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

INSPECTION OF ROB NO.251 NEAR GODAVARI RAILWAY STATION

Final Report

SEPTEMBER | 2020

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1. VISUAL INSPECTION

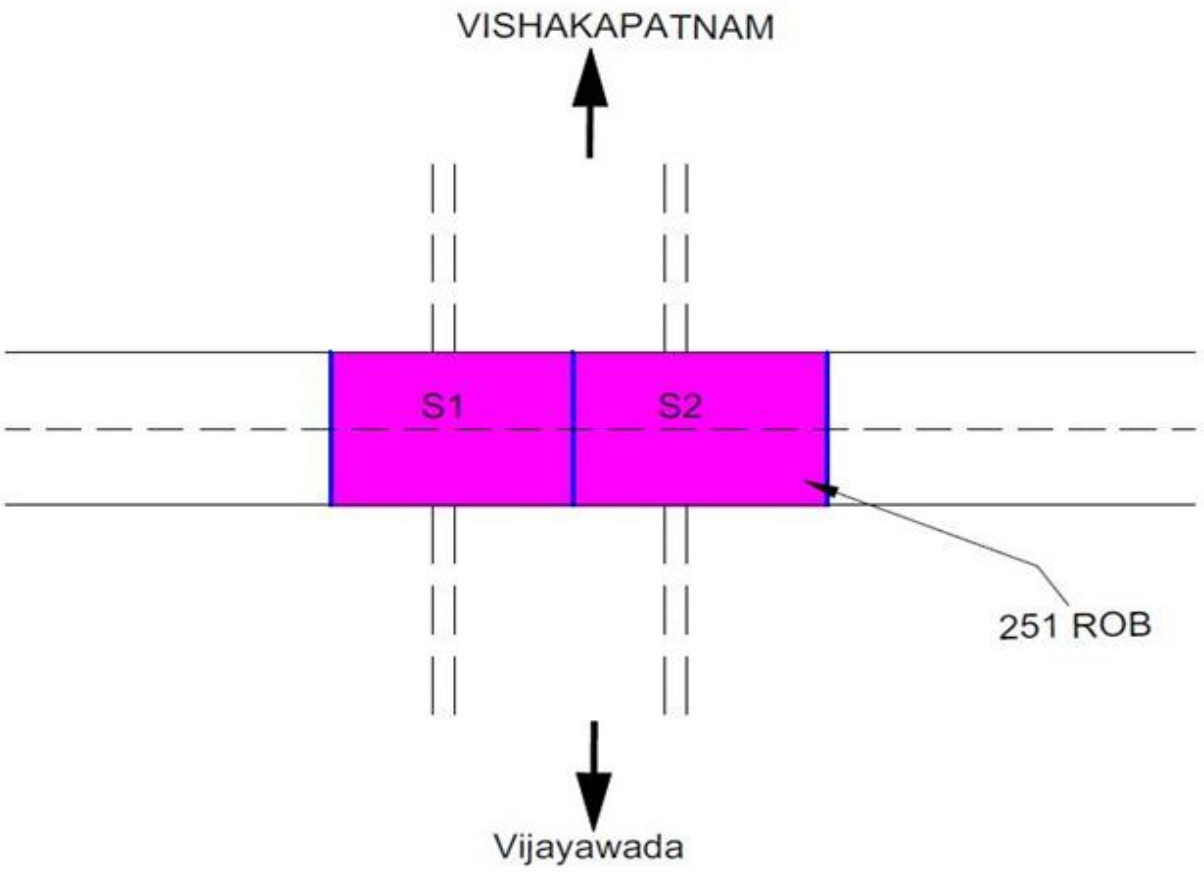
Name of the Project	:	**VISUAL INSPECTION OF ROB- 251**
Location	:	**Near Godavari Railway Station**
Location Co-ordinates	:	**17°00'57.04"N 81°77'47.55"E**
Date of Inspection	:	**2nd December, 2019**
Date of NDT	:	**26th Aug 2020**

Summary:

a) Cracks has been observed at Abutments and pier cap.
b) Reinforcement exposure has been observed at deck slab in both spans of ROB.
c) Spalling has been observed in Abutment 1 & 2.
d) Leaching observed on deck slab.
e) Water seepage is observed at abutment 2

PART 1.1 GENERAL INFORMATION AND OBSERVATION		
a.	Name of the Bridge	ROB 251
b.	Location Location co-ordinates	Near Godavari Railway station 17°00'20.4"N, 81°46'29.1"E
c.	Type of Bridge	Box type RCC
d.	Year of Construction	Data Not Available
e.	Grade of Concrete (Slab)	Data Not Available
f.	Design Load	Data Not Available
g.	Carriageway Width	7.35 m
h.	Overall Deck Width	10.36 m
i.	Average Skew	Not in skew
j.	Span arrangement (no x Span in meters)	2 x 5.15 m
k.	No of Railway Lines Crossings	2 tracks
l.	Vertical Clearance (from rail top to girder bottom)	5.7 m
m.	Horizontal Clearance (Pole to Rail track)	2.1m
n.	History of Repair/ maintenance	Yes , Patch works observed
o.	Existing structural drawings	Not available

