

SABARMATI RIVER FRONT DEVELOPMENT



Sabarmati River Front Development Corporation Limited

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BID DOCUMENT

Construction of Roof structure covering promenades near Vallabh Sadan for SRFD Project with Bamboo tree and tensile roofing etc.

VOLUME- 02

IV) Technical Specification

**TECHNICAL SPECIFICATION
FOR
CIVIL WORKS**

GENERAL

The specifications to be followed for this work are the specification for road & bridges are published by the MORTH/CPWD for relevant Items. This specification shall be supplemented by the technical specification as given here under in this document and also the provision in the relevant IRC & IS codes.

In case of any discrepancy or contradiction if any in the provision of above specification the order of the precedence shall be followed.

1. MORTH/CPWD
2. IRC Provisions
3. Technical Specification in this Volume
4. IS Provisions
5. Sound Engineering Practice
6. Manufacture specification for special items

All work shall be carried out in confirmation with the above specifications. These specifications broadly cover all major aspects of the work involved. Minor details may not be specified here however if these are necessary for completion of work the contractor shall execute such minor items without any additions to the costs.

All work shall be executed in accordance with good engineering practices.

The Contractor shall remain responsible for workmen's compensation if any, when such case occurs, the contractor shall arrange for red lamps at night and fencing etc. shall be responsible for any damage of life and or property if any happen, during the execution of work. In case of dispute for unseen or overlooked items, the decision of Engineer in charge shall be final. The Contractor shall have to give site clean of all rubbish on completion of work and handover the bridge with final finishing as directed. All the rejected materials shall be removed from site within 24 hours by Contractor at his risk and cost.

The Contractor shall have to make his own arrangement for water required for the work.

If in the interest of SRFDCL, it is necessary to change either any site or the design of the proposed work the Contractor shall carry out the works and he will be paid at the rates quoted by him and no claim for extra for subsequent changes made, entertained.

The cubical contents of the cement bag shall be taken as per actual weight of bag and the Contractor shall have to prepare the concrete mixes using weigh batches.

Contractor will be fully responsible for compliance of the various provisions under Contract Labour Act, 1970 and the Rules framed there under.

Contractor is requested to procure their quarry materials required for construction work through legal sources i.e. only from the quarry lease holders permit holders or middleman who satisfies the contractor as to the legality of the source of purchase by him of these materials.

GENERAL DETAILS

All work shall be carried out in confirmation with these specifications. In general, provisions of Indian Standard, Indian Road Congress codes and other national standards shall be followed unless otherwise specified. These specifications are not intended to cover the minor details. The work shall be executed in accordance with best modern practices & all latest codes and standards referred to in these specifications shall be read in conjunction with the various other documents forming the contract, tender specifications, BOQ, contract drawings and other related documents.

Measurement and payments

a) The methods of measurement and payment shall be as described under various items and in Price Bid. Where specific definitions are not given, the methods described in MORTH/CPWD will be followed. Should there be any detail of construction of materials which has not been referred to in the specifications or in Price Bid and drawings but the necessity for which may be implied or inferred there from, or which are usual or essential for the completion of the work in the trades, the same shall be deemed to be included in the rates quoted by the contractor in Price Bid.

b) Unacceptable work

All defective works are liable to be demolished, rebuilt and defective materials replaced by the contractor at his own cost. In the event of such works being accepted by carrying out repairs etc. as specified by the engineer in charge, the cost of repairs will be borne by the contractor and will be paid for the works actually carried out by him at reduced rates of the tendered rates, as may be considered reasonable by the engineer in charge, in the preparation of final or on account bills.

SPECIFICATION FOR CIVIL WORKS

1. The specification for various items of work shall be same as specified for such items in the MORTH SPECIFICATIONS FOR ROAD AND BRIDGE WORKS/CPWD Works for buildings, latest published prior to 1 month before issue of tender.
2. The inclusions and exclusions from quoted rates are specified in the details of each item of work in the specifications and the Bill of Quantities. In case there is no specific mention of a particular detail, the mode of specification as prescribed in MORTH SPECIFICATIONS for such an item shall be followed.
3. In the event of contradiction between the MORTH specifications referred to above and this Contract document, the provisions of this Contract document shall prevail.

Item No-01 Earth work in excavation by mechanical means / manual means in foundation trenches, drains, manholes, soak wells etc. including necessary shoring & strutting, dewatering, getting out the excavated soil, sorting and stacking of useful material, For all civil, electrical and plumbing works. All kinds of soil.

1.0 General

1.1 Nabhi's commentary on CPWD specifications clause no. 2.1, 2.2, 2.3 shall be followed.

2.0 Site Clearance

2.1 Nabhi's commentary on CPWD specifications clause no. 2.4 shall be followed except nothing extra will be paid for removing, diverting existing structures and services and providing fencing for the any archeological monuments within or adjacent to the area.

3.0 Setting out and making profiles

3.1 Nabhi's commentary on CPWD specifications clause no. 2.5 shall be followed.

4.0 Excavation

4.1 Nabhi's commentary on CPWD specifications clause no. 2.7 shall be followed up to any width (not restricted to 1.5m) and any area (not restricted to 10 sqm) on plan.

4.2 The Contractor shall do the necessary shoring and strutting or shall provide necessary slopes to a safe angle or steps as required or directed at his own cost. No extra payment shall be made for such precautionary measures, taken

4.3 The Contractor shall at his own expense and without extra charge make provision of supporting all utility services, lighting the trenches, separating and stacking serviceable materials neatly, shoring, timbering, strutting, bailing out water either sub-soil or rainwater, including pumping at any stage of the work. Trenches shall be kept free of water while masonry or concrete works are in progress and till the Architect and Engineer-in-charge considers it necessary, i.e. till the concrete is sufficiently set.

5.0 Disposal of the excavated stuff

5.1 The excavated stuff of the selected type shall be used in filling the trenches and plinth or leveling the ground in layers, including ramming and watering etc. complete as directed by the engineer-in-charge.

5.2 The Contractor has to dispose the surplus excavated earth within the plot at non objectionable place.

5.3 The lead is the shortest practical route and not necessarily the route actually taken. The decision of Engineer-In charge shall be final.

6.0 Mode of Measurement and Payment

- 6.1 Nabhi's commentary on CPWD specifications clause no. 2.10, 2.11 shall be followed.
- 6.2 The rate shall also include necessary shoring & strutting, dewatering, getting out the excavated soil, sorting and stacking of useful material, dressing of the sides, ramming of bottom, backfilling into trenches and disposal of surplus excavated earth at non objectionable place within the site.

ITEM No-2, PCC M-15

Providing and Laying Plain Cement Concrete Good quality of cement, sand, gravel shall be supplied for the work of plain cement concrete M-15. The sand and the gravel shall be actually measured and mixed with cement in the mixture machine to make uniform consistent concrete and this concrete shall only be used.

Whenever concrete is required to be mixed manually the same shall be mixed on the concrete / steel platform using 10% more cement, which shall not be paid extra. When the concrete is to be manually mixed, it shall be thoroughly mixed twice before the water is added and twice after the water is added and when the concrete is of uniform color then only it can be used. The concrete left unused for more than 20 minutes will not be allowed to be use. The form work for the cement concrete work shall be strong and of very good quality. Oil shall be applied on it before the concreting. The item shall include the rate of providing form work, centering nails, labour for removing form work, etc., and no separate charge shall be paid for it. The concrete work shall be kept wet by watering at least 3 times a day and cured for 15 days. The entire work shall be carried out using good quality material and form work and employing skilled masons. The rate shall be per cubic meter of concrete.

ITEM No-3 R.C.C. M-25

Providing and laying in position machine mixed machine vibrated reinforced cement concrete (ordinary concrete with volume batching) for columns, pillars, piers, abutments, beams, balconies, chajjas, lintels, kerbs, steps, arches, doms, shells, valults, chimneys, shafts, etc. of following grades at all floors including finishing, curing and excluding the cost of centering, shuttering etc. complete as directed by the engineer-in-charge.

1.0 Materials

1.1 Water

1.1.1 Water shall conform to M-1.

1.2 Cement

1.2.1 Cement shall conform to M-3.

1.3 Coarse Sand

1.3.1 Sand shall conform to M-6.

1.4 Coarse Aggregate

1.4.1 Coarse Aggregate shall conform to M-12.

2.0 Workmanship

2.1 Nabhi's commentary on CPWD specifications clause 5.4.1 to 5.4.10 shall be followed.

2.2 Relevant specifications of item no. 2.01 for inspection, sampling and testing of concrete, stripping shall be followed.

