GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

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No. 2024/35/CE-III/BR/Safety(E-3471085) New Delhi, Dt. 05.08.2024

General Managers
All Zonal Railways,

Sub: Review of Outcome of Third Party Audit of Railway Bridge/ROBs/FOBs

Ref:
- **(i) Rly. Bd. letter no. 2005/CE-I/BR-II/6 dated 13.06.2005.**
- **(ii) Rly. Bd. letter no. 2017/07/CE-III/BR/Safety dated 03.08.2018.**
- **(iii) Rly. Bd. letter no. 2016/52/CE-III/BR/Safety dated 24.05.2024.**
- **(iv) RDSO letter no. CBS/DOW dated 27.06.2024.**

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Railways, vide ref-(i) above, were advised to get the third party audit done of selected railway bridges on identified routes. The objective was to study the effect of running higher axle loads on various components of the bridges. Subsequently vide ref-(ii), instructions were issued to carry out third party audit of other critical bridges (Railway bridges, ROBs & FOBs) to have an independent assessment on the physical condition of such bridges.

2. The reports of all such audits by third party must have been scrutinized by the zonal railways. The summarised statement, containing details of all such bridges with type of bridge, location, span configuration, name of third party agency and the benefits derived out of the exercise shall be submitted to RDSO for information. The compliance of the final recommendations of third party audits shall also be advised to RDSO.

3. In future audits of older bridges (age more than 50 years) having steel super structure, the assessment of residual fatigue life (with or without instrumentation) of different bridge components /members shall also be included in the scope of audit. Assessment shall be done in accordance with **A & C Slip No. 42 of IRBM** with respect to route GMT and loading permitted.

Signed by
Niraj Kumar
Date: 06-08-2024 15:38:19

(Niraj Kumar)
Executive Director Civil Engg.(B&S)
Ph. No. 011-478-45474

Copy to:

1. PCEs/ All Zonal Railways for information and necessary action please.
2. PED/Infra-II/RDSO for information and necessary action please.

32

S.N.1

Government of India
Ministry of Railways
(Railway Board)

No.2005/CE-I/BR-II/6 13.06.2005

General Manager,
East Coast Railway, Bhubaneswar
Southern Railway, Chennai
South Eastern Railway, Kolkata

DG, RDSO,
Lucknow

Sub: Pilot project for running of (CC+8+2) axle wagons on identified Iron Ore Routes – reg. Inspection & testing of Bridges.

Ref.: 1. Railway Board letter no. 2003/CE-II/TS/5 Vol. 1 dated 4.05.2005
2. Railway Board letter no. 2003/CE-II/TS/5 Vol. 1 dated 1.06.2005

1.0 Instructions have been issued to Zonal Railway's vide reference (1) & (2) above for Pilot Study in connection with running of higher axle load wagons (CC+8+2)t on identified Iron Ore Routes. Subsequently, a meeting of PCEs of Zonal Railways was held in Board's office and followed by meeting of CBEs of SER, ECoR, SR and officers of RDSO on 03.06.2005 in Board's office. During the meeting, the scope of present pilot study involving instrumentation & observation of bridges & methodology for carrying out the same has been discussed along with time & physical constraints involved in carrying out the pilot study.

2.0 The pilot study is very important to study the effect of higher axle load on bridges especially in view of higher age profile of bridges on Indian Railways and there being some bridges where the completion drawings of old bridges are not available. The study to be carried out over 3 years is also critical for further planning of bridges for higher axle loads. The following scope of work has been defined:

3.0 Inspection & Testing of Bridges:

3.1 Zonal Rlys. should analyse individual bridges for the proposed loading with (CC +8+2) t axle load wagon trains & multiloco consist. All the bridges should then be inspected thoroughly initially & points of distress noted. Action required for repair/ strengthening should be taken. Sample bridges should be selected for instrumentation covering the various types, spans & materials. Those bridges as may require more frequently inspection as a result of theoretical analysis and inspection should be kept under watch closely by the PCEs. NDT testing be resorted to for quick assessment of health of bridges.

3.2 Bridge Load Monitoring system has been developed & demonstrated by M/s Sharma Associates, Chicago, USA. Each zonal railway should install one of the system to monitor the load spectrum including dynamic augment coming on the bridges.

3.3 Further bridge instrumentation & observations should cover:

3.3.1 Longitudinal load coming on bearing & proportion transferred to approaches should be measured.

3.3.2 The tilting, if any, of abutment/pier, pressures at critical locations & settlements shall be monitored. This can be done by use of Tiltmeters & flat jacks.

3.3.3 Deflection and stresses at critical locations.

3.3.4 Dynamic augment coming on bridge to be measured.

3.3.5 Dynamic characteristics and changes thereof to monitor health of bridges using vibration signature techniques. Equipment procured by KRCL may be studied.

3.3.6 Temperature stress & effect of temperature should be recorded to measure net stress due to loads.

The measurement of Parameters may be continuous real time or intermittent quarterly initially for one year and some parameters to be observed over a period of 3 years with reduced frequency.

3.4.0 Frequency of Tests

3.4.1 The tests for longitudinal loads on bearings and proportion transferred to approaches be done initially and further tests as may be required after analysis of results of tests.

3.4.2 The test for deflection/tilts & stresses at most critical points be done initially and repeated quarterly for one year and thereafter annually for three years or as otherwise required after study of test results.

3.4.3 Tests for Dynamic Characteristics i.e. Vibration Signature test for the bridge be repeated once a quarter for one year & then annually.

3.4.4 Load spectrum analysis including dynamic augment shall require continuous record. These system may be got installed with recording over a quarter by agency and thereafter Railway personnel could get trained & take over recording.

3.4.5 NDT tests be carried out once in six months for detection of any hidden defects/cracks development.

4.0 Work to be done by RDSO: The fixing of instrumentation, recording of observations & report preparation shall be done through specialised agencies by the zonal Rlys. RDSO shall associate from the beginning in the instrumentation scheme, analysis of results and the report preparation.

5.0 Agencies:

5.1.0 In view of the limited resources with various agencies, constraint of time, safety of bridges and the need to share knowledge resource of various experts and technologies it is decided to have the entire work carried out in sub groups:

5.1.1 SR should finalise offer with SERC/Chennai for detailed study of Bridge No. 42 already surveyed along with SERC as per their scheme. SR should further pursue SERC, Chennai to take up 10 (ten) more bridges for instrumentation & study.

5.1.2 SER should finalise offer with CRRI/New Delhi for detailed study of two major multi span bridges as per their scheme which may include fibre optic sensors & telemetry.

5.1.3 SER should finalise offer with M/s Sharma Associates, Chicago for Bridge Load Monitoring, Longitudinal Force measurement & instrumentation of the bridge for one bridge. SR and ECoR should also get the offer for one site from M/s Sharma Associates, Chicago and finalise the same.

5.1.4 The zonal Rlys (SER, ECoR) have to instrument more bridges to have a complete detailed study of effect of higher axle loads otherwise meaningful results & conclusions can not be drawn. Therefore the offer of Pixel Networks (in Association with IIT/Mumbai) as per their scheme adding the measurements for abutment tilts and pressures be finalized by SER & ECoR for 10 bridges each. SR may pursue with SERC for taking up at least 10 bridges and in case SERC is not able to do so and other agencies are also not coming forward, SR may pursue with PIXEL NETWORKS, Mumbai to take up the work in association of IIT/Mumbai. Some of the Railways may have to take up more than 10 to 12 bridges for study which may be considered to be given to other listed agencies in case their response is received subsequently.

5.1.5 Zonal Railways shall contact M/s Cintec India for instrumentation & evaluation of Arch Bridges besides other agencies listed.

5.1.6 SR shall take offer from M/s Ultra Technologies, Delhi for mapping of unknown foundations of 4 to 5 bridges. The firm takes up work in association with Olsen Engineers, USA. The offers shall be finalized quickly to take up study along with above for complete analysis.

5.1.7 Zonal Railways shall fix up with Geotechnical Engg. specialized agencies separately for determining insitu bearing capacity of foundation strata where required in critical bridges. The insitu bearing capacity may be determined using Cone penetro meters/ Pressure meter tests or other such tests as considered necessary.

5.1.8 The work assigned to the agencies shall include preparation of analytical model, computer analysis and rating of bridges.

6.0 The offers shall be finalized within 3 weeks. Inspection shall be started immediately thereafter. The frequency of the tests has been specified at para 3.3 & 3.4 above.

7.0 Funds may be charged to Revenue as this is a maintenance activity.

8.0 Foreign exchange may be required for a few items. For this LC may be opened in favour of the firm as per extant procedures.

