



## **MUNICIPAL CORPORA TENDER DOCUMENT**

**Proposed Construction of BMC GENERAL  
HOSPITAL land bearing C. T. S.No. 11A/4 of  
Village Chandivali in L ward, Sangharsha Nagar,  
Kurla, Mumbai**



## **VOLUME-III A TECHNICAL SPECIFICATION CIVIL & PLUMBING WORKS**

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**NAME OF PROJECT: -  
PROPOSED BMC GENERALHOSPITAL  
on land bearing  
C. T. S. No. 11A/4 of Village Chandivali  
in L ward, Sangharsha Nagar,  
Kurla, Mumbai**

**TECHNICAL SPECIFICATION FOR CIVIL  
& PLUMBING WORKS FAIR ITEMS**

**MUNICIPALCORPORATIONOFGREATERMUMBAI**



**M/S. PRAVIN NAIK & ASSOCIATES**

**REFER DETAILED  
TECHNICAL  
SPECIFICATIONS  
AVAILABLE ON MCGM  
PORTAL  
AND  
TECHNICAL  
SPECIFICATIONS FOR FAIR  
ITEMS ARE ATTACHED  
BELOW**

SIGNATURE CONTRACTOR

MCGM

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# **SECTION 1**

## **TECHNICAL SPECIFICATION**

### **FOR**

## **SPRAY VERMICULITE PAINT**

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## 1. PURPOSE

The purpose of this procedure is to establish, monitor and control all activities to execute the fireproofing of various locations, including, sampling, inspections & execution without any safety hazard. This procedure is exercised in order to meet the requirements specified in drawings, project specifications and up to the satisfaction level of client.

This Method Statement Proposal has been prepared for MCGM Hospital and Residential Building Project as per BOQ specification and is intended to supplement Membrane Manufacturer's Data Sheets.

## 2. SCOPE

This document serves as a Method Statement for the application of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat, a spray applied fire resistive coating on structural members, to provide a fire rating of 2 hours. This Method Statement covers the general requirement and application/installation techniques of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat on Structural Steel Frame construction. It covers requirements in regard to, Materials, Equipment & Accessories Product Storage, Substrate Preparation, Mixing, Application, Quality Control, Finish and Repair of the fire protection System.

## 3. RESPONSIBILITY

### **Project Director / Deputy Project Manager / Project Manager**

Shall be responsible for providing the clear front to execute the waterproofing work as per this procedure, shall be responsible for control supervision and direction for implementation and execution of waterproofing work.

## 4. CONTROLLING SPECIFICATION

- I) Technical Data Sheet

## 5. MATERIAL

**Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat** (based on vermiculite) is a spray applied, based on vermiculite and Portland cement based wet mix spray. After application it provides an approx. density of 400 kg/m<sup>3</sup> +/- 15% adequate potable water

### Equipment & Accessories

- Water storage drum
- Scaffold
- Wire Brush
- Plastic cover / Tarapaulin
- Spray & Mixer machine with air and material hoses with spares
- Compressor
- Personal Protective Gear
- Misc. hand and power tools

## 6. STORAGE

P400 will be stored under weatherproof cover. It should be protected from damp surfaces or areas of high humidity.

## 7. SITE REQUIREMENT

### **Before start of work check the following:**

- Floor area is cleared of all materials and debris
- Concrete is poured and cured on floors above
- No water leakages from above floor on the steel section being coated.
- 3 phase Power point is available on the floor
- Ventilation is proper for good drying
- Source of potable Water is available on the floor
- Scaffold
- Lighting
- Waste disposal area

## 8. PROCEDURE

### **Method Statement for the application of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat,**

#### **I. Surface preparation:**

- Surface must be free from grease, oil, rust, dirt or any other contaminants that affects bonding.
- Clean the surface if required with power tool machine, wire brush, emery paper and wash with water. Sample adhesion, if the base material is primed/painted with unknown product.
- In some cases, it may be necessary to mask off surrounding areas to protect from overspray.
- After surface is clean, roller application of primer / bonding agent (FosrocNitobond AR STD or Eq.) on the structural surface.

- Do not apply Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat on beams before completion of the concrete work on the deck panel for the floor above.
- Clips, Hangers, Supports, sleeves and other attachments to the substrate must be applied prior to the application of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat.
- Ducts, piping and other suspended equipment are to be installed after the application of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat.

## **II. Mixing of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat**

- Before commencing ensure the machine and components are clean. Clean Potable water (38 to 44 liters per bag) = (1.68 to 1.95 liters per kg) is required.
- Pour the measured quantity of potable water into the mixer retaining approximately 6 liters per bag to top up if necessary.
- Steadily add Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat whilst mixing.
- Add remainder of mixing water slowly until air entertainment occurs, normally 90 seconds after commencement of the mix.
- Mix for a total of 2 minutes at Speed of 35-40 RPM. Mixing time begins after the final bag is added to the mixer.
- Mixing time may vary due to external weather conditions. After completion of mixing transfer the material to the hopper of the spraying machine.
- If the next mix is required immediately then the mixer need not be washed out between mixes, however no material should be left in the mixer for more than 10 minutes.
- The nozzle will be kept perpendicular to the substrate at a distance ranging from 0.3m-0.6 m for better results.
- In application on steel beams, the top side of lower flange is sprayed first. Thereafter the section can be sprayed in any order.

## **III. Application technique**

Materials should be sprayed with air pressure consistent with satisfactory application to give an even coating over the background building up in a series of passes. Even coats are obtained with steady sweeps of the spray head which is held at 90 deg.(at a distance ranging from 0.3m to 0.6 m )to the work surface. The spray head must not be held stationary. Spray to achieve the desired thickness in one pass. The top surfaces of the bottom flange for horizontal beams should be given a quick first pass to avoid loose over-spray from dirtying the substrate surface and resulting in poor bond. Second coat the bottom of the top flange and then the web of the Beam. Coating thickness should be continuously checked to ensure that the correct thickness is applied. Areas of over thickness may be



leveled or cut back using a trowel. If the surface has become dry it should be well damped with clean water before continuing further.

#### **IV. Finish**

The Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat shall be sprayed textured natural colour finish.

#### **V. Work measurement**

The measurement of work shall be on peripheral finish coating for Steel Sections for Beams in accordance to manufacturers guidelines

Beams (4 Sided)  $(2 \cdot h + 4 \cdot ((b - 2wt) + 2 \cdot t)) \cdot L$  Plate  $((b + t) \cdot (h + t))$

Angle  $(2 \cdot (h + t) + 2 \cdot (b + t)) \cdot L$

Deck Panel Void Fill/Seal  $b \cdot L / 2 \cdot d / t$

Where,

h = Height (Web)

b = Breadth (Flange)

t = Thickness of Coating d = deck depth

Wt = Web Thickness

The Average Thickness Tolerance for a Section shall be -10% + 15% with no individual measurement below 25% and not above 6mm to calculate the average thickness.

### **9. QUALITY CONTROL & FIELD INSPECTION TEST**

The density of slurry will be checked from Mixer Discharge. It should be in range of 720 to 800 kg/cum. Records will be kept in form NPS/FP/1 as attached. The thickness of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat coating shall be measured in wet condition with Fireproofing Depth Gauge and recorded during the progress of work and shall conform to required thickness.

### **10. INSPECTION & REPAIR**

The area will be inspected at close distance to check for any large cracks (greater than 2 mm), or obvious signs of damage (areas where material is missing or minimum required thickness has not been achieved).

Hair line cracks are acceptable as this is normal consequence of expansion of steel/cementitious material. For any areas requiring repair, the full lining of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat in that area must be replaced. Care should be taken when removing any faulty area not to damage the material in adjacent areas.

Removal of Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat can be carried out using a chisel or similar tool. The area to be repaired should be cleaned of all loose material and any other debris and the undamaged material surrounding the repair area wetted with water before any new Bovia 279 of Soprema / M II of IsolatexNewkem / Monokote Z146 of Grace / P400 of Promat is installed. Cracks must be made into V grooves and other irregular area edges must be tapered. Small areas measuring less than 3 sqft. will be repaired by trowel. Larger areas will be sprayed. The previous surface should be rough in texture to achieve the best possible adhesion.

All the stage wise inspection shall be carried out as per approved Manufacturers' **method statement & QC Checklist.**

**11. HEALTH AND SAFETY PRECAUTIONS**

During application, the following precautions should be taken: Use chemical resistant gloves, eyeglasses, and loose work clothes. Keep work area ventilated, in case of inhalation, rinse throat with water and blow nose to evacuate dust. In case of skin contact, rinse the skin immediately with plenty of water and soap. Remove all dust as much as possible. Remove contaminated clothing. In case of eye contact, do not rub the eye. Rinse the eye out with plenty of clean water for at least 15 minutes. If eye irritation or inflammation persists, seek medical advice.

**SECTION 2**

**TECHNICAL SPECIFICATION**

**FOR**

**INTUMESCENT PAINT**

**CONTENTS:-**

1. PURPOSE
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3. RESPONSIBILITY
4. CONTROLLING SPECIFICATION
5. MATERIAL STORAGE
6. SITE REQUIREMENT
7. EQUIPMENT
8. PREPARATION OF BASE SURFACES
9. APPLICATION
10. MAINTENANCE
11. TROUBLESHOOTING
12. REPAIR
13. HEALTH AND SAFETY PRECAUTIONS

## 1. PURPOSE

The purpose of this procedure is to establish, monitor and control all activities to execute the fireproofing of various locations, including, sampling, inspections & execution without any safety hazard. This procedure is exercised in order to meet the requirements specified in drawings, project specifications and up to the satisfaction level of client.

This Method Statement Proposal has been prepared for MCGM Hospital and Residential Building Project as per BOQ specification and is intended to supplement Membrane Manufacturer's Data Sheets.

## 2. INTRODUCTION

Cafco SPRAYFILM® WB3/Nullfire SA 801 is a water based intumescent coating consisting of polyvinyl acetate resins and fillers for the fire protection of structural steel. It can be sealed and protected with a decorative top coat.

Cafco SPRAYFILM® WB3/Nullfire SA 801 is applied directly to the contour of primed I and H-section columns, angles, channels and beams, and hollow sections, to provide fire protection for up to 120 minutes. In a fire, a chemical reaction takes place, causing the Cafco SPRAYFILM® WB3/ Nullfire SA 801 to expand and form an insulating layer which prevents the temperature of the steel rising above a critical level.

## 3. RESPONSIBILITY

### **Project Director / Deputy Project Manager / Project Manager**

Shall be responsible for providing the clear front to execute the waterproofing work as per this procedure, shall be responsible for control supervision and direction for implementation and execution of waterproofing work.

## 4. CONTROLLING SPECIFICATION

## II) Technical Data Sheet

**5. MATERIAL STORAGE**

- Cafco SPRAYFILM® WB3 / Nullfire SA 801 should be stored in the original unopened container, protected from rain and direct sunlight, and maintained at an average temperature between 10°C and 40°C (50-100°F) during shipping and storage and protected from frost and freezing temperature.
- Cafco SPRAYFILM® WB3/ Nullfire SA 801 can be stored and applied for up to 10 months after the date of manufacture, provided the condition in point above are met

**6. SITE REQUIREMENTS**

Prior to application of Cafco SPRAYFILM® WB3/ Nullfire SA 801 material the applicator should ensure that adequate services are available for the application process and site conditions are within the given parameters. These include:

- Power and lighting are available.
- Proper ventilation during application. A ventilated air speed of 2 meters/second will generally improve drying characteristics, especially in a high humidity environment.
- Drying of the material should be recorded with readings at least twice daily, i.e. at the beginning and the end of the working day.
- Temperature of the steel substrate should remain 3°C above the dew point.
- Spared and adequate serviced spray equipment, e.g. high-quality latex brushes and short mohair rollers, scaffolding, masking, waste disposal.
- Do not apply materials if condensation is present.

**5.1 Application Temperature**

Preferred application temperature of the Cafco SPRAYFILM® WB3 / Nullfire SA 801 is when the ambient air temperature is between 10°C and 40°C.

The critical temperature is the substrate temperature; this range is between 10°C and 40°C. When the temperature of the substrate is exceeding the 40°C, it is recommended to apply a flash-coat of 150 pm Cafco SPRAYFILM® / Nullfire SA 801 WB3(that acts as an insulator between the paint and the steel). After this it is recommended to build up the needed thickness in layers of maximum 500 pm.

Steel surface temperature shall always be a minimum of 2°C above the dew point to prevent condensation from forming on the steel.

When the temperature at the job site is less than 10°C a minimum substrate and ambient temperature of 10°C shall be maintained prior to, during and a minimum of 24 hours after application. If necessary for job schedule, the contractor shall provide enclosures and heat to maintain proper temperature and humidity levels in the application area.

## 7. EQUIPMENT

**7.1 Pump**  
 A pneumatic, electric or diesel-powered airless spray pump should be used, operating with a minimum of 180kgf/cm<sup>2</sup> fluid output pressure at the spray tip. The unique properties of Cafco SPRAYFILM® WB3/ Nullfire SA 801 intumescent spray coating material require that the mesh filters commonly found in many airless spray units (both on the suction inlets and pressure sides of the pump assemblies) be removed prior to application of the material. Failure which will cause the meshes to filter out some of the coating ingredients and result in blockages around the filters. If the filters are fitted within the spray gun itself, they should be removed along with any differuser bars.

Normally the pump or spray gun filters are not to be used in line and should be removed if so. Please check with the pump manufacturers for recommendations.

**7.2 Air hose**  
 High pressure, rated to match pump capacity, maximum 60m in length of 10mm internal diameter hose providing minimum pressure should be maintained at the spray tip.

**7.3 Spray gun and tip**  
 A contract grade spray gun, capable of handling a minimum 180kgf/cm<sup>2</sup> fluid pressure, is suitable. The tip size should range from 0.53mm to 0.68mm, with 0.8-1.7 litres/minute of output. Promat recommend the use of a "bypass" type spray gun where the material bypasses the internal mechanical assemblies and reaches the spray tip directly.

**7.4 Brush or roller**  
 A high grade latex paint brush or a short mohair roller is recommended to achieve an even appearance of the coating application. Airless spraying method is preferred for a speedier application and uniformed finish.

**7.5 Scaffolding**  
 Rolling scaffolding should be provided for applications that are not accessible from the floor. The scaffold should have large locking wheels that can roll easily and be equipped with safety railings around the perimeter approximately in the applicator's waist height. The application throughout should be in full compliance with all safety regulations.

**7.6 Masking**  
 Typically consists of light weight polyethylene plastic and masking tape, a masking is required on all areas where coatings are not to be received.

## N OF BASE SURFACES

### 8.1 Cleaning substrates

New galvanized steel should be fully mechanically abraded with an electric /pneumatic attachment — carefully not to remove the galvanizing — for a clean and dry surface condition free from any contamination including zinc salts and all chromate solutions. This can be achieved by using a biodegradable detergent wash and/or a metal conditioner and degreaser (ISO 8504 and SSPC-SP1), followed by washing down and rinsing with fresh clean water.

Avoid chlorinated rubber, bitumen, red lead and any primers consist of organic zinc rich epoxy or inorganic zinc silicate.

A compatible etch primer at 20 microns of dry film thickness (DFT) should be applied to the newly cleaned galvanized steel. The DFT of the primer should be strictly observed and adhered to avoid excessive thickness that can result in adhesion failure.

All edges of the steelwork in particular should be treated with attention. Where fabricated steelwork sections to be primed are exposed to prolonged weather or humid atmospheres, the primers should be applied to a thickness of approximately 70-80um.

For damaged primed surface, all loose flaking primer and mill scale must be thoroughly wire brushed and removed before reinstating the original primed surface with a primer/tie coat, e.g. Cafco SPRAYFILM® Primer EP/ Nullfire SA 801 In the case of zinc enriched epoxy primer, a two-pack epoxy micaceous iron oxide primer is recommended as a sealer coat/tie coat.

Where a zinc enriched epoxy primer is exposed to external conditions for a significant period, the surface should be thoroughly washed down and rinsed with fresh clean water using a stiff bristle brush then allowed to dry fully prior to the application of tie coat. This is to ensure the removal of any zinc salts which could interrupt the intercoating adhesion.

## **8.2 Primed structural steel beams and columns**

Prior to application of Cafco SPRAYFILM® WB3/ Nullfire SA 801 intumescent spray coating material, it is essential to apply an anti-corrosive primer on the interior or exterior structural steelwork.

The steelwork must first be prepared in accordance with the requirements of SA 2.5 Swedish Standard SIS 05 09 00, BS 7079: 1989 and/or Class 2.5: AS 1627: Part 4, followed by coating of a compatible primer with approvals of Promat and application methods in full compliance with the manufacturer's recommendations.

The primer is for protection of the steelwork from corrosion during storage, transport and erection in the construction. Its compatibility should be controlled by a cross-cut test sample coated with Cafco SPRAYFILM® WB3/ Nullfire SA 801 material in accordance with criteria of the application method.

The primed steel surface should be blast cleaned for not more than 4 hours ideally before application of any Cafco SPRAYFILM® WB3/ Nullfire SA 801

coatings to prevent grease, oil, rust, dirt or any other contaminants from inhibiting bonding of the sprayed coating onto the primer.

If the existing steelwork was previously primed with an unknown primer, a compatibility and adhesion test must be carried out to ensure that the existing primer remains intact in a fire situation because the Cafco SPRAYFILM® WB3/ Nullfire SA 801 coating and its fire protection performance will rely on adhesion of the primer to the steelwork at all times. The primed steel surface must provide excellent adhesion for the fire protection coatings and should not soften, flow or flake off during a fire.

Unknown anti-corrosive primers and previously coated steelwork with thickness above 150um should be thoroughly tested for compatibility and adhesion in a fire. The primer thickness should be measured and recorded, prior to application of Cafco SPRAYFILM® WB3/ Nullfire SA 801 material, in order to check the thickness of the latter accurately during and after application.

To ensure a primer thickness is correct, frequent measurements should be taken using a wet film thickness gauge. To determine DFT based on the wet film thickness (WFT), multiply WFT by 0.70. For example, 1.3mm WFT x 0.70 = 0.91mm DFT.

A DFT reading must be taken as soon as the coating is fully cured within a minimum 7 days. An Elecometer 211 permanent magnetic banana gauge or electronic electromagnetic type may be used.

The primer thickness should be deducted from the final thickness reading previously recorded. It should not exceed 100 microns (0.1 mm).

**8.3 Compatibility and adhesion test**  
Apply approximately 400µm of Cafco SPRAYFILM® WB3/ Nullfire SA 801 material to a prepared steelwork surface of 0.25m<sup>2</sup> and allow to dry for approximately 24 hours. No cracks, bubbles or wrinkles should occur.

Direct a flame, e.g. propane gas burner (not cutting burner), onto the surface and edge zone of the specimen until the intumescent material is foamed up and/or clearly discoloured whilst the primer at edges of the surface is charred and/or clearly discoloured. The existing primer, top coat and coating of Cafco SPRAYFILM® WB3/ Nullfire SA 801 material must neither run nor flake off during the test.

## **9. APPLICATION**

Cafco SPRAYFILM® WB3/ Nullfire SA 801 intumescent spray coating material is supplied in sealed pail containers. The product is ready to use and generally does not need to be diluted; a maximum 5% of fresh clean water may be added depending on the application conditions.



The material, once removed from the container, should be thoroughly stirred with a rotar type mixer. If water is added, the required dry film thickness (DFT) must be recalculated.

Guide to all application methods and procedures of Cafco SPRAYFILM® WB3/ Nullfire SA 801 product should be duly followed by trained skillful applicators approved and certified by Promat.

### 9.1 Determination of thickness

The required wet film thickness (WFT), DFT and quantity of Cafco SPRAYFILM® WB3/ Nullfire SA 801 material is depending on various factors including the required fire resistance level (30, 60, 90 or 120 minutes), type of steelwork section, orientation, application method etc.

A calculation of the required WFT and DFT should be obtained prior to application of Cafco SPRAYFILM® WB3/ Nullfire SA 801 material. A test area should be completed by the applicator to establish an acceptable degree of finish for the project and agreeable for all relevant parties.

Maximum thickness for an application at 20°C temperature and 50% humidity depends on shape of the steelwork section and degree of the required cosmetic finish.

To ensure the coating thickness is correct during an application, frequent measurements should be taken using a wet film thickness gauge. Insert the teeth of the gauge into the still wet Cafco SPRAYFILM® WB3/ Nullfire SA 801 material carefully and avoid pressing the gauge onto any previously applied coatings that are not hardened yet. The highest reading indicated on the last tooth with paint on its tip is the WFT of the most recent coating. Typical calculation of a DFT is to multiply the WFT by 0.70. For example:

<b>Spray</b>	<b>application</b>
4.3mm	715
microns WFT = 0.715mm	
DFT = 1mm	DFT = 0.5mm

**NOTE:** Drying times are depending on temperature, air movement and relative humidity. Brush or roller application increases drying time by approximately 20%.

As a general guideline applicator may allow approximately 40% and 20% wastage respectively for spray and brush/roller application, depending on size of the steelwork section and other application conditions.

### 9.2 Final thickness check

Record the DFT reading as soon as the coating is sufficiently hard to avoid indenting the surface. Equipment such as an Elecometer 456 gauge is recommended for measurement of such readings.

DFT should be measured and recorded for each coating in accordance with the guideline of ASFP, i.e. TGN 003: Part 1: 1996. Please request Promat for details of the guideline.

Do not apply any top seal until the DFT has been checked and approved as passed and correct by a qualified applicator.

### **9.3 Top seal for protection and/or decoration purpose**

Dry interior environments typically do not require a top seal unless a decorative appearance is desired. Depending on the colour choice, up to two coatings may be applied.

Potentially damp interior areas require minimum two coatings of top seal at 40 microns DFT (0.4mm) per coating as a protection against moisture in the environment condition. Damages found in the top seal coating in such areas must be repaired immediately.

Exterior environments constantly exposed to highly damp or weathering condition require minimum two coatings at 40 microns DFT (0.4mm) per coating. Such top seal should be of moisture cured urethane or two component acrylic urethane type.

## **10. MAINTENANCE**

Maintenance of an existing Cafco SPRAYFILM® WB3/ Nullfire SA 801 application should take place with yearly inspections in accordance with the guidelines of AS 1851: Part 17 and/or BS 82022-2.

Any occurrence of damages, including impact, scuffing, abrasions etc., must be rectified immediately in order to maintain the required fire protection performance.

Please consult Promat for more information, especially for maintenance of this regard in exterior environments.

## **11. TROUBLESHOOTING**

### **11.1 Adhesion Failure**

- Temperature, humidity, dew point and condensation not in accordance with the specification of the environment.
- Water damage, e.g. inappropriate exposure to weather.
- Condensation entrapment of the Cafco SPRAYFILM® WB3/ Nullfire SA 801 product.
- Contamination of the substrate, primer or product.
- Incompatible primer, over or under cured.
- Excessive thickness of the product applied in single coating.
- The product has been thinned too much.
- Previous coating not fully cured.

### **11.2 Bubbles and blistering within coating**

- Temperature, humidity, dew point and condensation not in accordance with the specification of the environment.

- Equipment not cleaned properly prior to application.
- Temperature of the substrate was too high.
- Contamination of the primer.
- Incompatible primer, over or under cured.
- Spraying pressure was too high, e.g. the spray gun held too close to the substrate surface during coating application.
- Handling of roller application was too vigorous.
- The product has been thinned too much.

### 11.3 Spraying or flowing failure

- Equipment tips, spraying pressure and diameter of the hose must be ensured to be in good operation with regular inspection.
- Spray filters left in place.
- Blockages in the hose.
- Equipment not cleaned properly prior to application.
- The supplied Cafco SPRAYFILM® WB3/ Nullfire SA 801 product was too cold, the container lid was left off too long or the product's shelf life has been expired.
- The material not adequately stirred prior to use.

### 11.4 Slow drying time

- Temperature and humidity not in accordance with the specification of the environment.
- Excessive thickness of the product applied in single coating.
- Previous coating not fully cured prior to applying additional coating and/or top coat.

## 12. REPAIR

Any corrosion on the steel section surface areas should be rectified and finished with a compatible primer.

- Damaged surface areas should be abraded back to a firm, sound finish.
- The finished, primed surface should be clean, dry and free from any contaminations prior to applying Cafco SPRAYFILM® WB3/ Nullfire SA 801 material.
- New coating of the material should be applied at the appropriate DFT.
- Where applicable, top seal should be applied over the repaired, newly coated steel section.
- Cafco SPRAYFILM® WB3/ Nullfire SA 801 material must not be applied over existing top seal.

## 13. HEALTH AND SAFETY PRECAUTIONS

**Appropriate engineering controls:** During application, provide local exhaust or general room ventilation during application and drying. When using, do not eat, drink or smoke

**Hand protection:** Use chemical resistant, impermeable gloves. Wash hands after handling.

Eye protection: Use splash goggles as splashing is possible.

**Skin and body protection:** Wear protective waterproof clothing and boots.

**Respiratory protection:** Respirator

First-aid measures after **inhalation:**

Remove person to fresh air and keep comfortable for breathing. If person appears to have difficulty breathing or respiratory irritation, seek medical attention. If you feel unwell, seek medical advice.

**First-aid measures after skin contact:**

Remove contaminated clothing. Wash skin with mild soap and water. If skin irritation occurs: get medical advice/attention. Wash contaminated clothing before re-use.

**First-aid measures after eye contact:**

Do not rub the eye. Rinse the eye out with plenty of clean water for at least 15 minutes. If eye irritation or inflammation persists, seek medical advice.

**First-aid measures after ingestion:**

Rinse mouths thoroughly, drink plenty of water. If symptoms persist, consult doctor.

# **SECTION 3**

## **TECHNICAL SPECIFICATION**

**FOR**

**WATERPROOFING**

**Waterproofing System**

The Main Contractor shall nominate the specialist waterproofing contractor and taken written consent & approval from the RCC Design Consultant before commencement of works.

The waterproofing system shall be an approved waterproofing membrane (pre-applied for under raft and Confined walls / post- applied for retaining wall and Superstructure) with proven track records of being successfully used in internationally and locally. Product specifications, test reports and track record shall be submitted with the tender.

Foundations bearing on ground or rock, exposed to earth or water, shall include approved waterproofing membrane system.

Acceptable waterproofing membrane products (to be used with compatible complete systems as recommend and warranted by the manufacturer) are:

#### Sub Structure

##### I. Pre-applied external membrane for Under Raft Slab:

- Ultra High strength double reinforced fully bonded membrane with carbon dioxide crystals on top

#### Approved Brand

Soprema – Colphene BSW  
BLU Waters – Bluephene

##### II. Retaining Wall Unconfined, Lift Pit, Water Retaining Structures (UG, STP & OH Tank Internal) Side

- Efflorescence Free Trowel Applied Coating

Vandex  
International – Vandex BB 75

BLU Waters – Blue Dex

##### III. STP Tank – Additional coat of Epoxy

- Coal Tar Epoxy Coating

Asian Paints – SmartCare Coal Tar Epoxy

Ardex – R 816 CE

Tikidan – TIKI CTE

#### Super Structure

IV. Toilet and Pantry (Sunken), Kitchen (Non Sunken), Service and Refuge Area

- Two Component Undertile Acrylic based coating

Ardex – WPM 002  
BLU Waters – Blue Guard  
Tikidan - Revestidan

V. 100% Slab Area

- Polyisoprene Membrane

Hitchins – Formak 629  
BLU Waters – Blue Deck

VI. Terrace / LMR / Staircase / OHT Top

- Hybrid Polyurea Polyurethane Membrane

Tremco – Blueshield PMB  
BLU Waters – Bluesil 580  
MasterBuilders - Masterseal M862

VII. Terrace / LMR / Staircase / OHT Top

- TPO Membrane

Soprema – Flagon EP/PR  
BMI – BMI Everguard TPO  
Sika – Sikaplan TPO

The proposed waterproofing system shall be installed in full accordance with the manufacturer's specifications and recommendations.