Key Plan



	PART 1.2 **STRUCTURAL SYSTEM OF THE BRIDGE**		
			Note
a.	**Foundation details**		Not visible at site
	Type of foundation		
	Foundation Details (if available)		
	Foundation Status (Check Settlement, abnormal Scour and Tilting, if any etc.…)		
	Type of Damage (Check cracking,		
b.	**Abutment (A1 & A2)**		
	Type		
	Maximum height of Abutment	5.8 m	
	Abutment width along the Track	10.9 m	
	Abutment thickness	0.75 m	
	Condition (Crack, Settlement, Scour, Tilting, Steel Corrosion, Strains and other damages etc...)	Distresses Found	Shrinkage Cracks and Leaching is observed Water seepage is observed at abutments due to the flow of drain over ROB **(**Refer ***Fig- 4, 15*****)**,
	Efficiency of drainage of backfill behind Abutments (Check functioning of weep holes, evidence of moisture on Abutment faces, etc.)	Good	Proper functioning of weep holes observed.
c.	**Pier**		
	Material	RCC	Leaching, patch work and cracks observed
	No. of Piers in a row/column	1	
	Maximum Height of Pier	5.6 m	
	Pier Diameter/Dimension	8.5 x 0.5 m	
	Pier Cap Material	RCC	
	Pier Cap Condition	Crack observed	
	Pier Condition (Crack, Settlement, Scour, Tilting, Steel Corrosion, Strains, and other damages etc...)	Distresses Found	

d.	**Bearing & Pedestal**		
	Type of Bearings	Not applicable	No bearings are observed, as it is a Box type bridge
	General condition (Check Corrosion, cleanliness, seizing of plates silting, accumulations of dirt in case of submersible bridges)		
	Type/ shape of Pedestal		
	General condition (Check Corrosion,		
e.	**Super Structure (Concrete Girder)**	Not applicable	No girders are observed as it is a Box type bridge
	Type/Shape of Girder (I-beam, box-		
	Material of Girder		
	No of Girder		
	Dimensions of Girder		
	Structural System of Girder		
	Condition of Girder		
	Type/Shape of Secondary Girder		
	Material of Secondary Girder		
	No of Secondary Girders		
	Condition of Secondary Girder		
f.	**Slab**		
	Material of Slab	RCC	
	Thickness of Slab	Not accessible	
	Condition of Slab from Bottom	Distresses Found	Reinforcement exposure **(**Refer ***Fig-7*****)**, Spalling **(**Refer ***Fig-8)*** and cracks **(**Refer ***Fig-5*****)** Observed.
	Condition of Slab from Top		Not visible, as covered with wearing coat **(**Refer ***Fig-3)***
	Condition of Flooring/Wearing Coat		Minor Potholes observed
	Parapet wall/Railing		
	Type of Parapet wall/Railing	Parapet wall	
	Height	1.8 m	
	Condition of Wall/Railing		cracks are observed on Parapet wall. **(Refer Fig-3)**

PART 1.3 SURVEY OF SIGNS OF DISTRESS, DEFORMATION IN BRIDGES			
	Defects	**Location**	**Notes**
	Cracking in RCC components	Abutment & Pier	Cracks are observed at Abutments & Pier
	Water seepage	Abutments	Water seepage is observed near Abutments
	Spalling	Slab & Abutment	Spalling is observed at Slab & Abutment-1
	Reinforcement Exposure	Slabs	Reinforcement Exposure is observed at Slabs

Fig: 1 Front View of ROB

Fig: 2 Abutments (A1 and A2)

