

# Third Party Audit of ROB's and FOB's of SCR



**INSPECTION OF FOB AT BIBINAGAR RAILWAY STATION**

**Final Report**  
SEPTEMBER | 2020

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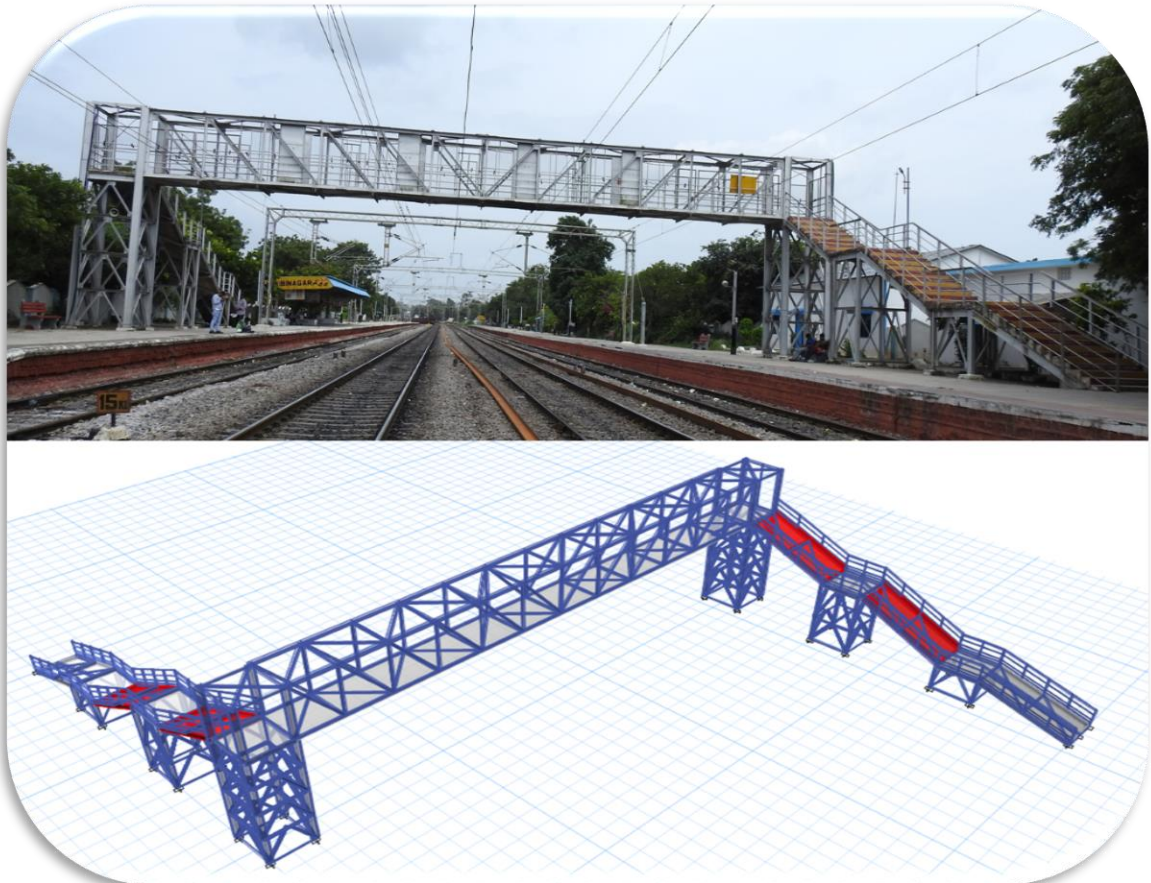
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## 1. VISUAL INSPECTION

|                              |   |                                                                    |
|------------------------------|---|--------------------------------------------------------------------|
| <b>Name of the Project</b>   | : | VISUAL INSPECTION OF FOB/ PF-1 - PF-2 AT BIBINAGAR RAILWAY STATION |
| <b>Location</b>              | : | BIBINAGAR RAILWAY STATION                                          |
| <b>Location Co-ordinates</b> | : | 17°28'14.3"N 78°47'35.8"E                                          |
| <b>Date of Inspection</b>    | : | 11 <sup>th</sup> OCTOBER, 2019                                     |



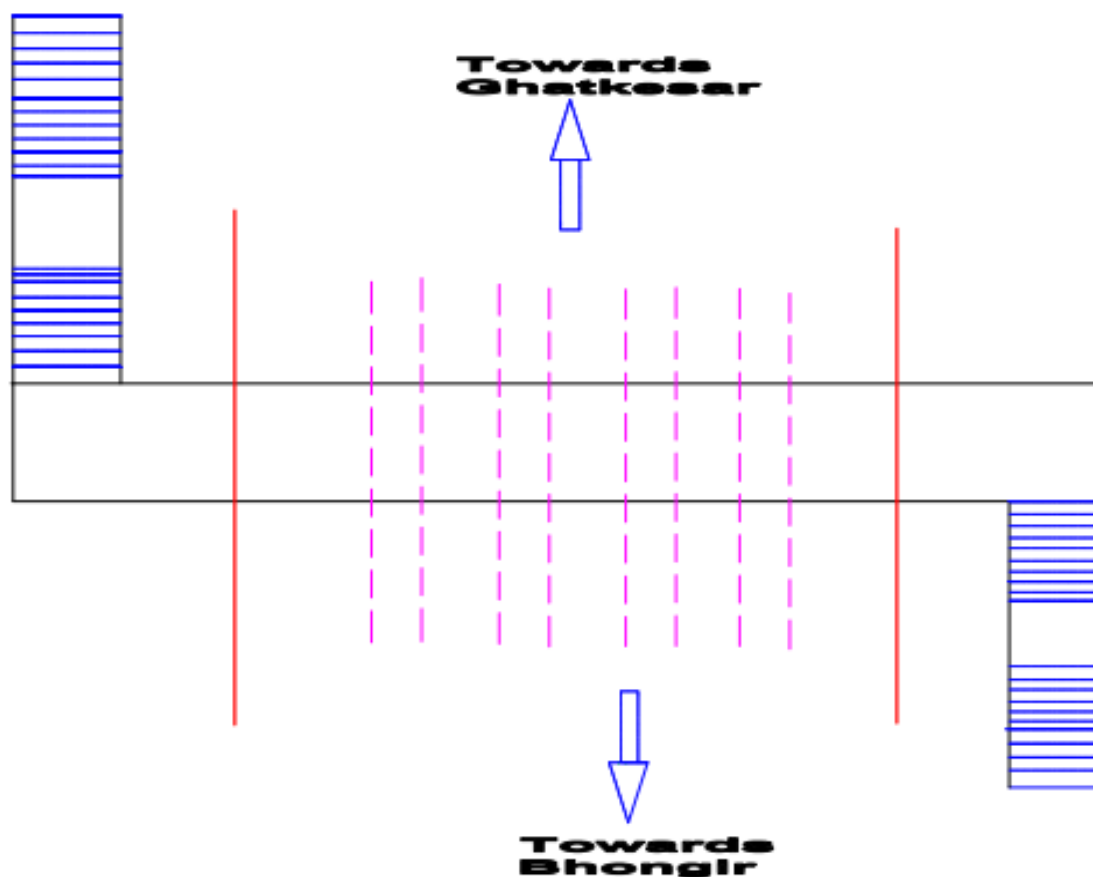
### Visual inspection Summary:

- Dampness on edge of the staircase slab and formation of the algae.
- Vegetation observed at certain location of FOB.
- Cracks are observed in pre-cast slab panels at staircase-1 at PF-1.
- Spalling and highly corroded reinforcement is observed in flight of staircase at PF-1
- Highly corrosion is observed at bottom slab joints (Gusset plate, angular section) and bottom main members.

### 1.1 GENERAL INFORMATION AND OBSERVATION

|           |                                                     |                                                           |
|-----------|-----------------------------------------------------|-----------------------------------------------------------|
| <b>a.</b> | Name of the Bridge                                  | FOB/ PF-1 - PF-2                                          |
| <b>b.</b> | Location of Bridge                                  | Bibinagar Railway Station                                 |
| <b>c.</b> | Type of truss Structure                             | N- type truss                                             |
| <b>d.</b> | Year of Construction                                | Not available                                             |
| <b>e.</b> | Description of the main use of the bridge           | Pedestrians Crossing                                      |
| <b>f.</b> | Major Materials used in different parts of bridge   | Structural Steel (truss, frame),<br>RCC (Slab, Staircase) |
| <b>g.</b> | Width of the pathway (m)                            | 1.85 m                                                    |
| <b>h.</b> | Length of the pathway (m)                           | 26.30 m                                                   |
| <b>i.</b> | No of Railway Lines Crossings                       | 4 tracks                                                  |
| <b>j.</b> | Span arrangement (no x Span in meters)              | 1x 26.30 m                                                |
| <b>k.</b> | Vertical Clearance (from rail top to girder bottom) | 7.12 m                                                    |
| <b>l.</b> | Head Room                                           | 2.65 m                                                    |
| <b>m.</b> | Damages due to accidental hitting, Grazing Marks    | No Visible signs appear                                   |
| <b>n.</b> | History of Repair/ maintenance                      | Not available                                             |
| <b>o.</b> | Existing structural drawings                        | Not available                                             |

