



STRUCTURAL HEALTH ASSESSMENT & REHABILITATION OF ROB

Mettuguda (254B)

February | 2020

SUMMARY

• OBSERVATIONS

Spalling and Reinforcement exposure has been observed at deck slab. Corrosion is observed at the steel concrete joint. Reinforcement exposure is also observed at overhang portion of slab. Pointing failure has been observed at pier. Leaching is observed at piers. Vegetation, algae growth is also observed on piers

• RECOMMENDATIONS

Shotcreting for slab, Repairing flanges and rivets of riveted girder and Replacing rivets with bolts.

• CONCLUSIONS

Based on the inspections carried, the bridge need immediate attention on deteriorated RCC slab and highly corroded steel members. Restrengthening is recommended. Clearance of vegetation and providing proper rain water drains is recommended to increase the service life of the bridge.

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1. VISUAL INSPECTION

Name of the Project	:	VISUAL INSPECTION OF ROB - (254B)
Location	:	NEAR METTUGUDA, HYDERABAD.
Location Co-ordinates	:	17°26'18.9"N 78°31'29.4"E
Date of Inspection	:	13th September, 2019.



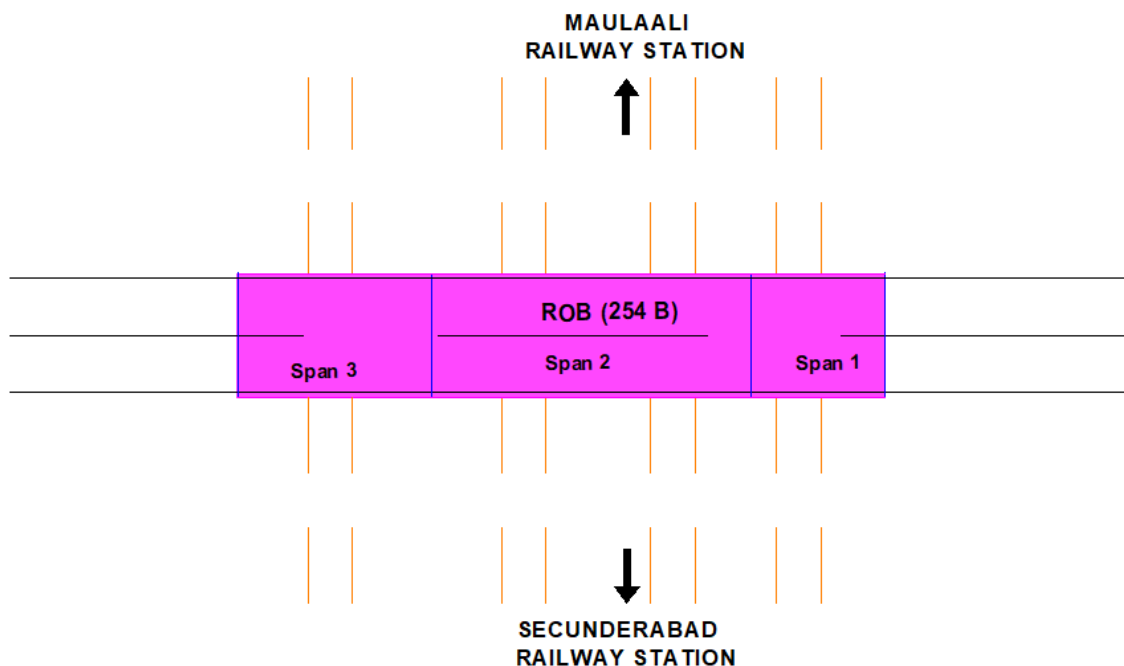
Summary:

- a) Spalling and Reinforcement exposure has been observed at deck slab
- b) Corrosion is observed at the steel concrete joint
- c) Reinforcement exposure is also observed at overhang portion of slab
- d) Pointing failure has been observed at pier.
- d) Leaching is observed at piers.
- e) Vegetation, algae growth is also observed on piers

1.1 GENERAL INFORMATION AND OBSERVATION

a	Name of the Bridge	ROB (254B)
b	Location Location co-ordinates	Near Lalaguda. 17°26'18.9"N 78°31'29.4"E
c	Type of Bridge	Composite Girder Bridge
d	Year of Construction	Data Not Available
e	Grade of Concrete (Slab)	Data Not Available
f	Design Load	Data Not Available
g	Carriageway Width	7.5 m
h	Overall Deck Width	8m
i	Average Skew	Not in skew
j	Span arrangement (no x Span in meters)	1x 5.17 m +1 x 13.7m + 1x 5.17 m (Clear span)
k	No of Railway Lines Crossings	4 tracks
l	Vertical Clearance (from rail top to girder bottom)	5.8m
m	History of Repair/ Maintenance	No Patch work observed
n	Existing Structural Drawings	Not available

Key Plan



1.2 STRUCTURAL SYSTEM OF THE BRIDGE			
			Notes
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, disintegration, decay, erosion, Cavitation's etc.,)		
b	Abutment (A1 & A2)		
	Type	wall	
	Maximum height of Abutment from Ground level	6.4	
	Abutment width along the Track	8.6m	
	Abutment thickness	3.2m	
	Condition (Crack, Settlement, Scour, Tilting, Steel Corrosion, Strains and other damages etc...)		Leaching has been observed.
	Efficiency of drainage of backfill Behind Abutments (Check functioning of weep holes, evidence of moisture on Abutment faces, etc.)		functioning properly
c	Pier		
	Type (Shape)	wall	Leaching and Algae formation and vegetation growth has been observed on piers.
	Material	Masonry	
	No. of Piers in a row/column	2	
	Maximum Height of Pier	5.8m	
	Pier Diameter/Dimension	8.6 x 2m	
	Pier Cap Material	RCC Bed block	
	Pier Cap Condition	Cracks observed	
	Pier Condition (Crack, Settlement, Scour, Tilting, Steel Corrosion, Strains and other Damages etc...)	Good	
	Efficiency of drainage of backfill behind Abutments (Check functioning of weep holes, evidence of moisture on Abutment faces, etc...)	Good	

d	Bearing & Pedestal		
	Type of Bearings		Not accessible / visible
	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, cleanliness, seizing of plates silting)		
e	Super Structure (Steel Girder)		
	Type/Shape of Girder (I-beam, box-Girder etc.)	I-girder	The Bridge is supported on 4 Longitudinal Built up Plate girders.
	Material of Girder	Steel	
	No of Girder	4 Nos.	
	Dimensions of Girder	1.2 m, 0.6m	Total Depth = 1.2m (span 2) Total Depth = 0.6m (span 1 & 3)
	Structural System of Girder		Simply Supported
	Condition of Girder	Distresses Found	corrosion is observed in along steel concrete joint (Refer Fig:6)
	Type/Shape of Secondary Girder		cross bracings of angle section is used as secondary girder
	Material of Secondary Girder	Steel	
	No of Floor beams	6 Nos.	
	Condition of Secondary Girder		Rusting is observed.
f	Slab		
	Material of Slab	RCC	
	Thickness of Slab	0.58m	
	Condition of Slab from Bottom	Distresses Found	Spalling & Reinforcement exposure has been Observed. (Refer Fig:4, 5)
	Condition of Slab from Top		Not visible, as covered with wearing coat
	Condition of Flooring/Wearing Coat	fair	
g	Parapet wall/Railing		
	Type of Parapet wall/Railing	RCC	
	Height	2.0m	
	Condition of Wall/Railing		Cracks and spalling observed

