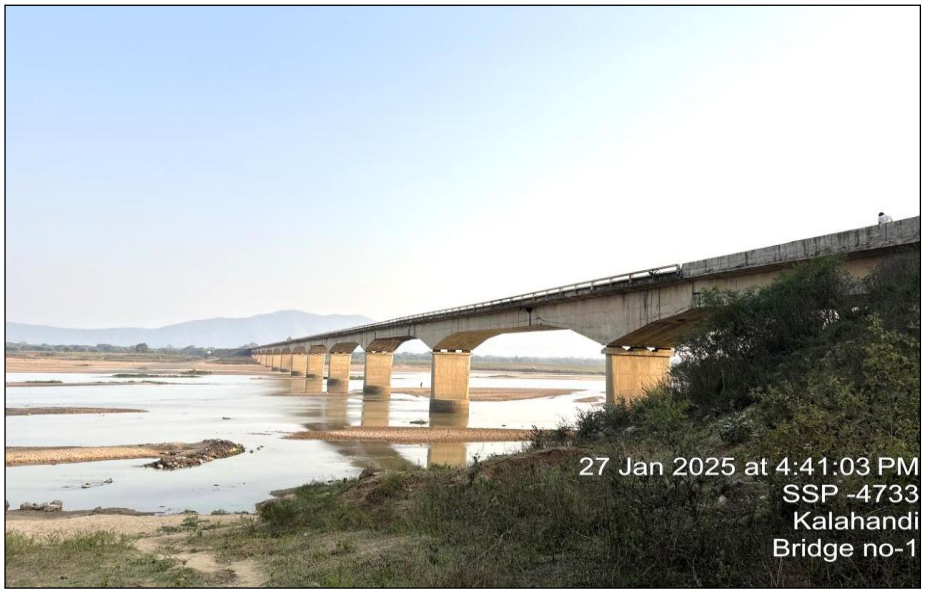
लोक निर्माण विभाग, ओडिशा सरकार के अंतर्गत, पुलों की आधुनिक परीक्षण प्रक्रियाओं का उपयोग करते हुए ओडिशा राज्य के रोड नेटवर्क के मेजर और माईनर ब्रिजो के स्थिति का आकलन और उपचारात्मक उपायों के लिए सुझाव

अंतिम रिपोर्ट

वॉल्यूम-3 : सेक्शन- 4

कालाहांडी डिवीजन के अंतर्गत भवानीपटना-खारियर रोड के 27+500 किमी पर स्थित एच एल टेल नदी ब्रिज की मरम्मत, पुनर्वास, रेट्रोफिटिंग उपायों और बीओक्यू के लिए सुझाव



प्रयोजक:

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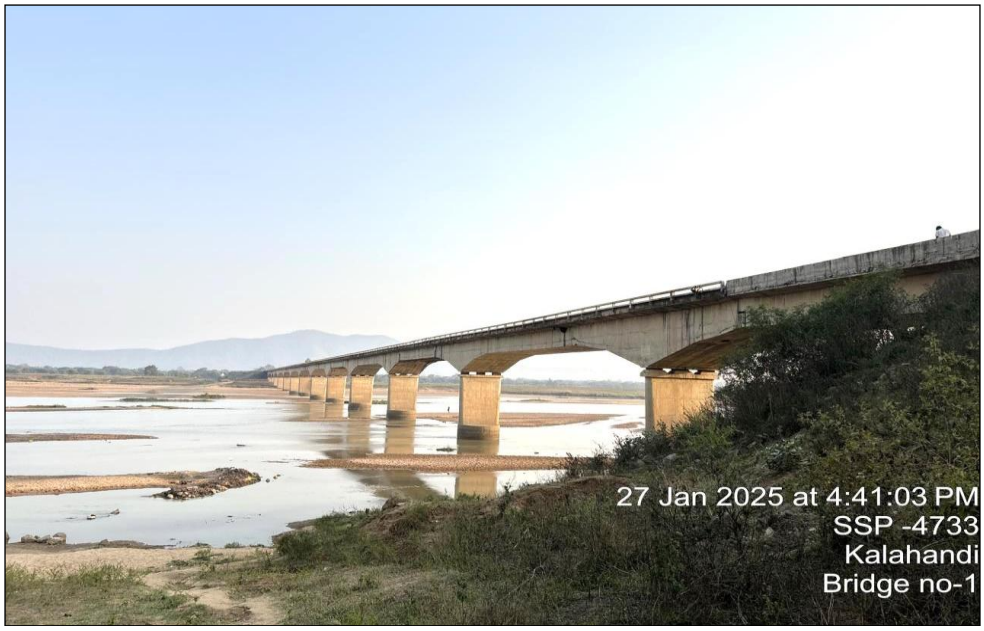
सीएसआईआर – केंद्रीय सड़क अनुसंधान संस्थान, नई दिल्ली-110025
फ़रवरी, 2026

Condition Assessment and Suggestions for Remedial Measures of Major and Minor Bridges of Odisha Road Network Using Modern Test Procedures of Bridges Under Public Works Department, Govt. of Odisha in the State of Odisha

Final Report

Volume-3 : Sec-4

Suggestions for Repair, Rehabilitation, Retrofitting Measures and BOQ For the H.L. Tel River Bridge at Ch. 27+500 of Bhawanipatna-Kharier Road under Kalahandi Division



Sponsored by:

Public Works Department
Government of Odisha
Bhubaneswar-751001

Bridge Engineering & Structures
CSIR – Central Road Research Institute, New Delhi - 110025

February, 2026

सीएसआईआर - केंद्रीय सड़क अनुसंधान संस्थान, नई दिल्ली
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अस्वीकरण

इस रिपोर्ट में प्रस्तुत सभी डेटा और तकनीकी जानकारी कार्यक्षेत्र में सम्पन्न अन्वेषणों और केंद्रीय सड़क अनुसंधान संस्थान (सीआरआरआई), नई दिल्ली की प्रयोगशालाओं में की गई जांच पर आधारित है। सी आर आर आई की जिम्मेदारी इस रिपोर्ट में शामिल तकनीकी और वैज्ञानिक मामलों तक ही सीमित है। इस रिपोर्ट के निष्कर्षों के आधार पर उचित कार्यान्वयन उपभोक्ता की जिम्मेदारी होगी।

उपभोक्ता के अलावा किसी अन्य एजेंसीया व्यक्ति द्वारा सी आर आर आई से परामर्श किए बिना रिपोर्ट के निष्कर्षों का कोई भी उपयोग पूरी तरह से उनके अपने जोखिम और जिम्मेदारी पर है।

DISCLAIMER

All the data and technical information furnished in this report are based on the investigations carried out in the field and at the laboratories of the Central Road Research Institute (CRRI), New Delhi. The responsibility of CRRI is limited to the technical and scientific matters contained in this report. Proper implementation based on the findings of this report will be the responsibility of the client.

Any use of the findings of the report without consulting CRRI by any other agency or person other than the client is solely at their own risk and responsibility.

प्रस्तावना

"लोक निर्माण विभाग, ओडिशा सरकार के अंतर्गत,ब्रिज की आधुनिक परीक्षण प्रक्रियाओं का उपयोग करते हुए ओडिशा राज्य के रोड नेटवर्क के मेजर और माईनर ब्रिजो के स्थिति का आकलन और उपचारात्मक उपायों के लिए सुझाव", शीर्षक वाली रिपोर्ट विभिन्न प्रकार के डी स्ट्रेस के विस्तृत निरीक्षण और उपचारात्मक उपायों की पद्धति, उपचारात्मक उपायों के लिए सुझाव और ब्रिज के लिए बी ओ क्यू और लागत अनुमानों पर संक्षिप्त टिप्पणियों से संबंधित है।

सीआरआरआई टीम ने 20 से 23 दिसंबर 2024, 27 से 31 जनवरी 2025 और 27 फरवरी 2025 को कालाहांडी डिवीजन के पुलों का प्रारंभिक इंस्पेक्शन किया गया। 10 जनवरी, 2026 को तेल ब्रिज का फिर से दौरा किया गया क्योंकि पुल के ऊपर से भारी कंसाइनमेंट गुजरने के बाद लम्बी दरारे रिपोर्ट की गई थीं।

यह रिपोर्ट डिटेल्ड विज़ुअल इंस्पेक्शन और अलग-अलग हिस्सों के लिए सुधार के तरीकों के सुझावों के बारे में संक्षेप में बताती है। इसके अलावा, संभावित फेलियर मैकेनिज्म की पहचान करने के लिए एक शुरुआती न्यूमेरिकल जांच की गई। फील्ड जांच के आधार पर, फेलियर के अलग-अलग कारणों की पहचान की गई है और इस रिपोर्ट में रिहैबिलिटेशन के उपाय बताए गए हैं। इस रिपोर्ट में कालाहांडी डिवीजन के तेल ब्रिज के BOQ और कॉस्ट एस्टिमेट के बारे में भी बताया गया है।

FOREWORD

The report entitled, "**Condition Assessment and suggestions for remedial measures of Major and Minor bridges of Odisha Road Network using Modern test procedures of bridges under Public Works Department, Govt. of Odisha in the State of Odisha**" deals with the brief observations on detailed inspection of various types of distresses and methodology of remedial measures, suggestions for remedial measures and BOQ & Cost Estimates for individual bridges.

CRRI team visited for the Preliminary and detailed inspection of bridges of the Kalahandi divisions on 20th to 23rd December 2024, 27th to 31st January 2025 and 27th Feb 2025. On 10th January, 2026 the Tel Bridge has been visited again as there were severe cracks reported after passing of heavy consignment over the bridge.

This report deals in brief the Detailed Visual Inspection, and suggestions of methodology of remedial measures for the distressed members of individual elements. Moreover, a preliminary numerical investigation was performed to identify the possible failure mechanism. Based on the field investigation various causes of failures have been identified and suitable strengthening measure have been provided in this report. The BOQ and Cost Estimates of the Tel bridge of Kalahandi Division are also described in this report.

ACKNOWLEDGEMENTS

We would like to thank Principal Secretary, **Public Works Department, Govt. of Odisha**, for sponsoring the project, **"Condition Assessment and suggestions for remedial measures of Major and Minor bridges of Odisha Road Network using Modern test procedures of bridges under Public Works Department, Govt. of Odisha in the State of Odisha".** We wish to record our appreciation to EIC- PWD Odisha and CE (Bridges) for providing support and cooperation. We are also grateful, in particular, to Dr. NC Pal, Former EIC (PWD) and now advisor to PWD, Govt of Odisha for his active participation at all level in smooth conduct of the investigation works. Thanks are also due to Er.Purna Mahapatra, Er D. C. Behra, Er. Sameer Hota, for the co-operation extended to the CRRI team during inspection and testing of the bridges. We would also like to convey our thanks to Dr. Subhransu, Er. Gyana Praksh Nayak, Er. Ashutosh Jena, Balangir and all the Co-ordinating officials and field staffs of various PWD division and their team for the co-operation in various site activities during the Inspection ad Testing of the Structures.

Thanks are also due to all the CSIR-CRRI officials who have directly or indirectly helped in carrying out the various activities related to this project work.

Condition Assessment and suggestions for remedial measures of Major and Minor bridges of Odisha Road Network using Modern test procedures of bridges under Public Works Department , Govt. of Odisha in the State of Odisha

Volume-3 : Sec-4

Suggestions for Repair, Rehabilitation, Retrofitting Measures and BOQ For the H.L. Tel River Bridge at Ch. 27+500 of Bhawanipatna-Kharier Road under Kalahandi Division

CONTENT

Condition Assessment and suggestions for remedial measures of Major and Minor bridges of Odisha Road Network using Modern test procedures of bridges under Public Works Department , Govt. of Odisha in the State of Odisha

Volume-3 : Sec-4

Suggestions for Repair, Rehabilitation, Retrofitting Measures and BOQ For the H L Tel River Bridge at Ch. 27+500 Km of Bhawanipatna-Kharier Road under Kalahandi Division

1.0 INTRODUCTION

The CSIR-CRRI offer for the **"Condition Assessment and suggestions for remedial measures of Major and Minor bridges of Odisha Road Network using Modern test procedures of bridges under Public Works Department , Govt. of Odisha in the State of Odisha"** dated 08/06/2023 was accepted by Public Works Department, Govt. of Odisha. The Public Works Department, Govt. of Odisha issued letter of award vide letter No. PMU-WB-58/2014-32560 dated 07th August, 2023 to CRRI. The condition assessment have to be carried out for 304 number of bridges either in the distressed state or more than 30 years old in the Odisha Road network under Public Works Department in the State of Odisha. These bridges are located in the 41 Civil Engineering Divisions of public works department.

Accordingly, CRRI team visited for the Preliminary and detailed inspection of bridges of the Kalahandi divisions on 20th to 23rd December2024, 27th to 31st January 2025 and 27th Feb 2025. On 10th January, 2026 the Tel Bridge has been again visited as there was severe distresses reported after passing of heavy consignment over the bridge. On detailed visual inspection of the structures, it has been noted that cracks of varying degree in some of the structural elements such as Pier heads, Box girders, girders abutments heads, bearing pedestals etc. observed. In addition to taking suitable rehabilitation measures to these structural defects, there is also need to stop the leakage of water through drainage spouts and expansion joints in almost all the locations of bridge. Areas of honeycombing, de-lamination and exposed reinforcement should also be treated properly. There is also need of cleaning of debris from all the pier heads and abutment heads and inside of the Box Girders.

This report deals in brief the Detailed Visual Inspection, and suggestions of methodology of remedial measures for the distressed members of individual elements as per prevailing guidelines of IRC: SP-18, IRC: SP-35, IRC-SP: 51, IRC-SP:37, IRC: SP-40 and other related

codes of IRC, MORTH, ACI 562-21 and EN-1504 etc. of the structures. The BOQ and Cost Estimates of the Tel bridge of Kalahandi Division are described in this report.

2.0 SCOPE OF WORK

The following scope of work was agreed upon between Public Works Department, Govt. of Odishaand CSIR-CRRI, New Delhi for the 304 old/distressed bridges in Road Network of Odisha:

- Preliminary and Detailed Visual inspection of the structures including distress mapping
- Review of available Technical Documents.
- Analysis of test data collected
- As per the condition of the various elements of structures and test results Suggestions for Rehabilitation Measures.
- Bill of Quantity

3.0 INSPECTION OF HL MAJOR BRIDGE OVER RIVER Tel AT KM 27+500 OF BHAWANIPATNA -KHARIAR ROAD

The Tel Bridge had been inspected and tested using Mobile Bridge Inspection Unit and Ladders. Photo 1 to 5 shows the typical views of condition of the various component of the bridge. The Tel bridge is comprises of 13 spans with total length about 500m. The GAD of the bridge is shown in Fig 1. As per the condition of the various components of the bridges suitable suggestions for repair, rehabilitation measures suggested. The detailed Methodology and specifications of repair materials are described in Section- 6 in this report. The BOQ and cost-estimate for the bridge is given in Appendix-1 of this report. The general observations are as follows:

(i) Cracks, leaching, exposed reinforcement and honeycombing observed from the deck slab in almost all the spans of the bridge.

(ii) At many locations on the deck slab repair of shear punching had been observed the same needs proper repair again to avoid further shear punching.

(iii) Flexure and shear cracks observed on all the box girders as well as girders.

(iv) At many locations at the suspended span and articulation joints; the bearings are not in working condition. It is observed that at some of the locations bearings locks and temporary supports are not removed, bearings miss aligned and full of debris all around bearings. Thus arms are resting on each other and bridge becomes continuous in the several spans.

(v) In case of Rocker-cum-cut Roller Bearings/Rocker-cum-Roller bearings the Tie plates are missing at several locations in the Piers and abutments. At some of the locations re-alignment of bearings are required. At some of the locations cracks have been seen on the bearing pedestal.

(vi) At some of the locations Rocker bearings/ Anchor plates are getting rusted; the same needs proper cleaning/replacement. At some of the locations cracks have been seen on the bearing pedestal.

(vii) Severe distresses observed in the span P11-P12 (as per OWD P1-P2) after passing of heavy consignment over the bridge. There is complete crushing of concrete at the severe distressed location. The tie reinforcement broken and main reinforcement bent-up at the distressed section. There is also isolation of

construction joints observed on the RHS (d/s) web in the severe distressed span of the bridge. The improper construction joint observed.

(viii) Severe cracks and honeycombing, long size cover blocks and exposed reinforcement observed in the simply supported spans with both side over hangs namely span A1-P1, P3-P4, P5-P6, P7-P8, P9-P10 and P11-P12 (As per OWD span numbers P1-P2, P3-P4, P5-P6, P7-P8, P9-P10and P12-A2 . These spans need proper strengthening measures.

(ix) From all the locations of expansion joints, the leakage of water seen in the bridge.

(x) Almost all the drainage spouts are leaking and not having sufficient projection.

(xi) Poor finishes observed at many locations such as surface unevenness, misaligned shuttering joints, honeycombing, etc. at the various locations on the bridge.

(xii) Weathering affects in the form of Cracks, spalling and exposed reinforcement also seen on the piers, abutment, Deck slab, Webs and soffit slab of the Box girders.

(xiii) Cantilever deck slabs are having cracks, spalling and severe exposed reinforcement in almost all the spans.

(xiv) At several locations Abutment and Pier heads are having a lot of debris materials and vegetation growth.

(xv) All bearings need proper cleaning and painting.

(xvi) At some of the location railings damaged, cracks, honeycombing and exposed reinforcement observed.

(xvii) At most of the locations Drainage Spouts not cleaned and water is accumulated on the deck slab on the bridge.

(xviii) At some of the locations at the top poor surface dressing seen around the bridge.