Key Plan



| 1.2 IDENTIFICATION OF LOADS ON BRIDGE            |                      |                                                                                                                                                                                                                                     |
|--------------------------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                  | Yes/No               | Photo ID                                                                                                                                                                                                                            |
| <b>a. Dead Loads at Roof level</b>               |                      |                                                                                                                                                                                                                                     |
| a) Pipeline - Utilities                          | No                   | Not observed at site                                                                                                                                                                                                                |
| b) Cables                                        | Yes                  | Cables are protected with 1-inch dia HDPE pipe and 2-inch GI pipe (Refer <b>fig :1.1</b> )                                                                                                                                          |
| c) Roof Truss                                    | Yes                  |                                                                                                                                                                                                                                     |
| d) Roof Sheet                                    | Yes                  |                                                                                                                                                                                                                                     |
| e) load of advertising hoarding                  | No                   | No Advertising boards are provided                                                                                                                                                                                                  |
| f) load of train/coach display boards            | No                   | No train coach display boards are provided                                                                                                                                                                                          |
| g) Electrical equipment (OHE), signal            | No                   | No electrical equipment and signal are provided                                                                                                                                                                                     |
| <b>b. Dead Loads at Floor level</b>              |                      |                                                                                                                                                                                                                                     |
| a) Additional wearing coat on Floor              | No                   | Only Chequered tiles used for Flooring                                                                                                                                                                                              |
| b) Provision of protective screen for passengers | Yes                  | Chain link fence made of Galvanized wire of 2 mm gauge and 2 mm Galvanized sheet is used above OHE Line on both side of pathway is used for Protection. Mesh frame is supported with angular and MS flats. (Refer <b>fig :1.2</b> ) |
| c) Type of Material used for mesh                | Galvanized wire mesh |                                                                                                                                                                                                                                     |

| 1.3 STRUCTURAL SYSTEM OF THE BRIDGE |                                    |                                                                                                                                                                                                                                                                           |
|-------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                     |                                    | Photo ID                                                                                                                                                                                                                                                                  |
| <b>a. Foundation Details</b>        |                                    | Not visible at site                                                                                                                                                                                                                                                       |
| <b>b. Trestles details</b>          |                                    |                                                                                                                                                                                                                                                                           |
| Type of Pedestal                    | Concrete                           | Concrete encasement is provided to trestles at bottom on platform level of dimensions 650x 550 mm for ISMB 300 and 450x480mm for ISMB 200 (Refer <b>fig :1.3</b> )                                                                                                        |
| <b>c. Roof Truss</b>                |                                    |                                                                                                                                                                                                                                                                           |
| Element of roof truss section       | No special roof truss is provided. | Vertical main trusses are connected by 2D plane horizontal bracings of 2/80x80x8 mm double angle sections. (Refer <b>fig :1.2</b> )                                                                                                                                       |
| Size of roof truss                  |                                    |                                                                                                                                                                                                                                                                           |
| Connection of Roof elements         | Bolted connection                  |                                                                                                                                                                                                                                                                           |
| <b>d. Steel Truss</b>               |                                    |                                                                                                                                                                                                                                                                           |
| Shape of Truss Section              | N- type truss                      | a. Top and bottom Main members are 2/150 x 150 x 12 mm double Angular section back to back.<br>b. Vertical members are 2/90 x 90 x 8 mm double angular section.<br>c. Bottom and top lateral Bracings are 2/80 x 80 x 8 mm Double angular sections bolted to gusset plate |
| Height of Truss (H)                 | 2.63 m                             |                                                                                                                                                                                                                                                                           |
| Girder/Truss Support Condition      | Ridged connection                  |                                                                                                                                                                                                                                                                           |
| Type/Shape of Floor beams /Bracings | Double angular section             |                                                                                                                                                                                                                                                                           |

|           |                                                          |                                                         |                                                                                                                                                                                                                                   |
|-----------|----------------------------------------------------------|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|           | No of Floor beams/bracings for span                      | 11 no's                                                 | d. Floor beams are Double angular section are supported for base slab. (Refer <b>fig:1.6</b> )                                                                                                                                    |
|           | Arrangement of Bracings                                  | Diagonal                                                |                                                                                                                                                                                                                                   |
|           | Type of Beam-Column Joint (shape of gusset plate if any) | Cleat angles                                            |                                                                                                                                                                                                                                   |
| <b>e.</b> | <b>COLUMN</b>                                            |                                                         |                                                                                                                                                                                                                                   |
|           | Type/Shape of Column section                             | I-Section                                               | a. Truss supported on ISMB 300 x 140 section                                                                                                                                                                                      |
|           | No of Columns/support                                    | 4                                                       | b. Supported with Double angular bracings of 2/75x 75 x 8 mm                                                                                                                                                                      |
|           | Dimensions of Column                                     | ISMB 300                                                | c. 10 mm and 12mm thick gusset plate are used. (Refer <b>fig :1.3</b> )                                                                                                                                                           |
|           | BEAM-Column joint (bolted, welded, riveted)              | Bolted connection                                       |                                                                                                                                                                                                                                   |
| <b>f.</b> | <b>FLOOR SLAB OF THE PATHWAY</b>                         |                                                         |                                                                                                                                                                                                                                   |
|           | Material of Slab                                         | RCC                                                     | a. RCC slab supported on sacrificial plate.                                                                                                                                                                                       |
|           | Thickness of Slab                                        | 120 mm                                                  | b. Chequered tiles of 25 mm thick are observed on FOB.                                                                                                                                                                            |
|           | Condition of Slab from Bottom                            | RCC slab is not visible, covered with Sacrificial plate | c. RCC slab is supported by floor beams of Double angular sections (Refer <b>fig :1.7</b> )                                                                                                                                       |
|           | Condition of Slab from Top                               | RCC slab is not visible, Covered with Chequered tiles   |                                                                                                                                                                                                                                   |
|           | Condition of sheeting – leaky roof                       | Not visible on site                                     |                                                                                                                                                                                                                                   |
| <b>g.</b> | <b>Staircase Details</b>                                 |                                                         |                                                                                                                                                                                                                                   |
|           | Number of Staircase                                      | 2 no's                                                  | a) Staircase steps are observed as RCC slab cast-in situ and Pre-cast slab panels of size 300 x 100 are used.                                                                                                                     |
|           | Number of Steps from PF – 1                              | 44 no's                                                 | b) Steps are supported on ISMC 200 Channel using cleat Angles.                                                                                                                                                                    |
|           | Number of Steps from PF – 2                              | 44 no's                                                 | c) Staircase Landing of 2 m wide is supported on ISMC 150 channel section members and diagonally supported with 75 x75x8 mm angular section and slab is supported with double angle 75x 75x8 mm sections. (Refer <b>fig:1.8</b> ) |
|           | Material used for steps                                  | RCC slab cast-in-situ and Pre-cast slab panels          |                                                                                                                                                                                                                                   |
| <b>h.</b> | <b>Staircase Railing</b>                                 |                                                         |                                                                                                                                                                                                                                   |
|           | Type of Parapet Railing                                  | Steel railing                                           | Stair case is provided with Railing on both sides of one-meter height using Angular and Hollow Circular sections. (Refer <b>fig:1.8</b> )                                                                                         |
|           | Height of Railing                                        | 1 m                                                     |                                                                                                                                                                                                                                   |
|           |                                                          |                                                         |                                                                                                                                                                                                                                   |

#### 1.4 SIGNS OF DISTRESS, DEFORMATION IN BRIDGES

- a. ✓ Dampness on edge of the staircase slab and formation of the algae



Dampness and formation of algae observed

- b. ✓ Spalling and highly corroded reinforcement is observed in flight of staircase at PF-1



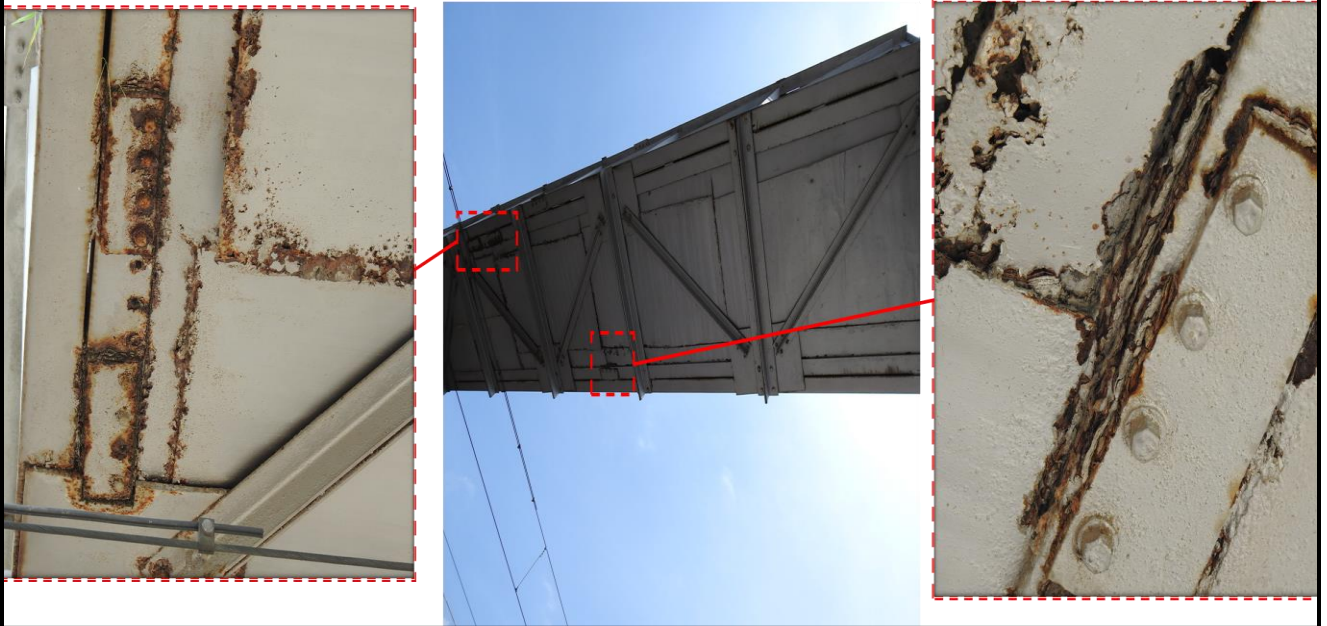
Spalling and corrosion on reinforcement

- c. ✓ Main angular sections of truss are highly corroded at certain locations along the concrete slab



Corrosion at bottom chord members

- d. ✓ Highly corrosion is observed at bottom slab joints (Gusset plate, angular section)



Corrosion observed at gusset plate and floor beams

- e. ✓ High corrosion is observed in sacrificial plate



Corrosion of sacrificial plate

f. ✓ Slipped and missing bolts observed at certain location of FOB



| SIGNS OF DISTRESS, DEFORMATION IN BRIDGES |                                          |                    |                                                                                                             |
|-------------------------------------------|------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------|
|                                           | Defects                                  | Location           | Comments                                                                                                    |
|                                           | Cracking in Steel Members                |                    | No cracks are observed                                                                                      |
|                                           | Cracking in RCC components               |                    | Minor cracks are observed on precast slab panels on flight-1 of PF-1 (Refer <b>fig:1.8</b> )                |
|                                           | Spalling                                 | At staircase       | Spalling is observed in flight-2 of PF-1 (Refer <b>part 1.4a – 1.4b</b> )                                   |
|                                           | Rust straining                           | Main truss members | Rust straining is observed all over the bottom slab joints and along the concrete slab and angular sections |
|                                           | Extent of Corrosion                      | Slab bottom        | Medium and highly corrosion is observed at the joints of the bottom slab (Refer <b>fig:1.4,1.5,1.7</b> )    |
|                                           | Corrosion in Gusset plate                | Slab bottom        | Slight corrosion at the bottom of the slab (Refer <b>fig:1.7</b> )                                          |
|                                           | Corrosion at steel-Concrete joint        |                    | Medium to high corrosion is observed (Refer <b>part 1.4a -1.4.b</b> )                                       |
|                                           | Condition of Painting of steel structure |                    | Painting is affected only at distressed places.                                                             |

**\*Rust:** Rust is a part of corrosion and is a chemical process which results in the formation of red or orange coating on the surface of metals.