9.0 The fixing of agencies for instrumentation, recording of observations and submission of reports be fixed by the General Managers as works contracts under GM's powers for inviting and finalizing single/limited tenders treating the works as Urgent Safety Works. Procedures for getting works done through Govt. agencies in case of Govt. research labs may be followed for SERC & CRRI i.e as a Deposit Work as per E-1116 against estimates submitted by them.

10.0 Weekly progress reports be submitted to Railway Board. The first comprehensive technical report may be submitted at the end of first quarter of testing.

(Surinder Kaul)
EDCE (B&S)

Copy to- The General Manager, Eastern Railway, South East Central Railway, S.C. Railway & S.W. Railway. They should also get five to ten sample bridges on the identified routes instrumented and tested.

Government of India
Ministry of Railways
(Railway Board)

No. 2017/07/CE-III/BR/Safety. New Delhi, dt 03.08.2018

General Managers,
All Zonal Railways

Sub: Third Party Audit of Railway Bridges/ROBs/FOBs.

During 2005, vide board's letter no. 2005/CE-I/BR-II/6 dated 13.06.2005, instructions were issued to zonal railways to carry out study including instrumentation/NDT testing/Geo-technical investigation etc. of railway bridges on identified routes in connection with running of higher axle load trains (CC+8+2 & CC+6+2) on these routes. The objective of this exercise was to study the effect of higher axle loads on bridges especially in view of higher age profile of bridges on Indian railways and non availability of completion drawings of old bridges. While issuing the instructions, zonal railways were advised to fix specialized agencies for the purpose under GM's power as works contracts and funds may be charged under revenue being maintenance related works. The encouraging results from this exercise enabled further decisions like universalization of CC+8+2/CC+6+2 loads on IR.

2. As far as inspection and maintenance of bridges on IR is concerned, there is a well established system of inspection of railway bridges/ROBs/FOBs by the designated railway officials as per the laid down schedule. The necessary corrective action is taken accordingly based on the condition assessed during the inspections. Though the present system of inspection of bridges is considered by and large adequate, however, keeping in view the recent incidents of part collapse/failure of ROBs, Railway Bridge/FOBs etc. it has been decided to carryout third party audit of identified and critical bridges to have an independent expert view on the condition of the bridge. ROBs & FOBs may be inspected treating them as Major bridges.

3. In view of above, zonal railways are advised to carry out one time third party technical audit of the bridges duly checking all aspects of the bridge (including NDT testing, under water inspection, design adequacy for present day loading including earthquake force etc. as considered necessary) by engaging expert national/international agencies. Based on the recommendation, further studies like instrumentation may be done. Few representative proof checks may be got done from IITs/NITs or any other reputed institute. Wherever considered necessary, ED B&S RDSO should also be associated with these studies. The agencies may be engaged under GM's power as works contracts charging the work to Revenue/PH-32/PH-30. The third party audit of the bridges should be undertaken as per the following priority:

i. All mega bridges, Railway Bridges with ORN 1 ratings, ROBs & RFOs and FOBs.
ii. Railway Bridges with ORN 2 ratings and bridges with speed restrictions.
iii. All important bridges more than 80 yrs old.
iv. Any other bridge which railway consider critical from condition point of view.

4. The scope of work and action plan to complete this exercise should be advised to Board in next 15 days.

This issues with the approval of Board (ME).

RKSingh 3.8.18
(A.K.Singhal)
EDCE/B&S
Railway Board

Copy for information and necessary action to:

i. **PCE/All Zonal Railways.**
ii. **DG/RDSO**

Issued by hand
on 24.05.2024

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

No.2016/52/CE-III/BR/Safety New Delhi, Dt. 24.05.2024

PED/Infra-II,
RDSO,
Manak Nagar,
Lucknow

Sub: Technical Report on repeated failure of vertical in 91.5M K Type truss of Bridge no-57 (Down) in Kharagpur Division of S. E. Rly.

Ref: (i) Rly Bd letter no. 2016/52/CE-III/BR/Safety dated 22.05.2024.
(ii)PCE/SER letter no. W/547/Br Progress/SRF-DRF/IG/4 dated 21.05.2024.

*****

In reference to above, officers of B&S Dte. may be directed to visit the Bridge site to assist the zonal railways to plan a safe & workable rehabilitation scheme for the damaged vertical. The cause of failure to be critically analysed and a detailed technical report, containing probable reasons, proposed action plan for rehabilitation, measures to be taken to prevent such failures in future is to be submitted early.

24/05/2024
(R K Goel)
PED (Bridge)
Railway Board

Copy to: DG/RDSO for information.

Issued by bmcell
on 24.05.2024

भारत सरकार GOVERNMENT OF INDIA
रेल मंत्रालय MINISTRY OF RAILWAYS
(रेलवे बोर्ड RAILWAY BOARD)

*****

No 2016/52/CE-III/BR/safety Dated 22.05.2024

Principal Chief Engineer
South Eastern Railway

Sub: Report on Bridge No 57 DN (2X30.5 m+7X91.4 m+ 2X30.5 m) across river Rupnarayan

Ref: SE Railway letter no W/547/Br. Progress/SRF-DRF/IG/4 dated 21-5-24.

*****

Vide letter under reference dated 21-5-24, report on condition of bridge has been received and it has been decided that to study the problem experts of design and instrumentation from reputed firms, institution like SERC etc should be engaged immediately. The problem shall be studied in depth & suitable remedies and further preventive measures shall be suggested by the experts.

Meanwhile, RDSO has been advised to depute the team to visit the site.

Niraj Kumar

Digitally signed by Niraj Kumar
Date: 2024.05.22 10:19:08 +05'30'

(Niraj Kumar)
Executive Director, Civil Engg./B&S
Railway Board
Ph. No. 011- 47845474

Copy to:- ED/BS-II/RDSO for N/A

विजय कुमार पंजियार
प्रधान मुख्य इंजीनियर
VIJAY KUMAR PANJIAR
Principal Chief Engineer

सत्यमेव जयते

South Eastern Railway
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✆ : 033-24392830 (O)
FAX : 033-2439-3134
Mobile : +91 9002080200
e-mail : pcesergrc@gmail.com

No.W/547/Br.Progress/SRF-DRF/IG/4 Date: 21.05.2024

The PED/Bridge,
Railway Board,
New Delhi

Sub: Structural Distress reporting on Down Mainline on Br. No. 57 DN (2x30.5m + 7x91.4m+ 2x30.5m) across river Rupnarayan on 17.05.2024.

1. The Downline Bridge across river Rupnarayan was constructed in 1900 having span arrangement of (2x30.5m + 7x91.4m+ 2x30.5m). Regirdering of this bridge was done in 1966 catering to BGML loading – 1926. This bridge falls in the DFC Feeder route "ADL-PKU-HLZ" of SER. The sectional speed is 130 Kmph. GMT of this section is approx. 88.The superstructure is Non-Standard type.

2. On 17.05.2024 at approx 13:10 hours, Sri Prasenjit, BRI staff, noticed cracks in the 2nd Vertical U1M1 (Upper) at the point U1 of span no. 5 of 91.4 m girder. The Vertical at U1 was found totally separated. 20Kmph speed restriction was immediately imposed only for passenger traffic and Goods traffic were not permitted.

3. It is stated that there was no adverse reporting of this bridge as per the available records.

4. Restoration work was immediately taken up and the various activities involved were as follows:-
   a) Erecting the scaffolding at U1, at a height of 10m from existing rail level.
   b) Arranging tools, plants, materials and subsequently splicing the separated Vertical by cutting, drilling, filling and fixing of splice plates and packing plates at the breakage point followed by providing fastenings.

5. Finally at 9:50 Hrs on 18.05.2024, the Speed Restriction was relaxed to 30 Kmph for passenger trains and 20 Kmph for Goods traffic.

6. Camber readings thereafter are recorded twice a day.

7. Watchmen from BRI and PWIs side had been deployed to keep a sharp watch on the structural members of this bridge of both UP and DN Lines.

8. Reputed Consultant will be engaged to assess the reasons for the probable distress, and to suggest temporary measures to be undertaken including residual fatigue life analysis of the girders.

9. Owing to the sudden failure of the member of Span 5 of this important bridge in Group –A route, it is suggested that a high power committee be engaged to conduct a study to analyse failure and provide necessary remedial measures to avoid recurrence of failure.

10. In the meanwhile, Bridge team from RDSO may also be requested to visit the site and provide valuable suggestions in this context.