1.3 SURVEY OF SIGNS OF DISTRESS, DEFORMATION IN BRIDGES			
	Defects	Location	Notes
	Cracking in RCC components	Pier cap	cracks are observed at pier cap (<i>Refer Fig:11</i>) & Pier (<i>Refer Fig:3</i>)
	Water seepage		No water seepage is observed
	Spalling	Slab	Spalling is observed in Slabs. (<i>Refer Fig:4, 5</i>)
	Reinforcement Exposure	Slab	Reinforcement Exposure is observed in Slabs (<i>Refer Fig:4,5,7</i>)
	Corrosion	Girder	Corrosion is observed at steel concrete joints of (<i>Refer Fig:6</i>)



Fig: 1 View of ROB



Fig:2 Bottom view of Slab



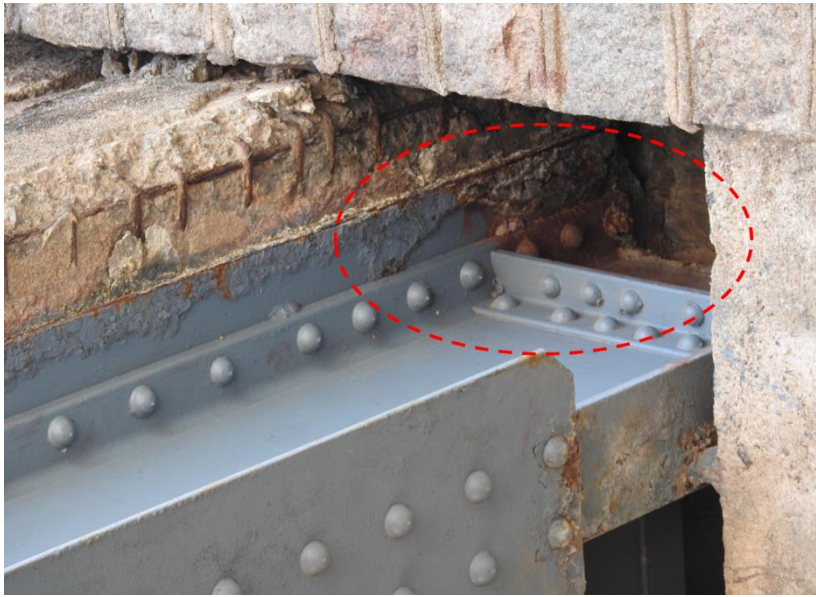
Fig: 3 Vegetation, algae growth, leaching and cracks observed at Piers



Fig: 4 Exposed reinforcement observed in span 2



Fig: 5 Exposed reinforcement observed in span 3



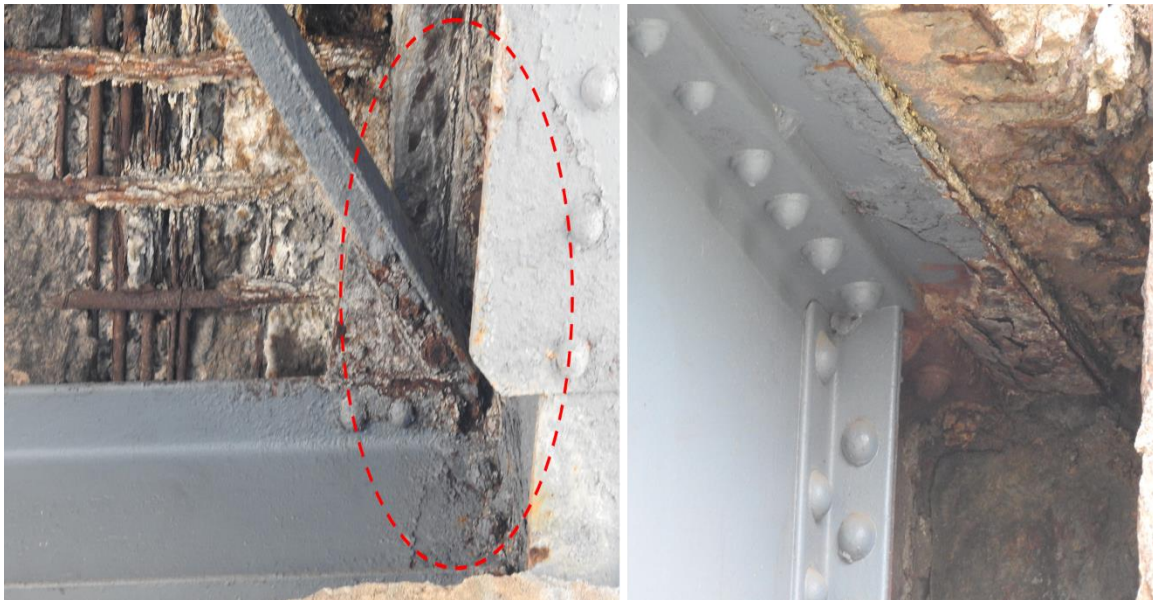


Fig: 6 Corrosion observed at steel concrete joint, severe damage observed at rivet head



Fig: 7 Spalling and reinforcement exposed at overhang portion of slab due to less cover



Fig: 8 Spalling and reinforcement exposed at span 1



Fig: 9 Additional load of utility is observed



Fig: 10 Patch work observed (A- original concrete, B-old patch work, C-new patch work)



Fig: 11 Reinforcement exposed due to Congested steel, caused no vibrations resulting voids.



