steel shall be treated with full corrosion protection system conforming to the requirements of Clause 6.3.1 of IRC:83-2018 (Part-III).

h. **SHOP DRAWINGS**

The Shop drawings to be submitted for Engineer's approval should contain the following necessary information, but not limited to:

- i. Quantity, type (fixed, guided expansion, non-guided expansion), and location of all bearing units.
- ii. A table containing maximum and minimum vertical and horizontal loads, design rotation requirements, and magnitudes and directions of movements.
- iii. Allowable contact stresses, maximum dimensions, and anchorage requirements at the bearing interfaces; grades, bevels, and slopes at all bearings; and allowable coefficients or friction of all sliding surfaces.
- iv. Any special consideration such as earthquake requirements, uplift details, or temporary attachments.
- v. Installation scheme of pot bearing.

i. **INSPECTION AND ACCEPTANCE SPECIFICATION:**

- i. Bearings shall be manufactured to high standards both in terms of material quality and workmanship. The manufacturer shall have requisite load test and NDT facilities required for process and acceptance control tests installed at his plant. The test facilities and their operation shall be open for inspection. For confirmatory tests on raw materials, tests shall be conducted at in-house facility of the manufacturer or at NABL accredited laboratory.
- ii. All tests on raw materials and finished bearings shall be carried out as per procedures described in this section. All the test reports duly certified by the Engineer shall be furnished by the manufacturer at the time of despatch of the bearing.
- iii. Acceptance testing shall commence with the prior submittal of testing program in form of Inspection and Test Plan (ITP) prepared by the manufacturer and approved by concerned authority, to the Engineer.
- iv. Lot by lot inspection, testing and acceptance shall be made in accordance with the clause 7 of IRC:83-2018 (Part-III).

j. **STORAGE, TRANSPORTATION AND HANDLING:**

- i. Bearings should be transported to bridge site after final acceptance by the Engineer/ inspection agency appointed by the concerned authority and shall be accompanied by an authenticated copy of the certificate to that effect.

- ii All bearings shall have suitable index markings made of indelible ink or flexible paint, which if practicable shall be visible after installation, identifying the information like Name of manufacturer, Month and year of manufacture, bearing designation, Type of bearing, Load and movement capacity, Centreline markings to facilitate installation, Direction of major and minor movement, if any, Pre-set, if any.
 - iii **Movement indicators shall be provided for bearing with sliding assembly to facilitate routine inspection during service period.**
 - iv After assembly bearing components shall be held together with steel strapping, or other means, to prevent disassembly until the time of installation.
 - v Packaging shall be adequate to prevent damage from impact as well as from dust and moisture contamination during transportation and storage.
 - vi "Provision against contamination of the sliding surface shall be made by suitable devices. Such protection devices shall be easily removable for the purpose of inspection". This may be achieved by the provision of a simple removable rubber apron around the bearing. This apron is connected by a Velcro-type fastener, allowing it to be easily removed without tools for inspections etc.
- k. **Installation of POT Bearing: -**
- A detailed method statement shall be submitted considering the points mentioned below for the approval of Engineer. Installation work of POT Bearings shall be commenced only after approval of method statement by the Engineer.
- i. Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure. Bearings shall be so located as to avoid accumulation of dirt and debris likely to interfere with their performance and the structure so detailed that water is prevented from reaching the bearings. Proper installation of bearing is of utmost importance to ensure proper functioning of bearing and its durability. Poor installation may not only damage a high quality bearing but also may cause damage, instability and collapse of structures.
 - ii. In order that moving surfaces are not contaminated, bearings should not normally be dismantled after leaving the manufacture's workshop but if for any reason they are, then this should only be done after Engineer's approval and under expert supervision and the manufacturer's assistance should be sought.
 - iii. Transfer of superstructure weight on to bearings should not be allowed until sufficient strength has developed in the bedding material to resist the applied load. Temporary clamping devices should be removed at an appropriate time before the bearings are required to accommodate movement. Consideration should be given to any treatment required to holes exposed on the removal of temporary transit clamps. Where reuse of these fixing holes may be required, the material selected to fill them should not only give protection against deterioration but also should be easily removable without damaging the threads.
 - iv. Correct location and orientation of the bearing with respect to the structures is of immense importance Mixing up in location or orientation may cause severe structural instability during construction and service.
- l. **Bedding**
- i. Bearing shall not be placed directly on matured concrete surface without use of appropriate bedding material.
 - ii. The choice of bedding materials is influenced by the method of installation of the bearings, the size of the gap to be filled, the strength required and the required setting time. When selecting the bedding material, consideration should therefore be given to various factors like type of bearing, size of bearing, loading on bearing, construction

sequence and timing, early loading, friction requirements, access around the bearing, thickness of material required, design and condition of surface in the bearing area, shrinkage of the bedding material etc. as appropriate.

- iii. The thickness of the bedding material should be made as less as possible maintaining the requirement of workability and strength.
- iv. It is essential that the composition and workability of the bedding material be specified with the above factors in mind. In some cases, it may be necessary to carry out trials to ascertain the most suitable material.
- v. Bedding Material shall be High Strength Non Shrink Epoxy Grout. Cost of this Grout material is included in the scope of work and nothing Extra is payable in this regard.
- vi. Bedding Material shall be got approved by Engineer before commencement of Work.
- vii. To ensure even loading on bearings and the supporting structures, it is essential that any bedding material whether above and below the bearing, extend over the whole area of the bearing. Improper application of bedding material, below and above the bearing, i.e. voids, gaps, impurity etc. may attribute to failure of the bearing irrespective of the quality of the product.

Bearings shall be bedded over their whole area. After installation there shall be no voids or hard spots. The bedding material shall be capable of transmitting the applied load to the structure without damage. Surfaces to receive bedding mortar shall be suitably prepared to a state compatible with the mortar chosen. The top surface of any extension of the bedding beyond the bearing shall have a downward slope away from the bearing.

m. Fixing of Bearing:

- i. To cater for vibration and accidental impact, some anchorage should be provided. Anchorage should be accurately set into recesses cast into the structure using templates and the remaining voids in the recesses should be filled with material capable of withstanding the loads involved i.e High Strength Epoxy Grout.
- ii. Bearings that are to be installed on temporary supports should be firmly fixed to the substructure by anchorage or other means to prevent disturbance during subsequent operations. Finally voids beneath the bearings should be completely filled with bedding material using the appropriate method.
- iii. Bearings may be fixed directly to metal bedding plates that may be cast in or bedded on top of the supporting structure or bottom of superstructure to the correct level and location. Generally recess are provided in the substructure for the anchorages.
- iv. If the structure is of steel, the bearings may be bolted or welded directly to it. Proper care shall be taken to ensure that there are no mismatch in the bolt holes of the structure and the bearing. In case of welding care should be taken to assess and avoid damage of bearing or its components due to heat or distortion.
Threaded fasteners shall be tightened uniformly to avoid overstressing of any part of the bearing.
- v. For bearings supporting precast concrete elements a thin layer of synthetic resin High Strength Non -shrinkage Epoxy mortar should be used between bearings and precast concrete beams. Bearings shall be bolted to anchor plates or metal bedding plates embedded in precast elements.
- vi. For bearing supporting steel elements a machined sole plate shall be used to ensure proper contact.

n. Installation Tolerance

- i. The tolerances given below shall be strictly adhered to unless otherwise specified.
- ii. Bearings shall be located so that their centrelines are within +/- 3 mm of their correct position.