(xix) At some of the locations scouring around the piers observed.

(xx) At both the ends of the bridge dense vegetation growth observed.

(xxi) Severe cracks and exposed reinforcement observed on the wearing course.

(xxii) Top BC surface is having severe pot holes and cracks; there is a need of relaying of BC layer after removal of old layer and application of spray type waterproofing.

Photo 1: A D/S view of H.L Bridge at 27/500 Km on Bhawanipatna - Khariar Road in the Kalahandi Division.

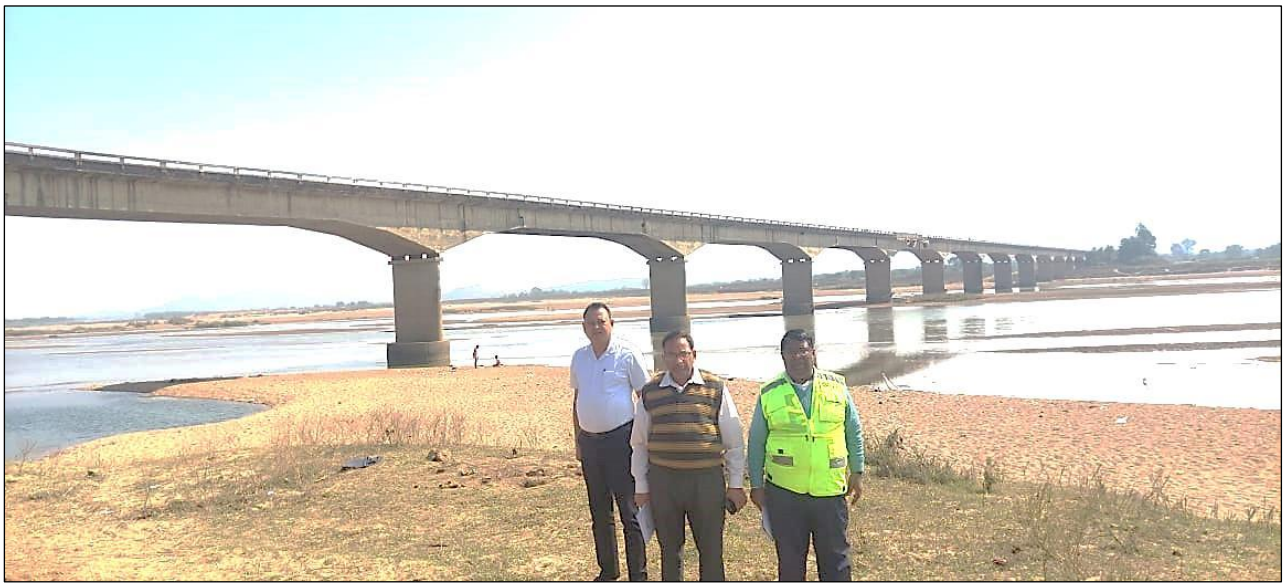


Photo 2(a): A U/S view of H.L Bridge at 27/500 Km on Bhawanipatna - Khariar Road in the Kalahandi Division.

Photo 2(b): A U/S view of H.L Bridge at 27/500 Km on Bhawanipatna - Khariar Road in the Kalahandi Division.

Photo 2(c): A view Inspection of distressed H.L Tel Bridge at 27/500 Km on Bhawanipatna - Khariar Road in the Kalahandi Division.

Photo 3: A view of joint Inspection through MBIU of H.L Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 4: A view of Inspection of Crack in box Girder in span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 5: A view of team Member on Carriageway of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

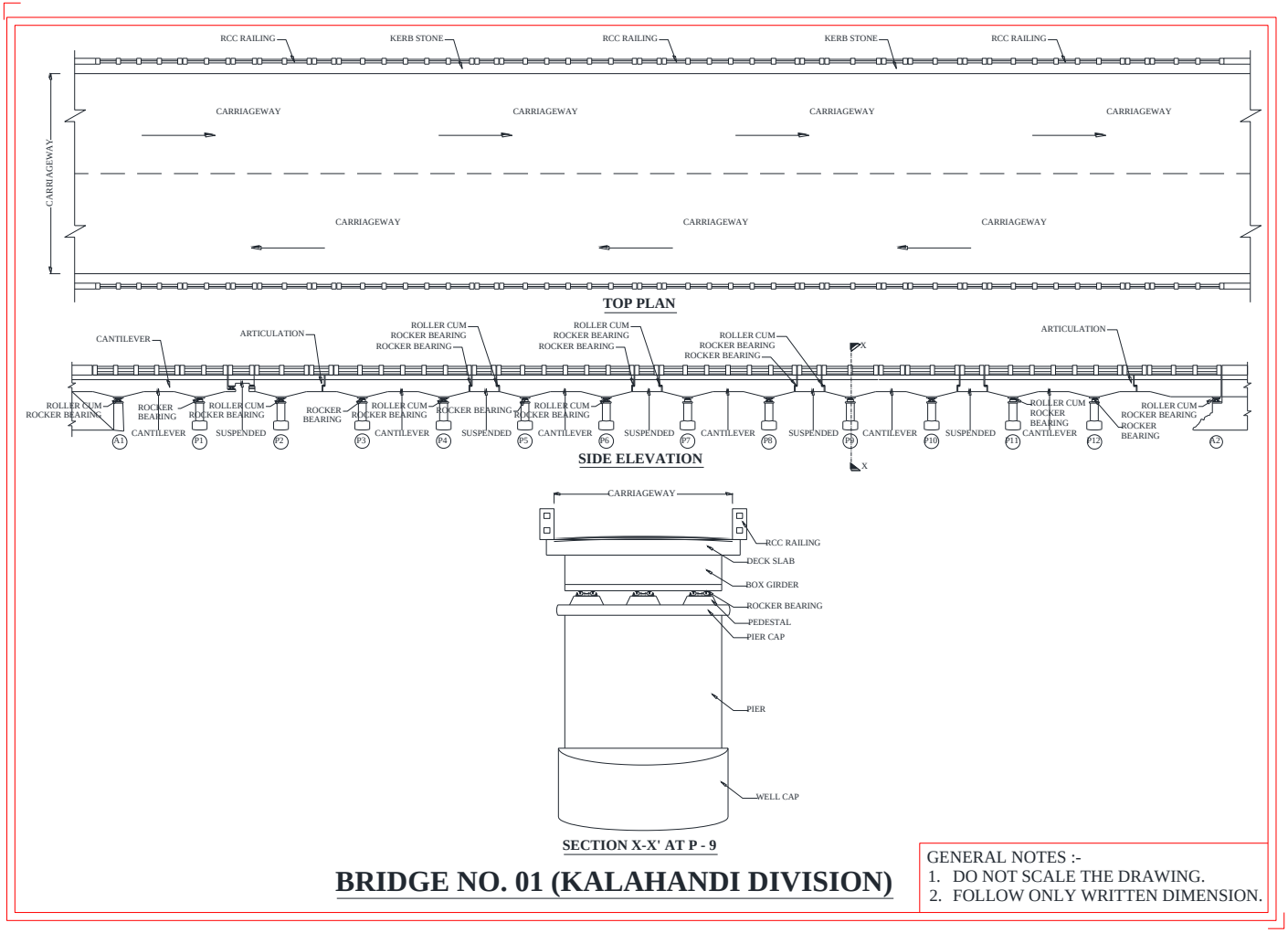


Fig.1: GAD of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

3.1 Inspection of the Span A1-P1 of HL Bridge at 27/500 Km

Photo 6 to 10 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 6: A view of Cantilever end towards A1 Side of the H.L Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division .

Photo 7: A view of expansion joint at Cantilever end towards A1 Side of the H.L Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

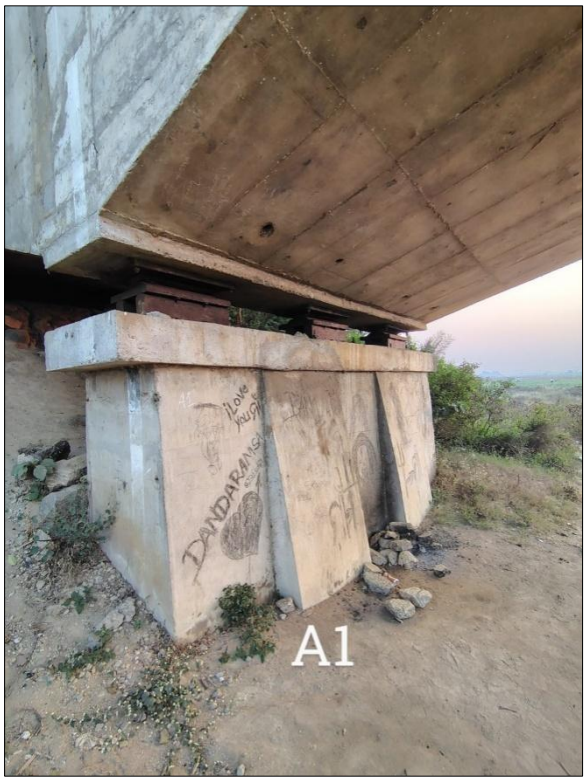


Photo 8: A view of Rocker-cum-Cut-Roller Bearing at Abutment A-1 of the H.L Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

(span 12-A2 as per OWD)

Photo 9(a): A view of cracks on Web(u/s) near Abutment A-1 in the span A1-P1 of the H.L Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 9(b): A view of Rocker-cum-cut Roller bearings at Abutment A-1 of the H.L Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 9(c): A view of Missing Tie plates in the Rocker-cum-cut Roller bearings at Abutment A-1 in the Tel Bridge of the Kalahandi Section.

Photo 9(d): A typical view of Missing Tie plates in the Rocker-cum-cut Roller bearings at Abutment A-1 in the Tel Bridge of the Kalahandi Section.

(span P12-A2 as per OWD)

Photo 10(a): A view of Shear Cracks in U/S near Pier P-1 in the span P1-A1 of Tel Bridge of the Kalahandi Section.

(span P12-A2 as per OWD)

Photo 10(b) : A view of Shear Cracks in U/S near abutment Abutment A-1 in the span P11-P12 of Tel Bridge of the Kalahandi Section.

(span P12-A2 as per OWD)

Photo 10(c):A view of Shear Cracks in U/S near Pier P-1 in the span P1-A1 of Tel Bridge of the Kalahandi Section.

Photo 10(d): A view of Shear Cracks in U/S near Pier P-1 in the span P1-A1 of Tel Bridge of the Kalahandi Section.

Photo 10(d): A view of Cracks in U/S in the span P1-A1 of Tel Bridge of the Kalahandi Section.

Photo 10(e): A view of cracks on U/S in the span P1-A1 of Tel Bridge of the Kalahandi Section.

3.2 Inspection in the Span P1-P2 of HL Bridge-1

Photo 11 and Photo 12 Show the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

(span P11-P12 as per OWD)

Photo 11: A view of leaching on gap slab in the span P1-P2 of the H.L Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 12(a):A view of Gap Slab in the span P1-P2 of Tel Bridge of the Kalahandi Section.

(span P11-P12 as per OWD)

Photo 12(b): A view of cracks on supporting cantilever arm of Gap Slab in the span P1-P2 Tel Bridge of the Kalahandi Section.

3.3 Inspection in the Span P2-P3 of HL Bridge-1

Photo 13 to 15 shows the typical views of condition of the various components of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 13: A view of cracks on the Web(u/s) in the span P2-P3 of the HL Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 14(a): A view of cracks on the Web (u/s) in the span P2-P3 of the HL Tel Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 14(b): A view of cracks on the web (u/s) in the Span P2-P3 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 14(c): A view of cracks on web in the Span P2-P3 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 15: A view of cracks on web near articulation in the Span P2-P3 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

3.4 Inspection in the Span P3-P4 of HL Bridge-1

Photo 16 show the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 16: A view of the Web (u/s) in the Span P3-P4 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

3.5 Inspection of the Span P4-P5 of HL Bridge-1

Photo 17 to 19 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders/girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 17: A view of Rocker bearing in suspended Span P4-P5 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 18: A view of Cracks on RHS Web near Pier P-5 in the Span P4-P5 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

Photo 19: A view of repaired shear punching on the deck slab near pier P-5 in the Span P4-P5 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

3.6 Inspection in the Span P5-P6 of the Bridge -1

Photo 20 to 27 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 20: A view of Cut-Roller-cum-Rocker bearing on Pier P-5 in the Span P5-P6 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 21: A view of cracks and honeycombing on Pier head at Pier P-5 in the Span P5-P6 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 22: A view of cracks on RHS Web in the span P-5-P6 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

Photo 23: A view of Cracks on RHS web in the span P5-P6 of H L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 24: A view of Cracks on RHS web in the span P5-P6 of H L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 25: A view of crack width measurement (0.40mm) on RHS web in the span P5-P6 of H.L Bridge at Km 27/500 on Bhawanipatna – Khariar Road in the Kalahandi Division.

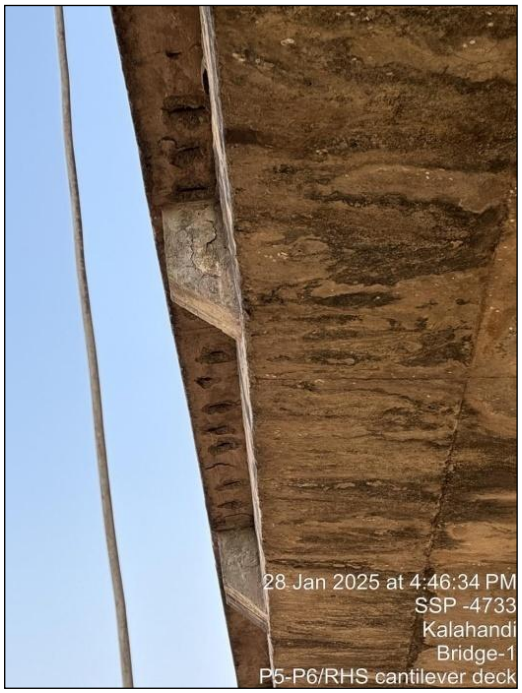


Photo 26: A view of cracks and exposed reinforcement on cantilever deck slab in the Span P5-P6 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

Photo 27: A view of cracks and exposed reinforcement and seepage through drainage spout on cantilever deck slab in the Span P5-P6 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

3.7 Inspection of Span P6-P7of the Bridge-1

Photo 28 to 49 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on

the deck slab. Flexure and shear cracks have been observed on the Box girders/girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 28: A view of horizontal cracks on Web at Pier P-6 in the Span P6-P7 of H L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 29: A view of crack on Cross girder Between girders G1-G2 near Pier P-6 in the Span P6-P7 of H.L Bridge at 27/500 Km on the Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 30: A view of Honeycombing on Girder-1 in the Span P6-P7 of H L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 31: A view of Cracks on Girder-1 in the Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 32: A view of Cracks on the Girder-1 in the Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 33: A view of Cracks on Girder-2 in the Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 34: A view of Crack on Girder-2 in the Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

Photo 35: A view of Cracks on Girder-2 in the Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division

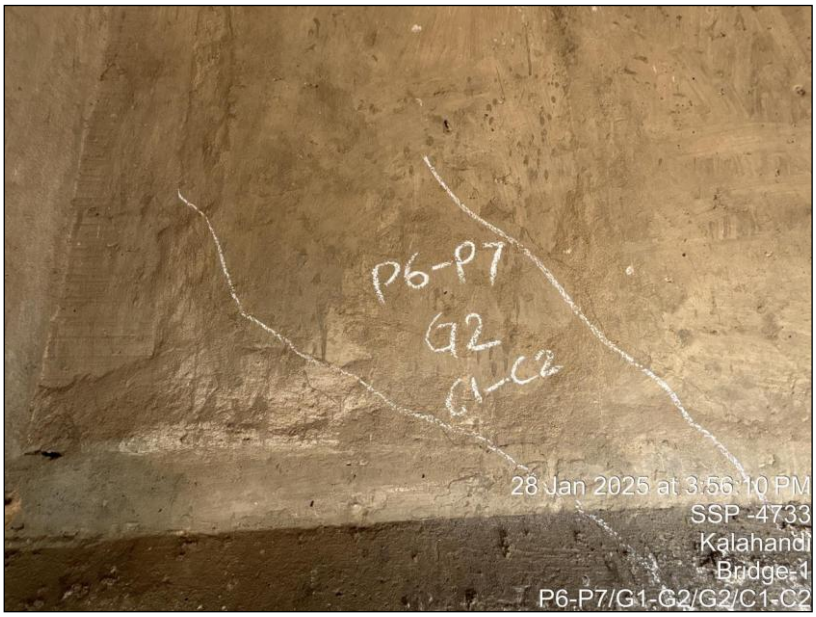


Photo 36: A view of Cracks on Girder G-2 between Cross Girder C1, C2 in the Span P6 P7 of HL Bridge at Km 27/500 on the Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 37: A view of Deck Slab Between girder G1-G2 and Cross girder C2-C3 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 38: A view of Crack on RHS web near Pier P-6 in the Span P6-P7 of HL Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 39: A view of Span P6-P7 of HL Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 40: A view of Cracks on middle web in cell-1 near Pier P-7 in the Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 41: A view of inspection inside RHS cell-1 near Pier P-7 of Box girder in the Suspended Span P6-P7 of HL Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 42: A view of leaching on Deck Slab in Cell-2 near Pier P-7of Box girder in the Suspended Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 43: A view of leaching on deck slab in cell-3 (longitudinal) of Box girder in the suspended Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 44: A view of leaching on Deck Slab in Cell-3 (longitudinal) of Box Girder in the suspended Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 45: A view of dampness in Cell-3 (longitudinal) of Box girder in the suspended Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 46: A view of projected reinforcement on web in cell-3 (longitudinal) of Box Girder in the Suspended Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 47: A view of cracks and leaching on Deck Slab in Cell-3 (longitudinal) of Box girder in the suspended Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 48: A General view of projected reinforcement on RHS wall of Cell-3 (longitudinal) in the suspended Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 49: A view of seepage on Deck Slab at Pier P-6 in Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

3.8 Inspection of Span P7-P8 of the bridge-1

Photo 50 to 85 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on

the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 50: A view of Roller-cum-Rocker bearing at Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 51: A view of Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 52: A view of Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 53: A view of Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 54: A view of Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 55: A view of Crack width measurement on RHS web in the Span P7-P8 of HL Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 56: A view of Crack on Web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 57: A view of Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 58: A view of Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 59: A view of Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 60: A view of 0.50mm Crack on RHS web in the Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 61: A view of 0.50mm Crack on RHS web in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 62: A General view of cracks on Middle wall of Cell-1 near Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division

Photo 63: A General view of cracks on RHS web in Cell-1 at Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 64: A view of crack on Deck Slab in Cell-1 of Box Girder near Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 65: A view of Cracks on Middle web of Cell-1 near Pier P-7 in the Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 66: A view of Deck Slab in Cell-1 near pier P-7 in the Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 67: A view of crack width measurement (0.40 mm) on Deck Slab of Cell-1 near Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 68: A view of crack width measurement (0.40 mm) on Deck Slab in Cell-1 in the Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 69: A view of Cracks on Deck Slab in Cell-1 in the suspended Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 70: A view of Crack on RHS web of Cell-2 near Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 71: A view of Cracks on mid wall in Cell-2 near Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 72: A view of deck slab in Cell-2 near Pier P-7 in the Suspended Span P7-P8 of HL Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 73: A view of Inspection inside of cell-2 of Box Girder near Pier P-7 In the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 74: A view of Inspection inside cell-2 of Box Girder near Pier P-7 In the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 75: A view of RHS web in Cell-2 near Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 76: A view of cell-2 of Box Girder near Pier P-7 In the suspended Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 77: A view of repaired shear punching patch work on Deck Slab in cell-2 near Pier P-7 In the suspended Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 78: A view of crack on Deck Slab in cell-2 near Pier P-7 in the Span P6-P7 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 79: A view of repaired shear punching of Deck Slab in cell-2 near Pier P-7 in the Span P7-P8 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 80: A view of seepage and cracks at deck Slab in cell -2 near Pier P-7 in the Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division .