2.3 All concrete work shall have fair finished surface unless otherwise specified in the item.

3.0 Mode of Measurement and Payment rendering

3.1 Nabhi's commentary on CPWD specifications clause 5.4.11.1, 5.4.11.4, 5.4.11.5, 5.4.12, 5.4.13.1, 5.4.13.2, 5.4.13.4 shall be followed. The rate includes the cost of formwork but excludes the cost of reinforcement.

3.2 All structural elements like footing, slab, beam, columns, walls, lintels, chajjas etc. shall not be classified, measured and paid separately.

3.3 The rate includes the cost of material, labour, tools and plant required for mixing, placing in position vibrating and compacting, finishing as directed by engineer-in-charge curing and all other incidental expenses for producing concrete of specified strength, for all floors, all shapes at any height and level, and in any position.

3.4 The rate shall be for an unit of one cum. The cost of formwork shall be included or excluded as per the item description.

ITEM No-4 TMT Fe-500 Grade Reinforcement

Supplying, fabricating and placing / fixing in position TMT reinforcement bars FE-500 conforming to IS-1786 reinforcement for RCC structures / items as per design including transporting steel to the work site, handling, decoiling, hooking, cutting, bending, cranking, fabricating to required shape, placing in position and tying / binding the system with MS 18 gauge wires, welding if necessary etc., for

all floors / all levels / all heights complete as per specifications and direction of Engineer Incharge. Measurement will be made on the length basis and converted into weight by using standard co-efficient (rolling margin's and wastage shall not be paid). The quoted rate should be inclusive the cost of Binding wire and the same will not be measured and paid separately. for all civil, plumbing, electrical & infrastructure works. The quoted rate should be inclusive the cost of Binding wire, laps, chairs, hooks for lifting, spacers etc and the same will not be measured and paid separately.

1.0 Material

1.1 Reinforcement

1.1.1 Reinforcement shall conform to M-17.

1.2 Binding Wire

1.2.1 Binding Wire shall conform to M-18.

2.0 Workmanship

2.1 CPWD Technical specifications clause no. 5.3.1 and 5.3.2 is to be followed.

2.2 The type of reinforcement shall be as per the item description. The contractor shall submit the test certificate from steel manufacturer as and when required. The test results shall be verified, if required in any reputed laboratory.

2.3 Bar bending schedule shall be made by the contractor before starting the work. The payment shall be done based on quantity worked out in bar bending schedule. The bar bending schedule shall be prepared as per SP 34.

2.4 All the reinforcement bars shall be accurately placed in exact position shown on the drawings and shall be securely held in position with 18 guage MS binding wire as approved by Engineer-in charge. The rebars shall be placed with stay blocks or metal chair spacers, metal hangers, supporting wires or other approved devices at sufficiently close intervals. Bars shall not be allowed to sag between supports nor displaced during concreting or any other operations of the work. All devices used for positioning shall be of non-corrodible material. Wooden and metal supports shall not extend to the surface of concrete, except where shown on drawing. Placing bars on layers of freshly laid concrete as the work progresses for adjusting bar spacing shall not allowed. Pieces of broken stone or brick and wooden blocks shall not be used. Layers of bars shall be separated by spacer bars at 1m c/c , Precast cover blocks in cement mortar 1:2 (1cement : 2 coarse sand) about 4 X 4 cm square section or 4 cm dia round section or PVC cover blocks shall be used to maintain the cover of the concrete members as directed by Engineer In charge or Architect. Reinforcement after being placed in position shall be maintained in a clean condition until completely embedded in

concrete. Special care shall be exercised to prevent any displacement of reinforcement in concrete already placed. To prevent reinforcement from corrosion, concrete cover shall be provided as indicated on drawing. All the bars projecting from concrete and to which other bars are to be spliced and which are likely to be exposed for a period exceeding 10 days shall be protected by a thick coat of neat cement grout.

- 2.5 Bars crossing each other where required shall be secured by 16 gauge GI binding wires (annealed) of size not less than 1 mm., in such manner than they do not slip over each other at the time of fixing and concreting.

As far as possible, bars of full length shall be used. In case this is not possible, overlapping of bars shall be done as directed. Where directed and practicable overlapping bars shall not touch each other, but be kept apart by 25 mm. or 1.25 times the maximum size of the coarse aggregate, whichever is greater by concrete between them. Where not feasible, overlapping bars shall be bound with annealed wires not less than 1 mm. thick, twisted tight. The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending movement is maximum in beam and slab.

Whenever indicated on the drawings or desired by the Architect and Engineer-in-charge, bars shall be joined by couplings which shall have a cross section sufficient to transmit the full stresses of bars. The ends of the bars that are joined by coupling shall be upset for sufficient length so that the effective cross sectional the base of threads is not less than normal cross section of the bar. Threads shall be standard threads. Steel coupling shall conform to IS : 226.

When permitted or specified on the drawings, joints of reinforcement bars shall be welded with appropriate welding rod as per the instructions given by Structural Engineer. The type of welding, size of fillet etc shall be as approved by Structural Engineer. Welded joints shall preferably be located at points when steel will not be subject to more than 75 % of the maximum permissible stresses and welds so staggered that any one section not more than 20 % of the rods are welded. Only electric arc welding using a process which excludes air from the molten metal and conforms to any or all other special provisions for the work shall be accepted. Suitable means shall be provided for holding bars securely in position during welding. It shall be ensured that no voids are left in welding and when welding is done in 2 or 3 stages, previous surface shall be cleaned properly. Ends of the bars shall be cleaned of all loose scale, rust, grease paint and other foreign matter before welding. Only competent welders shall be employed on the work. The M.S electrodes used for welding shall conform to IS: 814. Welded pieces of reinforcement shall be tested. Specimen shall be taken from the actual site and their number and frequency of test shall be as directed. Welding shall be done by electric arc process as per IS : 816 and IS : 823.

At the time of concreting, a bar fitter shall remain at site to keep the reinforcement in position.

3.0 Mode of Measurement and Payment

- 3.1 Reinforcement shall be measured in length including overlaps, separately for different diameters as actually used in the work. Where welding or coupling is resorted to in place of lap joints, such joints shall be measured for payment as equivalent length of overlap as per design requirement. From the length so measured, the weight of reinforcement shall be calculated in tones by using standard IS co-efficient. Length shall include hooks at the ends. The wastage of steel and binding wires shall not be measured and paid extra. The rolling margin of steel shall not be paid extra.

The rate for reinforcement shall include the cost of labour and material required for all operations described above like cleaning of reinforcement bars, straightening, cutting, hooking, bending, binding, welding placing in position etc. as per the drawing or directed by the Architect or engineer-in-charge Rate shall also include the cost of GI binding wires of 16 to 18 gauge, devices like chairs, pins, spacer bars, cover blocks of PVC or cement mortar etc. for keeping reinforcement in position. The rate shall for an unit of MT.

Item No.-5/6/7 Dismantling and demolition of RCC / PCC / Paved flooring

The contractor shall have to dismantle existing RCC/ PCC/ Brick work according to requirement and instruction of engineer – in – charge. The removed stuff shall be transported and placed without affecting the work and general peoples according to instruction of engineer-in-charge.

Item No-8 Construction of Bamboo Structure Roof

Providing and constructing of Bamboo structure using Dendocalamus Stoksii 45-55 mm diameter as per drawing incl. transportation, loading, unloading, carting, Assembling jointing (using MS 250 Grade Joinery with 60-80 Micron powder coating and SS 304 Grade nuts and bolts and clamps as per fixing detail as shown in drawing) Joining, bending and fixing, placing, erecting in desired shape and size including making of mesh with bamboo splits (Bambusa Balcoa) of size 30mm wide 150mmx150mm incl. required supports and tools, plants, scaffolding, equipments, formwork , labour, polishing with water based PU as per details provided. The Item includes provision of structural stability certificate for Detailed engineering.

Mode of measurement will be actual area of curvature as per site (in sq. mt.)

1.1 Overview

Bamboo structures are innovative, sustainable, and versatile solutions used in modern and traditional construction. As a renewable material with excellent mechanical properties, bamboo has found applications in residential, commercial, and industrial structures. Below is a comprehensive overview of bamboo structures, covering their characteristics, benefits, challenges, and uses.

1.2 Characteristics of Bamboo as a Construction Material

- **Renewable Resource:**
Bamboo grows rapidly (3–5 years to maturity) and can be sustainably harvested.
- **Mechanical Strength:**
High tensile strength (comparable to steel) and good compressive strength.
- **Lightweight:**
Easy to transport and handle, making it ideal for both temporary and permanent structures.
- **Flexibility:**
Naturally elastic, making it resistant to earthquakes and strong winds.