**\*Corrosion:** it is the process of deterioration of materials as a result of chemical, electrochemical or other reactions.



**Fig 1.1:** Electrical Cables



**Fig 1.2:** Protective screening mesh for passenger and flooring and roof elements



**Fig 1.3:** Trestles and their protection with concrete encasement



**Fig 1.4:** Corrosion of sacrificial plate

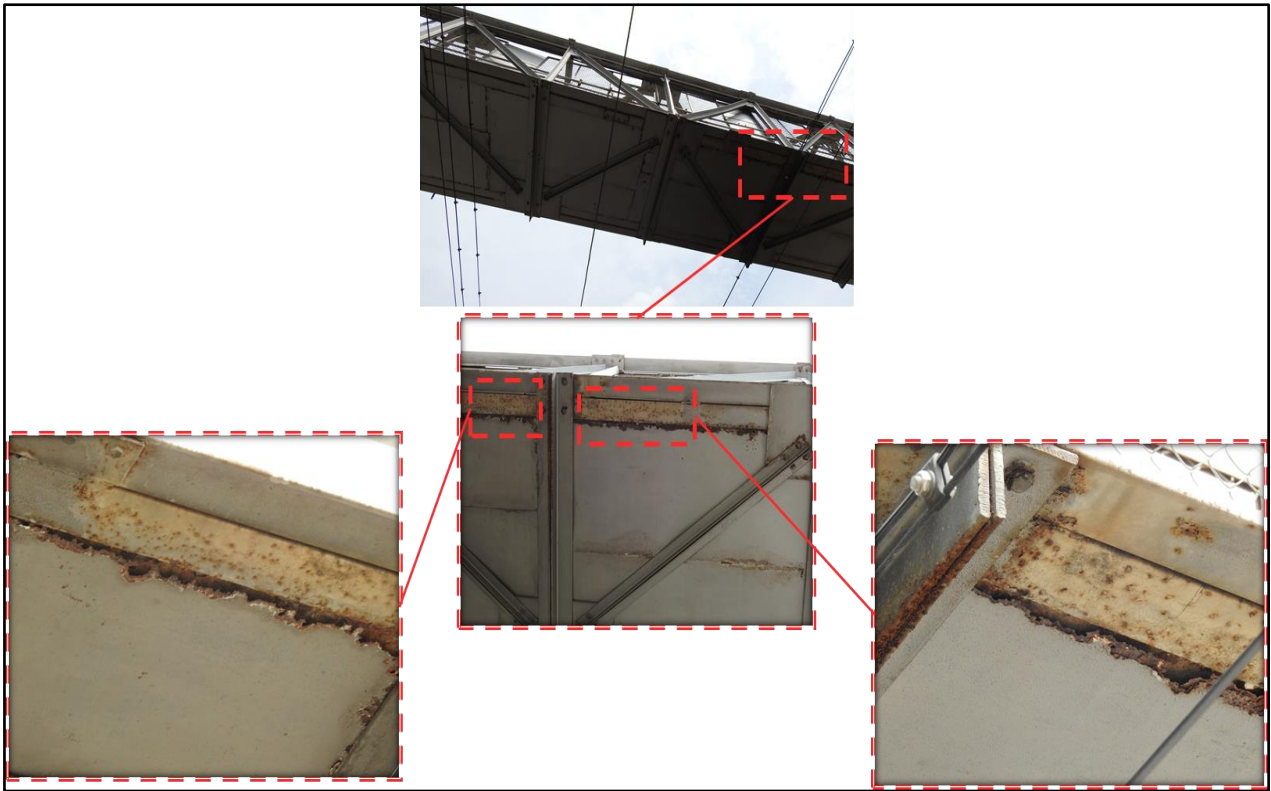


**Fig 1.5:** Corrosion of sacrificial plate, bottom chord members and mild corrosion observed at floor beams



**Fig 1.6:** Vegetation at truss level and shape of truss



**Fig 1.7:** Corrosion observed at bottom chord members along the span of FOB



**Fig 1.8:** View of staircase and cracks in Pre-cast RCC panels in staircase at PF-1

## 1.5 Numerical Model

- Three-dimensional numerical model has been developed from the dimensions obtained by visual inspection and loads considered for foot over bridge is  $5\text{kN/m}^2$  obtained model and results are shown below.