- iii. The level of a bearing or the mean levels of more than one bearing at any support shall be within a tolerance of ± 0.0001 times the sum of the adjacent spans of a continuous girder but not exceeding ± 5 mm.
- iv. Bearings shall be placed in a horizontal plane within a tolerance of 1 in 200 in any direction unless otherwise specified, even under superstructure in gradient

a ELASTOMERIC BEARINGS

The terms "bearing" in this case refers to an elastomeric bearing consisting of one or more internal layers of elastomer bonded to internal steel laminates by the process of vulcanization. The bearing shall cater for translation and/or rotation of the superstructure by elastic deformation.

i. Raw Material

- a. Chloroprene (CR) only shall be used as raw polymer in the manufacture of Elastomeric Bearing. Blending with up to 5% of another polymer, which may be added to aid processing, is permitted.
- b. For Chloroprene Rubber Compound, grades of raw elastomer of proven use in elastomeric bearings, with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bayprene 110, Skyprene B-5 and Denka S-40V) shall be used.
- c. No reclaimed rubber or vulcanized wastes or natural rubber shall be used. The raw elastomer /polymer content of the bearing shall not be lower than 50 per cent by its weight. The ash content shall not exceed 5 percent (Polymer content shall be determined in accordance with ASTM D- 297, subsection 10 and ash content as per IS 3400 Part-XXII).
- d. EPDM and other similar candidate elastomer for bridge bearing use shall not be permitted.
- e. Tests for polymer identification through Pyrolysis test and confirmation about percentage of polymer content shall be carried out as per IS: 3400 (Part XXII).

ii. Properties

- a. The elastomer(CR) shall conform to the properties specified in Clause 4.2.1 of the IRC:83-2018 (Part-II). .
- b. The adhesion strength of elastomer to steel plate, determined according to IS: 3400 Part XIV method A, shall not be lesser than 7kN/m.
- c. Ozone resistance test shall be conducted in all cases of use of elastomeric bearings.
- d. Laminates of mild steel conforming to IS: 2062/ IS: 1079 or equivalent international grade shall be used. The yield stress of the material shall not be lesser than 250 MPa. Uses of any other materials like fibreglass or similar fabric as laminates are not permitted.

iii. Manufacturing and Tolerances

The Contractor shall submit the Design & Fabrication drawings for the approval of Engineer. Manufacturing of Bearing shall be commenced only after the approval of Design and Fabrication drawings by the Engineer. The bearings shall be manufactured in accordance with the clause 6 of IRC:83-2018 (Part-II) with the tolerances as specified in Table 5 of IRC:83-2018 (Part-II).

iv. Acceptance Specifications

- a. The manufacturer shall have all test facilities required for process and acceptance control tests installed at his plant to the complete satisfaction of the engineer. The test facilities and their operation shall be open to inspection by the engineer on demand.
- b. All acceptance and process control tests shall be conducted at the manufacturer's plant. Cost of all materials, equipment and labour shall be borne by the Contractor.

- c. Acceptance testing shall be commenced with the prior submittal of testing programme by the Contractor to the engineer and after obtaining his approval.
- d. All acceptance testing shall be conducted by the Engineer with aid of the personnel having adequate expertise and experience in rubber testing provided by the Contractor, working under the supervision of Engineer and to his complete satisfaction.
- e. Lot by lot inspection, testing and acceptance shall be made in accordance with the clause 7 of IRC:83-2018 (Part-II).
- f. A lot under acceptance shall comprise of all bearings, including the extra test bearings of equal size produced under identical conditions of manufacture to be supplied by the contractor. The level of acceptance testing shall be 'Level 1' as per the clause 7.8 of IRC:83-2018 (Part-II). **The cost of extra test bearings shall be borne by the contractor irrespective of the Lot size.**
- g. Bearings tested at ULS condition, i.e. destructive testing, cannot be used in the structure since its performance at SLS cannot be guaranteed after such treatment.
- h. If any further testing of materials is required by Engineer, such as polymer identification, Accelerated Ageing, Ozone Resistance etc., in accordance with the clause 7.9 of IRC:83-2018 (Part-II) , it shall be arranged for by the contractor at NABL accredited laboratory as approved by Engineer. For this, nothing extra shall be payable to the contractor.
- i. In addition to tests mentioned above, all bearings shall be also weighed actually and compared with the theoretical weight.
- j. Criteria for Selection of bearing manufacturer shall conform to the **RDSO's list of approved manufacturers for Elastomeric bearings.**

v. Warranty of Elastomeric bearings.

All bearings shall carry a warranty of not less than 15 years in a format as approved by the Employer. The contractor shall be responsible for immediate repair or replacement of the bearings in case of failure / distress to the satisfaction of the Employer at no extra cost to the Employer within the warrantee period.

The following undertaking shall be taken by the contractor from the Manufacturer of Elastomeric Bearing for submission to the Employer:

- a. "We undertake to use -----(Name of Chloroprene) in the manufacturing of the Elastomeric bearings and the same shall be imported by us directly from ----- (name of Manufacturer)/purchased from ----- (Name of Agent) who is the authorized Indian agent of M/s----(Name of the Manufacture)."
- b. "We hereby guarantee against defective materials manufactured workmanship as well as certify quality assurance at every step of manufacturing of bearings. Elastomeric bearings that may be supplied by us as per this office and which shall be installed at the -----(Name of the Bridge) shall have life of 15 years under normal loading, normal traffic and routine maintenance. We also stand guarantee for free repair and replacement (including the cost of placing the new bearings in position) in part or full, if any, defect is found, in the bearings or part thereof within the period 36 months from the date of supply or 24 months from the date of installation whichever is earlier, except for defects arising out of theft pilferage, floods, earthquake or any other natural calamity etc, over which we have no control, shall be replaced free of cost."
- c. "We also give an undertaking that the entire manufacturing and testing process shall be open to inspection for the client or their authorized representatives and that all possible help shall be extended in conducting the relevant tests required as per IRC 83 (Part-II) 2018 and other instructions issued by Ministry of Road Transport & Highways from time to time."

vi. Design

The design of elastomeric bearings shall conform to the provisions of the DBR of BSRP and Design criteria specified in the Employer's requirement of the tender document.

The design, drawings and detailed method statements for installation and replaceability of the bearings shall be checked and certified by approved independent agency before submitting to the Engineer for approval.

vii. Storage, Transportation and Handling

Each bearing shall be uniquely and individually numbered for identification on its external faces. The identification number shall be unique and such as to enable other bearings manufactured at the same time to be traced through the production control records should the need arise. Where practicable the identification number shall also be visible after installation of the bearing in the structure. The top of each bearing shall be clearly marked and the size and direction of preset, if any, and the direction of installation shall be indicated.

During transport and handling prior to and during installation, bearing shall be wrapped in a cover. They shall be packed in timber crates with suitable arrangement to prevent movement and to protect columns and edges. Care shall be taken to avoid mechanical damage, contamination with oil, grease and dirt, undue exposure to sunlight and weather to the bearings during transport and handling prior to and during installation.

viii. Installation

- i. Bearings should be installed with care to ensure their correct functioning in accordance with the design for the whole structure and shall be installed in the structure as specified or approved by the engineer to ensure that right bearing is being installed at the right location.
 - ii. Transfer of superstructure weight on to bearings should not be allowed until sufficient strength has developed in the bedding to resist the applied load.
 - iii. For precast concrete or steel superstructure elements, fixing of bearing to them may be done by application of epoxy resin adhesive to interface, after specified surface preparation. The specification for adhesive material, workmanship and control shall be approved by the engineer. Care shall be taken to guard against faulty application and consequent behaviour of the adhesive layer as a lubricant. The bonding by the adhesive shall be deemed effective only as a device for installation and shall not be deemed to secure bearing against displacement for purpose of design.
 - iv. Bearings must be placed between true horizontal surfaces (maximum tolerance 0.2 per cent perpendicular to load) and at true plan position of their control lines marked on receiving surfaces (maximum tolerance ± 3 mm). Concrete surfaces shall be free from local irregularities (maximum tolerance ± 1 mm in height).
 - v. After installation, bearing and their surrounding areas shall be left clean.
 - vi. The contractor shall submit the detailed procedure for installation of bearing, including the type of Non-shrink epoxy grout material to be used for filling the top / bottom gap of the bearing, for the approval of Engineer. Cost of Non-shrink epoxy grout above / below the bearing is included in the cost of bearing and nothing extra shall be payable on this account.
- o. SHEAR KEY DEVICE**
- a. GENERAL DESCRIPTION OF THE SYSTEM**
 - i. General**

The shear key is made of concrete cast in place in second pour before concrete decks are assembled.