Fig: 3 Wearing coat & cracks observed on parapet wall

Fig: 4 Water seepage at abutment

Fig: 5 Cracks observed at Abutment 1

Fig:6 Patch work & Leaching observed at Abutment-1

Fig 7: Vegetation growth observed at Abutment-1

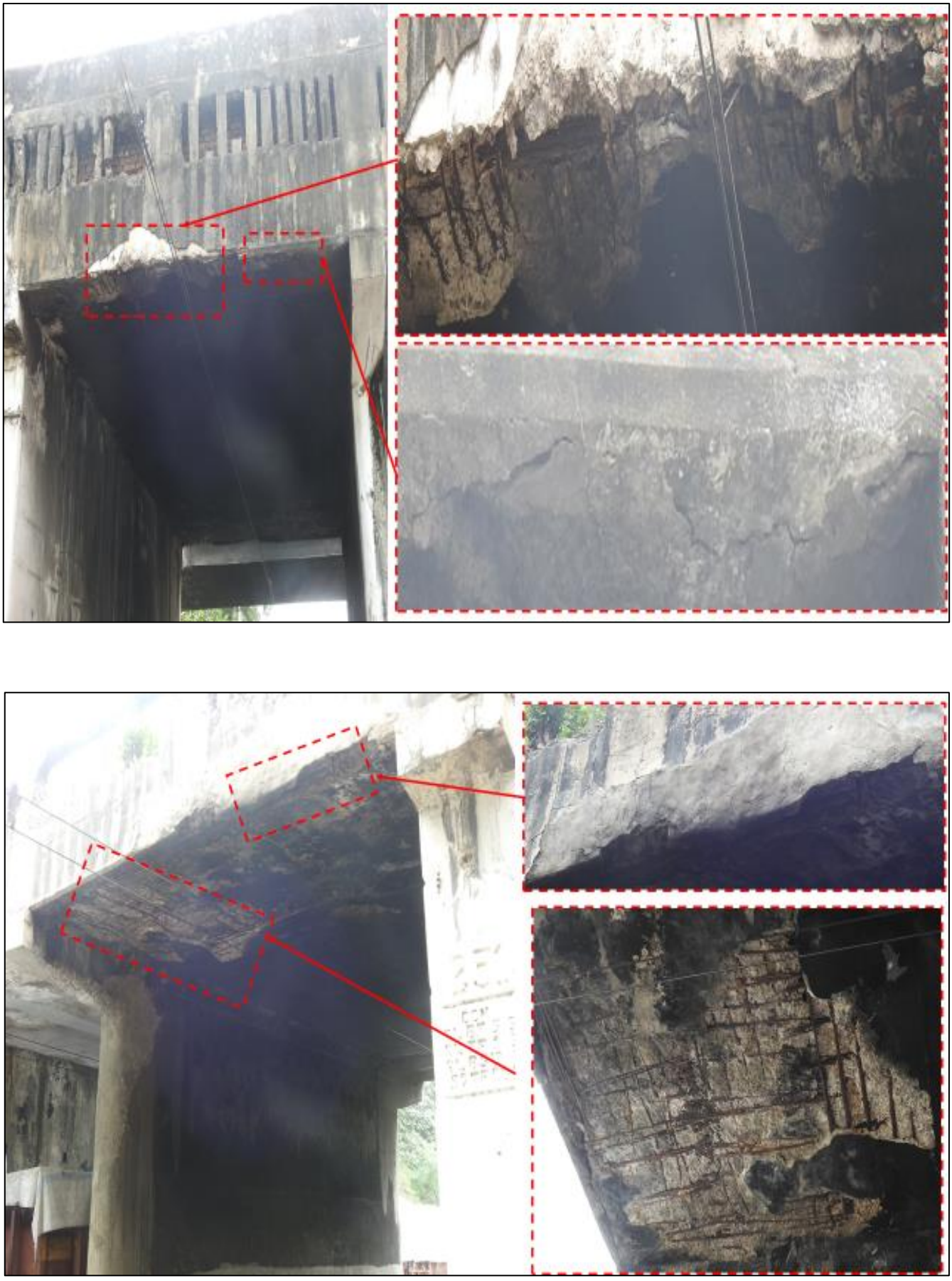


Fig 8: Reinforcement exposure & Spalling observed at Span-1

Fig 9: Leaching observed on Slab – 1 & Slab-2

Fig 10: Cracks & Spalling observed at Pier

Fig 11: Reinforcement exposure observed at Span-2

Fig 12: Spalling observed at both Abutment Pier caps

Fig 13: Shrinkage cracks observed on A1 & A2 Abutments

Fig 14: Algae observed on Abutment-2

Fig 15: Wearing coat and drain at ROB

2. NON-DESTRUCTIVE TESTING

The following tests were carried out to investigate strength and quality of "**ROB (251) near Godavari Railway Station (Kadiyam)"** elements such as pier and slab as specified:

a) Rebound Hammer test by Schmidt Rebound Hammer as per IS: 13311 part 2
b) Ultrasonic Pulse velocity test, as per IS:516 part 5

A. RESULTS AND OBSERVATIONS OF REBOUND HAMMER TEST:

The test results of rebound hammer test carried out on Piers, Abutments and Slab are presented in the Table1.

Table 1: Shows Observations of Rebound hammer test

Sl. No	Member	Location ID	Method	Rebound Numbers	Corrected Rebound Number	Estimated Compressive Strength (N/mm^2)
1	Slab Span 2	3.5m from BZA end	Vertical	56,48,49.5,52, 49,42.5,45	48	40
2	Slab Span 2	1.2m from Vishakhapatnam end	Vertical	44,32,52.5,42, 55,60.5	47	39
3	Pier wall	1.5m from BZA end	Horizontal	49,46,54,49.4, 45.5,44,45	47	39
4	Pier wall	5.0m from BZA end	Horizontal	41,51,45,46,59 .5,42,54	48	40
5	Pier wall	1.6m from Vishakhapatnam end	Horizontal	57,45,56,59.5, 42,54	52	47

Note: Estimated compressive strength is referred from the standard charts developed for particular strength. Probable accuracy is ± 25%

B. RESULTS AND OBSERVATIONS OF ULTRASONIC PULSE VELOCITY TEST (UPV Test):

The test results of UPV test carried out on Pier and Slab are presented in the Table2.

Table 2: Shows Observations of Ultrasonic Pulse Velocity test

Sl. No.	Member Id*	Location	Test Method	Path Thickness (mm)	Pulse Velocity (km/sec)	Corrected Pulse Velocity (km/sec)	Concrete Quality As per Referred Table – II
1	Slab Span 2	3.5m from BZA end	In-Direct	400	1.675	1.675	**Poor**
2	Slab Span 2	1.2m from Vishakhapatnam end	In-Direct	400	0.829	0.829	**Poor**
3	Pier wall	1.5m from BZA end	In-Direct	400	2.270	2.270	**Poor**
4	Pier wall	5.0m from BZA end	In-Direct	400	2.865	2.865	**Poor**
5	Pier wall	1.6m from Vishakhapatnam end	In-Direct	400	1.213	1.213	**Poor**

CONCRETE QUALITY GRADE CHART FOR ULTRASONIC PULSE VELOCITY TEST (As per IS: 516 Part 5, Clause 2.5.2, Table –I)

PULSE VELOCITY(Km/Sec)	CONCRETE QUALITY
Above 4.40	Excellent
3.75 to 4.40	Good
3.0 to 3.75	Doubtful
Below 3.0	Poor

Note:

1. In the case of "doubtful "quality, it may be necessary to carry out the further test.
2. As per IS: 516 (Part 5) Clause 2.4.3.2.5, Surface probing, in general, gives lower pulse velocity than in case of cross-probing and depending on a number of parameters, the difference could be of the order of about 0.5 km/sec.