**For Under Raft Slab– Using Ultra High strength double reinforced fully bonded membrane with carbon dioxide crystals on top**

General

Waterproofing treatment by using min. 4.5 mm thick Colphene BSW of Soprema of Tikidan / Bluephene of BLU Waters before casting of the base RCC slab. The pre-applied membrane gets bonded to the underneath of the poured concrete used as base / raft slab.

#### SUBSTRATE PREPARATION

All Surfaces - It is essential to create a sound and solid PCC substrate to eliminate membrane movement during the concrete pour. Substrates must be regular and smooth with no gaps or voids greater than 12mm.

#### Horizontal Concrete Blinding/ PCC

Substrate should be monolithic concrete. The PCC/ blinding must be free of loose aggregate, hollows and sharp protrusions. An angular profiled PCC/ blinding is recommended rather than a rounded substrate. "Colphene BSW of Soprema /Bluephene of BLU Waters" fully bonded sheet membrane is a pre-applied sheet membrane and hence it is preferred to have a uniform PCC.

All horizontal concrete surfaces receiving Colphene BSW of Soprema /Bluephene of BLU Waters" "fully bonded membrane shall be treated in accordance with membrane manufacturer's requirements. Voids and honeycombed areas shall be made good with cement mortar. All horizontal surfaces receiving the membrane shall be smooth and in accordance with the membrane manufacturer's requirements. All abrupt irregularities, voids and honeycombed areas shall be made good with cement mortar. All surfaces shall be clean, uniform and free from sharp protrusions at the time of membrane installation. Where a hard-core bed is specified, Monolithic concrete PCC is preferred with not less than 50 mm thickness, which should be regular, smooth and free of loose aggregate and sharp protrusions.

#### Vertical Blinding –

The concrete should be laid to a regular surface free from dust, sharp protrusions and hollows. Avoid applying primer to the "Colphene BSW /Bluephene of BLU Waters" surface. Masonry or block work must be uniform & flush pointed.

#### Method Statement

Application of "Colphene BSW /Bluephene of BLU Waters" on PCC concrete surface for basement base slab

Install materials carefully in accordance with the manufacturer's instructions and the recommendations of BS 8102:2009 Grade 3. BS 8102:2009 gives recommendations and provides guidance of methods of dealing with and



preventing the entry of water from surrounding ground into a structure below ground level.

#### Laying of Membrane

##### 1. Roll Size :

“Colphene BSW /Bluephene” membranes are supplied in rolls 1M wide with selvedge on one side to provide laps for continuity between rolls. Roll Length is 8M / 10M

##### 2. Unrolling :

Unroll “Colphene BSW /Bluephene of BLU Waters” fully bonded membrane, SBS reinforced layer facing the substrate and weather resistant layer facing the concrete which is to be placed on top

##### 3. End Laps & Side Laps

End laps should be staggered to avoid a buildup of layers. Accurately position succeeding sheets to overlap the previous sheet 120mm along the duo-selvedge, 40mm self-adhesive and 80 mm torch on

4. Ensure underside of the succeeding sheet and top of release liner on selvedges are clean, dry and free from contamination before attempting to bond overlap.

5. Peel back and completely remove plastic release liner from the selvedge to seal the 80mm overlap by torch on as the two layers are bonded together.

6. Ensure continuous bond is achieved without creases and then roll or press-down firmly.

#### Vertical Blinding –

7. Mechanically fasten the “Colphene BSW /Bluephene of BLU Waters” membrane vertically using fixings appropriate to the substrate.

8. Membrane may be installed in any convenient length. Secure the top of the membrane using a batten or fixing 50mm below the top edge.

9. Fixings can be made through the selvedge so that the membrane lays flat and allows firmly rolled overlaps. Ensure the underside of the succeeding sheet and top of release liner is clean, dry and free of contamination before attempting to progressively bond the overlap. Roll overlap firmly to ensure a watertight seal.

10. Where applicable, laps to be over banded with sealed tape and firmly rolled to ensure security of the system

#### Roll ends & Cut edges

Overlap all roll ends & cut edges by a minimum 100mm & ensure area is clean and free from contamination, wiping with a damp cloth if necessary. Allow to dry and apply sealed tape centered over the lap and roll firmly.

#### Placing of temporary formwork

Timber & steel shuttering should be positioned with care onto “Colphene BSW /Bluephene” membranes and measures taken to minimize grout loss. Where grout loss occurs to surrounding areas of membrane it should be completely removed before curing begins & surfaces involved cleaned with damp cloths/ water. This will enable future structural concrete to bond to the membrane rather than contact cured grout

It should be noted that grout spillage onto “Colphene BSW /Bluephene of BLU Waters” membranes where a subsequent overlap is to occur should also be removed/cleaned as soon as possible.

#### Damage Repair Procedure

Holes and tears in the membrane must be repaired with a reinforcement membrane (Colphene BSW /Bluephene). The repair must exceed the affected surface area by at least 100 mm.

#### Technical Specifications -

PROPERTIES	TYPICAL VALUE
Peel Adhesion to Concrete	> 1500 N/M (per ASTM D 903)
Tear Strength MD	> 600 N (as per ASTM D 5147)
Resistance to Hydrostatic Head	> 110M (as per ASTM D 5385)
Puncture Resistance	> 1050 N (as per ASTM E 154)

#### DETAILS

- All angle changes as well as inside and outside corners must be reinforced by installing an additional 300 mm piece of (Colphene BSW /Bluephene) centered in the angle.
- All small protrusions (steel work, pile cap, etc.) through the waterproofing membrane, must be sealed with PU FLASHING waterproofing coating and FLASHING REINFORCEMENT as required.

#### **For Retaining Wall Unconfined – Using Efflorescence Free Trowel Applied Cementitious Coating**

##### **VandexBB75orBlue Dex**

Treatment to concrete defects like Construction Joints Cold Joints, Honey Combs & porous & Porous Concrete.

All construction joints, honey combs, cold joints, of concrete shall be treated by hacking open the affected area to sound concrete, fixing nozzles and grouting the same, under pressure with cement

slurry mixed with plasticizer non shrink additive and sealing all the construction joints with non-shrink mortar.

Cleaning the surface thoroughly, providing and applying Vandex BB 75 or Blue Dex waterproofing system in two coats by trowelling as per manufacturer's specifications. The 1st coat of BB 75 or Blue Dex shall be applied to the prepared surface at coverage of 1.5 kg / sqmt. Whilst the 1st coat is still "green" a second coat comprising of BB 75 or Blue Dex at coverage of 1.5 kg/Sqmt. The slurry coatings shall be applied with a stiff masonry brush or stiff broom and worked into every irregularity on the surface shall be done by means of trowelling or by spray only.

Treatment to floor slabs shall be carried out by trowel application in 3.0 kg / Sqmt coverage of BB 75 or Blue Dex a steel trowel into hardened concrete slab surface including curing, cleaning etc complete.

#### General and area of application

Generally, all concrete surfaces shall be in a clean, sound and watertight condition, free of any dust, sand particles, oil and any other unwanted particles to the satisfaction of the Employer / EIC. The area of application shall be for Retaining Wall, etc.

#### Waterproofing material

The waterproofing material to be used shall be a cementitious, ready-mixed, efflorescence-free surface waterproofing membrane that consists of hydrophobic properties. Application of the waterproofing treatment can be applied by means of slurry coating, trowel or spray application. It can be either applied on the external surface or internal surface or both, depending on the thickness of the wall or floor.

The waterproofing material shall consist of rapid-hardening Portland cement, specially treated and graded grain-size distribution, and special chemical ingredients of an inorganic nature. The Cementitious waterproofing membrane shall remain waterproofed even under pressure and tested to 7.0 bar, and at the same time allow the concrete to "breathe" by allowing the passage of water vapour through the structure. In addition, the Vandex Cementitious waterproofing material shall protect the concrete against ground water, aggressive ground water and certain chemical solutions. The Cementitious waterproofing membrane shall be able to be applied to surfaces or substrates such as concrete, masonry and render that require proper sealing and protection against the influence of water and moisture.

#### Preparation of substrate

Concrete to receive the waterproofing treatment must have a clean surface and an open capillary system to ensure maximum bonding and sealing. All surfaces shall be examined for structural defects and remedied prior to the waterproofing treatment.

Faulty concrete such as protrusions and honeycombs shall be chiseled and work back to sound concrete and cleaned (by the concreter). Construction joints that are not pre-treated with waterproofing treatment, and cracks exceeding 0.3mm widths, shall be routed out to a minimum depth of 25mm and properly cleaned (by the concreter). Form-ties shall be removed and chiseled back to sound concrete (by the concreter).

One slurry coat of waterproofing membrane shall be applied over all chiseled out areas, at coverage of 1.5 kg/m<sup>2</sup>. After reaching its initial set and while the waterproofing material is still "green" (about 30 minutes after application). The chiseled out areas shall be filled with cement: sand mortar (by the concreter).

#### Waterproofing treatment

Prior to the waterproofing treatment, all concrete surfaces shall be properly prepared and remedied as item 3 above. All concrete surfaces shall be cleaned and free from all forms of scales, laitance, mould oil, curing agents and any other foreign materials.

Extremely smooth concrete surface shall be roughened by using high pressure water jet of minimum pressure 150 bar to assure maximum bonding. All concrete surfaces to be treated with BB 75 or Blue Dex waterproofing material shall be thoroughly wetted down before application. The concrete surfaces shall only be moist (not wet), and lying water shall be removed leaving only a damp condition just prior to the application of the waterproofing treatment.

The waterproofing material shall be mixed in accordance with the manufacturer's instructions. Application by means of slurry coating shall be applied with a stiff masonry brush or stiff broom and worked into every irregularity on the surface. Vandex BB 75 or Blue Dex can also be applied by trowel or by spray.

#### Technical Specifications –

PROPERTIES	TYPICALVALUE
Compressive Strength	class R3≥ 25 MPa
Chloride ion content	≤ 0.05 %

Adhesive bond	≥ 1.0 MPa
Carbonation resistance	Passed
Modulus of elasticity	≥ 20 GPa
Thermal compatibility Part 1: Freeze thaw with de-icing salt immersion Part 4: Dry thermal cycling	≥ 2.0 MPa ≥ 2.0 MPa
Capillary absorption	≤ 0.5 kg/m <sup>2</sup> . h 0.5
Reaction to fire	Class A1
Dangerous substances	Complies with 5.4

**Protection over membrane:**

Supply & spot bonding 7-8mm thick dimple board as specified in the BOQ onto the membrane with liquid mastic and shall be applied prior to backfilling. The backfilling shall be done in stages (150-200) mm and within 2-3 days of fixing protection board.

**Backfilling:**

Place back fills as soon as possible, avoiding any damage to the waterproofing membrane. Back filling should be laid in layer and shall be compacted in lifts.

**Health & Safety Precautions:**

There is no health hazards associated with this product.

**Trowel Applied Efflorescence Free Cementitious Membrane - For Lift Pit, OH Tank, UG and STP (Internal)**

**Vandex BB 75/Blue Dex**

Treatment to concrete defects like Construction Joints Cold Joints, Honey Combs & porous & Porous Concrete.

All construction joints, honey combs, cold joints, of concrete shall be treated by hacking open the affected area to sound concrete, fixing nozzles and grouting the same, under pressure with cement slurry mixed with plasticizer non shrink additive and sealing all the construction joints with non-shrink mortar.

Cleaning the surface thoroughly, providing and applying Vandex BB 75 / Blue Dex, waterproofing system in two coats by trowelling as per manufacturer's specifications. The 1st coat of Vandex BB 75 / Blue Dex shall be applied to the prepared surface at coverage of 1.5 kg / sqmt. Whilst the 1st coat is still "green" a

second coat comprising of Vandex BB 75 / Blue Dex at coverage of 1.5 kg/Sqmt. The slurry coatings shall be applied with a stiff masonry brush or stiff broom and worked into every irregularity on the surface shall be done by means of trowelling or by spray only.

Treatment to floor slabs shall be carried out by trowel application in 3.0 kg / Sqmt coverage of Vandex BB 75/Blue Dex using a steel trowel into hardened concrete slab surface including curing, cleaning etc complete.

#### General and area of application

Generally, all concrete surfaces shall be in a clean, sound and watertight condition, free of any

dust, sand particles, oil and any other unwanted particles to the satisfaction of the Employer /

EIC. The area of application shall be for Water Tank etc.

#### Waterproofing material

The waterproofing material to be used shall be a cementitious, ready-mixed, efflorescence-free surface waterproofing membrane that consists of hydrophobic properties. Application of the waterproofing treatment can be applied by means of slurry coating, trowel or spray application. It can be either applied on the external surface or internal surface or both, depending on the thickness of the wall or floor.

The waterproofing material shall consist of rapid-hardening Portland cement, specially treated and graded grain-size distribution, and special chemical ingredients of an inorganic nature. The Cementitious waterproofing membrane shall remain waterproofed even under pressure and tested to 7.0 bar, and at the same time allow the concrete to "breathe" by allowing the passage of water vapour through the structure. In addition, the Vandex Cementitious waterproofing material shall protect the concrete against ground water, aggressive ground water and certain chemical solutions. The Cementitious waterproofing membrane shall be able to be applied to surfaces or substrates such as concrete, masonry and render that require proper sealing and protection against the influence of water and moisture.

#### Preparation of substrate

Concrete to receive the waterproofing treatment must have a clean surface and an open capillary system to ensure maximum bonding and sealing. All surfaces shall be examined for structural defects and remedied prior to the waterproofing treatment.

Faulty concrete such as protrusions and honeycombs shall be chiseled and work back to sound concrete and cleaned (by the concreter). Construction joints that are not pre-treated with waterproofing treatment, and cracks exceeding 0.3mm widths, shall be routed out to a minimum depth of 25mm and properly cleaned (by the Main contractor). Form-ties shall be removed and chiseled back to sound concrete (by the Main Contractor).

One slurry coat of waterproofing membrane shall be applied over all chiseled out areas, at coverage of 2 kg/m<sup>2</sup>. After reaching its initial set and while the waterproofing material is still “green” (about 30 minutes after application). The chiseled out areas shall be filled with cement: sand mortar (by the Main Contractor).

#### Waterproofing treatment

Prior to the waterproofing treatment, all concrete surfaces shall be properly prepared and remedied as mentioned above. All concrete surfaces shall be cleaned and free from all forms of scales, laitance, mould oil, curing agents and any other foreign materials.

Extremely smooth concrete surface shall be roughened by using high pressure water jet of minimum pressure 150 bar to assure maximum bonding. All concrete surfaces to be treated with Vandex BB 75 / Blue Dex waterproofing material shall be thoroughly wetted down before application. The concrete surfaces shall only be moist (not wet), and lying water shall be removed leaving only a damp condition just prior to the application of the waterproofing treatment.

The waterproofing material shall be mixed in accordance with the manufacturer’s instructions. Application by means of slurry coating shall be applied with a stiff masonry brush or stiff broom and worked into every irregularity on the surface. Vandex BB 75 / Blue Dex can also be applied by trowel or by spray.

#### Technical Specifications –

PROPERTIES	TYPICALVALUE
Compressive Strength	class R3 ≥ 25 MPa
Chloride ion content	≤ 0.05 %
Adhesive bond	≥ 1.0 MPa
Carbonation resistance	Passed
Modulus of elasticity	≥ 20 GPa
Thermal compatibility Part 1: Freeze thaw with de-icing salt immersion Part 4: Dry thermal cycling	≥ 2.0 MPa ≥ 2.0 MPa



Capillary absorption	$\leq 0.5 \text{ kg/m}^2 \cdot \text{h} \cdot 0.5$
Reaction to fire	Class A1
Dangerous substances	Complies with 5.4

### Curing and Protection

- Membrane must be protected from sunlight and rain until setting by covering with plastic sheeting or hessian.
- Membrane takes 2-4 hours to set. It can take light traffic after 12 hours and be screeded or tiled on after 24 hours.
- For maximum effectiveness it is essential that the layers are kept damp for at least five days.
- Full setting takes 7 days & final ponding test to be done for 3 days for leak testing.
- **Protection over the membrane not required in this system.**

### **Additional Treatment for STP over Trowel Applied Efflorescence Free Cementitious Membrane of Coal Tar Epoxy**

#### Application of Epoxy Coating:

- Epoxy coal tar coating application: SmartCare coal tar epoxy / R 816 CE / TIKI CTE (2 components solvent free, alkali resistance, chemical resistant, flexible water resistant epoxy coal tar coating), mix two parts of resin (Part A) with one part of hardener (Part B) in suitable size mixing vessel, using heavy duty slow speed drilling machine fixed with mixing paddle to obtain a uniform mix. Apply the first coat of SmartCare coal tar epoxy / R 816 CE / TIKI CTE over the prepared surface at coverage of 5 Sqm/litre/coat at 150 microns WFT using roller / brush / airless spray and allowed to dry completely for 6 hours. Apply the second coat of SmartCare coal tar epoxy / R 816 CE / TIKI CTE in perpendicular direction to the first coat and allow it to dry for completely. In case of very high chemical resistance is required apply the third coat of SmartCare coal tar epoxy / R 816 CE / TIKI CTE in perpendicular direction to the dried second coat and allow it to dry completely.

#### Sealing / Packing joints in Outlets pipes :

- Cut open the construction joints in the form of "V" shape in size 20mm x 20 mm and make it free from contaminants.
- Clean the groove & 75 mm wide at both side of the joint to make it free from all dirt, dust & other contaminants. Fix nozzles with cement & metal. Grouting with cement, water & cebex 100 @125gms.
- Cut the nozzles & seal with Micro concrete (ACC Grout / Ultratech / Grout HS).



- Curing the applied mortar for 3 days.

### **Anti Skid Car Park Coating for Ramp**

Providing & applying High Performance, Odourless , moisture tolerant car parking flooring system based on Xolutedc™ technology consisting of Scratch coat and Body coat of minimum 1.5-2 mm thickness to have a Texture & even matt finish. Application shall be done by an authorised applicator of the manufacturer in accordance to the application guidelines provided by the manufacturer.

#### **Surface Preparation**

Remove cement laitance and weak concrete by grinding followed by vacuum cleaning. The bond strength of the substrate must be at least 1.5 Mpa. The compressive strength of the floor concrete must be atleast 25 Mpa. The moisture content of the substrate should not be more than 5-7%.

### **Anti Skid Car Park coating using XoluTech Technology**

#### **First Layer :-**

MasterTop P920 shall be applied at a consumption rate of 0.80 kg/sqm consisting of One pack of resin(PTA) + One pack of Hardener ( PTB ) and one pack of Filler ( PTC ) as a primer/scratch coat to seal the pores in the substrate.

#### **Second Layer :-**

The cured scratch coat is followed by MasterTop BC 920 another coat of mix consisting of One pack of Each ( PTA+PTB+PTC+PTD) at a consumption of 0.80 kg/sqm. The product must have the following properties.

- > Scratch Resistance
- > Compressive Strength ( EN ISO 604 ) - 45 Mpa @7 Days
- > Tensile Strength ( ISO 527) - 12 Mpa @7 Days
- > Flexural Strength ( EN ISO 178) - 15 Mpa @7 Days
- > Abrasion Resistance ( EN ISO 7784, C17 Wheels) - 65mg loss in mass
- > Impact Resistance - 30 Joules

This coat is immediately followed with special sand MasterTop SRA broadcasted in the entire area at a consumption of 0.8-1.0 kg/sqm.

#### **Third Layer :-**

Excess sand is removed and MasterTop BC 920 shall again be applied at a consumption rate of 0.4 kg/sqm (excluding the filler component Part C) over the cured sand sprinkled surface.

### **UV Resistant Top Coat ( For Expose Areas like Ramp Entries/Exits)**

Use a heavy-duty drilling machine fitted with a helical paddle to mix the polyurethane UV Stable top coat Product Master seal TC 268 or MasterSeal TC

258 at a consumption of 0.25-0.3 kg/Sqm to achieve a UV resistant traffickable floor system.

### **Two Component Undertile Acrylic Based Membrane for Toilet (Sunken Areas)**

The entire surface receiving the Toilet Non sunken waterproofing system shall be sufficiently cleaned by appropriate methods to remove dust, oil, sand and stones, etc. and other unwanted particles such as nails, cut-off steel material, glass and broken glasses, etc. The waterproofing material to be used shall be WPM 002 / Blueguard / Revestidan applied waterproofing system. The Liquid Applied waterproofing system shall be single / Two component Acrylic based under tile waterproofing membrane consisting of two layers, with a nominal thickness of 1 mm minimum. The reinforcement if required shall be either 225 gsm or 300 gsm chopped strand fiber - glass mat.

Acrylic waterproofing material shall be flexible and passes the 1.5 mm mandrel, and shall be able to bridge hairline and minor cracks. When not reinforced, it shall have at least 150% elongation. At all detailing like pipe protrusions, rain-water-down-pipes, edges and corners, application of the waterproofing system shall be sufficiently dressed up and reinforced with fiberglass reinforcement. Upon completion of the application the entire surface shall be check for uniformity to ensure proper application of the system. All materials shall be applied by an approved and trained applicator, and a warranty of ten (10) years shall be issued to the client for the installed waterproofing system.

#### Technical Specifications-

PROPERTIES	TYPICALVALUE
Elongation at break	>150%
Tensile Strength	1 Mpa (ASTM D412)
Water Absorption	4.3%
Shore A Hardness	>80 (ASTM D2240)
Resistance to UV	Excellent (ASTM-D-822)

#### **Surface preparation:**

- All surface area shall be cleaned well to make visible of hair cracks / aggregate texture.
- Cleaning of RCC member should be done by hacking tool, wire brush, wire grinder & air blower etc.

- All minor cracks shall be open in "v" shape shall be treated with Conplast WL or equivalent non shrink additive and after grouting.
- All clean & treated area should tested for water tightness by flooding water.
- All wet spots & water leakage area shall mark for treatment. If any leakage is observed the source of leakage shall be located and it shall be treated either by injection grout or by closing the crack. The treatment shall be continued till the leakages are stopped.
- Fixing Deck web / Choppstrand matt sandwiched between waterproofing coats on the junction of floor and walls.
- Fixing Coving Bandage on the junction of horizontal and vertical surface.

**Note: (Major cleaning and Concrete chipping, cutting off exposed steel in slab, removing nails, binding wire to be done by main Contractor. All columns starter shall be casted so that waterproofing can be terminated at columns.)**

Making of Threshold at the Toilet door sill:-

- Bund of size 100mm x 25mm shall be made with Micro concrete at the toilet door sill.
- 72 hours curing shall be done.
- Cementitious coating shall be terminated upto 150 mm from toilet outer side of barrier bund.

**Primer :**

- Stir Primer (2 component water based epoxy primer), prior to application.
- All surfaces shall be primed in one coat at Coverage of 0.17 Ltr / Sqm by brush/ roller.
- Applying primer allow to dry for completely.

**Application:**

- Take suitable size mixing vessel which can accommodate all components. Stir and pour 20 Kg Part A, start mixing using heavy duty electric slow speed drilling machine attached with suitable mixing paddle, and add 20 Kg Part B and mix it till homogeneous mix is obtained. For single component stir it slowly before application.
- Apply first coat using brush / roller at all corners /, install Deck Web / chopstrand matt (at pipe penetrations and at all solid wall to solid wall and solid wall to floor junctions) over the wet first coat and continue application at remaining wall and floor areas.
- Allow the applied coating including reinforcing / Sealing Tape to dry completely for 4 hours at 230 C, 50% RH.
- Apply the second coat in opposite direction to the first coat and allow it to dry completely.
- Minimum two coats are recommended at coverage of min. 2.2 kgs / sqm.
- No any water curing is required.

### Protection over the membrane

#### Screed on Floor:

- Providing & laying 10-12mm thick protective screed on floor in CM 1:4 admixed with Conplast WL of 125ml dosage per bag of cement on top of the membrane for protection

#### Protection over the screed using brick / block bat coba

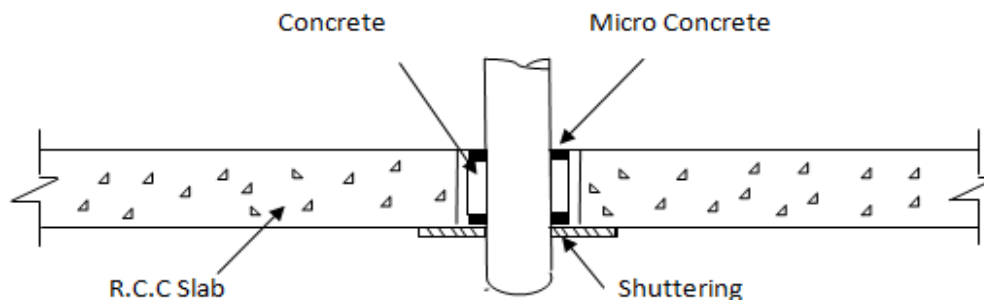
- Applying cement slurry using 2.75 kg/Sqm of cement mixed with Conplast WL or equivalent waterproofing compound @125ml per bag of cement.
- Brick / Block pieces of quarter half and three quarter size are laid piece by piece in the form of horizontal Brick / Block masonry in waterproof mortar with waterproofing compound made up of cement and crush sand 1:3 with waterproofing compound (Conplast WL or equivalent) to be added @ 125ml per bag of cement for protection.
- The Brick / Block bat coba is finally covered with 20mm jointless waterproofing plaster in CM 1:3 with waterproofing compound (Conplast WL or equivalent) to be added @ 125ml per bag of cement for protection.
- The entire surface shall be cured for minimum 7 days by storing water.

#### Plaster on Wall:

- Providing and laying avg.10-12 mm thick plaster in CM 1:4 admixed with (Conplast WL of 125ml dosage per bag of cement) integral waterproofing compound.

#### Waterproofing for Core Cutting Areas (Upto 150mm dia):

- Core cut the slab (To be done by Main Contractor)
- Hacked around the slab (To be done by Main Contractor)
- Wash thoroughly this hacked off areas to expose the clean concrete surfaces between outlet pipe and concrete.
- Place and fix the pipe mechanically make necessary shuttering from the bottom.
- Fill the concrete around the periphery of the pipe and seal with micro concrete from both the side as shown in the drawing.
- Pour micro concrete, 4 parts micro concrete and 1 part of water to fix and seal the pipe. Remove the shuttering after one day / two day and curing done for 7 days.



#### Detailing Around The Pipe

- Cleaning the surface, coving around the pipe with 1/2" cement mortar 1:4 using deck web / fibre mesh sandwiched with Cementitious membrane.

Note: - All cut outs to be packed by the Main Contractor before handing over to Waterproofing Contractor

### **Two Component Undertile Acrylic Based Membrane for Kitchen (Non Sunken Areas)**

The entire surface receiving the Toilet Non sunken waterproofing system shall be sufficiently cleaned by appropriate methods to remove dust, oil, sand and stones, etc. and other unwanted particles such as nails, cut-off steel material, glass and broken glasses, etc. The waterproofing material to be used shall be WPM 002 / Blueguard / Revestidan applied waterproofing system. The Liquid Applied waterproofing system shall be single / Two component Acrylic based under tile waterproofing membrane consisting of two layers, with a nominal thickness of 1 mm minimum. The reinforcement if required shall be either 225 gsm or 300 gsm chopped strand fiber - glass mat.