The shear keys shall take all horizontal loads (longitudinal and transverse).

It is equipped with vertical bearings as per approved drawings.

ii. Vertical/Lateral Elastomeric bearings system

On the movable side of deck, one sliding elastomeric bearing shall be installed longitudinally on each side of the shear key.

On the fixed side of deck, one laminated elastomeric bearing shall be installed longitudinally on each side of the shear key. In addition, at the interface between the shear key, one laminated elastomeric bearing with adequate recesses to allow for replacement without taking out the high tensile bars shall be installed transversally.

These elastomeric bearings shall be made of polychloroprene, and manufactured according to Euronorm EN 1337-3 or equivalent.

All the Technical specifications mentioned for Horizontal Elastomeric bearings shall be valid for Vertical/lateral Elastomeric Bearings also except the following tests Shear Deformation and Shear Bond tests.

iii. INSTALLATION PROCEDURE

The installation procedure is proposed as follows. Alternate methods can be submitted by the contractor, subject to the Client approval.

1. Shear Key is poured before precast concrete deck segments are installed .The span must be assembled on higher level to avoid conflicts with already built concrete key.
2. Superstructure should have recess of 20mm for grouting by non-shrinkage grout at later stage
3. Erect the superstructure on temporary bearings/jacks with sliding surface at top at both ends
4. Provide some arrangement to prevent deck sliding (e.g. under seismic load).
5. Move the girder by nearly 20mm
6. At this stage vertical faced elastomeric pad is placed in position
7. Replace the temporary bearing with the permanent elastomeric bearing
8. Grout the gap between the girder (with hacked surface at grouting location) and the elastomeric bearing

Notes:

iv. MAINTENANCE PROCEDURE

The system shall be such that any device can be replaced without any destruction of concrete part of the structure.

The system shall be such that the maintenance procedures described below can be undertaken.

a) Vertical/lateral elastomeric bearings

For the lateral vertical bearings, a theoretical gap of 2mm shall be provided on each side of the shear key. If it is needed to change one or all of these lateral bearings, then, as the 'deck will not be in contact on each side at a time, the lateral bearings on the non: compressed side are taken out first. First the sliding plate is taken out, then the elastomeric bearing. Then the deck may need to be translated laterally to take out the elastomeric bearings on the compressed side. For this, steel angles can be split in the concrete on each side of the elastomeric bearings to provide support for jacks or threaded bars. The needed force to distort the neoprene bearings supporting the deck will be calculated.

p. HOLD-DOWN DEVICES

1 GENERAL DESCRIPTION OF THE SYSTEM**i. General**

The holds down devices are designed to take the lifting loads between the pier caps and the girders that may occur mainly during earthquakes in curved sections. The system of hold down device must take relative horizontal movements between the pier and the girder without any significant tensile stresses in the bars due to these movements.

ii. Description of the proposed system

(a) Movable end of the deck On the movable end, the system shall be composed of the 3 following devices:

- 1- A lower high tensile bar embedded in the pier cap concrete.
The bar is smooth and it is threaded only at its two ends. The bars are only threaded at their ends and they are smooth on the full length in order to increase the fatigue performances. The bar is equipped with a repartition plate and a nut.
- 2- A system of spherical articulation allowing the relative angular rotation between the lower and the upper bar. This device shall be composed with:
 - A washer with adequate thickness to permit a good setting of the articulation device. Between the washer and the concrete shall be installed an elastomeric membrane to provide the waterproofing of the device.
 - A lower nut with an internal threading to be assembled with the lower bar and an external threading to be assembled with the spherical room. - An articulation room equipped with a spherical contact surface.
 - A spherical nut in contact with the spherical surface of the articulation room.
 - A rubber protection skirt installed between the articulation room and the upper bar to avoid any dust in the upper opening of the articulation.
 - A rectangular repartition plate to take into account the oblong recess.
 - A protection cap that shall be equipped such as to avoid the rotation of the nut and to adjust precisely the gap between the nut and the repartition plate.
- 3- A high tensile upper bar installed in an oblong recess provided in the girder.
As for the lower bar, the upper bar shall be smooth and threaded at the two ends. The threading shall be made by rolling method. The corrosion protection of the bar shall be done by a heat shrinkable sleeve. In order to ensure that the lower bar will never break because this lower bar will not be replaceable, the diameter of the lower bar shall be always greater than the upper bar diameter, so that the upper bar shall always break (fuse principle) before the lower bar.
The upper threading shall be longer in order to take the variation of distance between the girder and the pier cap, and the variation of height of the lower part of the girder. It shall also take into account the construction tolerance. Important:
 - a) The articulation system will be designed in order to permit a rotation of at least 8° in all the directions without any tensile stress in the bar.
 - b) The articulation system will be designed in order to avoid any rotation of any component under the vibrations.
 - c) Fixed end of the deck In that case, the articulation device can be simplified and replaced by a coupler having two different threading diameters. The other devices are the same as for the movable end.

Nevertheless, attention is brought to the fact that the design of the articulations and of the couplers shall be such that there is the possibility to replace a coupler by an articulation in case of non-verticity of the lower bar. Therefore the "fixed end" device may need to be replaced with the more complex "movable end" device if construction tolerances are not met.

2 MATERIALS CHARACTERISTICS

i) High tensile bars

Quality of steel: the quality of the raw material steel shall be according to the DIN EN 10083-1 or equivalent. The chemical composition shall be such as to guarantee the following mechanical characteristics: - Yield stress $F_y > 1050$ MPa

-Tensile stress $F_u > 1200$ MPa

-Elongation at breaking $> 10\%$

-Resilience at $20^\circ\text{C} > 50$ Joules;

The threading of the bars shall be made by rolling method (cold plastic deformation of the metal between two dies) in order to give a good resistance to the fatigue. The threads shall have a rectangular profile H7 according to ISO 262 - NFE 03014 and 03053. The tolerance of the length of the bars is ± 5 mm Foreseen Diameters of bars :

The stress in the bar will not exceed $0.85 F_u$. The lower bar shall not reach the yield strength before upper bar is broken. The following upper/lower U.T.S bars are contemplated, but may be adjusted (\pm) during detailed design phase:

upper diameter (U.T.S)	lower diameter (U.T.S)
500kN	700kN

ii) CORROSION PROTECTION D.3.1 High tensile bars

The protection against corrosion of the high tensile bars shall be performed by using a heat shrinkable sleeve in order to give a very good protection against corrosion due to humidity, ozone, UV rays and shocks.

iii) other materials

The upper repartition plate and the protection cap shall be sandblasted and shall receive 3 layers of coating.

The articulation room, the Coupler and the lower ring shall be sandblasted and shall receive 3 layers of coating and a petrolatum tape.

The articulation room and the upper protection cap shall be filled up with grease.

iv) TRANSPORTATION & STORAGE

The bars and the accessories shall be transported in wooden cases and in containers, or equivalent.

The bar threading shall be temporarily protected against shocks by a greased tape and a steel ring or equivalent. The protection of the threads shall be taken off only right before the installation of the bars.

The bars and accessories shall be carefully stored in the jobsite in the following conditions:

- They shall be protected from rain, and the storage room shall have ventilation.
- If the bars have to be kept stored for a long time, it will be necessary to protect them with a layer of solvable oil or equivalent in order to protect them against corrosion.