NDT Summary:

a) Estimated strength as per rebound hammer test indicated that concrete strength is >39MPa.
b) Ultrasonic Pulse Velocity test indicates that the quality of concrete for Pier wall and deck slab is poor.

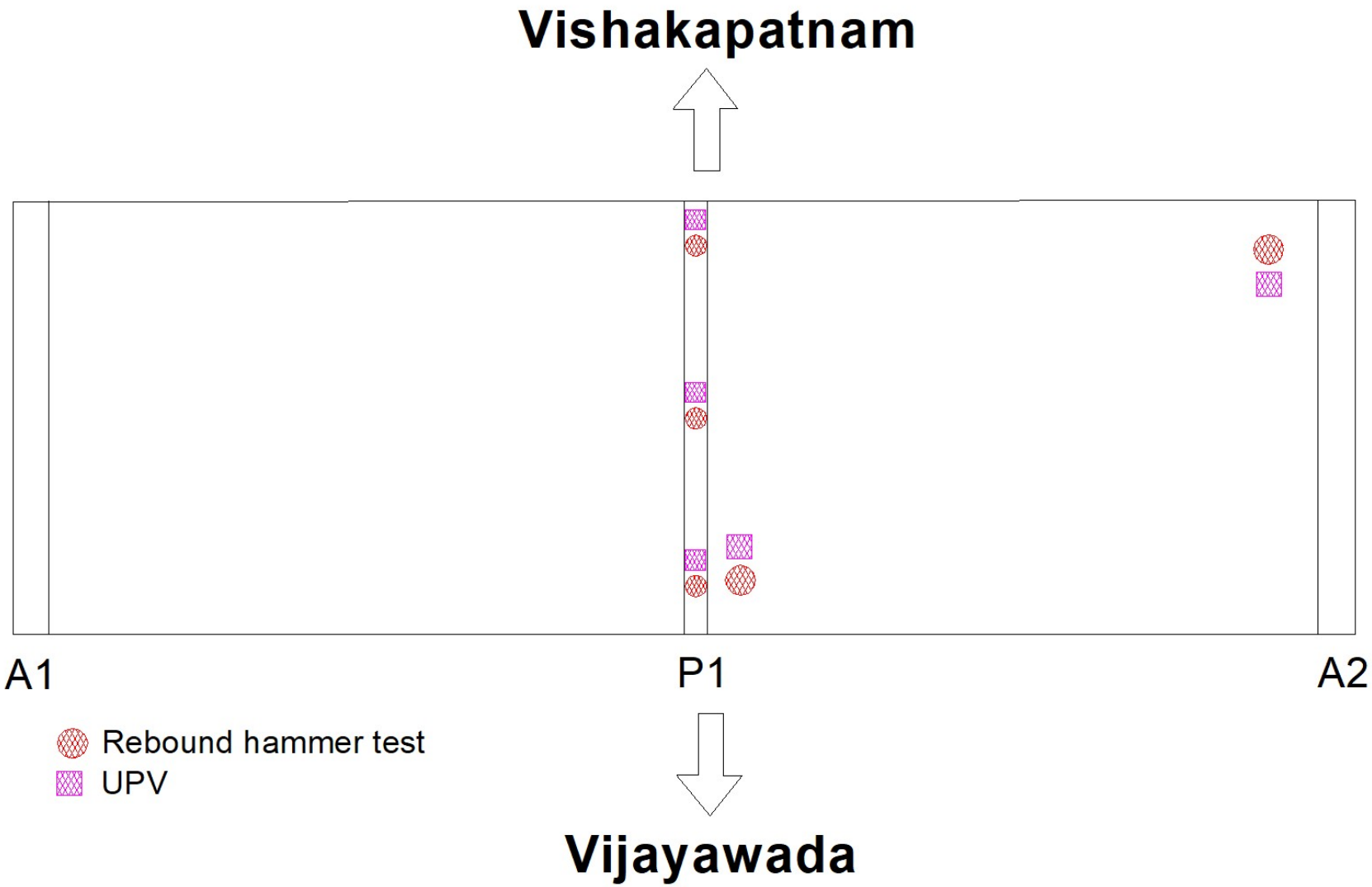


Fig 16: Bottom view of ROB with NDT Test Locations

Fig 17: UPV test at Kadiyam ROB

Fig 18: Rebound hammer test at site

3. Repair and Retrofitting Recommendations

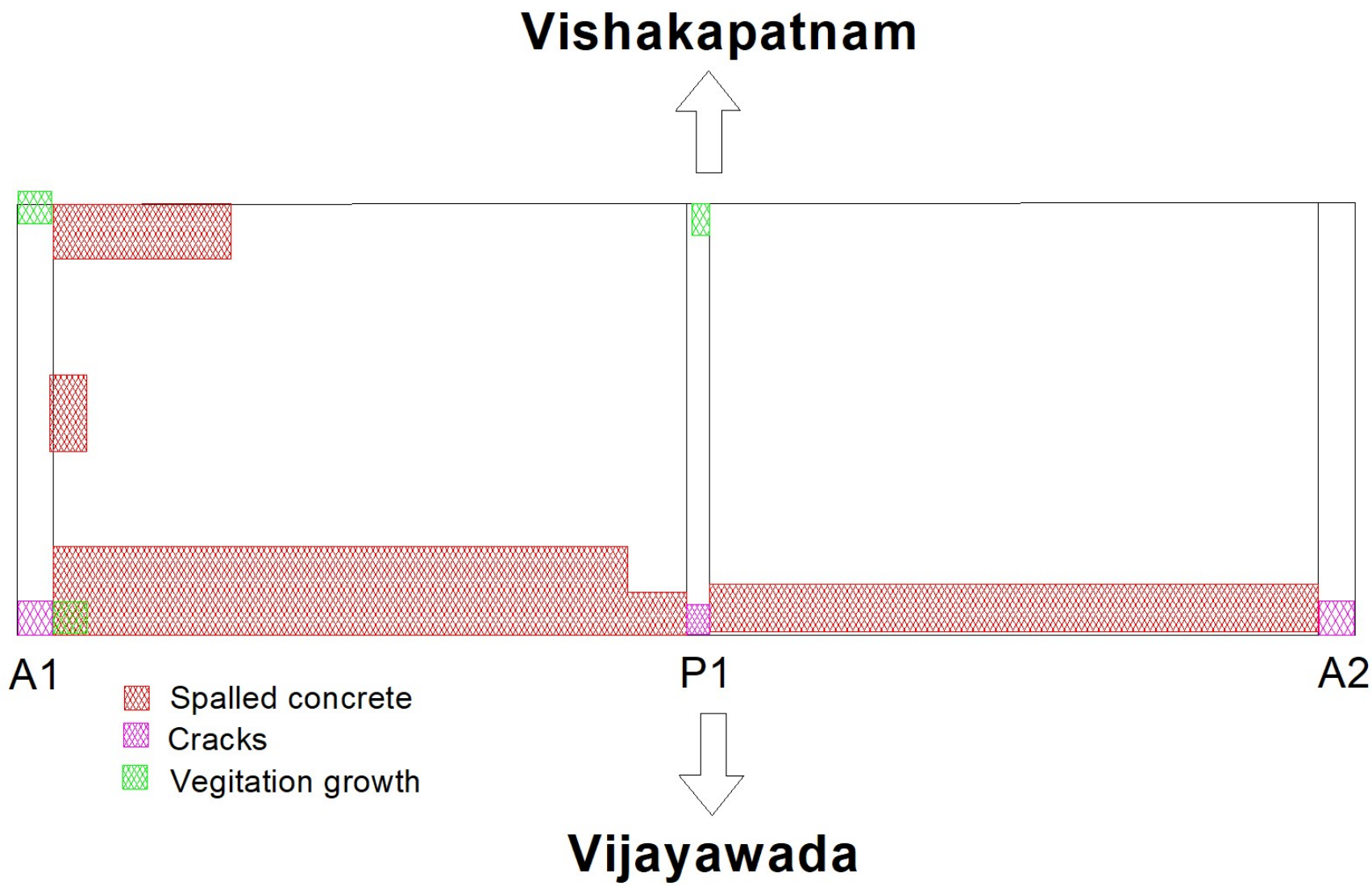


Fig: 19 Bottom view of ROB with damaged locations

The detailed visual observation of ROB, the following observations are made. Major Spalling and Reinforcement exposure are observed at Deck slab as shown in the above figure, Corrosion is seen in the exposed rebars of the Slab. Cracks have been observed at Abutments and Pier cap, Vegetation growth is also observed.

Fig: 20 Deterioration of Reinforcement and Major spalling of Deck slab.