1.3 Types of bamboo structures

A. Traditional Bamboo Structures

- **Houses and Huts:** Found in rural and tribal areas, often using untreated bamboo.
- **Community Halls and Pavilions:** Designed with simple frameworks and natural finishes.

B. Modern Bamboo Structures

- **Eco-Resorts:** Bamboo is a key material for resorts and cottages.
- **Bridges:** Lightweight pedestrian and vehicular bridges.
- **Temporary Shelters:** Used in disaster-prone areas for emergency housing.
- **Greenhouses and Sheds:** Frameworks for agricultural use.

C. Innovative Designs

- **Arched and Geodesic Structures:** For modern architecture and exhibitions.
- **High-Performance Buildings:** Laminated bamboo beams and panels are used for greater load-bearing capacity.

1.4 Applications of bamboo structures

- **Residential Construction**
- **Homes and Huts:**
 - Used in rural and semi-urban areas for low-cost housing.
 - Lightweight and seismic-resistant, making them suitable for earthquake-prone regions.
- **Roofing and Ceiling:**
 - Bamboo panels, planks, or woven mats serve as cost-effective, aesthetic roof and ceiling materials.
- **Flooring:**

- Durable and polished bamboo planks or laminated bamboo flooring add elegance to interiors.
- **Commercial and Public Buildings**
- **Eco-Resorts and Hotels:**
 - Popular in eco-tourism for cottages, gazebos, and reception areas due to their natural appeal.
- **Pavilions and Exhibition Halls:**
 - Bamboo's flexibility and lightweight properties make it ideal for temporary or semi-permanent structures.
- **Landscaping and Recreational Spaces**
- **Gazebos and Pergolas:**
 - Create outdoor leisure spaces with a rustic touch.
- **Bridges and Walkways:**
 - Small-scale pedestrian bridges and pathways in parks and gardens.
- **Temporary and Emergency Shelter**
- Bamboo is extensively used in constructing emergency shelters during natural disasters due to its portability and quick assembly.
- **Agricultural and Industrial Applications**
- **Storage Sheds:**
 - Grain or tool storage in farms, with structures tailored to weather conditions.
- **Greenhouses:**
 - Frameworks for lightweight and cost-efficient greenhouse covers
- **Urban Applications**
- **Fencing and Boundary Walls:**
 - Bamboo fences offer privacy and are aesthetically pleasing for urban homes.
- **Partition Walls:**
 - Used indoors for separating spaces in an open-plan layout.
- **Infrastructure Applications**
- **Scaffolding:**
 - Widely used in construction projects for lightweight and strong support.
- **Temporary Bridges:**
 - For light vehicles and pedestrians, especially in rural areas.

1.5 Properties of bamboo

1. Physical Properties

- **Lightweight:**
 - Bamboo has a low density (approximately 0.6–0.9 g/cm³), making structures easy to transport and assemble.
- **High Flexibility:**
 - Can withstand deformation under load without breaking, making it ideal for seismic and wind-resistant designs.
- **Hollow Cylindrical Shape:**
 - Efficient load distribution with high strength-to-weight ratio.

2. Mechanical Properties

- **High Tensile Strength:**
 - Tensile strength ranges from 100–400 MPa, comparable to mild steel. This makes bamboo suitable for structural applications.
- **Compressive Strength:**
 - Compressive strength varies from 40–80 MPa, allowing it to support significant loads as columns or beams.
- **Bending Strength:**
 - Exhibits bending strength of 50–100 MPa, enabling use in curved or arched structures.
- **Elastic Modulus:**
 - Elastic modulus ranges from 10,000–20,000 MPa, indicating moderate stiffness for flexibility in design.
- **Ductility:**
 - Can bend significantly before failure, which helps absorb seismic energy.

3. Thermal Properties

- **Thermal Insulation:**
 - Bamboo provides natural insulation due to its hollow structure and cellular composition.
- **Thermal Conductivity:**
 - Low thermal conductivity (~0.2 W/m·K), making bamboo structures energy-efficient in moderate climates.

4. Durability Properties

- **Longevity:**
 - Treated bamboo can last 20–30 years or more when properly maintained.
- **Resistance to Moisture:**
 - Requires treatment to resist rot and decay in humid conditions.
- **Pest Resistance:**
 - Untreated bamboo is prone to termite and insect attacks; chemical treatments like borax-boric acid are essential for durability.

5. Environmental Properties

- **Sustainability:**
 - Bamboo is a renewable resource with a fast growth rate (3–5 years for maturity).
- **Low Carbon Footprint:**
 - Absorbs significant CO₂ during growth and requires minimal energy for processing.
- **Biodegradability:**
 - Bamboo components decompose naturally without harming the environment.

6. Structural Properties

- **Seismic Performance:**
 - High flexibility and ductility make bamboo structures highly resistant to earthquakes.
- **Wind Resistance:**
 - Bamboo's lightweight yet strong structure performs well in high wind speeds.
- **Load Bearing:**
 - Capable of supporting both live and dead loads when designed per standards like IS 6874:2008.

7. Aesthetic Properties

- **Natural Appearance:**
 - Provides a rustic, eco-friendly look that blends with natural surroundings.
- **Versatility:**
 - Can be used for both traditional and modern architectural designs.

8. Limitations

- **Moisture Sensitivity:**

- Requires proper treatment to avoid swelling or decay due to water.
- **Fire Resistance:**
 - Untreated bamboo is combustible; fire retardant coatings are necessary.
- **Dimensional Stability:**
 - Prone to shrinkage during drying; requires seasoned bamboo to minimize dimensional changes.

1.6 Technical Specifications of bamboo

Bamboo structures are an eco-friendly and aesthetically appealing choice for modern construction. Below are the technical specifications for designing and constructing bamboo structures with arched designs, adhering to relevant standards, including the National Building Code of India (NBC 2016) and IS codes.

- General Specifications

- **Material:** Bamboo, preferably from species such as *Dendrocalamus strictus* or *Bambusa balcooa*, due to their high strength and durability.
- **Design Standard:** Follow the guidelines in **IS 6874:2008** (Method of treatment of bamboo for structural purposes).
- **Moisture Content:** Ensure bamboo has a moisture content of **12–16%**, achieved through proper drying methods.
- **Treatment:** Bamboo must be treated to prevent insect and fungal attacks, using methods like:
 - Borax-boric acid treatment
 - Hot and cold soaking
 - Pressure impregnation as per IS 1902:2006.

- Design Parameters

Arched Design Considerations

1. **Span and Curvature:**
 - Maximum span: **6–12 meters** (depending on the bamboo species and thickness).
 - Radius of curvature: **2–5 meters** for moderate arches; design calculations are necessary to ensure stability.
2. **Load-Bearing Capacity:**

- Live load and dead load must be calculated as per **IS 875 (Part 2):1987** and **IS 875 (Part 1):1987**.
- Factor of safety for bamboo structures: **3–4** as per IS guidelines.

3. Connections:

- Joints: Use **metal straps, bolts, or lashings** for high-strength joints.
- Adhesives: Epoxy or polyurethane-based adhesives compatible with bamboo.
- Lashing techniques: Use natural fibers or treated synthetic ropes, ensuring durability and aesthetics.

- Foundation

- **Type:** Raised or embedded foundations are preferred to prevent direct ground contact.

- **Materials:** Concrete, stone, or treated wood.

- **Specifications:**

- Depth of foundation: Minimum **600 mm**, adjusted for soil conditions as per **IS 1904:1986**.
- Anchoring: Use bamboo anchors or metal plates embedded in concrete.

- Structural Elements

Bamboo Selection:

- **Culm Dimensions:**

- Diameter: **45–55 mm** for main structural members.
- Wall thickness: Minimum **10 mm**.
- Nodes: Spacing not exceeding **300 mm**.

Roof Design:

- Roofing Material: Compatible materials include **thatch, metal sheets, or bamboo mats with waterproof coatings**.
- Pitch: Optimal roof pitch of **30–45 degrees** to prevent water accumulation.

Flooring:



- Flooring materials: Bamboo planks treated for durability or composite bamboo flooring.
- Support: Ensure load transfer through a well-distributed lattice or framework.




- Durability and Maintenance





- **Coatings:** Use water-resistant and UV-resistant coatings to enhance the lifespan of bamboo.
- **Inspection:** Conduct periodic inspections for pest damage or structural wear.