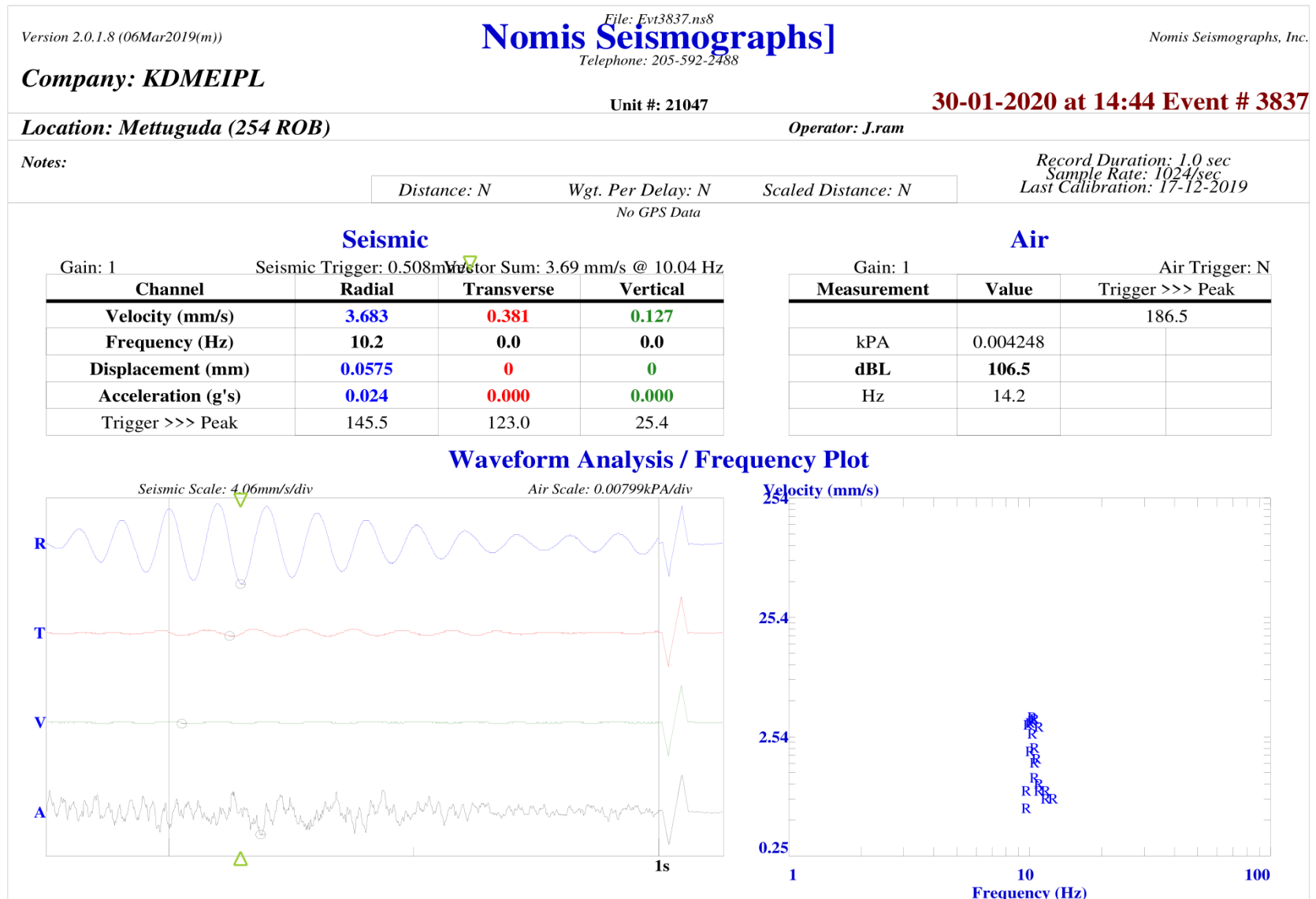
Fig: 12 pointing failure observed at bed block



Fig: 13 Wearing coat and parapet wall

2. Vibration Analysis

2.1 Interpretation Vibration Analysis



Company: KDMEIPL

Unit #: 21047

30-01-2020 at 14:41 Event # 3826

Location: Mettuguda (254 ROB)

Operator: J.ram

Notes:

Distance-Source: N

No GPS Data

End Time: 15:43:18
Sample Rate: 1024/sec
Last Calibration: 17-12-2019

Seismic

Gain: 1

Vector Sum: 3.69 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	3.683	0.508	0.508
Frequency (Hz)	8.8	15.3	341.3
Time	14:44:55	14:58:08	14:58:25
Displacement (mm)	0.0666	0.0053	0.0002
Acceleration (g's)	0.021	0.005	0.111

Air

Gain: 1

Measurement	Value		
kPA	0.017493		
dB L	118.8		
Hz	146.3		
Time	15:13:49		

BarGraph

Seismic Scale: 4.06mm/s/div

Air Scale: 0.03197kPA

Bar Samples total/shown: 61/61

Summary Interval (min): 15
Bar Interval (sec) 60



The permissible amplitudes of vibration are generally specified during analysis and design of the structure. Below fig. suggested by Richart may be adopted during design or operation of the structure

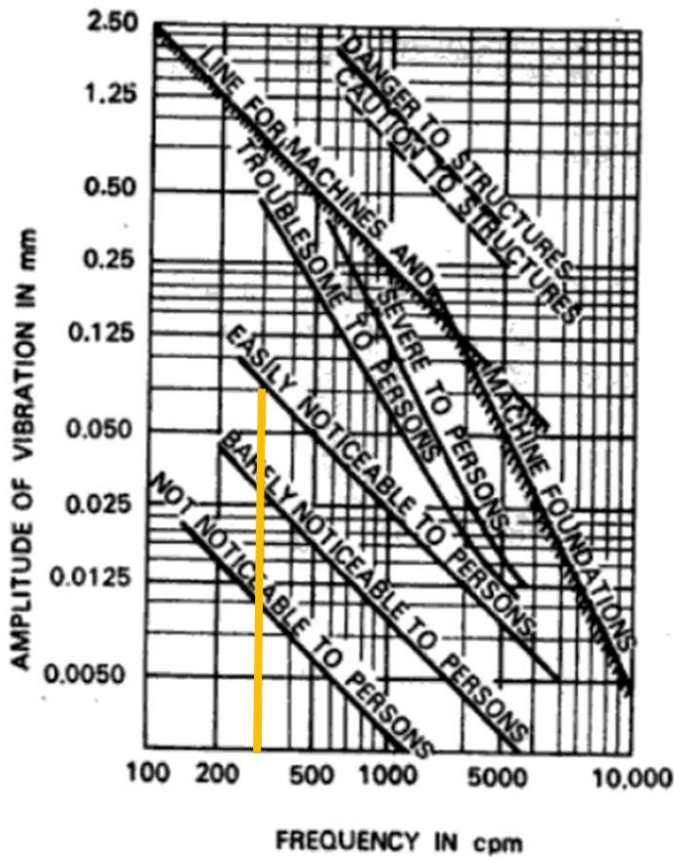


Fig. 1.4: Allowable Limits for Vertical Vibration Amplitudes (After Richart, F. E., Jr. *et al.*, *Vibration of Soils and Foundations*, Prentice-Hall Inc., New Jersey, USA, 1970; with permission).