- Before installation of the bars, if there is some corrosion, they shall be cleaned up. Acceptance of the bars shall be subject to the client approval.

v) INSTALLATION PROCEDURE

The installation procedure is proposed as follows. Alternate methods can be submitted by the contractor, subject to the client approval.

a) Installation of the lower bars

- Place the bar with the repartition plate and the nut into the reinforcement of the pier cap.
- Check that the length out of the concrete pier cap concrete is sufficient to install the articulation or the coupler.
- Check that the bar is installed vertically.
- Pour the pier cap concrete.

b) Installation of the articulation (or the coupler) and the upper bar

- Install the lower washer and the elastomeric pad on a plane and horizontal layer of mortar.
- Install the lower ring with the external and internal threading around the lower bar.
- Bring the upper bar equipped with the articulation room and the spherical nut and put in position the nut and the upper bar; the length of the pins installed between the nut and the ring shall be such to avoid any gap between the lower nut and the spherical articulation.
- Screw the articulation room until it is in contact with the lower washer.
- Apply a closing tape or equivalent between the bar end and the spherical nut.
- Fill the upper hole of the articulation room with grease or equivalent.
- Install the upper repartition plate on a plane and horizontal mortar.
- Apply a dosing tape or equivalent between the end of the bar and the spherical nut.
- Install the upper spherical nut around the bar in order to be in contact with the spherical surface of the repartition plate. At this stage, there shall be no gap between the two spherical nuts, the articulation room and the repartition plate.

The installation of the protection cap will allow to give a 2mm gap necessary to let the system free of rotation when there is any horizontal movement.

- Install a tape around the articulation room and the lower ring.
- Install the rubber protection skirt between the articulation room and the upper bar (the rubber skirt shall be filled up with grease).

NOTE: the same procedure can be applied for the fixed end, where the articulation room is replaced by a coupler.

vi) MAINTENANCE PROCEDURE

The system shall be such that the maintenance procedures described below can be undertaken.

a. Periodical inspection

- Every 5 years or after an earthquake, a visual inspection of the articulation room and the rubber protection skirt will have to be made to check the corrosion protection.

- At the same time, the upper protection cap will be taken off to check if the 2mm gap is still there and to adjust again this gap if necessary.
- The protection against corrosion of the upper bar will also be checked.

b. Maintenance

The system does not need any maintenance if it works in normal conditions. Nevertheless, if there is an earthquake, a special inspection will be carried out. If it is necessary to change the upper bar. The articulation device or the coupler, it will be necessary to take off the upper bar first, and to change the damaged devices according to the installation procedure.

q. **EXPANSION JOINTS**

a. Scope of Work

The scope of work will include:

- i) Preparation of detailed engineering and installation drawings, supply and supervision during fixing of strip seal/compression seal expansion joints conforming to specifications. The expected expansion/contraction of the superstructure at the location of expansion joints are shown in relevant drawings.
- ii) Design, manufacture, providing and seating of expansion joints by the specialized agency and approved by the Engineer.
- iii) Necessary technical supervision for installation of each and every expansion joint during different stages of installation including rectification of any deficiency or defect attributable to fixing and installation will be provided by the manufacturer / supplier.
- iv) The expansion joint shall be provided for the full width of viaduct including the railing.
- v) Leak tightness of all joints shall be ensured which shall also carry a warranty of **10 years** from the contractor.
- vi) Criteria for Selection of Expansion Joint manufacturer shall conform to the RDSO's list of approved manufacturers for Elastomeric bearings. All bearings shall carry a warrantee of not less than **10 years in** a format as approved by the Employer. The contractor shall be responsible for immediate repair or replacement of the Expansion joints in case of failure / distress to the satisfaction of the Employer at no extra cost to the Employer within the warrantee period.
- vii) The expansion joints provided over elevated structure decks should be so designed as to be compatible with the bearings.
- viii) The expansion joint system of W-seal or equivalent shall comprised of EPDM flexible Seal and work on Arch Principals fixed by Epoxy adhesive, the seal must confirm to BS-4225 and epoxy adhesive confirm to ASTM C—881specification.The EPDM moisture barrier must be provided underneath of each joint fixing by binding wire with deck reinforcement. EPDM moisture barrier having predetermined holes and must be imported and confirm to ASTM 2240 & ASTM - G53 & 84 all complete as per manufacturer drawing.
- ix) The contractor shall submit design and drawing of expansion joints based on design criteria mentioned under "scope of Work" to the Engineer for approval. The design of expansion joint shall be done as per IS and International codes as applicable and Sound Engineering practices.
- x) Any modification to the design and drawings submitted by the Contractor, if suggested by the Engineer, shall be incorporated without any reservations. The design and drawings including changes approved by the Engineer shall form basis of execution and that Contractor shall undertake all necessary action for ensuring execution of work on

that basis. For design, manufacture, testing and supply of W-seal expansion joints, following will be followed in order of preferences.

- (a) Details in this chapter and elsewhere in tender documents.
 - (b) IRC Codes and MORTH specifications for Roads and bridges published by Indian Road Congress.
 - (c) Sound Engineering Practice (Decision of Engineer will be final in this case) which shall include specialized literature as decided by Engineer-in-Charge.
- b. Building Expansion Joints:** Specialised expansion joints consisting of extruded aluminium frame assemblies of suitable profile to receive free floating cover plate of required shape and profile / or elastomer suited to building applications shall be used. These will be provided for covering the structural gap at expansion joints along the horizontal faces of slabs and beams, vertical faces of retaining walls, etc. Necessary block-outs as per the manufacturer's recommendations shall be provided in the structure which shall be filled in the approved manner after placing the expansion joints. The base of the expansion joint assembly shall be fixed onto the concrete base using anchor fasteners (not exposed to top surface) as per manufacturer's specifications. The joint shall have, and anti-skid serrated top plate with a free-floating central plate. All aluminium in contact with concrete shall have zinc chromate finish. The joint assembly shall be capable of accommodating the specified movement without loss of cover and shall include all the necessary accessories, sealant etc as per manufacturer's drawings. The joint fixing shall be carried out by the main contractor under the supervision of supplier/manufacturing agency of approved expansion joint. The expansion joint cover assemblies shall withstand a minimum 500lb point load without damage or permanent deformation. The joint should be watertight and test on same if required on direction of Engineer shall be conducted without any extra payment for same.

c. SPECIFICATION FOR STRIP SEAL EXPANSION JOINT:

Expansion joint type described here-after is the "strip seal" type, but alternate designs can be proposed for concerned organisation approval (e.g., elastomeric omega-shape cover joint, or any other suitable joint type)

1) Components:

Strip seal expansion joint shall comprise the following items:

- i. Edge beam:
This shall be either extruded or hot rolled steel section or cold rolled cellular steel section with suitable profile to mechanically lock the sealing element in place throughout the normal movement cycle. Further the configuration shall be such that the section has a minimum thickness of 10mm all along its cross section (flanges and web). The minimum height of the edge beam section shall be 80mm. The minimum cross-sectional area of the edge beam shall be 1500mm^2 .
- ii. Anchorage:
Edge beams shall be anchored to the deck by reinforcing bars or bolts or anchor plates cast in concrete or a combination of anchor plate and reinforcing bars. Anchor bars studs or bolts shall engage the main structural reinforcement of the deck and in case of anchor plates or loops, this shall be achieved by passing transverse bars through the loops or plates.

The minimum thickness of anchor plate shall be 12mm. Total cross sectional area of bar on each side of the joint shall not be less than 1600mm^2 per meter length

of the joint and the centre to centre spacing shall not exceed 250mm. The ultimate resistance of anchorage shall not be less than 600 kN/m in any direction.

2) Material

- i. The steel for edge beams shall conform to any of the steel grade corresponding to RST 37-2 or 37-3 (DIN), ASTM A36 or A588, CAN/CSA Standard G40.21 Grade 300W or equivalent.
- ii. Anchorage steel shall conform to IS:2062 or equivalent.
- iii. All steel sections shall be protected against corrosion by hot dip galvanizing or any other approved anticorrosive coating with a minimum thickness of 100 micron.
- iv. Chloroprene of strip seal element shall conform to Clause 915.1 of IRC:83 (Part-II).

The properties of chloroprene shall be as specified in Table-1.