ANNEXURE

Annexure-1a: Repair methods

Defects/Deficiency	**Debris accumulation**
Remedial Measures	**Cleaning**

Work sequence

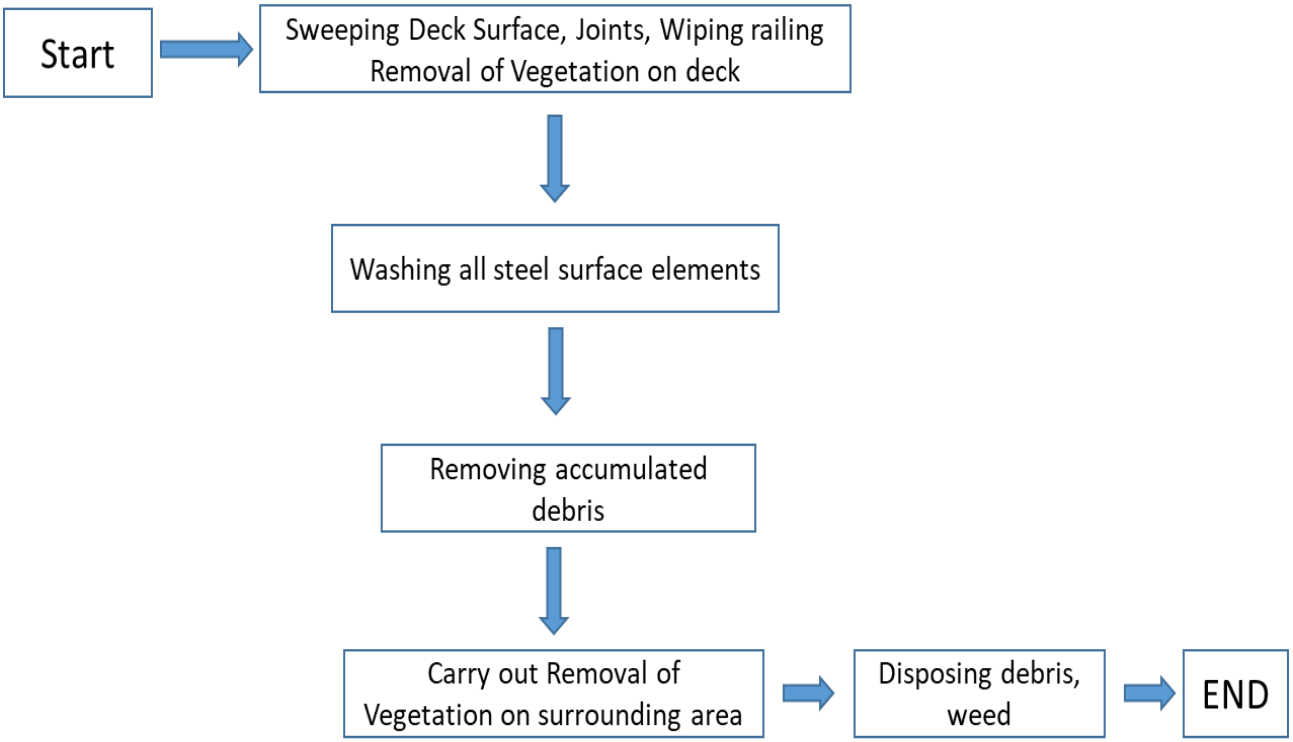


Figure:1.1 Work sequence of removal of vegetation and accumulated debris

REQUIREMENT, SPECIFICATION

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.

The contractor shall obtain necessary approvals of the source of water to be used for cleaning. Engineer's approval shall be taken on the source and quality of water. 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.

Work Requirement

1. General

All accumulated foreign materials shall be removed from bridge sidewalks, bridge decks, top of curbs, beam flanges, gusset plates, abutment bridge seats, 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 governing local regulations. At no time shall these materials be allowed to be disposed into the river or on dry land portions below the bridge.

2. High pressure water

Salt contaminants, dirt, and other detrimental foreign matters shall be removed without damaging the structure. If high-pressure water is used, the maximum water pressure shall not be so high that may cause damage. The cleaning operation shall be discontinued if the foreign materials have not been easily removed or if cleaning operation is causing damage to existing structure.

All deck drains and its accessories shall be flushed with high-pressure water after the accumulated foreign material has been carefully 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.