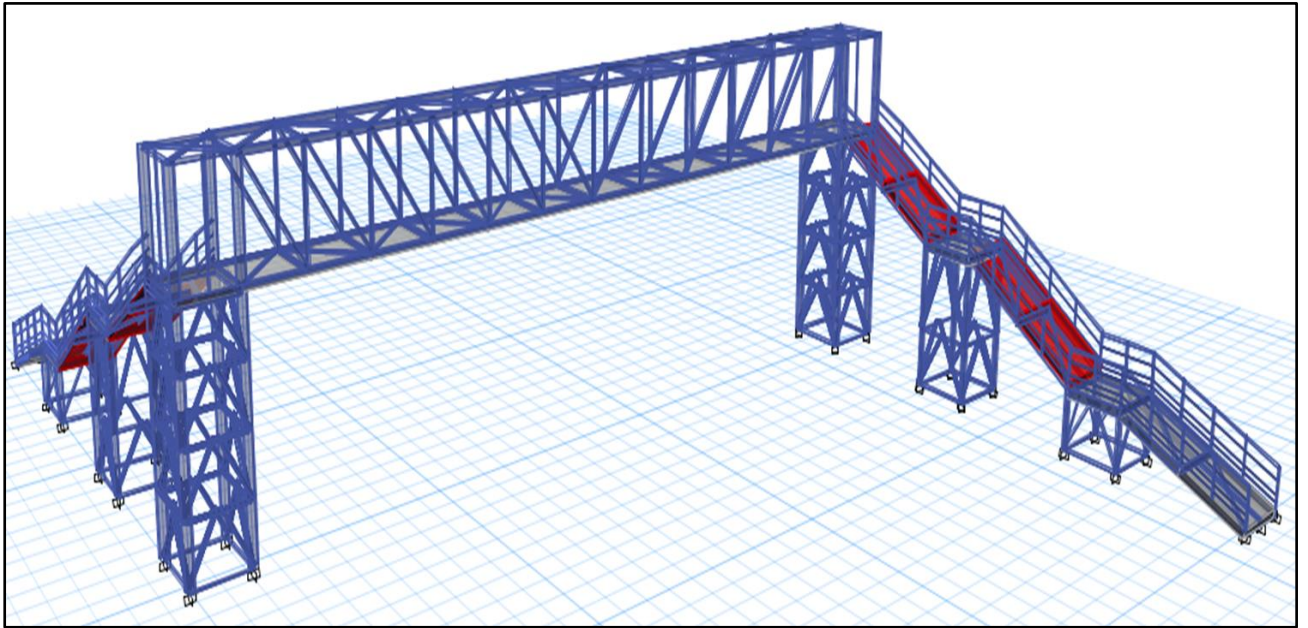


**Fig: 1.9.** Numerical Modelling of Bibinagar Railway station FOB  
(Developed from the Visual inspection)

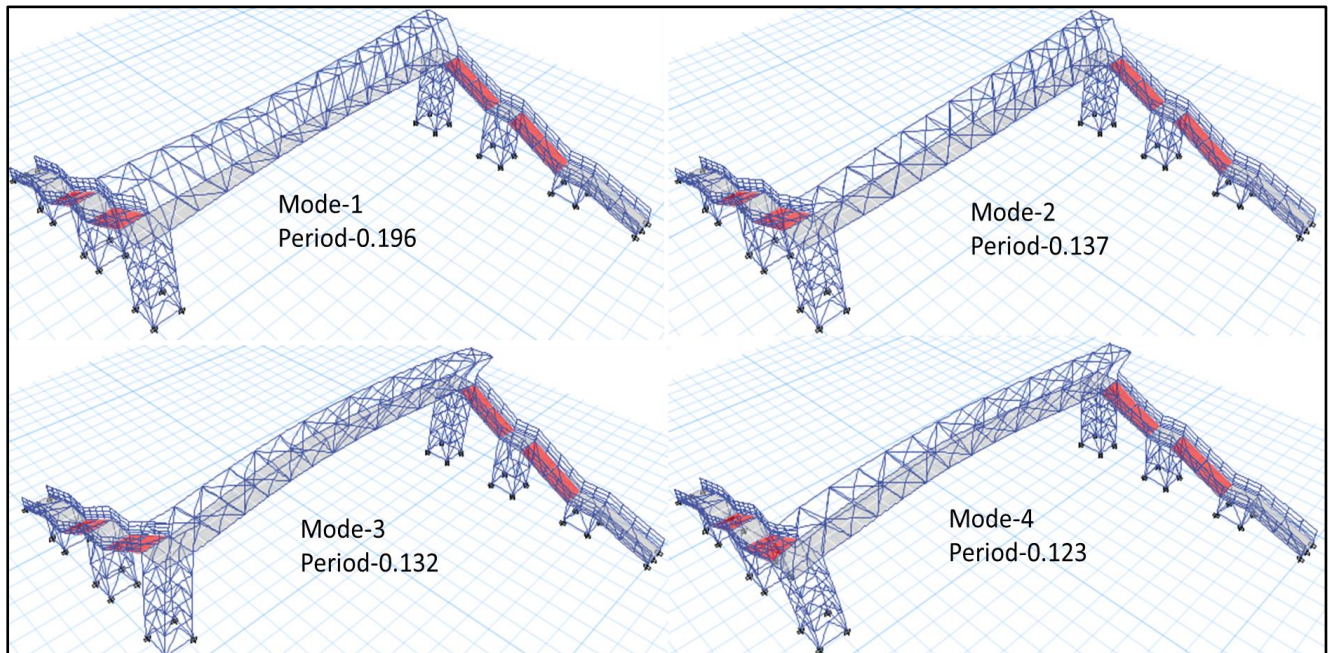


**Fig: 1.10 .**Modal analysis of FOB

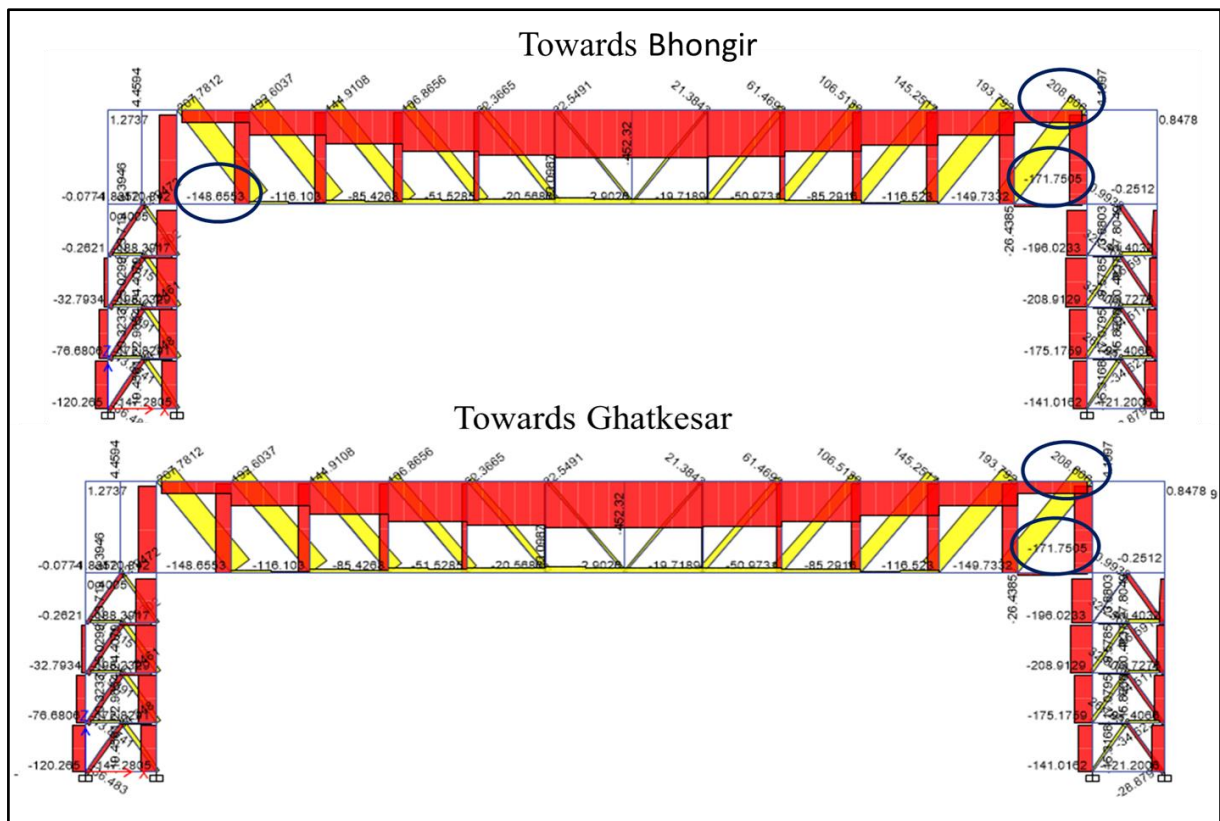


**Fig: 1.11** Axial Forces of all Members

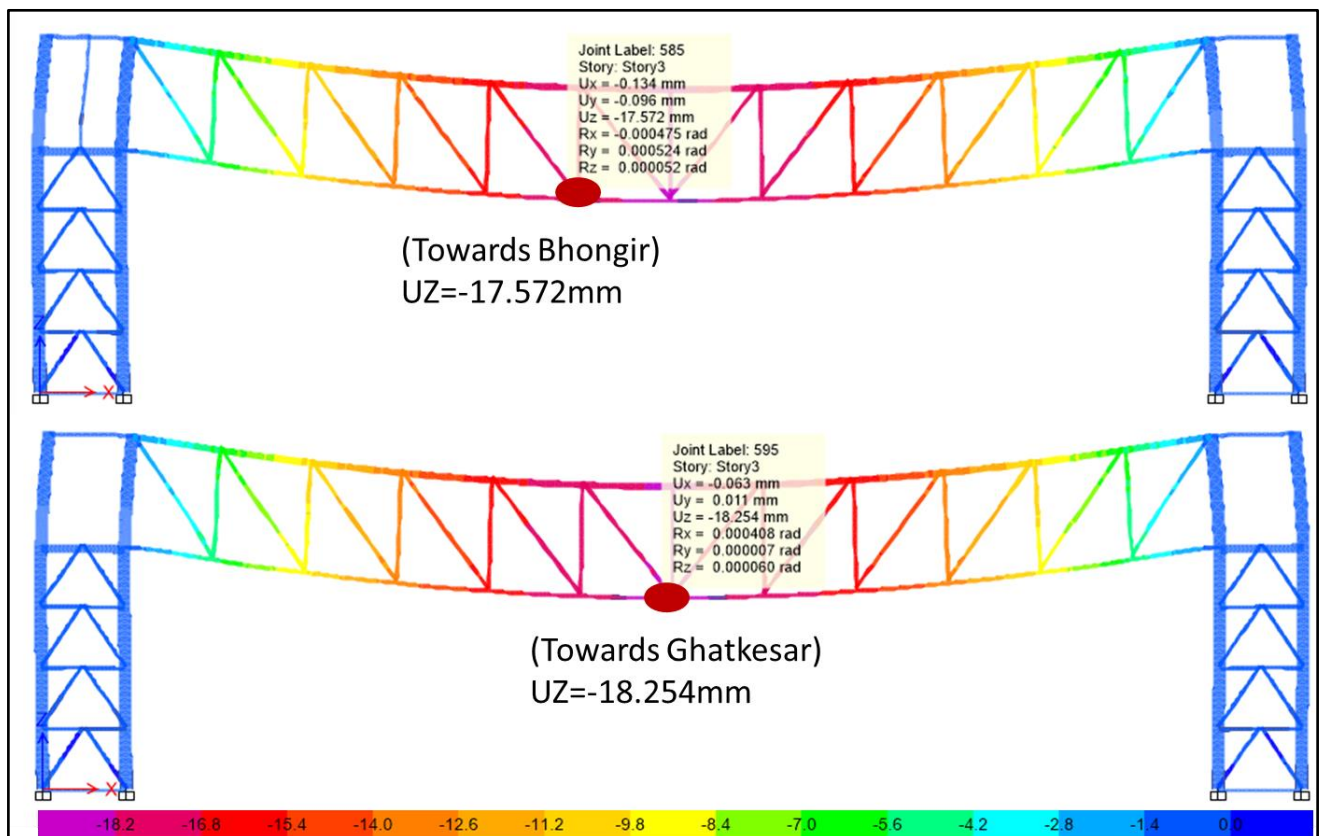


**Fig: 1.12** Displacements in truss

## 2. Repair and Retrofitting Recommendations

### 2.1 Repairs/Maintenance

#### a. Cleaning

**Methodology for cleaning:** Generally foreign material is deposited or accumulated on bridge deck and in several bridge components,

**Debris removal:** The surface areas of a FOB should be cleaned and washed by brushing with fresh water or using high-pressure water blasting, including Deck slab top, sides along steel concrete joint on either side of deck, Supporting Railing and connecting staircase.

#### b. Patchwork (spalling, honey comb, voids)

Reinforced cement concrete Slab at Deck level and some precast panels in staircase are observed with exposed rebar in many locations. (*Photographs of the same can be see in fig 2.6*)

**Methodology for patching:** Hand applied Mortar (Patching) repair is performed to restore small areas where sound concrete is damaged by spalling, scaling and/or impact. This method of repair is generally applied using trowel and require minimum or formworks. The patch thickness is limited to a maximum of 100 mm depth of hollow surface. Hand applied Mortar repair is classified into two types considering defective area and surface. Hand applied Mortar

- a) **Type - A** is applicable to surfaces without exposed rebar is having defective widths of up to 300mm and depths of up to 50 mm.
- b) **Type - B** is for surfaces with exposed rebar, with defective widths between 300 mm and 600 mm, and up to 100 mm depths.

Hand applied Mortar repairs may be composed of Polymer cement mortars or non-shrinkage cement mortars depending on the type of patching, location and extent of damage. To keep good bond ability to the existing concrete.

#### c. Corrosion:

Based on Steel Surface area effected by corrosion on steel member are classified into three grades as follows

- i. **Grade 1-** Mild Corrosion: 10 – 20 % of Surface area is affected with and peeled-off coating film is partially visible.
- ii. **Grade 2-** Moderate Corrosion: 20 – 30 % of Surface area is affected with corrosion and coating film is almost visible but partially deteriorated due to corrosion.
- iii. **Grade 3-** Severe Corrosion: 30% and more of Surface, area is affected by Corrosion and coating film is almost gone.

#### Methodology for Corrosion:

- If the paint condition is identified as Grade-1, aluminum paint shall be applied with a similar shade.
- Where condition of paint is evaluated as Grade-2 special anticorrosion paint shall be applied to restrict corrosion from progressing further.
- When the condition of the member is observed to be in Grade – 3, which might have occurred due to environmental conditions or age of the structure. In such cases section loss is calculated by using caliper where it is accessible and UPV at one accessible location. The first step in dealing with corrosion is to measure the section loss in the member. The member may be measured using calipers or other appropriate methods for totally exposed sections.
  - a. Section Loss < 15% - Clean the Surface and Apply the anticorrosion protective coat.
  - b. Section Loss 15% - 40% Repair the member as per design.
  - c. Section Loss > 40% - Replace the member.