Based on the vibration analysis carried out the structure is in permissible limit of vibrations. (Frequency observed is 300 cpm and maximum amplitude observed during the test time of complete 3hrs is 0.0575 mm)

3. Repair and Retrofitting Recommendations

a. Concrete Deck Strengthening

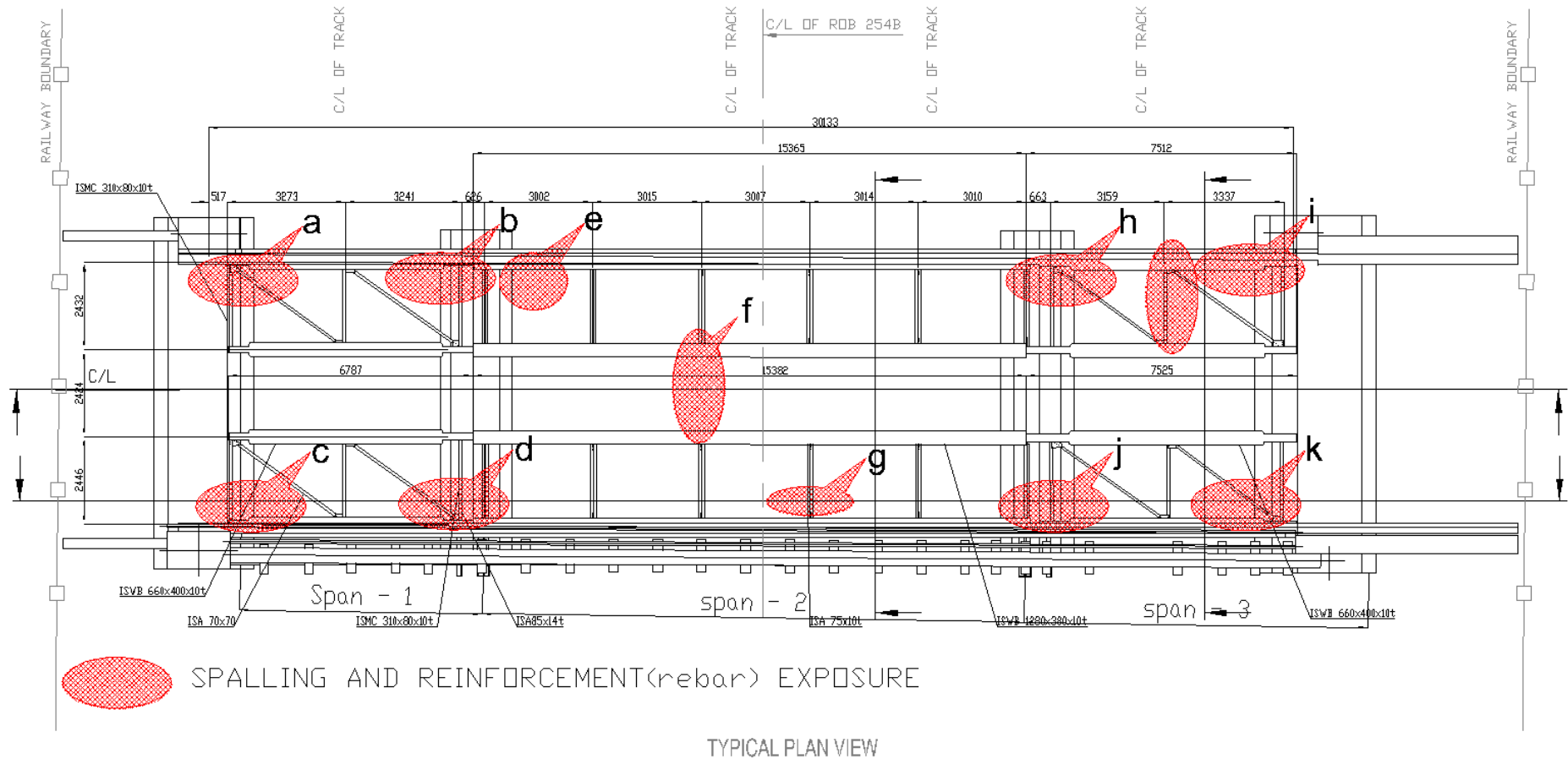


Fig 14: Bottom view of slab deck with reinforcement exposed (damaged) locations

During the detailed visual observation, is made of Deck slab on the above said locations and the following observations are made, excessive spalling was noticed in span 1, 2 & 3 in majority of the deck slab is effected with dampness, rebar corrosion and cracks were noticed at the steel concrete joints.

1. Repair Methods and Recommendations for Reinforced Concrete Deck Slab

- Spalling and Rebar exposure in deck slab



Fig 15: Damage locations identified in span 1 at “a, b, c & d”



Fig 16: Damage locations identified in span 2 at “e, f & g”