Photo 81: A view of Crack on Deck Slab in cell-2 near Pier P-7 in the Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division .

Photo 82: A view of repaired patch work on Deck Slab near Pier P-7 in the Span P7-P8 of H.L Bridge at Km 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 83: A view of vegetation growth on the Cantilever portion in the Span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 84: A view of cracks and damaged bracket of supporting railing in the RHS cantilever in the span P7-P8 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 85: A view of cracks and exposed reinforcement on RHS cantilever deck Slab in the span P7-P8 of HL Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

3.9 Inspection of Span P8-P9 of the HL Bridge-1

Photo 86 to 101 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders/girders of the

bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 86: A view of bearing at Pier P-8 in the Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 87: A view of bearing at Pier P-8 in the Span P8-P9 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 88: A view of Crack on Girder G-3 at Pier P-8 in the Suspended Span P8-P9 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 89: A view of Crack on RHS web near Pier P-8 in the Suspended Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 90: A view of Crack on RHS web near Pier P-9 in the Suspended Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 91: A view of Crack on RHS web at Pier P-9 in the Suspended Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 92: A view of Crack on RHS web near Pier P-8 in the Suspended Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 93: A view of Crack on RHS web near Pier P-8 in the Suspended Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 94: A view of Crack on RHS web near Pier P-8 in the Suspended Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 95: A view of Patch repair and exposed reinforcement on Deck Slab in RHS cell-3 near Pier P-9 in the Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 96: A view of deck slab in the Span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

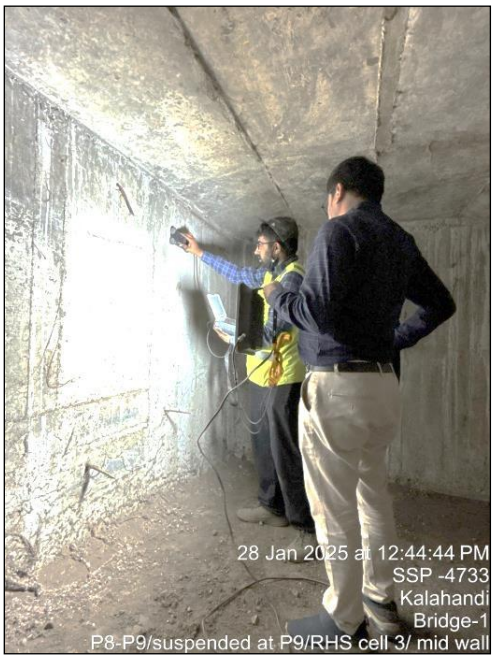


Photo 97: A view of cover meter test on RHS web wall in cell-3 (longitudinal) at pier P-9 in the Span P8-P9 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 98: A view of Rebound hammer test on RHS web wall in cell-3 (longitudinal) at pier P-9 in the Span P8-P9 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 99: A view of inspection of bearings in the Span P8-P9 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

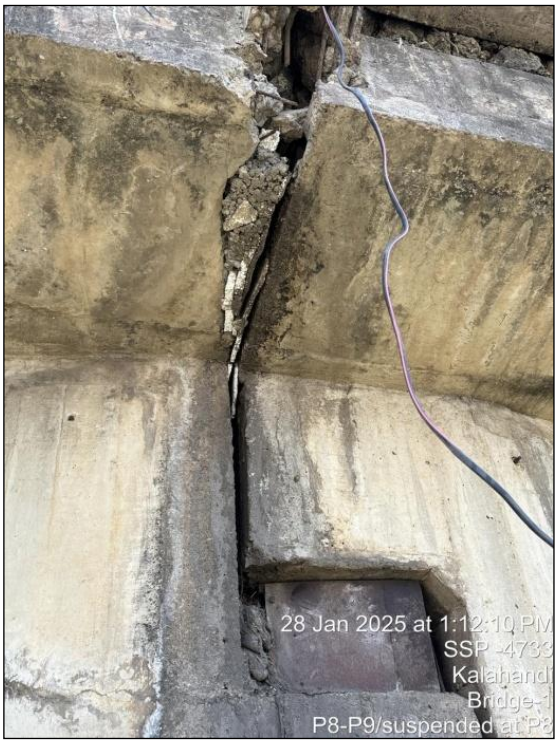


Photo 100: A view of leakage through expansion joint in the span P8-P9 of H.L Bridge at Km 27/500 on Bhawanipatna-Khariar Road in the Kalahandi Division.

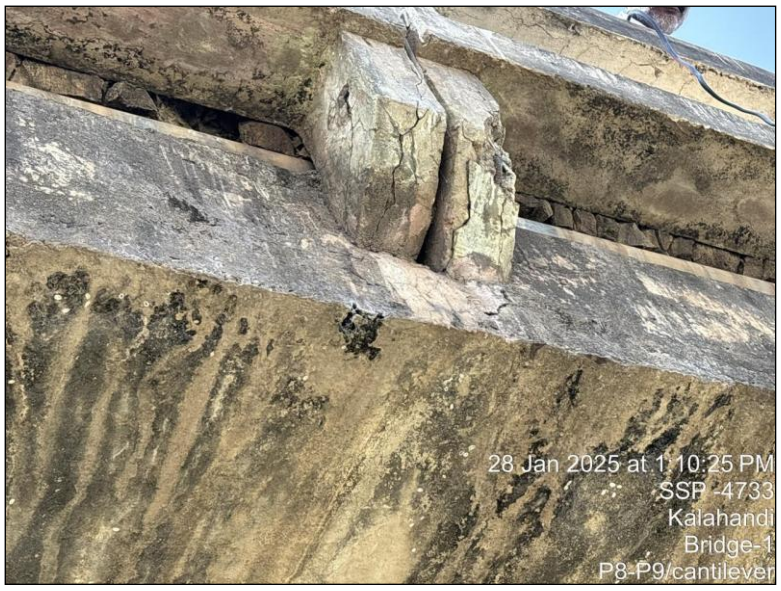


Photo 101: A view of Cracks on supporting bracket of railing in the span P8-P9 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

3.10 Inspection of Span P9-P10 of the HL Bridge -1

Photo 102 to 118 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 102: A view of Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 103: A view of bottom surface of girder near Pier P-9 in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 104: A view of crack on RHS web in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 105: A view of scouring at Pier P-8 in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 106: A view of crack on RHS web in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 107: A view of crack on RHS web in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 108: A view of Seepage through drainage spout on RHS web in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 109: A view of Pier P-9 in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 110: A view of bottom surface near Pier P-10 in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 111: A view of cracks and Exposed Reinforcement on soffit slab in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 112: A view of scouring at pier P-10 in the Span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

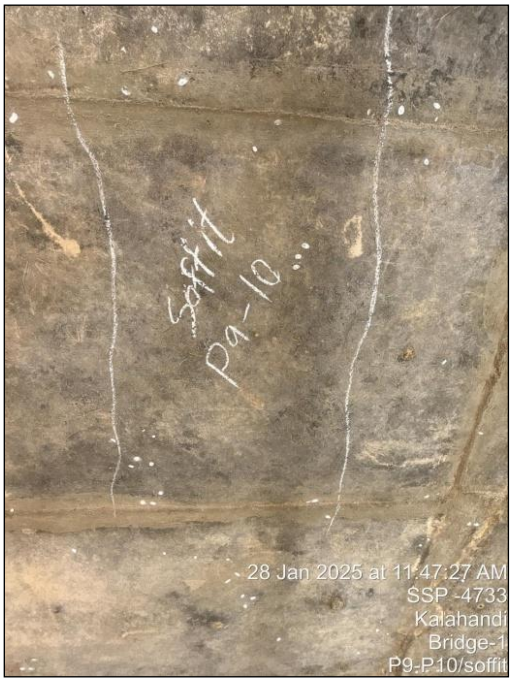


Photo 113: A view of Crack on Soffit in the span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 114: A view of carbonation depth measurement (30mm) on RHS Soffit in the Span P9-P10 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

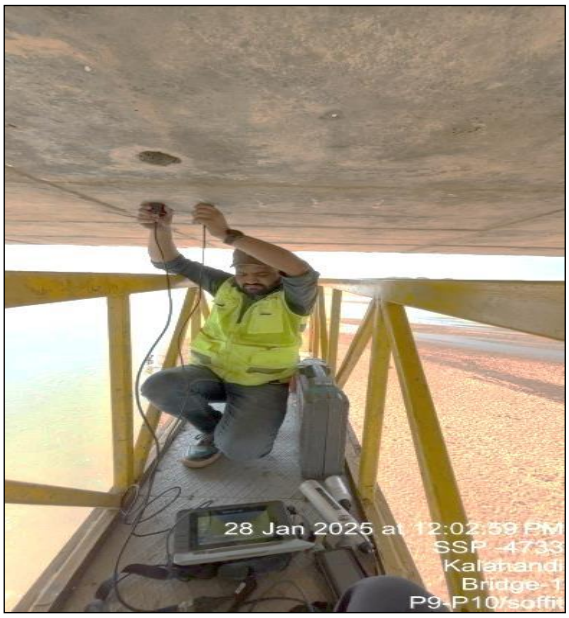


Photo 115: A view of UPV test on Soffit slab in the span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 116: A view of cover measurement on Soffit Deck slab in the span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

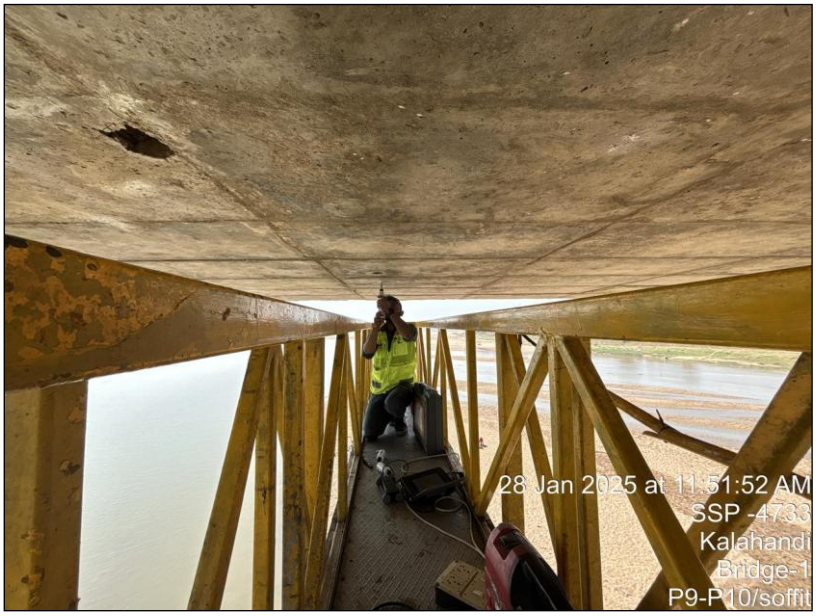


Photo 117: A view of Rebound hammer test on Soffit slab in the span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 118: A view of Pier P-10 in the span P9-P10 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

3.11 Inspection in the Span P10-P11 of the H.L Bridge-1

Photo 119 to 135 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 119: A LHS view of suspended span in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 120: A RHS view of suspended span in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 121: A view of Pier P-10 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 122: A view of cracks on RHS web in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 123: A view of Inspection of Roller bearing of Suspended span in the span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 124: A RHS view of Suspended span in the span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 125: A view of leaching on deck slab between girders G1-G2 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 126: A view of leaching on deck slab between girder G2-G3 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 127: A view of leaching on deck slab between longitudinal girder G2-G3 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 128: A view of girder G2 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 129: A view of leaching on Deck slab between girders G1-2 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 130: A view of leaching on Deck slab between girders G2-G3 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 131: A view of Pier P-10 in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 132: A view of leaching on Soffit slab in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 133: A view of leakage on cantilever deck Slab through Expansion joint in the Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 134: A view of Rocker Bearing on Suspended Span P10-P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 135: A view of vegetation growth on railing Support of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

3.12 Inspection in the Span P11-P12 of the Bridge-1

Photo 136 to 162 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders/girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning. This span is the severely damaged span due to movement of the heavy consignment as informed by the officials at site. At the severely damaged cross section it is observed that the section is having many big sizes cover blocks, honeycombing concrete and improper construction joints. As informed a group of 4 trailers carrying heavy gross load had been taken over the Tel Bridge without maintaining the gaps between the Trailers. Thus it appears that the heavy loads as well as less effective cross section of the bridge is the main reason of failure.

(Severe distressed Span P1-P2 as per OWD)

Photo 136: A Top view of Severe distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

(Severe distressed Span P1-P2 as per OWD)

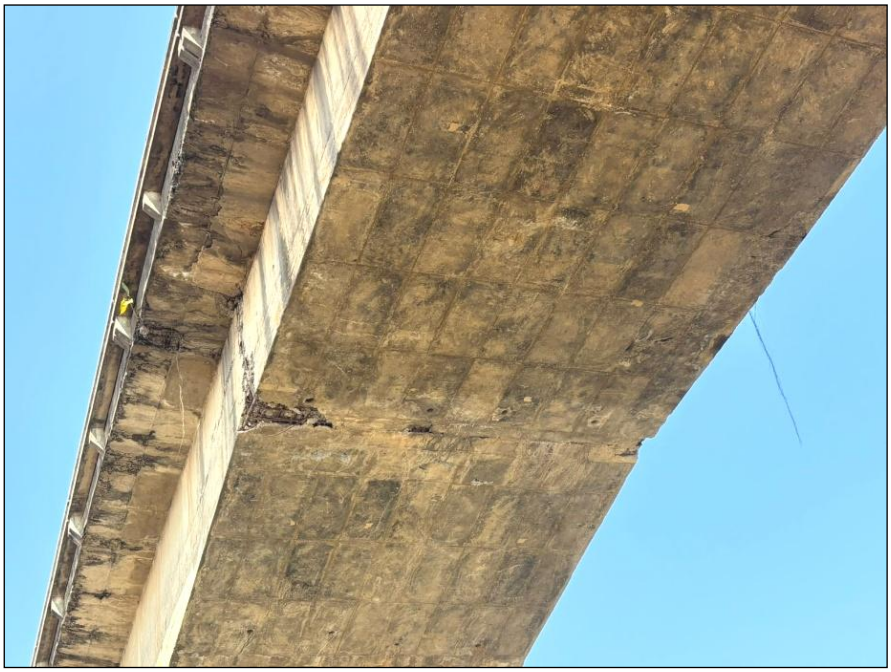
Photo 137:A top view of distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

(Severe distressed Span P1-P2 as per OWD)

Photo 138: A LHS (u/s) view of Severe distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

(Severe distressed Span P1-P2 as per OWD)

Photo 139: A LHS (u/s) view of Severe distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.