## SPAN - 1

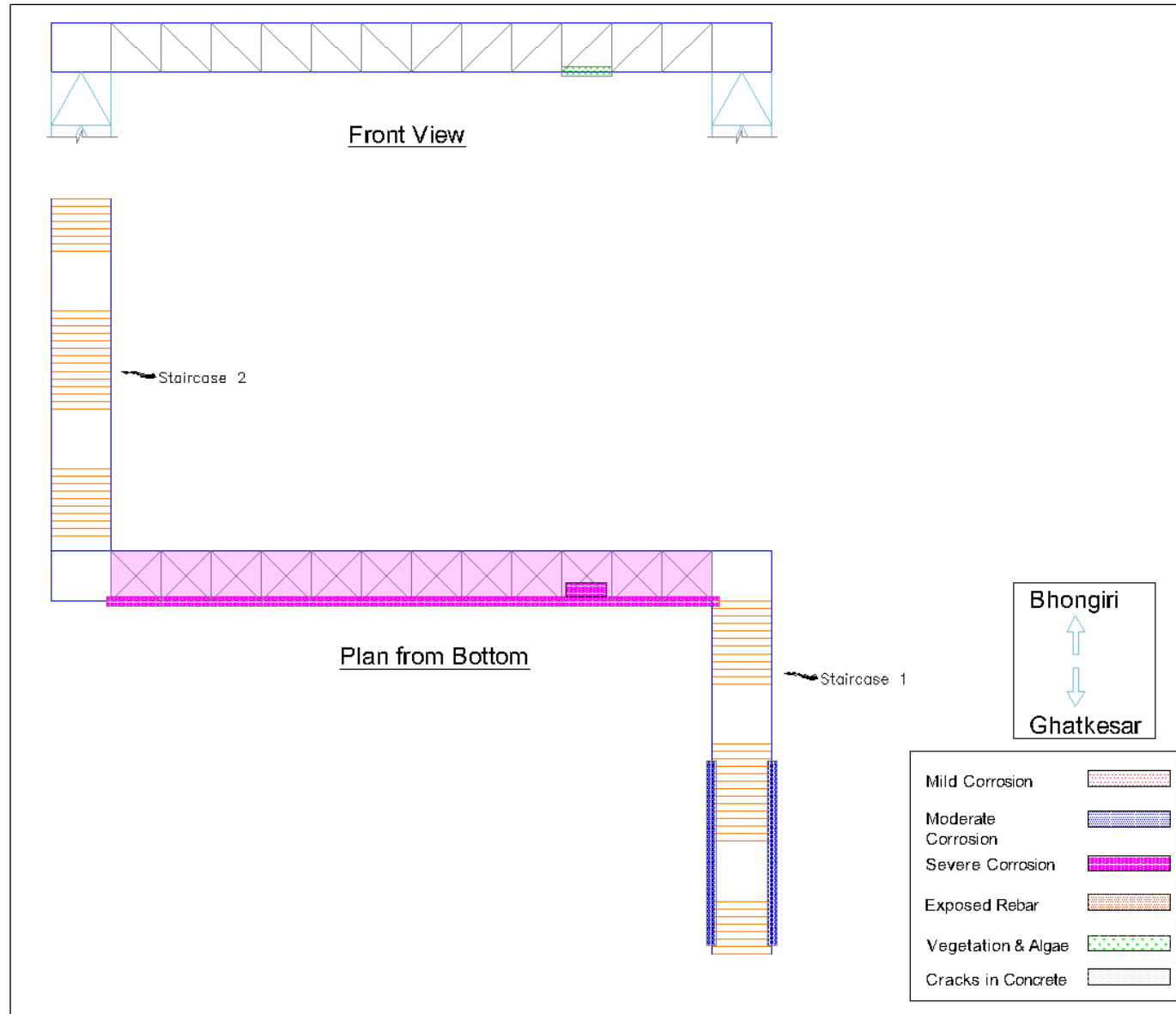


**Fig 2.1:** Locations of Deteriorations

## Span one

Structural members are in fair condition, displaying mild corrosion for top chord members, verticals, diagonals, moderate corrosion for bottom chord members, and staircase stringer beam along steel concrete joint. Sacrificial plate and gusset plate is severely corroded from bottom at deck level.

**Table 2.1:** Grading of corrosion in FOB

| Span 1                     | Mild Corrosion | Moderate Corrosion | Sever Corrosion | Remark |
|----------------------------|----------------|--------------------|-----------------|--------|
| Floor Beams/ Cross Girders |                | ✓                  |                 |        |
| Bottom Chord               |                |                    | ✓               |        |
| Top Chord                  | ✓              |                    |                 |        |
| Bottom Lateral Bracings    | ✓              |                    |                 |        |
| Diagonals                  | ✓              |                    |                 |        |
| Vertical                   | ✓              |                    |                 |        |
| Gusset Plates              |                |                    | ✓               |        |
| Sacrificial plate          |                |                    | ✓               |        |
| Bolts                      | ✓              |                    |                 |        |



**Fig 2.2:** Locations of Splice joint and bottom chord Deteriorations



**Fig 2.3:** Locations of floor beam Deterioration



**Fig 2.4:** Locations of Sacrificial plate Deteriorations

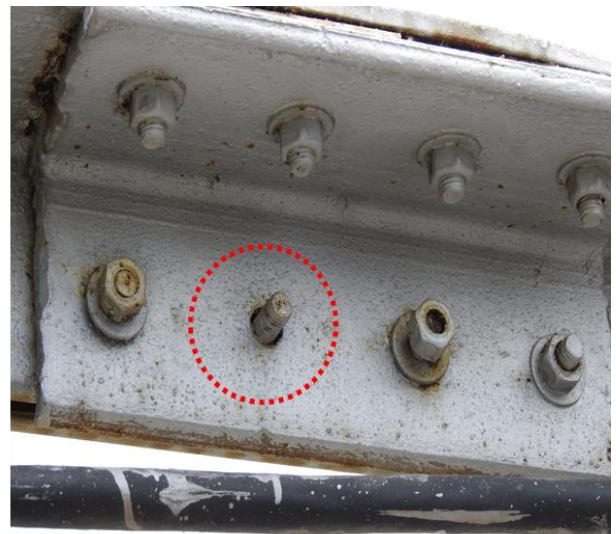


**Fig: 2.5** missing of bolts at mid land at staircase stinger beam



**Fig: 2.6** spalling, Reinforcement exposure and cracks is observed at staircase 1

# ANNEXURE

## Annexure-1a: Repair methods

|                           |                            |
|---------------------------|----------------------------|
| <b>Defects/Deficiency</b> | <b>Debris accumulation</b> |
| <b>Remedial Measures</b>  | <b>Cleaning</b>            |

During the Bridge service life, several components of bridges get unclean due to deposition of foreign materials. Materials that collect on the deck surface flow with the rain water towards the drainage spouts which may choke the outlets and affect drainage. Also the materials that collect on the deck and carried by the rain water towards edges of the gangway and accumulate in the gaps or on the steel members. Such debris accumulation can cause acceleration of the corrosion in metal since debris tend to hold water. Also growth of vegetation such as grass, shrubs and other plants on the components of bridges is very common. But, they should be thoroughly cleaned of accumulated dust, debris and other foreign materials at regular intervals. This is to prevent deterioration of the bridge, which will therefore preserve the bridge components in their intended conditions resulting in increased service life of the bridge as well as provide safety and comfort to the users.

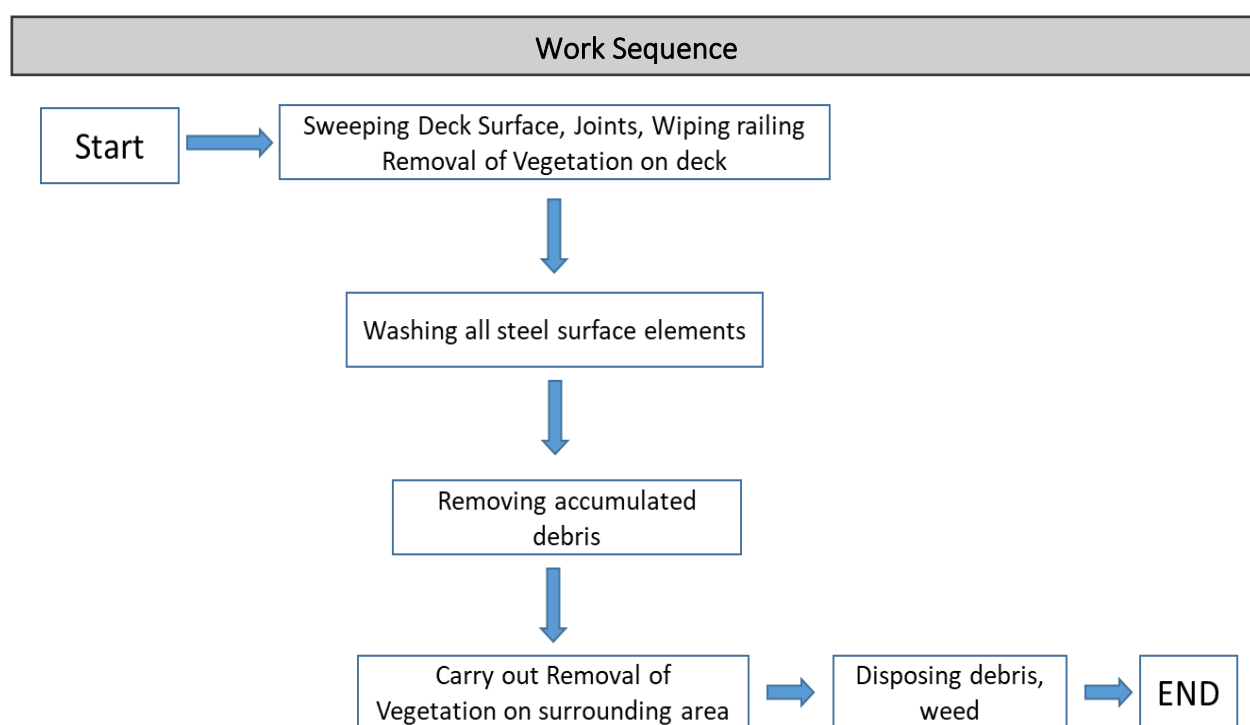


**Figure:1.1** Work sequence of removal of vegetation and accumulated debris

### Requirement and Specification

#### 1. Material Requirement

Water to be used for cleaning of the bridge components shall be clean and free from unwanted foreign materials such as sediments, salt contaminants, chemicals, grease, oil, rubbish and other substances which are harmful to the bridge components.

All necessary tests shall be performed on water samples at laboratories to be specified by the Engineer, and test certificates shall be provided as required.

## **2. Work Requirement**

### **1) General**

All accumulated foreign materials shall be removed from gangway, its sides and check at beam flanges, gusset plates, truss joints, deck drain systems, and other locations specified and as directed by the Engineer, prior to cleaning with water pressure. Removal shall be performed using hand brooms, hand shovels, scrapers, vacuum cleaners or other methods acceptable to the Engineer. The removed materials shall be collected and disposed at an approved waste area in accordance with railway regulations. At no time shall these materials be allowed to be disposed within the vicinity of the bridge or on the tracks.