Detailed report is enclosed.

Encl : As above

21/5/24.
(V.K. Panjiar)
Pr. Chief Engineer

Copy to Chief Bridge Engineer, S.E. Railway, GRC for information and necessary action please.

REPORT ON THE CRACKS & DEFECTS IN DIFFERENT MEMBERS OF OPEN WEB THROUGH TYPE K - SHAPE GIRDER OF BRIDGE NO. 57 (7X$300^{/}0^{//}$G+4X$100^{/}0^{//}$G) AT KM: BETWEEN KOLAGHAT (KIG) & DEULTI (DTE) STATIONS OF KGP DIVISION

Rupnarayan Bridge: History

The Kolaghat Bridge, a crucial transportation link in the Indian state of West Bengal, spans the Rupnarayan River. At the end of August 1895, the government of India sanctioned the construction of the line and the Kolaghat rail bridge over the Roopnarayan was opened on 19 April, 1900 . The bridge was a pivotal railway connection between Kolkata and Chennai.The existing span arrangement of this bridge on down main line is (2x30.5m+7x91.4m+2x30.5m)

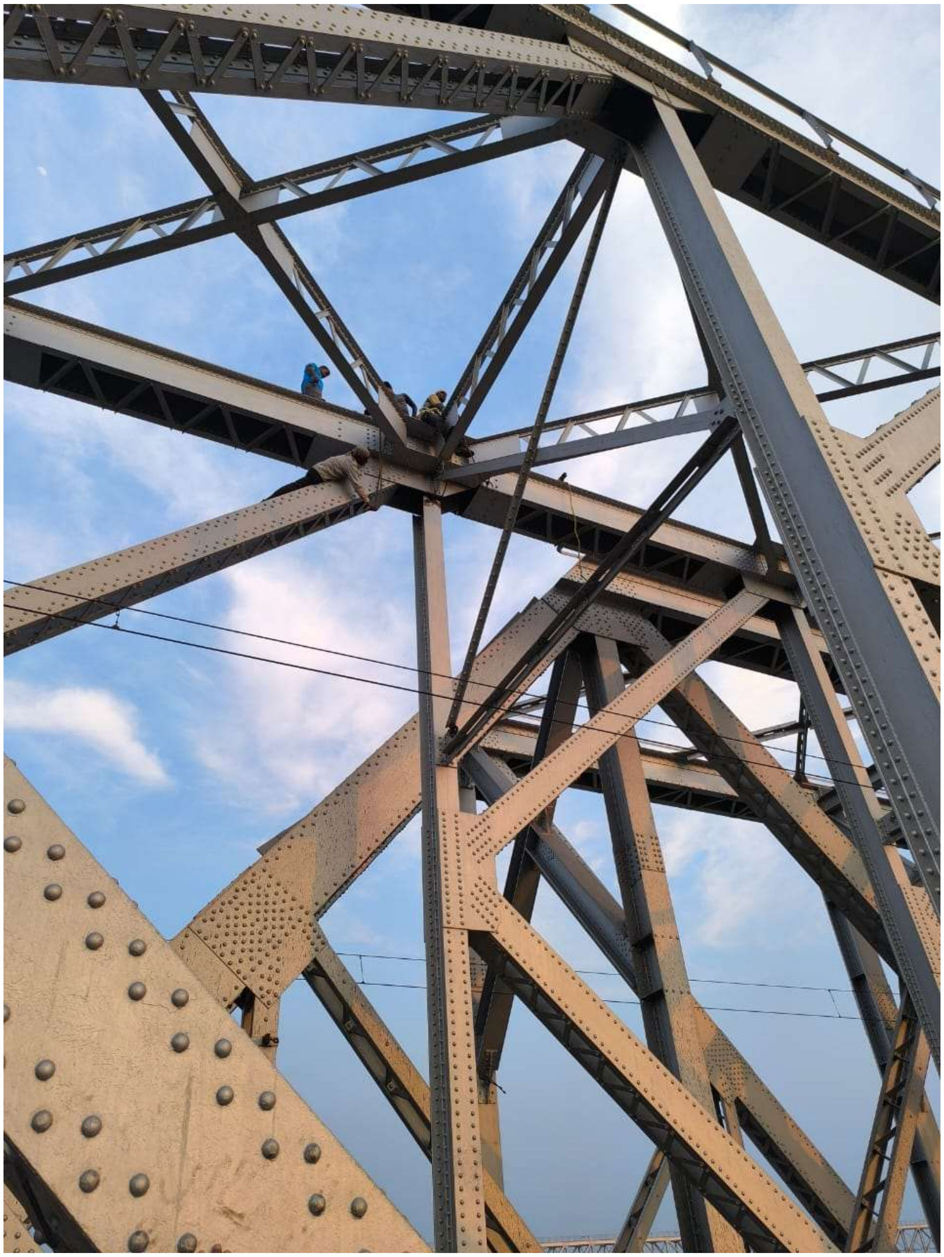
1.0 Bridge no. 57 DN is existing on Kharagpur-Howrah section of KGP division of this railway having 7 nos $300^{/-}0^{//}$ through type girders to Drg no. The DN line regirdering was done in the year 1964.

2.0 The girders were designed for BGML loading-1926. It is to be noted that this bridge is situated in the DFC Feeder route "Baltikuri-ADL-PKU-HLZ" of this railway.

Clear Span of Bridge : 91.5M
Width of Girder : 5.5m C/C
Height of Girder : 12.5m (approx.)
Nos. of Panels: 7 x 2
Weight of Girder : 500 Ton approx.
Name of manufacturer : THE BRAITHWAITE BURN & JESSOP CONST. CO. LTD. , CALCUTTA.

3.0 Cracks were noticed in the 2nd vertical U_1M_1 (upper) at the joint 'U_1' of span no.5 of 300feet girder by Sri Prasenjit, BRI staff under SSE/Br/KIG /SER at about 13:00 hours.Immediately 20kmph was imposed.The details are as shown:-

DETAILS OF CRACKS :

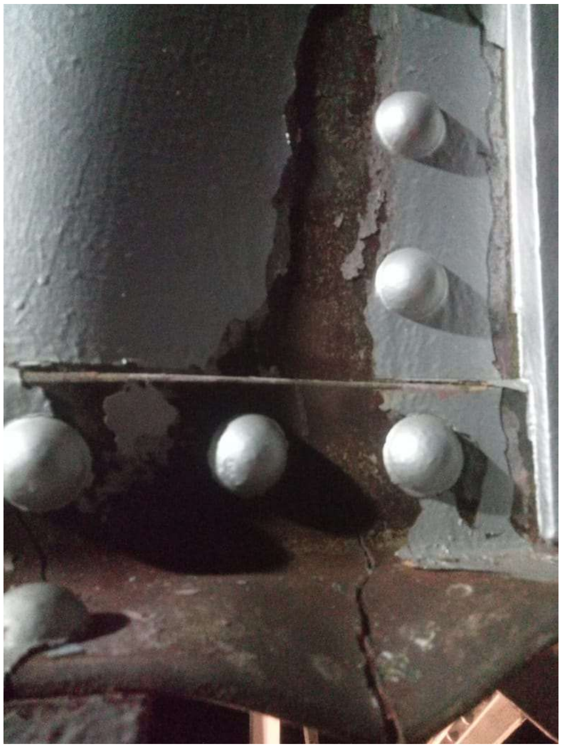


2nd vertical U_1M_1 (upper)

SPAN NO. 5

GAP OF 65mm OCCURRED IN THE VERTICAL

WARPING OBSERVED IN THE WEB



CRACKS AT JOINT “U1”