(Severe distressed Span P1-P2 as per OWD)

Photo 140: A bottom view of Severe distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 141: A LHS (u/s) view of Severe distressed web in Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

(Pier P-1 OWD)

Photo 142: A view of well foundation at Pier P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

(Pier P-2 OWD)

Photo 143:A view of well foundation at Pier P11 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

(Pier P-2 OWD)

Photo 144: A view of Rocker cum Roller bearings at Pier P-11 in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Before distress 27th Jan, 2025

Photo 145: A view Crack on the RHS web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Before distress 27th Jan, 2025

Photo 146: A view of construction joint on the RHS web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Before distress 27th Jan, 2025

Photo 147: A view of construction joint on the RHS web in the span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Before distress 27th Jan, 2025

Photo 148: A view of Horizontal construction joint on the RHS(d/s) web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

(Severe distressed Span P1-P2 as per OWD)

Photo 149: A view of severe distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 150: A view of distressed Horizontal construction joint on the RHS(d/s) web and , big cover block in the Span P11-P12 of H L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Before distress 27th Jan, 2025 **After distressed 10th January,2026**

Photo 151: A view of construction joint on the RHS web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Before distress 27th Jan, 2025 **After distressed 10th January, 2026**

(Severe distressed Span P1-P2 as per OWD)

Photo 152: A view of Crack on the RHS (d/s) web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Before distress 27th Jan, 2025 After distressed 10th January, 2026

Photo 153: A view of Crack on the RHS(d/s) web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 154: A view of Crack on the distressed LHS web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 155: A view of Cracks on the distressed RHS web in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 156: A LHS (u/s) view of cantilever deck slab of distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 157: A LHS (u/s) view of distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 158: A view of long cover block on u/s web of distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 159: A view of side drains on u/s web of distressed Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 160: A view of RHS Cantilever Deck Slab in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 161: A view of distressed d/s soffit in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

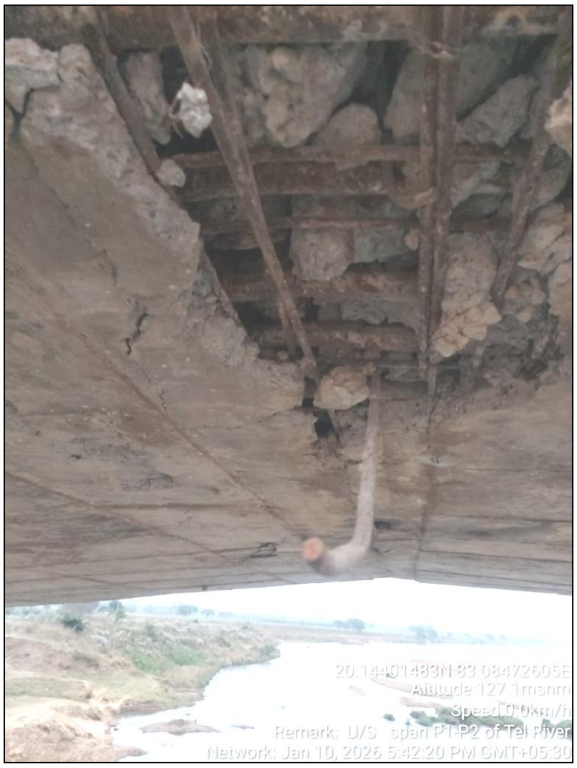


Photo: 162: A view of distressed soffit in the Span P11-P12 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

3.13 Inspection in the Span P12-A2 of the H.L Bridge-1

Photo 163 to 182 shows the typical views of condition of the various component of the bridge span. There are cracks, leaching, and honeycombing, spalling and exposed reinforcement on the deck slab. Flexure and shear cracks have been observed on the Box girders/girders of the bridge. Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 163: A view of Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 164: A view of Joint Inspection of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

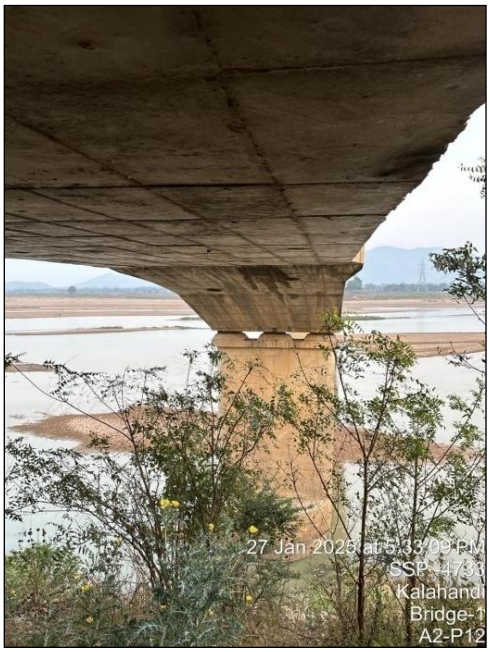


Photo 165: A view of Bottom Deck Slab near Pier P-12 in the Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

(Span A1-P1 as per OWD)

Photo 166: A view of Span P12-A2(u/s) of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

(Span A1-P1 as per OWD)

Photo 167: A view of Span P12-A2 (d/s) of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 168: A view of Rocker Bearing B-1 at articulation joint near Pier P-12 in Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

(Span A1-P1 as per OWD)

Photo 169: A view of Rocker Bearing B-1 at articulation joint near Pier P-12 in Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 170: A view of Rocker Bearing in the Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

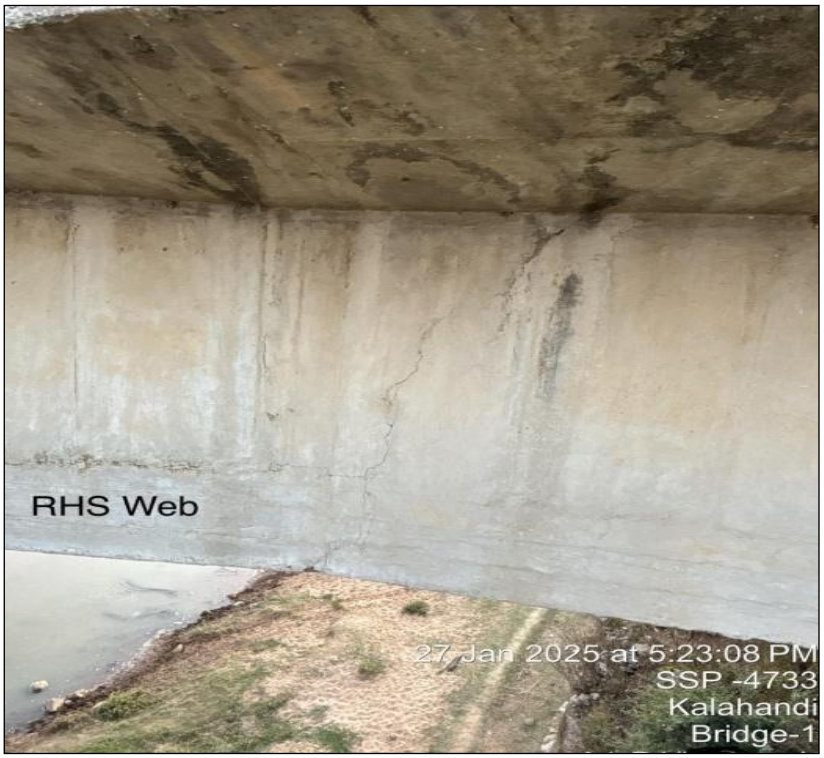


Photo 171: A view of Crack on RHS web in the Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

Photo 172: A view of Crack on RHS web in the Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

Photo 173: A view of from Expansion Joint at the articulation in the Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 174: A view of Exposed Reinforcement at the Bottom of Cantilever Deck Slab in span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 175: A view of Exposed reinforcement and Honeycombing on Crash barrier in the Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna–Khariar Road in the Kalahandi Division.

Photo 176: A view of Exposed reinforcement and Honeycombing on RHS Crash barrier in the Span P12-A2 of H.L Bridge at 27/500 Km on Bhawanipatna – Khariar Road in the Kalahandi Division.

Photo 177: A view of debris accumulated near around Roller-Cum-Rocker Bearing B-1 at Abutment A-2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 178: A view of debris accumulate near Roller-Cum-Rocker Bearing B-2 at Abutment A-2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

Photo 179: A view of debris accumulated near Roller-Cum-Rocker Bearing B-3 at Abutment A-2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 180: A view of debris accumulated at Abutment A-2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 181: A view of Abutment A-2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 182: A view of Expansion joint and Exposed Reinforcement near Abutment A-2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division.

3.14 Inspection of Expansion Joints and drainage spouts

Photo 183 to 190 shows the typical views of condition of the Expansion joints and drainage spouts on the span of the bridge are found not functioning.

Photo 183: A view of damage Expansion joint at abutment A2 of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 184: A view of Expansion joint fill with dust of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 185: A view of Expansion joint fill with dust of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 186: A typical view of leakage through Expansion joint of H.L Bridge at Km 27/500 on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 187: A typical view of leakage through Expansion joint of H.L Bridge at Km 27/500 on Bhawanipatna-Khariar Road in the Kalahandi Division

3.15 Inspection of Drainage spouts

Photo 189: A typical view of drainage spout of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

Photo 190: A typical view of drainage spout of H.L Bridge at 27/500 Km on Bhawanipatna-Khariar Road in the Kalahandi Division

4.0 PRELIMINARY NUMERICAL MODELLING AND ANALYSIS

It is to be noted that the calculations are part of the preliminary analysis for finalizing the qualitative strengthening measures. The exact details can be obtained by detailed analysis where exact mapping of the current geometry of the bridge and reinforcement details are required. It is also to be noted that this work is not currently in the scope of work of CRRI.

In order to investigate the possible cause of failure of bridge, numerical modelling was performed using finite element (FE) software MIDAS Civil (refer Annexure 2). From the numerical investigation it was concluded that the combined effect of non-functional bearings and consecutive movement of heavy consignment over the bridge may have caused the failure of the bridge superstructure at the location where the effective section was less to resist the applied shear forces and moments.

The existing and strengthened capacity of the distressed box section has been analysed using section designer in ADSEC software. The corresponding details are presented in a separate file with the numerical results.

5.0 SUGGESTIONS FOR REPAIR/STRENGTHENING MEASURES OF STRUCTURE

Almost all the components of the structures have been inspected through Mobile Bridge Inspection Unit and Ladders. Conditions of the various components of the structures are shown in Photos in Section-4 and distresses observed have been listed in Section 4. The Section-5 described the detailed methodology for the strengthening measures.

The detailed Visual Inspection and tests on the major bridge leads to repair, rehabilitation and strengthening measures as detailed in Para-5. The executing agency should prepare detailed working drawings and execution methodology for each work to be executed and implement only after approval of the Engineer-in-Charge/ CSIR-CRRI/ a reputed Institute.

The broad technical specifications and methodologies are given in Para-5. The rehabilitation & strengthening measures suggested in the report is based on visual examinations accompanied with series of tests, distresses seen etc. Accordingly, damages were assessed and remedial measures of structural members are suggested. It is suggested that these measures should be preferably taken up after adopting proper support, barricading the area along with safety measures including stoppage of traffic/diversion of traffic. The scaffolding

etc. must be provided properly. The load transferring mechanism of temporary support system must be ensured. The rehabilitation/strengthening measures shall be taken up as per technical specifications detailed in Para-5 above, IRC specifications and good repair and rehabilitation practices. The methodology suggested in Para-5 can be changed by the suitable alternate better proposal and to be adopted only after vetting by the CSIR-CRRI, New Delhi/reputed organizations.

Before start of repair/strengthening measures the traffic should be diverted properly and well-designed support system to be erected. Proper reaction frames have to be designed along with suitable capacity jacks with centralized power pack system to be used for lifting the super structure for replacement of bearings and reconstruction of distressed spans of the Tel Bridge.

Keeping in view the nature of distresses in superstructure elements, the repair strategy has been devised into three category namely: (i) Span P11-P12,damaged/failed partially- where repairs also attempted for the dislocated superstructure length by recasting the affected portion and providing other repairs and strengthening measures, (ii) Super structure spans of continuous types where similar distresses have been observed and (iii) Suspended spans. The remedial repair/strengthening measures to be adopted for the various defects observed on the structures are detailed below:

5.1 Strengthening Measures for Severely Distressed Section in Span P11-P12

In the span P11-P12 (span P1-P2 as per OWD), there is severe distressed including partial collapse of box section observed in the form of crushing of concrete due to severe honeycombing, improper construction joint, reduced cross sections due to several longer length of cover blocks varying from 30cm to 45 cm put in the same section, passing of heavy consignment over the bridge. It is also observed that on the first lift and second lift of webs the construction joints clearly visible and concrete not reached properly which also leads to separation between soffit and webs in the distressed span P11-P12. This can also be seen in other spans but with lesser severity. There is level difference between 100mm to 150mm and torsional rotation of box girder due to failure of box section also observed at the distressed location in the span P11-P12.

In general, in visual inspection honeycombing, patch work, shear and flexure Cracks, exposed reinforcement have been observed at various locations on the box girder. The following methodology to be adopted for repairing of above Box girder :

(a) Before starting the rehabilitation work of the failed span P11-P12 as per the report (P1-P2 as per PWD identification), the span at P11-P12 and its adjacent spans i.e. P10-P11 and P12-A2 should be properly supported. For providing support, a well designed scaffolding system should be approved by the Engineer-in Charge to cover the influence lengths to avoid distresses in adjacent spans as there is load transfer mechanism. Preferably, supports may rest on a well designed and tested river bed after diversion of water, as there is hardly any space on Piers to erect the supporting struts/frame. The Engineer-in Charge should ensure that the bearing capacity of the river bed is sufficient to take the load of the scaffolding system.

(b) The major affected length of the Box girder (P11-P12) where the deformation/distortion has occurred, to be dismantled beyond 1m on either side. The dismantling of entire box section has been assumed by 3m. A proper records of existing reinforcement which is MS bars to be kept before fixing the up new TMT (550D) reinforcement with adequate laps or couplers. After removal of affected box section, a new box section of same design with fresh reinforcement to be recast for about 3m length with M-35 grade of concrete. The lap length with old and existing reinforcement shall be provided accordingly by couplers or otherwise as shown in Photo 191 (Refer **Annexure-I** also). The reinforcement in extra chipped portion shall be treated for corrosion before placing new concrete as per suggested methodology. (Refer methodology no. 6.3 at Vol. 2).

(c) Since there is sagging/settlement and distortion of the said span, a profile correction shall also be carried out in line with original bridge geometry before placement of new reinforcement and fresh concrete.

(d) The girder has also been subjected to horizontal separation between web and soffit to a large extent specially on RHS face (d/s). The repair methodology with micro-concrete for the same is given at Section 6.3 of Vol. 2. Similarly at the portion where such large voids and empty pockets of web and soffit connection have been found are to be treated.

(e) The cracks in remaining portion the box girders including the deck slab to be repaired by pressure grouting as detailed in the Section 6.2 of Vol 2. The honeycombed areas also have to be also pressure grouted as detailed in Section 6.2 of Vol 2.

(f) Shear punched areas of the deck slabs shall be recast (refer methodology at 6.3 of Vol 2). The patch area around the shear punched area including 150mm all around shall be dismantled and reconstructed with M35 concrete. If required, the existing reinforcement to be replaced with the steel bars with couplers. \

(g) In general during visual inspection exposed reinforcement, spalling of concrete, localized leaching and cracks seen on the deck slab on various spans. There are some local damages in some of the spans. The following measures to be adopted:

- The damaged surfaces to be repaired up to 40mm depth by the polymer mortar as detailed in the Section 6.1 and beyond 40mm depth by the polymer concrete as detailed in Section 6.3.
- Cracks, leaching to be sealed through pressure grouting as detailed in section 6.2 .
- The localized cracked Deck slab to be strengthened using CFRP wraps as detailed in section 6.6.

(h) Keeping in view the failure pattern of the box section, the distressed section may also be strengthened through Ultra-High Strength and High Performance Concrete with minimum 120 MPa compressive strength jacketing of 50 mm all around (Annexure 1) in the 5m length in affected section of the box girder. Since this section is rebuilt in 3m length in P11-P12, the extra width of 50mm shall be extended from the new reinforcement. For remaining length (1m either sides), the provision of shear connector shall be made after chipping the existing concrete.

(i) In addition to above, as a part of strengthening measure, the affected box girder to be provided with prestress CFRP laminates (10% pre-stress force) and WRAPS using CFRP fabrics as per section 6.7 of Vol 2 (and in detail mentioned in Annexure 1). The properties of CFRP laminates and wrapping has been mentioned in Table 1 and Annexure-I.

(j) The cracked Diaphragm to be strengthened by FRP as detailed in Section 6.8 of Vol 2.

(k) Other provisions like replacement of expansion joint, cleaning, greasing and resetting of bearings, repairs/replacement of crash barriers, bridge deck water proofing, fixing of drainage spouts and fresh PMB BC course shall apply.

(l) For repair and resetting of bearings, the methodologies shall be approved by Engineer-in-Charge.

(m) To validate the efficiency of the proposed strengthening measures, load test shall be carried out at P11-P12 span immediately after the repair.

(n) The bridge shall be restricted for plying of Extra heavy vehicle for future. A strict monitoring with height restricted (4.5 m) frame shall be erected on approaches of both sides.

Table 1 CFRP material properties.

DESCRIPTION	TENSILE STRENGTH (MPa)	TENSILE MODULUS (GPa)
CFRP LAMINATES **(100mm x 1.2mm thick)**	2300	165
CFRP DRY FABRIC **(400 GSM)**	4000	240

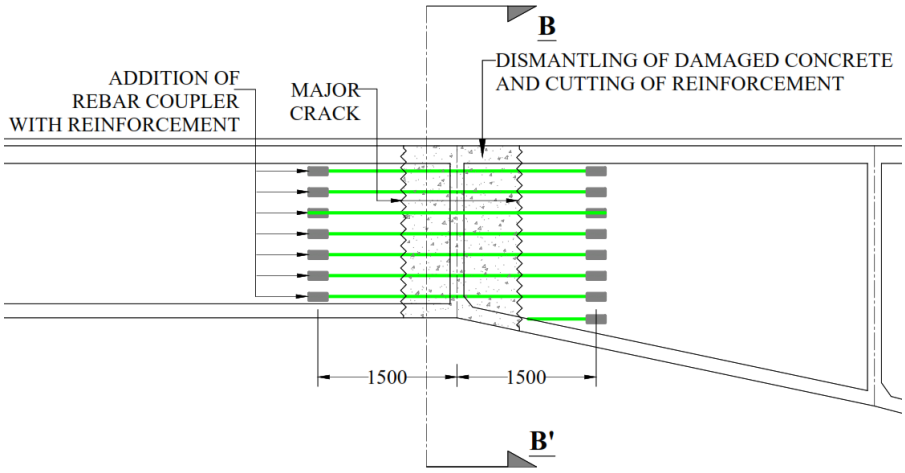


Photo 191 Details of repair methodology for major crack at highly distressed section between span P11−P12.