Annexure-1b: Repair methods

Defects/Deficiency	**Spalling, Honeycomb**
Remedial Measures	**Patching**

Work sequence

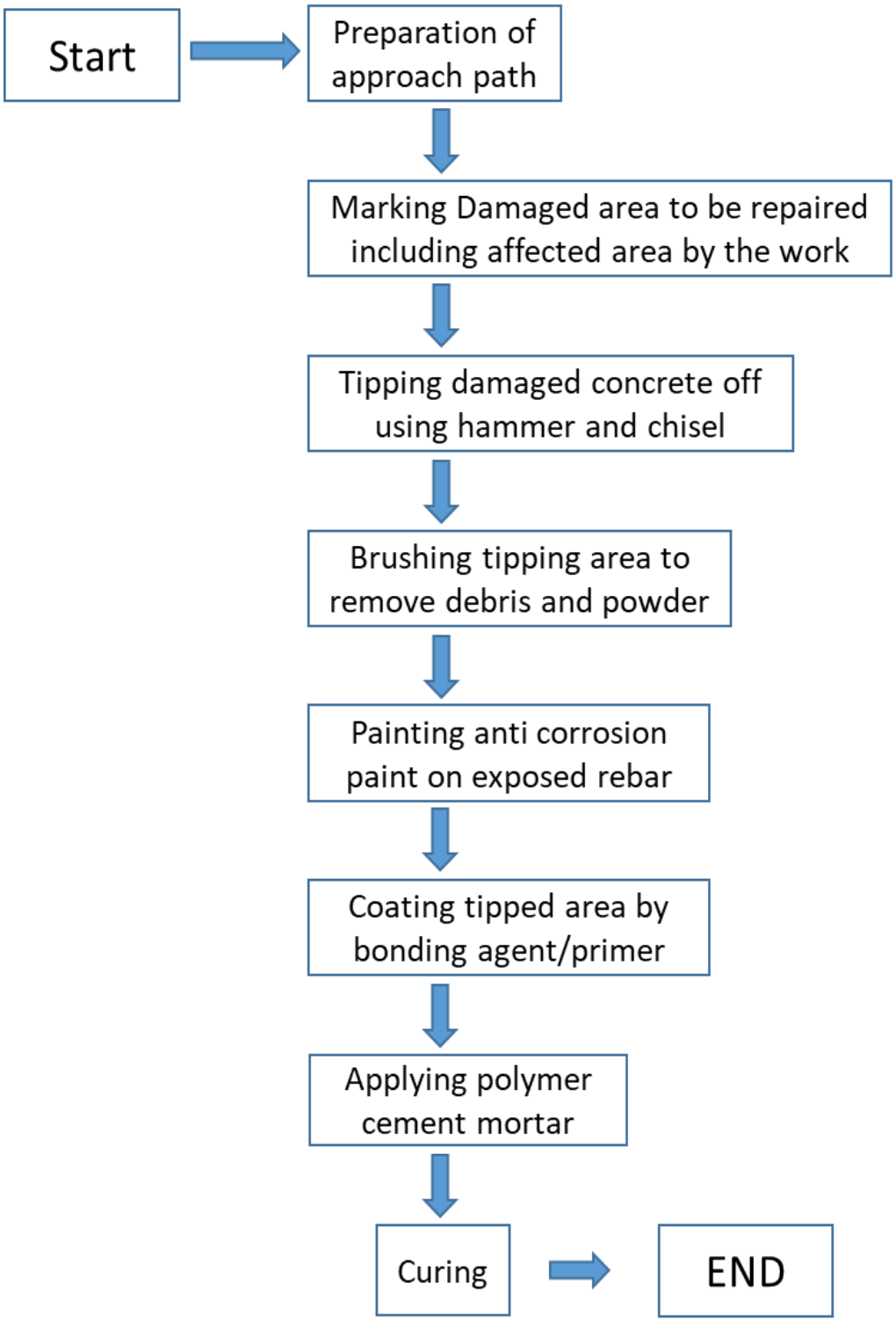


Figure: 1.2 Work sequence of Epoxy Coating

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, Specification

Material Specifications

The Engineer through mill certificate of the supplier shall approve the material.

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	$2.0x10^{-5}$ mm/mm/ ^{o} C
Slant shear bond to concrete	ASTM C882	Concrete failure above 15 N/mm^2
Compressive strength	ASTM D695M	above 20 N/mm^2

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^2
Flexural strength	ASTM D790M	40 N/mm^2
Tensile strength	ASTM D638M	30 N/mm^2
Tensile shear bond to steel	ASTM 1002	15 N/mm^2
Slant shear bond to mortar	ASTM C882	15 N/mm^2
Bond Strength of Cured Concrete to Fresh Concrete	ASTM D7274	15 N/mm^2

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 sledgehammer 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 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
   mortal 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	**Reinforcement Exposure, Spalling and Cracking**
Remedial Measures	**Shotcrete**