Acrylic waterproofing material shall be flexible and passes the 1.5 mm mandrel, and shall be able to bridge hairline and minor cracks. When not reinforced, it shall have at least 150% elongation. At all detailing like pipe protrusions, rain-water-down-pipes, edges and corners, application of the waterproofing system shall be sufficiently dressed up and reinforced with fiberglass reinforcement. Upon completion of the application the entire surface shall be check for uniformity to ensure proper application of the system. All materials shall be applied by an approved and trained applicator, and a warranty of ten (10) years shall be issued to the client for the installed waterproofing system.

Technical Specifications-

Technical Specifications- PROPERTIES	TYPICAL VALUE
Elongation at break	>150%
Tensile Strength	1 Mpa (ASTM D412)
Water Absorption	4.3%
Shore A Hardness	>80 (ASTM D2240)
Resistance to UV	Excellent (ASTM-D-822)

### **Surface preparation:**

- All surface area shall be cleaned well to make visible of hair cracks / aggregate texture.
- Cleaning of RCC member should be done by hacking tool, wire brush, wire grinder & air blower etc.

- All minor cracks shall be open in "v" shape shall be treated with Conplast WL or equivalent non shrink additive and after grouting.
- All clean & treated area should tested for water tightness by flooding water.
- All wet spots & water leakage area shall mark for treatment. If any leakage is observed the source of leakage shall be located and it shall be treated either by injection grout or by closing the crack. The treatment shall be continued till the leakages are stopped.
- Fixing Deck web / Chopstrand matt sandwiched between waterproofing coats on the junction of floor and walls.
- Fixing Coving Bandage on the junction of horizontal and vertical surface.

**Note: (Major cleaning and Concrete chipping, cutting off exposed steel in slab, removing nails, binding wire to be done by main Contractor. All columns starter shall be casted so that waterproofing can be terminated at columns.)**

Making of Threshold at the Toilet door sill:-

- Bund of size 100mm x 25mm shall be made with Micro concrete at the toilet door sill.
- 72 hours curing shall be done.
- Cementitious coating shall be terminated upto 150 mm from toilet outer side of barrier bund.

**Primer :**

- Stir Primer (2 component water based epoxy primer), prior to application.
- All surfaces shall be primed in one coat at Coverage of 0.17 Ltr / Sqm by brush/ roller.
- Applying primer allow to dry for completely.

**Application:**

- Take suitable size mixing vessel which can accommodate all components. Stir and pour 20 Kg Part A, start mixing using heavy duty electric slow speed drilling machine attached with suitable mixing paddle, and add 20 Kg Part B and mix it till homogeneous mix is obtained. For single component stir it slowly before application.
- Apply first coat using brush / roller at all corners /, install Deck Web / chopstrand matt (at pipe penetrations and at all solid wall to solid wall and solid wall to floor junctions) over the wet first coat and continue application at remaining wall and floor areas.
- Allow the applied coating including reinforcing / Sealing Tape to dry completely for 4 hours at 230 C, 50% RH.
- Apply the second coat in opposite direction to the first coat and allow it to dry completely.
- Minimum two coats are recommended at coverage of min. 2.2 kgs / sqm.
- No any water curing is required.

### Protection over the membrane

#### Screed on Floor:

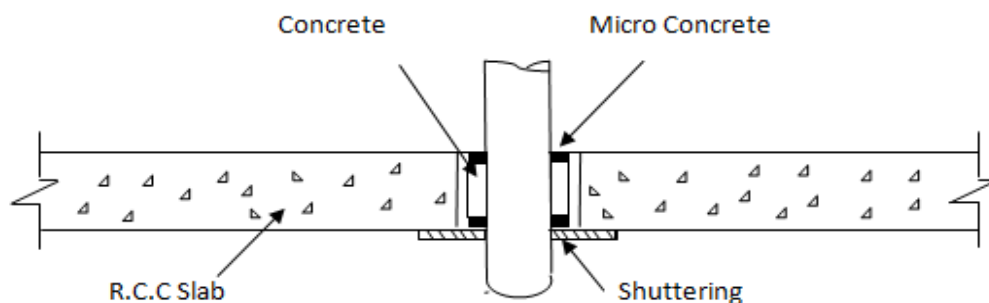
- Providing & laying 25mm thick protective screed on floor in CM 1:4 admixed with Conplast WL of 125ml dosage per bag of cement on top of the membrane for protection

#### Plaster on Wall:

- Providing and laying avg.10-12 mm thick plaster in CM 1:4 admixed with (Conplast WL of 125ml dosage per bag of cement) integral waterproofing compound.

#### Waterproofing for Core Cutting Areas (Upto 150mm dia):

- Core cut the slab (To be done by Main Contractor)
- Hacked around the slab (To be done by Main Contractor)
- Wash thoroughly this hacked off areas to expose the clean concrete surfaces between outlet pipe and concrete.
- Place and fix the pipe mechanically make necessary shuttering from the bottom.
- Fill the concrete around the periphery of the pipe and seal with micro concrete from both the side as shown in the drawing.
- Pour micro concrete, 4 parts micro concrete and 1 part of water to fix and seal the pipe. Remove the shuttering after one day / two day and curing done for 7 days.



#### Detailing Around The Pipe

- Cleaning the surface, coving around the pipe with 1/2" cement mortar 1:4 using deck web / fibre mesh sandwiched with Cementitious membrane.

Note: - All cut outs to be packed by the Main Contractor before handing over to Waterproofing Contractor

#### **Hybrid Polyurea Polyurethane based Membrane (Blueshield PMB / Masterseal M 862 / Bluesil 580) for Terrace / Staircase / LMR / OH tank top**

#### **Surface Preparation:**



- Over the protective Screed. All surface area shall be cleaned well to make visible of hair cracks / aggregate texture.
- Cleaning of RCC member should be done by hacking tool, wire brush, wire grinder & air blower etc.
- All minor cracks shall be open in "v" shape shall be treated with Conplast WL or equivalent non shrink additive and after grouting.
- All clean & treated area should tested for water tightness by flooding water.
- All wet spots & water leakage area shall mark for treatment. If any leakage is observed the source of leakage shall be located and it shall be treated either by injection grout or by closing the crack. The treatment shall be continued till the leakages are stopped.
- Fixing Coving Bandage on the junction of horizontal and vertical surface.
- **Note: (Major cleaning and Concrete chipping, Cutting off exposed steel in slab if any, removing nails, binding wire to be done by main Contractor. All columns starter shall be casted so that waterproofing can be terminated at columns.)**

### **Primer**

- Components A (resin) and B (hardener) are packed in two separate containers, having the correct predetermined mixing ratio by weight. The whole quantity of component B is added into component A. The two components should be mixed for about 2-3 minutes with a low-speed mixer (300 rpm), until the mixture becomes uniform. It is important to stir the mixture thoroughly near the sides and bottom of the container, to achieve uniform dispersion of the hardener. Then add equal quantity of water (100% by weight of primer) and continue mixing to ensure that the mixture obtains the desired workability
- Apply the product using a Roller or Brush @ 80-90 g/sq.m consumption. If the substrate is porous apply a second coat of primer after 4 hours and before 6 hours of 1st application.
- Sprinkle Dry Silica Sand of 0.6mm – 2mm on second coat when wet / tacky @ 800gms/sq.m to create mechanical anchorage for Plaster etc.

### **Application of Continuous Membrane:**

- Components A (resin) and B (hardener) are packed in two separate containers, having the correct predetermined mixing ratio by weight. The whole quantity of component B is added into component A. The two components should be mixed for about 3-5 minutes with a low-speed mixer (300 rpm), until the mixture becomes uniform. It is important to stir the mixture thoroughly near the sides and bottom of the container, to achieve uniform dispersion of the hardener. Apply 1st coat of waterproofing membrane liberally by brush or roller to floor area.
- After mixing Hybrid Polyurea Polyurethane A&B component one shall wait for at least 45min for floor application however wait 60 min for vertical application



to achieve a desire viscosity or to get gelling into the mix to decrease the spread ability

- Check the moisture of Surface to be coated, the moisture content of substrate should be < 4%
- Apply 1st coat of Hybrid Polyurea Polyurethane Membrane using a roller, brush or airless spray @ a consumption of 0.8-0.9 kg/sq.m on primed substrate.
- Spiked Roller shall be used after each Hybrid Polyurea Polyurethane Membrane coat to prevent unevenness when coating. After coating it is used to remove trapped air bubbles after coating. The spiked roller is made of solvent-resistant plastic. It has a plastic impregnated core of hard paper and so the roller will remain stiff.
- After 6 hours and within 24 hours of 1st coat application of Hybrid Polyurea Polyurethane Membrane apply the second coat of Hybrid Polyurea Polyurethane Membrane using roller, brush or airless spray @ a consumption of 0.8-0.9 kg/sq.m
- Spiked Roller shall be used after each Hybrid Polyurea Polyurethane Membrane coat to prevent unevenness when coating. After coating it is used to remove trapped air bubbles after coating. The spiked roller is made of solvent-resistant plastic. It has a plastic impregnated core of hard paper and so the roller will remain stiff.
- Total application rate shall be 2.4 kg/m<sup>2</sup> to achieve the required Thickness of 2mm.

#### **Application of the Smartcare Ultron at Day Lapping Joints :**

- Where a new waterproofing of Hybrid Polyurea Polyurethane Membrane is joint to previous day coating of Hybrid Polyurea Polyurethane Membrane at day joints, a new application will be lapped into existing by minimum 100 mm.
- Where existing cured membrane of Hybrid Polyurea Polyurethane Membrane is done 24 hours prior or surface is contaminated by dust , dirt etc , minimum 100 mm of Lapped end will be cleaned using cleaning agent – Acetone
- First a coat of prepared primer will be applied using primer (preparation as mentioned above).
- Allow the primer to dry and after 4 hours minimum apply Hybrid Polyurea Polyurethane Membrane as per procedure listed in Section : application of Hybrid Polyurea Polyurethane Membrane
- Sprinkle Dry Silica Sand of 0.6mm – 2mm on second coat when wet / tacky @ 800gms/sq.m to create mechanical anchorage for Plaster etc.

#### **Curing**

- Allow the Hybrid Polyurea Polyurethane Membrane to cure to a firm rubber, [Min. 24 hours at 23 °C, 50% RH], the coating achieves full cure in 7 days. Any subsequent activities (including testing, if any) on the coating can be carried out after 7 days. Cover / protect the coating from UV, within 30 days of application.

- Please note Hybrid Polyurea Polyurethane Membrane may turn yellow in exposure to sunlight but the mechanical characteristics of Coated material will not change.
- On horizontal slabs, a flood test should be run in accordance with ASTM D5957. The membrane should be cured to a firm rubber set (5 days minimum) before flooding. Flood with a minimum of 2.5 cm of water for 24 hr.
- **Setting Time:** The applied Hybrid Polyurea Polyurethane Membrane takes approx. 90 minutes to set completely. In case it rains before the setting, same has to be protected using polythene covering till it is set.

#### Technical Specifications of the Liquid applied membrane -

PROPERTY	TYPICAL VALUE
Tensile Strength	> 8.0 MPa
Elongation	>500 %
Shore A Hardness	60
Chemical Resistance	Excellent

#### Separation layer

- A suitably good quality material such as 120gsm polyester- or glass-fleece shall be used as a separation layer between the applied membrane and the protective screed.

#### Over the Separation layer laying TPO Membrane for Terrace

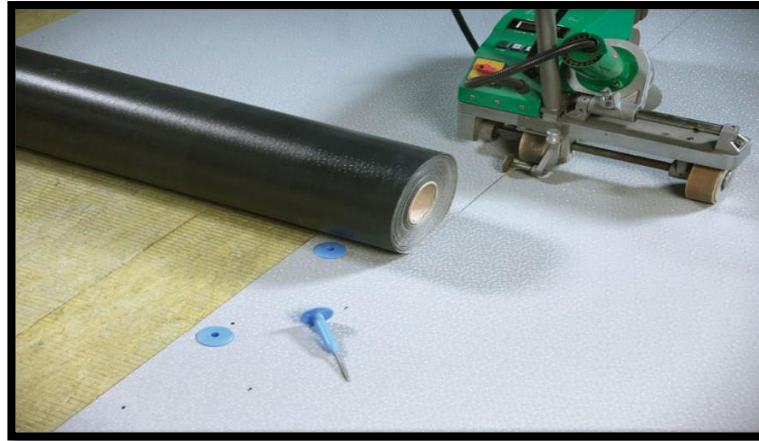
##### Waterproofing Layer

Providing and fixing insulation board (**Client's Scope**)

Over the Insulation Board Installation and laying of modified polyolefin TPO synthetic membrane obtained by coextrusion reinforced by a polyester mesh. This membrane contains special pigment, they confer to the membrane. Furthermore the membrane is featured by a very high resistance to weather agents and UV rays. Manufactured in a plant certified by UNI EN ISO 9001 (Quality management system) and UNI EN ISO 14001 (environmental management system).

Features:

- High solar reflection index (SRI)
- Weatherproof and UV resistance
- Resistant to wind stress
- Mechanical resistance and resistance to punching
- Adaptability to structural movements
- Flexibility at low temperatures

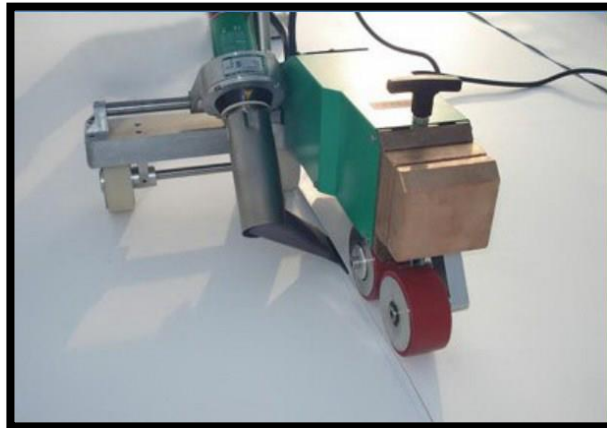


### **Application**

- Mechanically fixed to substrate by independent plates and screws
- The overlap should be 12 cm for mechanically fixed roofs
- It is always necessary to fix around the perimeter with a pre-drilled flange bar. The bar can be mechanically fixed on the horizontal or vertical surface at the base of the upstand

All welding including detail work to be carried out in dry conditions using:

- Leister automatic welder



- Leister hot air gun

Laying by installer approved by Flag S.p.A Finishing and accessories with elements manufactured and approved by Flag S.p.A.

**Note:** it is advisable to unroll and lay down the waterproof membrane on the support at least 30 minutes before its application.

**Note:** The instructions for the correct installation of the membranes can be found in the Flag installation procedures.

### **Fixing Elements**

Laying mechanically fixing system using special mechanical fasteners with plates according to specifications of the producer of the fasteners. The mechanical fixing

must be made following a plan of application according to EN 1991-1-4:2010 provided by the fastener producer.

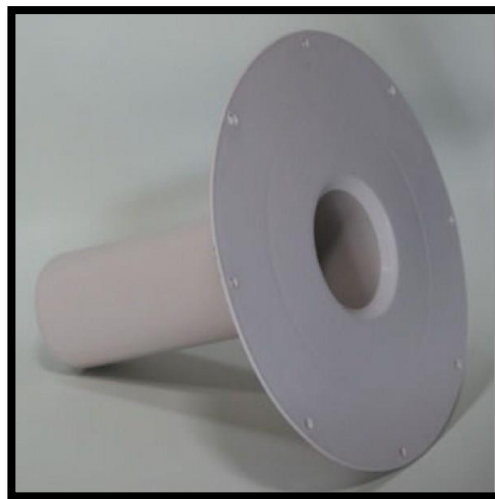
### **Perimeter Fastening**

Installation of perimeter fixing element consisting of a prepunched galvanized bar. Fixing with a suitable fastener.

Insert **Flag Bar End Protectors** at the junction between two adjacent bars and in the corners and hot-weld the tear prevention curb **Flagofil TPO**.

### **Accessories**

Installation and laying of **TPO rainwater outlet** with a diameter ranging from 60 mm to 150 mm (depending on the design requirements) equipped with universal leafs guard or universal gravel guard, weldable using Leister hot air gun. Provide appropriate mechanical fixing of the TPO membrane with at least three fasteners.



Installation and laying of finishing element for Flagon TPO membrane, **TPO vapour aerator**, colour sand grey, resistant to weathering and ultra-violets rays, weldable using Leister hot air gun. Laying by installer approved by Flag S.p.A. The number of the vapour aerator to be installed per square meter should be appropriate to the situation of the site and depending on the specific thermo hygrometric calculation to be carried out by a qualified professional.



### **Protection over the membrane**

**Separation Layer**

- Over TPO membrane providing separation layer, polyester geo textile of 120GSM.

**Protection over the membrane using brick / block bat coba**

- Applying cement slurry using 2.75 kg/Sqm of cement mixed with Conplast WL or equivalent waterproofing compound @125ml per bag of cement.
- Brick / Block pieces of quarter half and three quarter size are laid piece by piece in the form of horizontal Brick / Block masonry in waterproof mortar with waterproofing compound made up of cement and crush sand 1:3 with waterproofing compound (Conplast WL or equivalent) to be added @ 125ml per bag of cement for protection.
- The Brick / Block bat coba is finally covered with 20mm jointless waterproofing plaster in CM 1:3 with waterproofing compound (Conplast WL or equivalent) to be added @ 125ml per bag of cement for protection.
- The entire surface shall be cured for minimum 7 days by storing water to a depth of 110mm.

**China Mosaic for Terrace Floors:**

- Surface preparation by cleaning the surface.
- Bedding of cement mortar (1:4) with waterproofing compound Conplast 100 ml/bag of cement 20-25mm thick.
- Side by side fixing of china mosaic in required multi coloured broken tile pieces shall be started.
- Floating of cement/dry cement over the laid china mosaic.
- Cleaning after setting of china mosaic.

**Two Component Undertile Acrylic Based Membrane for Service and Reuge Area**

The entire surface receiving the Toilet Non sunken waterproofing system shall be sufficiently cleaned by appropriate methods to remove dust, oil, sand and stones, etc. and other unwanted particles such as nails, cut-off steel material, glass and broken glasses, etc. The waterproofing material to be used shall be WPM 002 / Blueguard / Revestidan applied waterproofing system. The Liquid Applied waterproofing system shall be single / Two component Acrylic based under tile waterproofing membrane consisting of two layers, with a nominal thickness of 1 mm minimum. The reinforcement if required shall be either 225 gsm or 300 gsm chopped strand fiber - glass mat.

Acrylic waterproofing material shall be flexible and passes the 1.5 mm mandrel, and shall be able to bridge hairline and minor cracks. When not reinforced, it shall have at least 150% elongation. At all detailing like pipe protrusions, rain-water-down-pipes, edges and corners, application of the waterproofing system shall be

sufficiently dressed up and reinforced with fiberglass reinforcement. Upon completion of the application the entire surface shall be check for uniformity to ensure proper application of the system. All materials shall be applied by an approved and trained applicator, and a warranty of ten (10) years shall be issued to the client for the installed waterproofing system.

Technical Specifications-

PROPERTIES	TYPICALVALUE
Elongation at break	>150%
Tensile Strength	1 Mpa (ASTM D412)
Water Absorption	4.3%
Shore A Hardness	>80 (ASTM D2240)
Resistance to UV	Excellent (ASTM-D-822)

#### Surface preparation:

- All surface area shall be cleaned well to make visible of hair cracks / aggregate texture.
- Cleaning of RCC member should be done by hacking tool, wire brush, wire grinder & air blower etc.
- All minor cracks shall be open in "v" shape shall be treated with Conplast WL or equivalent non shrink additive and after grouting.
- All clean & treated area should tested for water tightness by flooding water.
- All wet spots & water leakage area shall mark for treatment. If any leakage is observed the source of leakage shall be located and it shall be treated either by injection grout or by closing the crack. The treatment shall be continued till the leakages are stopped.
- Fixing Deck web / Choppstrand matt sandwiched between waterproofing coats on the junction of floor and walls.

**Note: (Major cleaning and Concrete chipping, cutting off exposed steel in slab, removing nails, binding wire to be done by main Contractor. All columns starter shall be casted so that waterproofing can be terminated at columns.)**

#### Primer :

- Stir Primer (2 component water based epoxy primer), prior to application.
- All surfaces shall be primed in one coat at Coverage of 0.17 Ltr / Sqm by brush/ roller.
- Applying primer allow to dry for completely.

#### Application:



- Take suitable size mixing vessel which can accommodate all components. Stir and pour 20 Kg Part A, start mixing using heavy duty electric slow speed drilling machine attached with suitable mixing paddle, and add 20 Kg Part B and mix it till homogeneous mix is obtained. For single component stir it slowly before application.
- Apply first coat using brush / roller at all corners /, install Deck Web / chopstrand matt (at pipe penetrations and at all solid wall to solid wall and solid wall to floor junctions) over the wet first coat and continue application at remaining wall and floor areas.
- Allow the applied coating including reinforcing / Sealing Tape to dry completely for 4 hours at 230 C, 50% RH.
- Apply the second coat in opposite direction to the first coat and allow it to dry completely.
- Minimum two coats are recommended at coverage of min. 2.2 kgs / sqm.
- No any water curing is required.

Protection over the membrane

#### **Protection over the membrane using brick / block bat coba**

- Applying cement slurry using 2.75 kg/Sqm of cement mixed with Conplast WL or equivalent waterproofing compound @125ml per bag of cement.
- Brick / Block pieces of quarter half and three quarter size are laid piece by piece in the form of horizontal Brick / Block masonry in waterproof mortar with waterproofing compound made up of cement and crush sand 1:3 with waterproofing compound (Conplast WL or equivalent) to be added @ 125ml per bag of cement for protection.
- The Brick / Block bat coba is finally covered with 20mm jointless waterproofing plaster in CM 1:3 with waterproofing compound (Conplast WL or equivalent) to be added @ 125ml per bag of cement for protection.
- The entire surface shall be cured for minimum 7 days by storing water to a depth of 110mm.

#### **Polyisoprene Membrane for 100% Slab Area**

The entire surface receiving the balcony waterproofing system shall be sufficiently cleaned by appropriate methods to remove dust, oil, sand and stones, etc. and other unwanted particles such as nails, cut-off steel material, glass and broken glasses, etc. The waterproofing material to be used shall be Formak 629 / Blue Deck applied waterproofing system. The Liquid Applied waterproofing system shall be single component ready-mixed heavy-bodied polyisoprene waterproofing membrane consisting of three layers, with a nominal thickness of 1.2 mm minimum.

The reinforcement if used shall be either 225 gsm or 300 gsm chopped strand fiber - glass mat. Polyisoprene waterproofing material shall be flexible and passes the 3mm mandrel, and shall be

able to bridge hairline and minor cracks. When not reinforced, it shall have at least 400% elongation. At all detailing like pipe protrusions, rain-water-down-pipes, edges and corners, application of the waterproofing system shall be sufficiently dressed up and reinforced with fiberglass reinforcement. Upon completion of the application the entire surface shall be check for uniformity to ensure proper application of the system. All materials shall be applied by an approved and trained applicator, and a warranty of ten (10) years shall be issued to the client for the installed waterproofing system.

#### Technical Specifications -

PROPERTIES	TYPICALVALUE
Tensile Strength	>2.5 M/mm <sup>2</sup> (ASTM D412)
Solid	68.03% (ASTM G 53)
Elongation	> 400% (ASTM D412)
Shore A Hardness	> 53 (ASTM D2240)
Resistance to UV	Excellent (ASTM-D-822)

#### Surface Preparation

- All surfaces to be treated with Formak 629 / Blue Deck must be thoroughly inspected; the concrete surface must be clean and free from oil, Grease, paint, loose dust, mud and laitance.
- Horizontal surfaces should not have curing agents or hardeners applied prior to the Formak 629 / Blue Deck application.
- Honeycombs should be hacked off to expose the concrete.
- All chipping and loose particles should be removed, clean surface with water before repairing.
- Repair all the hacked off areas with Injection Grout.
- New concrete must be at least three days old before it should be treated.

#### Angle Fillet

- At all junctions between slabs and walls, do an angle fillet of 25mm X 25mm with cement mortar 1:3 waterproofing compound conplast WL Fosroc make 125ml per bag of cement .
- Mix 3 part of sand and 1 part of cement to mix thoroughly to a mortar consistently and applied with a trowel to form an angle fillet.

#### Application Procedures

- After the surface of the concrete is prepared up to the acceptable condition for applying waterproofing material, Membrane can be applied by using brush or roller over the entire surfaces.
- Membrane should be applied in primer + three coats for horizontal surface. (total consumption shall be 1.8 Kgs / Sqmt)



- The single coat as a Primer should be applied at the rate 0.1 Lit/m<sup>2</sup> in dilution with water (1:1) & allowed it to dry for 3-4 hrs.
- The first coat of Membrane shall be applied @ 0.9 Lit / Sqm with a proper roller ensuring that all surface of the concrete surface is covered.
- Leave the first coat to dry. When the first coat is reasonably dry and can accept foot traffic without lifting off the material when stepped on. This would at least be 3 to 4 hours after the second coat application @ 0.9 Lit / Sqm.
- Apply second coat with laying fiber mesh/ deck web on all floor. The fiber cloth/ deck web to be sandwiched between First and Second coat.
- Leave the Second coat to dry. When the Second coat is reasonably dry and can accept foot traffic without lifting off the material when stepped on. This would at least be 3 to 4 hours after the third coat application.
- Wait for the final coat Membrane to be dry at least over night or 3 hours minimum.
- Clean all tools and equipment with clean water immediately after use, before the liquid dries. In case of spills, dike and contain spill with sand or earth. Once the spill has dried, only removal by hacking is possible.

### **Protection over the membrane**

#### **Screed on Floor:**

- 
- Providing & laying 25mm thick protective screed on floor in CM 1:4 admixed with Conplast WL of 125ml dosage per bag of cement on top of the membrane for protection

**SECTION 4**

**TECHNICAL SPECIFICATION**

**FOR**

**STRUCTURAL STEEL WORKS**

## SECTION 4

### STRUCTURAL STEEL WORKS

#### 1.00 GENERAL SCOPE

- 1.01 This specification deals with the technical requirements needed for the fabrication and erection of Structural Steel Works for various structures coming under the scope of this contract. All shop connections shall be welded unless otherwise specified in Consultant's design drawing. Field connections shall be either welded or bolted and as shown in design drawings.
- 1.02 The specification cover the technical requirements for supply of all steel items were specified fabrication, loading / unloading and transportation of fabricated members, inspection, testing, painting, lifting and erection to desired position, alignment, etc. complete including preparation of fabrication drawings for structural steel work involving rolled section, pipes and built up sections fabricated out of plates, rolled section and or combination of plates and rolled sections in columns, beams, gantry girders, roof trusses, portals, purlins, shear connector, galleries, well beams, brackets, stub columns, bracings, trestles, base plates, chequered plate flooring, grating with binders, walkway platform, ladders, stairs complete with stringers, treads, landing, handrails posts, erection bolts and nuts, permanent bolts and nuts, dismantling, modification and re-erection of fabricated/erected steel, etc. including all sampling and testing as given in annexure-A for the areas of work as specified above.
- 1.03 The scope of work also includes design of all connections, preparation of shop fabrication drawings, along with erection mar-wise material list and bolt list for each erection work, inspection of fabricated materials, shop and field painting after necessary surface preparation of all fabricated items. The scope of work also includes but is not limited to proper stacking and storage of fabricated materials, transport from place of storage to place of erection including touch up of primer shop coat damaged in transit.
- 1.04 The scope also includes fastening and fittings of every type which are described in or implied by this specification, whether shown on the Drawings or not. The scope also includes every detail required for satisfactory completion of the structural works placed in its final position and in perfect state including shop drawings etc. The works shall be generally as shown on the Drawings as to overall dimensions and sizes.
- 1.05 This specification contains the requirement for fabricating & erecting steel structures. When this specification is stipulated in contract documents, conformance with all provisions of the specification shall be required, expect

for those provision that the client or contract document specifically modifies exempts.