### **2) High pressure water**

Salt contaminants, dirt, and other detrimental foreign matters shall be removed without damaging or peeling the paint from any structural steel. If high-pressure water is used, the maximum water pressure shall not be so high that any paint is damaged. The cleaning operation shall be discontinued if the foreign materials have not been easily removed or if cleaning operation is causing damage to existing paint coating. In this situation, the high-pressure water shall be adjusted to clean the surface without damaging the paint coating.

All deck drains or gangways and its accessories shall be flushed with high-pressure water after the accumulated foreign material has been properly removed. Drain systems may have to be disassembled to remove large blockages of accumulated foreign material. Should this be necessary, these shall be returned to their original configuration immediately after cleaning. Drainage systems shall drain properly after cleaning.

The Contractor shall flush out the interior surfaces of all truss members using high-pressure water. This flushing shall continue until such time that clear water is being draining out. The exterior surfaces of all truss members, miscellaneous structural steel connecting the truss members, and floor beam-ends projecting outwardly from the row of exterior stringers shall be thoroughly washed down using high-pressure water.

The Contractor shall obtain approval of the source of water used. They shall use fresh water, which is free of sediments and salt contaminants, and be responsible for all expenses involved in securing the approved water.

### **3) Power block**

During this activity power block is mandatory and has to be carried in the presence of BRI.

## Annexure-1b: Repair methods

|                           |                            |
|---------------------------|----------------------------|
| <b>Defects/Deficiency</b> | <b>Spalling, Honeycomb</b> |
| <b>Remedial Measures</b>  | <b>Patching</b>            |

Spalling of concrete requiring patching, which is usually caused by corrosion of steel reinforcement. Honeycomb is the effect of inadequate compaction of concrete while being cast. Patching is a temporary repair measure unless all the chloride-contaminated concrete is removed before the concrete deck or staircase is patched. If only the spalled and delaminated concrete is removed, the corrosion process continues, and additional spalling can soon appear.

Studies of deck-sealing practice suggest that while sealing or overlaying of chloride contaminated concrete cannot stop the process of corrosion and deterioration of steel and concrete, it can slow the process, which may be acceptable depending upon the schedule of future major rehabilitation. Further, moving passengers increases the impact loading, which can result in increased damage.

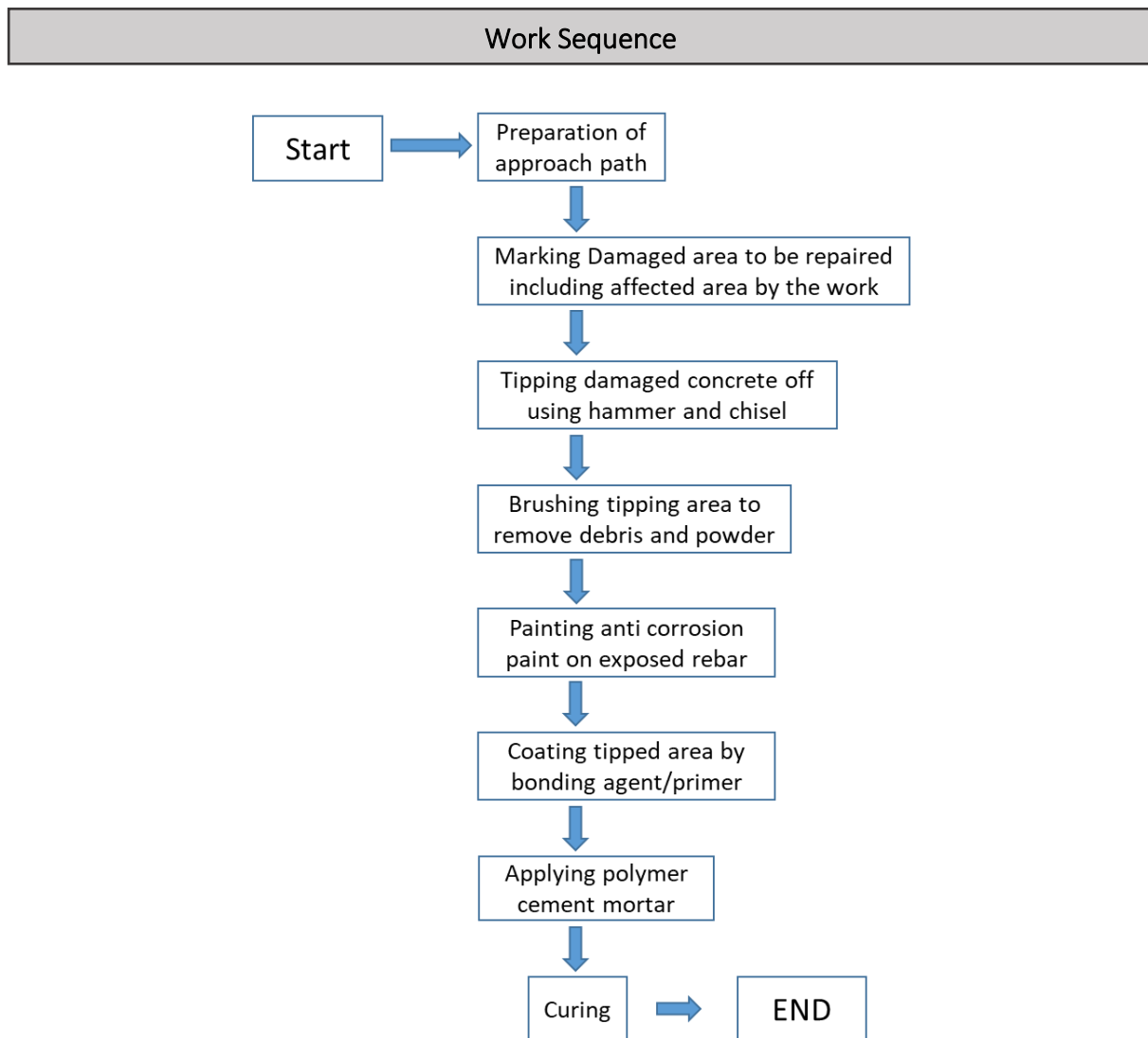


**Figure: 1.2** Work sequence of Epoxy Coating

## Required equipment / Tool and material

### Material List –

- Polymer Cement Mortar
- Portland Cement
- Epoxy Bonding
- Zinc rich primer

### Tool/Equipment List –

- Chisel
- Portable Generator
- Wire Brush

## Requirement and Specification

### Material Specifications

#### 1) Polymer Cement

Polymer cement mortar shall conform to the requirements of the specifications shown in Table 1.1 or equivalent ASTM Specifications.

Table:1.1 Specification of Polymer Cement for Patching

| Property                     | Test Method | Specification                               |
|------------------------------|-------------|---------------------------------------------|
| Initial setting time         | -           | above 60 minutes                            |
| Shrinkage                    | ASTM D2566  | below 0.05 %                                |
| Thermal expansion            | ASTM C531   | $2.0 \times 10^{-5}$ mm/mm/ ° C             |
| Slant shear bond to concrete | ASTM C882   | Concrete failure above 15 N/mm <sup>2</sup> |
| Compressive strength         | ASTM D695M  | above 20 N/mm <sup>2</sup>                  |

#### 2) Epoxy bonding agent

The epoxy-bonding agent to concrete surface shall conform to the requirements of the specification indicated in Table 1.2 (Anti-corrosion zinc rich primer shall be applied to exposed rebar).

Table 1.2 Specification of Epoxy Bonding Agent to Concrete Surface

| Property                                          | Test Method | Specification        |
|---------------------------------------------------|-------------|----------------------|
| Compressive strength                              | ASTM D695M  | 70 N/mm <sup>2</sup> |
| Flexural strength                                 | ASTM D790M  | 40 N/mm <sup>2</sup> |
| Tensile strength                                  | ASTM D638M  | 30 N/mm <sup>2</sup> |
| Tensile shear bond to steel                       | ASTM 1002   | 15 N/mm <sup>2</sup> |
| Slant shear bond to mortar                        | ASTM C882   | 15 N/mm <sup>2</sup> |
| Bond Strength of Cured Concrete to Fresh Concrete | ASTM D7274  | 15 N/mm <sup>2</sup> |

- 3) **Zinc Rich Primer:** The zinc rich primer to rebar shall be in accordance with the requirements of the specifications in Table 1.3

Table 1.3 Specification of Zinc Rich Primer for Rebar

| Property                           | Test Method | Units | Specification |
|------------------------------------|-------------|-------|---------------|
| Gloss @ 60°Angle                   | ASTM D 523  | -     | Flat          |
| Adhesion                           | ASTM D 3359 | -     | Minimum 3A    |
| Salt Spray Resistance              | ASTM D3-37  | -     | Excellent     |
| %Zinc by Weight in Dried Film Test |             | %     | 87.5±2        |

### Work requirement

1) **General**

Patching repair works using Portland cement mortar shall be carried out in accordance with provisions of relevant standards and manufacturer's specifications. Patching, as a minor repair work, should be carried out using an appropriate means to access the repair area, before the defect worsens. Patching repair work method using polymer cement mortar shall be carried out as follows:

2) **Marking of patching area**

Evaluate surface area to be patched using hammer for hollow sounding delaminated area (or by using instruments to detect unsound concrete). Mark the area to be patch-repaired with paint or marker. Ensure complete coverage of the damage.

3) **Tipping damaged concrete off**

Using a small sledge hammer and chisel, remove all damaged concrete at the edges and corners of area to be repaired. Use a wire brush to remove loose debris. Care should be taken to ensure that no reinforcement is damaged. **Surface** shall be cut to expose the reinforcement and to reach the sound concrete substrate, without breaking the concrete behind the reinforcement. If rebar is exposed, anticorrosion agent coating should be applied on the bar surface prior to patching. All works shall be subjected to the approval of the designated Engineer. **Patch areas** that are within 600 mm of each other should be combined into a single large patch. If necessary, provide formwork around the damaged concrete to straighten the edges of the damaged section.

4) **Coating tipping area**

Concrete surfaces to receive repair mortar shall be prepared by mechanical scrubbing to remove loose materials, surface laitance, organic contaminants and moss. The clean and dust free surface shall then be coated by a bonding primer. Care shall be taken to ensure that vibration associated with the repair works does not cause delamination of existing adjacent plaster or concrete.