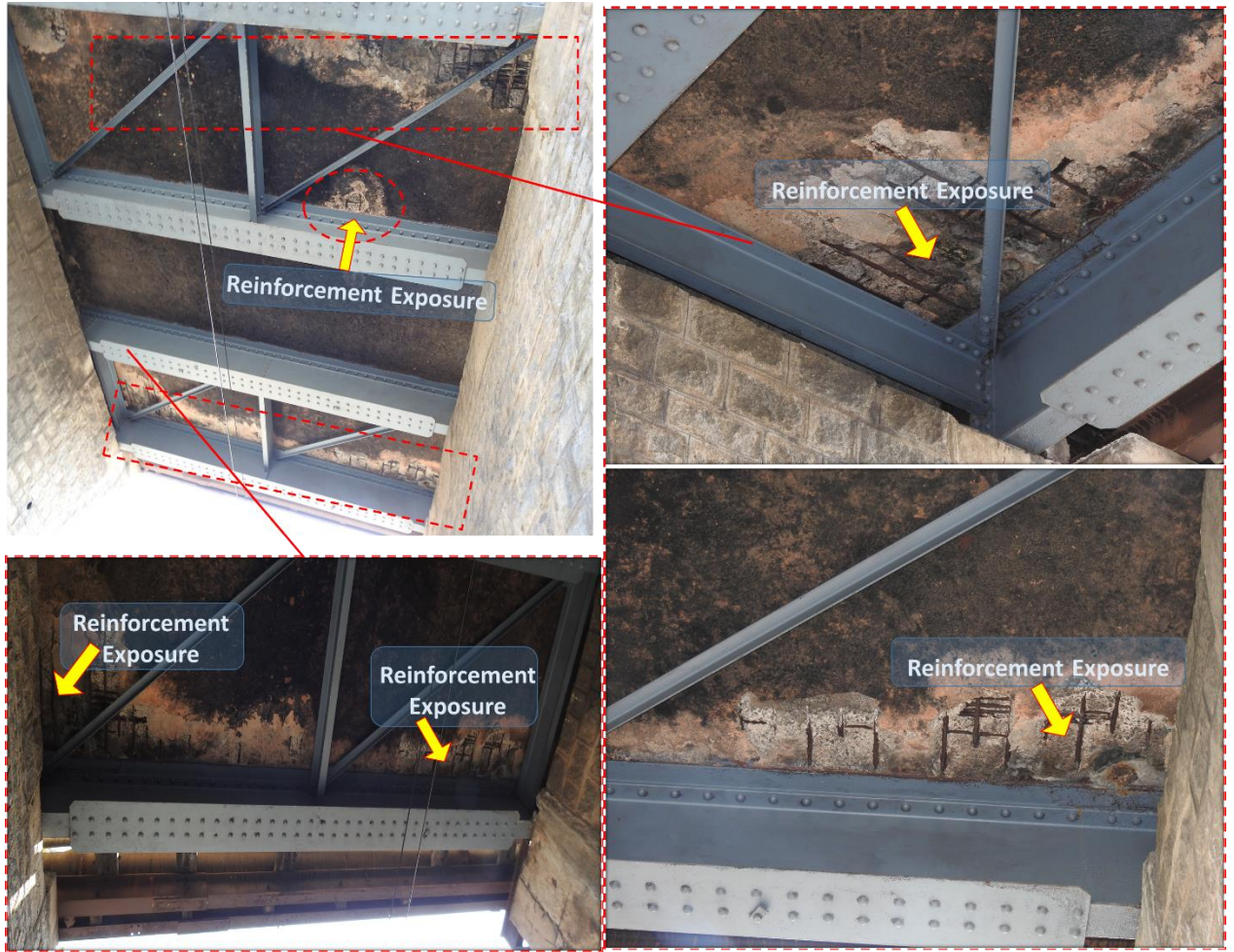


Fig 17: Damage locations identified in span 3 at “h, l, j & k”

SHOTCRETE AND GROUTING

- This specification covers only to the extent of restoring the concrete slab by way of shot creating and injection grouting. The specification excludes bearing replacement, expansion joint treatment etc.
- Remove all loose and spalling concrete and expose the corroded reinforcement wherever possible by careful chipping.
- Carryout thorough sand blasting using dry coarse sand or by grinding.
- 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.
- 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.
- Fix 50 mm x 50 mm x 4 mm Geo grid tied to the exposed reinforcement / shear connectors.
- Carryout 40 to 50 mm thick shot - creating to underside of slab etc, using a mix proportion of 1: 2: 2 (cement: sand: aggregate).
- Now carryout cement injection grouting through the nozzles in sequential manner until rejection.
- Carryout curing for 7 days.

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

b. Steel Girder Strengthening

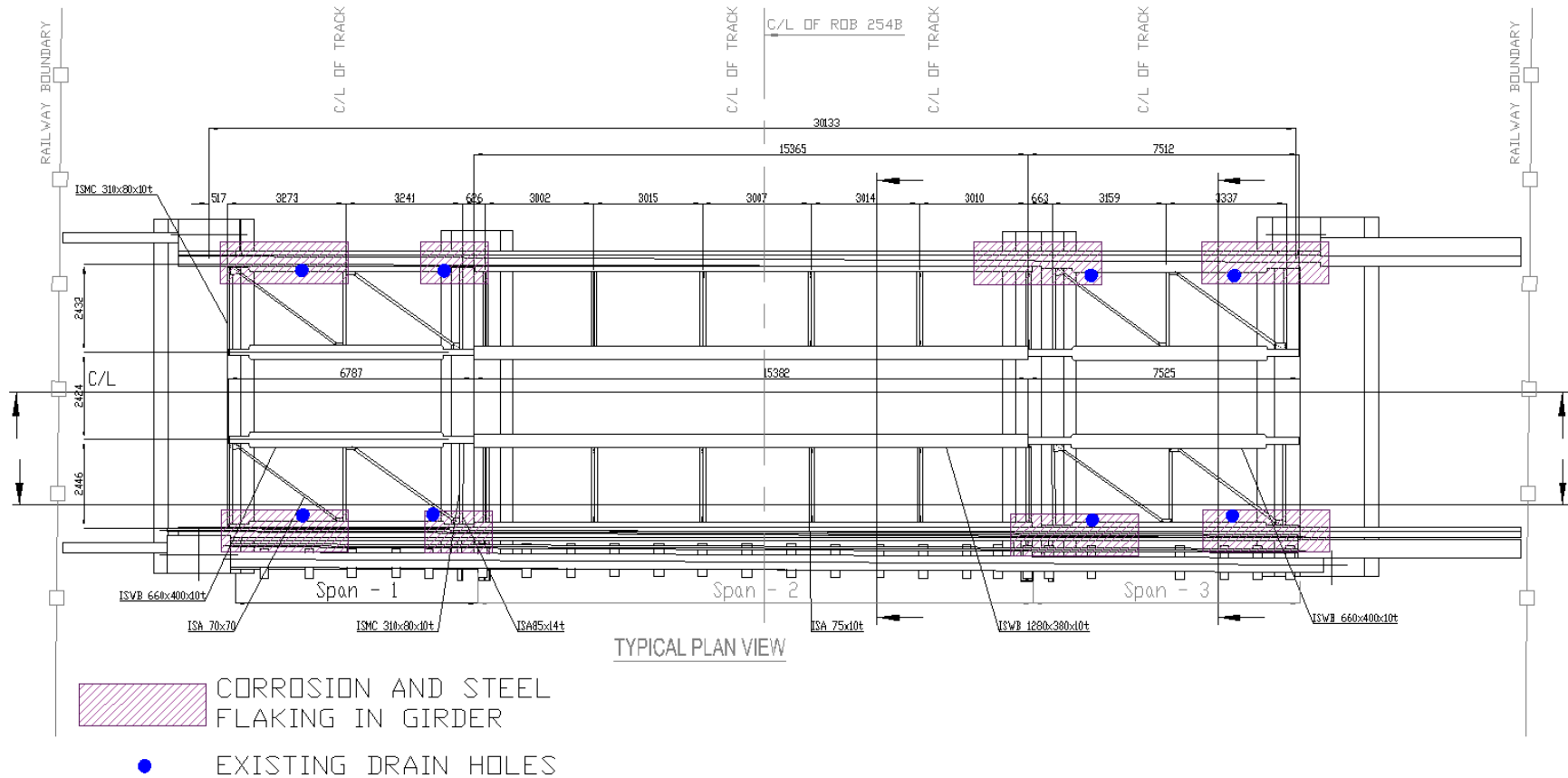


Fig 18: Bottom view of slab deck with Steel girder exposed (damaged) locations

A detailed visual observation is made on steel girders on the above said locations and the following observations are made, excessive corrosion and steel flaking was noticed in span 1, & 3 near drain holes and supports. Near steel concrete joints cover plate on the girders and angular bracing members connected with rivets are damaged.