GAP OCCURRED IN THE VERTICAL

WARPING OBSERVED IN THE WEB

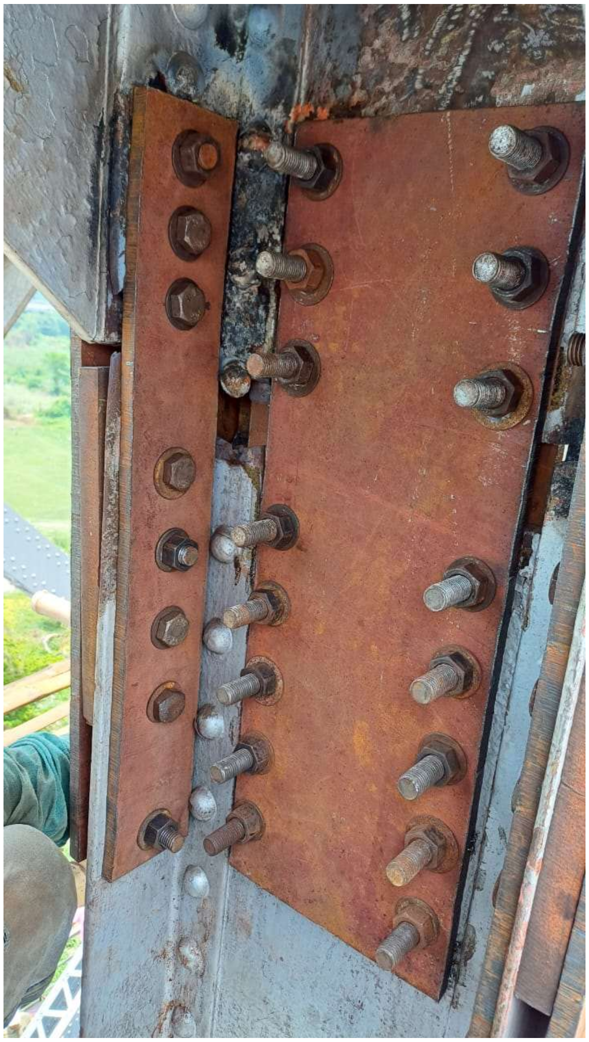
DISTORTION IN THE TOP CHORD MEMBER

SEPARATION OBSERVED IN VERTICAL

WARPING IN TOP CHORD WEB/ANGLE

4.0 Strengthening done immediately on 17.05.2024 by temporary splicing. The details are as follows:-

REPARING IS IN PROGRESS



REPAIRING DONE BY SPLICING AND BOLTING

5.0 The section of the verticals is built-up section consisting of four angles (125x75x8) and one web plate (414 mm x 8 mm thick). The cracks have developed from inside of gusset plate, resulting separation of this vertical member near gussets and observed in hanging condition. Simultaneously, top boom at joint 'U_1' twisted severely along with warping of gusset plate, top chord members & cracks also noticed at several locations.

6.0 Theoretical analysis done and it is observed that vertical, being the tension member probably cracked suddenly due to fatigue resulting into severe distortion in the top chord members at the joint 'U_1'. Diagonal member at this joint is compression member.No irregularity /defect was noticed on the diagonal member at U1 joint

7.0 Camber of the downstream truss has been measured. It is observed that L1 node, corresponding to the cracked U1-M1-L1 vertical has lost its camber. Camber Diagram of the downstream truss is furnished at Annexure-1

8.0 GMT of the DN line bridge is 85

9.0 The bridge is being kept under closed watch by stationary watchman. Levels of the affected node and the adjacent nodes are being taken at two hours interval. Cambers of all nodes of the downstream side truss are being measured twice in a day.

10.0 CONCLUSION AND PERMANENT REPAIR/REHABILITATION OF THE GIRDER: It is assumed that these failure issues may have significant impact of fatigue life of above steel girder bridge. Joint U1 is very complicated due to connection of several members and number of members have got fractured at this location. A detailed study is required for a workable scheme to strengthen all the distressed members connecting joint U1 from safety point of view. Only splicing of vertical member U1-M1 is not a permanent solution as top chord members along with some bracings have also been affected due to sudden detachment of vertical member from joint U1. Temporary rehabilitation scheme for replacement of the cracked U1-M1 portion of the U1-M1-L1 vertical, shown in a advanced copy sketch, is furnished at Annexure-2.

Annexure-1

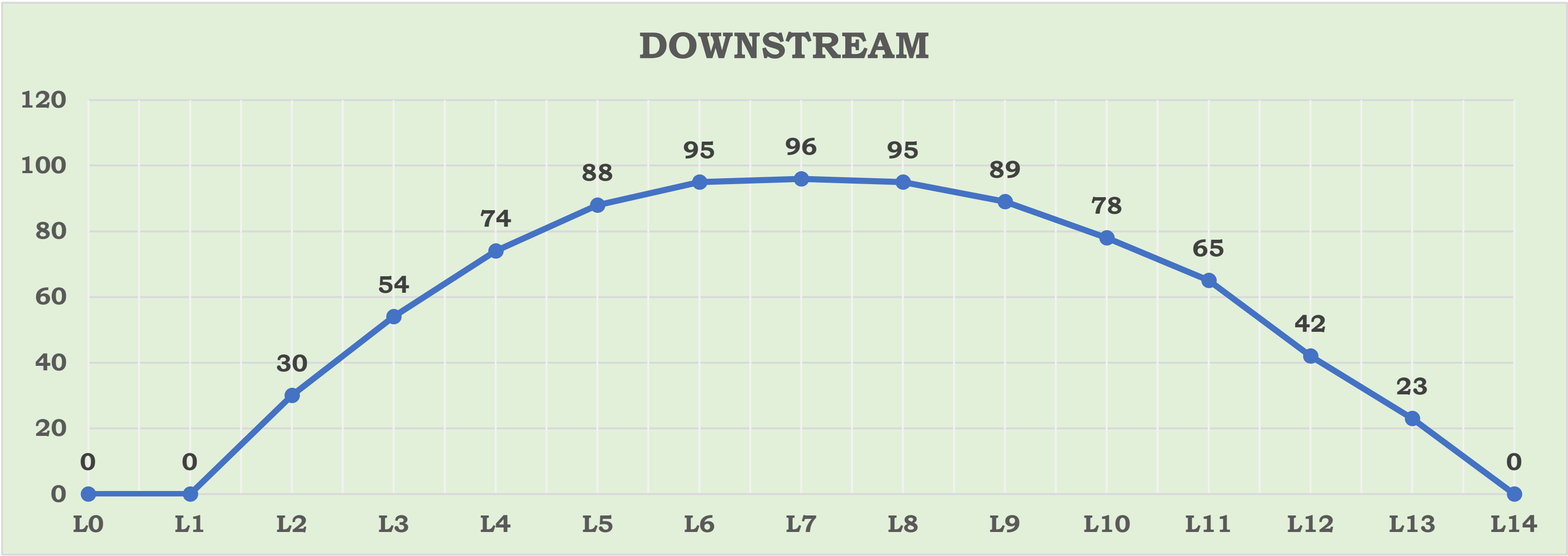
PRESENT CAMBER DIAGRAM: BR. NO. 57 DN, SPAN NO.5, DOWNSTREAM TRUSS