5) **Applying bonding agent and anti-corrosion paint**

Apply bonding agent to the damaged area in order for the patch material to adhere. Additionally, concrete nails/bids may be set to reinforce the repair. If rebar is exposed, anticorrosion coating should be applied on the bar surface prior to patching.

6) **Patching mortar**

Prepare the mortar mix in a bucket using equipment approved by the Engineer. Use a trowel to spread fresh mortar over the area, covering the concrete nails driven halfway in the old concrete. Smoothen and level the mortar with a trowel. Polymer cement mortar is suitable for both vertical and horizontal surface applications, with a thin coating of up to 15 mm.

7) **Finishing**

As may be required, the mortar surface can be smoothened using a trowel or broom finished. The texture of the finish of the final repair mortar layer shall match the finish of the existing surface. The repair mortar application shall be built up to the original surface profile in layers not exceeding 20 mm with the final layer not exceeding 15 mm, unless otherwise recommended by the manufacturer and approved by the Engineer. The Engineer may approve repair mortar application thickness of up to 50 mm for lightweight mortars, provided the mortar manufacturer furnishes technical data to justify a layer thickness of greater than 20 mm.

8) **Curing**

All types of concrete repair with repair mortar need thorough and continuous curing to develop strength and impermeability. Curing also minimizes drying shrinkage while bond strength is developing. Curing of the repair mortar shall be in accordance with the manufacturer's instructions related to the polymer modified additive. Where curing agents are specified by the manufacturer, they shall be applied immediately after the surfaces have been scarified for the next repair mortar layer, or troweled to a finish.

### Annexure-1c: Repair methods

|                    |                                  |
|--------------------|----------------------------------|
| Defects/Deficiency | Minor corrosion of steel element |
| Remedial Measures  | Touchup painting                 |

Due to thin paint coverage on steel surfaces or formation of pin-holes in paint, the steel surface may get exposed to atmosphere resulting in initiation of corrosion. Touch up painting at the early stages prevents progress of corrosion. Work included in this section comprises field touchup painting on steel members at localized areas including surface preparation and other associated works. This section covers only painting on relatively small affected areas which can be carried out with the use of small power tools / hand tools. Painting of larger areas requiring sand blast cleaning should be carried out in accordance with the specifications covered under major repairs.

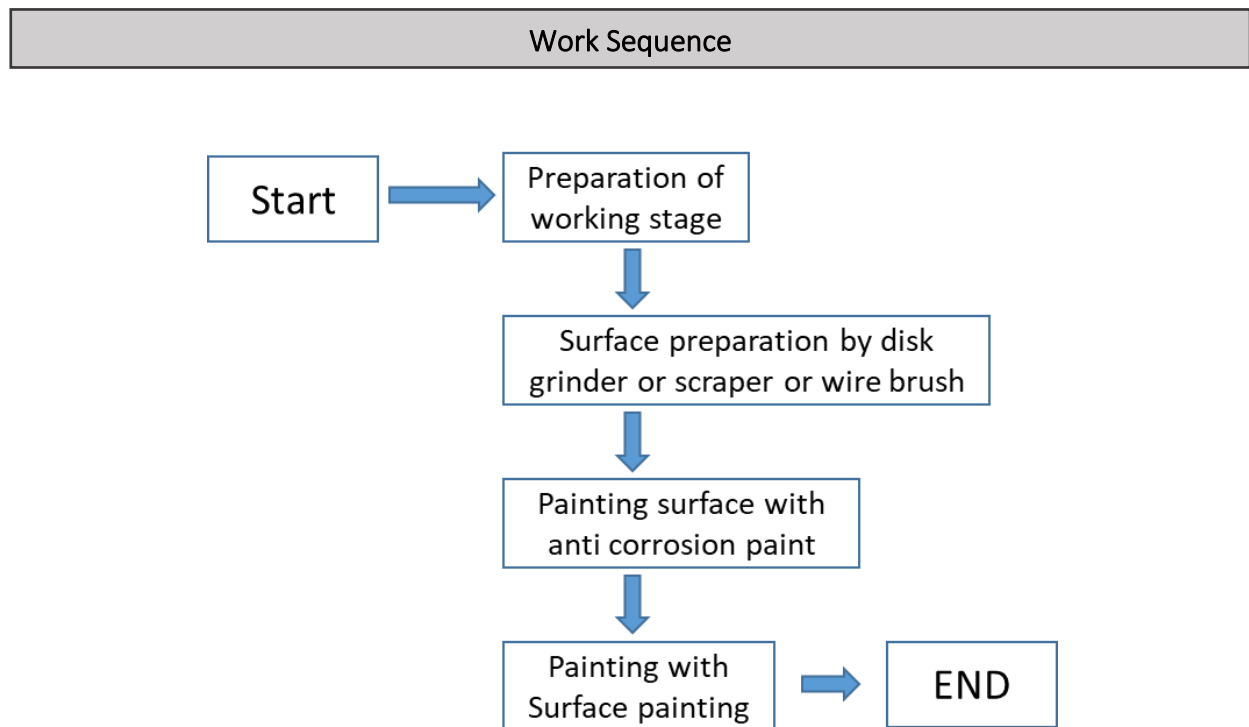


**Figure: 1.3** Work sequence of Painting with anti-corrosion paint

## Required Equipment / Tool and Material

### i. Materials

- Aluminum paint / special anticorrosion paint as required
- Thinner
- Epoxy resin filler

### ii. Tools/Equipment

- Scaffolding, inspection vehicle
- Portable generator (3 kVA)
- High pressure water blaster (8.0Mpa, 10.0 liters/min.)
- Sandpaper, portable power disk grinder
- Paint brush, roller

## Requirement and Specifications

### i. Material

Aluminum paint material shall be in accordance with the manufacturer's specifications and as approved by the Engineer.

For special anticorrosion paint, the materials shall satisfy the test requirements indicated in the relevant ASTM specifications as follows:

Table 1.4 Specification of Aluminum paint

| Test           | Test reference | Specification                                              |
|----------------|----------------|------------------------------------------------------------|
| Adhesive test  | ASTM D7234     | 7days 1.0 N/mm <sup>2</sup> , 28days 1.5 N/mm <sup>2</sup> |
| Elongation     | ASTM C190      | 7days 0.40 % , 28days 0.40 %                               |
| Saltwater test | ASTM D6943     | No defection                                               |

### ii. Work requirement

#### 1) Scaffolding

Scaffolding shall be installed for close access to the corrosion-affected surfaces of the steel members to be repaired. Standard scaffoldings may be used however mobile scaffolding/inspection vehicle may be found suitable as it allows for free movement in most cases and provides access with convenience to various parts of a bridge.

#### 2) Preparation of Steel Surface

Surface preparation shall conform to the paint manufacturer's specifications. Hand or power tools shall be applied for cleaning the surface. Groves and ridges formed on the affected surface shall be removed with power grinder. Where appropriate, as an alternative, epoxy resin filler may be used to fill the surface to a smooth and even finish. Where depth of roughness is within 0.5 mm, paint adequacy and durability can be achieved without application of multiple coats of surface leveling paints. Thickness of each coat shall not exceed the limiting value recommended in the paint manufacturer's specifications.

Application of aluminum paint material shall be in accordance with the manufacturer's specifications and as approved by the Engineer.

**3) Application of Touchup Paint**

Paint shall be applied with brush or roller. The paint shall be applied in such a way that a uniform and smooth surface is formed without wrinkles, runs, streaks, sags, or any other defects. Components of the paint shall be mixed in accordance with the manufacturer's instructions and the application shall also conform to such instructions and specifications. Paint shall be applied immediately after the surface preparation, preferably within 4 hours. Total dry film thickness for special anticorrosive paint shall be 500  $\mu\text{m}$  (equivalent 1.5kg/m<sup>2</sup>) consisting of two layers of coating as follows: -

*Layer-1: 250  $\mu\text{m}$  and Layer-2: 250  $\mu\text{m}$*

Anticorrosion paint shall be applied in accordance with the stipulations of paint manufacturer's specifications. Minimum total film thickness for aluminum paint shall be not less than 125  $\mu\text{m}$ . Roval paint is recommended for galvanized member touchup painting. Total dry film thickness for Roval paint shall be 80  $\mu\text{m}$  (equivalent 0.5kg/m<sup>2</sup>) consisting of two layers of coating as follows: -

*Layer-1: 40  $\mu\text{m}$  and Layer-2: 40  $\mu\text{m}$*

Roval paint shall be applied in accordance with the stipulations of paint manufacturer's specifications.

## Annexure-1d: Repair methods

|                           |                               |
|---------------------------|-------------------------------|
| <b>Defects/Deficiency</b> | Spalling, Abnormal Anchorage  |
| <b>Remedial Measures</b>  | Hand applied Mortar (A) & (B) |

Hand applied Mortar (Patching) repair is performed to restore small areas where sound concrete is damaged by spalling, scaling and/or impact. This method of repair is generally applied using trowel and require minimum or formworks. The patch thickness is limited to a maximum of 100 mm depth of hollow surface.

Hand applied Mortar repair is classified into two types considering defective area and surface. Hand applied Mortar (A) is for defects without exposed rebars while Hand applied Mortar (B) is applied to surfaces with exposed rebars. Hand applied Mortar repairs may be composed of Polymer cement mortars or non-shrinkage cement mortars depending on the type of patching, location and extent of damage.