- **Replacement:** Design joints for easy replacement of individual bamboo members.
- **Fire Safety**
 - Treat bamboo with fire-retardant chemicals as per **IS 9096:1979**.
 - Ensure firebreaks in larger structures.
- **Sustainability and Environment**
 - Use locally sourced bamboo to minimize carbon footprint.
 - Employ modular designs to allow for future expansion or reconfiguration.
- **Aesthetic Considerations**
 - Ensure uniformity in the arched design by using pre-curved bamboo or heat-bent methods.
 - Highlight natural bamboo finishes, complemented with sustainable coatings for aesthetics.
- **References**
 1. **IS 6874:2008** – Method of treatment of bamboo for structural purposes.
 2. **IS 875:1987** (Parts 1 and 2) – Code of practice for design loads.
 3. **IS 1902:2006** – Code of practice for preservation of bamboo.
 4. **National Building Code of India, 2016** – Structural safety and fire safety provisions.



Detailed Technical Specifications:

S.No	Resources/Item of work	Specification	Image
01	Bamboo for canopy structure Dendrocalamus stocksii	Dendrocalamus stocksii is a strong, durable and flexible bamboo used as a pillar/pole. 45mm to 55 mm diameter is best suitable as a pole, of length 12'-18'.	
02	Treatment Method for Dendrocalamus stocksii: Copper chrome Boron (CCB) is one of the best bamboo preservative.	CCB is fix type water borne wood preservative which provides fine protection to various bamboo damaging insects and factors. CCB is used in vacuum pressure method CCB is very effective against wood borers, fungi, decay, marine orgasms and termites andprotects bamboo for a long time which is highly exposed and is in ground contact.	

03	<p>Roofing Bamboo Splits Mesh Bamboo splits will be used to make the bamboo mesh grid, as required as per architect's need.</p>	<p>Cross-cutting culms into sections of a standard length Longitudinal splitting of culms into splits Removing the green epidermal layer and knots to produce slabs Splitting the slabs into splits</p>	
04	<p>Roofing Clear Sheet</p>	<p>Clear Polycarbonate Roofing Sheets, Weather-Resistant Transparent Acrylic Plastic Sheet</p>	
05	<p>Hardware: SS threaded rod and SS nut, flanged nut, dome nut, hose clamps, electrical hardware and as per site condition and structure requirement.</p>	<p>6mm-10mm threaded rod, 6mm-10mm nut, The 202 grade has 16% minimum chromium and 0.5% minimum nickel in the composition where the 304 has 18% minimum chromium and 8% minimum nickel</p>	



<p>06</p>	<p>Tools and Machinery Various hand and electrical tools are required for different tasks.</p>	<p>Measuring Tapes 3m,5m And 30m Hack Saw+ Blades Prune Saw+ Blades Kukri Long Knives Coping Saw Miter Saw Drilling Machines Metal Drill Bits Hinge Hole Cutter Chisel Chisel Sharpener Rubber Mallet Plastic Mallet Iron Hammer Spanner Set Sand Paper Wood Filler Metal Filler Hose Clamps Plumb Bob Coloured Cellotapes Notepads Safety Goggles Safety Gloves Helmet Harness Led Lights Switch Boards Wires Chalks And Lime Ropes And Thread Paint Brush And Buckets Marking Tools Araldite Tarpaulins And Etc.</p>	   
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07	Scaffolding and Formwork	Local bamboo and metal scaffolding will be required for making a base and to work on heights, and marking the levels	 
08	Fabrication: Metal Frame	Metal skeleton structure needs to be erected for bamboo structure, by using box sections, 100mmX100mm – 150mmX150mm. L section, 25mm-75mm. Box section pipe, 25mmX25mm-45mmX45mm. Welding rods and other hardware included. Foundation details may also include metal work.	
09	Fabrication: Joinery	Metal fabrication joinery to be derived after designing and structural consultancy. It consists of a metal plate with varied thickness and sizes and box sections as per structure needs.	  

10	Polishing, Cleaning, and Finishing	<p>Cleaning will be done with soft water, detergent and metal scrub</p> <p>Polishing will be done using water based spraying agent in two layers of base coat and finish coat. Around 180-220lts of solvent required.</p>	 
11	Trained Bamboo Artisans	<p>Artisan team will be called for making the structure from various region of India</p> <p>The number of members may depends of nature of work and site condition.</p> <p>Local Helpers may also be trained and included in the ongoing work,</p> <p>For master artisan: per day cost range will be 850-1000 rs.</p> <p>Helper cost range: 600-800 rs.</p> <p>Local helper range:500-750rs</p>	
12	Artisan Food, Travel, and Stay	<p>Artisans needs accommodation needs to be arranged nearby site, with basic amenities of toilet, electivity and hygiene.</p> <p>Food needs to be provided either in tiffin form or ration form (with gas stove and cylinder)</p> <p>Travelling charged needs to be covered.</p>	
13	Architects and Engineerteam Logistics, Lodging and Food	<p>Basic amenities of toilet, electivity and hygiene.</p>	

		<p>Workable space for laptop usage</p> <p>Food needs to be provided either in tiffin form.</p> <p>Travelling charged needs to be covered.</p> <p>Local logistics charges to be covered.</p>	
14	Execution and Management	<p>Description of the services to be provided</p> <ul style="list-style-type: none"> • Technical consultancy for bamboo construction • Material sourcing and finalization • Designing and detailing, including developing architectural plans and ensuring the design aligns with structural integrity and aesthetic preferences • Fabrication details development for bamboo joinery • Incorporation of services such as electrical, plumbing, HVAC, and roofing into the bamboo structure • Coordination with various service providers <p>Bamboo execution and quality supervision, including:</p> <ul style="list-style-type: none"> • Site supervision and management • Sampling of necessary items • Overseeing the construction process • Managing labor and resources • Quality checks and regular inspections 	
15	Structural Consultancy	<p>Providing optioneernig and a proposal for a structural concept and structural assembly based on the architectural intent.</p> <p>Preliminary structural analysis.</p> <p>Preliminary BOQ based on the structural proposal.</p> <p>Design development, providing a 3D model, and finalizing the structure of</p>	



		the proposed construction assembly.	
14	Transportation	Materials will be coming from various region of India depending upon structure needs and Quantity. We may need to transport material and hardware.	
15	Bamboo Bending	Bamboo bending will be required for getting the required curves and bends. Heating of bamboo will be done, and curved will be achieved.	 
16	Miscellaneous	Unseen and unexpected minor and major cost not included in the budget.	

ITEM No-9 Polycarbonate sheet:

Providing and Fixing roofing sheet of solid Poly carbonate 3 mm Thick UV stabilized as per IS: 14443-1997 with light transmission more than 85% on all outer layer above 2500 mm Height from Ground level including cutting, bending in required shape and size including wastage and 50mm overlap if any and fixing on bamboo grid structure of 150mm x 150mm with all necessary materials, labour and SS nut, hooks and washers etc. complete

Mode of measurement will be actual area of curvature as per site (in sq. mt.)

ITEM No-10 Structural steel Work

Structural steel work in riveted, bolted or welded in built up sections, trusses and framed work including supplying, fabricating, cutting, assembling, hoisting and



fixing in position at all heights of all shapes and size with all leads and lifts . It should be including necessary rolled joists, channels, angles, tees, flats, angle cleats, gusset plates, position hip and jack lifters, purling, etc. including cutting and welding the members as per detailed drawing and design. The rate shall include dry sanding, degreasing (wet cleaning) & preparation of rust free surface manually or mechanically, metal putty to make the surface even and smooth, 1 coat of epoxy primer and 2 top coats of Metal PU Paint of having of approved shade of MRF or equivalent paint as per manufacture's specification over all the surfaces of the steel sections

1 Material

1.1 Structural steel

1.1.1 Structural Steel shall conform to M-60.

2.0 Workmanship

2.1 Laying Out

2.1.1 Nabhi's commentary on CPWD specifications clause no. 10.3.1 shall be followed.

2.2 Preparation of Surface

2.2.1 Surfaces which are to be welded together shall be free from loose mill scale, rust paint, grease or foreign matters. A coating of linseed oil shall be permitted.

2.3 Fabrication

2.3.1 Nabhi's commentary on CPWD specifications clause no. 10.3.2, 10.4.2.1, 10.4.2.2, 10.4.2.3 10.4.2.4, 10.4.2.5, 10.4.2.6 shall be followed.