2. Repair Methods and Recommendations for Steel Girders and Other Elements

Corrosion and steel flaking observed near support

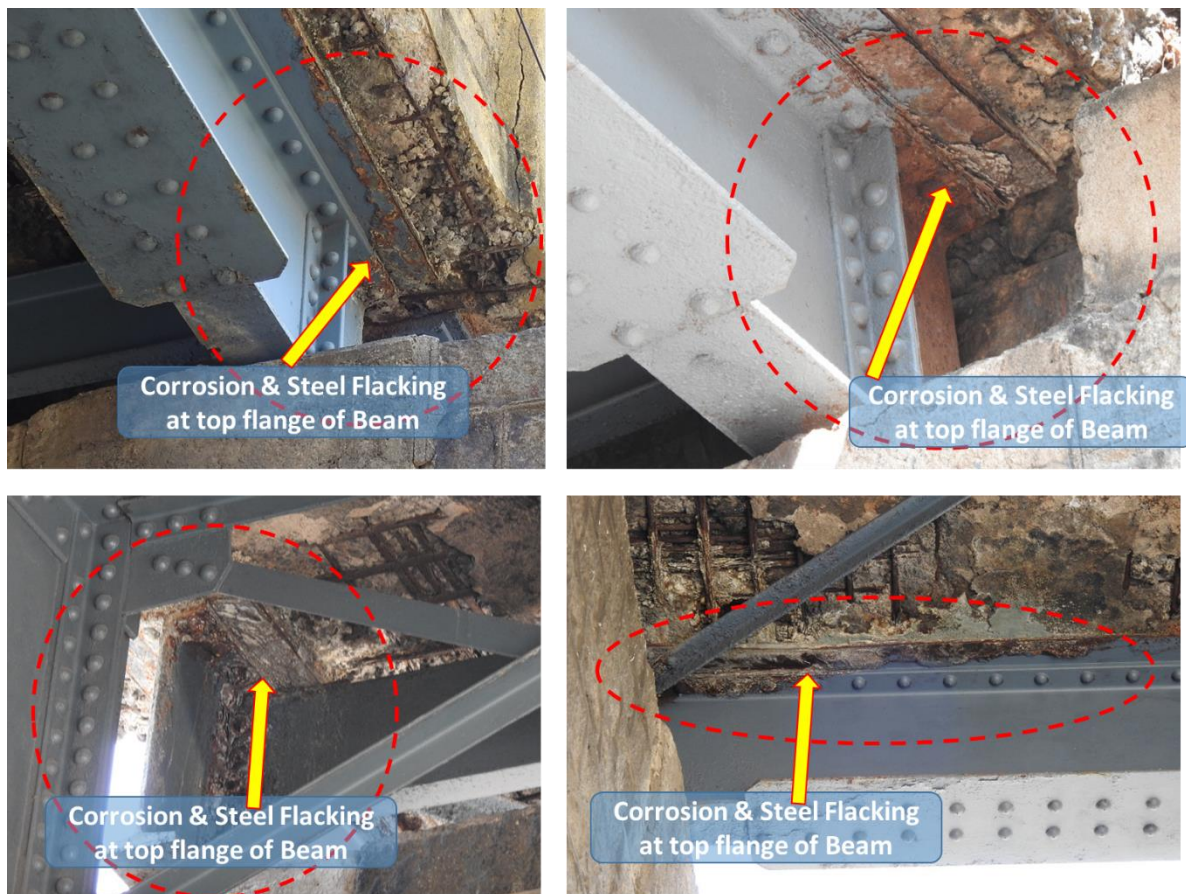


Fig 19: Damaged locations identified in span 1 and 3

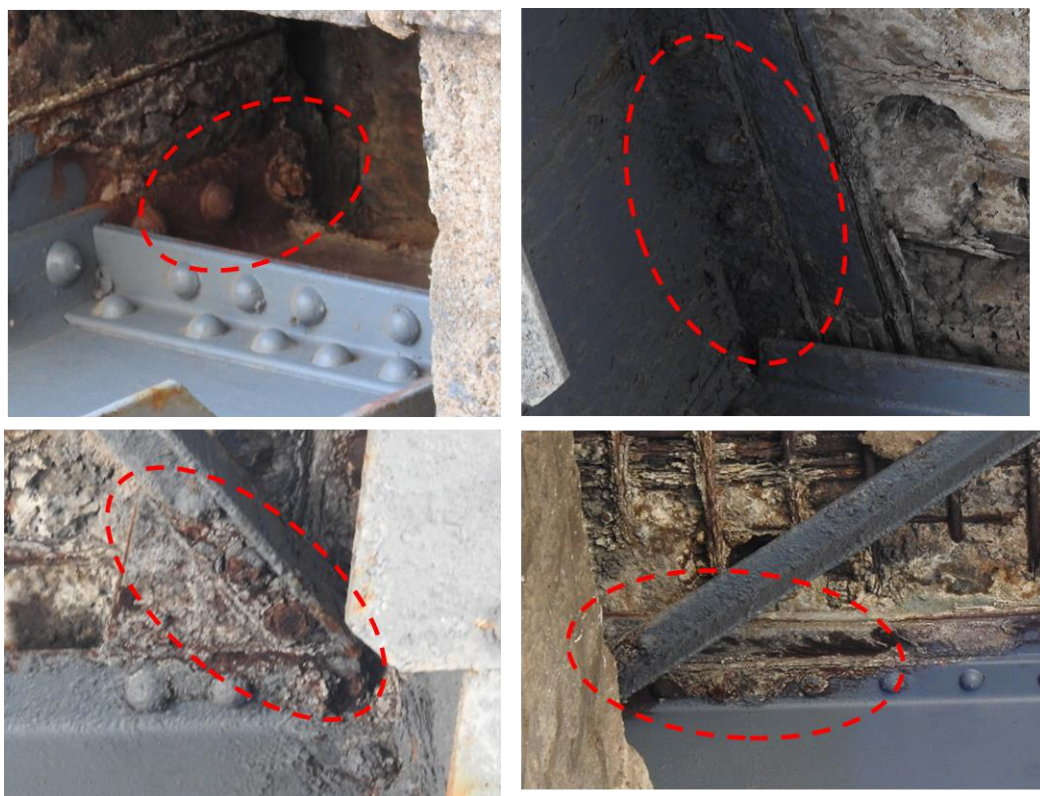


Fig 20: Rivet Damaged locations identified in span 1 and 3

CORROSION OF STEEL BRIDGE ELEMENTS

Corrosion is important and frequent causes of degradation of steel structure mainly in severe environmental condition. For steel elements embedded in concrete the corrosion generally arises from rainwater ponding at the interface of the steel element with concrete because of inadequate design details for draining water way.