Date of Measurement : - 18.05.2024

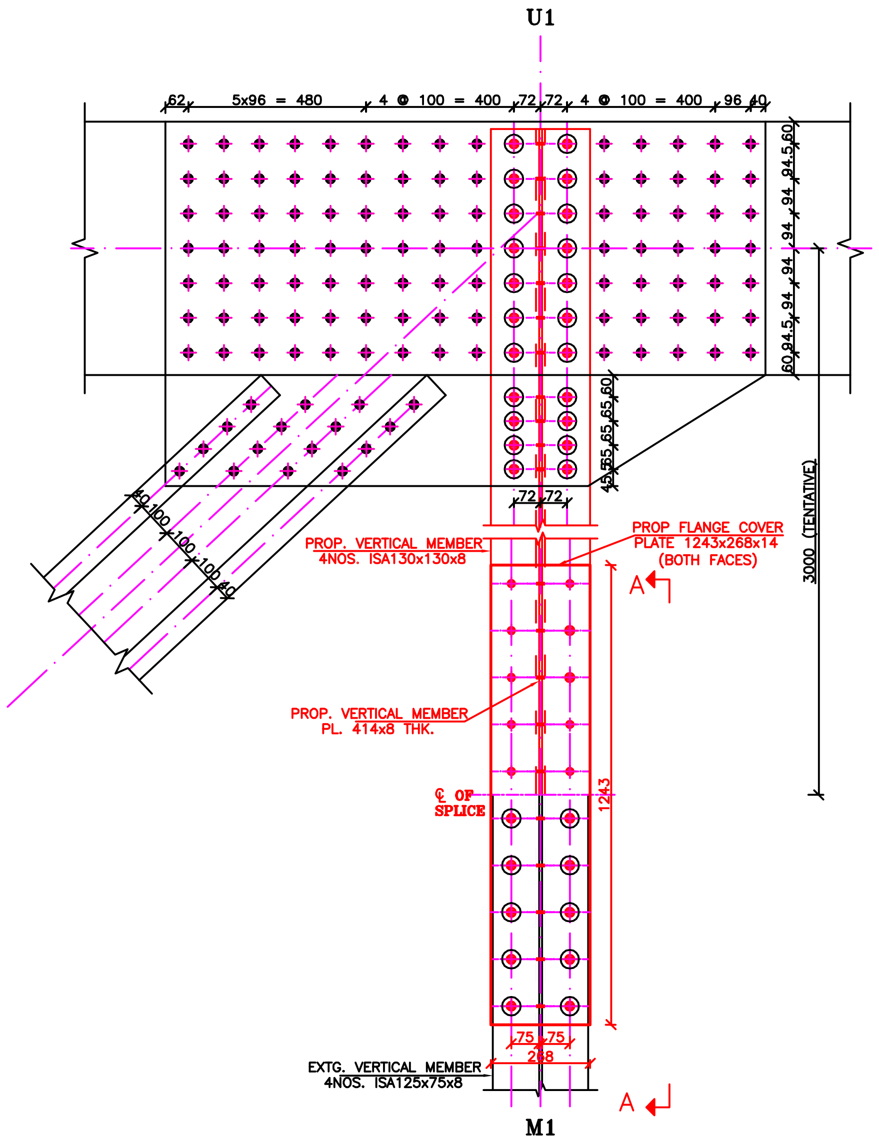
Time: - 8.00am

Ambient Temp: - 32º C

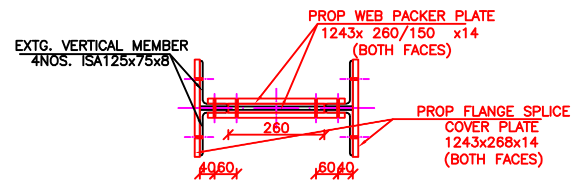
Node	Camber (mm)
L0	0
L1	0
L2	30
L3	54
L4	74
L5	88
L6	95
L7	96
L8	95
L9	89
L10	78
L11	65
L12	42
L13	23
L14	0



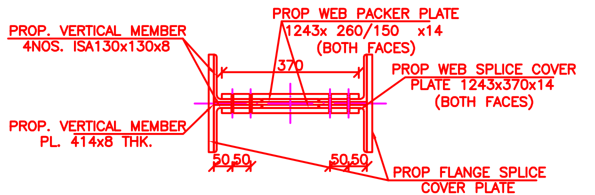
Annexure-2



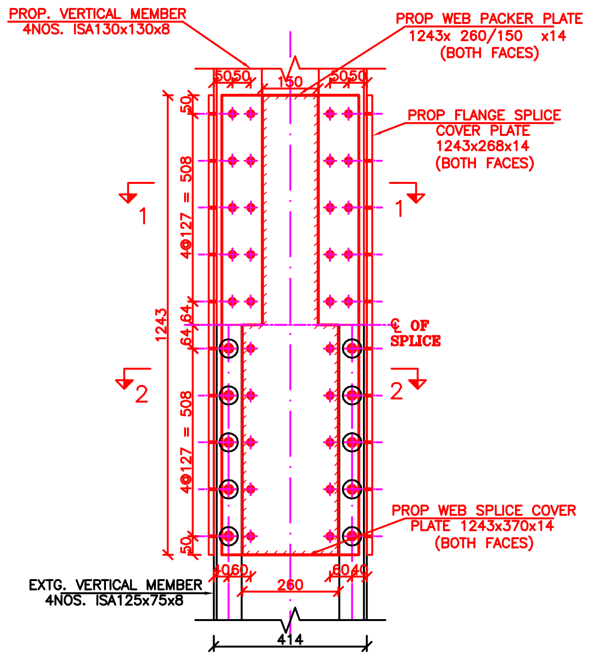
ELEVATION OF JOINT U1



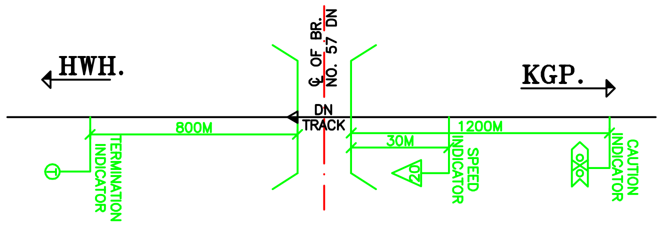
SECTION 2–2



SECTION 1–1



SECTION A–A



TEMPORARY SIGNAL & SPEED RESTRICTION DIAGRAM
(NOT TO SCALE)

NOTES:–

1. ALL DIMENSION ARE IN MM UNLESS STATED OTHERWISE.
2. ALL EXISTING RIVETS ARE SHOWN– ⊕
3. ALL PROPOSED HSFG BOLTS ARE CONFORMING TO IS:3757, 22 DIA(8.8 GRADE) IN 24 DIA HOLES AND SHOWN AS– ⊕
4. ALL PROPOSED HSFG BOLTS OVER EXISTING HOLES ARE 22 DIA AND SHOWN AS– ⊕
5. THE MINIMUM EDGE DISTANCE FROM THE CENTRE OF RIVETS/BOLTS HOLE TO A SHEARED EDGE OR HAND FLAMECUT SHALL BE 1.75 TIMES THE DIAMETER OF THE HOLES AND TO A ROLLED, MACHINE FLAMECUT, SAWN OR PLANED EDGE 1.5 TIMES OF DIAMETER AS PER IRS BRIDGE STEEL BRIDGE CODE.
6. ALL DIMENSIONS SHOULD BE VERIFIED AT SITE AND DISCREPANCIES, IF ANY, SHOULD BE RECONCILED BEFORE FABRICATION.
7. STRUCTURAL STEEL SHALL CONFORM TO IS–2062 : 1992 GRADE–B, FULLY KILLED AND NORMALISED.
8. RIVETS ARRANGEMENTS AND SPACINGS ARE TENTATIVE, PATTERN AS PER SITE CONDITION MAY BE FOLLOWED.
9. ALL EXISTING WORKS ARE SHOWN IN BLACK ▬
10. ALL PROPOSED WORKS ARE SHOWN IN RED ▬
11. CONDITION OF THE TOP BOOM TO BE CHECKED AND CORRECTED, IF REQUIRED AS PER SITE CONDITION.

OPERATION SCHEDULE:–

1. IMPOSE 20KMPH RUN THROUGH RESTRICTED SPEED AS PER TEMPORARY SIGNAL AND SPEED RESTRICTION DIAGRAM.
2. PROP. STRENGTHENING WORK TO BE DONE AFTER SUPPORTING THE AFFECTED VERTICAL MEMBER, AS PER SITE COND.
3. IN A SUITABLE TRAFFIC CUM POWER BLOCK,
   (a) LOWER PART OF THE EXISTING VERTICAL TO BE TIED BY SPECIAL MEANS AS PER SITE CONDITION/ FEASIBILITY, SO THAT LOWER PART OF THE EXTG. VERTICAL SHALL NOT BE TILTED AFTER REMOVAL OF THE UPPER PART OF THE EXTG. VERTICAL.
   (b) CUT THE EXTG. VERTICAL (U1–M1) UPTO THE HEIGHT AS SHOWN IN THE DRAWING.
   (c) REMOVE THE UPPER PART OF THE EXTG. VERTICAL AND INSERT THE PRE–FABRICATED VERTICAL IN THE EXTG. POSITION.
   (d) COMPLETE THE CONNECTION OF U1 JOINT BY HSFG. BOLTS AND SIMULTANEOUSLY SPLICE THE PROPOSED VERTICAL WITH THE REMAINING PORTION OF EXTG. VERTICAL BY BOLTS.
4. CANCEL THE BLOCK, ALLOW TRAFFIC AS PER TEMPORARY SPEED RESTRICTION DIAGRAM, KEEP THE MEMBER UNDER CLOSE WATCH FOR 30 DAYS.
5. RAISE THE SPEED GRADUALLY TO NORMAL SECTIONAL SPEED AFTER PERFORMANCE REVIEW COMPLETION OF ALL RELEVANT WORK.

ADVANCE COPY

SANTANU SAHA/CHIEF BRIDGE ENGINEER/GRC
शांन्तनू साहा/मुख्य पुल अभियंता/जीआरसी

A.K. BHOWMIK/DY. C.E.(DESIGN)/GRC
ए के भौमिक/ उप मुख्य अभियंता(डिज़ाइन)/जीआरसी

S.RAY/AXEN(DESIGN)/GRC
एस रॉय/अधिशाषी अभियंता(डिज़ाइन)/जीआरसी

DRAWN BY–SOUMEN MAJEE/JE(DRG)/GRC
आरेखण- सौमेन माजी/कनिष्ठ अभियंता(आरेख)/जीआरसी

दक्षिण पूर्व रेलवे
SOUTH EASTERN RAILWAY

केजीपी डिवीजन
KGP DIVISION

CASE FILE NO.
CE'S NO.