5.2 Strengthening Measures for other Continuous Spans

The distress observed in the critical span (P11-P12) can also be seen in other spans with lesser severity. During visual inspection honeycombing, patch work, shear and flexure Cracks, exposed reinforcement have been observed at various locations on the box girders

of other continuous spans. These spans are P9-P10, P7-P8, P6-P5, P3-P4, P2-P3, P1-A1 (as per OWD: P3-P4, P5-P6, P7-P8, P9-P10, P10-P11, P12-AR, respectively). The following methodology to be adopted for repairing of the above spans:

(a) The cracks in the box girders including the deck slab to be repaired by pressure grouting as detailed in the Section 6.2 of Vol 2. The honeycombed area also have to be also pressure grouted as detailed in Section 6.2 of Vol 2.

(b) Shear punched areas of the deck slabs shall be recast. The patch area around the shear punched area including 150mm all around shall be dismantled and reconstructed with M35 concrete. If required, the existing reinforcement to be replaced with the steel bars with couplers.

(c) In general during visual inspection exposed reinforcement, spalling of concrete, localized leaching and cracks seen on the deck slab on various spans. There are some local damages in some of the spans. The following measures to be adopted:

- The damaged surfaces to be repaired up to 40mm depth by the polymer mortar as detailed in the Section 6.1 and beyond 40mm depth by the polymer concrete as detailed in Section 6.3.
- Cracks, leaching to be sealed through pressure grouting as detailed in section 6.2 .
- The localized cracked Deck slab to be strengthened using CFRP wraps as detailed in section 6.6.

(d) The girder has also been subjected to horizontal separation between web and soffit at some locations. At the portion where such large voids and empty pockets of web and soffit connection have been found are to be treated as per section 6.3 of Vol 2.

(e) Keeping in view the chances of failure of the box section, the reduced section of the remaining continuous spans may also be strengthened through Ultra-High Strength and High Performance Concrete jacketing of 50 mm all around (**Annexure 1)** in the 5m length in reduced section of the box girder. The provision of shear connector shall be made after chipping the existing concrete.

(f) In addition to above, as a part of strengthening measure, the affected box girder to be provided with prestress CFRP laminates (10% pre-stress force)

and WRAPS using CFRP fabrics as per section 6.7 of Vol 2 (and in detail mentioned in Annexure 1). The properties of CFRP laminates and wrapping has been mentioned in Table 1 and Annexure-I.

(g) The cracked Diaphragm to be strengthened by FRP as detailed in section 6.8 of Vol 2.

(h) Other provisions like replacement of expansion joint, cleaning, greasing and resetting of bearings, repairs/replacement of crash barriers, bridge deck water proofing, fixing of drainage spouts and fresh PMB BC course shall apply.

(i) For repair and resetting of bearings, the methodologies shall be approved by Engineer-in-Charge.

5.3 Strengthening Measures for Suspended Spans

During visual inspection honeycombing, patch work, shear and flexure Cracks, exposed reinforcement have been observed at various locations of the suspended spans. These spans are P12-A2, P10-P11, P8-P9, P6-P7, P4-P5, P1-P2 (as per OWD: P1-AL, P2-P3, P4-P5, P6-P7, P8-P9, P11-P12 respectively). The following methodology to be adopted for repairing of the above spans:

(a) The cracks in the girders including the deck slab to be repaired by pressure grouting as detailed in the Section 6.2 of Vol 2. The honeycombed area also have to be also pressure grouted as detailed in Section 6.2 of Vol 2.

(b) In general during visual inspection exposed reinforcement, spalling of concrete, localized leaching and cracks seen on the deck slab on various spans. There are some local damages in some of the spans. The following measures to be adopted:

- The damaged surfaces to be repaired up to 40mm depth by the polymer mortar as detailed in the Section 6.1 and beyond 40mm depth by the polymer concrete as detailed in Section 6.3.
- Cracks, leaching to be sealed through pressure grouting as detailed in section 6.2 .
- The localized cracked Deck slab to be strengthened using CFRP wraps as detailed in section 6.6.

(c) In addition to above, as a part of strengthening measure, the affected box girder to be provided with prestress CFRP laminates (10% pre-stress force)

and WRAPS using CFRP fabrics as per section 6.7 of Vol 2 (and in detail mentioned in Annexure 1). The properties of CFRP laminates and wrapping has been mentioned in Table 1 and Annexure-I.

(d) The cracked Diaphragm to be strengthened by FRP as detailed in section 6.8 of Vol 2.

(e) Other provisions like replacement of expansion joint, cleaning, greasing and resetting of bearings, repairs/replacement of crash barriers, bridge deck water proofing, fixing of drainage spouts and fresh PMB BC course shall apply.

(f) For repair and resetting of bearings, the methodologies shall be approved by Engineer-in-Charge.

5.4 Strengthening Measures for Piers of the bridge

In general, in visual inspection localized Cracks have been observed at some locations on the piers. There is localized exposed reinforcement and spalling of concrete at some locations of the piers. Localized cracks are also found in the pier head of the pier. The following methodology to be adopted for repairing of piers:

(a) The top surface of pier head to be cleaned properly and repaired at the required locations up to 50mm depth by the polymer mortar as detailed in the Section 6.1 and beyond 50mm depth as detailed in Section 6.3.

(b) Cracks on the pier/pier head to be repaired by pressure grouting as detailed in the Section 6.2.

5.5 Strengthening Measures for Abutment Walls of structures

At some locations Cracks and exposed reinforcement have been observed on the abutment wall, local damages have also been observed on the abutment walls. The surfaces to be repaired as follows:

(i) By the polymer mortar /concrete as detailed in the section 6.1 & 6.3

(ii) Cracks to be pressure grouted as detailed in section 6.2.

5.6 Strengthening Measures for exposed well steining of the bridge

In general in visual inspection localized Cracks and leaching have been observed at some locations on the exposed well steining. There is localized exposed reinforcement and spalling of concrete at some locations of the well steining. The following methodology to be adopted for repairing of well foundation:

(a) The surfaces of well steining to be cleaned properly and repaired at the required locations up to 50mm depth by the polymer mortar as detailed in the Section 6.1 and beyond 40mm depth as detailed in Section 6.3.

(b) Cracks on the well steining to be repaired by pressure grouting as detailed in the Section 6.2.

(c) Well steining having larger area of exposed reinforcement to be shotcreted as per section 6.5.

(d) Boulder pitching around the exposed wells has to be carried out as scouring seen at some of the wells.

5.7 Expansion Joints on Structure

It is observed that the expansion joint gaps are filled with debris/ B C materials. The expansion joint seals are totally in-effective. Some of the expansion joints edge angles are damaged. The following are proposed:

(i) The expansion joints to be replaced by the new strip seal expansion joints.

(ii) Rubber seals to be inserted properly and get cleaned regularly.

5.8 Drainage Spouts

In general drainage spouts are not in a good condition. At all locations the drainage spouts are not functioning properly. All the mal functioning drainage spouts are required to be replaced with new one along with about 100cm projections at the bottom.

5.9 Railings walls

In general condition of the Railings/ Parapet walls are not good. At some of the locations proper repairing work have to be carried out; with polymer mortar/concrete as explained in section 6.1 and 6.3. Painting is also required. The 50% Railings seems to be replaced by new one.

5.10 Water Proofing

Spray type liquid waterproofing to be applied after proper surface preparation; before application of B C.

5.11 Bituminous Concrete

It is observed that there is a B C layer over the deck slab is not in a good condition. Re-laying of the mastic asphalt of 25mm thick over 40mm BC has to be carried out after removing the previous layers.

5.12 Approach Slab

In general no approach slabs are provided on both the end of the bridge. Some locations at the approach repairing work are required for smooth movements of traffic on both the ends of the structures. It is better to have approach slabs on both the ends of the structures of 3.5 m length with 300mm thick with M-40 grade of concrete

5.13 Road Safety devices:

Road marking, sign boards and glow studs to be provided to avoid accidents.

5.14 Anticarbonation painting:

After rehabilitation work the Abutment, Pier and super structure to be painted with Anticarbonation paints.

5.15 Stone pitching

The damages due to scouring around the well and abutment have to be pitched with boulder and cement grout. The stone pitching with cement grout has to be also done at both the ends of the bridge.

6.0 BILL OF QUANTITIES AND COST ESTIMATES

Based on visual inspection, test results, detailed strengthening methodology and measures recommended in Section- 5, the Cost Estimate has been prepared for the bridge. The detailed Cost Estimate and BOQ are given in Appendix-1 considering locally dismantling of the severe distressed affected stretch (about 3m) in the span P11-P12 after providing continuous support to the last three spans. The strengthening of the distressed stretch by Ultra High strength and high performance Concrete considered in the 5m stretch of the distressed location and similar location at other 11 points also considered in the Six Simply Supported spans with both side over hangs. The estimated cost of repair/rehabilitation/strengthening measure are provided in the BOQ. Generally in case of repair/rehabilitation work the estimated amount may vary 10 to 25% of the estimated values.

7.0 CONCLUSIONS

It is evident from the visual inspection, that the bridge has some issues during the construction, like using larger continuous cover blocks and honeycombing at the junction of soffit and web. In addition, cracks by honeycombing have been observed at the location where the section of the box girder was reduced. In several locations shear and flexural cracks, corrosion of reinforcement and spalling of cover concrete has been observed. The lack of timely inspection and measures also contributed to accumulation of defects in the bridge. The problem has been worsened with consecutive movement of heavy consignment over the bridge may have caused the failure of the bridge superstructure at the location where the effective section was less to resist the applied shear forces and moments. Also,

As described above severe cracks had been observed on all the box girders of the bridge. There is an urgent need to adopt Rehabilitation/Strengthening measures in piers, abutments and superstructures of the bridge as described in Para-5. There is also need of replacement of drainage spouts, bearings and expansion joints of the bridge.

In view of the existing severe cracks and distressed condition of the box girder of span P11-P12 of the bridge; to avoid failure of the bridge components and any miss happening/accident it is highly recommended that no traffic should be allowed on the bridge until the rehabilitation/strengthening measures have been successfully completed for the entire bridge length. Proper posting along with height barriers on both the bank of the bridge has to be immediately installed at the bridge site.

The following measures are proposed:

a) It is necessary to rehabilitate all the 13 spans of the bridge. Additionally, it is recommended to dismantle and reconstruct the severely distressed portion of span P11-P12 (3m length). Further, this severely distressed section is to be strengthened with Ultra high strength and high performance concrete jacketing about 50mm thick in about 5m length. To avoid the failure of other sections, 6 continuous spans are also to be strengthened in a similar manner.

b) To validate the efficiency of the proposed strengthening measures, load test should be carried out at P11-P12 span immediately after the repair.

c) After proper strengthening of the bridge, the competent authority should ensure to restrict the movement of heavy loaded/special vehicle.

d) Strengthening measures for other suspended, continuous spans and other structural elements of the bridge have also been suggested as per the visual inspection.

e) Parallel to existing bridge the construction of a new bridge is to be planned.

Suggestions for Implementation

(a) The experienced agency having at least 10 years of experience in the area of strengthening /rehabilitation/repairing of bridges and executed at least one work of 50% value of the requisite capacity should be selected. The proposed technical proposal (methodology and designed scheme for strengthening measures) by the executing agency to be vetted by CRRI or a reputed organization before implementation.

(b) It is suggested that during the implementation of strengthening works of structures, random visit of CRRI is desirable to ensure the compliance of the proper repair methodology. This is not included in the scope of present project.

(c) The suggested strengthening methodology is preliminary in nature and is not included in the scope of the present project.

(d) It is also suggested that the bridge have to be load tested and randomly checked through NDT after the execution of rehabilitation measures.

(e) All the undesired materials shall be removed from pier and abutment heads and from the inside of the box girders.

(f) Traffic should be diverted properly with all safety measures during the strengthening works of structures.

(g) Routine inspection at an interval of six months (Before and after Monsoon) and detailed inspection of the structures to be done after every three years. A proper inspection register has to be maintained for the bridge.

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Annexure 1

Assumptions made for Qualitative Strengthening Methodology in Tel Bridge

The following are the observations for strengthening measures for Tel Bridge:

1. The demand values and capacity calculations are not available as no reinforcement details are provided. The qualitative strengthening scheme is suggested.
2. The sagging moment capacity can be increased using the external bonding of prestress CFRP laminates (10% pre-stress force) at the soffit of the box girder and longitudinal girders in the suspended spans.
3. Shear strengthening can be carried out using the U wrap in the outer perimeter of the box and the interior perimeter of the twin cells.
4. For improving the hogging moment capacity, the CFRP laminate strengthening should be continued over the supports. It can be achieved by removing the wearing course and bonding the CFRP laminates on the top of the deck slab. In the view of complexity involved in the removing entire wearing course, strengthening at the soffit of the deck slab is proposed. It can be achieved by cross girders/diaphragm walls will be cut for a small portion (120 mm x 10mm depth) at the locations of the CFRP laminates.
5. The diaphragm junction will be further strengthened with CFRP fabric.

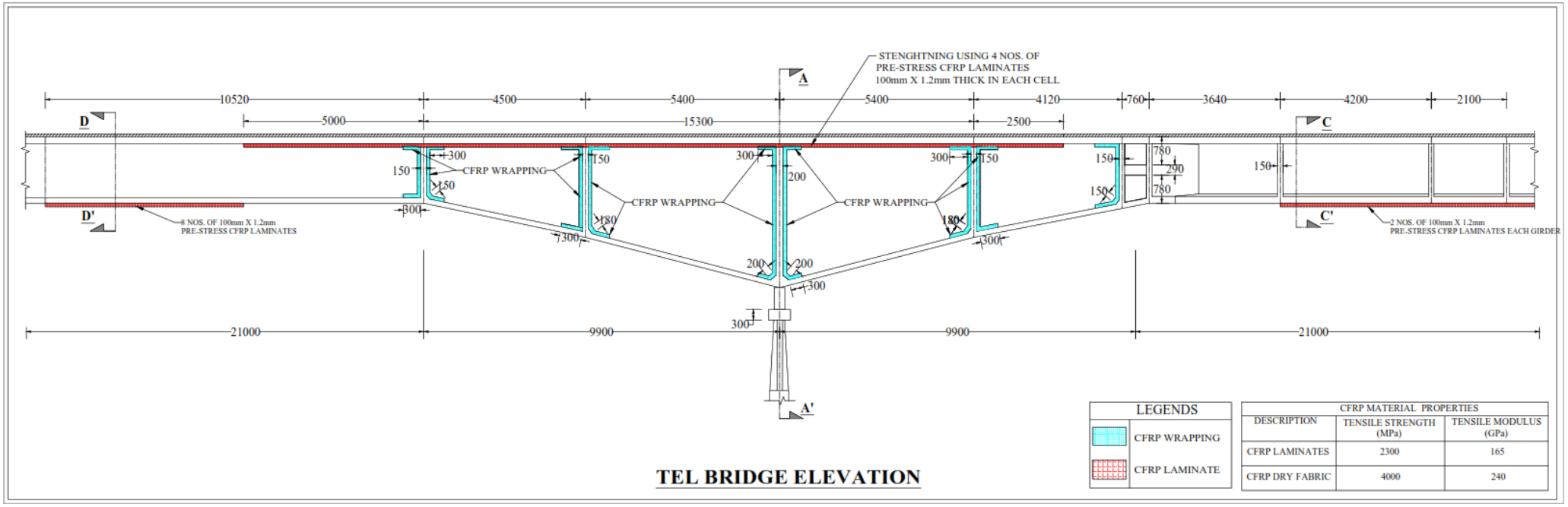
Strengthening Methodology

In addition to the concrete repair and surface preparation mentioned in the Section 5 of the Tel Bridge report, the following procedure will be followed for strengthening of spans using the CFRP materials.

A1.1 Simply supported spans with overhang on the both sides (Box Girder sections)

- The overhang portion will be strengthening using 4 no. pre-stress (10% pre-stress force) laminates of 100 mm x 1.2 mm at the soffit of the deck slab of each cell for improving the hogging moment capacity as shown in Figure 1 and Figure 2.
- The web portion of the box girder cells will be strengthened to enhance the shear capacity using U wrapping with 2 layers of 400 GSM CFRP fabric as shown in Figure 2.
- The diaphragm portion of the box girder is strengthened with 2 layers of 400 GSM CFRP fabric one layer in each direction as shown in Figure 1 and Figure 3.

- The mid-span portion of the box girder over the simply support span will be strengthened using the 8 no of 100 mm x 1.2 mm thick prestress (10% pre-stress force) CFRP laminates to improve the sagging moment capacity as shown in Figure 1 and Figure 2.