Corrosion Damage

Extensive corrosion might have occurred to one or many members due to environmental conditions or age of the structure. Corrosion, by definition, involves the oxidation of a metal, or in other words, the conversion of a solid metal into ions of the metal, which in turn combine with 41 other elements to form rust. A more complete discussion of the mechanisms involved in corrosion.

There are many types of corrosion that might be present in bridge members including galvanic, pitting, and crevice. The mechanisms for these varieties of corrosion may differ. However, the result is identical, a net loss in available section to carry the applied loads.

Common areas in which corrosion can be exacerbated include:

- Top flange of floor-beams due to roadway leakage
- Bottom flanges of members due to debris build-up
- Lacing bars
- Pinned connections where small relative movements might trap moisture

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. If in the case of floor-beams, in which a portion of the member might be embedded in concrete, NDT methods such as ultrasonic inspection might be employed to evaluate the remaining section. An excellent reference for the evaluation of corroded members. In this article, a series of tests were completed to quantify the performance and remaining strength of corroded bridge members. This research confirmed the common approximation that the strength of a member can be determined by multiplying the remaining area by the ultimate stress. The researchers also found that corrosion did not affect ductility. Fatigue tests were also completed to quantify the influence of corrosion on fatigue strength. It was found that if the corrosion loss was less than 50%, notch effects rather than section loss governed fatigue capacity. Other articles, which discuss properties and evaluation of corroded members, include

Section Loss > 15% - Clean the Surface and Apply the protective coat.

Section Loss 15% - 40% Repair the member with Suitable method

Section Loss < 40% - Replace the member with Suitable method

CORROSION IN FLANGES OF RIVETED GIRDERS

The procedure for repairing flange corrosion in riveted girders involves the following, Remove heads of rivets that are to be replaced by bolts. Remove the underside heads for bottom flanges and the topside heads for top flanges. For top flange rivet removal, fit clamps to the underside to prevent rivets falling out.

- i. Prepare the flange surface for cover plating by removing all loose rust and dirt and by grinding where necessary to create a smooth surface. Fill any deep pitting ($>1\text{mm}$ deep) or any area of unevenness to create a flat surface for seating the cover plate.
- ii. Position the packer plates and cover plate, holding them in place with clamps.
- iii. Progressively remove rivets to be replaced and fit and tension replacement bolts. Note that no more than 10% of rivets, evenly distributed along the member, are to be removed at any one time.
- iv. Seal open interfaces to new steel where required. Fill exposed rivet head holes on the top flange to prevent collection of water.
- v. Prepare for and paint new steelwork and areas of existing steelwork to the extent.

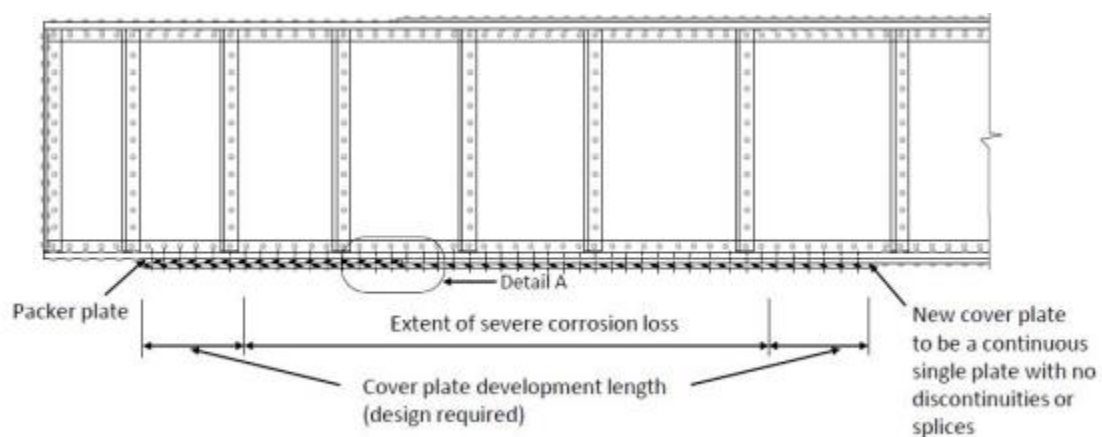


Fig: 21 a Typical Riveted Girder

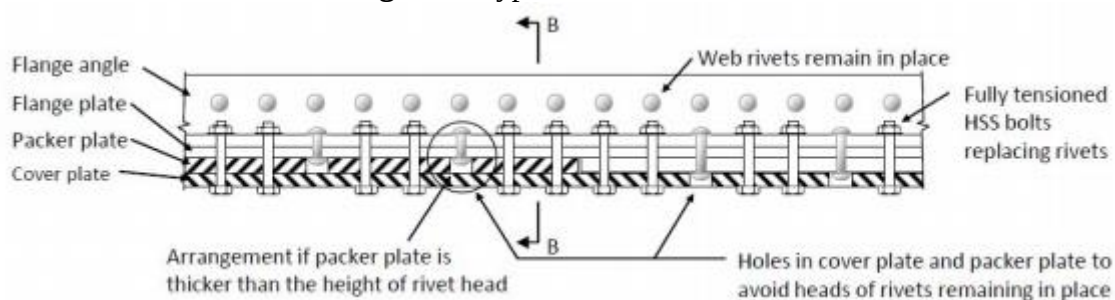


Fig: 22 b Detail "A"

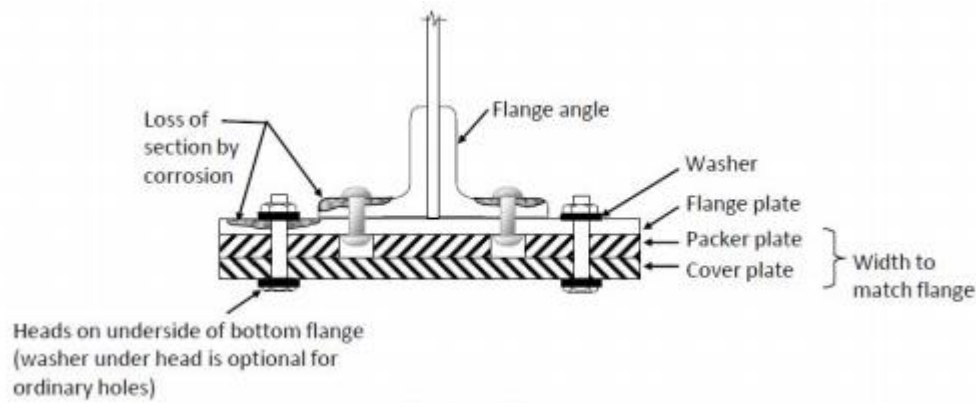


Fig 23 c Detail “B”

REMOVING RIVETS AND REPLACING WITH BOLTS

This section covers the removal of existing rivets and replacement with either high strength friction grip bolts or snug tightened bolts.