2.4 Erection

2.4.1 Nabhi's commentary on CPWD specifications clause no. 10.3.3, 10.4.2.7 shall be followed. Grouting shall be done with cement mortar 1:3 (1 cement: 3 coarse sand) or nonshrink free flow cement



grout of approved make as per manufacture's specification as directed by engineer-in-charge.

2.5 Precautions

2.5.1 2.4.1 Nabhi's commentary on CPWD specifications clause no. 10.4.2.3 shall be followed.

2.5.2 2.4.2 The following points shall be borne in mind during the process of welding

- 2.5.3 (a) Welds shall be made in flat position wherever practicable.
(b) Arc length, voltage and amperage shall be suited to the thickness of material, type of groove and other circumstances of the work.
(c) The segments of welding shall be such that where possible, the members which offer the greatest resistance to compression are welded first.
(d) Proper care shall be taken while welding, for shrinkage and distortions, as the drawing dimensions are the finished dimensions of the structure.

2.5.4 The defective welds which shall be considered harmful to the strength shall cut out and re-welded.

2.5.5 Finished welds and adjacent part shall be protected with clean boiled linseed oil and after all stag has been removed welds and adjacent parts shall be painted after the same are approved.

2.5.6 All the members shall be thoroughly cleaned of rust, cakes, dust etc. and given a priming coat of zinc chromate red oxide before fixing them in position. All fabricated members shall be suitably packed to be protected from any damage while transportation, if any.

2.5.7 Grinding to the finished level is to be done, if directed by Engineer in charge. All exposed weld shall be ground smooth. Welds which have not been ground shall be scrubbed with a 10% solution of Hydrochloric acid which shall be washed of with water before painting unless alkali resistant paint is used.

2.6 Painting



2.6.1 Nabhi's commentary on CPWD specification clause no. 10.2.2 shall be followed except paint shall be as per

Item description.

2.6.2 First priming coat of zinc chromate yellow oxide is to be applied on the fresh steel arrived at site.

2.6.3 Once the cutting, fabrication, grinding work gets completed second coat of primer and first coat of enamel paint is to be applied on the priming coat.

2.6.4 After paint has been already dried erection is done as specified in the item or as directed by engineer-in-charge.

2.6.5 After the erection final coat or second coat of paint is to be applied on the structural steel.

3 Mode of Measurement and Payment

- 3.1 The weight of steel plates, sections and strips shall be taken from relevant IS Codes, based on 7.85 kg/m^2 for every mm. sheet thickness, if steel is supplied by the Contractor, otherwise, the weight shall be calculated on the actual weight basis on which steel is supplied to the Contractor by the Client. If the steel is supplied by the client, testing & checking as per relevant IS code, recording and intimation of quality of steel (to client and consultant) shall be sole responsibility of the contractor.
- 3.2 For forged steel and steel castings, weight shall be calculated on the basis of 7850 kg/m^3 .
- 3.3 Rolling Margin and wastage shall not be considered when weight is determined by standard weight on the basis of IS codes.
- 3.4 The rate includes cost of all material, labor involved in all operations as described above like erection, hoisting, scaffolding, painting as specified in item description, safety measures and sundry required for proper completion of the item of work, at all heights, all shapes and all places. This shall also include conveyance and delivery, handling, loading, unloading and storing etc. required for completion the item described above including necessary wastage involve.



3.5 The rate shall be for an unit of one Kg.

ITEM No-11 Structural steel Work-Extra arte for bending

Relevant specifications of item no. 10.01.a shall be followed except the work is to be carried out where bending of specific curvature is required to be applied on machine

ITEM No-12 Hot deep galvanizing

Hot deep galvanizing work confirming to IS 4579/ 2629/ 2633 with zinc of 85 micron thickness on Railing, Handrail, flag fixing sleeve pole, garbage box, Street furniture and similar works etc made from solid flat, bar, RHS, SHS, tubular hollow sections etc. as per the drawing and as instructed by engineer in charge. The rate shall include preparing the surface by shot blasting/ acid washing prior to hot deep galvanizing, labor, tools, machinery etc complete (Sample to be approved).

Scope

This specification covers the general requirements of hot dip galvanizing for fabricated M.S. sections-plates, foundation bolts including cleaning of any paint, grease, rust, scale, acid or alkali or such other foreign matters.

Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable.

- (i) IS: 4759-20.79: Specification for Hot Dip Zinc Coatings on Structural Steel and other allied Products.
- (ii) IS: 209-20.79: Specification for zinc.
- (iii) IS: 2629-20.66: Recommended Practice for Hot Dip Galvanizing of Iron and Steel.
- (iv) IS: 6158-20.71: Recommended Practice for Safe-guarding against Embrittlement of Hot Dip Galvanized Iron & Steel Product.
- (v) IS: 2633-20.72: Method of Testing Uniformity of Coating on Zinc Coated Articles.
- (vi) IS: 6745-20.72: Method for Determination of weight of Zinc Coating on Zinc coated iron and steel articles (with amendment No. 1).
- (vii) ASTM A-123: Spec. for Zinc (Hot Galvanized) Coatings on (20.78) Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strips.



General Requirements

QUALITY OF ZINC: Zinc conforming to at least grade Zn 99.95 specified in IS: 209-20.79 shall be used for the purpose of galvanizing.

BASE METAL: The steels and castings shall be in accordance with clause 2 of IS: 6158-20.71. Where steel is supplied by the fabricator, it is the responsibility of the fabricator to select suitable steel which will withstand normal galvanizing operation without embrittlement.

The edges of tightly contacting surfaces should be completely sealed by welding. The residue of coated electrodes should be removed, prior to pickling, by brushing, chipping or sand blasting.

SURFACE PREPARATION: Surface shall be cleaned and prepared as per clause 4 of IS: 2629-20.66. Malleable iron castings shall be shot and grit blasted before galvanizing.

GALVANISING: The members shall be galvanized in accordance with the practice contained in the IS: 2629-20.66 unless otherwise specified in the succeeding paragraphs.

Coating Requirements

MASS OF ZINC COATING: Minimum average mass of zinc coating on different kinds of articles shall be as under:

Fabricated steel

Thickness less than 2 mm
but not less than 1.2 mm
340 gms/sq.m

Thickness 2 mm and above 750 gms/sq.m

Fasteners

Up to nominal size M10 270 gms/sq.m

Over M10 300 gms/sq.m



Note: Articles galvanized with 1000 g/m² zinc coatings shall be identified by a band of green paint by the galvanizer.

FREEDOM FROM DEFECTS: The zinc coatings shall be uniform, adherent, reasonably smooth and free from imperfections such as flux ash and dross inclusions, bare patches, black spots, pimples, lumpiness and runs, rust stains, bulky white deposits and blisters, etc. These terms have been defined in IS: 2629-20.66 (duly amended wherever necessary).

STEEL EMBRITTLEMENT: The design of the product and the selection of steel, wherever steel is to be supplied by fabricator, for its suitability to withstand normal galvanizing operations without embrittlement or the method of fabrication shall be the responsibility of the fabricator. Recommended precautions to properly design, fabricate and prepare the material for galvanizing to prevent embrittlement shall be as per IS: 6158-20.71.

Tests

TYPE TESTS

- (a) Visual Inspection
- (b) Adhesion of coating
- (c) Uniformity of coating
- (d) Mass of zinc coating

Each test shall be conducted on three samples.

ACCEPTANCE TESTS

- (a) Visual Inspection
- (b) Adhesion of coating
- (c) Uniformity of coating
- (d) Mass of zinc coating

ROUTINE TESTS

- (a) Visual Inspection

Scale of Sampling and criteria for conformity

LOT: All the material of the same type in a coating bath whose characteristics are intended to be uniform shall be grouped together to constitute a lot.

A lot shall not consist of more than one shift's production or 100 nos. whichever is lower.



Sample shall be taken from each bath and tested for conformity of coating. Where the galvanizing is done without the presence of Purchaser, the manufacturer may prepare lots consisting of the articles of the same type and material and galvanized in the same bath. If there are more than one bath, separate lots shall be prepared for each bath.

SCALE OF SAMPLING:

Samples in accordance with TABLE 1 shall be taken, at random, from each lot for tests.

TABLE 1: Scale of Sampling

Lot size	Sample size	Permissible no. of defective units
Up to 25	3	0
26-50	5	0
51-100	8	0
101 and above	13	1

For materials of inconvenient lengths and from which it is not possible to cut a specimen for coating characteristic tests, two test pieces of same cross section and not less than 90 cms length shall be galvanized in the same bath.

The samples selected in accordance with Table 1 above shall be subjected to the visual inspection.