## 2.00 REQUIREMENTS

2.01 The Principal Contractor shall furnish all structural steel material, labour, plant, equipment, scaffolding, tools, tackles, all materials and consumables such as welding electrodes, bolt and nuts, oxygen and acetylene gases, oils for cleaning etc. of approved quality as per relevant Indian Standards any everything that is required for complete execution of the work on schedule in accordance with the drawings and as described herein and/or as directed by the

2.02 Fabrication, Erection and approval of Steel Structures shall be in compliance with;

- These General Specifications, IS: 800 and other relevant Indian Standards as listed in clause 3.02.
- Drawings and supplementary drawings to be supplied to the Principal contractor by EIC & PMC during execution of the work.

2.03 Reference points and benchmarks

The Principle Contractor shall make his own arrangements for locating the coordinates and positions of all work and reduced level (RL) at these locations based on two reference grid lines and one bench mark which shall be furnished by the Employer. The Principle Contractor has to provide at site all the required survey instruments to the satisfaction of the EIC so that the work can be carried out accurately according to the specifications and drawings.

2.04 Drawings

- a) Fabrication drawings shall be prepared by the Principal Contractor approved by Employer at his own cost based on the Design drawings released for construction. All the drawings for the entire work shall be prepared in metric units. The drawings shall preferably be of one standard size and the details shown therein shall be clear and legible.
- b) The details shown shall be drawn to the minimum scale as under. A) Marking plan 1:75, b) Joint details 1:5, 1:10, 1:15 c) Elevations 1:20. These drawings shall indicated structural layout and elevation complete details of fabrication and erection including all splicing details, lacing details, weld sizes and lengths, detailing of all joints, bill of materials in the proforma approved by the & and all other customary details in accordance with standard structural engineering practice whether or not given by the Employer. He shall furnish along with the fabrication drawings, necessary calculation regarding design of joints viz. Size and length of welds, dia and number of bolts, and calculations justifying other fabrication details as a well as design of erection and fabrication splices in accordance with IS:800 and other relevant standards. He shall also furnish a scheme of erection.

Quality of structural steel, welding electrodes, bolts, nuts and washers to be used shall be indicated in the drawing in accordance with the technical specification.

- b) The fabrication drawing shall indicate identification (erection) marks for purposes of dispatch and erection etc. Fabrication drawing shall include the following

Non-destructive testing (NDT):

Girders	-	20 % dye penetrate examination (DPE) of root runs.
	-	10 % Radiography of all butt welds
Others	-	10 % DPT

- c) In addition, the total quantity as well as abstract of quantities is to be indicated in the fabrication drawings. The Principal contractor shall prepare a consolidated schedule of permanent bolts and nuts, showing the quality, length, size, weight and numbers required for each fabricated member.
- d) Three copies of the detailed fabrication drawings including bolts and nuts schedule shall be submitted by the Principal Contractor for approval in the first instance along with Bill of materials showing the description of members, their erection marks, quantity, etc. (Proforma to be approved by the in case the approval accorded to the fabrication drawings is subject to any modifications, additions, and alternations, the Principal Contractor shall submit two sets of the revised drawings for final approval after incorporating these changes.
- e) In case the drawings are approved as submitted, he shall submit six additional prints of such approved fabrication drawings. In addition, the Principal Contractor shall also be required to furnish one reproducible copy of final fabrication drawings (as built).
- f) The design drawings may require revision either before or after the preparation and approval of fabrication drawings. Such revision shall be duly incorporated in the fabrication drawings and nothing extra shall be payable on this account for preparation/revision of fabrication drawings and execution of works.
- g) The fabrication work shall start only after approval to the fabrication drawings is accorded by the
- h) Such approval shall however, not relieve the Principal Contractor of his responsibility for the safety of the structure, good connections, erectability, etc.

## 2.05 Material supply and Samples

Steel materials shall comply with the specifications laid down under clause 3.0 and/or as called for in the design drawings. All materials used shall be new, unused and free from defects.

All steel and other material shall be procured and supplied by the Principal contractor, from the reputed sources as approved by and shall conform to the following:

Principal contractor shall use materials for fabrication as specified in the approved drawings. All materials supplied by the Principal Contractor shall be in sound condition, of recent manufacture, free from defects such as mill scales, slag intrusions, laminations, pitting, flaky, rust etc. and be of full weight and thickness as specified.

The Principal contractor shall furnish the mill / manufacturer's test reports, along with the materials and satisfactorily demonstrates the specific grade and quality. Material test certificate shall be original.

All materials required for the work shall be correlated with manufacturers test certificates. In the absence of test certificates, the Principal Contractor shall test materials through reputed laboratories approved for establishing quality at his cost and as directed.

Material supplied against these Test Certificates (TC) should have identification stamped or stenciled on them. All such identification markings shall be authenticated by the inspection agency, which has inspected and approved the material.

They shall have the right to test random samples to prove authenticity of the test certificates produced by the Contractor at the Contractor's cost. Any material found not meeting the required specification would be rejected.

Whenever the Contractor desires to substitute structural members / shapes, plates for the sizes shown on the drawings, for want of availability of requisite materials, such substitutions shall be made only after authorization in writing by the may also direct that substitution be made, when he considers such substitution to be necessary.

Samples for checking the quality of materials procured by the Principal Contractor and workmanship in the execution of the works may be called for at any time by the. In case such samples are found to be of substandard/unacceptable quality, the Principal Contractor shall immediately discontinue use of such materials and workmanship and get fresh samples approved by the nothing shall affect the liberty of the to reject whole or portions of structures where such defective materials and workmanship has already been used before detection.

### **3.00           Manufacturer's Test Reports**

#### **3.01           Structural Steel**

The fabricator shall submit, for record, copies of material test reports, commonly called milltest reports, for all structural steel. Material test reports shall comply with the requirements of relevant Standard or code.

Manufacturer certifications for structural steel shall contain at least the following information:

- Heat analysis or heat number
- Mechanical test results
- If galvanized, measured zinc coating weight or thickness,
- Results of visual inspection and/or ultrasonic plate scanning
- Statement of compliance with code
- Lot number and purchase order number,
- Complete mailing address of responsible party

To cross verify the submitted Material TC, raw material shall be tested as per code requirement. Frequency of testing shall be 1 randomly selected sample per heat/batch no.

In case of non-availability of heat no. / Lot no. on the raw material, extent of testing shall be mutually agreed between the client, the contractor, the consultant & the inspector.

### 3.02 Fastening Material

The Contractor supplying fastener products shall submit, for record, copies of all Manufacturer's Certifications for all fastener components, including bolts, nuts, washers, and direct tension indicators.

Manufacturer certifications for bolts shall contain at least the following information:

- Heat analysis, heat number, and a statement certifying that heat having prohibited elements intentionally added were not used to produce the bolts.
- Results of hardness, tensile and proof load tests, as required and performed, If galvanized, the results of rotational capacity tests, including the test method used (solid plate or tension measuring device) and the lubricant present,
- If galvanized, measured zinc coating weight or thickness,
- Results of visual inspection for bursts,
- Statement of compliance with dimensional and thread fit requirements,
- Lot number and purchase order number,
- Complete mailing address of responsible party

To cross verify the submitted Material TC, raw material shall be tested as per code requirement. Frequency of testing shall be 1 randomly selected sample per heat/batch no.

In case of non-availability of heat no. / Lot no. on the raw material, extent of testing shall be mutually agreed between the client, the contractor, the consultant & the inspector.

### 3.03 **Shear Connectors (Shear Studs)**

The Contractor shall submit the following items:

- Stud Manufacturer's Certification that the studs, as supplied, meet the requirements of AWS D1.1, Sections 7.2 and 7.3,
- Certified copies of the stud manufacturer's test reports covering the last completed set of in-plant quality control mechanical tests for the diameter supplied, and certified material test reports from the steel supplier indicating diameter, chemical properties and grade on each heat number supplied.

To cross verify the submitted Material TC, raw material shall be tested as per code requirement. Frequency of testing shall be 1 randomly selected sample per heat/batch no.

In case of non-availability of heat no. / Lot no. on the raw material, extent of testing shall be mutually agreed between the client, the contractor, the consultant & the inspector.

### 3.07 **Test at works**

- a) The Principal Contractor shall submit Mill / Manufacturers test certificates for all the materials procured by him. If test certificates are not available or identification marks are not clear, the Principal Contractor shall arrange for such materials to be tested at an approved laboratory as and when required by the.
- b) If material is supplied by the Clients, the Clients shall furnish a mill certified report of the tests for each grade of steel from which the material is to be fabricated. In both the cases (material supplied by the contractor or the client) the certification shall contain the results of chemical and physical tests required by the specification for the material. In the event the results of any test are not in conformance with the requirements of these specifications, the clients shall conduct additional mill and laboratory tests. The additional costs of furnishing, cutting and machining additional test specimens shall be borne by the client.
- c) Structural steel not conforming to the requirements of any of the above standards may be used only if permitted in writing by the Consultant. This permission may be granted after the steel is tested for yield point stress, ultimate tensile stress, elongation, ductility, weld ability or any other property as required by the Consultant.



- d) For structural steel test samples shall be cut out of the materials from the locations indicated by the and samples shall be prepared in accordance with the requirements of Indian Standards Specifications for conducting such tests. One set of tests will include tests of three individual specimens of samples.

#### 4.0 CODES AND STANDARDS

4.01 Except where otherwise specified herein or authorized by the EIC & PMC, all items of work shall conform to the requirements of relevant latest Indian standards. Any item of work, for which there is no India Standard available, shall conform to the latest British standard (B.S.) the item of work shall be best of its kind and subject to approval of the EIC & PMC. In case of conflict between this specification and those referred to in the standard, the former shall prevail.

4.02 The pertinent clauses and sections of the following codes, standards and specifications (latest editions including all applicable official amendments and revisions) shall apply to the material, design, detailing, fabrication, inspection of the work and painting covered by this specification and as specified in the other sections of this specification. In the event of the conflict of certain requirements of this specification with the details shown in drawings, the decision of the EIC & PMC shall be final.

All structural steel shall conform to the requirements of any one of the following Indian Standards as specified. The list of some important IS codes and standards applicable to the structural steel work for the aforesaid project. However the applicable standards and codes shall be as per but not limited to the list given below.

IS: 228	Methods of chemical analysis of steels
IS: 432 steel (parts I & II)	Mild steel and medium tensile steel bars and hard drawn wire for concrete reinforcement.
IS: 800	Code of practice for general construction in steel.
IS: 801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
IS: 808	Dimensions for hot rolled steel beam, column, channel and angle sections
IS: 811	Cold form light gauge structural steel sections.
IS: 812 metals.	Glossary of terms relating to welding and cutting of
IS: 813	Scheme of symbols for welding.

IS: 814	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel
IS: 816	Code of practice for use of metal arc welding for general construction in mild steel.
IS: 817 welders.	Code of practice for training and testing of metal arc
IS: 822	Code of procedure for inspection of welds.
IS: 875	Code of practice for design loads (other than earthquake) for buildings and structures.
IS: 962	Code of practice for architectural and building drawings
IS: 1079	Hot rolled carbon steel sheets and strips
IS: 1161	Steel tubes for structural purposes.
IS: 1182	Recommended practice for radiographic examination of fusion-welded butt joints in steel plates/sections.
IS: 1200	Methods of measurements of building and civil engineering works
IS: 1239	Mild steel tubes, tubular and other wrought steel fittings.
IS: 1363 C.	Hexagon head bolts, screws and nuts of product grade
IS: 1364 A & B.	Hexagon head bolts, screws, and nuts of product grades
IS: 1367	Technical supply conditions for threaded fasteners.
IS: 1477	Code of practice for painting of ferrous metal in buildings.
IS: 1599	Method of bend tests
IS: 1608	Method of testing of metals – Tensile testing
IS: 1852 products.	Rolling and cutting tolerances for hot rolled steel
IS: 2016	Plain washers.
IS: 2062	Steel for general structural purposes

IS: 2074	Ready mixed paint, air drying, red oxide-zinc chrome priming.
IS: 2595	Code of practice for radiographic testing.
IS: 3138	Hexagonal bolts and nuts.
IS: 3502	Steel chequered plate.
IS: 3613	Acceptance tests for wire flux combination for submerged arc welding.
IS: 3658	Code of practice for liquid penetrate flaw detection.
IS: 3664	Code of practice for ultrasonic pulse echo testing by contact and immersion methods.
IS: 3696	Safety code of scaffolds and ladders.
IS: 3757	High strength structural bolts.
IS: 4218	ISO metric screw threads
IS: 4353	Recommendations for submerged arc welding of mild steel and low alloy steels.
IS: 5334	Code of practice for magnetic particle flaw detection of welds.
IS: 5369	General requirements for plain washers and lock washers
IS: 5372	Taper washers for channels (ISMC)
IS: 5374	Taper washers for I-beams (ISMB)
IS: 5624	Foundation bolts
IS: 6610	Heavy washers for steel structures
IS: 6639	Hexagonal bolts for steel structures
IS: 7205	Safety code for erection of structural steel work.
IS: 7215	Tolerances for fabrication of steel structures.
IS: 7293	Safety code for working with construction machinery.

IS: 7318	Approval test for welders when welding procedure is not required
IS: 7973	Code of practice for architectural building and working drawings
IS: 8500	Structural steel – micro alloyed (medium and high strength qualities)
IS: 9595	(Metal arc welding of carbon and carbon manganese steel Recommendations)
IS: 10720	Technical drawings for structural metal works
IS: 10748	Hot – cold steel scalp / strips for welded tubes and pipes
IS: 10842	Evaluation procedure for Y groove weld crack ability test in structural steel.
IS: 12843	Tolerances for erection of structural steel.
SP: 6 (Part 1 to 7)	ISI Handbook for structural engineers

## **5.00 MATERIALS**

5.01 Structural steel all the consignment received at site shall be with the test

certificate pertaining to that particular lot.

IS800 - 1984 Code of Practice for General Construction Steel

IS 2062 – 2006 (MTD) 4 Structural Steel (Standard quality/Fusion welding quality) / Weld able Structural Steel.

All structural steel shall conform to E 350 grade with yield strength of 350 Mpa & Tensile strength of 490 Mpa & E 250 grade with yield strength of 250 Mpa & Tensile strength of 570 Mpa.

5.02 Structural steel rolled sections and plates shall conform to specified grade of IS: 2062 Pipes used in handrails, embedment etc., shall conform to IS: 1161 or IS: 1239. Chequered plate shall conform to IS: 3502. High strength steel shall conform to IS: 8500 of specified grade. All other materials shall be as per the list of standards codes given above or mentioned elsewhere in the relevant sections.

The Principal Contractor may use alternate materials as compared to design specification only with written approval of the consultant & PMC.

5.03 All steel sections and plates shall be straight, sound and free from twists, cracks, flaws, laminations, rough, jagged and imperfect edges, loose mill scales and other defects. (Contractor shall use materials for fabrication as specified in the approved drawings. All materials supplied by the Contractor shall be in sound condition, of recent manufacture, free from defects such as mill scales, slag intrusions, laminations, pitting, flaky, rust etc. and of full weight and thickness as specified.)

5.04 In case any defect like laminations is noticed in the steel sections and plates during fabrication and erection, the same shall be brought to the notice of the EIC & PMC. These sections and plates shall be rejected unless specifically approved for acceptance by the EIC & PMC.

#### 5.05 Rolled Steel Sections

The following grades of steel shall be used for steel structures.  
Structural steel shall conform to IS 2062 Gr "B".

#### 5.06 Rolled Steel Sections – Brands.

The approved brands for the structural steel shall be one of the following...

- SAIL
- TISCO
- VIZAG and
- Jindal

#### 5.07 Cold Formed Sections

Steel and strip used for making these sections shall conform to IS 1079 - 1994 Specifications for light gauge structural quality hot rolled carbon steel sheet and strip.

#### 5.08 Steel Plate and Protection Angles

Steel plate and protection angles required for the protection of concrete work shall be erected true to line and grade within the tolerances specified below. The edges of exposed faces may have a vertical or horizontal distortion from a straight line not greater than 3 mm per meter of length, provided, that distortion for any single piece shall not exceed 1 mm and provided, that when the warp is greater than 1.6 mm an extra anchor hole shall be drilled near the proper corner and the piece drawn into position thereby. All bolt heads on the exposed face shall be countersunk and fitted or ground so that the heads are flush with the finished surface. Joints between abutting sections shall be square and flush and the butting ends shall be sawed or otherwise made smooth and regular.

#### 5.09 Receipt and Storing of Materials:

- a) Each rolled section must be marked for identification and each lot should be accompanied by Manufacturer's quality certificate, confirming chemical analysis and mechanical characteristics.
- b) All steel parts furnished by Supplier shall be checked, sorted out, straightened and arranged by grades and qualities in stores.
- c) Structural steel with surface defects such as pitting, cracks, laminations etc. shall be rejected if the defects exceed the allowable tolerances specified in relevant Standards.
- d) Welding electrodes shall be stored separately by qualities and lots inside a dry and enclosed room, in compliance with IS: 816 and as per instructions given by EIC & PMC. Electrodes shall be perfectly dry and drawn from an Electrode oven, if required.
- e) Checking of quality of bolts of any kind as well as storage of the same shall be made conforming to relevant standards.
- f) Each lot of electrodes, bolts, nuts etc. shall be accompanied by Manufacturer's test certificates.
- g) Structural steel shall be stored consignment wise and size off the ground by at least 150 mm above protected by suitable cover as desired by EIC & PMC. The steel shall be protected from rusting, oil, grease, distortion and deterioration.
- h) The Passage and space between the stacks shall be sufficient for inspection, identification and rigging operations and the stacks shall be easily measurable.

#### 5.10 Material Tests:

- a) Principal Contractor shall be required to produce Manufacturer's quality certificate for the material or wherever quality certificates are missing or incomplete or when material quality differs from standard Specifications the Principal Contractor shall conduct all appropriate tests as directed by the EIC & PMC, at no extra cost, in test houses approved by EIC & PMC.
- b) Materials for which Test Certificates are not available or for which test results do not tally with relevant standard Specification, shall not be used.

#### 5.11 Certificates of Compliance

Coincident with the submittal of manufacturer's test reports and certifications for structural steel, fasteners, welding filler metals, and shear studs, the Contractor shall submit a letter stating that the Contractor has reviewed the submitted manufacturer's certifications and test reports, and

that the materials being furnished for the project are in conformance with the applicable standards, specifications and project documents.

#### 5.12 Welding Materials (Electrodes, filler wires and flux)

Electrodes, filler wires and flux used for welding shall be from approved manufacturers/Suppliers. When requested by the EIC & PMC, the contractor shall furnish certification that electrode or electrode flux combination will meet the requirements of classification. The classification and size of electrode, arc length voltage & amperage shall be suited to type and thickness of material, type of groove, welding positions and other circumstances attending work.

The Contractor shall also submit the manufacturer's product data sheets for all welding material to be used. The data sheets shall describe the product, limitations of use, recommended welding parameters, and storage and exposure requirements, including baking and rebaking, if applicable.

The contractor should also submit the Material test certificate of all the welding consumable used at site.

Electrodes, filler wire and consumables shall conform to the requirements of ASME Sec. II Part C or relevant acceptable standards.

Only low hydrogen electrodes shall be used for welding. All electrodes having low hydrogen covering shall conform to AWS A5. 1 / AWS A5.5 or relevant acceptable standards. These electrodes shall be purchased in hermetically sealed containers or baked by the user as recommended by electrode manufacturers. Electrode flux coating shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. SMAW electrodes shall be properly stored. Before welding, the electrodes shall be dried in a holding oven at 1200 C at least for 1 hour or as per manufacturer's recommendations. Only limited quantities shall be issued to the welders. The electrodes shall be kept in "carry ovens" and shall not be exposed to the atmosphere.

The filler wire and flux combination for submerged arc welding shall conform to the requirements of ASME Section II, Part C or relevant acceptable standards. The weld metal deposited by the submerged arc process shall have mechanical properties not less than that of base material specification. The flux used for the SAW process shall be dry and free of contamination from dirt, mill scale or foreign material. The flux purchased in packages shall be stored in a dry place. Flux shall be dried in case of damaged packages at the temperature of 260°C for 1 hour prior to welding operation. Flux shall be placed in the dispensing system immediately upon opening a package.

Welding plants and accessories shall have capacity adequate for welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. Contractor shall furnish and obtain approval from EIC& PMC the details of equipment he proposes to deploy for the works. All the electrical plants in connection with the welding operation shall be properly and adequately earthed



and adequate means of measuring the current shall be provided. Proper safety rules shall be strictly followed.

#### 5.11.1 Electrodes

They shall conform to the requirements of the following Indian Standards as specified.

IS: 814 - 1991 Specifications for covered electrodes for metal arc welding of structural steel. Part 1 and 2.

IS: 816 - 1996 Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high-tensile steel.

IS: 822 - 1970 Code of procedure for inspection of welds.

Some of the approved brands for the electrodes shall be as follows. The electrodes shall conform to E 7018-1 norms.

#### **i) Advani Orlikon ii) ESAB iii) D & H – Sechiron and iv) Anand Arc.**

The electrodes shall be dried in an electric oven as per the recommendations of manufacturers. Only DC current shall be used for welding and the Contractor shall make his own arrangements of all welding power and for equipment.

- a) The electrodes used for welding shall be suitable type and size depending upon specifications of the parent materials, the method of welding, the position of welding and quality of welds desired e.g. normal penetration welds or deep penetration welds. However, only low Hydrogen electrodes shall be used for plates conforming to IS: 2062 steel and for all thickness of high strength steel conforming to IS: 8500.
- b) All low hydrogen electrodes shall be baked and stored before use as per manufacturer's recommendation. The electrodes shall be re-baked at 250° - 300°C for one hour and later on cooled in the same oven to 100°C. It shall be transferred to a holding oven maintained at 60°C – 70°C. The electrodes shall be drawn from this oven for use.
- c) Where coated electrodes are used they shall meet the requirements of IS : 814 and relevant ASME-SEC IX and IIC. Coating shall be heavy to withstand normal conditions of handling and storage. They shall be free from all defects which would interfere with performance of electrodes.
- d) Only those electrodes which give radiographic quality welds shall be used for welds which are subjected to radiographic testing.
- e) Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform to the requirements of IS:3613. The electrodes shall



be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

- f) Specific approval shall be taken by the Principal Contractor for the various electrodes proposed to be used on the work before any welding is started.
- g) Electrodes for all welding shall be procured as envisaged in the welding procedure sheet predetermined before actual welding operation starts/
- h) Electrodes shall bear the IS/BS/AWS or equivalent Certification mark.

The approval for all the consumables for welding shall be specifically obtained beforehand.

#### 5.11.2 Filler Wire & Flux

The filler wire & flux combination for submerged arc welding shall conform to the requirements for the desired application as laid down in IS 3613 - 1974, acceptance tests for wire flux combination for submerged arc welding.

### 6.0 SHOP DRAWING & ITS APPROVAL:

The Contractor shall submit three (3) complete sets of detailed working and shop drawings, schedules of all structural steelwork and sequencing of work activity. Fabrication shall not commence until (1) set of the shop drawings has been returned to the Contractor and duly stamped by the Engineer as approved for fabrication.

The contractor shall submit to the Inspection Agency detailed, coordinated and drawing for all structural steel for review prior to the start of fabrication and/or erection.

Shop drawings shall be in metric units and shall clearly show all sizes, dimensions, markings, connections, splices etc. and shall set out the positions, sizes and lengths of all welds as are necessary for the complete fabrication, assembly and erection of the steelwork. Marking plans and sufficient elevations shall be included in the shop drawings to define the positions of all members detailed. Splices may be made only where shown on the approved shop drawings.

The Contractors in advance of the actual fabrication shall prepare shop drawings. These drawings should clearly distinguish between the shop and field bolts and welds. A marking diagram allotting distinct identification marks to each separate piece of steel work shall be prepared on the shop drawing. The shop drawings shall be sufficient to ensure convenient assembly and erection at site. They shall be submitted in triplicate to the Consultant for their scrutiny. One copy will be returned within 14 days to the Contractor with the Consultant's comments for amendment of the drawings and re-submission till final approval. The Contractor should provide for this period of submission and resubmission as often as required, in determining the total contractual time for completion of works. The

Consultant will not scrutinize the shop drawings for numbering off the components or for dimensional accuracy of fit. The shop drawings shall have to be updated to incorporate changes and revisions during the progress of the work and finally a triplicate set of As-Built drawings are to be submitted.

No other substitutions in sizes or shapes of members shall be made without prior approval and no variation to the details shown on the shop drawings shall be made unless authorized by the Consultant. Minor details not shown on the drawings shall conform to the relevant Indian code and to the approval of the Consultant.

The Contractor shall note that the Consultant for general conformity with the contract Drawings and Specification check shop drawings only. The responsibility of all aspects of the fabrications remains with the Contractor.

The Contractor shall be responsible for checking closing dimensions and detail where new work connects to existing. The Consultant for lack of fit will consider no payment for extras.

The complete process from preparation of shop drawing to placement of girder in its final position shall be looked after/ inspected /checked & certified by an approved agency expert in the structural steel Girder and framing work. The agency shall be approved by the structural Engineer & duly appointed by the Clients

#### 6.01 Shop Drawing - Shop drawing shall show:

1. Size and location of all structural members and connection material,
2. Complete information necessary for the fabrication of members including cuts, copes, holes, doubler plates, stiffeners, and camber,
3. Type, size and location of bolts and welds,
4. Surface preparation and finishes,
5. Details of assembly,
6. Identification of shop-installed high-strength bolted connections as snug-tight, pre-tensioned or slip-critical, as required by the Contract Documents, and
7. Identification of Welding Procedure Specification (WPS) applicable to each shop weld.

Welded connections shall be identified using standard AWS symbols as given in AWS A2.4, Standard Symbols for Welding, Brazing and Nondestructive Testing, and shall clearly distinguish between shop and field welds.

#### 6.02 Erection Drawings

The Contractor shall submit to the Consultant & the third party Inspecting agency a detailed, coordinated and checked erection drawings for all structural steel for review prior to the start of fabrication and/or erection.

Erection drawings shall be submitted that show:

1. Location of all structural material,
2. Identification mark of members,
3. Orientation and relation of members to appropriate grid lines,
4. Setting elevations for column bases,
5. Standard and special details for bolted and welded field connections.
6. Identification of field-installed high strength bolted connections as snug-tight, pretension or slip-critical, as required by the Contract Documents, and
7. Identification of WPS applicable to each field weld.