3) Fabrication (Pre-installation)

- i. The strip seal joint system and all its component parts including anchorages shall be supplied by the manufacturer /system supplier.
- ii. The width of the gap to cater for movement due to thermal effect, prestress, shrinkage and creep, superstructure deformations (if any) and sub-structure deformations (if any) shall be determined and intimated to the manufacturer. Depending upon the temperature at which the joint is to be installed, the gap dimension shall be pre-set.
- iii. Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Pre-setting shall be done in accordance with the joint opening indicated on the drawing.
- iv. The finally assembled joint shall then be clamped and transported to the work site.

TABLE-1 STRIP SEAL ELEMENT SPECIFICATION

Sealing element is made of chloroprene and must be extruded section. The working movement range of the sealing element shall be at 70mm.

Property	Specified Value
Hardness*	63+ /-5 Shore A
DIN 53505	55 +/- 5 Shore A
ASTM D 2240 (Modified)	
Tensile Strength*	Min 11 MPa
DIN 53504	Min 13 .8Mpa
ASTM D 412	
Elongation at fracture*	Min 350 per cent
DIN 53504	Min 250 per cent
ASTM D 412	
Tear Propagation Strength	Min 10 N/mm
Longitudinal	Min 10 N/mm
Transverse	Min 25 per cent
Shock elasticity	Min 220 Cu.mm

Abrasion	
Residual Compressive Strain (22h/70 deg C/30 per cent Strain))	Max 28 per cent
Aging in hot air (14days/70 deg C)	Max + 7 Shore A
Change in hardness	
Change in tensile strength	Max –20 per cent
Change in elongation at fracture	-20 per cent
Ageing in Ozone (24 h/50 pphm/25 deg C/20 per cent elongation)	No cracks
Swelling behaviour in Oil (168h/25 deg. C)	
ASTM Oil No. 1 Volume Change	Max + 5 per cent
Change in hardness	Max –10 Shore A
ASTM Oil No. 3	
Volume Change	Max + 25 per cent
Change in hardness	Max –20 Shore A
Cold Hardening Point	Max –35 deg C

Only one set of specification viz. ASTM or DIN shall be followed depending on the source of supply.

- v. Each strip seal expansion joint system shall be fabricated as a single entity unless stage construction or excessive length prohibits monolithic fabrication. It shall fit the full width of the structure as indicated on the approved drawing. The system shall be pre-set by the manufacturer prior to transportation. Pre-setting shall be done in accordance with the joint opening indicated on the drawing.
- vi. The finally assembled joint shall then be clamped and transported to the work site.

4) Handling and Storage

- i. For transportation and storage, auxiliary brackets shall be provided to hold the joint assembly together.
- ii. The manufacturer/supplier shall supply either directly to the Engineer or to the Bridge Contractor all the materials of strip seal joints including sealants and all other accessories for the effective installation of the jointing.
- iii. Expansion joint material shall be handled with care. It shall be stored under cover on suitable lumber padding.

5) Supply/Installation:

Components of expansion joint such as edge beam and strip seal shall be imported from the specified foreign manufacturer / collaborator to ensure quality and performance. The joint shall be supplied and installed only by the MOST approved manufacturer. Contractor shall furnish a warranty of trouble-free performance for at least ten years and free rectification of defects / replacement, if any, during this period.

The joints shall be installed by the manufacturer/supplier (only MOST Approved) or their authorised representative who will ensure compliance to the manufacturer's instructions for installation.

Taking the width of gap for movement of the joint into account, the dimensions of the recess in the decking shall be established in accordance with the drawings or design data of the manufacturer. The surfaces of the recess shall be thoroughly cleaned, and all dirt and debris removed. The exposed reinforcement shall be suitably adjusted to permit unobstructed lowering of the joint into the recess.

The recess shall be shuttered in such a way that dimensions in the joint drawing are maintained. The formwork shall be rigid and firm.

Immediately prior to placing the joint, the pre-setting shall be inspected. Should the actual temperature of the structure be different from the temperature provided for pre-setting, correction of the pre-setting shall be done. After adjustment, the brackets shall be tightened again.

The joint shall be lowered in a pre-determined position. Following placement of the joint in the prepared recess, the joint shall be levelled and finally aligned and the anchorage steel on one side of the joint welded to the exposed reinforcement bars of the structure. Upon completion, the same procedure shall be followed for the other side of the joint. With the expansion joint finally held at both sides, the auxiliary brackets shall be released, allowing the joint to take up the movement of the structure.

High quality concrete shall then be filled into the recess. The packing concrete must feature low shrinkage and have the same strength as that of the superstructure, but in any case, not less than M40 grade. Good compaction and careful curing of concrete is particularly important. After the concrete has cured, the movable installation brackets and shuttering still in place shall be removed.

The neoprene seal shall be field installed in continuous length spanning the entire roadway width. To ensure proper fit of seal and enhance the ease of installation dirt, spatter or standing water shall be removed from the steel cavity using a brush, scrapper or compressed air. The seal shall be installed without any damage to the seal by suitable hand method or machine tools.

The deck surfacing shall be finished flush with the top of the steel sections. The horizontal leg of the edge beam shall be cleaned beforehand. It is particularly important to ensure thorough and careful compaction of the surfacing in order to prevent any premature depression forming in it.

6) Acceptance Criteria:

- i. All steel elements shall be finished with corrosion protection system.
- ii. For neoprene seal, the acceptance test shall conform to the requirements stipulated in Table-1. The manufacturer/supplier shall produce a test certificate, accordingly, conducted in a recognized laboratory, in India or abroad.
- iii. The manufacturer shall produce test certificates indicating that anchorage system had been tested in recognized laboratory to determine optimum configuration of anchorage assembly under dynamic loading.
- iv. Prior to acceptance 25 percent of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be

continuously pounded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm anytime during the test. A close inspection of the underside of the joint shall not reveal any leakage.

- v. As strip seal type of joint is specialized in nature, generally of the proprietary type, the manufacturer shall be required to produce evidence of satisfactory performance of this type of joint.

7) Test and Standards of Acceptance:

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite certificates from the recognized testing laboratory of India or abroad.

8) Waterbars / Waterstops

Where waterbars are required, the joints shall incorporate PVC water bar such as "Fixostop" or approved equivalent (conforming to IS: 12200). The water bars shall be complete with all the necessary moulded or prefabricated intersection pieces assembled with bends and butt joints in running lengths made by welding in an electrically heated jig. The fabrication drawing made by the manufacturer shall be submitted by the Contractor for approval of the Engineer

Jointing and fixing of waterbars shall be carried out strictly in accordance with the manufacturer's instructions which should be enumerated in a detailed method statement and submitted for approval / comments of the Engineer-in-Charge. The following types of waterstops are proposed to be used in the Work.

- i. 'FIXOSTOP' Type 230 KD or equivalent – To be used at construction joint in base slab
- ii. 'FIXOSTOP' Type 230 KV or equivalent – To be used at expansion joint in base slab
- iii. 'FIXOSTOP' Type 240 RS or equivalent – To be used at construction joint in between wall and base slab
- iv. 'FIXOSTOP' Type 240 H or equivalent – To be used at expansion joint in base slab

Waterbars shall be of approved and appropriate type obtained from approved manufacturers.

The waterbars shall be installed so that they are securely held in their correct position during the placing and compacting of the concrete. Necessary supporting devices to prevent sagging of the water bars shall be provided.

Where reinforcement is present adjacent to waterbars, adequate clearance shall be left between the reinforcement and waterbars to facilitate compaction of the concrete.

Double headed nails maybe used in the edge of the waterbar outside the line of the external grooves for fixing purposes, but no other holes shall be permitted through the waterbar.

A representative of the manufacturer shall be present at site during the operations of installing, jointing and embedment of waterstop. He shall monitor and certify that the work is being carried out strictly as per specifications and recommended practices.

d. SPECIFICATION FOR OMEGA TYPE EXPANSION JOINT

1. Expansion joint type described here-after is the "OMEGA TYPE EXPANSION JOINT".
As per IRC 83 part II 2018

- i. Deleted.
- ii. Material.
- iii. Deleted.