CFRP MATERIAL PROPERTIES		
DESCRIPTION	TENSILE STRENGTH (MPa)	TENSILE MODULUS (GPa)
CFRP LAMINATES	2300	165
CFRP DRY FABRIC	4000	240

Figure 1. Typical elevation with the details of various strengthening measures using CFRP materials

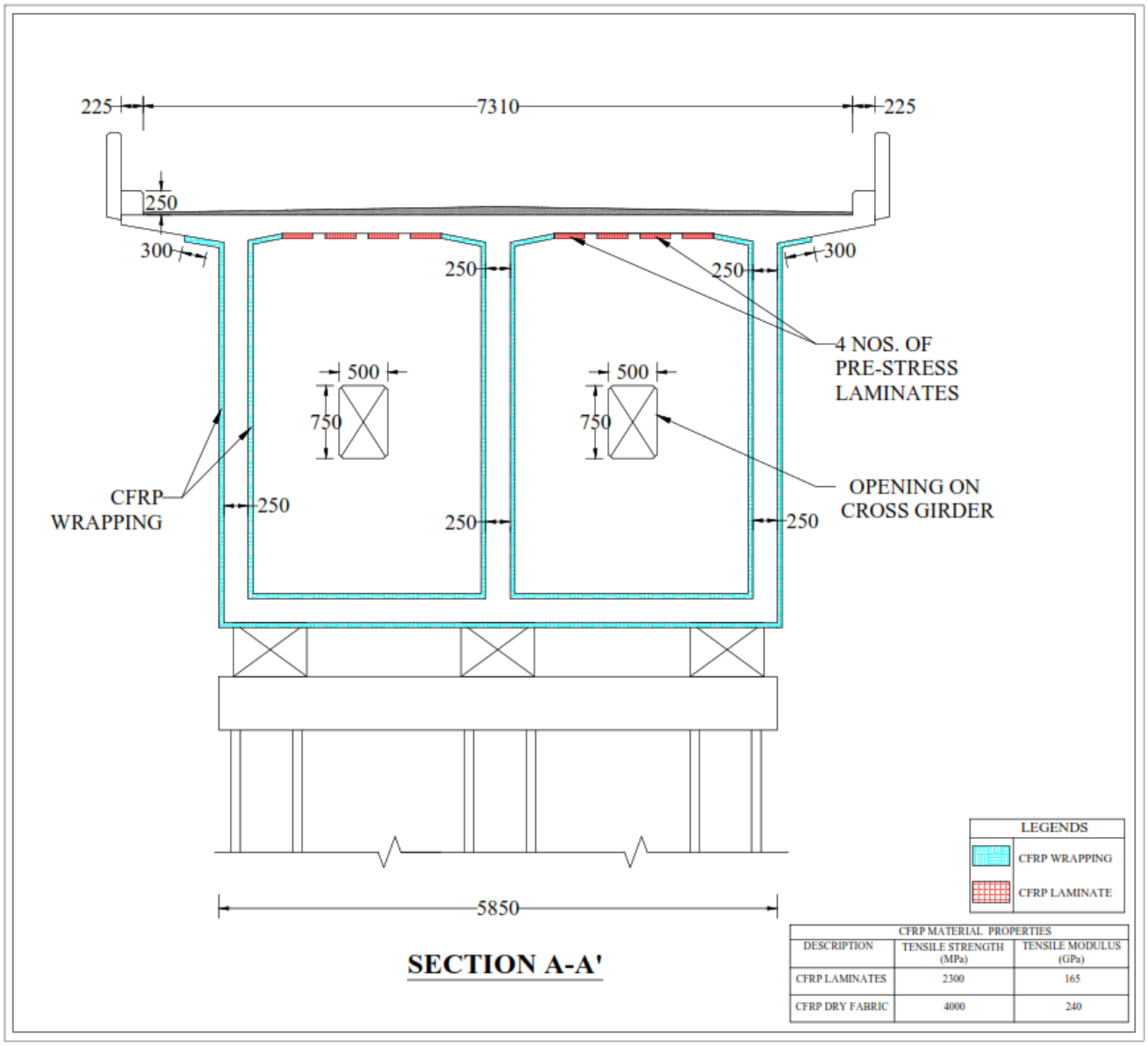


Figure 2. Strengthening details at section A-A over the support

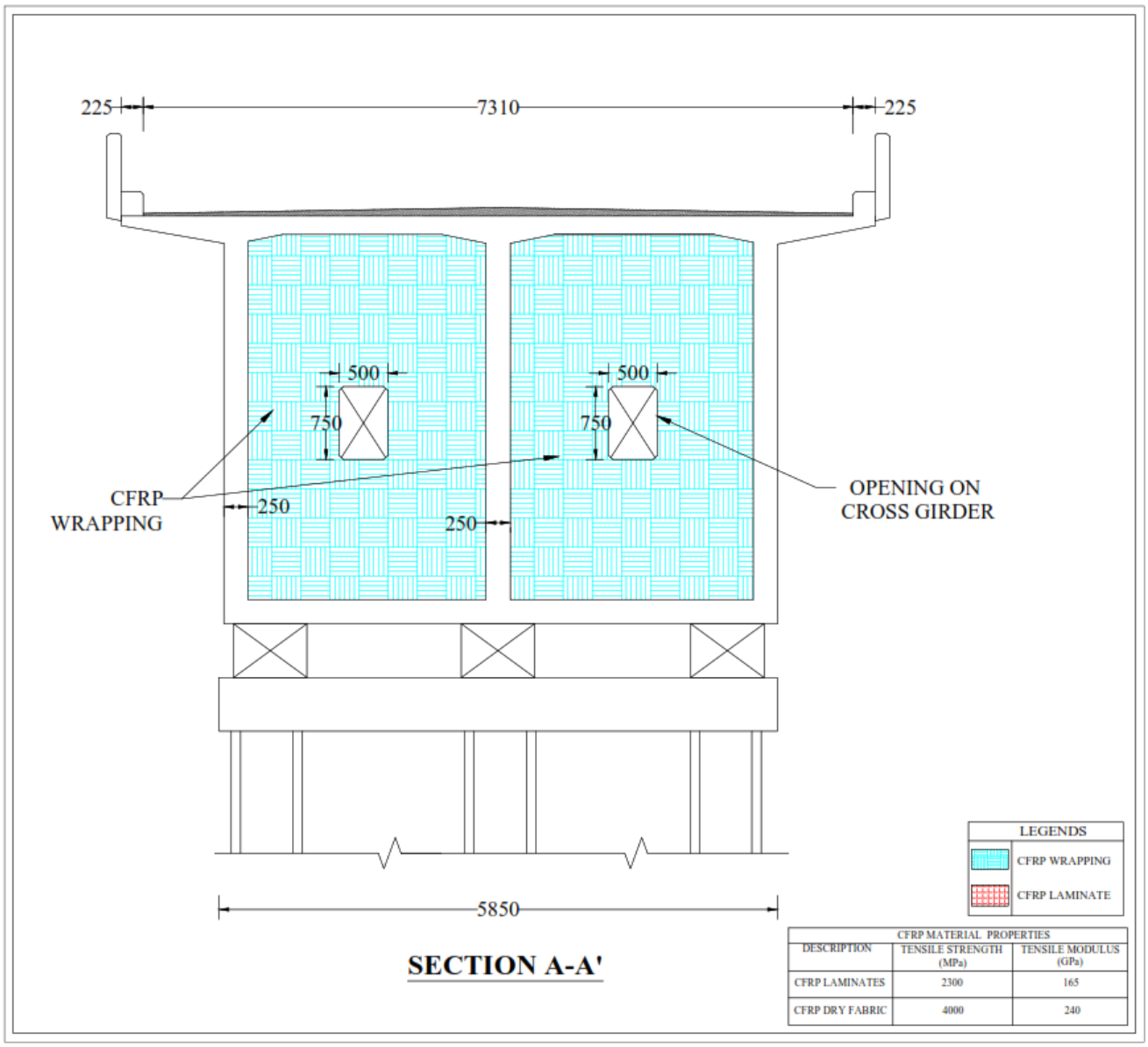


Figure 3. Strengthening of details of Diaphragm using 2 layers of CFRP fabric

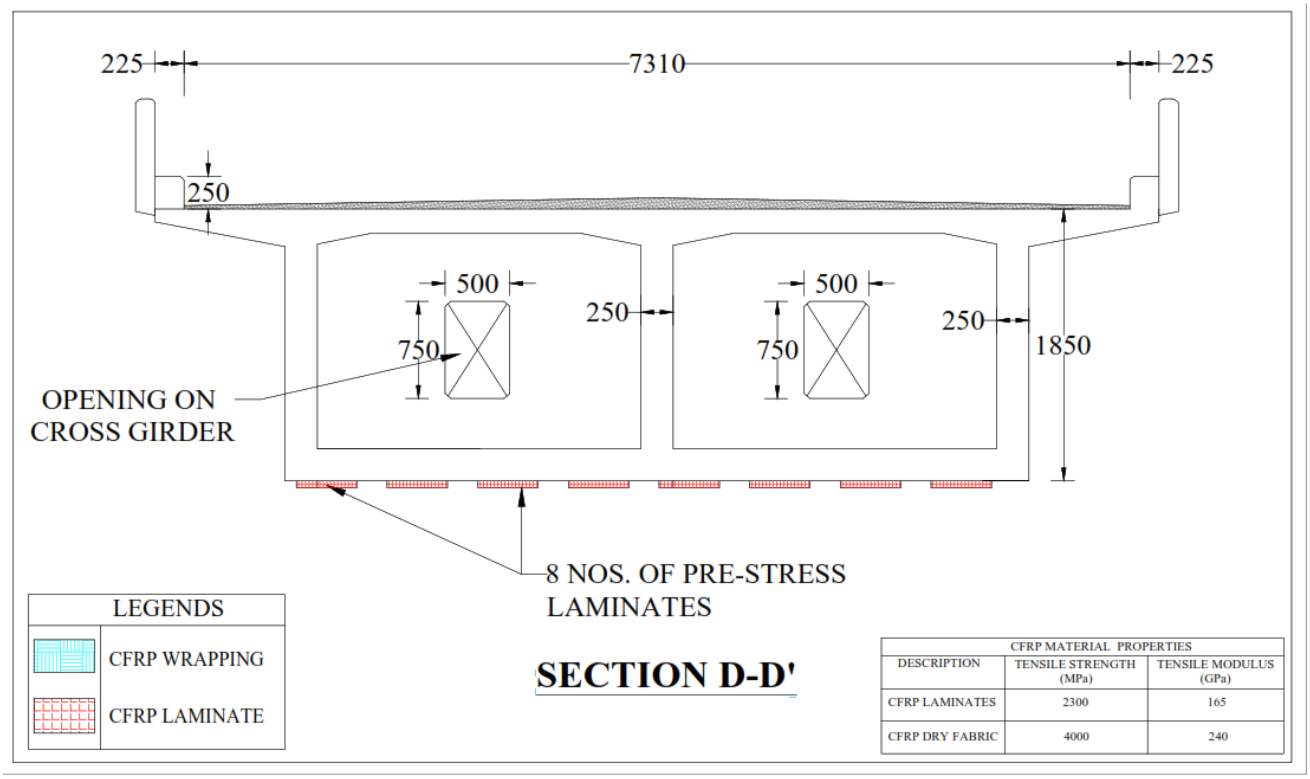


Figure 4. Strengthening details at mid-span of the box girder

A1.2 Suspended Spans (I Girder sections)

- The soffit of the I girder will be strengthened using the 2 no of 100 mm x 1.2 mm thick prestress CFRP laminates in each girder to improve the sagging capacity as shown in Figure 1 and Figure 5.
- The I girders are further strengthened to improve the shear capacity using U wrap with 400 GSM CFRP fabric as shown in Figure 5.

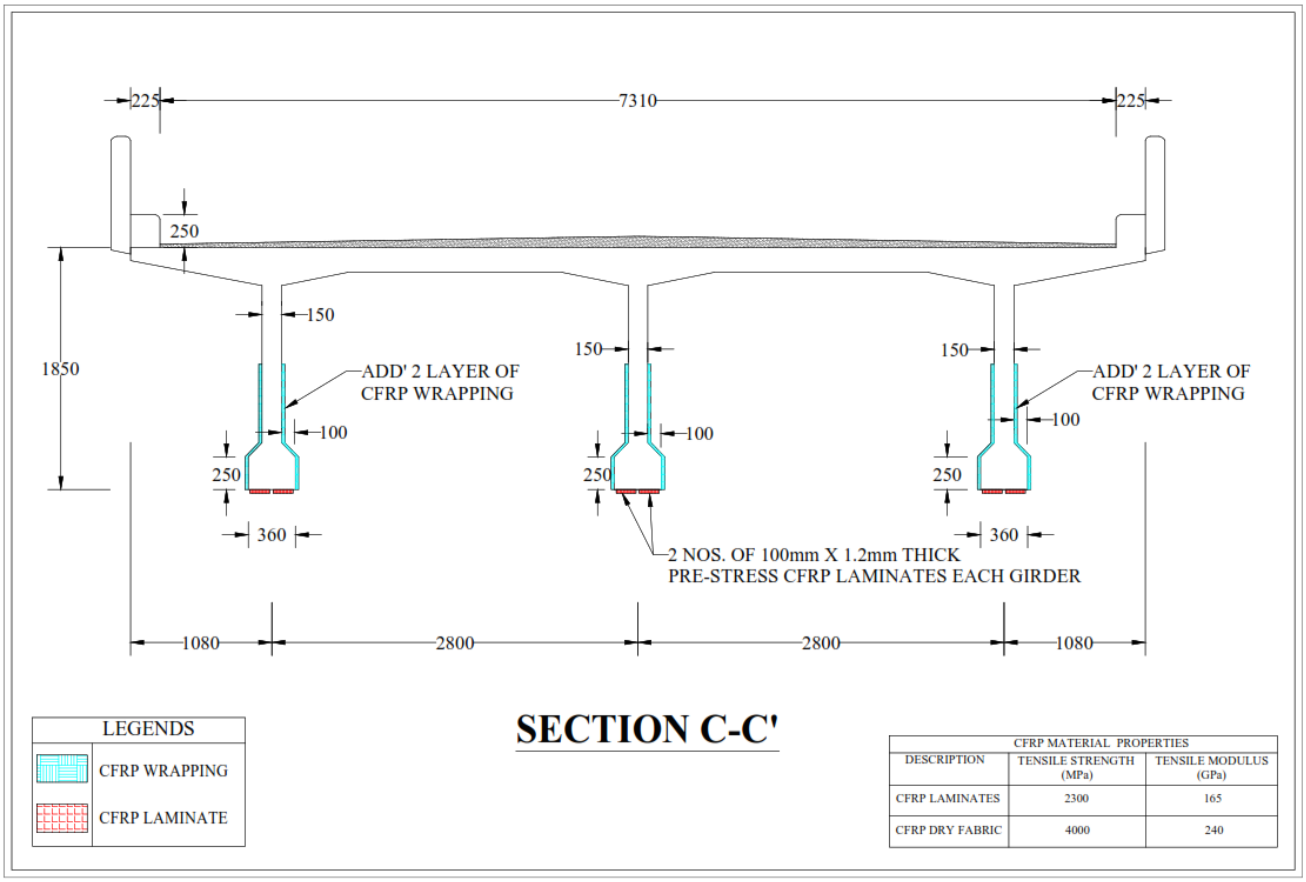


Figure 5. Strengthening details of suspended spans

A1.3 Methodology for Strengthening through Ultra-High Strength and High-Performance Concrete (UHPC)

Strengthening using UHPC (of 50 mm) for the reduced cross section of the continuous span. The detailed methodology is as follows:

a) Wherever reinforcing bars are exposed, the concrete should be removed at least 50 mm around the bars, to allow the repair mortar to properly bond to steel and concrete as shown in Fig. 6.

b) All the loose material, both concrete chips and rust film, shall be removed and the surface shall be cleaned by a jet of compressed air.

c) The corroded reinforcing steel, if any, shall be sand blasted/cleaned properly to get rid of the rust. In case of loss of corroded rebar diameter in the range of 25-30% of the original diameter (if any) shall be supplemented by additional reinforcing bars as per site requirements. The exposed bar shall be treated with an anticorrosive coating layer such as epoxy coating. A second coat if needed may be provided to achieve a uniform and continuous film.

d) Shear connectors are required for bonding old and new concrete. A good bond can be obtained by grooving the surface of the exposed concrete surface.

e) Drill and insert the dowel bars to develop the bond between existing and newly laid UHPC jacketing as shown in Fig. 7 to Fig. 9.

f) Proper shuttering should be ensured to cast the UHPC jacketing.

g) The U wrapping with 400 GSM CFRP fabric of the box girders to improve shear capacity can be carried out after UHPC jacketing as shown in Fig 2 and 8.

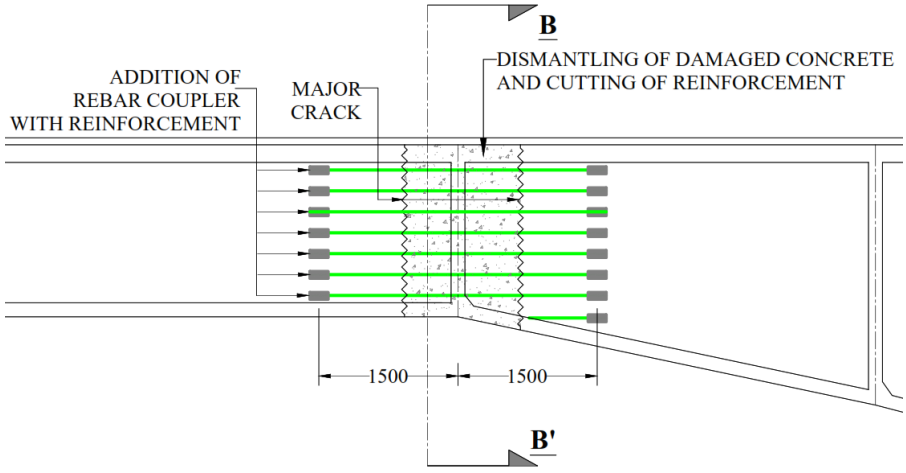


Figure 6 Details of repair methodology for major crack at highly distressed section between span P11-P12.