Welded connections shall be identified using standard AWS symbols as given in AWS A2.4, Standard Symbols for Welding, Brazing and Nondestructive Testing, and shall clearly identify field welds.

#### 6.03 Erection Plans (Erection Method Statement)

Before starting work the Contractor shall submit the Erection Plans to the client, consultant & Inspector (For jobs involving critical erection, this shall be the criteria to evaluate the contractor. And hence, Erection plan shall be submitted with the bid in the job involving critical erection) for record purposes.

An erection plan shall have description of the methods, scheme of erection, sequence of erection, and type of equipment proposed for use in erecting the structural steel work. Included shall be design information, plan and elevations showing proposed temporary bracing and shoring systems, with the magnitudes, locations and directionality of construction loads imposed on the permanent structure.

#### 6.04 Contractor's Statement of Responsibility

The Contractor shall be responsible for the work shall submit a written Statement of Responsibility to the Owner and Building Official prior to commencement of the work.

The statement shall contain the following.....

- a) Acknowledgment of awareness of the special requirements contained in the Quality Assurance Plan,
- b) Acknowledgment that control will be exercised to obtain conformance with the construction documents,
- c) Procedures for exercising control within the Contractor's organization the method and frequency of reporting, and the distribution of reports,
- d) Identification and qualifications of the persons exercising such control and their positions in the organization.

#### 6.05 Procedures

Procedures shall assign responsibility to a person or position in the organization and shall contain enough detail to be useful to the workforce without reference to governing specifications.

The procedures also act as work instructions. Procedures shall be dated and indicate the person or position that has the authority to maintain the procedure.

#### 6.06 Fastener Installation Procedures

The Contractor shall submit written procedures for the pre-installation testing, installation, snugging, pre-tensioning and post-installation inspection of fasteners, client specification and the project documents. Procedures shall be submitted only for the methods of installation to be used by the Contractor, which may include the turn-of-nut, calibrated wrench, twist-off type tension control bolt, and direct tension indicator methods.

### **7.01 Welding Procedure Specifications (WPSs)**

The Contractor shall prepare Welding Procedure Specifications (WPSs) & submit to the inspection agency for review. All the WPSs shall be made as per AWS D 1.1. The Supporting Procedure qualification Record (PQR) shall also be submitted with the WPS. Contractor shall use welding consumable which is used for qualifying WPS. Else contractors should qualify the WPS with new consumable.

The contractor has to qualify the WPS in the presence of inspection agency, if asked by the client

### **7.02 Welding Performance Qualification Records (WPQ)**

The Contractor shall offer all the all welding personnel i.e. welders for Welding Performance Qualification Records (WPQ) to the Inspection Agency. The Inspection Agency shall Witness the test & document the successful completion of the appropriate welding in form of WPQ. All welder qualification testing shall be performed in accordance with the current or a previous version of AWS D1.1.

### **7.03 Pre - Fabrication / Pre - Erection Conferences**

Prior to performing any fabrication or erection work, the Client, the PMC, the Consultant, the Inspection Agency, together with Steel Fabricator personnel and Steel Erector personnel supervising the shop, field and Quality Control work shall

hold a Pre-Fabrication and Pre-Erection Conference to review welding procedures, bolting procedures, and inspection requirements for all welding and bolting operations.

## **8.00 FABRICATION**

### **8.01 General**

Structural steel shall be shop fabricated in accordance with the applicable AISC Specification, AISC Code of Standard Practice, and AWS D1.1, as modified by the provisions of the contract documents. High-strength structural steel shall be identified according to grade.

Members shall be marked and match-marked as needed for field assembly. Members shall be fabricated for delivery in a sequence that will expedite erection and minimize field handling of structural steel.

Cuts, holes, and openings in structural steel members, shown on the design drawings, shall also be shown on the shop drawings for structural steel and shall be done in the shop.

The Contractor shall cooperate fully with requests from inspection and testing personnel for access to the connections and joints to be inspected or tested. This includes beam and column turning in the shop, weld backing removal when nondestructive examination indicates rejectable conditions, and access to platforms or scaffolding as required performing the work safely. Weld backing removal shall also be performed where required by the Contract Documents. When weld backing must be removed for test verification, the inspection must be performed in a timely manner so as not to hinder production nor require duplication of effort.

The Contractor shall conduct all necessary corrections of deficiencies in material and workmanship. Repair procedures shall be submitted to the Inspection Agency for review and acceptance.

The Contractor shall comply with requests to correct deficiencies, when such corrections are required by the Inspection Agency. The Inspection Agency shall check the repairs with relevant NDT Technique.

### **8.02 Bolted Construction**

Standard holes shall be used, unless otherwise indicated on the Drawings.

Holes shall be drilled or punched at right angles to the surface of the metal, not more than 1/16 inch larger than the fastener diameter, except where oversize holes are specified. Making or enlarging holes by burning is prohibited unless hole slotting is required between two punched or drilled holes. Center piercing with a torch and reaming to the required diameter is permitted. Material having a thickness in excess of the connector diameter plus 1/8 inch shall be drilled rather than punched. Burrs that would prohibit solid seating of the connected parts shall be removed.

Connections shall be assembled in accordance with the drawing requirement, using provisions for pre-tensioned joints, unless snug-tight bolts are indicated on the Drawings. Pre-tensioned joints shall be prepared as for Class A or better slip-critical joints unless otherwise indicated on the drawings.

#### 8.03 Welded Construction

Each welder working on the project shall be assigned an identification no. & card. Each welder shall mark or stamp this identification symbol at each welding completed. Stamps, if used, shall be the low-stress type.

Welding personnel shall be qualified in accordance with AWS D1.1, Section 4, Parts A and C. Welders whose work routinely exhibits poor workmanship shall be requalified before performing further welding. WPSs shall be available to welders and inspectors prior to and during the welding process. Prior to welding, joint fit-up shall be verified by the welder for conformance with the WPS and AWS D1.1. Welding shall be performed in accordance with the appropriate WPS for the joint.

Groove welds shall be complete joint penetration groove welds, unless specifically designated otherwise on the Drawings. Groove preparation details are at the Contractor's selection, subject to qualification, if required, in accordance with AWS D1.1.

Faces of fillet and groove welds exposed to view shall have as-welded surfaces that are reasonably smooth and uniform. No finishing or grinding shall be required, except where clearances or fit of other items may so necessitate, or as preparation for coating.

#### 8.04 Headed Shear Studs

Shear studs shall be welded in accordance with AWS D1.1, Section 7, and the manufacturer's recommendations. Procedure for the same shall be qualified as per AWS D1-1 requirement prior to welding. Qualification of operator for stud welding shall be done in accordance with AWS D1.1

8.05 The fabrication and erection of works shall be carried out generally in accordance with IS: 800 as well as the stipulations contained in this specification. All materials shall be completely fabricated at the Principal Contractor's shop or at the shop established by him at the project site and finished with proper connection materials for ready assembly in the field. Checklist format, inspection certificate for fabrication, erection, alignment and protocol for handling over structural steel shall

be submitted by the Principal Contractor in the form as agreed to by the EIC & PMC. Fabrication work shall be taken up based on the approved fabrication drawings.

#### 8.06 Cutting Plans

Fabrication work shall be taken up based on the fabrication drawings duly approved by EIC & PMC. The Principal Contractor shall prepare necessary cutting plans before commencement of fabrication.

#### 8.07 Straightening

All steel material shall be straight and free from bends or twists. If the sections are distorted or twisted during transit, storage, etc. they shall be straightened and/or flattened by straightening machine at ambient temperature, though minor kinks or bends may be corrected by limited heating under careful supervision.

All materials before being laid off or worked shall be straight and free from twist. If rectification is necessary, it shall be affected by cold working and applying pressure, but not by hammering or any other method that will affect or injure the metal. Material with kinks or bends shall be rejected.

Surfaces of members that are to be joined by lap or fillet welding or bolting shall be even so that there is no gap between overlapping surfaces.

#### 8.08 Marking:

- a) Marking of Members shall be made on horizontal platforms or on appropriate racks or supports in order to ensure horizontal and straight placement of such Members.
- b) Marking accuracy shall be within  $\pm 1$  mm.

#### 8.09 Temporary erection before dispatch:

The steel work shall be temporarily shop erected complete and shown to EIC so that accuracy of fit may be checked before dispatch. The parts shall be shop assembled with a sufficient number of parallel drifts to bring and keep the parts in place.

#### 8.10 Labeling & Packing

Prior to transportation of the steelwork all projecting plates or bars, and all ends of members at joints shall be stiffened. All straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed. All rivets, bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit.

#### 8.11 Inspection and Testing



The Project Engineer shall have free access at all reasonable times to those parts of the Contractors works which are concerned with the fabrication of the steel work. He shall be afforded all reasonable facilities for satisfying himself that the fabrication is being undertaken in accordance with the provisions of the Specification.

Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work. The Contractor shall guarantee compliance with the provisions of the Specification, if required to do so by the Engineer.

Should any structure or part of a structure be found not to comply with any of the provisions of the Specification, it shall be liable to rejection. No structure or part of the structure, once rejected shall be resubmitted for test, except in cases where the Consultant considers the defect as rectifiable.

Defects, which may appear during fabrication, shall be made good by the Contractor with the consent of, and according to the procedure laid down, by the Consultant.

The Contractor shall supply all gauges and templates necessary to satisfy the Consultant. The Consultant may, at his discretion, check the test results obtained at the Contractor's works by independent tests at the Government Test House or elsewhere. Should the material tested be found to be unsatisfactory, the costs of such tests shall be borne by the Contractor, and if satisfactory, the costs shall be borne by the Employer.

#### 8.12 Bending

- a) The bending of plates and sections to specially required shapes shall be done either on appropriate machines or by angle smithy and black smithy processes.
- b) Bending of plates, flats and sections shall be carried out on bending rolls or in presses.
- c) Cold bending may be accepted when bending radius is equal to or more than :
  - 25 times member thickness for plates and flats or pipes.
  - 25h or 25b for rolled steel beams and channels according to bending plane
  - 45b for angle

Where h = section height and b = flange width.

- d) When bending radius is less than that indicated in 5.05(c), bending shall be done by heating the member up to 850 – 900°C (light red radiance). Cooling shall be done slowly as directed by EIC& PMC.  
Bending shall be discontinued when temperature drops below 500°C.



- e) Accuracy of bending operations shall be checked by means of Templates and the clearance between member and template shall not be more than 1 mm.
- f) Bent members shall not have cracks or deep indentations from bending equipment.

#### 8.13 Cutting

Cutting may be affected by shearing, cropping, sawing or by gas cutting by mechanically controlled torch and shall be reasonably square and free from distortion with all burrs removed. Gas cutting by hand may only be used when specifically authorized in writing by the No electric metal arc cutting shall be allowed. If directed by the Consultant the edges shall be ground afterwards.

The edges of all plates shall be perfectly straight and uniform throughout. Shearing, cropping and gas cutting shall be clean, square and free from distortion and burrs, and should the EIC & PMC find it necessary the edges shall be ground afterwards by the Principal Contractor. Cutting tolerances shall be as follows.

For members connected at both ends  $\pm 1$  mm & elsewhere + 3 mm

For gas cutting high tensile steel, sufficient metal shall be left beyond the required profile so that all metal that has been flame hardened can be removed later by machining. Except where the material is subsequently joined by welding, no load-transmitting surface shall be gas cut.

Plates in built-up members shall be end and edge planed, except where flats with square edges are used. Plates specified to be planed, milled or chipped, shall be cut in the first instance to such size as to allow 3 mm to be planed, milled or chipped, from the sides and ends.

Edges of gussets up to and including 8 mm in thickness may be sheared in a machine, which can take the full side in one cut. Planing, milling or grinding shall prepare edges of gussets of greater thickness. Edge preparation for surfaces to be welded shall be carried out by grinding planing but not shearing or cropping.

#### 8.14 Grinding

- a) All the edges cut by flame shall be ground before they are welded. Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom. The maximum permissible gap between the bearing stiffeners and the flanges shall not be more than 0.2 mm locally.
- b) In case of gantry girders, the bottom of the knife-edge support shall be accurately ground to provide effective bearing on the column bracket with a clearance not exceeding 0.2 mm locally at any place. The top surface of the column bracket shall also be ground similarly. The column splices and butt joints of struts and compression members shall be accurately ground and closely butted over the whole section with tolerance not exceeding 0.2

mm locally at any place. Notwithstanding the above, full load shall be transferred through welds.

- c) The ends of shafts together with attached gussets, angles, channels, etc. after welding together shall be accurately ground so that the parts connected, butt over the entire surface of contact. Care shall be taken to see that these connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by grinding by more than 1 mm.
- d) The slab bases shall be similarly ground over the bearing surface and shall have effective contact with the end of the shaft. The bearing face which is to be grouted directly to a foundation need not be ground if such face is true and parallel to the upper face. To facilitate grouting and escape of air, holes shall be provided wherever necessary in column bases.
- e) Column ends bearing on each other, resting on base plates, compression joints designed for bearing, base plates coming in contact with column end and cap plat shall be ground smooth to ensure 90% contact with local gap not exceeding 0.10 mm (filler gauge shall be used to check this gap). All ground surfaces shall be protected from dirt and mechanical damages till the assembly is completed. However the underside of base plate bearing on grout need not be machined.

#### 8.15 Drilling / Punching

- a) Holes through more than one thickness of material for members, such as compound stanchion and girders, flanges, shall where possible, be drilled after the members are assembled and tightly clamped or bolted together. Sub-punching may be permitted before assembly, provided the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full size. Punching shall not be adopted where the thickness of metal exceeds 16 mm.
- b) Drilled or reamed holes shall be cylindrical and perpendicular to the surface. They shall not be more than 1.5 mm larger than the specified diameter of bolts up to and including 25 mm in diameter.
- c) When holes are being drilled in one operation through two or more separable parts, those parts, when so specified by the EIC & PMC, shall be separated after drilling and burrs removed.
- d) Holes in connecting angles and plates, other than splices, also in roof members and light framing, may be punched full size through material not over 13 mm thick, except where required for close tolerance or barrel bolts.
- e) Matching holes for and black bots shall register with each other so that a gauge of 1.5 mm or 2.0 mm (as the case may be, depending on whether the diameter of the bolt is less than or more than 25 mm) less in diameter

than the diameter of the hole will pass freely through the assembled members in a direction at right angles to such members. Finished holes shall not be more than 1.5 or 2.0 mm (as the case may be) larger in diameter than the diameter of the black bolt passing through them unless otherwise specified by the EIC & PMC.

- f) Holes for bolts shall not be formed by a gas cutting process, except in special cases with specific permission of the EIC & PMC. Wherever a horizontal member is likely to collect water, suitable holes for drainage shall be provided.
- g) Bolt holes shall be drilled. Materials of thickness up to 16 mm, may be punched.

Drilling shall be made to the diameter specified in drawings.

No enlarging of holes by filing, man drilling, or oxyacetylene flame shall be allowed.

Allowable variations for holes (out of roundness, eccentricity, plumb-line deviation) shall be as per IS: 800.

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

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

Unless otherwise noted in the – Pitch of holes – 3D drawing

Edge distance – shear edge – 1.5 D

Rolled edge – 1.25 D

l) Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to H8 tolerance specified in IS: 919-1959 Recommendations for Limits and Fits for Engineering. Preferably, parts to be connected with close tolerance or barrel bolts shall be firmly held together by tacking bolts on clamps and the holes drilled through all the thickness at one operation and subsequently reamed to size. All holes not drilled through all thickness at one operation shall be drilled to a smaller size and reamed out after assembly. Where this is not practicable, the parts shall drill and reamed separately through hard brushed steel jigs.

j) A gas cutting process shall not form holes for bolts. All holes shall be free of burrs, fins and other defects. No holes shall be drilled in structural members at locations other than those indicated on the drawings unless approved in writing by the Consultant.

8.16 Procedure to be adopted for fabrication of the structural steel work ...

8.16.1 Fabrication shop at project site

In case the Principal Contractor prefers to fabricate the structural steel work put to tender at site, the Fabrication shop of the Principal Contractor at the project site shall have all facilities required for carrying out the work. The Principal Contractor shall get the details of the shop approved by the EIC & PMC.

Any approval, instructions, permission, checking, review, etc. whatsoever by the EIC & PMC shall not relieve the Principal Contractor of his responsibility and obligation regarding adequacy, correctness, completeness, safety, strength, workmanship etc.

8.16.2 Fabrication at contractor's yard, away from the site: -

Fabrication of the structural members shall be partially fabricated at the contractor's workshop and then, the balance work shall be completed at the site. Till this approval is sought no work of steel cutting shall proceed. In the event the contractor wishes to deviate from the sequencing, in the interest and pace of work shall submit his remarks, suggestions for Clients, structural Engineers review.

8.16.3 Work Methodology / Sequence of Fabrication and Erection: -

The total sequence & methodology of complete activity starting from fabrication and erection to erection at its final location shall be submitted by the contractor to the Clients representative and specialized agency appointed by the Clients for their approval.

8.17 Bolt Tightening

Bolts shall be "snug tightened" as defined as the tightness attained by a few impacts of an impact wrench or by the full effort of a man using a standard podger spanner

Snug tightening shall be achieved by using a standard wrench to ensure intimate positive contact between mating surfaces. Bolts, nuts and washers that are snug tightened shall be hot dipped galvanized.

## **9.0 STEEL STRUCTURES ASSEMBLY, INSPECTION AT SHOP:**

9.01 Shop Test Pre-assembly

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

- ii) In case one member does not meet the limiting deviations specified in the general specification in pre-assembly shop test, all members shall be shop tested.
- ii) For bolted Steel Structures, shop test pre-assembly is mandatory for all elements as well as for the entire structure in conformity with clause 10.00 (c).

## 9.02 Shop Inspection and Approval

### i) General:

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

- ii) Technical approval of the Steel Structure in the shop by the EIC & PMC is mandatory.
- iii) The Principal Contractor shall not limit the number and kinds of Tests, final as well as intermediate ones, or extra tests requested by the EIC & PMC.
- iv) The Principal Contractor shall furnish necessary tools, gauges, instruments etc. and technical and non-technical personnel for shop tests required by EIC & PMC, free of cost.

## 9.03 Shop Acceptance

The EIC & PMC shall inspect and approve at the following stages.

- i) The following approvals may be given in shop:
  - Intermediate approvals of work that cannot be inspected later.
  - Partial approvals.
  - Final approvals.
- ii) Intermediate approvals of work shall be given when -
  - a part of the work is performed later
  - Inspection would be difficult to perform and results may not be satisfactory.
  - Cannot be inspected later
- iii) Partial approval in the shop is given on members and assemblies of Steel Structures before the primer coat is applied and includes :
  - Approval of field joints
  - Approval of part with planed surface
  - Test Erection

- Approval of members
- Approval of markings
- Inspection and approvals of special features, like rollers, loading platform mechanism etc.

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

#### 9.04 Final Approval in the Shop

- i. The final approval refers to all elements and assemblies of the Steel Structures with shop primer coat, ready for delivery from shop, to be loaded for transportation or stored.
- ii. The final approval comprises:
  - Partial approvals.
  - Approvals for shop primer coat
  - Approval of mode of loading and transport
  - Approval of storage (for materials stored)
- iii. Inspection by EIC & PMC shall be only at random and on critical factors and shall not absolve the Principal Contractor of the responsibility to fabricate the structures as per the specified standards & specifications.

### 10.00 NOTCHES

The ends of all joints, beams and girders shall be cut truly square unless required otherwise and joist flanges shall be neatly cut away or notched where necessary, the notches being kept as small as possible.

### 11.00 ASSEMBLY

- 11.01 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in a member the component parts shall be positioned by using clamps, clips, dogs, fixtures and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, parallel and tapered drifts shall be used to align the parts so that the bolts can be accurately positioned.
- 11.02 Items like roof trusses, galleries, plate girders etc. shall be trial assembled keeping in view the actual site conditions, prior to dispatch to site for erection so that they can be conveniently pre-assembled before erection. Necessary match marks shall be made on these components before disassembly in the shop and dispatching.

11.03 For columns which are fabricated in two or more parts, Controlled assembly shall be carried out in the fabrication yard before dispatch to the erection site.

## **12.0 Erection**

### **12.01 General**

Structural steel shall be erected in accordance with the AISC Specification and the AISC Code of Standard Practice, as modified by the project documents.

Where erection requires performing fabrication work on site, the work shall conform to the applicable standards of Section 3.1, Fabrication.

The Contractor shall cooperate fully with requests from inspection and testing personnel for access to the connections and joints to be inspected or tested. This includes weld backing removal when non-destructive testing indicates rejectable conditions, and access to platforms or scaffolding as required to perform the work safely. When such services are required, the inspection must be performed in a timely manner so as not to hinder production nor require duplication of effort.

The Contractor shall perform all necessary corrections of deficiencies in material and workmanship. The Contractor shall comply with requests to correct deficiencies, when such corrections are required by the Inspection Agency. The Inspection Agency Technician should be apprised of any repairs to be made by the Contractor, prior to performance.

### **12.02 Storage and Handling**

Structural steel shall be stored and handled in a manner that prevents damage or distortion. Do not store materials on the structure in a manner that might cause distortion or damage to members of the supporting structure. Store materials to permit easy access for inspection and identification. Keep steel members off the ground by using blocking, cribbing, platforms, or other supports.

### **12.03 Temporary Shoring and Bracing**

Contractor's erection scheme and temporary bracing and shoring shall provide lateral support and stability for all columns until permanent lateral-support systems (for example: wind bracing bents and horizontal deck/slab diaphragms) are in place and complete. Provide temporary shoring and bracing members in vertical and horizontal planes as required, with connections of sufficient strength to bear the imposed loads. Remove temporary members and connections when permanent support systems are in place and final connections are made.

### **12.04 Erection Procedures**

The Contractor shall be responsible for the control of all erection procedures and sequences.

### **12.05 Bolted Construction**



Fasteners shall be stored in a protected place. Except for ASTM F1852 "twist-off" type assemblies, clean and re-lubricate bolts, nuts and washers that become dry or rusty before use.

F1852 fastener components may be re-lubricated following the manufacturer's written instructions, and must be retested after re-lubrication and prior to use to verify suitability for installation.

Do not use flame cutting to align bolt holes except as permitted by the inspection agency.

Ream holes that must be enlarged to admit bolts. Do not enlarge holes by more than 1/32 in. Additional reaming beyond 1/32 in. shall not be performed without approval of the inspection agency. When reaming beyond 1/32 in. is approved, drill or ream to the next larger hole size and use the next larger size bolt.

Bolt holes may be made by punching or drilling. Bolt holes may also be made by thermal cutting to a smaller diameter, followed by reaming to the required diameter.

#### 12.06 Corrective Work

Structural elements having fabrication errors or which do not satisfy tolerance limits shall be repaired. Submit drawings showing reasons for, and details of, proposed corrective work for approval by the Engineer prior to performing corrective work. Corrective work shall be performed in accordance with the requirements of the Contract Documents. Pre-approved repair and correction procedures may be used when authorized by the Engineer for specific conditions.

#### 12.07 Thermal Cutting

Thermal cutting torches may be used in the field for cutting raw material as well as correcting fabrication errors in structural framing only with the approval of the Inspection Agency. When thermal cutting is permitted, cutting shall be done only with a mechanically guided torch or a torch controlled using a guide bar, except as permitted below:

1. Thermal-cut edges that are not welded and will be free of substantial stresses, may be cut manually with an unguided torch provided the specified AISC edge distances to holes are maintained.

2. Other thermal-cut edges and edges to be welded may be cut manually with an unguided torch to a line within 1/8 in. of the finished dimension, with final removal of material completed by chipping or grinding to produce a surface quality equal to that of the base metal edges.



Cuts shall be smooth and regular in contour, and free of notches. The radius of reentrant corners shall be no less than one-half inch. Cuts performed to modify beam copes may be made with a smaller radius, but shall not be cut square.

## 12.08 Supplemental Welding Requirements

### 12.08.1 Electrode Storage and Exposure Limits

All the consumable shall be received and stored in the original, undamaged manufacturer packaging, until ready for use. Electrodes in packages that have had the internal plastic wrapping damaged shall not be used. Modification or lubrication of an electrode after manufacture is not permitted, except that drying is permitted as recommended by the manufacturer.

Mother Oven shall be used for backing/drying of electrodes along with a portable oven for mobility. Temperature of backing shall be taken as per manufacturer's recommendation and/or as per AWS D 1.1

### 12.08.2 Minimum Preheat and Interpass Temperature

Minimum preheat and interpass temperatures shall be provided for all welds, including tack welds, in accordance with AWS D1.1, Table 3.2. The Contractor may specify higher minimum temperatures, if desired, as a part of the WPS for a particular application. In such cases, the WPS minimum preheat and interpass temperatures shall be provided.

Preheat and interpass temperatures lower than those required by AWS D1.1, Table 3.2, are permitted provided the WPS has been qualified by test, and the WPS and PQR have been accepted by the consultant.

Minimum preheat and interpass temperatures shall be verified at a distance of 3 in. from the weld, at the point of arc initiation or for materials over 3 in. in thickness, at a distance equal to the thickness of the part.

### 12.08.3 Maximum Preheat and Interpass Temperature

The minimum preheat 20 °C and maximum interpass temperature permitted is 250oC, measured at a distance of 1 in. from the point of arc initiation. This maximum temperature may not be increased by the WPS, regardless of qualification testing.

#### Non-fusible Backing

The use of non-fusible backing materials, including ceramic and copper, is permitted only with satisfactory welder qualification testing performed using the type of backing proposed for use, using the test plate shown in AWS D1.1, Figure 4.21, except that groove dimensions shall be as provided in the WPS and PQR. Should the joint to be welded include welding a beam flange to a column flange

through an access hole, the Supplementary Welder Qualification Test shall be performed using the type of backing proposed for use.

For non-fusible weld tabs and short segments of non-fusible backing bars used at the ends of welds between shear tabs and column faces, or at the ends of continuity plate welds, special welding personnel and welding procedure qualification testing is not required. The welder shall be trained in the proper welding techniques for using such non-fusible weld tabs and backing bars prior to performing such welding on the project.

#### 12.08.4 Peening

The use of peening is permitted at the Contractor's option, but is not required. See AWS D1.1, Section 5.27. If the Contractor elects to use peening, a written procedure for performing peening shall be incorporated into the WPS for the joints to be peened.

### 13.0 Controlled Cooling

The use of controlled cooling is permitted at the Contractor's option, but is not required. If the Contractor elects to use controlled cooling, a written procedure for controlling cooling after welding shall be incorporated into the WPS for the joints to receive such treatment. The procedure shall include the method of heating, the maximum temperature permitted, cooling rate range to be provided, and the method and frequency of temperature measurements.

The use of insulating blankets after completion of welding, without the addition of heat, is permitted at the Contractor's option, but is not required. For the use of insulating blankets only, a written procedure and temperature measurements are not required.

### 14.0 Post Weld Heat Treatment

The use of Post Weld Heat Treatment (PWHT) is permitted at the Contractor's option, but is not required. The use of PWHT shall meet the Stress-Relief Heat Treatment limitations of AWS D1.1, Section 5.8. If the Contractor elects to use PWHT, a written procedure for performing PWHT shall be incorporated into the WPS for the joints to be treated.

Controlled cooling, or the application of heat immediately following completion of a joint to maintain a nominal temperature at or below 250°C, is not considered PWHT.