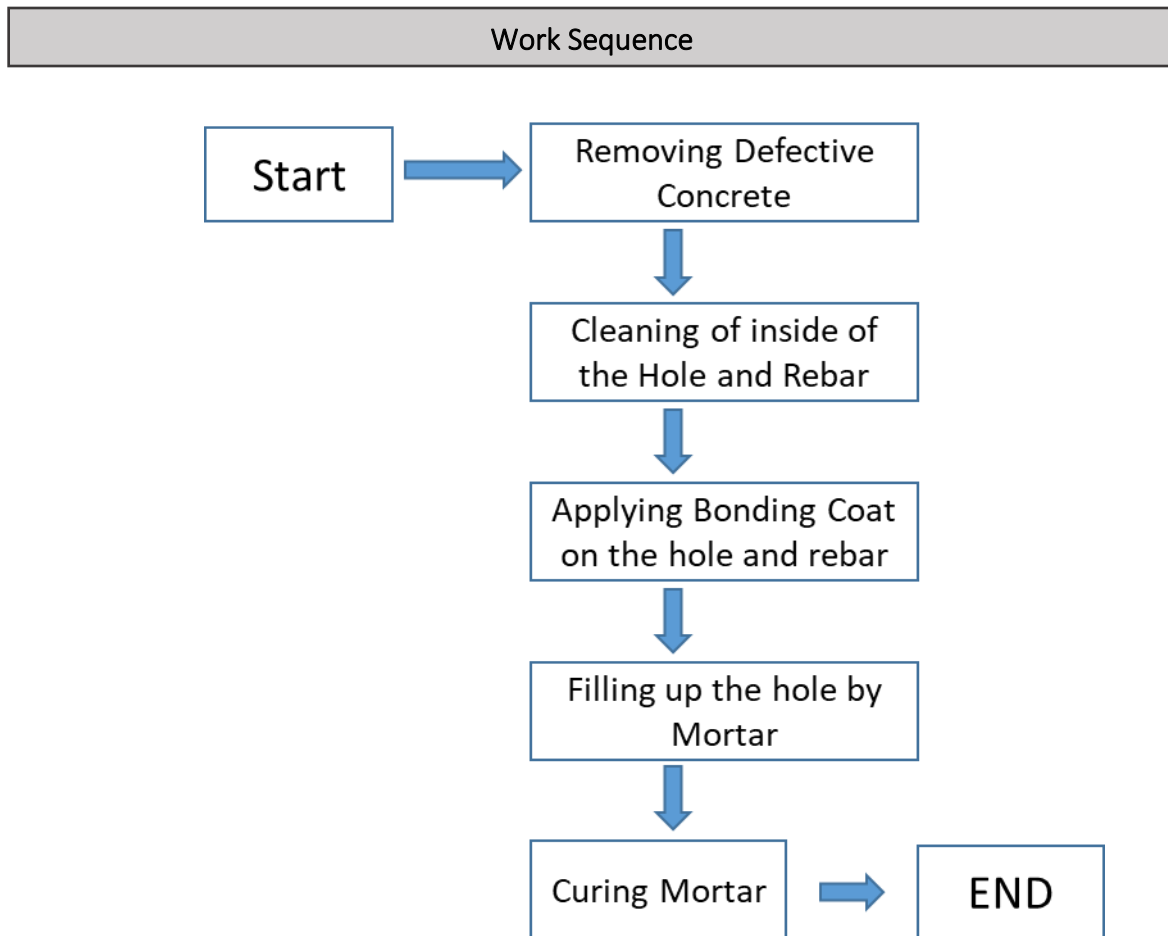


**Figure: 1.4** Work sequence of Hand applied mortar

### Required tools / Equipment and Material

#### 1) Tools/Equipment

For Hand applied Mortar (A) and Hand applied Mortar (B): -

- Power Disc Grinder
- Portable Generator
- Brush

## 2) Material

Hand applied Mortar (A): -

- Polymer Cement
- Epoxy Bonding Coat

Hand applied Mortar (B) –

- Polymer Cement
- Epoxy Bonding Coat
- Zinc Rich Primer

### Requirements and Specifications

#### i. Material

##### 1) Polymer Cement

Polymer cement mortar shall conform to the requirements of the specifications shown in Table 1.5 or equivalent ASTM Specifications.

Table 1.5 Specifications of Polymer Cement

| Property                            | Test Method | Units             | Specification        |
|-------------------------------------|-------------|-------------------|----------------------|
| Thermal Expansion                   | ASTM C531   | mm/mm°C           | $2.0 \times 10^{-5}$ |
| Slant Shear Bond to Concrete        | ASTM C882   | N/mm <sup>2</sup> | 1.5 /above           |
| Compressive Strength (7days x 20)°C | ASTM C579   | N/mm <sup>2</sup> | 20 /above            |

##### 2) Corrosion Protective Coating

The Protective Coating of rebar shall conform with the requirements of the specifications in Table 1.6.

Table 1.6 Specifications of Corrosion Protective Coating to Rebar

| Property                    | Test Method | Units             | Specification |
|-----------------------------|-------------|-------------------|---------------|
| Compressive Strength        | ASTM D695M  | N/mm <sup>2</sup> | 75            |
| Flexural Strength           | ASTM D790M  | N/mm <sup>2</sup> | 40            |
| Tensile Strength            | ASTM D638M  | N/mm <sup>2</sup> | 30            |
| Tensile Shear Bond to Steel | ASTM D1002  | N/mm <sup>2</sup> | 10            |
| Slant Shear Bond to Mortar  | ASTM C882   | N/mm <sup>2</sup> | 15            |

##### 3) Zinc Rich Primer

The zinc rich primer to rebar shall be in accordance with the requirements of the specifications in Table 1.7.

Table 1.7 Specifications of Zinc Rich Primer to Rebar

| Property                           | Test Method | Units | Specification |
|------------------------------------|-------------|-------|---------------|
| Gloss @ 60 Angle                   | ASTM D 523  | -     | Flat          |
| Adhesion                           | ASTM D 3359 | -     | Minimum 3A    |
| Salt Spray Resistance              | ASTM D3-37  | -     | Excellent     |
| %Zinc by Weight in Dried Film Test | -           | %     | 87.5 ±2       |
|                                    |             |       |               |

**ii. Work requirement**

The Contractor shall submit the Methodology (Procedures) to the Engineer-in-Charge for his review and approval before commencement of the work.

**1) Remove of defective concrete**

Remove all defective, unsound and contaminated concrete and prepare the edges for the patch area based on the visual inspection. If local corrosion in reinforcement with section loss is found, which would require additional bars, remove only the damaged concrete including the length needed to bond the new reinforcement.

Concrete within marked out areas shall be removed using light mechanical breakers or hammer and chisel, the exposed reinforcement shall be cut and the sound of concrete substrate shall be determined to the satisfaction of the Engineer-in-Charge, without breaking out behind the reinforcement.

**2) Cleaning of Concrete and Rebar**

Remove loose particles and dust using high pressure water or vacuum cleaner. Concrete surfaces to be bonded must be free from dirt, oil, grease, asphalt etc. Corrosion must be removed before placing the new concrete. If deterioration is due to chloride contamination or if the reinforcement is covered with loose corrosion elements having pits, use water abrasive blasting until all the rust is removed

The concrete surfaces selected for repair shall be prepared by mechanical scrubbing to remove loose materials, surface laitance, organic contaminants and moss, and then coated by bonding primer. Utmost care shall be taken to ensure that vibration generated during the process does not cause delamination of adjacent render or concrete.

**3) Additional concrete breakout**

Where the breakout indicates that the exposed reinforcement is further corroded or the surrounding concrete is not sound, an enlarged area shall be agreed to be broken to the satisfaction of the Engineer-in-Charge. The Contractor shall test the concrete for extent of carbonation at the reinforcement depth. The depth of breakout in clearly defined areas can be increased based on written instructions from the Engineer-in-Charge, in order to remove all carbonated concrete. The additional concrete breakout shall not extend more than 20 mm behind the bottom layer main reinforcement. During breakout, utmost care shall be undertaken to minimize damage to the existing reinforcement.

**4) Additional or replacement rebar**

The Contractor shall report to the Engineer any rebar which has 10% or more section loss as a result of corrosion. Additional or replacement rebar shall be provided as instructed by the

Engineer. Replacement rebar shall be cleaned to the same standard as the existing rebar. This replacement rebar shall be lapped on the side of the existing bars and be spot welded on one side. It shall be fixed along its length at suitable intervals to prevent sagging. The corroded rebars shall be cleaned and applied with zinc rich primer to prevent further corrosion. The Contractor shall obtain Engineer's approval for the rebar coating prior to proceeding with repair mortar application.

**5) Bonding coating to concrete and rebar**

Epoxy bonding coats are applied to dry and clean concrete surfaces in order to bond firmly. Specially formulated resins are also available for damp surfaces. Apply the selected bonding coat to steel bars as shown in the photo; with a brush working vigorously to ensure that they are evenly covered all around.

**6) Filling up repair material**

The mortar should be placed in layers of about 20 mm thickness. Compact each layer thoroughly over the entire surface using a wooden trowel or hammer. Generally, there should be no time delays between the placing and compacting of layers. The patching to the surrounding concrete is performed using a form material, and then hammered using a mallet, wood float or steel trowel. The mortar shall be mixed using equipment (normally a force action mixer) approved by the Engineer. The mixing liquid shall be added to the dry components and thoroughly mixed to achieve a uniform consistency, unless otherwise approved by the Engineer. The mortar shall then be applied to the bonding agent using hand packing and trowel to the satisfaction of the Engineer-in-Charge. The textured finish of the final repair mortar layer shall match the finish on the existing interior surface. The repair mortar application shall be built up to the original surface profile in layers not exceeding 20 mm and the final layer shall not exceed 15 mm, unless otherwise recommended by the manufacturer and approved by the Engineer-in-Charge. The Engineer may approve repair mortar application thickness of up to 50 mm for lightweight mortars, provided the repair mortar manufacturer can furnish a technical data to justify a layer thickness of greater than 20 mm.

**7) Curing**

All types of cement repairs need thorough and continuous curing to develop strength and impermeability, and to minimize drying shrinkage while bond strength is developing. Curing of the repair mortar shall be in accordance with the polymer modified additive manufacturer's instructions. Where curing agents are specified by the manufacturer, they shall be applied immediately after the surfaces have been scarified for the next repair mortar layer or troweled to a finish.

## Summary

- **Visual inspection of the Bibinagar railway station FOB has been conducted on 11<sup>th</sup> October 2019 and following major observations were made.**
  - i. Dampness on edge of the staircase slab and formation of the algae.
  - ii. Vegetation observed at certain locations of FOB.
  - iii. Cracks are observed in pre-cast slab panels at staircase-1 at PF-1.
  - iv. Spalling and highly corroded reinforcement is observed in flight of staircase at PF-1
  - v. Highly corrosion is observed at bottom slab joints (Gusset plate, angular section) and bottom main members.
- **Based on visual inspections and its interpretations following recommendations can be made:**
  - i. Anti-corrosive treatment for Grade-1 and Grade-2 highlighted corrosive members like floor beams, top chord, and bottom chord.
  - ii. Replacement of severely corroded splice joints, gusset plate and sacrificial plate.
  - iii. Patchwork with modified concrete at bottom of staircase 1.

**Note: Provided step wise procedure for each recommendation are detailed out in annexure based on requirements**