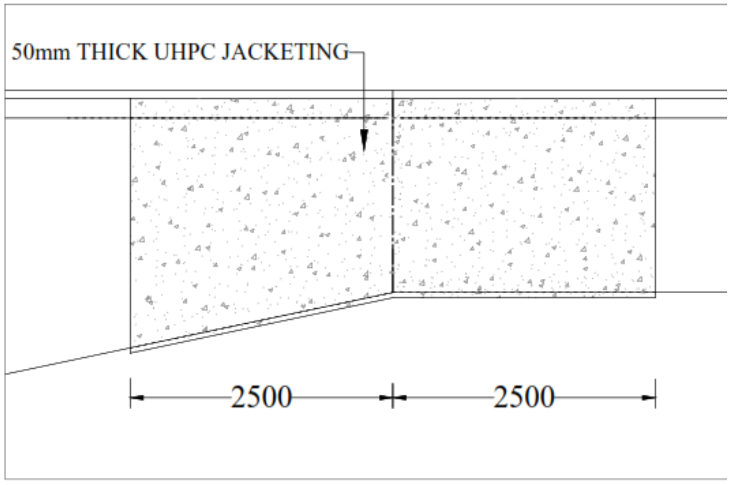


Figure 7 Detail of UHPC strengthening where cross section/geometry of box girder is changing in continuous span.

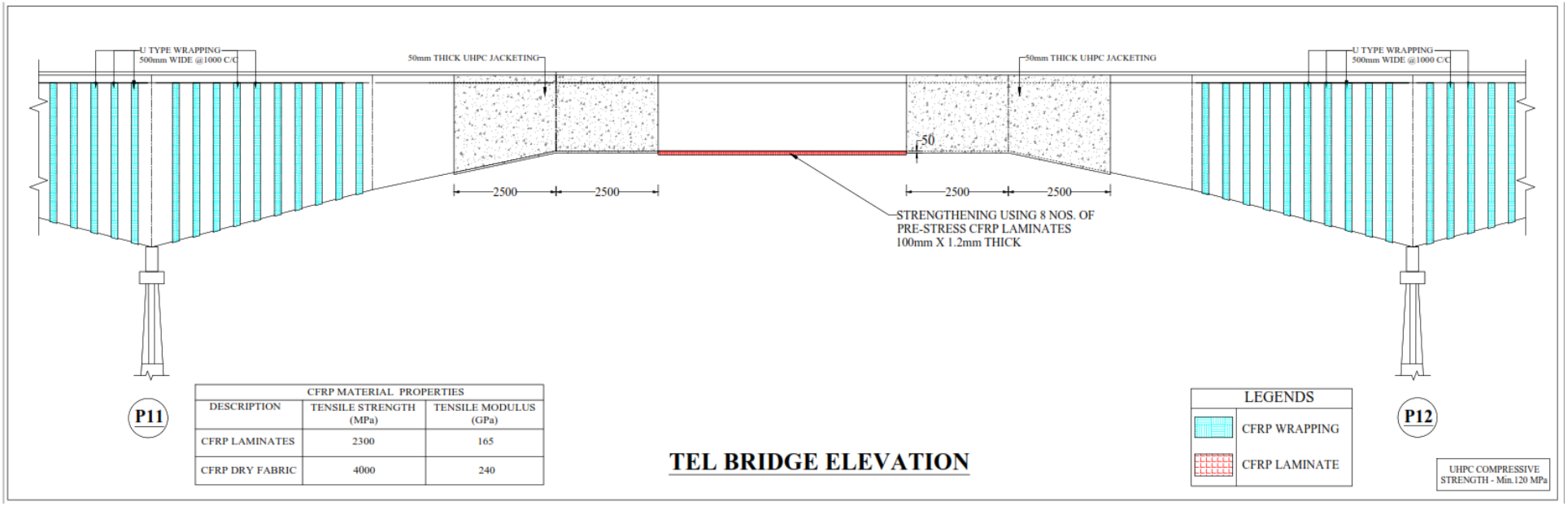


Figure 8 Detail of FRP wrapping to be carried out on the box girder sections after UHPC jacketing.

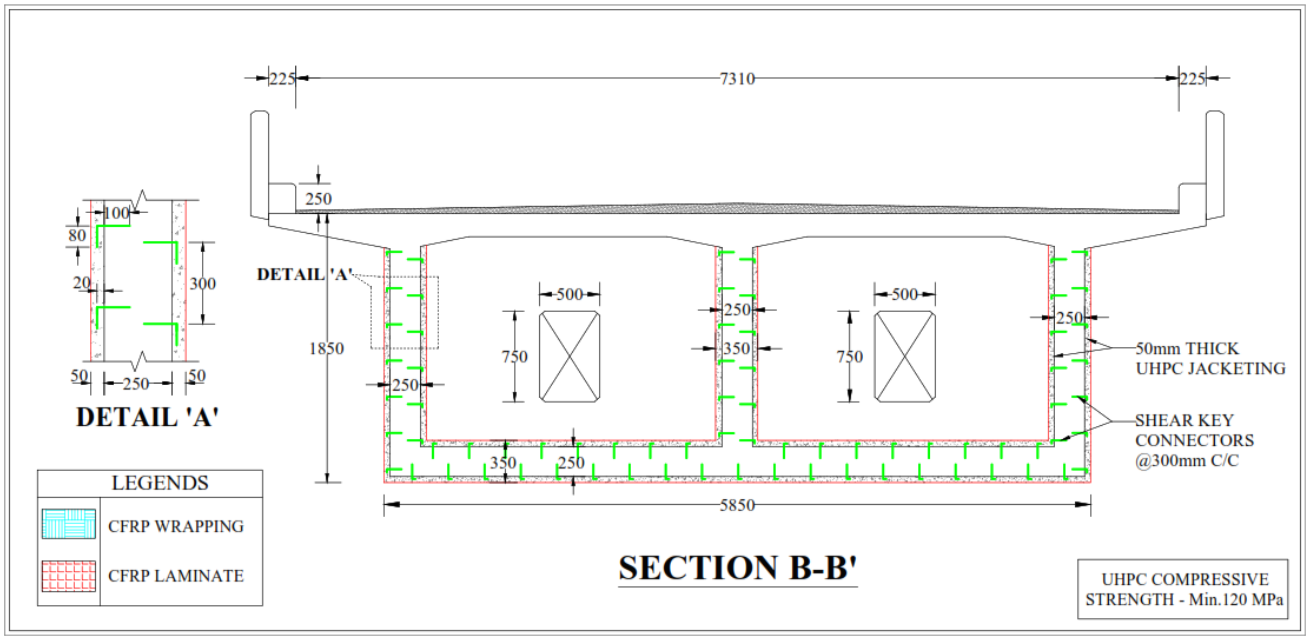
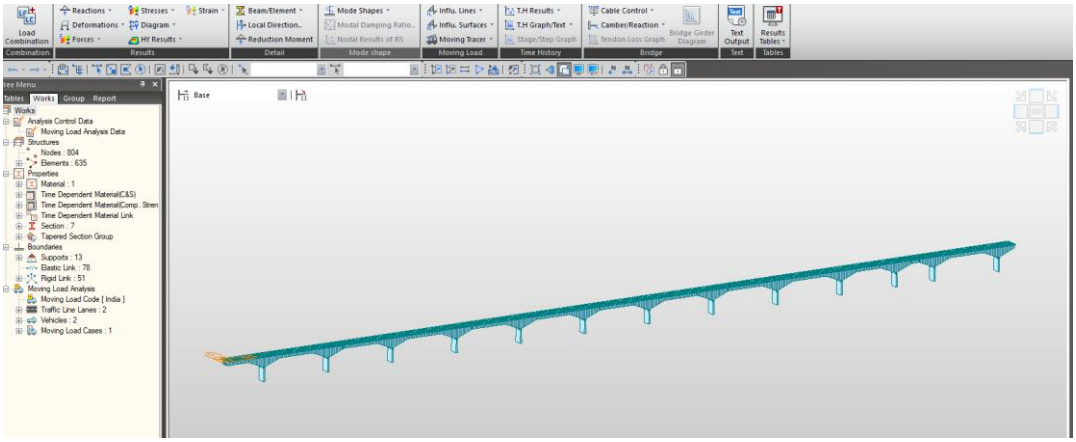


Figure 9 Details of shear links in UHPC jacketing.

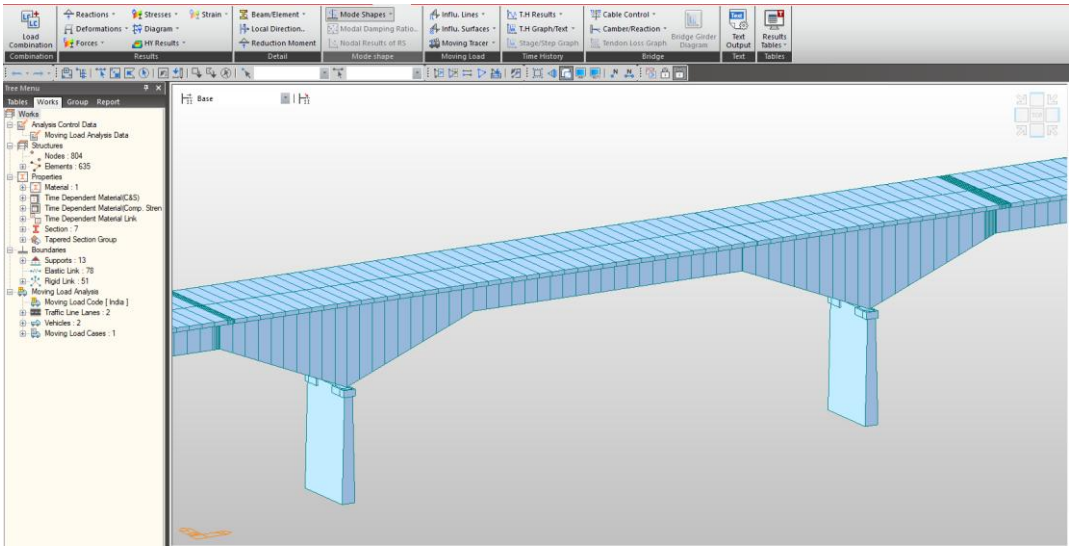
Annexure 2

Numerical Modelling and Analysis

In order to investigate the possible cause of failure of bridge, numerical modelling was performed using finite element (FE) software MIDAS Civil. A typical view of the FE model is shown in Fig. 1.



(a)



(b)

Fig. 1 A typical view of the numerical model for (a) complete bridge; and (b) critical span (P11-P12).

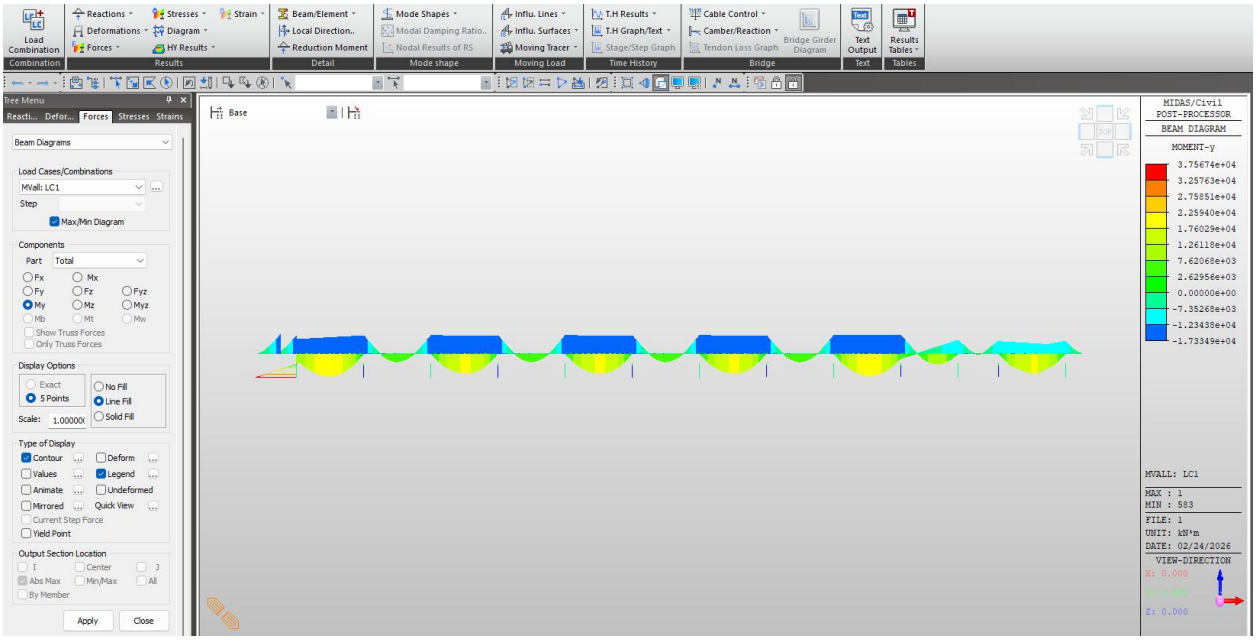
Salient details of the FE model and analysis:

- The grade of concrete was considered as M20 for the analyses.
- Sections of superstructure, pier cap and pier were considered as per actual.
- The well foundation was not modelled and piers were provided with fixed support (all 6 degrees of freedom restrained) at the bottom.
- The connection of bearings with superstructure was modelled using elastic link element, with bearing stiffness. A value of 10^8 for restrained movement and a value of 10 for free movement was provided.

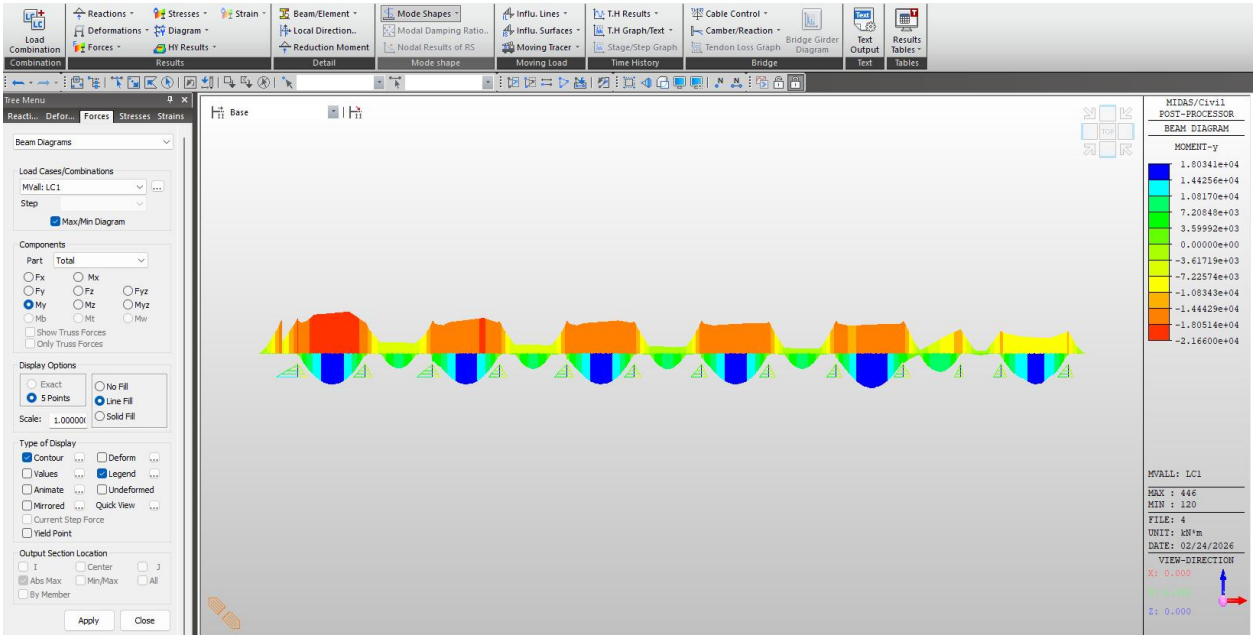
- 2 analysis cases were considered: 1) with consideration of proper bearing stiffness; and 2) without consideration of proper bearing stiffness (to simulate damaged bearing arrangement).
- Moving load analysis was performed as per the provisions of IRC 6 (2017).
- The results, in terms of shear force and bending moment distribution were compared for the 2 analysis cases.

Results and Discussion

The distribution of bending moment and shear force envelope for the 2 analysis cases are shown in Fig. 2a, b and Fig. 2c, d, respectively.