For thickness greater than or equal to 25 mm, if Contractor is not opting for PWHT then the contractor has to qualify WPS keeping all the variables the same.

### 15.0 Quality Control and Quality Assurance

#### 15.01 Specifications

The specifications and standards listed in this Section govern the execution of Quality Control and Quality Assurance, including nondestructive testing, except as noted otherwise in this document.

15.02 Codes

AWS D1.1 (2006) structural welding code-Steel

15.03 Nondestructive Testing Personnel Qualification

ASNT Recommended Practice No. SNT-TC-1A, Personnel Qualification & Certification in Nondestructive Testing, 1995

15.04 Quality Guidelines

This list shall not be considered exclusive of any additional inspection tasks that may be necessary to meet the requirements of the codes or the Quality Assurance Plan.

1. Review and understand the applicable portions of the specifications, the Contract Documents and the shop drawings for the project.
2. Verify that all applicable welder qualifications, welding operator qualifications and tack welder qualifications are available, current and accurate.
3. Require requalification of any welder, welding operator or tack welder who has, for a period of six months, not used the process for which the person was qualified.
4. Verify welder identification and qualification. Verify that any required supplemental welder qualification testing, if required for the joint, has been executed and that the welder has passed.
5. Verify that each welder has a unique identification mark or die stamp to identify welds.
6. Verify that all applicable Welding Procedure Specifications (WPSs), with Procedure Qualification Records (PQRs) as needed, are available, current and accurate.
7. Verify that an approved Welding Procedure Specification (WPS) has been provided and that each welder performing the weld has reviewed the WPS. A copy of the appropriate WPSs shall be available for each joint, although need not be present at each joint location.
8. Review mill test reports for all main members and designated connection base material for compliance with the project requirements.

9. Verify base material identification with the approved shop drawings and specifications.
10. Verify the electrode, flux and shielding gas certifications for compliance with the Contract Documents.
11. Verify welding consumables with the approved shop drawings and approved WPSs.
12. Verify that electrodes are used only in the permitted positions and within the welding parameters specified in the WPS.
13. Verify that electrodes and fluxes are properly stored, and that exposure limits for the welding materials are satisfied.
14. At suitable intervals, observe joint preparation, assembly practice, preheat temperatures, interpass temperatures, welding techniques, welder performance and any post weld controlled cooling or heat treatment to ensure that the applicable requirements of the WPS and Code are satisfied.
15. At suitable intervals, verify proper current and voltage of the welding equipment in application of the WPS, if needed, by using a hand held calibrated amp and volt meter. Current and voltage shall be measured near the arc with this equipment.
16. Inspect the work to ensure compliance with AWS D1.1 or the specified weld acceptance criteria. Size and contour of welds shall be measured with suitable gauges. A strong light, magnifiers, or other devices as needed may be used to aid visual inspection.
17. Schedule NDT technicians in a timely manner, after the visual inspection is complete and the assembly has cooled. The final NDT on a specific weld shall not be performed sooner than 24 hours after the welding has been completed.
18. Mark the welds, parts, and joints that have been inspected, and accepted, with a distinguishing mark or die stamp, or maintain records indicating the specific welds inspected by each inspector.
19. Document the accepted and rejected items in a written report. Transmit the report to the designated recipients in a timely manner.
20. Review all NDT procedures before testing. Check for level III approval on all the procedures.
21. Perform stage wise inspection at every stage of the fabrication like material, fit-up, weld visual, NDT, painting & coating and final inspection.
22. Review procedure in reference to paint spec, fire rating and green building requirement etc. for painting & coating before starting painting operation.
23. Coating & Painting inspection has to be performed for all the painted structures.

24. On successful acceptance of the job Inspection agency shall give release notes to the contractor.

25. Any NC raised by the inspection agency shall be addressed by the contractor on priority basis.

26. NDT technicians working for testing shall be evaluated as per the approved procedure by the inspection agency on successful evaluation. Competency certificates shall be issued to the NDT technician by the inspection agency.

27. Fabrication & Erection tolerances shall be derived from,

- AWS D1.1 (Latest Revision) : Structural Welding code
- IS 12843 (Latest Revision) : Erection Tolerances
- IS 7215 (Latest Revision) : Fabrication Tolerances
- AISC 303-05 : Code of Standard Practices of Steel Buildings & Bridges

However, final tolerances should be considering site conditions & design assumptions. Tolerances for different parts & stages of steel structure should be approved by structural consultants & client/third party inspection agencies.

#### **16.00                    BOLTS AND NUTS:**

All bolts and nuts shall conform to the requirements of

IS 1363 & IS 1367- Technical supply conditions of threaded fasteners. (First Revision)

IS: 1680-1960 Method for Tensile Testing of Steel Products viz for all mild steel for bolts and nuts in accordance with Other than Sheet, Strip, Wire and Tube and

IS: 1367-1960 Technical Supply Conditions for Threaded Fasteners shall have a tensile strength of not less than  $44 \text{ kg/mm}^2$ , and a minimum elongation of 23 percent on a gauge length of  $3.65\sqrt{A}$ .

The dimensions and tolerances of all bolts, nuts and washers shall conform to the requirements of the following Indian Standards.

IS 6639-1970 Specifications for hexagon bolts for steel structures

IS 5624-1993 Specifications for foundations bolts

IS 6761-1994 Specification for countersunk head screws with hexagon socket.

All materials shall conform to their respective specifications. The use of Equivalent or higher grade or alternate materials shall be considered only in very special cases subject to the approval of the EIC & PMC.

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

**17.00 WASHERS**

Plain washers shall be made of steel conforming to IS: 226-1962 Specification for Structural Steel (Standard Quality) (Third Revision), or St 44-O of IS: 1977-1962 Specification for Structural Steel (Ordinary), or IS: 2062-1992 Specification for Structural Steel Fusion Welding Quality).

Washers shall be as per IS: 2016, IS: 5372 & IS: 5374

**18.00 WELDING**

## 18.01 General

Welding shall be in accordance with the following Indian Standards as applicable.

IS 816-1969 Code of Practice for use of metal arc welding for general construction in Mild steel.

IS 822-1970 Code of practice for inspection of welds

IS 1024-1979 Code for practice for use of welding in bridges and structures subject to dynamic loading.

IS 1323-1982 Code of practice for oxy-acetylene welding for structural work in mild steel.

IS 9595-1980 Recommendations for metal-arc welding of carbon and carbon manganese steels.

For welding for any particular type of joint, welders shall submit evidence acceptable to the Consultant of having satisfactorily completed appropriate tests as described in the following relevant Indian Standards.

IS: 7307-1974 Approval tests for welding procedure.

IS 7310-1974 Approval tests for welders working to approve welding procedures

All welding procedures shall be arranged, to suit the details of joints indicated on the drawings. Welding shall be carried out shall be such as to ensure that the weld metal is full and satisfactorily deposited throughout the length and thickness of all joints.

Members to be welded shall be securely held in their relative position during welding, either by jigs or tack welding. Profiles of fusion faces may be prepared by shearing, chipping, or gas cutting. In all cases the faces should be dressed by chipping, filing or grinding and made regular.

Vertical down welding shall not be permitted. All welds shall be back-gouged and welded from the backside unless specifically approved otherwise. All welds shall

be carried out in such a sequence and manner as to cause minimum distortion of the welded parts.

Multiple run welds shall be carried out with each run closely following the previous run, but so that sufficient time is allowed for slag removal. Welds shall on completion present an even, smooth and regular finish free from defects. The weld metal shall be solid throughout with complete fusion between weld metal and parent metal and between successive runs throughout the joints. Caulking shall not be used to correct defects.

The electrodes shall be dried in an electric oven as per the recommendations of manufacturers. Only DC current shall be used for welding and the Contractor shall make his own arrangements of all welding power and for equipment.

#### 18.02 Surface Cleaning Prior to Welding

Surfaces to be welded shall be free from loose scale, slag, rust, grease, paint and other foreign materials. Surfaces need not be cleaned of Zinc Silicate primer if present prior to welding.

#### 18.03 Surface Cleaning after Welding

Upon completion of each welding pass, the weld shall be cleaned of spatter, slag and flux deposits. The weld must show a good clean contour and on a cut specimen good fusion with the parent metal. After welding is complete, adjacent surfaces shall be thoroughly cleaned of all spatter and deposits.

#### 18.04 Size of Welds

All structural welds shall be continuous around all mating faces and edges of the members being connected. If not detailed on the drawings, welds shall be sized to develop the full strength of the smaller of the two members being joined and not less than 6mm.

In joints connected only by fillet welds, the minimum size of fillet weld to be used shall be as shown in the following table unless otherwise specified in the drawing.

Material thickness of Thicker part joined (mm)	Minimum size of fillet weld (leg dimension of fillet weld) (mm)
Up to 6	3
Over 6 to 12	5
Over 12 to 18	6
Over 18	8

Fillet welds 5 mm or larger in size for SMAW and 10mm for SAW shall be made with two or more passes. Welding rods shall be 3.15 in diameter maximum for root



passes, and 4 mm and above in diameter for subsequent passes. Complete penetration butt well shall be terminated at the ends of the joint in manner that will ensure their soundness. Where abutting parts are 20mm or more in thickness, suitable run-on and run-off plates with similar edge preparation and having a width not less than the thickness of the thicker part shall be used. These extension pieces shall be removed after completion of weld and the end of the weld made smooth and flush with the abutting parts.

#### 18.05 Compatibility of Welds

All welds shall develop the strength and ductility specified for the steel being welded. Welds forming connections between steel of different grades shall develop at least the same unit strength as that specified for the higher strength steel.

#### 18.06 Automatic Welding

Automatic and semi-automatic welding processes may be employed provided they are approved by the Engineer and conform to the requirements of these specifications. All equipment for automatic and semi-automatic welding shall be subject to approval by the Consultant. Pre-heating will be required where any section thickness exceeds 30mm. Requirements for, and method of, pre-heating shall be submitted to the Consultant for approval.

#### 18.07 Welding procedure

Before the start of the work, the welding procedure shall be submitted to EIC & PMC for approval. Welding shall be entrusted to only qualified and experienced welders who shall be periodically tested and graded as per relevant standards.

Welding procedure specification (WPS) shall be established and Qualification of weld procedure (QWP) shall be done in accordance with the requirements of ASME Sec IX, or AWS D 1.1 or as per approved standards as and where specified. Welders employed shall also be qualified as per above standards prior to taking up fabrication. Contractor shall obtain approval from EIC & PMC before the start of the work.

18.08 Following pre-qualified welding process shall be employed for fabrication, Erection and repair by:

- a) Submerged Arc Welding (SAW).
- b) Shield Metal Arc Welding (SMAW).
- c) Gas Metal Arc Welding (GMAW).
- d) Gas Tungsten Arc Welding (GTAW).

All welds shall be free from defects like blowholes, lack of penetration, undercutting, cracks etc. All welds shall be cleaned of slag or flux and show sections, smoothness of weld metal, feather edges without overlap and freedom from porosity.



50mm on either side of the surfaces on which weld metal is to be deposited shall be smooth, uniform, free from fins, tears, burrs cracks and absolutely free from grease, paint, loose scale, moisture or any other substance which would adversely affect quality and strength of weld.

Machining, thermal cutting or grinding may be employed for joint preparation or removal of unacceptable work or metal. The weld edges shall be smooth & regular surface free from cracks & notches. Flame cut material above 50mm thick shall be pre-heated to 100°C prior to flame cutting.

All weld fit-up shall comply with tolerances specified in the design drawing and/or relevant standards. The parts to be joined by fillet welds shall be brought into close contact as practicable. The root gap in no event shall be greater than 3 mm for SMAW process and 1.5mm for SAW process. If the separation is greater than 1.5mm the leg of the fillet weld shall be increased by the amount of root opening. This shall apply only in the case of continuous welds. Abutting parts to be butt-welded shall be carefully aligned and the correct root gap shall be maintained throughout the weld operation. The fit up of joints at contact surfaces that are not completely sealed by welds shall be close enough to exclude water after painting. The separation between laying surfaces of lap joint and butt joints with backing plate shall not exceed 1.5mm. Abutting parts to be butt-welded shall be carefully aligned and the correct root gap maintained throughout the welding operation. Misalignments greater than 25% of the thickness of the thinner plates or 3mm, whichever is smaller, shall be corrected and in making the correction, the parts shall not be drawn into a slope sharper than 2 degrees.

All tack welds shall be made using qualified procedure and qualified welders. Any preheat requirement specified in the welding procedure shall also apply to tack welds. All tack welds shall be examined visually for defects and if found defective, shall be removed.

Welding of temporary attachment/fixtures to retain fit up is allowed in case the parts have nominal thickness of at least 5mm. Temporary attachments are welded at the minimum distance of at least 50 mm for the weld seam. Welding of temporary attachments/fixtures into the joint slot is not allowed. All temporary fixtures to be removed after welding by grinding them to weaken the welded portion and hammering thereafter followed by grinding the portion of any weld remaining on the base metal. A dye check at the discretion of the quality surveyor shall be done to detect any crack/defect at the point of fixture temporary weld.

It is not allowed to turn over and carry over heavy assemblies in tacking condition in order to control the geometric dimensions to the requirements of the drawings.

During the installation of the structural steel members care shall be taken to prevent damage of the sheets and of the welding seams. The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided as far as possible.

In the joints of the parts with dissimilar thickness smooth transition of one part to the other must be provided by way of the gradual decreasing of the thickness of the thicker part with the slope of the surface not exceeding 15 degree.

Welding shall not be done when the surface of the members are wet or exposed to rain, or high wind velocities unless the welding operator and the work are properly protected.

In case of full penetration butt welds without backing, root weld shall be back gouged to sound metal before second side welding for complete fusion throughout the entire cross section. However, in case of square around butt welds done in flat position from both sides and with thickness of parts joined less than 8mm and root opening not less than half the thickness of the thinner part, gouging can be dispensed with.

Preheating for welding of steel shall conform to relevant acceptable standards. No stress relief using oxyacetylene flame is permitted.

In assembling & joining parts of a structure or built-up members and in reinforcing parts to members, the procedure and sequence shall be such as to minimize distortion and shrinkage. The fabricator shall prepare a welding sequence for a member of the structure, which in conjunction with WPS and overall fabrication method will produce members or structure meeting the quality requirement specified. The welding sequence and distortion control programme shall be submitted to for approval before start of welding such programme shall include, besides other appropriate details, full particulars in regard to the following:

- a) Proposed pre-bending tubes and components, pre-setting of joints to offset expected distortion.
- b) Makeup of sub-assemblies proposed to be welded before incorporation in the final assembly.
- c) Proposed joint forms, classification of wire and flux or covered electrodes, welding process including fit up and welding sequence with directions in which freedom of movement is to be allowed.
- d) Proposed number, spacing and type of storage backs and details of jigs and fixtures for maintaining proper fit up and alignment during welding.
- e) Any other special features like assembling similar members back to back or stress relieving procedure.
- f) For sections made of rolled sections with cover plates, the ends of the plate shall be seal welded or alternatively flange cover plates terminated 25mm short of the full length and welded across to the beam for proper and sealing and/or as directed by the EIC & PMC.

- g) If so desired by the EIC &PMC , mock up welding shall be carried out at Contractor's cost to establish the efficiency of the proposed programme, with any modification suggested by the EIC & PMC I limiting distortion or / and residual stress to acceptable levels.

Welds shall be defect free and surfaces shall be thoroughly cleaned to remove all visible weld defects and extra material. All welds shall be labeled / stamped / identified with System / Joint No / Welder punch etc. as per approved procedure at a distance of 30-35 mm from the weld seam.

For all built up sections such as Columns, Girders etc. welding between web and flange plates shall be carried out by submerged arc welding process. Especially for girders full penetration of weld between top web plate and top flange shall be ensured. Welding shall be continuous and shall be both sides of the connecting member. One side fillet weld is not acceptable.

### **19.00 PRE-HEATING AND POST WELD HEAT TREATMENT**

Base metal shall be preheated to a temperature not less than minimum value as listed below. For a combination of base metals the minimum preheat shall be based on the highest minimum preheat. This pre-heat and all subsequent minimum inter-pass temperature shall be maintained during the welding operation for a distance at least equal to thickness of the thickest part but not less than 75mm in all directions from the point of welding. Minimum inter pass temperature requirements shall be considered equal to preheat requirements. The preheat and inter pass temperature shall be checked just prior to initiating the arc for each pass.

Carbon Steel	SMAW welding with low hydrogen electrodes, SAW, GMAW	3mm to 19mm	10°C
		19.1 to 38mm	10°C
		38.1mm to 50mm	66°C
		Over 50mm	107°C

When the thickness of one or both the members is over 50mm the butt welds shall be stress relieved. For restrained joints of complicated design and configuration post weld heat treatment may be required for smaller thickness. The weld joint detail and procedure for Post weld heat treatment shall be submitted by the Contractor for approval from or his authorized representative. Stress relieving is to be done at 600-650°C with a soaking of 1hour per 25mm thickness of the thicker plate. No stress relief using oxyacetylene flame is permitted in local stress relief the width of the heated band on each side of the greater width of the finished weld shall not be less than two times the maximum material thickness.

The works shall be done as per approved fabrication drawing which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld. Symbols for welding on fabrication drawings shall be

according to IS: 813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.

## 20.00 PREPARATION OF MEMBERS FOR WELDING

- a) Assembly of structural members shall be made with proper jigs and fixtures to ensure correct positioning of members (angles, axes, nodes, etc.)
- b) Sharp edges, rust of cut edges, notches, irregularities and fissures due to faulty cutting shall be chipped or ground or filed over the length of the affected area, deep enough to remove faults completely.
- c) Edge preparation for welding:
  - i) Proper edge preparation shall be made for jointing of materials before welding. The edge preparation for welding shall be carefully and accurately made so as to facilitate a good joint.
  - ii) Type of edge preparation shall depend on the thickness of parent materials that are to be joined. Generally no special edge preparation shall be required for members under 8 mm thick.
  - iii) The edge forms shall be chosen to suit the design, technology and production conditions and shall be subject to the approval of the EIC & PMC.
  - iv) The edge form of weldments shall be prepared either by machines or by automatic gas cutting with surface roughness of the welding area not exceeding 50%.
  - v) All edges cut by flame shall be ground before they are welded.
  - vi) Edge preparation (beveling) denotes cutting so as to result in V, X, K, or U seam shapes as per IS: 816.

Unless otherwise noted in the drawing :	$\leq 6$ mm	-	Square butt
	8 – 11 mm	-	Single V
	$\geq 12$ mm	-	Double V

- vii) The members to be assembled shall be clean and dry on the welding edges. Under no circumstances shall wet, greasy, rust or dirt covered parts be assembled. Joints shall be kept free from any foreign matter, likely to get into the gaps between members to be welded.
- viii) Before assembly the edges to be welded as well as adjacent areas extending for at least 20 mm shall be cleaned (until metallic polish is achieved.)

- d) When assembling members, proper care shall be taken of welding shrinkage and distortions, as the drawing dimensions cover finished dimensions of the Structure.
- e) The elements shall be checked and approved by the EIC & PMC or his authorized representative before assembly.
- f) The permissible Tolerances for assembly of members preparatory to welding shall be as per IS: 816.
- g) After the assembly has been checked temporary tack welding in position shall be done by electric welding, keeping in view finished dimensions of the Structure.
- h) Preheating of members to be joined to be carried out as per standards wherever necessary.

### **21.0 Welding Procedures**

Welding shall be carried out only by fully trained and experienced welders as tested and approved by the EIC & PMC or his representative or the Inspectors. The cost involved for such tests shall be borne by the Principal Contractor himself.

Qualification tests for Welders as well as tests for approval of electrodes will be carried out as per IS: 816. The nature of test for performance qualification of welders shall be commensurate with quality of welding required on this work as judged by the EIC & PMC.

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

Welding shall begin only after the checks shown under 8.02 have been carried out.

Welding procedures and tests for welder's skill shall be conducted as per IS: 816 and approved by the EIC & PMC.

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

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

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

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

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

The welding seams shall be left to cool slowly. The Principal Contractor shall not be allowed to force cool the welds.

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

The order and method of welding shall be so that:

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

The defects in welds must be rectified according to IS: 816 and as per instructions of EIC & PMC.

## 22.0 Weld Acceptance Criteria

### 22.1 Client's Authority

Welds or portions of welds that fail to meet the acceptance criteria of AWS D1.1 shall be repaired or replaced. The Contractor may request acceptance by the client of a weld discontinuity, without repair or replacement, when it can be determined that the effect of the discontinuity will not be detrimental to the performance of the structure. The client is the final authority for acceptance of such welds.

### 22.02 Magnetic Particle Testing

If a surface discontinuity or near-surface discontinuity, within 1/8 inch of the surface, is detected, the discontinuity shall be rejected and removed. If the separation from the surface cannot be determined, the discontinuity shall be categorized as a surface flaw, rejected and removed.

Regions of welds that cannot be inspected shall be identified and recorded, and the Engineer shall be notified.

All partial penetration joints (PPJ) & fillet joints shall be checked using MT. Procedure for MT shall be made & approved by ASNT level III personnel. MT shall be performed only by ASNT level II in MT as per SNT-TC-IA requirement. Extend of testing for PPJ & fillet weld shall be as per QAP.

### 22.03 Ultrasonic Testing - Flaw Detection

When ultrasonic testing is required, the joint shall be scanned for flaw detection purposes following the procedures prescribed in AWS D1.1, Annex K, with exceptions as noted below. Joints that fail the acceptance criteria described below may be inspected using the Ultrasonic Testing - Flaw Sizing methods as prescribed in Section 5.8.4 of this specification, or, at the Contractor's option, may be excavated for further investigation and repaired, then re-inspected using these Flaw Detection procedures.

When ultrasonic testing is required, CJP and PJP groove welds in Seismic Weld Demand Categories A, B and C shall be scanned for flaw detection. Acceptance criteria shall be as for statically loaded welds in Annex K, Table K-1, of AWS D1.1.

Commentary: As an alternative, the engineer may elect to permit CJP and PJP groove welds in Seismic Weld Demand Categories A, B and C to be scanned for flaw detection purposes using AWS D1.1, Table 6.2 as the acceptance criteria. In this case, Note 3 regarding "tension welds" is not applicable. Joints with backing bars remaining in place shall not be rejected on the basis of indication ratings (db values) from the interfaces between backing bar and base metal or backing bar and weld. The UT Procedure shall prescribe methods for distinguishing between backing bar indications and root discontinuities.

PJP groove weld joints shall not be rejected on the basis of indication ratings (db values) from the root area of the weld. Notches within the weld, located a distance more than 1/8 inch from the as-welded root, shall be scanned for acceptance using the criteria above.

Regions of welds that cannot be inspected shall be identified and recorded, and the Engineer shall be notified. Regions of welds adjacent to cope holes may be inspected with multiple probe techniques.

#### 22.04 Ultrasonic Testing - Flaw Sizing

Ultrasonic testing for flaw sizing shall be performed following written procedures as required by AWS D1.1, Annex K. When flaw-sizing techniques are implemented, the following acceptance criteria apply to groove welds:

1. If a surface flaw or near-surface flaw (within 1/8 inch of the surface) is detected, the flaw shall be rejected and removed. If the separation from the surface cannot be measured, the flaw shall be categorized as a surface flaw, rejected and removed.



2. When backing bars remain in place, the position of notch tips that extend into the weld metal shall be determined. The notch shall be rejected if it extends greater than 1/8-inch into the thickness of the weld. The weld present between the backing bar and column face shall not be considered a part of the weld thickness in determining the depth of notch or thickness of weld.

3. Embedded flaws, defined as those that do not come within 1/8 inch of the surface, shall be rejected if their height exceeds ¼ inch.

4. Embedded flaws shall be rejected if their area, as calculated by multiplying the maximum discontinuity height by the maximum discontinuity length, exceeds the thickness of the thinner parent metal multiplied by the thickness of the thicker parent metal.

5. Embedded flaws, either individually or as a group within a length of weld 12 inches or less, shall be rejected if they exceed a total area (the sum of the areas of individual discontinuities) equal to 10% of the thickness of the thinner parent metal multiplied by the weld length.

The weld length used for this calculation shall not exceed 12 inches, with longer welds being evaluated in multiple parts.

6. Aligned discontinuities of lengths L1 and L2 separated by less than  $(L1+L2)/2$  shall be evaluated as continuous.

7. Parallel discontinuities of heights H1 and H2 separated by less than  $(H1+H2)/2$  shall be evaluated as continuous.

All full penetration joints (FPJ) shall be checked using UT. Procedure for UT shall be made & approved by ASNT Level III personnel. UT shall be performed only by ASNT Level II in UT as per SNT-TC-1A requirement. Extent of testing for FPJ shall be as per approved QAP.

## 22.05 Weld Inspection

The weld seams shall satisfy the following:

- shall correspond to design shapes and dimensions
- shall not have any defects such as cracks, incomplete penetration and fusion, undercuts, rough surfaces, burns, blow holes inclusion, porosity etc. beyond permissible limits.

During the welding operation and approval of finished elements, inspections and tests shall be made as per specification.



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

## 22.06 End Plate Moment Connections

### 22.06.1 Flange Welds

Beam-flange-to-end-plate welds shall be detailed and welded as CJP groove welds, except that in the area of the flange directly above and below the beam web, back gouging and back welding of the weld root is not required.

The groove weld detail shall be such that the root of the weld is located on the beam web side of the joint. Following back gouging and back welding of the groove weld root, a 5/16 inch reinforcing fillet weld shall be placed on the inside portion of the flange weld, at the groove root.

Alternatively, the 5/16-inch reinforcing fillet weld located on the beam web side of the beam flanges may serve as a backing weld. The root of the fillet must then be back gouged to solid weld metal, and the groove weld placed. No backing is provided in the vicinity of the beam web.

Using either method, no MT of the back gouged area is required prior to placement of the back weld or the groove weld.

### 22.06.2 Web Welds

The beam web shall be welded full length to the end plate using fillet welds on each side of the beam web. Alternatively, groove welds may be substituted for the fillet welds.

The weld detail limitations of this specification regarding the k-area are not applicable to this connection, but MT following completion of all welds in this area is required.

#### a. Stiffener Welds

When Bolted Stiffened End Plate (BSEP) connections are used, the stiffener shall be welded to the end plate and the beam flange using CJP groove welds. A stiffener clip (snipe) shall be provided at the intersection of beam flange and end plate.

#### b. Weld Access Hole

o weld access holes are permitted at the intersection of beam web, beam flange and end plate.

#### c. NDT Requirements

The beam flange to end plate welds, and the welds between stiffener and beam flange and end plate, shall be inspected using MT and UT as QC/QA Category.