To remove rivet heads, one of the following two methods can be used:

- Cutting using oxy-fuel equipment;
- Grinding off all or part of the head/tail.

The following notes are useful to observe for removing of the rivet heads.

Oxy-fuel cutting:

Oxy-fuel cutting can be used in the following circumstances where the head to be removed is adjacent:

- Any steel that is to be removed and discarded as part of the repair process;
- Intermediate web stiffeners; or
- Minor bracing members that are not subject to dynamic or cyclic loading.

Do not allow the oxy flame or molten steel to touch any other steel element except those listed above.

In cases (ii) and (iii) above, where the steel adjacent to the rivet head is to remain in place, take care to avoid or minimize flame effects on that steel, to leave a neat hole for installation of the bolts.

If the use of oxy-fuel cutting cannot be avoided in cases other than those above, take great care to avoid flame effects on the adjacent steel. Any flame affected steel around the hole must be completely removed by reaming prior to installing the bolt.

Grinding:

Use grinding to remove the head, if it is necessary to remove the portion of the head outside the shank diameter.

Take care to avoid creating grooves and indentations in steel that is to remain in place. If such indentations and grooves occur, remove them by grinding the surface smooth after removing the rivet.

Where large numbers of rivets are to be removed, consideration should be given to procuring a grinding bit such as a broaching bit, which when positioned centrally on the domed head will grind away material outside the shank diameter.

Holes in Members (Clause 6.0, as per IS 4000-1992)

The procedure for preparing the hole for the bolt and limitations (in accordance with IS 4000 – 1992) are described below:

Unless specified otherwise, the diameter of a hole shall be 1.5 mm and 2.00 mm more than the nominal bolt diameter for bearing type joints and friction type joints respectively.

The edge distance for any hole and the distance between holes, (pitch) shall conform to the requirements of IS 800: 1984.

Holes shall be provided by drilling only for all dynamically loaded connections and also friction type joints and by any of the following methods (a), (b) or (c) for other type of joints: a) 9 C)

- a) DRILLING - Holes drilled full size.
- b) SUB PUNCHING - Holes sub-punched 3 mm undersize and reamed to size.
- c) PUNCHING FULL SIZE - Holes punched full size provided:
 - i. The joint is not located at a plastic hinge,
 - ii. The material shall not have a yield stress (f_y) in excess of 360 MPa, and
 - iii. Thickness of individual members does not exceed 12 mm.

Oversize and Slotted Holes

- a) Oversize holes shall not exceed $1.25 d$ or $d+8\text{mm}$,
- b) Short slotted holes shall not exceed $d+2$ mm in width and $1.33 d$ or $d+10$ mm in length, and
- c) Long slotted holes shall not exceed $d + 2$ mm in width and $2.5 d$ in length.

Limitation on Use

- a) Oversize holes - Oversize holes may be used in any or all plies of bearing-type and friction-type connections provided hardened washers are installed over the oversize holes.
- b) Short slotted holes - Short slotted holes may be used in shear-type connections in any or all plies of friction-type and bearing-type joints provided-hardened washers are installed over the exposed holes.

In friction-type, joints the slots may be used without regard to direction of loading but in bearing-type joints slotted holes may be used only where the joint is not eccentrically loaded, where the bolts can bear uniformly and where the slots are normal to the direction of the load.

c) Long slotted holes - Long slotted holes may be used in shear-type connections only in alternate plies of either friction type or bearing-type, joints provided a special washer or cover plate, not less than 8 mm thick, is used to completely cover all exposed long slotted holes.

DEBRIS ACCUMULATION



Fig 24: Vegetation observed on the top of the pier (abutment wall)

Various components of a bridge, namely deck surface, curbs and sidewalks, expansion joints, pier caps, abutment caps, trusses and their web members, lower flanges of beams and girders, wind bracings and drains shall 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 road users. Areas which have been cleaned shall be ensure freedom from accumulated sand, gravel, dirt, and other foreign materials. Vegetation grown on the components

of bridges shall be removed. In addition, vegetation near the bridge that might affect the normal performance of the bridge, such as free flow of water under the bridge, etc. shall be removed.

Cleaning applied to the bridge including its steel girder; deck and substructure are recommended below:

1) Surface of steel plate:

The surface areas of a steel bridge should be cleaned and washed by brushing with fresh water or using high-pressure water blasting, including the top and bottom flanges, web plates, diaphragms, lateral members and gusset plates. For convenience, inspection vehicle may be utilized to carry out cleaning of the bridge soffit.

2) Bridge deck slab:

All surface areas of the bridge deck should be cleaned including the curbs, expansion joints, drain pits and railings. This may be performed by manual shoveling/sweeping or using high pressure water blasting.

3) Bridge substructure:

All areas under the superstructure should be cleaned, including the bearing shoe bed, concrete diaphragms and pier caps. This may be done by manual shoveling/sweeping or using high pressure water blasting. Accessing the top of piers, a higher ladder or hang ladder will be useful and an inspection vehicle can be utilized, if possible.

4) Vegetation growth:

These shall be removed from the components of the bridges as well as from near the bridges if it is found that they affect the soundness of the structure in course of time.

4.Conclusions

Based on the inspections carried it can be concluded that the bridge has shown high deterioration in the slab and concrete steel joints. Exposed reinforcement is seen at the bottom of slab at several locations. Vegetation and algae growth is also effecting the strength of the piers.

Vibrations analysis carried on the structure shows vibrations are in permissible limit. During the test time observed frequency is 300 cpm and maximum amplitude observed is 0.0575 mm at the center of the bridge. This is only for the loads which have been traveled during the test time.

So, based on the above observations an immediate action of strengthening is recommended for both RCC slab and steel girder members apart from vegetation clearance and providing proper drain water pipes.