2. **Anchorage:**

The steel plate shall conform to IS: 2062 or equivalent. The bolt and nut shall be anchored to the deck by welding to the main reinforcement Steel plate used for shall be 8 mm thick hot dip galvanized. The center-to-center spacing of bolts shall not exceed 400 mm.

3. **Corrosion Protection:**

All steel section shall be protected against corrosion by hot dip galvanizing or any other approved anticorrosive coating with a minimum thickness of 100 micron.

4. **Joint Seal:**

G. 2.4.1 The sealing element shall be a **preformed chloroprene with high tear strength**. Insensitive to soil, gasoline and ozone. It shall have high resistance to ageing and ensure water tightness. The seal should be vulcanized in a single operation for the full length of the joint. The seal shall cater for a horizontal movement up to 100mm and vertical movement of 3mm. G. 2.4.2 the physical properties of **chloroprene sealing** element shall conform to the following:

- (a) Deleted.

- (b) **Elastomeric seal**

It shall be performed extruded **Omega type** section of **Elastomeric Seal** of such a shape as to promote self-removal of foreign material during normal service operations. **Elastomer** of joint seal shall conform to clause 915.1 of IRC:83 (Part-II) and satisfy the properties stipulated in Table 2 strip seal element specifications of these specifications **given in MORTH Circular no. RW/NH-34059/96-5 & R dated 30 Nov 02 on the subject** except in respect of the working movement range of the sealing element which shall be as specified in **CI G.2.4.1** above.

- (c) Deleted.

F.2.5. Deleted.

F.3. 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.

F.4 Installation:

- i. The expansion joint shall be installed by the manufacturer/supplier or their authority's representative, who will ensure compliance of installation procedure and instructions.
- ii. The dimension of the joint recess edge beam above deck slab and the width of the gap shall conform to the approved drawing.
- iii. Bolts shall be welded to the main reinforcement in the edge beam deck maintaining the level and alignment of the joint.
- iv. Concreting of edge beam shall be done with great care using proper mix conforming to same grade as that of the deck concrete but no less than M30 grade in any case. The water cement ratio shall not be more than 0.40. If needed, suitable admixtures may be used to achieve the workability. Care shall also be taken to ensure efficient bonding between already cast/existing deck concrete and the concrete in the joint recess edge beam.
- v. At the time of installation, joint shall be clean and dry and free from spalls and irregularities, which might impair a proper joint seal.
- vi. Concrete or metal surfaces shall be clean, free of rust, laitance, oils, dirt, dust or other deleterious materials.
- vii. Deleted.
- viii. The joint seal shall be compressed to the specified thickness for the rated joint opening and ambient temperature at the time of installation, which shall be between +05 to +35 degree C. the joint seal shall be installed without damage to the seal. Loose fitting or open joints shall not be permitted.

F.5. Acceptance Criteria:

- F.5.1. All steel elements shall be furnished with corrosion protection system.
- F.5.2. For the joint seal the acceptance test shall conform to the requirements stipulated in para G.2.4 above. The manufacturer/supplier of this type of joint shall produce a test certificate to this effect conducted in a recognized laboratory in India or abroad.
- F.5.3. Prior to acceptance 25% of the completed and installed joints, subject to a minimum of one joint, shall be subjected to water tightness test. Water shall be continuously ponded along the entire length for a minimum period of 4 hours for a depth of 25mm above the highest point of deck. The width of ponding shall be at-least 50mm beyond the anchorage block of the joint on either side. The depth of water shall not fall below 25mm any time during the test. A close inspection of the underside of the joint shall not reveal any leakage.

F.6. Tests and Standards of Acceptance:

The materials shall be tested in accordance with these specifications and shall meet the prescribed criteria. The manufacturer/supplier shall furnish the requisite from the recognized testing laboratory of India or abroad.

The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

F.7. Rates:

The contract unit rate shall include the cost of all materials, labour, equipment, cost of testing including cost of test samples and other incidental charges for fixing the joints complete in all respects as per specifications.

10.3 RAILINGS**10.3.1 General**

Prefabricated railing as per approved design and drawing shall be provided and erected at site. Fixing arrangements on segment parapet shall be carefully designed and incorporated.

Railing shall be carefully erected true to line and grade. Posts shall be vertical with a tolerance not exceeding 6 mm in 3 m. All edges and corners shall be straight and finished to true line and level.

Contractor should prepare and submit his own drawings and Method Statement as per best industrial practises for approval of Engineer before commencement of work. The work shall be commenced only after approval of the Method statement by Engineer.

10.3.2 Metal Railings

10.3.2.1 General

- i. MS Hand Railings shall be provided as per tender drawings attached.
- ii. All complete steel railing elements, terminal sections, posts, and other fittings shall be of shape, size and designation of approved material and make as given in the item of work or as directed by Engineer.
- iii. All these elements shall be painted with an approved paint. Primer coat (zinc epilux or equivalent) & three coats of PU paint as per specification and drawing. with all lead and lifts and as per the directions of engineer. If straightening is necessary, it shall be done by methods approved by Engineer.
- iv. The Contractor shall take every precaution against damage of the components during fixing in position.
- v. Damaged painted surfaces shall be cleaned and repainted. Special care shall be taken to prevent staining of all products, rust, mortar, etc. before it is put into use.
- vi. The Contractor shall take every precaution against damage of the components during fixing in position.

10.3.2.2 Fixing

- i. The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints, correct alignment and camber throughout their length. Fixing shall be strictly as per fixing details shown on approved drawing or as directed by engineer.
- ii. All necessary holes, anchor bolts etc., required in fixing shall be made by the contractor and made good after installation, without any extra charge
- iii. Any damages done to the parapet while installing MS Railing shall be rectified by the contractor at his own cost. As per method statement approved by Engineer Nothing extra is payable in this regard.
- iv. Maximum continuous length at topmost pipe shall be restricted to 15.5m.
- v. Where the span length is less than 31m, 50mm gap shall be provided between continuous railing at Mid span Location(L/2)
- vi. Where the span length is greater than 31m, 50mm gap shall be provided between continuous railing at Location(L/3).

10.4 DRAINAGE SPOUTS AND DRAINAGE PIPE

10.4.1 GENERAL

- i. This work shall consist of supply and fixing in position of drainage spouts and drainage pipes for bridge decks and piers true to lines, levels and position in accordance with details shown on drawings and to the requirements of these specifications and drainage plan for structure.
- ii. Where details are not given on drawings, contractor should prepare and submit his own drawings and Method Statement as per best industrial practises for approval of Engineer before commencement of work. The work shall be commenced only after approval of the Method statement by Engineer.

- iii. Underground / Surface drainage works are to be designed by Contractor and carried as per CPWD specifications 2019 and paid for separately under DSR items.
- iv. Drainage pipe (Down take Pipe) to be embedded in pier and seismic Arrestor shall be of HDPE corrugated double wall and drainage pipe (Runner pipe) from Drainage spout outlet till Seismic Arrestor including bends shall be made of UPVC
- v. UPVC pipes shall be fixed to deck slab using adequate clamping, details of clamping shall be mentioned in the Method Statement and drawings submitted for approval of Engineer.
- vi. Minimum Working Pressure of UPVC pipes shall be 4Kg per Sq.cm and minimum diameter of UPVC Runner pipe shall be 160mm. Minimum diameter of HDPE down take pipe shall be 200mm.
- vii. UPVC pipes Specifications and fixing, including jointing of pipes using suitable approved solvents at connections, shall Confirm to IS 4985 latest revision, Drainage spouts shall be as per MOST Type design No.SD/303. The waterspouts shall be provided at locations shown as per relevant layout drawing, and with a spacing not exceeding 5m.
- viii. Door bends i.e. (opening with a door/cap) shall be provided at all U-PVC pipe bend locations, to access and remove any debris choked at bend locations.
- ix. UPVC pipe shall be temporarily placed in the HDPE Pipe fixed in the pier during concreting and shall be moved up and down to avoid any ingress of slurry and avoid choking of HDPE Pipe due to damage of HDPE Pipe during needle vibrator compaction of pier concrete.