If any sample fails to conform to the requirement, the lot shall be rejected. The galvaniser, however, may segregate the good pieces of the lot and submit them once again for inspection.

If the lot inspected for visual inspection, passes the test, 3 samples for coating characteristics shall be taken from the samples, which were subjected to the visual tests

Each of the 3 samples will be subjected to test for adhesion, uniformity, mass of zinc coating. Should any sample fail in any test, six more samples shall be taken from the lot and all the 3 tests repeated. Should any sample fail in the retest, the lot shall be rejected. If it is not possible to take six samples for the test, the lot shall be rejected.



The material in a lot which has been rejected may be stripped and re-galvanized and submitted for inspection and tests.

TEST METHODS

VISUAL INSPECTION: The material shall be inspected visually to observe that it is smooth, reasonably bright, continuous and free from such imperfections as flux/ash/dross inclusions, bare patches, black spots, pimples, lumpiness runs, rust stains, bulky white deposits and blisters. The stains of flux, usually white in colour, shall not be regarded as flux intrusions.

ADHESION OF GALVANISED COATING:

Coating shall withstand the knife tests as prescribed in IS: 2629-20.66. When cut or pried into, such as with a stout knife applied with considerable pressure, in a manner tending to remove a portion of the coating, it shall only be possible to remove small particles of the coating; and it shall not be possible to peel any portion of the coating so as to expose iron or steel underneath.

On articles fabricated from angles, channels, beams and rolled sections of 8 mm or more thickness, the adhesion may, alternatively, be tested by pivoted hammer tests as per IS : 2629-20.66. This test is not suitable for curved and round surfaces.

UNIFORMITY OF GALVANISED COATING:

On small articles, which can be conveniently handled the uniformity of the coating shall be determined by Preece Test in accordance with IS: 2633-20.66 by dipping the whole article in the copper sulphate solution. For sheets, strips and other fabricated articles a 10 cm x 10 cm specimen may be cut for tests. For tubes, 100 mm long piece shall be cut from each end of the product, after discarding 300 mm length from the end. The article shall withstand 5 dips of one minute each.

For long articles, measurement of coating thickness at a number of places by magnetic method shall be taken as a uniformity test.

Note: The Preece Test is primarily meant for articles where surface is mechanically scrapped or wiped after dip in the galvanizing baths etc

MASS OF GALVANISED COATING:



The average mass of galvanized coating shall be determined by any one of the following methods as agreed between the purchaser and the galvaniser before the tests.

Mass before and after galvanizing: The mass of coating may be determined by weighing the article before and after galvanizing, subtracting the first mass from the second and dividing the result by the coated surface area. The first mass shall be determined after pickling, rinsing and drying; and the second after cooling to the ambient temperature.

Stripping method: In case of materials galvanized without purchasers' inspection, average mass of coating shall be determined by stripping the entire article in accordance with IS: 6745-20.72. If the surface area of the entire article cannot be measured easily or if the article is inconveniently large, a specimen of 100 sq. cm. area may be cut from each of the three samples and stripped.

Magnetic thickness gauge method:

For large products such as poles, towers, structural shapes and castings the average weight of the coating shall be determined by a magnetic thickness gauge.

Before making the measurement the gauge shall be calibrated by measuring the thickness of zinc coating on a test panel and comparing the measured value with the value obtained by stripping method on the same piece.

For castings etc. at least 5 readings may be taken at convenient locations nearly in the centre. Thickness, in micro-meters, when multiplied by 7.047 would give the average mass of zinc coating (g/m²). Three articles in each lot of up to 100 shall be tested in this manner.

RECTIFICATION OF DAMAGE

Normally all fabrication work in the case of galvanized articles shall be completed prior to galvanizing. If, for any reason, fabrication such as cutting, drilling or welding has to be undertaken after galvanizing, protection of metal exposed as a result of fabrication and rectification of damaged galvanized areas shall be done in accordance with either the following methods or any other method approved by the Purchaser.

USE OF ZINC BASED SOLDERS: The surface to be protected, or the surface where galvanizing has been damaged, shall be cleaned and any oxides removed with a weak acid solution and a wire brush. The surface shall be thoroughly washed with water



to make it free from any traces of acid. The cleaned area shall be heated with a welding torch and rubbed with white salammoniac. A piece of zinc stick or rod 5-10 mm diameter of high purity shall be melted on this area and spread out with a heated piece of salammoniac. The areas shall then be washed down by water and lightly wire brushed. The workmanship shall be such that the finished surface is smooth and non-porous.

USE OF ZINC RICH PAINTS : The damaged surface after cleaning, as mentioned in para 7.2 shall be painted with two or more coats of zinc rich primer followed by a finishing coat of a zinc rich paint as per the painting schedule recommended by the manufacturers. It is to be ensured that the dry film thickness of zinc rich primer shall not be less than the average thickness of the galvanized coating. The complete painting system i.e. zinc rich primer with the finishing zinc rich paint for this purpose shall be produced from a source of repute and approved by the Purchaser.

DEFECTS, THEIR CAUSES AND REMEDIAL MEASURES

Defects	Causes	Recommended actions	Ground for rejection
	Paint grease or oil residues	Check cleaning practices	Yes, if bare spots are bigger than 8 mm dia. or 8 mm diagonal.
Bare spots	Scale or rust residues	Check pickling practices	
	Residual welding slag	Blast-clean wells; avoid coated rods	
	Breakdown of preflux coating	Check preflux and drying conditions	
	Aluminum content of bath too high	Regulate aluminum additions	
	Rolling defects in basic steel	Check steel supply	
	Article in contact	Keep articles separated.	



Defects	Causes	Recommended actions	Ground rejection for
	during galvanizing.		
General	Analysis or original surface condition of steel.	Check steel supply.	
roughness	Over-pickling	Reduce pickling use inhibitor	No
	High galvanizing temperature or long immersion time or both	Adjust galvanizing conditions.	
Pimples	Entrapped dross particles	Avoid agitation of dross layer; check carryover of pickle salt.	No, unless dross contamination is heavy
	Withdrawal speed too high	Remove work slowly	No.
	Cold galvanizing bath.	Increase temperature.	
Lumpiness and runs (uneven	Delayed run-off from seams, joints, bolt holes, etc.	Remove work slowly.	
drainage)	Article in contact during withdrawal.		



Defects	Causes	Recommended actions	Ground for rejection
	Stale flux burnt on during dipping.	Refresh or renew flux blanket.	Yes.
Flux inclusions	Surface residues on steel.	Check steel preparation.	
	Flux picked up from top of bath.	Skim before withdrawal.	
	Ash burnt on during dipping.	Skim bath before dipping.	Yes, if in gross lumps.
Ash inclusion	Ash picked up from top of bath.	Skim before withdrawal.	

Black spots	Includes flux particles from flux 'dusting'.	Confine fluxing to top of bath.	Yes.
	Dirt smuts, splash marks.	Check storage conditions.	No.
Dull grey coating (all alloy, no free zinc).	Steel composition (high sili-con, phosphorous or carbon) severe cold work.	Check steel supply for composition order to adjust for galvanizing.	No.
	Slow cooling after galvanizing.	Avoid hot stacking quench.	
	Release of absorbed hydro-gen	Avoid over pickling; use inhibitor.	



	during solidification of coating.		
	Weeping of acid etc. from seams and folds.	Check product design and fabrication.	
Rust stains	Storage near rusty material.	Check storage condition.	No.
Bulky white deposit (wet storage stain, white rust).	Confinement of close packed articles under damp conditions.	Storage dry well-ventilated conditions, separate articles with spacer.	No.
	Packing of articles while damp.	Dry before packing; include desiccant.	
Blisters	Expansion of entrapped hydrogen and moisture in flaws.	Check steel quality	Yes, if general.
	Driving off of hydrogen absorbed during pickling.	Use shot blast instead of pickle; check steel supply.	
	Improper malleabilising (for malleable iron castings only)	Check malleabilising practice.	



Tiny blisters	Effect sometimes observed on quenched work notably malleable castings. May be caused by gas evolved from the work resulting from absorbed hydrogen or break-down of combined carbon near surface.	Use shot blast instead of pickle. Check malleabilising treatment. Should have no combined carbon near surface of casting.	Yes, if blistering is generally wide spread.
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STRIPPING METHOD (Extracted from IS: 6745-20.72)

Cleaning of test piece: The test pieces shall be washed with solvent naphtha, trichloro ethylene or any other suitable organic solvent, then with alcohol and finally dried thoroughly.