## 22.07 Welding of Structural Steel Work

- a) Welding of Structural Steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be used, testing and inspection procedure to be applied shall be subject to the approval of the EIC & PMC and shall conform generally to relevant acceptable standards viz. IS:9595, and Indian Standard Handbook for metal arc welding, and other standard codes of practice Internationally accepted.
- b) Submerged-Arc-Welding/MIG/MAC (using Carbon dioxide) welding process employing semi-automatic welding machine and fully automatic welding machine (of approved make) used for welding longitudinal fillet welds, girders, unless manual arc welding is specifically approved by the Necessary jigs & fixtures and rotation of structures shall be so arranged that down-hand position of welding becomes possible.
- c) 'Open-Arc-Welding' process employing coated electrodes shall be employed for fabrication of other welded connections not covered under 8.05 (b) and field welding.
- d) Wherever welding is done for assembling the components of structures, the job shall be so positioned that down hand welding is possible. In cases where positioning of the job is not possible other manual welding positions could be resorted to.
- e) Any structural joint shall be welded only by those welders who are qualified for all welding procedures and positions required in such joint that is welded. The entire weld of the joint shall be made by one welder.
- f) Each welder shall be assigned an identification mark and such mark shall be marked on the structure adjacent to the weld on completion of any structural welded joint.
- g) The Principal Contractor shall maintain records of all the welders identification marks, the joints welded by each welder, the welding procedure adopted, welding machine employed, pre and post heating done and any nondestructive test done and stress relieving heat treatment performance on such joints. All such records for the entire welding operation shall be accessible to the for scrutiny and such record shall be countersigned by for welding work accomplished in the preceding months in token of acceptance. But such acceptance shall not relieve the Principal Contractor of his responsibility regarding adequacy & safety of welding operation.

## 22.08 Preheating inter-pass temperature and post weld heat treatment

- a) Mild steel plates conforming to IS: 2062 and thicker than 20 mm, may require preheating of the parent plate prior to welding as mentioned in Table-1. For high strength steel conforming to IS: 8500 the minimum preheat temperature shall be as specified in Table-1. However, higher preheat temperature may be required as per approved welding procedure and same shall be followed. In welding materials of unequal thickness, the thicker part shall be considered for this purpose.
- b) Base metal shall be preheated notwithstanding provisions of IS: 9595 to the temperature given in Table-1 prior to welding or tack welding. When base metal not otherwise required to be preheated is at a temperature below 0 °C it shall be preheated to at least 20 °C, prior to tack welding or welding. Preheating shall bring the surface of the base metal to the specified preheat temperature and this temperature shall be maintained as minimum interpass temperature while welding is in progress.

**TABLE – 1**

**MINIMUM PREHEAT / INTERPASS TEMPERATURE FOR WELDING**

Thickness of thicker part at point of welding	Other than low hydrogen electrode	Welding used			
		Low hydrogen electrodes/or submerged arc welding			
steel	IS: 2062 steel	IS: 8500 steel	IS: 2062 steel	IS: 8500	
	1	2	3	4	5
	Upto 20 mm including	None	Welding by this None	None	None

Over 20 mm to 40 mm including	66°C	Electrode not allowed	20°C	66°C
Over 40 m to 63 mm including	not allowed	–	66°C	110°C
Over 63 mm	not allowed	–	110°C	150°C

- c) Preheating may be applied by external flame which is non-carbonising like LPG, by electric resistance or electric induction process such that uniform heating of the surface extending upto a distance of four times the thickness of the plate on either side of the welded joint is obtained.
- d) Thermo-chalk, thermo-couple or other approved methods shall be used for measuring the plate temperature.
- e) All butt welders with sections or plates thicker than 40 mm require post weld heat treatment as per procedure given in AWS D-1.1 Post heating shall be done up to 600 °C and rate of heating shall be 200° C per hour. The post heat temperature shall be maintained for 60 minutes per 2.5 cm thickness. For maintaining slow and uniform cooling, asbestos pads shall be used for covering the heated areas. The Principal Contractor shall submit and finalise post weld heat treatment procedure at the time of finalization of quality plans.

#### 22.09 Sequence of Welding

- a) The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect or by a counter distortion. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.
- b) Each case shall be carefully studied before finally following a particular sequence of welding.
- c) Butt weld in flange plates and/or web plates shall be completed before the flanges and webs are welded together.
- d) The beam and column stiffeners shall preferably be welded to the webs before the web and flanges are assembled unless the web and flanges are assembled by automatic welding process.
- e) Approval of welding sequence and procedure shall not relieve the Principal Contractor of the responsibility for the correct welding and for minimizing

the distortion in the finished structure which in no case shall exceed that laid down in Indian Standards.

- f) All welds shall be finished full and made with the correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being removed from exposed faces immediately after each run.
- g) Current shall be appropriate for the type of electrode used. To ensure complete fusion, the welding procedure should go proper and rate of arc advancement should not be so rapid as to leave the edges unmelted.
- h) Pudding shall be sufficient to enable the gases to escape from the molten metal before it solidifies.
- i) Non-uniform heating and cooling should be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.
- j) The welding shrinkage shall be minimized by adopting the correct welding procedure and method. In long and slender members extra length should be provided, at the time of fabrication, for shrinkage.
- k) The ends of butt welds shall have full throat thickness. This shall be obtained on all main butt welds by the use of run off and run on pieces adequately secured on either side of main plates. Additional metal remaining after the removal of extension pieces shall be removed by grinding or by other approved means and the ends and surface of the welds shall be smoothly finished.
- l) The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presenting. Correct gap and alignment shall be maintained during the welding operation.
- m) All main butt welds shall have complete penetration and except where it is impracticable they shall be welded from both sides, the back surface of the weld being gouged out clean before the first run of the weld is given from the second side. However, partial penetration butt weld shall be permitted, when specifically shown in the fabrication drawings.
- n) Intermittent welds shall not be permitted without the approval of the IE & PMC. These shall be permitted only when specifically approved in the fabrication drawings.

### **23.0 Testing of Welders**

All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 817 and IS: 7318. If the welder fails in these tests, two further sets of tests shall be undertaken and the welder to qualify must pass both these sets of tests.

The EIC & PMC also reserves the right to have any welder retested at any time. All the necessary arrangements required for the testing of the welder are to be provided by the Principal Contractor.

## **24.0 Inspection of welds**

### **24.1 Inspection of the structural works**

The inspection / checking of the structural steel fabrication work shall be done in various stages as mentioned herein...

- Regular testing & checking of material received at site.
- Qualification of the welders & conducting their tests.
- All butt welds shall have 100% radiographic test conducted and the fillet welds shall be 100% ultrasonically tested.
- Keeping of proper, appropriate & regular record of the day-to-day proceedings.

## **25.0 QAP and Third Party Inspection:-**

The Contractor shall prepare the Quality Assurance Plan, which shall be reviewed by the Inspection Agency & approved by the client & consultant.

The Client shall appoint an independent agency to conduct all necessary tests as per approved Quality Assurance Plan (QAP) and/or Inspection and Testing Plan (ITP) which shall typically include material identification and testing, setup inspection, weld visual inspection with relevant NDT method like radiographic (RT), ultra-sonic (UT), Magnetic particle (MT), Penetrant Test (PT) and if required for other non-destructive tests on the structural steel during various states of work starting from material procurement , material testing, weld test, qualifying the welding procedure and welders, checking fabrication and erection work and checking of fire proofing works etc.

The specialized checking agency shall ensure that the requirements as detailed in the relevant codes, specifications and drawings are satisfied. Any rectification and/or replacement of faulty material or workmanship shall be at the Contractors expense. Remedial work shall not be carried out without prior approval of the Engineer.

Though the appointments of 3<sup>rd</sup> Party Testing Agency is done by the client, the

cost for carrying out the testing shall be entirely borne by the Structural Steel Contractor and the same shall be deducted from Contractors bill.

#### 25.1 Visual Inspection

100 percent of the welds shall be inspected visually by naked eye or lens for external defects. Dimensions of welds shall be checked. The lengths and size of weld shall be as per approved fabrication drawings. It may be slightly oversized but should not be undersized. The profile of weld is affected by the position of the joint but it should be uniform. The welds should have regular height and width of beads. The height and spacing of ripples shall be uniform. The joints in the weld run shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from unfilled craters on the surface, under-cuts, slags on the surface and visible cracks. Such inspection shall be done after cleaning the weld surface with steel wire brushes and chisel to remove the spatter metal, scales, slag etc. If external defects mentioned above are noticed, there is every possibility of internal defects and further radiographic/ultrasonic examination shall be undertaken as per Indian Standards. Weld gauges shall be used to measure the size of the welds.

#### 25.2 Mechanical testing

Test plates shall be incorporated on either side of 10% of main butt welds and the weld shall be continuous over the test plate. The test plate shall be cut from extensions of the main plates and shall be fixed so that metal lies in the same direction as that of the main plate. Test plates shall be prepared and tested in accordance with the accepted Standards, in the presence of the on his authorized representative. All testing equipment and facilities for carrying out these tests shall be provided by the Principal Contractor. Should any of these tests fail further radiographic examination of the welds in question on the main members, shall be undertaken. These tests for the test plates and radiographic examination are additional to those contemplated under routine inspection and testing. The Principal Contractor shall carry out these additional radiographic tests as per normal testing procedure.

#### 25.3 Non-destructive and special testing

In addition to the normal supervision and testing procedure, radiographic/ultrasonic or other non-destructive examination shall be carried out, as stipulated in the Fabrication/Erection checklist on butt or fillet welded joints and/or on test specimens, as per Annexure-A. All test of welds shall be carried out by the Principal Contractor at his own cost as per Annexure-A. However, for checking the quality of weld, the Employer/ shall carry out additional tests at his own cost. The Principal Contractor shall provide necessary supporting facilities free of cost, as may be required by the including cordoning of radiation zones while Radiography testing is in progress. Prepared etched sections of the welds may be required for



examination. The Principal Contractor shall, at his own cost provide these prepared sections.

In case of failure of any of the tests, the cost of re-test of the portion shall be recovered from the Principal Contractor, Rectification of such components shall also be carried out by the Principal Contractor at his own cost.

Rectification of defective welding work wherever defects like improper penetration, presence of blow holes, undercuts, cracking, slag inclusion, etc. are noticed by visual inspection/other tests, the welds, in such location shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary, and rewelded. The gouging shall as far as possible be done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the EIC.

## **26.0 ACCEPTANCE OF WELDED STRUCTURES**

The acceptance of the welded work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the inspection and testing of the joints and the test specimens as per quality checklist and upon general workmanship being good meeting the tolerance requirements given in the quality checklist as per Annexure-A.

## **27.0 BOLTING**

a) Preparation of Members for Bolting:

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

Before assembly, all sharp edges, shaving, rust, dirt etc. shall be removed. Before assembly, the contacting surfaces of the members shall be cleaned and given a coat of primer as specified.

The members which are bolt assembled shall be set according to drawings and temporarily fastened with erection bolts (minimum 4 pieces) to check the coaxiality of the holes.

The members shall be finally bolted after the deviations have been corrected. Before assembly, the member shall be checked and got approved by the EIC.

The difference in thickness of the sections that are butt assembled shall not be more than 3% or maximum 0.8 mm whichever is less. If the difference is large, it shall be corrected by grinding or filling.

Reaming of holes to final diameter or cleaning of these, shall be done only after the part has been checked assembled.



As each hole is finished to the final dimension (reamed if necessary) it shall be set and bolted up. Erection bolts shall not be removed before permanent bolts are set.

b) **Bolting Up**

Final bolting of the members shall be done after the defects have been rectified and approval of joints obtained.

The bolts shall be tightened starting from the center of the joint towards the edge.

c) **Holes for Field Joints**

Holes for field joints shall be drilled in the shop to final diameters and tested in the shop, with trial assemblies. Gas cutting of holes shall not be permitted.

When three-dimensional assembly is not possible in the shop, the holes for field joints may be drilled in the shop and reamed on site after Erection, on approval by the EIC & PMC.

For bolted steel structures, trial assembly in shops is mandatory. The tolerance for spacing of holes shall be  $\pm 1$  mm.

d) **Tolerances**

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

e) Every bolt shall be provided with a washer under the nut part of the threaded portion of the bolt to be within the thickness of the parts bolted together.

f) Flat washer shall be circular of a diameter 2.5 times that of the bolt and of suitable thickness. Where bolt heads/nuts bear upon the beveled surface they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

g) All bolts and nuts shall be of steel, with well-formed hexagonal head unless specified otherwise, forged from the solid and shall be dipped in not boiled linseed oil as soon as they are made. The nuts shall be a good fit on the bolts and two clear threads shall show through the nut when finally tightened up.

h) Notwithstanding anything contrary contained in IS 1363, 1364 and IS: 1367 the threaded length shall be equal to at least the diameter of bolts.

Marking for identification:-

- i) All elements and members prior to dispatch for erection should be shop marked.
- ii) The size and thickness of the numbers shall be so chosen as to facilitate the identification of members.
- iii) For the small members that are delivered in bundles or crates, the required marking shall be done on small metal tags securely tied to the bundle, while the crates shall be marked directly.
- vi) Each bundle or crate shall be packed with members for one and the same assembly. In the same bundle or crate, general, utility members such as bolts, gussets, etc. may be packed.
- v) All built of material showing weight, quality and dimension of contents shall be placed in the crates.
- vi) The members shall be marked with a durable paint, in a visible location, preferably at one end of the member so that these may be easily checked during storage and erection.
- vii) The members shall be marked in the shop before inspection and acceptance.
- viii) When the member is being painted the marking area shall not be painted but bordered with white paint.
- ix) The marking and job symbol shall be registered in all shop delivery documents (transportation, for erection etc.)
- x) All members over 200 kgs in weight should have slinging marks.

## **28.0 Dimensions and Tolerances**

The dimensions, form, weight, and tolerances of all hot rolled shapes (and other members) shall conform to the following Indian Standards and other relevant standards:

IS 1852-1985 Specifications for rolling and cutting tolerance for hot rolled Steel products.

IS 808 - 1989 Dimensions for hot rolled steel Sections

IS: 1730-1989 Dimensions for steel plate, sheet and strip for structural

and

general engineering purposes.

IS 1732-1989          Dimensions for round and square steel bars for structural & general engineering purpose.

IS 7215-1974          Tolerances for fabrication of steel structures

### **29.0          Dimensional Tolerances for Structural Work**

Dimensions shall be measured by means of an approved calibrated steel tape of the same temperature as the structure at the time of measurement.

An allowable variation of 1 mm is permissible in the overall length of members with both ends milled. Members without milled ends, which are to be assembled to other steel parts of the structures, shall not deviate from the dimensions shown on the drawings by more than 1.8 mm for members 10 meters or less in length, and by not more than 3 mm for members over 10 meters in length.

The erection clearance for cleared ends of members connecting steel to steel should preferably be not greater than 2.0 mm at each end. The erection clearance at ends of beams without web cleats should be not more than 3 mm at each end, but where, for practicable reasons, greater clearance is necessary, suitably designed seating should be provided.

### **30.0          Resources planning: -**

The contractor shall submit a detailed report in respect to

#### **30.1          Qualified supervisor**

Workmanship shall be of the highest quality for all phases of the work. Contractors supervising engineers or welding supervisors dedicated for the structural work shall be qualified in accordance with the Standards and Codes designated. The Contractor or his supervisor shall not adopt any practice, which will damage materials.

#### **30.02          Qualified welders & grinder operator**

All welders and grinder operators, to be employed on the works shall be qualified to an appropriate standard as per the procedures outlined in the relevant Indian Standard. Testing of all welders shall be carried out before any work is commenced. Only Welders who pass the test shall be permitted to work only for those positions for which they were tested and passed.

30.03 Plant, Machines & equipment's deployed during handling of fabrication & Erection operations

The suitability and capacity of all plants and equipment used for erection shall be to the satisfaction of the Consultant. Details of the proposed equipment shall be submitted for approval 6 weeks prior to erection commencing.

30.04 Storing and Handling

All structural steel should be so stored and handled at the site that the members are not subject to excessive stresses and damage.

30.05 Setting out

The positioning and leveling of all steel work with accuracy shall be in accordance with the approved Drawings, Specifications and to the satisfaction of the Consultant.

### **31.0 SAFE WORKING**

The Principle contractor shall strictly follow, at all stages of fabrication, transportation and erection of steel structures, the stipulations contained in the Indian Standard Safety Code for erection of Structural steel work IS:7205 and provision of the safety rules as specified in the General conditions of the contract for ensuring safety of men and materials.

31.01 Safety during handling and erection

During erection, the steel work shall be securely bolted or otherwise fastened and, where necessary, temporary bracing provided for all load to be carried by the structure during erection including those due to erection equipment and its operation. No permanent bolting or welding should be done until proper alignment has been obtained.

31.02 Storing and Handling

All structural steel should be so stored and handled at the site that the members are not subject to excessive stresses and damage.

31.03 Setting out

The positioning and leveling of all steel work with accuracy shall be in accordance with the specified safety norms, approved Drawings, Specifications and to the satisfaction of the Consultant.

31.04 Field Connections

All field assembly and welding shall be executed in accordance with the requirements for shop fabrication, excepting such as manifestly apply to shop conditions only. Where the steel has been delivered painted, the paint shall be

removed before field welding, for a distance of at least 50 mm on either side of the joints.

31.05 Platform for working and inspection: -

The contractor shall make all necessary arrangements in form of a suitable platform in wooden plank or steel plate as the case may be, supported by steel scaffolding and side railing up to adequate height. The platform shall be strong & sturdy and shall be used by the workers and the engineers for movement & day-to-day inspection till satisfactory encasing work is complete. This shall include proper approach and working platform during erection of the structures.

## **32.0 PACKING, TRANSPORTATION, DELIVERY**

After final shop acceptance and marking, the item shall be packed and loaded for transportation. Packing must be adequate to protect items against warping during loading and unloading and should have slinging marks.

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

Slender projecting parts shall be braced with additional steel bars before loading for protection against warping during transportation.

Loading and transportation shall be done in compliance with transportation rules. If certain parts cannot be transported in the lengths stipulated in the Design, the position and type of additional splice joints shall be approved by EIC & PMC.

Items must be carefully loaded on platforms for transportation with adequate means to prevent warping, bending or falling during transportation. Small parts such as fish plates, gussets etc. shall be securely tied with wire to their respective parts.

Bolts, nuts and washers shall be packed and transported in crates or bags. The parts shall be delivered in the order stipulated by the EIC & PMC and shall be accompanied by documents showing:

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

32.01 Marking of identification:-

- i) All elements and members prior to dispatch for erection shall be shop marked.
- ii) The size and thickness of the numbers shall be so chosen as to facilitate the identification of members.
- iii) For the small members that are delivered in bundles or crates, the required marking shall be done on small metal tags securely tied to the handle, while the crates shall be marked directly.

- iv) Each bundle or crate shall be packed with members for one and the same assembly. In the same bundle or crate, general utility members such as bolts, gussets etc. may be packed.
- v) All bills of materials showing weight, quality and dimension of contents shall be placed in the crates.
- vi) The members shall be marked with a durable paint, in a visible location, preferably at one end of the member so that these may be easily checked during storage and erection.
- vii) The members shall be marked in the shop before inspection and acceptance.

### **33.0 TRANSPORT, HANDLING AND STORAGE**

Steel shall be handled and transported with care, and in such a manner that parts will not suffer strain, distortion or abrasion. The Engineer shall reject distorted or damaged steelwork. All steel shall be stored above the ground and supported in timber packers.

Lifting and handling of all steel, whether painted or not shall be done with synthetic webbing flat slings or bagged chains. All slings shall comply with the local workplace, health and safety acts.

Under no circumstances shall unprotected chains be used for lifting steel.

Paintwork damaged during transport and erection shall be rectified as specified in the Surface Treatment Section of the Specification.

Where large portal frames are being used, the flexibility of the frames requires that care be taken when accepting delivery, stacking, lifting and erecting. It is expected that a foreman competent and familiar with all aspects of lifting a large portal frame be appointed to the site. Beams and trusses shall be lifted such that bending occurs about the axis for which the member was designed.

Unless otherwise stated on the Drawings a space of not less than 25mm shall be provided between undersides of column base plates and between all beam and roof truss bearings, and concrete pads, footings etc.

After steel work has been wedged up to line and level fixed in position, the space between steelwork and concrete shall be grouted with a mixture of Portland cement and approved commercial grit or washed sand. The mix shall be of equal proportion by volume of cement and sand (or grit) mixed with just sufficient water to form a mixture of "damp earth" consistency, and shall be used within 20 minutes. The grouting mix shall be rammed to approval into the space between steelwork and concrete and protected from damage until it sets.

### **34.0 ERECTION PROCEDURE**

#### **34.01 Erection Marks**

- a) The erectability of the structures shall be checked by the Principal Contractor before commencement of the fabrication work to avoid future modification.

Before any steel work leaves the Principal Contractor's fabrication site, it shall be suitably marked in accordance with the approved fabrication drawings and according to an approved marking plan.

- b) The erection marks assigned to various components of the structural steel work, excepting secondary beams, shall also contain an erection sequence number indicating the sequence in which the various components are to be erected.
- c) Erection marks shall be clearly painted on the work item, each piece being marked in at least two places. Each piece shall also have its weight marked thereon. In order to help identification, each erection piece, i.e. erection mark item, shall bear its erection mark and erection sequence number. Erection marks shall be painted on the structures, during the process of fabrication to facilitate their identification during inspection. Where a number of components are identical and bear the same erection mark, these components shall be further identified by assigning numerals in addition to the common erection mark.
- d) Fabrication sections shall be suitably marked on the sections with the utmost care to ensure proper alignment and assembly of the pieces at site.

#### 34.02 Erection

Considering the complexity of the structure it may be necessary to assemble one or two frames at site before actual erection in situ is undertaken. Hence the contractor shall make necessary provisions at site for such mock-up assembly.

- a) The Principal Contractor shall submit for approval of the EIC & PMC his Erection Scheme for the erection of all types of structures. Erection shall commence only after approval of the Principal Contractor's proposed erection scheme.
- b) The erection scheme shall give full details of the method of handling, transport, hoisting and erection including false work/staging, temporary bracing, guying, temporary strengthening, etc. It will also give the complete details of the quantity and capacity of the various items of erection equipment that will be used. Any modifications to the erection scheme as directed by the EIC & PMC for various reasons or due to the interference with the work of other agencies shall be incorporated by the Principal Contractor.
- c) The Principal Contractor shall examine the site conditions and transportation clearances before deciding whether columns are to be



fabricated and erected in one piece or more than one piece. Erection of structures is to be carried out preferably with a crane and in case this is not possible, only the upper portion of the columns can be erected with a derrick. Further, the erection of columns and portals etc. shall be carried out in one single piece as far as practicable. No column shall be fabricated and erected in more than 3 pieces. Proper splicing shall be provided at the erection joints indicated in fabrication drawings. When erection joints are provided in columns, their location shall generally be just above a floor level.

- e) The structural steel shall as far as practicable be erected frame wise. Thereafter, the frames shall be progressively aligned and all erection welding completed. The secondary beams shall thereafter be erected, aligned and welded completely as per the approved schedule of work. Touch up painting in these areas shall be completed and as soon as a particular portion of the structure/floor is completed in all respects, it shall be handed over to other Principal Contractors for carrying out other civil works as well as mechanical/electrical erection works. Conveyor galleries shall generally be erected as a completely fabricated box, i.e. the bottom chord and bracings, top chord and bracings, side vertical posts and bracings, and portals and roof-trusses shall be completely welded prior to erection. The inside sheeting runners and roof sheeting purlins may be erected individually.

#### 34.03 Protection against Damage in Transit

- a) All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All projecting plates or bars and ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all bolts, nuts, washer and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members the Principal Contractor shall immediately report the matter to the EIC & PMC. Distorted steel received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the EIC & PMC can be removed by acceptable methods.

These distortions shall be rectified by the Principal Contractor by cold-bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the EIC & PMC whose approval shall be taken before such rectification.

The temperature of heat treatment shall not exceed the limits beyond which the original properties of the steel are likely to be impaired.



- b) If in the opinion of the EIC & PMC the steel has been unduly bent in transit from the project stores to the fabrication yard or during handling by the Principal Contractor which cannot be rectified, such steel shall be counted as wastage and the cost of such steel shall be recovered from the Principal Contractor as per the provisions of the contract.

34.04 Storage and Preparation of Parts prior to erection:

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

34.05 Erection and Tolerances

- a) Erection in general shall be carried out as required and approved by the EIC & PMC.

- b) Positioning and leveling of the structure, alignment and plumbing of the Stanchion and fixing every member of the structure shall be in accordance with the relevant drawings and to the complete satisfaction of the EIC & PMC.
- c) The following checks and inspection shall be carried out before, during and after Erection.
- Damages during transportation.
  - Accuracy of alignment of Structures
  - Erection according to Drawings and Specifications.
  - Progress and workmanship
- d) In case there are any deviations regarding positions of foundations, or anchor bolts, which would lead to erection deviations, the EIC & PMC shall be informed immediately. Minor rectifications in foundations, orientation of bolt holes etc. shall be carried out as a part of the work, at no extra cost.
- e) The various parts of the Steel Structure shall be so erected as to ensure stability against inherent weight, wind and Erection stresses.
- f) The structure shall be anchored and final erection joints completed after plan and elevation positions of the Structural members have been verified with corresponding drawings and approved by the EIC & PMC.
- g) The bolted joints shall be tightened so that the entire surface of the bolt heads and nuts shall rest on the member. For parts with sloping surfaces, taper washers shall be used.
- h) Site painting after erection shall be as per clause 16.02.

#### 34.06 Stability of Structures

- a) The Principal Contractor shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracing and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations. Guying and bracing shall be done in such a way that they do not interfere with the movement or working of other agencies working in the area. For the purpose of guying, the Principal Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy.
- b) Setting Column Bases

Column bases shall be set so that the column load is uniformly transmitted to the foundation. The Principal Contractor shall carefully check the location and layout of anchor bolts embedded in foundations constructed to ensure that the structures can be properly erected as shown on the drawings.

- c) The Principal Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the columns are in plumb. The permissible erection tolerances for the structural members are given in Table 'A' given at the end of this specification.
- d) Before erection of columns on their foundations, the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose material. The Principal Contractor shall also be responsible to provide all packing and shim plates. No steel structure shall be erected on their foundation unless such foundations have been certified fit for erection of steel by the EIC & PMC. Adequate number of air release holes and inspection holes shall be provided in the base plate. The grouting/underpinning of base plate and chipping of foundation to desired level are also in scope of the Principal Contractor.

#### 34.07 Final Acceptance and Handling Over of Structure

- a) At acceptance, the Principal Contractor shall submit the following Documents :
  - b) Shop and Erection Drawings – either in tracings or reproducible.
  - c) Copies each of the following.

- Shop acceptance documents
  - Quality Certificates for Structural Plates, electrodes, welding wire, bolts, nuts, washers etc.
  - List of Certified Welders, who worked on Erection of Structure. (With documents or qualification tests)
  - Acceptance and Intermediate Control Procedure of Erection Operations.
- a) Approval by the EIC & PMC at any stage of work does not relieve the Principal Contractor of any of his required guarantees of the contract.

### 35.00 SAMPLING, TESTING AND QUALITY CONTROL

#### 35.01 General

- a. The Principal Contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and/or International Standards and shall conduct such tests as called for by the EIC & PMC. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the EIC & PMC. Tests shall be done at a laboratory approved by the EIC & PMC and the Principal Contractor shall submit to the EIC & PMC, the test results in triplicate within three days after completion of a

test. The EIC & PMC may at his discretion, waive off some of the stipulations given for small and unimportant operations.

- b. Material/work found unsuitable for acceptance, shall be removed and replaced by the Principal Contractor. The work shall be redone as per specification requirements and to the satisfaction of the EIC & PMC.
- c. Radiography and ultrasonic testing of welds shall be carried out by specialist agencies only.

35.02 An indicative programme of Inspection and testing for raw materials, welds and dimensional tolerances for fabrication & erection of steel structures are given in Annexure-A. The Principal Contractor shall draw-up a comprehensive quality control programme for executing the works based on this indicative programme.