DESIGN:**Drainage:**

The drainage of deck shall be designed to cater the maximum envisaged rainfall intensity and suitable longitudinal and transverse slope should be provided. Moreover, the provisions of Clauses-10.4.1.1 & 15.2.2 of IRS-CBC shall be followed.

Solid Pier

The drainpipe of double wall HDPE corrugated pipes will be located within solid pier to avoid unpleasant aesthetics.

10.4.2 FABRICATION

- i. Drainage assembly including drainage-spouts, gully-gratings and clean-out fixtures, shall be fabricated to dimensions shown in the drawings, and adequately fixed to the deck.
- ii. All materials shall be corrosion resistant; steel components shall be of mild steel conforming to IS 2062. The drainage assembly shall be seam welded for water tightness and then hot dip galvanised @ 650g/m² and further painted with anti-corrosion powder coated paint.
- iii. Drainage outlets shall be so provided that the discharge of the rainwater drained by them is not directed towards any part of the superstructure or substructure component.

10.4.3 PLACEMENT

The galvanised assembly of drainage spout shall be placed in true position, lines and level as shown in drawing with necessary cut-out in the shuttering for deck slab and held in position firmly. Where reinforcement of the deck is required to be cut, equivalent reinforcement shall be placed at the corners of the assembly.

10.4.4 FINISHING

After setting of deck slab concrete, shrinkage cracks around the assembly shall be totally sealed with polysulphide sealant or bituminous sealant as per IS: 1834 and excess sealant trimmed.

10.5 Manhole Cover

- A. The covers and frames shall conform to IS 1726 for cast Iron shall be of the following grades and types. Grade of Manhole Cover shall be either Medium, MD - 10 Rectangular/Circular or as decided by Engineer.
- B. The size of man hole cover shall be minimum of 900mm.

C. The following specifications for Cast Iron Manhole Covers and Frames shall be followed:-

- (i) Manhole covers and frame shall be manufactured from appropriate grade of grey cast iron not inferior than FG150 grade of IS 210.
- (ii) They shall be cleanly cast and shall be free from air and sand holes, cold shuts and warping.
- (iii) Covers shall have on its operative top a raised chequered design to provide for an adequate no-slip grip. The rise of chequers shall be not less than 4mm.
- (iv) Key holes, keys and lifting devices shall be provided in the manhole covered to facilitate their placement in the frames and their operative maintenance.
- (v) Manhole covers and frames shall be coated with materials having base with a black bituminous composition. The coating shall be smooth and tenacious. It shall not flow when exposed to temperature of 63°C and shall not be so brittle as to chip off at temperature of 0°C.
- (vi) Size and shape and performance requirement of manhole covers, and frames shall conform to IS 1726.
- (vii) Each manhole covers and frame shall have cast on them the following information:
 - (a) Manufacturer's name or trademark
 - (b) Grade designation
 - (c) Date of manufacturer
 - (d) The words SWD or 'Sewer' to denote 'storm water drain' or 'sewer' respectively
 - (e) Identification marks as required by Engineer-in-Charge.
- (viii) The cover shall be gas tight and watertight.
- (ix) The sizes of covers specified shall be taken as the clear internal dimensions of the frame.
- (x) The approximate weight of the various type of manhole covers and frames shall be as per IS 1726.
- (xi) The cover shall be capable of easy opening and closing and it shall be fitted in the frame in workmanship like manner

10.6 SEALANTS

10.6.1 General

- i. Joint sealing compounds shall seal joints in concrete against the passage of water, prevent the ingress of grit or other foreign material and protect the joint filler. The compound shall have good extensibility and adhesion to concrete surfaces and shall be resistant to flow and weathering.
- ii. Approved Sealant where specified on the drawings shall be provided strictly in accordance with the manufacturer's written instructions, such joints shall be formed to the correct dimensions, thoroughly cleaned and treated with recommended primer strictly in accordance with the manufacturer's written instructions prior to sealing. Wherever width of gap to be sealed is wide enough to necessitate the use of backer rod, the same shall be provided at no extra cost. The contractor shall use only competent personnel experienced in the application of sealant for such work.
- iii. Where specified in the drawings, silicon/polyurethane/ polysulphide based sealants shall be of an approved manufacture. The treatment of the joint and the use of sealing compound shall be strictly in accordance with the manufacturer's written instructions. The entire work shall be carried out as per IS:3414, IS.6509, IS:11433.
- iv. Sealants shall be as follows:
Silicon sealant shall be one part gun grade type with minimum movement capability of $\pm 25\%$ and elongation at break of 450% confirming to BS 5889 or TTS 001543A. This Sealant shall be of approved colour and shall be non-staining to the parent concrete surface.

10.6.2 Ancillary Materials

The Contractor shall provide all ancillary materials such as cleaning solutions epoxy mortar, primer, tool cleaner, bond breaker type, filler boards, back up material, backing rods, polyethylene foam, masking tapes, sealant slot former etc.

10.6.3 Primer

Primer for sealants shall only be as recommended by the sealant manufacturer, Primer shall have been tested for compatibility and durability with the sealant to be used and on samples of the surfaces to be selected.

10.6.4 Backdrop Material

Backdrop material shall be an expanded polyethylene of nominal density 35 kg/cum as recommended by the sealant manufacturer. It shall be of non-absorbent and non-staining material compatible with the sealant used. Tube or rod stock shall be rolled into the joint cavity.

10.6.5 Bond-preventive Materials

Bond-preventive materials shall be pressure-sensitive adhesive polyethylene tape or aluminum foil.

10.6.6 Equipment

The Contractor shall inter alia provide the following plant and equipment for the work. T-paddle, follower plate, solid barrel gun, plastic nozzle, wire brush, heavy duty 500 rpm electric drill, palette knife, masking tape and paint brush for priming etc.

10.6.7 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.

10.6.8 Curing Period

No portion of the work where sealant has been applied shall be allowed to be submerged or be wetted by any liquid for a period of 7 days after application of the sealant. This period may be modified depending on the temperature and humidity prevalent at the time.

10.6.9 Environmental Requirements

The ambient temperature shall be within the limits as given by the manufacturer, when the sealants are applied. The work shall not be carried out in a dusty atmosphere or when it is raining or when the humidity is high. Sealants shall not be applied when the ambient temperature is below 4 degree C. When the ambient temperature is below 10 degree C but greater than 4 degree C, the sealant containers shall be stored for some hours at 21 degree C, to ease mixing and application

10.6.10 Delivery and Storage

Materials shall be delivered to the job site in the manufacturer's original unopened containers.

The containers shall include the following information on the label.: a) Name of supplier,

- b) Name of material,
- c) Formula,
- d) Lot number,
- e) Colour
- f) Date of manufacture,
- g) Mixing instructions
- h) 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.

10.6.11 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
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		Minimum	Maximum
For concrete masonry or stone:	6 mm	6 mm	6 mm
	Over 6 mm up to 12 mm	6 mm	Equal to width
	Over 12 mm	½ width	½ width

10.6.12 Surface Preparation**General**

The surface of joints to be sealed shall be clean, dry, sound and free of all release agents, water repellents, laitance, oil, grease, dirt, chalk, particles of mortar, dust, loose rust, loose mill scale and other foreign substances. Oil and grease shall be removed with solvent and the surfaces shall be wiped with clean clothes.

10.6.13 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, Litanice, efflorescence and loose mortar shall be removed from the joint cavity. The surfaces/edges shall be repaired with epoxy mortar to give smooth and even surfaces to correct lines and levels with a uniform gap for the length to be sealed.

10.6.14 Application Masking Tape

Masking tape shall be placed on the finished surface on one or both sides of a joint cavity to protect adjacent finished surfaces from primer or compound smears. The masking tape shall be removed within 10 minutes after the joint shall be filled and tolled.

10.6.15 Bond-preventive materials

Bond-preventive materials shall be installed on the bottom of the joint cavity and other surfaces to prevent the sealant from adhering to the surfaces covered by the bond- preventive materials. The materials shall be carefully applied to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those covered by the bond- preventive materials.