DETAIL OF SPLICING ARRANGEMENT WITH HSFG BOLTS
FOR BRIDGE NO 57 DN BETWEEN DEULTI-KOLAGHAT
STATION OF KGP DIVISION AT KM

DETAILS OF SPLICING OF VERTICAL MEMBER U1-M1

SCALE: 1:10, NOT TO SCALE
SHEET SIZE A1
SHEET NO. 1

राजेश कुमार श्रीवास्तव
Rajesh Kumar Srivastava
कार्यकारी निदेशक/पुल एवं संरचना
Executive Director/B&S

भारत सरकार - रेल मंत्रालय
अनुसन्धानअभिकल्प और मानक संगठन
लखनऊ-226011
Government of India-Ministry of Railways
Research Designs & Standards Organization
Lucknow- 226011
Phone / Fax : 0522-2465704

संख्या: CBS/DOW

दिनांक: 27.06.2024

PED/Bridge,
Railway Board,
Rail Bhawan,
New Delhi

विषय: Action taken report on instructions of Railway Board regarding failure of vertical in 91.5m K Type truss (non-RDSO design) of Bridge No. 57 (Down) in Kharagpur Division of S.E. Railway.

संदर्भ: PED/Bridge, Railway Board letter no.2016/52/CE-III/BR/Safety dated 24.05.2024.

1. Vide above referred letter, Railway Board issued various instructions to RDSO regarding failure of vertical member of Bridge No. 57 of S.E. Railway. Item wise compliance of above instructions is as follows –
    a. RDSO team visited the site first time on 22-23.05.2024 and second time on 31.05.2024 as instructed.
    b. S.E. Railway has appointed a consultant to develop a safe and workable rehabilitation scheme for the damaged vertical U1-M1 and damaged top chord U1-U2. RDSO is continuously working with S.E. Railway and is providing all the necessary technical inputs/ scrutiny as asked by SER time to time.
    c. Railway Board had also instructed RDSO to critically analyze the failure and to submit a detailed technical report containing probable reasons, proposed action plan for rehabilitation, measures to be taken to prevent such failures in future. Accordingly, please find enclose herewith the technical report of RDSO as instructed above.

This is for your kind information and necessary action please.

Encl.: Technical Report (19 pages)

Digitally Signed by Rajesh Kumar Srivastava
Date: 27-06-2024 11:06:47
Reason: Approved

(राजेश कुमार श्रीवास्तव)
(Rajesh Kumar Srivastava)
कार्यकारी निदेशक/पुल एवं संरचना
Executive Director/B&S

सत्यमेव जयते

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYs

TECHNICAL REPORT ON FAILURE OF BRIDGE NO. 57 OF S.E. RAILWAY

June, 2024

RESEARCH DESIGNS & STANDARDS ORGANIZATION
LUCKNOW-226011

INDEX

1. DETAILS OF BRIDGE

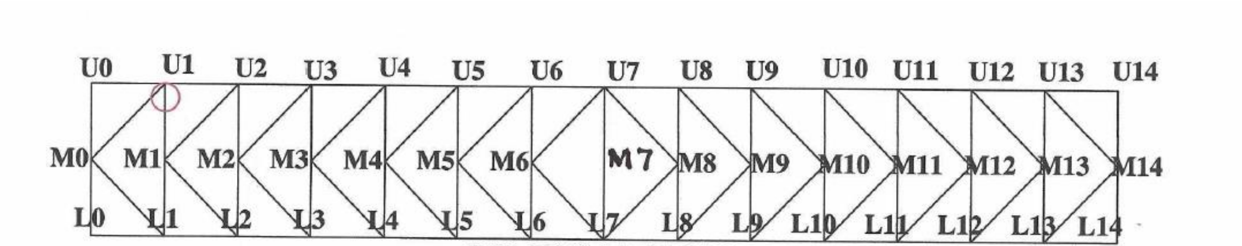
1.1. Brief History

As per the information given by SE Railway, Roopnaryan Bridge (Bridge No. 57 of SE Railway) is a crucial transportation link in the Indian state of West Bengal. It spans the river Roorpnarayan and also known as the Kolaghat Rail Bridge. The bridge is a pivotal railway connection between Kolkata and Chennai. This bridge consists of 3 lines namely 57-UP, 57-MID & 57-DN. The existing span configuration are: 2x30.5m OWG + 7x91.4m + 2x30.5m OWG for 57-UP line and 2x30.5m USG + 7x91.4m + 2x30.5m USG for 57-MID & 57-DN line. It is existing on Kharagpur-Howrah section of Kharagpur division of South Eastern Railway. This bridge is situated in the DFC Feeder route “Baltikuri-ADL-PKU-HLZ” of SER. The substructure of bridge no.57-UP was built in 1964 and superstructure was built in 1966. The substructure of bridge no.57-MID & 57-DN was built in 1896. Regirdering of 91.4m span of 57-DN was done in the year 1966 with BGML loading compliant girders.

1.2. Design Criteria Adopted

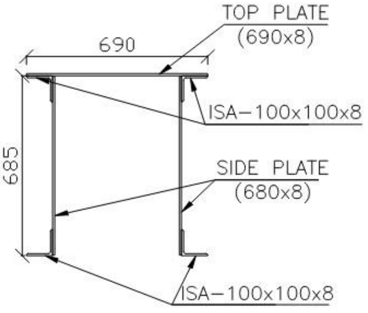
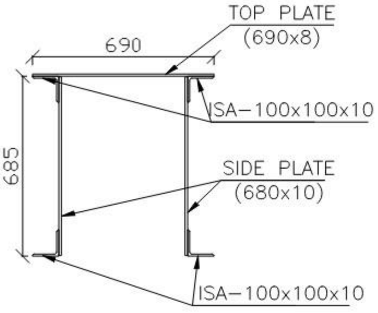
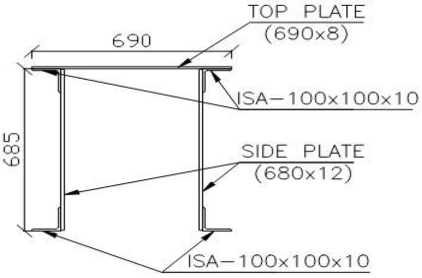
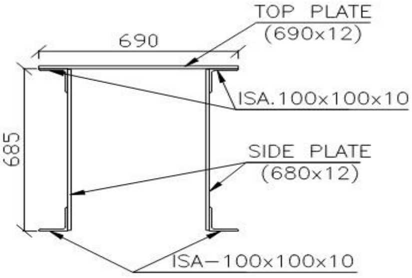
As reported by SE Railway the girders used in 1966 were designed for BGML loading-1926 of IRS Bridge Rules 1941. Materials of Members, Rivets and Gusset were HTS as per IRS Steel Bridge Code 1941.The allowable stress in fatigue were taken as per appendix- G of Steel Bridge Code 1941. This fatigue criteria was based on stress ratio concept, desired design detailing and specific number of stress Cycles of loading. These Fatigue provisions had certain deficiencies and had been rendered obsolete. The new fatigue provision is more rational as it is based on concept of stress range and it includes parameters like GMT factor, configuration of truss, loading and design life etc.