Stripping Solutions:

Dissolve 20 g of antimony trioxide (Sb_2O_3) or 32 g of antimony trichloride ($SbCl_3$) in 1000 ml of concentrated hydrochloric acid (specific gravity 1.1).

Immediately before tests, prepare the stripping solution by adding 5 ml of the solution, 1 to 100 ml of concentrated hydrochloric acid (specific gravity 1.16). Mix well.

Procedure – Weigh the cleaned test specimen whose mass is less than 200 g nearest to 0.01 g; for test piece whose mass is between 300 to 1000 g to the nearest 0.1 g; and for test specimen of over 1000 g to the nearest 0.5 g. After weighing immerse each test piece singly in test solution and allow to remain there until the violent



evolution of hydrogen and only a few bubbles are being evolved. This requires about 15 to 30 seconds.

The mass of zinc coating (in g/m²) of surface may be calculated as per the following formula:

$$\frac{M}{A} = \frac{M1 - M2}{x} \quad 106$$

Where,

M = mass of zinc coating, in g/m², of surface. M1 = original mass, in g, of test piece. M2 = mass in g, of stripped test piece, and A = coated area of the test piece, in mm².

Mode of Measurement and Payments:

The item shall be measured and paid in unit of kg.

Item No-13

Construction of Tensile Fabric Roof

2.1 Overview

Tensile fabric structures are innovative architectural solutions characterized by their use of lightweight, durable fabric materials and structural efficiency. These structures leverage tension rather than compression or bending to maintain their form, allowing for creative and aesthetically appealing designs.

2.2 Characteristics of Tensile Fabric Roof

2.2.1 Lightweight Construction

- Utilizes fabric as the primary structural element, reducing dead load on supporting elements.
- Requires less material compared to traditional roofing systems, enabling cost-effective and efficient designs.

2.2.2 Strength and Flexibility

- Designed to handle high tensile stresses without compromising structural integrity.
- Flexibility allows the material to absorb dynamic forces (e.g., wind and vibrations) while maintaining its form.

2.2.3 Structural Efficiency

- Relies on tensioning forces distributed evenly across the fabric for stability.
- Incorporates minimal compression or bending elements such as masts, cables, or rings.



2.2.4 Durability

- High-performance fabrics like PTFE (Polytetrafluoroethylene), PVC (Polyvinyl Chloride)-coated polyester, and ETFE (Ethylene Tetrafluoroethylene) are resistant to UV radiation, weathering, and chemical attacks.
- Coatings (e.g., PVDF or acrylic) enhance durability, ensuring long service life.

2.2.5 Aesthetic Versatility

- Offers flexibility to create dynamic, flowing shapes and forms, such as free-form designs or double-curvature surfaces.
- Serves as an architectural feature, enhancing the visual appeal of spaces like stadiums, pavilions, and plazas.

2.2.6 Translucency and Light Control

- Provides soft, diffused natural lighting to interiors, reducing reliance on artificial lighting.
- Fabrics can be customized to achieve varying levels of translucency or opacity.

2.2.7 Weather Resistance

- Protects against environmental elements like rain, wind, and snow.
- Designed to meet load requirements specified in codes such as **IS 875 (Part 3): 2015** (wind loads) and **NBC 2016**.

2.2.8 Quick Installation

- Prefabricated components allow for rapid assembly and minimal on-site construction time.
- Suitable for both temporary and permanent installations.

2.2.9 Thermal and Acoustic Performance

- Reflects solar radiation, reducing heat gain and improving indoor thermal comfort.
- Acoustic properties can be enhanced with multilayered or insulated systems.

2.2.10 Low Maintenance

- Self-cleaning coatings, such as PTFE or PVDF, prevent dirt and debris buildup, requiring minimal cleaning.
- Resistant to biological growth (e.g., mold, mildew).

2.2.11 Sustainability

- Lightweight and efficient designs minimize material usage and environmental impact.
- Certain materials, such as ETFE, are fully recyclable



2.2.12 Longevity

- Lifespan varies based on material and environmental exposure:
 - PVC-coated polyester: 15–20 years.
 - PTFE-coated fiberglass: 25–30 years.
 - ETFE film: Up to 50 years.

2.2.13 Modular Adaptability

- Easily adaptable to various configurations and expansions.
- Modular systems support versatile applications ranging from small canopies to large-span roofs.

2.2.14 Cost-Effectiveness

- Reduces material and foundation costs due to lightweight nature.
- Offers excellent performance-to-cost ratio over its lifespan.

2.2.15 Safety Features

- Fire-retardant properties meet international and local safety standards, including:
 - **Class A** under ASTM E84.
 - **B1 or B2 ratings** as per DIN 4102.
 - National Building Code of India (NBC) compliance.

2.3 Types of Tensile Fabric Roof

2.3.1 Based on Structural Form

Tensile structures are defined by their geometry, with designs that leverage tension to maintain shape and stability.

2.3.1.1 Saddle or Anticlastic Structures

- Feature a double-curvature surface with opposing curvatures (one concave and one convex).
- Provides high stability against wind loads due to its shape.
- Example: Roofs of stadiums or open-air amphitheatres.

2.3.1.2 Conical Structures

- Designed with a cone-like form where the fabric is pulled taut from a central point or pole.
- Efficient in shedding rain and snow due to its steep profile.
- Example: Entrance canopies and shade structures in public spaces.

2.3.1.3 Arch-supported Structures

- Fabric is stretched over a series of arches, creating curved shapes.
- Commonly used in walkways, outdoor seating areas, and event spaces.



2.3.1.4 Dome-shaped Structures

- Encloses large areas with minimal supports by creating a dome-like surface.
- Example: Sports arenas or large exhibition halls.

2.3.1.5 Barrel Vault Structures

- Long, curved shapes resembling a half-cylinder.
- Ideal for covering long spans such as corridors or railway platforms.

2.3.2 Based on Support Systems

2.3.2.1 Cable-supported Structures

- Relies on cables to provide tension and support to the fabric.
- Suitable for long spans with minimal obstructions.
- Example: Bridges, large canopies.

2.3.2.2 Mast-supported Structures

- Fabric is anchored to masts or poles that carry the primary load.
- Example: Circus tents, outdoor pavilions.

2.3.2.3 Frame-supported Structures

- Fabric is stretched over a rigid frame, such as steel or aluminium, providing stability and shape.
- Example: Skylights, temporary exhibition structures.

2.3.2.4 Free-form or Hybrid Structures

- Combines elements of multiple support systems to achieve unique architectural shapes.
- Example: Custom-designed tensile roofs for iconic buildings.

2.3.3 Based on Material

2.3.3.1 PVC-coated Polyester

- Cost-effective and widely used for temporary or semi-permanent structures.
- Lifespan: 15–20 years.

2.3.3.2 PTFE-coated Fiberglass

- Durable, high-strength material with excellent fire resistance.
- Lifespan: 25–30 years.

2.3.3.3 ETFE Film

- Transparent and lightweight material ideal for permanent structures requiring natural light.



- Lifespan: Up to 50 years.

2.3.3.4 Silicone-coated Glass Fabric

- Flexible and highly resistant to extreme temperatures.
- Used for specialized applications.

2.3.4 Based on Application

2.3.4.1 Permanent Structures

- +Designed for long-term use with durable materials and strong anchoring systems.
- Example: Stadium roofs, airport terminals.

2.3.4.2 Temporary Structures

- Designed for ease of assembly and disassembly, often for short-term use.
- Example: Event tents, exhibition canopies.

2.3.4.3 Modular Structures

- Prefabricated and adaptable to various configurations.
- Example: Temporary shelters, trade fair pavilions.

2.3.5 Specialized Types

2.3.5.1 Pneumatic Structures

- Supported by air pressure, with fabric forming the enclosed space.
- Example: Inflatable domes for sports or events.

2.3.5.2 Cable Net Structures

- Fabric is supported by an intricate network of cables, offering lightweight solutions for large spans.
- Example: Suspension roofs in stadiums or arenas.

2.4 Applications of Tensile Fabric Roof

- Sports and Recreation
- Commercial and Retail Spaces
- Public and Institutional Buildings
- Cultural and Exhibition Spaces
- Residential and Hospitality
- Temporary and Portable Structures
- Urban and Landscape Design
- Transportation Infrastructure
- Industrial and Logistics
- Iconic and Artistic Installations



2.5 Properties of Tensile Fabric Roof

2.5.1 Mechanical Properties

- Tensile Strength:

- Tensile fabric materials are designed to withstand significant tensile forces without tearing or deforming.
- Typical fabrics like PTFE and PVC-coated polyester exhibit tensile strengths in the range of 200–400 kN/m.