### **36.00 EMBEDDED PARTS**

#### 36.01 Scope

This section of specification deals with the supply, fabrication (where called for and / or erection of embedded steel parts.

#### 36.02 General Requirements

- a) Embedded steel parts shall be either furnished by the Employer/ EIC & PMC for transportation and erection by the Principal Contractor or supplied, fabricated and directed by the Principal Contractor as stipulated. If supplied by the Employer/EIC & PMC, these parts shall be furnished anywhere within the project area and the Principal Contractor shall transport the same to the work site.
  - i. embedded steel parts supplied, fabricated and erected by the Principal Contractor shall include items such as, but not limited to, foundation grillages, anchor bolts, pipe sleeves, equipment mounting plates, steel pieces properly welded with necessary lugs as shown on the drawings, auxiliary framing for equipment supports, pasty plugs for door and window frames, dowel bars for concrete work, miscellaneous frames, etc.
  - ii. Embedded steel parts supplied, fabricated / erected by the Principal Contractor shall also include items such as but not limited to plate inserts, edge protection angles, rolled sections with or without properly welded lugs.
  - iii. Cold work deformed steel bars shall not be used for lugs.

#### 36.03 Materials

The materials shall be in accordance with the relevant clauses of Technical Specification for the respective works which shall be deemed to form a part of his

specification. Mild steel pipes shall conform to IS: 1161. Unless otherwise specified, medium class pipes shall be provided.

#### 36.04 Fabrication, Erection Etc.

The Principal Contractor shall fabricate, transport to site and erect accurately in position all embedded steel parts either by welding, bolting or any other means as approved by the EIC & PMC. Exposed surfaces of embedded parts other than holding down bolts, unless otherwise stated, are to be painted with two coats of approved anticorrosive paint (as per IS: 2074) and/or or bituminous paint as directed. The threads of holding down bolts shall be greased and protected with water proof tape.

During erection, the Principal Contractor shall provide necessary strong temporary bracings and supports to ensure proper installation of the embedded parts which shall be erected at the true locations as shown on the drawings and these shall be in plumb and level (unless otherwise shown on drawings). The Principal Contractor shall furnish the EIC & PMC with fabrication and assembly drawings prepared for embedded steel parts showing the erection procedure, for major items, wherever necessary.

Fabrication and erection shall be carried out as per IS: 800. Welding rods and site / field welding shall conform to IS: 816 and IS: 9595.

### **37.0 FOUNDATION BOLT ASSEMBLY**

#### 37.01 Scope

This section of the specification deals with the requirements of supply, fabrication and erection of foundation bolt assembly etc.

#### 37.02 General Requirements

Supply, fabrication, erection and installation of foundation bolt assembly shall comprise of foundation bolts, stiffener plates, washers, nuts, lock nuts, pipe sleeves etc.

#### 37.03 Materials

Foundation bolts shall generally conform to IS: 5624. Mild steel bars used for the fabrication of bolt assembly shall conform to grade – 1 of IS: 432, IS: 2062 or any other material including high carbon / high tensile steel as specified.

Hexagonal nuts and lock nuts shall conform to IS: 1363 and IS: 1364 up to M-63 dia. And IS: 3138 and M-42 to M-150 dia.

Flat plain washers shall be of mild steel and punched / machined type conforming to IS: 5369. Steel pipe sleeves shall conform to medium class of IS: 1161.

#### 37.04 Fabrication, Erection, Etc.

The fabrication and erection of bolt assemblies shall include threading, cutting, grinding, drilling, welding, etc. complete. All bolts, bolts assemblies, etc. shall be fabricated by the Principal Contractor to the correct dimensions and shapes as shown on drawings, supplied by the EIC & PMC. The bolts shall have coarse pitch screw thread in the diameter range, 8 to 64 and 6 mm pitch screw for diameter >64 mm as per IS : 4218.

For fabrication of any particular size of bolt indicated on the drawing, the diameter of the threaded portion of the bolt shall be considered as the diameter of the bolt.

Every bolt shall be provided with a steel washer, under the nut. The washer shall be flat and min outside circle have a diameter 2.50 times that of the bolt and of suitable thickness. All nuts shall be of steel with well-formed hexagonal heads unless specified otherwise, forged from solid metal and shall be dipped in hot boiled linseed oil as soon as these are made. The nuts shall fit well on the bolts.

During erection, the Principal Contractor shall provide necessary template, temporary bracings, supports, etc. to ensure proper positioning of the assemblies and holding them

firmly until they are cast / grouted and the grouted has set. All materials shall be erected in plump and in level (unless otherwise specified) and at true locations as shown on the drawings. Threads shall be protected by using PVC taps.

Fabrication and erection shall be carried out as per IS: 800. Welding shall conform to IS: 816 and IS: 9595

#### **38.0 WORKMANSHIP: -**

Workmanship shall be of the highest quality for all phases of the work. Supervising engineers, welding supervisors and welders shall be qualified in accordance with the Standards and Codes designated. The Contractor shall not adopt any practice, which will damage materials.

The whole of the structural steel fabrications shall be done in the Contractors workshop unless specific approval has been obtained from the Engineer for the sub-contracting of any part of the work prior to the placing of the sub-contract.

All steel shall be new and each member shall be free from any butt-welded or other form of splice for the full length between joints shown in or indicated by the drawings unless such splice shall have been shown in the approved shop drawings and/or approved in writing.

Steel sizes shall be as indicated on the drawings. Under no circumstances can any other member size or type be made without the written approval of the Consultant who will consider only a written application showing specified size and dimensions and required substitute size and dimensions.

Clamps, magnets, holding devices or other setting up fixtures shall be used in assembling structural members in order to avoid tack welding whenever practicable.

Finished members shall be free from kinks or bends. Shearing shall be accurately done, and all portions of the work neatly finished. Corners shall be square and true, unless otherwise shown on the drawings. Where shearing cannot make reentrant cuts, a rectangular punch may be used. Reentrant cuts shall be filleted, unless otherwise approved by the Consultant. Approved dies shall make bends, except for minor details, or bending rolls. Where heating is required, precautions shall be taken to avoid overheating the metal and it shall be allowed to cool in such a manner as not to destroy the original properties of the metal. Hammer marks shall not be evident. Steel with welds will not be accepted, except where welding is definitely specified, called for on the Drawings, or otherwise approved. All bolts, nuts, and screws shall be tight. The ends of pipes, except for hand railing, shall be reamed.

Fabrication in general shall conform to the requirements of IS 800-1984, Code of practice for use of structural steel in general building construction.

### **39.0 FINISHES**

All steel work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust, grease and foreign matter and shall be treated in the workshop prior to transportation. If painted it shall be applied to dry surfaces and shall be thoroughly and evenly spread and well worked into joints and open spaces. Abrasions in field erection shall be touched up (including primer) immediately after erection.

Steel plate and protection angles required for the protection of concrete work shall be erected true to line and grade within the tolerances specified below. The edges of exposed faces may have a vertical or horizontal distortion from a straight line not greater than 3 mm per meter of length, provided, that distortion for any single piece shall not exceed 1 mm and provided, that when the warp is greater than 1.6 mm an extra anchor hole shall be drilled near the proper corner and the piece drawn into position thereby. All bolt heads on the exposed face shall be



countersunk and fitted or ground so that the heads are flush with the finished surface. Joints between abutting sections shall be square and flush and the butting ends shall be sawed or otherwise made smooth and regular.

#### **40.0 SEALING**

All tubular, square and rectangular hollow sections shall be welded so as to completely seal the internal sections against air and moisture. All ends will be fully welded into adjacent members or capped with 6 mm end plates as applicable. To ensure this condition is met, the Consultant may require the Contractor to carry out pressure tests on internal sections of any part of the structures, at the Consultant's discretion and Employers cost. The Contractor at his cost will rectify any defective areas found by such a test.

#### **41.0 GROUTING**

Unless otherwise stated on the Drawings a space of not less than 25mm shall be provided between undersides of column base plates and between all beam and roof truss bearings, and concrete pads, footings etc.

After steel work has been wedged up to line and level fixed in position, the space between steelwork and concrete shall be grouted with a mixture of Portland cement and approved commercial grit or washed sand. The mix shall be of equal proportion by volume of cement and sand (or grit) mixed with just sufficient water to form a mixture of "damp earth" consistency, and shall be used within 20 minutes. The grouting mix shall be rammed to approval into the space between steelwork and concrete and protected from damage until it sets.

TABLE – A.1

**TOLERABLE DEVIATION FROM DESIGNED LINEAR  
DIMENSIONS IN MM IN THE PARTS PROCESSED FOR FABRICATION**

S. No.	Characteristic	Deviation / Tolerances in mm					
		1.5m Below	1.5m 2.5m	2.5m 4.5m	4.5m 9.0m	9m 15m	15m above
1	2	3	4	5	6	7	8
1	a	Deviation in length and width of part cut out by					
	i)	Manual gas cutting					
	ii)	Gas cutting by automatic and semi automatic machines					
	iii)	Shear or saw cutting					
	iv)	Parts machined by edge-planing or milling machines					
	b	Difference in diagonal lengths of sheet parts :					
	i)	For butt welding					
	ii)	For lap welding					
	c	Deviation in distances between hole centres, form as per :					
	i)	Marking of extreme holes					
	ii)	Marking of adjacent holes					
2	Deviation in the dimension of structural dispatch members after finishing :						
a	When assembled upon assembly benches as per marking.						
b	When assembled in the jig and other devices fastening with fixtures.						

	C	Dimensions (length and breadth) between milled surface (after finishing)	0.5	1.0	1.5	2.0	2.0	2.0
3		Distance between groups of erection holes (in finished members) :						
	a	Formed during machining of assembling as per marking.	3.0	3.0	3.0	3.0	3.0	3.0
	b	Formed during machining of with the help of fixtures.	2.0	2.0	2.0	2.0	2.0	2.0
	c	Drilled with the help of templates in finished members.	0.5	1.0	1.0	1.0	1.0	1.0

---

## FABRICATION CHECKLIST

TABLE – A.2

## Tolerable deviations of fabricated members from designed geometrical shape

Sr. No.	Characteristic Remarks	Deviation/Tolerance	
1.	Curvature of assembly Parts		
a)	Gap between a sheet and a steel rule face over 1 m length	1.5 mm	
b)	Gap between a taut string and of vertex face of an angle flange or web of channel and joist.	0.001 L, but not greater than 10 mm.	L-length member
2.	Deviation of edge line steel sheet parts from theoretical profile:		
a)	During butt and toe welding	1.5 mm	
b)	During lap welding	3 mm	
3.	Deviation of radius of the bend :		
a)	Clearance between template and the surface of rolled sheet (1.5m flange or face of cold bend profile. curve)	1.5 mm	length long the
b)	-do- for hot bend profile	2 mm	-do-
4.	Deformation of dispatch members :		
a)	Inclination of flanges with the web :		
	i) at junction of flange	0.005b	b-width
	ii) at other places	0.01 b	-do-
b)	transverse bending of flanges :		
	i) at junction with members of flange	0.005 b	b-width

ii) at other places	0.01 b	-do-
c) Warping of the web of the member	0.003	h-depth
d) Sag of member of than 10 mm	L/750 but not more than 10 mm	L-length
5. Other deviations :		
a) Shifting of axes of riveting/bolting lines for lattice structures from theoretical eccentricity.	3.0 mm	
b) Inclination of the milled surface from designed position.	1/1500	

**FABRICATION CHECKLIST****TABLE – A.3**

**Tolerances given are for general structures such as columns, crane girder, trusses etc. Furnish acceptable tolerances for the tubular structures under consideration.**

Acceptance deviations in as fabricated steel structures.

<b>Sr. No.</b>	<b>Characteristic</b>	<b>Deviation/Tolerance</b>
1.	<b>COLUMNS</b>	
a)	Deviation in length 'L' measured distance from bottom surface of the column footings, to the group of holes for 'trusses', fasteners, collar beams, purlins and other elements to be connected to columns.	
	When L is under 10 m	$\pm 10$ mm
	When L is over 10 m	$\pm 15$ mm
b)	Deviation is distance 'L' from bottom surface of the column footing to the top of the crane bracket.	
	When L is under 10 m	$\pm 5$ mm
	When L is over 10 m	$\pm 10$ mm
c)	Deviation in distance from bearing surface of the bracket to the first fastener of the element to be connected to a column.	$\pm 1$ mm
d)	Deviation in distance between any groups of holes for connection of bracings to columns.	$\pm 1.5$ mm
e)	Sag of column element (curvature)	1/1000 of length element but not more than 10 mm
f)	Difference in web depth of column	
i)	At splice joint	$\pm 2$ mm
ii)	At any other location	$\pm 10$ mm
g)	Deviation in distance from supporting surface of milled end of the dispatched element of column to the cleat or seating plate for fastening of collar beams, purlins, girders etc. (Fish plates, brackets)	$\pm 3$ mm

## 2. TRUSSES

a) Deviation in span 'L' of the truss between end erection holes in gussets of supporting units or between external planes of supporting gussets or angles when trusses are resting on brackets or supports :

When L is under 25 m  $\pm 7$  mm

When L is over 25 m  $L/2500$  but not more than 15 mm

b) Deviation in distance between the centres of holes or webs of angles for fastening bracing, purlins, monitors, etc.

$\pm 3$  mm

c) Deviation in distance between the first row of erection holes and the

more than 1.5 mm

d) Distance between holes for fasteners to top and bottom chords of trusses on supports.

$\pm 3$  mm

e) Sag of separate elements between node points. But not more than 10 mm

$1/1500$  of length of element

## 3. BEAMS

a) Deviation in span L of beams between end erection holes, outer surfaces of end plates:

When L is under 25 m  $\pm 10$  mm

When L is over 25 m  $\pm 1/2500$  length but not more than 15 mm

b) Deviation in the height of beam as measured from the bearing surface to the top of the upper flange.

$\pm 3$  mm

c) Deviation in distance between the group of holes for fastening of purlins, monitors, bracings, bracing grids etc.

$\pm 3$  mm

d) Sag (curvature) of the girder or diaphragm member

$1/1000$  length but not more than 15 mm

## 4. ELEMENTS OF FRAMEWORK BRACING, PURLINS ETC.

a) Deviation in distance between end erection holes, determining span of element.

$\pm 3$  mm



- |    |   |                       |
|----|---|-----------------------|
| b) | Sag of dispatch members more than 15 mm                                   | 1/1000 length but not |
| c) | Deviation in distance between the groups of erection holes of the element | $\pm 3$ mm            |
| d) | Gratings, Stair, Railings, ladders, etc.                                  | $\pm 12$ mm           |

5. **SHOP ASSEMBLY (BEFORE DESPATCH FOR ERECTION)**

- |    |  |                                  |
|----|--|----------------------------------|
| a) | Columns weighing more than 20 T        | i) Every first and further every |
| b) | Roof trusses of 30 m or more span      | put for control assembly.        |
| c) | Crane girders with span more than 18 m |                                  |

## FABRICATION CHECK LIST

TABLE – A.4

Acceptable Deviation in Holes or Bolts

Sr. No.	Characteristic	Deviation	Tolerance No. of deviation in each group
1.	a) Deviation of dia of holes for rivet and bolts :		
	Upto 16 mm	$\pm 1$ mm	No limit
	Over 16 mm	$\pm 1.5$ mm	
	b) Deviation of dia of turned and fitted bolts:		
	Nominal dia of bolts and holes	Upper limit: Lower limit: 0.00	+ 0.125 mm No limit
2.	Quality (difference between the greatest and lesser dia):		
	Up to 16 mm hole dia	+ 1 mm	No limit
	Up to 16 mm hole dia	+ 1.5 mm	
3.	Deformity in size greater than 1.5mm and cracks in the edge of holes.		Not permitted
4.	Misalignment of holes in Separate plates in the joints:		
	i) Upto 1 mm		up to 50%
	ii) From 1 to 1.5 mm		up to 10%

Note : Burrs in the holes shall be removed, the depth and width of countersunk shall not deviate from the standard by more than 1.5 mm.

## FABRICATION CHECKLIST

**TABLE – A.5**

Permissible Fabrication Deviation of Structural Steel

<b>Sr. No.</b>	<b>Type of Structures</b>	<b>Name of Deviations</b>	<b>Value of (Tolerance)</b>
1.	Column	Assembly fits a) Base plate and column b) Frame Joints c) Web and flange d) Web & stiffeners e) Flange & stiffeners Intermediate stiffeners & Bearing stiffeners f) Cap plate & column g) XXXXX girder seat h) Beam brackets	0.1 2.0 mm 1.5 mm 1.5 mm 1.5 mm 0.1 mm 0.1 mm 2.0 mm
2.	Beams	(c), (d) (e) of S. No. 1 Above	1.5 mm
3.	Girders Above and knife edge supports	(c), (d) (e) of S. No. 1	0.1 mm
4.	Purlin	Deviation in distance between purlins.	5 mm

**ERECTION CHECKLIST****TABLE – A.6**

Maximum permissible Tolerances in Steel Structures

Sr. No.	Description	Tolerance
1.	i) Deviation of column axis at Foundation top level with respect to true axis :	
	a) in longitudinal direction	$\pm 5$ mm
	b) in lateral direction	$\pm 5$ mm
	ii) Deviation in the level of bearing surface of columns at foundation top with respect to true level	$\pm 5$ mm
	a) For columns without any special requirements:	
	1) up to and including 30 mm height	$\frac{+H}{1000}$ or $\pm 25$ mm whichever is less
	2) over 30 m height	$\frac{+H}{1200}$ or $\pm 40$ mm whichever is less
	b) For column with special requirements like cranes or such similar requirements :	
	1) upto and including 30 m height	$\frac{+H}{1000}$ or $\pm 25$ mm whichever is less
	2) over 30 m height	$\frac{+H}{1200}$ or $\pm 30$ mm whichever is less
	iv) Deviation in straightness in longitudinal and transverse column at any point along the height. 1500 whichever is less	$\frac{+H}{1500}$ or $\pm 10$ mm
	v) Difference in the erected positions of adjacent pairs of columns along length or across width of building prior to connecting trusses/ beams with respect to true distance.	$\pm 5$ mm
	vi) Deviation in any bearing or seating level with respect to true level.	$\pm 5$ mm

- vii) Deviation in difference in bearing levels of a member on adjacent pair of columns both across and along the building.  $\pm 5$  mm

**NOTES :**

1. Tolerance specifies under iii (a) and iii (b) should be read in conjunction with iv and v.

2. 'H' is the column height in mm.

3. Erected Steel Trusses/Gantry Sections

- i) Shift at the centre of span of top chord member with respect to vertical plane passing through the centre of bottom chord.  $\frac{+1}{250}$  of height of truss in mm at centre of span or  $\pm 15$  mm whichever is less
- ii) Lateral shift of top chord truss at the centre of span from the vertical plane passing through the centre of supports of the truss.  $\frac{+1}{1500}$  of span of truss in mm or  $\pm 10$  mm whichever is less
- iii) Lateral shift in location of purlin from true position.  $\pm 5$  mm
- iv) Deviation of difference of bearing levels of trusses from the true difference.  $\pm 1/1200$  of span of truss in mm or  $\pm 20$  mm Whichever is less.

3. Erected Portals / Structures.

- i) Shift in the centre line of crane rail with respect to centre line of web crane girder.  $+(Web\ thk\ in\ mm) + 2\ mm$
- ii) Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point.  $\pm 5$  mm
- iii) Deviation in the level at any point from true level  $\pm 10$  mm
- iv) Difference in levels between crane track rails at :

- a) Supports of girders
- b) Mid span of girders

15 mm  
20 mm

- iv) Relative shift of surface at a joint plan and elevation.

2 mm subject to grinding of surfaces for smooth transition.

A - TYPICAL WELDING PROCEDURE DATA SHEET

Principal contractor  
.....Address.....

Quality of weld .....Specification  
.....

Material Specification .....Thickness  
.....Batch/

Cast No ..... Joint preparation (Fig)  
.....

Gap ..... Location of Specimens  
.....

Whether condition ..... Type of Day  
.....

Wind break used  
.....

Electrode Group No..... Make ..... Specimen  
.....

Pre and Post Heating  
.....

Welding position  
.....

Size of reinforcement ..... Whether removed  
.....

Welding Sequence  
.....

Backing strip used ..... Type  
.....

Welding process  
.....

Current conditions Polarity  
.....

Size of electrode  
.....

Amperage and voltage  
.....

Number of Electrodes used per run

.....

Cleaning method

.....

Remarks

.....

.....

**WELDING ENGINEER**  
**Employer/ EIC & PMC**  
 (Inspecting Authority)Signature

**Quality Assurance & Quality Control pointsfor structural steel fabrication & erection**

**Fabrication:**

Raw materials - All structural steel sections, plates & fasteners shall be confirmed with manufacture TC against heat no / batch no / identification marked traceable to manufacture TC.

1. Batch wise / heat no wise / lot wise random checking of material by independent external LAB confirming to product manufacturing specification (manufacture TC) – the frequency of testing can be based on Inspection & test plan # ITP  
**# ITP to be submitted by contractor and to be agreed by structural consultant, client & TPI (3<sup>rd</sup> party inspection).**
2. For plates with thickness  $\geq 16$  mm UT for plate scanning is recommended the scope can be random per heat no per size based on the ITP
3. Welding procedure & Welder Qualification to be established by contractor under witness of TPI
4. Welding consumables used should have tractability with batch test certificates ( consumables shall have min 3 classification society approval or prequalified by structural consultant / TPI involve)  
 Inspection of job setup & fit-up , in-process fabrication & final dimension of assembly shall be in confirmation to design code / relevant IS specification / drawing / welding procedure requirements , the project based applicable tolerances shall be specified in ITP, the inspection responsibilities shall be shouldered by contractor & TPI in tandem as per ITP scope 100% Weld visual inspection to confirm the visual weld quality, weld dimension, weld length & location shall be in confirmation to fabrication drawing requirements. The weld quality acceptance shall be in confirmation to



design code requirements. The acceptance criteria and frequency of testing shall be specified in ITP, this activity shall be shouldered by contractor & TPI in tandem as per ITP scope

5. 100% UT / RT for all full penetration weld in butt & Tee joint. (PT for root weld is recommended if back-chipping is performed) - NDT procedure & acceptance shall be as per the approved NDT procedure to be accepted by TPI
6. Random scope of MT / PT for all partial penetration weld in butt & Tee joint. (PT for root weld is recommended if back-chipping is performed)
7. If Plug, Slot & Stud welding are under scope of project same shall be tested randomly by suitable NDT test method as per ITP
8. Blasting and surface finish requirements shall be as per the applicable painting & coating scheme, the paint manufacture specification recommendation shall be followed for the same, the application requirements, technique and inspection criteria and type & frequency of testing shall be specified in blasting & painting procedure, same shall be prepared by contractor in accordance to paint manufacture data sheet and send it for approval of structural consultant after review of TPI
9. Primer / Painting (including fire proof paint) scheme shall be based on the paint manufacture specification recommendation, the material, application requirements, technique and inspection criteria and type & frequency of testing shall be specified in blasting & painting procedure, same shall be prepared by contractor in accordance to paint manufacture data sheet (confirming to any recognized national or international code / standards) and send it for approval of structural consultant after review of TPI
10. As briefed during the Pre Bid meeting, the primer to be applied over the structural steel elements shall be compatible for fire proof treatment / paint using an Intumescent paint for exposed steel sections/ structural elements on the building face and spray vermiculite treatment for rest of the elements that are not visible.

#### **Erection:**

1. For welded connection follow applicable steps as per fabrication.
2. For bolted connection bolt tightening procedure shall be made available by contractor for preloaded & non preloaded connection same shall be approved by structural consultant after review of TPI. the final assembly shall be in confirmation to the approved procedure / design code / relevant IS specification / drawing requirements, the project based applicable tolerances shall be specified in procedure and the inspection requirements shall be based shouldered by contractor & TPI in tandem as per ITP scope

The level, alignment, verticality and other applicable erection checkpoints shall be as per design code / relevant IS specification / erection drawing , the project based applicable tolerances shall be specified in ITP and the inspection responsibilities shall be shouldered by contractor & TPI in tandem as per ITP scope

3. Critical erection elements methodology and typical mockup before final erection shall be offered by contractor to structural consultant if called for.

**Important Note –**

The above scope is generic and tentative in nature. Any addition or deletion in the scope can be discussed and concluded at the time of finalization of ITP by structural consultant to meet specific quality requirements in said project.

## **Third Party Structural Steel Testing Agency**

### **Broad Scope of Work**

1. Preparing Quality Assurance Plan for the structural steel work in consultation with the structural consultant.
2. Finalization and approval of WPS (Welding procedure specifications) + PQR (Procedure qualification record) + WPQ (Welders prequalification record) documents.
3. Detailed discussion about scope of work and close coordination with the structural steel contractor on board.
4. Deputation of qualified & experience personnel for completing the testing scope of work as and when required and at contractor's fabrication yard or at the site as the case may be.
5. Review of inward material documents.
6. Checking the tractability of plates based on heat no with plate supplier mill TC.
7. Performing UT on all plates (100%) for lamination check.
8. Witnessing Physical & Chemical testing at NABL approved lab of samples drawn from plates (one sample for each variety per heat number)
9. Hard stamping & marking on each accepted plate.
10. Review of test certificate for welding consumables.
11. One procedure qualification sample testing using actual variables listed in WPS followed by operator performance qualification test.

12. Welding Process assessment based on approved WPS.
13. Review of RT procedure submitted by contractor.
14. Performing random UT (15%) before final stamping.
15. Marking & Stamping for final dispatch.
16. Stage-wise inspection as per QAP requirement which includes, Raw material & consumable inspection, Dimensional Inspection, Inspection during Erection, Its Placement, Connection, Plumb Checking at assembly etc.
17. Helping erection team while erection for getting their dimensions right.
18. Issuing welder ID card.
19. Review of Welding procedure & welder Performance qualification & welding machine calibration.
20. Performing NDT (UT, RT, MPT and PT) on the welded joints as per QAP requirement / QAP final approved document.
21. Daily reporting to the Project Team on the test results, production updates etc.
22. Preparation / Review of QAP, WPS, PQR, WPQ, PWPS-NDT Procedures, Production sequence, Welding sequence, Welding machine calibration, General Work Instructions, instructions & implementations for Storage & material handling and the Fabrication Book at Pre Fabrication Stage.
23. Visual inspection of welding, Stage wise inspection of Raw material, Consumable, Dimensions, availability of Welding procedure, Checking Welder Qualification, Witnessing Welding etc during Fabrication.
24. Dimensional Inspection of the structures, Witnessing / Performing NDT, generating & documenting of reports, Painting Inspection and Final Inspection & Stamping at Post Fabrication stage.
25. Reviewing, commenting of fabrication drawing & its approval in consultation with the structural consultant.
26. Review of test certificate & performance of required testing for directly brought out items at yard.
27. Review of erection method statement.
28. Witnessing the PQR test.

29. Inspection of joint fit-up carried out at site, as per drawing.
30. Dimension & visual inspection of fabricated part as per shop drawings.
31. Pre-dispatch assembly inspection on test bench.
32. Inspection & checking of application of compatible primer depending upon type of fire protection (either Spray vermiculite OR Intumescent paint) to be applied.
33. Material, Fabrication, Erection, Connection and Quality certification, marking & stamping for final dispatch.
34. Review of final dispatch documents.
35. Preparation of final report (fabrication book) for submission to Client and the Structural consultant.