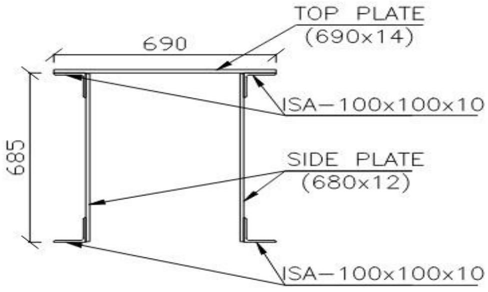
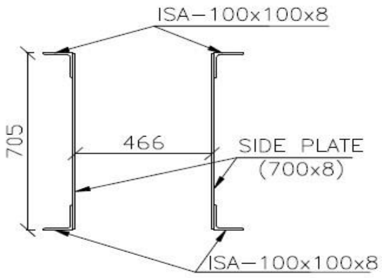
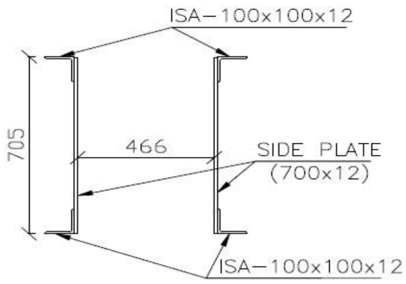
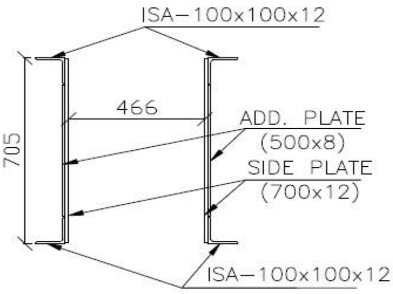
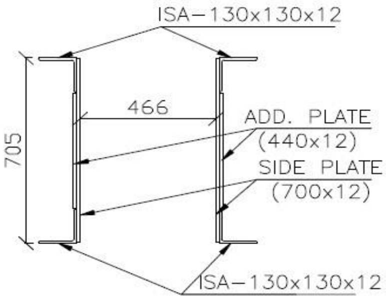
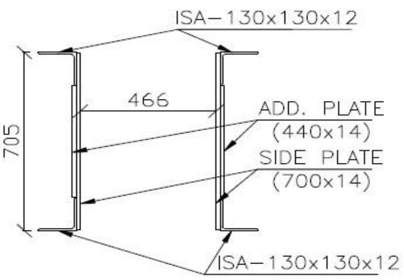
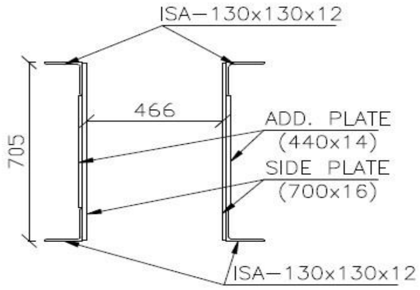
1.3. Details of Sections

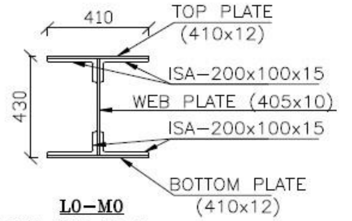
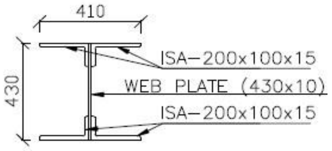
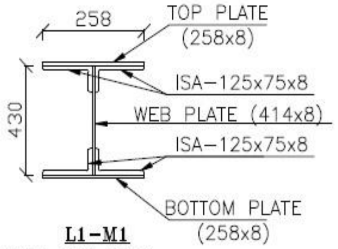
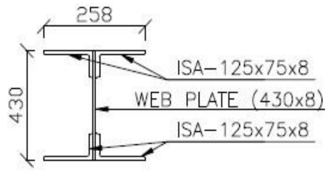
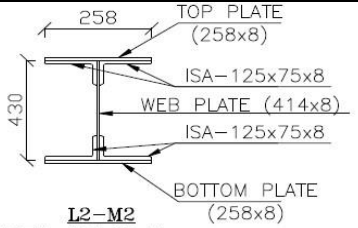
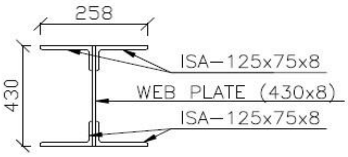
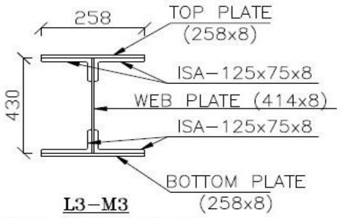
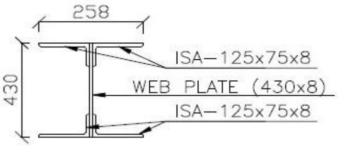
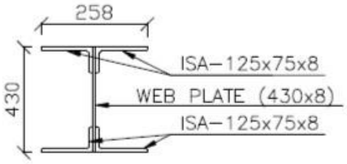
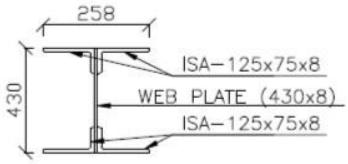
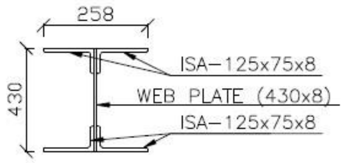
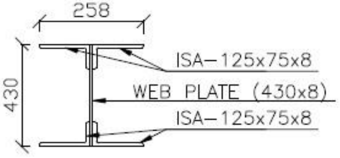


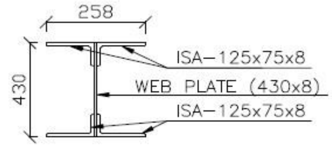
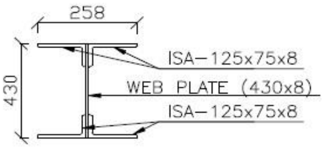
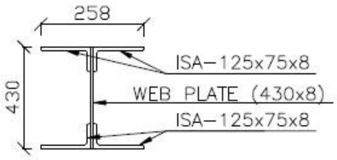
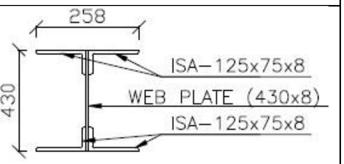
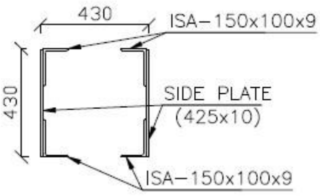
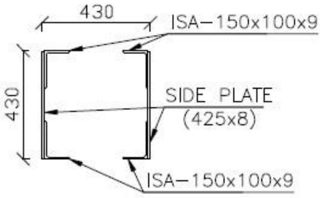
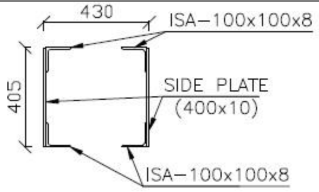
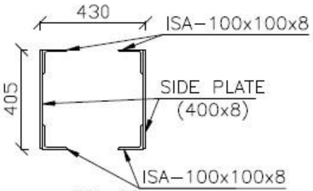
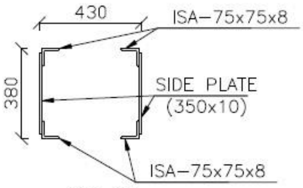
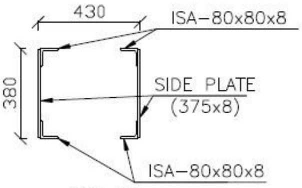
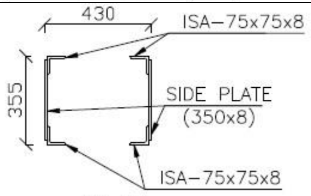
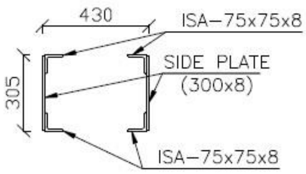
ELEVATION

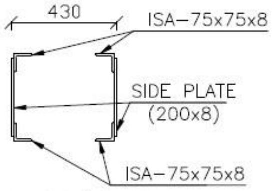
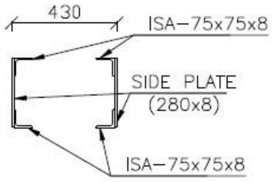
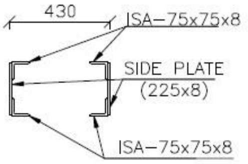
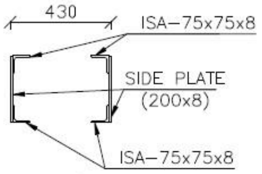
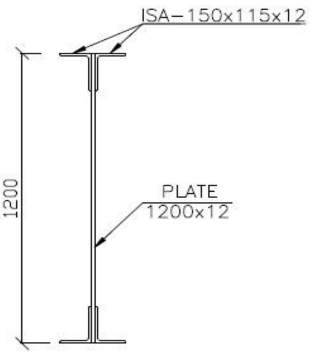
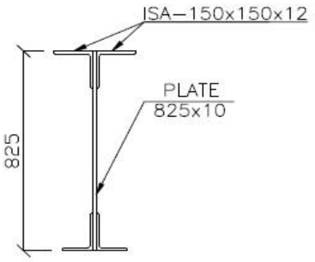
The member thickness varies from 8 mm to 15 mm as shown in the details of member sections below:

	MEMBER NAME	MEMBER SECTION
1.	Top chord	 U0-U1, U1-U2 & U2-U3 (AREA–225.56 Sq.cm)  U3–U4 (AREA–267.32 Sq.cm)  U4–U5 (AREA–294.52 Sq.cm)  U5–U6 (AREA–322.12 Sq.cm)