10.6.16 Backstops

The back or bottom of joints constructed deeper than specified shall be packed tightly with an approved backstop material to provide a joint of the depth specified.

10.6.17 Primer

The primer shall be used in accordance with the manufacturer's instructions. The primer shall be applied to the joint surfaces to be sealed only and not spill over or be applied to surfaces adjacent to the joints.

10.6.18 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.

10.6.19 Cleaning

The surfaces adjoining the sealed joints shall be cleaned of smears and other soiling resulting from the sealing application as the work progresses. Sealant adhering to, porous surfaces shall be left until is just cured and then removed by abrasion or other mechanical means.

10.7 FIRE PROOFING OF STEEL STRUCTURES**10.7.1** DELETED.**10.7.6 FINISHING AND JOINT SEALING**

Fire proof coating shall be finished with 2 coats of microporous exterior top coat as recommended by manufacturer, compatible to cement surfaces of approved make colour conforming to IS: specifications.

10.7.7 TEST

The contractor shall submit the certificate of test results for the vermiculite cementitious coating over structural member from a laboratory, approved by the Engineer. Test shall be performed as per the requirements laid down in UL-1709 for 2 hours duration when tested on W10 x 49 I-beam.

10.7.8 MEASUREMENT

Measurement for fire proofing coating of 2hrs shall be in Sqm based on the net surface of structural steel on which it is applied.

10.7.9 APPROVED MANUFACTURERS/ SUPPLIER

All materials and products shall conform to the relevant standard specification, IS codes and other relevant codes etc. and shall be of approved makes and design.

10.8 SPECIFICATION FOR COATING OF PSC GIRDERS AND RCC SUBSTRUCTURES:**1.1 MATERIALS:**

1.1.1 The coating materials shall meet the standards specified by various codes and formulation set forth by the patentor.

1.1.2 A written certification shall be furnished to the Engineer that properly identifies the number of each batch of coating material used in the work, material, quantity represented, date of manufacture, name and address of manufacture and a statement that the coating material used must meet the requirements specified by CBRI/Roorkee. Also proof of purchase from CBRI's approved manufacture shall be submitted.

1.1.3 The coating material shall be stored in the manner as per recommendations of the manufacturer until ready for use. The coating material shall be used within the manufacture's written recommended shelf life.

1.1.4 When a representative sample of the material is to be sent to CBRL, Roorkee laboratory, then the sample shall be packaged in an airtight container and identified by batch number. The cost of testing will be borne by the Contractor.

1.2 SPECIFICATION OF COATING MATERIAL

Sr.No.	Description	Primer coat	Middle Coat	Top Coat
1.	Base	Interpenetrating Polymer (Epoxy phenolic)	Interpenetrating Polymer (Epoxy phenolic)	Interpenetrating Polymer (Aliphatic Polyurethane)
2.	Pot life	1 Hour for 2 lt. mix	1 Hour for 2 lt. mix	1 Hour for 2 lt. mix
3.	Curing	Air Curing	Air Curing	Air Curing
4.	Colour	Clear or as specified by the Engineer in charge	Yellow/Grey or as specified by the Engineer in charge	Yellow/Grey or as specified by the Engineer in charge
5.	Shelf Life	One year in tightly sealed container.	One year in tightly sealed container	One year in tightly sealed container
6.	Dry film thickness	55- 65 microns	90-100 microns per coat	40-50 microns per coat

7.	Coverage	5-6 sq.mt/lit(5.5 sq.mt Average)	4-5 sq.mt/lit(4.5 sq.mt Average)	6-7 sq.mt/lit(6.5 sq.mt Average)
8.	Recommended No. of coats	One	One	One
9.	Recoatibility	Subsequent coat shall be applied after 6 hours to 7 days	4 hours to 7 days. Ensure the surface is dust and deposit free prior to application	N.A
10.	Mix proportion	Base:1 PBV*/Curing Agent: 1 PBV*-Parts by volume	Base:1 PBV*/Curing Agent: 1 PBV*- Parts by volume	Base:1 PBV*/Curing Agent: 1 PBV*- Parts by volume

- 1.2.1 Tensile strength: Minimum tensile strength of the coating must be 15 N/mm² and it should be determined as per ASTM-2370.
- 1.2.2 Elongation: Minimum elongation of the coating must be 15% and it should be determined as per ASTM D-2370-73.
- 1.2.3 Specific permeability: The maximum value must be 0.15 mg/cm²/mm/24hr and it should be determined as per ASTM d-1653-74.
- 1.2.4 Adhesion with concrete: The minimum adhesion with concrete by pullout method must be 2.5n/mm² and it should be determined as per BS-3900-E-270.
- 1.2.5 For consumption calculation of various coats (primer, middle and top), average values of the specified coverage shall be adopted.

1.3 **SURFACE PREPARATIONS:**

- 1.3.1 In order to have better bonding, the concrete surface should be clean, dry and mechanically sound. The surface of the concrete structure to be coated shall be cleaned of all traces of mould oil, laitance, salt deposits by mechanised means. Finally, the surface should be washed with clean water jet to remove any salt deposits. The surface should be dried. All the protrusions should be removed and cracks, joints should be sealed with IPNet putty as per Central Building Research Institute (CBRI), Roorkee's recommendation.

1.4 **APPLICATION OF COATING:**

- 1.4.1 Mix the base and curing agent in prescribed proportion by volume thoroughly for 5-10 minutes and allow it to remain in a container for five minutes.
- 1.4.2 A primer coating of IPN polymer (transparent) shall be applied to the cleaned surface after surface preparation within the pot life.
- 1.4.3 After air curing, Intermediate and top coating should be applied with time lag as per manufacturer's specification.
- 1.4.4 The coating shall be applied by airless spray or other approved means.
- 1.4.4 The coating shall be applied by airless spray or other approved means.

1.5 **COATING THICKNESS:**

- 1.5.1 **Superstructure and Sub structures-** The minimum total thickness of all coats (primer coat +middle coat + top coat) must be 200+15 microns.

1.6 MEASUREMENT OF COATING THICKNESS

- 1.6.1 During the application of IPNET system clean abraded steel plates of approximately 10cm x 8cm shall be adhered to the concrete surface by means of putty /adhesive in such a way that these can be detached. IPNet system can be applied over the plates in the course of application over the concrete surface. Dry film thickness (DFT) can be measured using magnetic electrometer. DFT measurement should be done every 500 to 600 sqm area or as per the direction of engineer-in-charge.

1.7 COATING CONTINUITY:

- 1.7.1 The coating shall be visually inspected after curing for continuity of the coating and shall be free from holes, voids, contamination, cracks and damaged areas discernible to the unaided eye

1.8 PERMISSIBLE COATING DAMAGE AND REPAIR OF DAMAGED COATING:

- 1.8.1 All coating damage shall be repaired with patching material by the contractor at his own cost.
- 1.8.2 Repaired areas shall have a minimum coating thickness of 200+ 15 microns for Superstructure and sub structures.
- 1.8.3 Repair of damaged coating shall be done in accordance with the patching material manufacturer's written recommendations within the accepted rates.

1.9 INSPECTIONS:

The Engineer shall have free entry at all times to the parts of the contractor's works. The contractor shall afford the Engineer's representative all reasonable facilities to satisfy that the material is being furnished in accordance with this specification.

1.10 TESTING OF MATERIALS:

Following tests may be performed on the coating materials at CBRL, Roorkee testing laboratory by the contractor and testing report should be furnished to the Engineer

- Tensile strength, N/mm²
- Elongation, %
- Specific permeability, mg/cm²/mm/24hrs
- Adhesion with concrete, N/mm²

1.11 CERTIFICATION AND TEST REPORT:

Engineer shall be furnished with, at the time of completion, written certification that samples representing each lot have been tested as directed in this specification and the requirement have been met. A report of the test results shall be furnished to the Engineer.