Elasticity:

- Controlled elasticity allows the fabric to adapt to tension forces while maintaining its shape and structural integrity.
- Low elongation is desirable to prevent excessive sagging under loads.

- Shear Resistance:

- Ensures the fabric can resist sliding forces when subjected to wind or uneven loads.

- Tear Resistance:

- High tear strength prevents small damages from propagating across the material.

2.5.2 Physical Properties

- Lightweight:

- Tensile fabrics are lightweight, which reduces the overall dead load of the structure and minimizes the need for heavy support systems.
- Material weight is typically in the range of 800–1500 g/m².

- Durability:

- Materials such as PTFE (up to 30 years) and PVC-coated polyester (up to 20 years) offer long life spans with minimal degradation under normal conditions.

- UV Resistance:

- Coatings such as PVDF (Polyvinylidene Fluoride) or PTFE enhance UV protection, preventing fabric degradation from prolonged sun exposure.

- Weather Resistance:

- High resistance to environmental factors like rain, snow, and wind.
- Some materials, like ETFE, are also resistant to chemical attacks and pollution.

- Thermal Stability:

- Retains structural and mechanical properties across a wide temperature range:
 - PVC-coated polyester: -30°C to +70°C.



2.5.3 PTFE: -70°C to +230°C.

2.5.4 Optical Properties

- **Translucency:**

- Allows natural light to pass through, creating well-lit interiors while reducing glare and heat.
- Translucency varies from 10% to 90%, depending on material and coatings.

- **Reflectivity:**

- Reflective coatings can minimize heat absorption, improving thermal comfort and reducing cooling costs.

- **Color Customization:**

- Fabrics can be coated or treated for a variety of colors and finishes to enhance aesthetics.

2.5.5 Thermal Properties

- **Insulation:**

- Offers limited thermal insulation unless combined with additional layers or treatments.
- Double-membrane systems or ETFE cushions enhance thermal performance.

Heat Resistance:

- PTFE-coated materials and ETFE films can withstand high temperatures without degrading.

- **Fire Resistance:**

- Fabrics meet fire safety standards such as:
 - Class A (ASTM E84).
 - B1 or B2 under DIN 4102.
 - Compliance with NBC 2016 standards.

2.5.6 Structural Properties

- **Form-Finding:**

- Achieves double-curvature shapes (anticlastic geometry) for enhanced stability.
- Shape ensures even tension distribution and prevents material sagging.\

- **Wind and Snow Load Resistance:**

- Designed to withstand dynamic loads like wind (as per IS 875 Part 3: 2015) and static loads like snow accumulation.



- **Vibration Resistance:**

- Flexibility of the fabric allows it to absorb dynamic forces, minimizing vibrations and potential structural fatigue.

2.5.7 Environmental Properties

- **Sustainability:**

- Lightweight construction minimizes material usage and energy consumption.
- Some materials, like ETFE, are recyclable, making them environmentally friendly.

- **Self-Cleaning:**

- PTFE and PVDF coatings provide a non-stick surface, preventing dirt and debris accumulation.

- **Moisture Resistance:**

- Coated fabrics are impervious to water, ensuring no seepage occurs during rainfall.

2.5.8 Aesthetic Properties

- **Flexibility in Design:**

- Allows for creative architectural shapes, free-form designs, and dynamic curves.
- Materials support bright colors and custom patterns.

- **Seamless Appearance:**

- Welding or bonding techniques ensure smooth, uninterrupted surfaces.

2.5.9 Maintenance and Lifespan Properties

- **Low Maintenance:**

- Requires periodic cleaning and tension adjustments to maintain optimal performance.
- Resistance to biological growth such as mold or mildew reduces maintenance frequency.

- **Longevity:**

- Lifespan depends on material:
 - PVC-coated polyester: 15–20 years.
 - PTFE-coated fiberglass: 25–30 years.
 - ETFE film: Up to 50 years in certain conditions.

2.6 Technical Specifications of Tensile Fabric Roof

2.6.1 Fabric Material

- **PVC-Coated Polyester (Polyvinyl Chloride):**



- Tensile Strength: ≥ 3000 N/50 mm (warp and weft) as per EN ISO 1421.
- Tear Strength: ≥ 500 N (warp and weft).
- UV Resistance: Should meet ISO 4892-2 standards.
- Expected Lifespan: 10–20 years.

- **PTFE-Coated Fiberglass (Polytetrafluoroethylene):**
 - Tensile Strength: ≥ 4000 N/50 mm.
 - Tear Strength: ≥ 600 N.
 - UV Resistance: Superior to PVC; lifespan of 25–30 years.

- **ETFE (Ethylene Tetrafluoroethylene):**
 - Thickness: 100–300 microns.
 - Tensile Strength: > 40 MPa (per ASTM D638).
 - Highly resistant to environmental degradation and UV exposure.
 - Lifespan: 30–50 years.

- **HDPE (High-Density Polyethylene):**
 - Tensile Strength: > 20 MPa.
 - Ideal for temporary and semi-permanent structures.

2.6.2 Structural Framework

- **Steel:**
 - Grade: IS 2062 (E250 or higher) for mild steel sections.
 - Coating: Hot-dip galvanization as per IS 4759 for corrosion protection.
 - Yield Strength: 250 MPa (minimum).

- **Aluminium:**
 - Grade: IS 733 and IS 1285 for extruded sections.
 - Coating: Anodized or powder-coated for durability.

- **Cables (if used):**
 - Material: Galvanized steel wire ropes conforming to IS 3459.
 - Minimum Tensile Strength: ≥ 1570 MPa.

2.6.3 Surface Coatings

- **PVC-Coated Polyester:**
 - Self-cleaning properties.
 - Flame retardant coating conforming to BS 7837 or NFPA 701.
- **PTFE:**
 - Non-stick, high-temperature resistance, and anti-fungal properties.



- **ETFE:**

- Transparent surface with anti-reflective coatings for specific applications.

2.6.4 Tensile Properties

- Minimum elongation at break: $\leq 15\%$ for durable, sag-resistant structures.
- Fabric pre-stress values:
 - Warp Direction: 0.5–2.5 kN/m.
 - Weft Direction: 0.5–1.5 kN/m

2.6.5 Wind and Snow Load Design

- **Wind Load:** Designed as per IS 875 Part 3 (Wind Loads).
 - Factor of safety for wind pressure: ≥ 1.5 .
 - Wind Speed: Designed for 50-year return period speeds.
- **Snow Load:** If applicable, designed as per IS 875 Part 4 (Snow Loads).
 - Considered for regions with significant snowfall.

2.6.6 Fire Resistance

Flame retardant as per local and international standards:

- PVC-Coated Polyester: Conforms to DIN 4102 B1 or equivalent.
- PTFE: Fire performance as per ASTM E84 Class A.
- ETFE: Meets NFPA 701 fire-resistance standards.

2.6.7 Thermal Performance

- **PVC Fabric:**
 - Insulation Value: R-value ~ 0.5 – 1.5 .
 - Reflectance: $\geq 70\%$.
- **PTFE Fabric:**
 - Reflectance: $\geq 75\%$.
 - Transmission: 10–20%.
- **ETFE Foil:**
 - Excellent light transmission (up to 95% for single-layer).

2.6.8 Anchoring System

- Use of high-strength anchor bolts (IS 1367 Class 8.8 or higher).
- Foundations designed as per IS 456: 2000 for concrete and IS 2911 for pile foundation (if needed).

2.6.9 Waterproofing and Drainage

- Tensile fabric materials should be waterproof with a minimum water column resistance of 1000 mm.



- Proper drainage systems integrated into the design to handle rainwater effectively.

2.6.10 Assembly and Installation

- Pre-stressed with hydraulic tensioning tools for accuracy.
- Bolts, washers, and plates should conform to IS 1367 and IS 2062.
- Joints and seams: High-frequency welding or sewing using PTFE threads for durability.

2.6.11 Durability and Maintenance

- Expected lifespan: 10–50 years depending on material.
- Regular cleaning and inspection intervals (annually recommended).
- Replace or repair damaged sections using compatible materials.

2.6.12 Standards and Compliance

- Indian Standards:

- IS 875 (Design Loads for Buildings and Structures).
- IS 2062 (Structural Steel Specification).
- IS 800 (General Construction in Steel Code of Practice).
- IS 456 (Plain and Reinforced Concrete).

- International Standards (as applicable):

- ASTM D4851 (Standard Guide for Polymeric Materials in Tensile Membrane Structures).
- EN 13501 (Fire classification for construction products).