(a)



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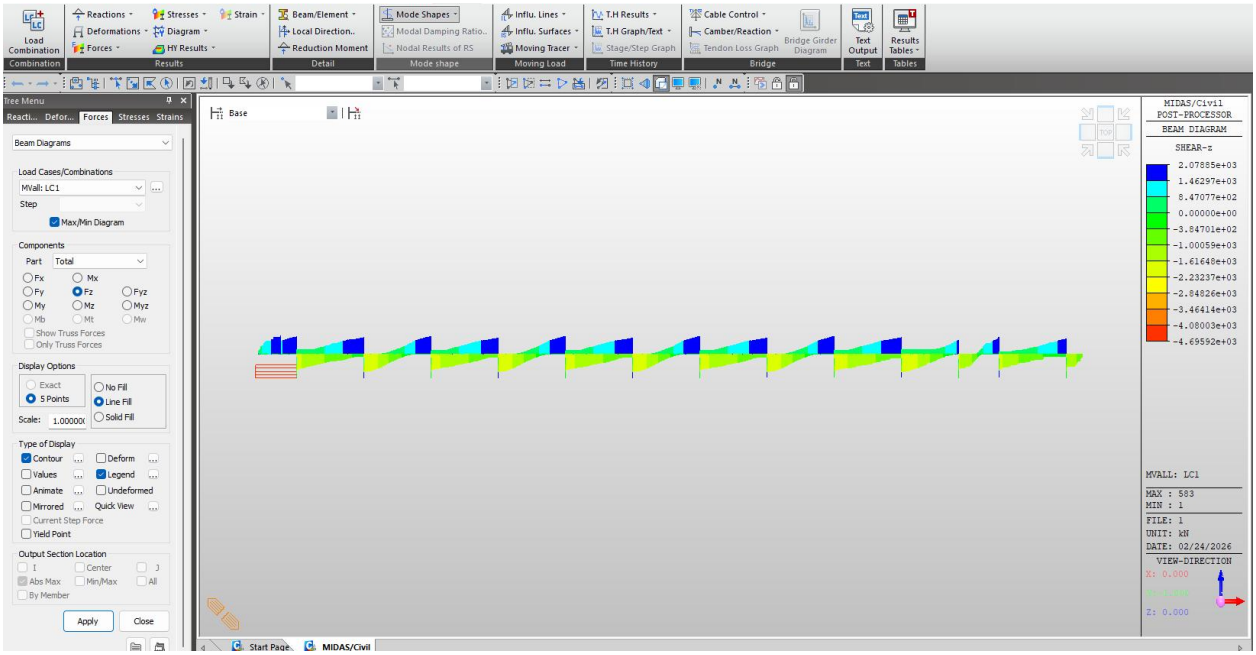
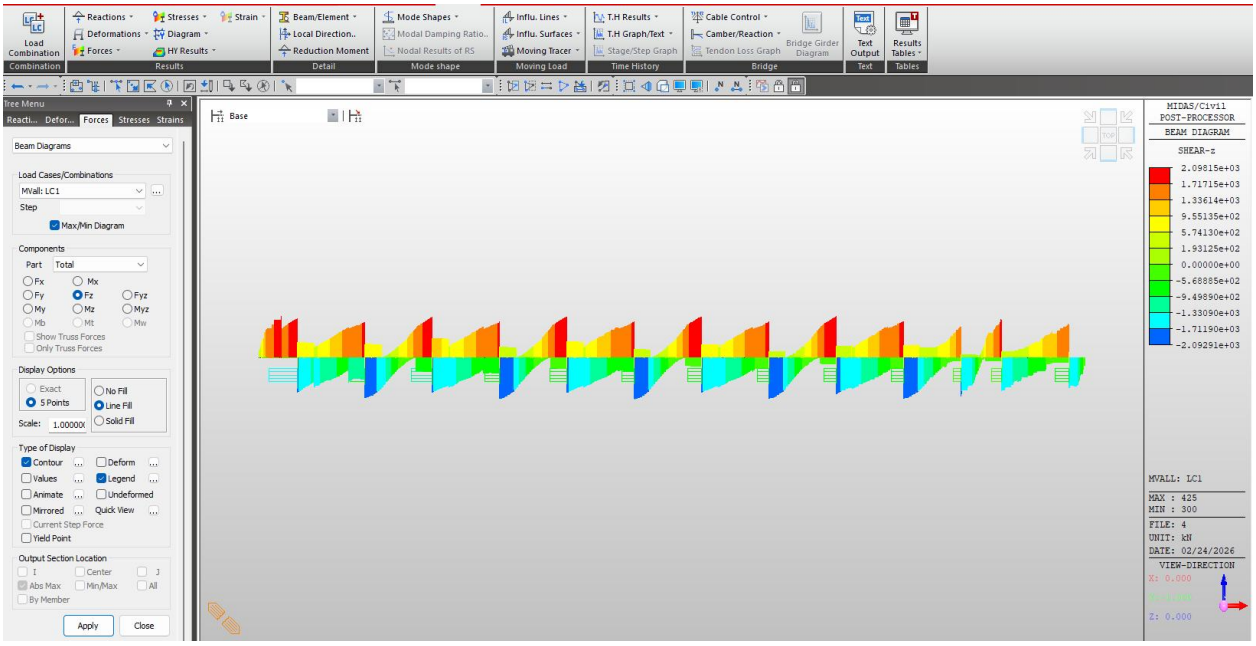


(c)



(d)

Fig. 2 Distribution of (a) bending moment, Case 1; (b) bending moment, Case 2; (c) shear force, Case 2; and (d) shear force, case 2.

From Fig. 2 it can be observed that the distribution of BM and SF for case 1, with proper bearing stiffness, was regular. However, for case 2, where the bearing stiffness were considered continuous to simulate damaged bearing arrangement, the distribution shows a peak value at the span where plastic hinge was observed to form (Span P11-P12) due to movement of the heavy consignment.

In order to further understand this irregular distribution of SF and BM at the end span, the corresponding position of moving load was also obtained through the moving load tracer command available in MIDAS Civil. The corresponding position is shown in Fig. 3.

It can be observed that for the maximum value of forces at the critical section (Span P11-P12), the corresponding loading profile shows 3 consecutive vehicles. This load case corresponds to the vehicles (Class 70R) moving in the direction from A1 to A2, and positioned near P11 and in between Span P11-P12. This observation is in line with the field observation, which suggests that a consecutive movement of a heavy consignment might be the reason of failure of the cross section, along with the non-functional/damaged bearings of the bridge.

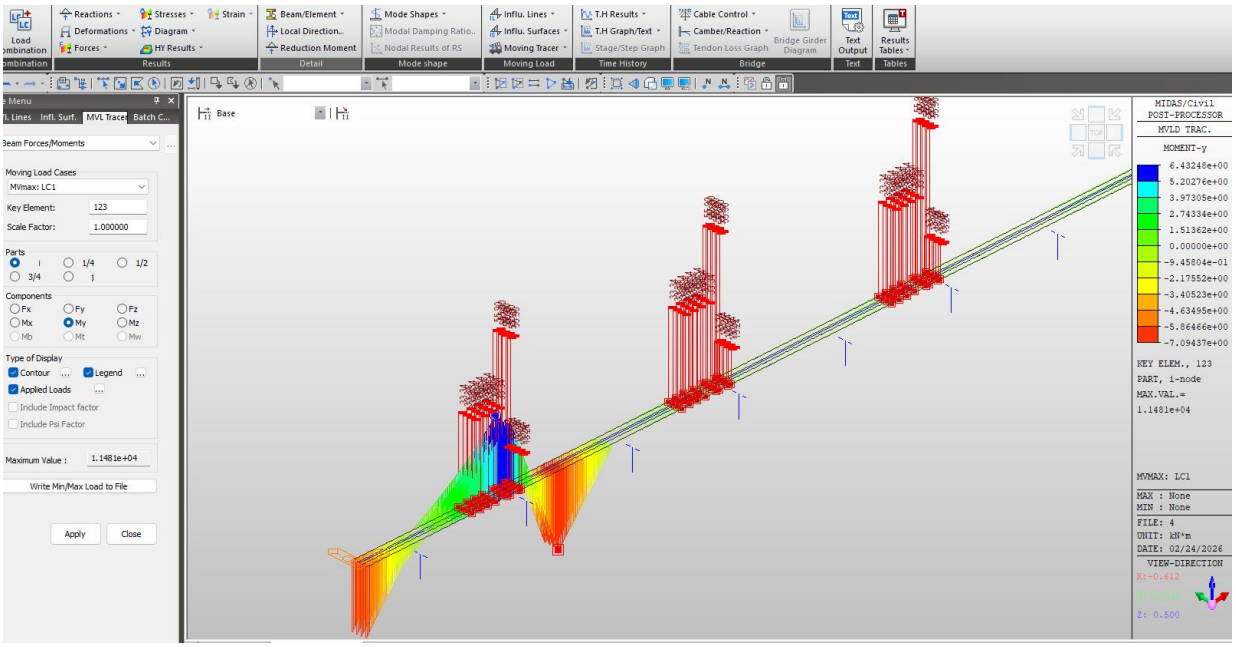


Fig. 3 Position of live load for the maximum bending moment at the critical section (Span P11-P12) obtained through moving load tracer for element at critical location.

Using the results of these analyses, and with the actual reinforcement details of the bridge. A detailed and efficient rehabilitation scheme can be designed based on the difference in the demand and capacity.

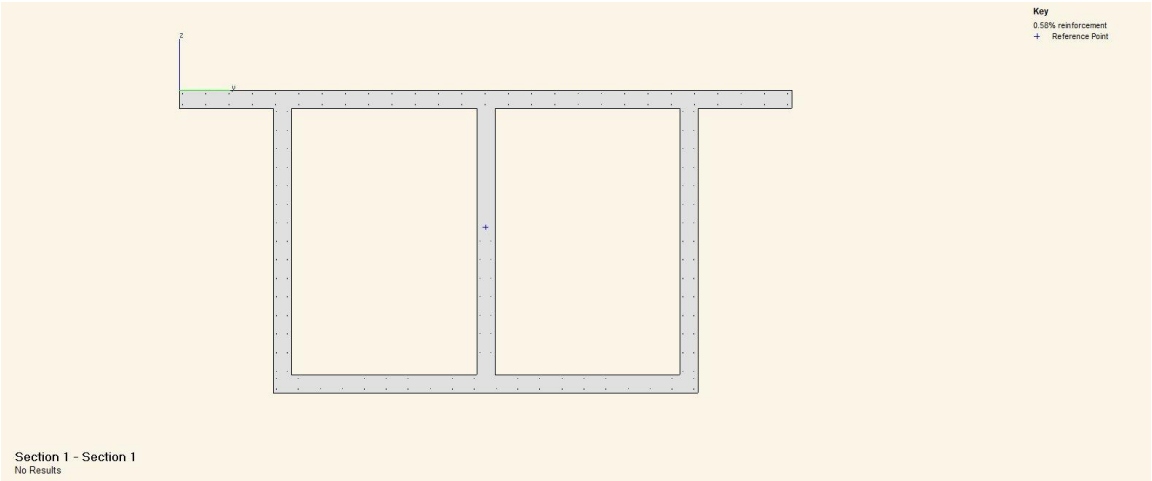
A2.1 Section Analysis and Estimation of Capacity

The existing and strengthened capacity of the distressed box section has been analysed using section designer in ADSEC software.

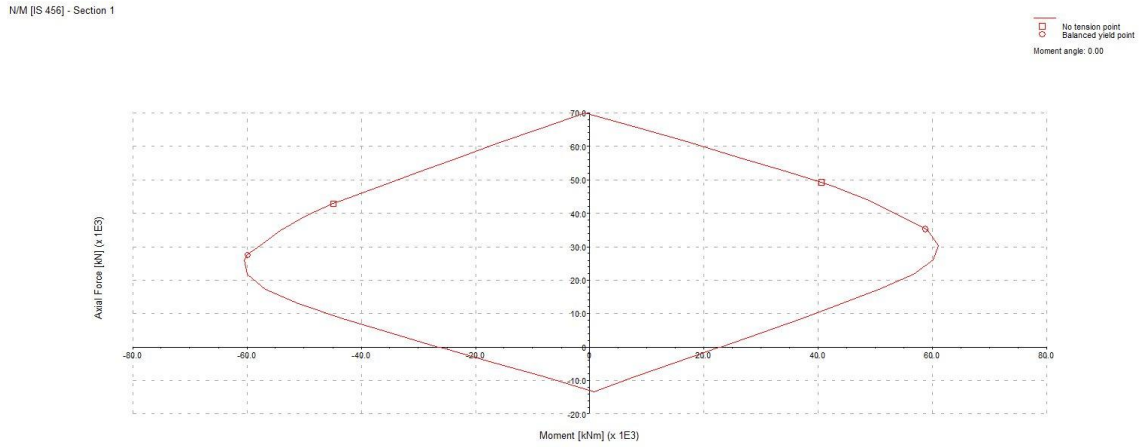
Salient details are as follows:

- The percentage reinforcement in the box girder is assumed as 0.5% as there are no details available. Based on the assumptions 2 layers of 16mm dia @300c/c, 1 layer at each face, considered in deck slab, soffit slab and web portions as shown in Fig. 4a.
- Based on the existing cross sectional details considered from the provided GAD drawings and the assume reinforcement ratio the capacity of the box girder over support was assessed using ADSEC section designer software.
- The hogging capacity of the box girder over the support was estimated as 22000 kNm as shown in Fig. 4b.
- As the qualitative analysis has considered the strength enhance requirement assumed as 30% in improving the flexural capacity.
- The modified moment capacity due to strengthening was calculated by considering equivalent reinforcement ratio with reduction factor of 0.25 (8 no. of CFRP laminates equivalent to 25 no. of 16mm dia) as shown in Fig. 5a.
- The modified moment capacity was estimated as 30000 kNm (which is more than 22000x1.3=28600) as shown in Fig. 5b.

It is to be noted that the calculations are part of the preliminary analysis for finalizing the qualitative strengthening measures. The exact details can be obtained by detailed analysis where exact mapping of the current geometry of the bridge and reinforcement details are required. It is also to be noted that this work is not currently in the scope of work of CRRI.

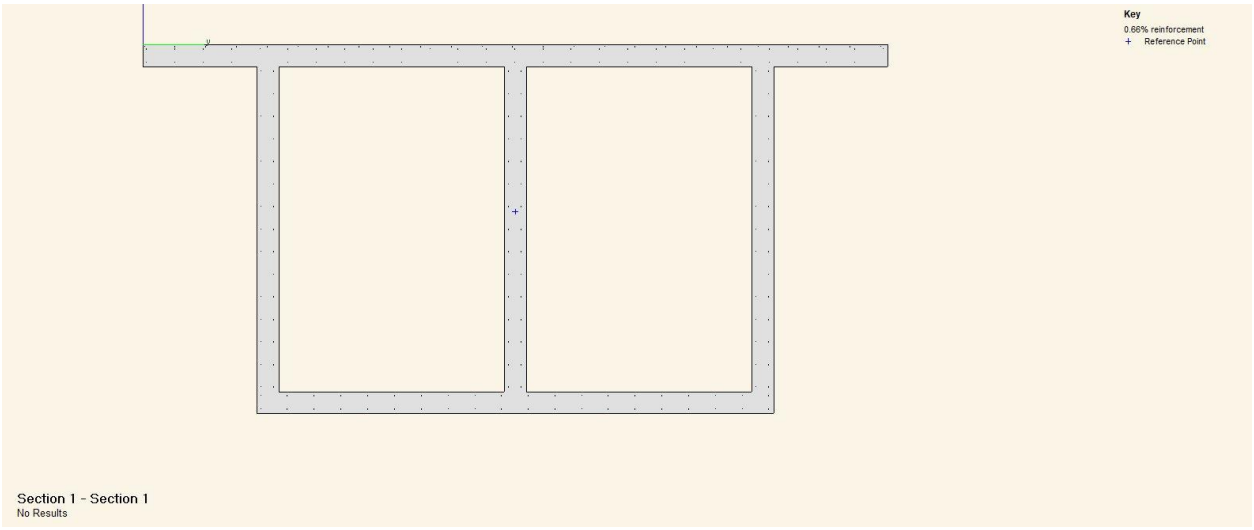


(a)

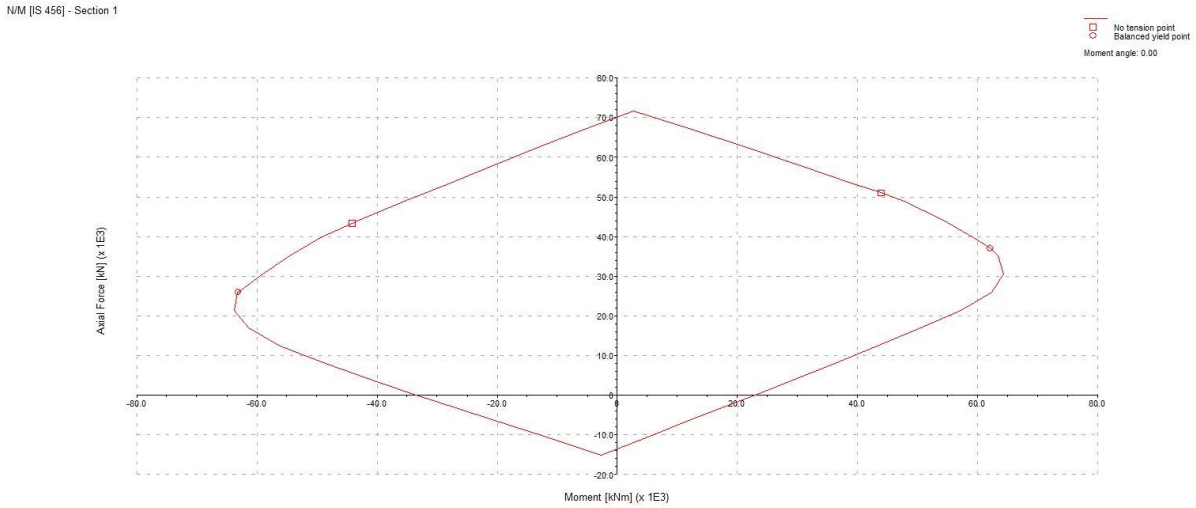


(b)

Fig. 4 (a) Initial section created in ADSEC; and (b) modified P-M interaction diagram for the section.



(a)



(b)

Fig. 5 (a) Modified section created in ADSEC; and (b) modified P-M interaction diagram for the section.