Work sequence

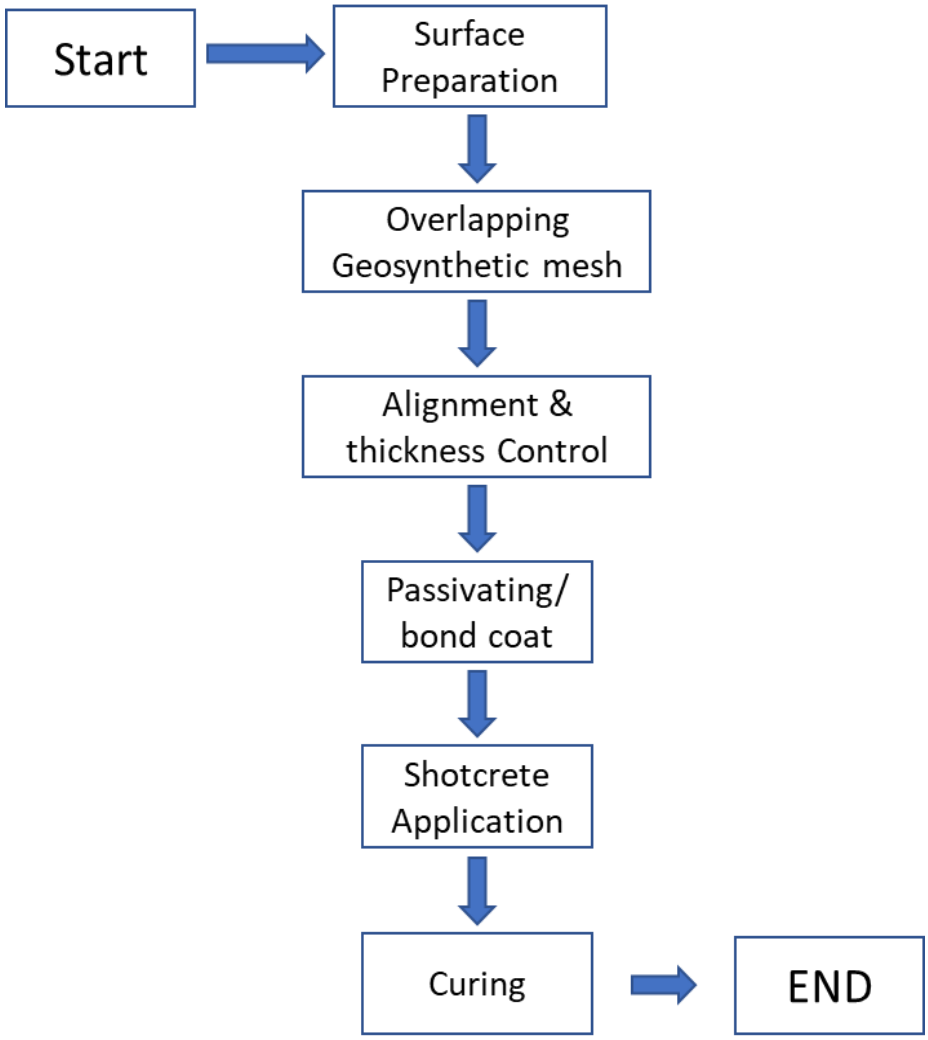


Figure: 1.4 Work sequence of Shotcrete

Required Equipment/Tool and Material

Materials

- Cement
- Fine Aggregate
- Coarse Aggregate
- Admixture
- Water

Tools/Equipment

- Batching and mixer
- Guniting equipment
- Compressor

Requirement, Specification

Materials

Cement: The cement shall be ordinary Portland cement of 43 grade conforming to relevant B.I.S. Code of Practice

Aggregates:

Sand for shotcrete shall comply with the requirements given in IS 383 and graded evenly from fine to coarse as per Zone-II and Zone III grading. Sand failing to satisfy this grading may, however, be used only if pre-construction testing establishes that it gives good results.

Coarse aggregate when used shall comply with the requirements of IS 383. It shall, generally conform to the grading given below:

Table 1.5 Gradation of the coarse aggregate

GRADING OF COARSE AGGREGATES	
IS Sieve Designation, mm	**Percentage Passing by mass for aggregate of nominal maximum size**
10	100
4.75	10 – 30
2.36	0 – 10
1.18	0 - 5

All over sized pieces of aggregate shall be rejected by screening. Gradation of the combined coarse and fine aggregate mixture used for shotcrete shall generally lie between the following limits.

Table 1.6 Gradation of the combined coarse and fine aggregate mixture

I.S Sieve	**Percent passing by Weight Gradation**
10 mm	100
4.75 mm	72 - 85
2.36 mm	52 - 73
1.18 mm	36 - 55
600 microns	28 - 38
300 microns	7 - 20
150 microns	0 - 8

Water used for shotcrete shall conform to the requirement of I.S. 456-2000

Admixture: Guniting admixtures & quick setting agents may be used to minimize the rebound loss and increase the bond & enable thicker layers per coat. The admixture shall meet the requirement of I.S. 456 and I.S. 9103

Concrete: The grade of concrete shall be as specified i.e. the characteristic compressive strength of 15 cm cube at 28 days should be as specified. The water cement ratio for shotcrete shall be within the range 0.45- 0.50 by mass.

Work requirement

1) This specification covers only to the extent of restoring the concrete slab by way of short creating. The specification excludes bearing replacement, expansion joint treatment etc.
2) Remove all loose and spalling concrete and expose the corroded reinforcement wherever possible by careful chipping.
3) Carryout thorough sand blasting using dry coarse sand or by grinding.
4) Fix 8 mm dia PVC nozzles at all honey combed areas and wherever cavities exist. At all other vulnerable areas drill 12/14 mm dia hole to a depth of 50 to 75 mm and fix 8 mm PVC nozzles.
5) Now drill 12/14 mm dia holes at a spacing of 500 mm c/c to a depth of 50 mm and fix 8 mm dia shear connectors using polyester resin grout.
6) Fix 50 mm x 50 mm x 4 mm Geo grid tied to the exposed reinforcement / shear connectors.
7) Carryout 40 to 50 mm thick short - creating to underside of slab etc., using a mix proportion of 1: 2: 2 (cement: sand: aggregate).
8) Now carryout cement injection grouting through the nozzles in sequential manner until rejection.
9) Carryout curing for 7 days.

Note: Grouting is done only after shotcrete to fill any leftover voids in the concrete slab.

Summary

- Visual inspection of Kadiyam ROB (251) has been conducted on 2nd Dec 2019, following observations were made
    a) Cracks has been observed at Abutments and pier cap.
    b) Reinforcement exposure has been observed at deck slab in both spans of ROB.
    c) Spalling has been observed in Abutment 1 & 2.
    d) Leaching observed on deck slab.
    e) Water seepage is observed at abutment 2

- Non-Destructive Testing of Kadiyam ROB (251) has been conducted on 26 Aug 2020, following observations were made
    a) Estimated strength as per rebound hammer test indicated that concrete strength is >39MPa.
    b) Ultrasonic Pulse Velocity test indicates that the quality of concrete for Pier wall and deck slab is poor.

- Based on visual inspections and NDT Testing and its interpretations following recommendations were made:
    a) Epoxy Grouting of cracks and complete Jacketing of the pier wall should be done
    b) Application of Anti corrosive paint for exposed rebars with Minimal deterioration
    c) Replacement of severely Corroded bars in slab and Shotcreting of the deteriorated concrete
    d) Clearing of Vegetation growth immediately to avoid deterioration of concrete.

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