		 **U6-U7/U7-U8** **(AREA-335.92 Sq.cm)**
2.	Bottom Chord	 **L0-L1/L1-L2** **(NET AREA-158.52 Sq.cm)**  **L2-L3** **(NET AREA-235.8 Sq.cm)**
		 **L3-L4** **(NET AREA-287.6 Sq.cm)**  **L4-L5** **(NET AREA-336.48 Sq.cm)**
		 **L5-L6** **(NET AREA-374.56 Sq.cm)**  **L6-L7** **(NET AREA-397.86 Sq.cm)**

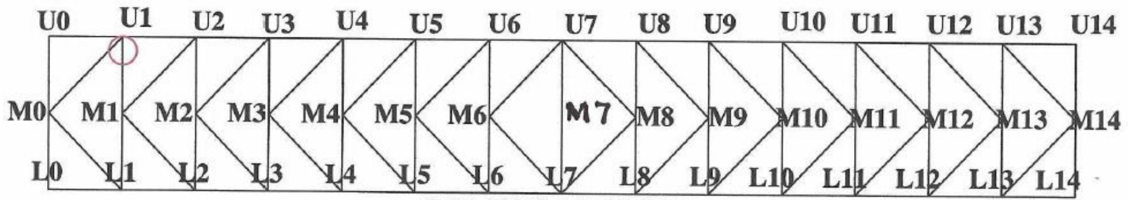
3.	Verticals	 L0–M0 (AREA–310.02 Sq.cm NET AREA– 239.52 Sq.cm)  U0–M0 (AREA–214.12 Sq.cm NET AREA– 195.32 Sq.cm)  L1–M1 (AREA–135.92 Sq.cm NET AREA– 109.6 Sq.cm)  U1–M1 (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  L2–M2 (AREA–135.92 Sq.cm NET AREA– 109.6 Sq.cm)  U2–M2 (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  L3–M3 (AREA–135.92 Sq.cm NET AREA– 109.6 Sq.cm)  U3–M3 (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  L4–M4 (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  U4–M4 (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  L5–M5 (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  U5–M5 (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)

		 **L6–M6** (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  **U6–M6** (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)
		 **L7–M7** (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)  **U7–M7** (AREA–94.64 Sq.cm NET AREA– 83.36 Sq.cm)
4.	Diagonals	 **U1–M0** (AREA–167.32 Sq.cm)  **M0–L1** (NET AREA–135.28 Sq.cm)
		 **U2–M1** (AREA–141.56 Sq.cm NET AREA–124.64 Sq.cm)  **M1–L2** (AREA–125.56 Sq.cm NET AREA–110.52 Sq.cm)
		 **U3–M2** (AREA–115.52 Sq.cm NET AREA–98.6 Sq.cm)  **M2–L3** (AREA–108.84 Sq.cm NET AREA–93.8 Sq.cm)
		 **U4–M3** (AREA–101.52 Sq.cm NET AREA–86.48 Sq.cm)  **M3–L4** (AREA–93.52 Sq.cm NET AREA–78.48 Sq.cm)

		 U5–M4/U6–M5 (AREA–77.52 Sq.cm NET AREA–62.48 Sq.cm)	 M4–L5 (AREA–90.32 Sq.cm NET AREA–75.28 Sq.cm)
		 U7–M6 (AREA–81.52 Sq.cm NET AREA–66.48 Sq.cm)	 M5–L6/M6–L7 (AREA–77.52 Sq.cm NET AREA–62.48 Sq.cm)
5.	Cross Girder and Stringer	 CROSS GIRDER	 STRINGER

2. REPORTNG OF DISTRESS BY SER

2.1 SER vide letter No. BR/CBE Cell/ dated 21.05.2014 reported structural distress in the Bridge No 57 DN. Cracks were noticed on Second Vertical U1M1(Upper) near U1 of span no. 5 (91.4m span) by BRI staff on 17.05.2024. A gap of approximately 65mm was reported at the location of crack in U1M1.



ELEVATION

Fig.1: Full crack near U1 Node in the line of the last rivet (from Top) in Vertical & Gusset Connection.

Also in the attached top chord component U1-U2, both the Top Chord Bottom Flange Angles were found having cracks. Both Web Plates were partially cracked. Web Plates & Bottom Flanges angles were bulged.

Fig.2: U1-U2 member

2.2 Subsequently on 22/23.05.2024 RDSO team visited the site. On 23-05-2023 further cracks were observed by SER bridge team in another vertical U13-M13 (Upper) at similar location. One (out of the four) Flange angles ISA 125x75x8 was found having crack in both the legs of the angle (Track side, HWH end). Length of crack was approx. 200mm

Fig.3: Vertical U13- M13 D/Stream

2.3 RDSO officials again visited the site on 31-05-2023 in compliance to Railway board letter No.2016/52/CE-III/BR/safety dated 24.05.2024.

2.4 During further through inspections by SER team, more cracks were detected. On 01.06.2024 in vertical U13-M13 (upstream), near U13 node in the line of the last rivet (from top) in vertical and gusset connection one (out of the four) Flange angles ISA 125x75x8 was found cracked at 125mm leg of the angle (Outer side, HWH end). Length of crack was 45mm.

Fig.4: Vertical U13-M13 U/Stream

2.5 On 07.06.2024 in vertical U13-M13 (downstream), near U13 node in the line of the last rivet (from Top) in Vertical & Gusset Connection One (out of the four) Flange angles ISA 125x75x8 was found cracked at 125mm leg of the angle (Outer side, HWH end). Length of crack was100mm.

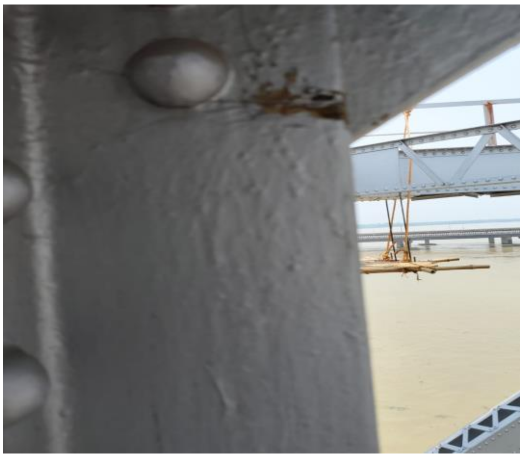


Fig.5: Vertical Chord U 13-M13 D/ Stream

2.6 Near U13 node in the line of the last rivet (from Top) in Vertical & Gusset Connection one (out of the four) Flange angles ISA 125x75x8 was found cracked at 125mm leg of the angle (Outer side, HWH end). Length of crack was 60mm.

Fig.6: Vertical U13 - M13 U/Stream

2.7 on 08.06.2024 near U1 node in the line of the last rivet (from Top) in Vertical & Gusset Connection one (out of the four) Flange angles ISA 125x75x8 was found cracked at 125mm leg of the angle (Outer side, KIG end). Length of crack was100mm.

Fig.7: Vertical U1 - M1 U/Stream

2.8 On 10.06.2024 near U11 node in the line of the last rivet (from Top) in Vertical & Gusset Connection one out of the four Flange angles ISA 125x75x8 was found cracked at both the legs of the angle (Track side, HWH end). Length of crack was 115mm. Intermittent/ Tack in-situ weldings were found at Vertical & Gusset Connection.

Fig.8: Vertical U11 - M11 D/ Stream

2.9 On 11.06.2024 near U11 node in the line of the last rivet (from Top) in Vertical & Gusset Connection one (out of the four) Flange angles ISA 125x75x8 was found cracked at both the legs of the angle (Track side, HWH end). Length of crack was 200mm. Intermittent/ Tack in-situ weldings were found at Vertical & Gusset Connection.

Fig.9: Vertical U11 – M11 U/ Stream

3. REPAIR AND RESTORATION WORK

3.1 The traffic was immediately restored after performing temporary repairs. Splicing of the cracked portion of vertical U1-M1 was done on 18.05.2024 as follows –

3.2 For developing proper repair scheme, SER has engaged private consultant. Primarily the scheme will aim at designing and fixing of equipotential members with affected parent members.

4. FAILURE ANALYSIS

After analyzing the problem in detail, based upon information provided by SER, it was found that failure occurred on account of many factors which will now be discussed one by one.

4.1 Increase in axle loading and GMT

4.1.1 Regirdering of Br. No. 57 was done in 1966 catering to BGML loading – 1926. This bridge falls in DFC feeder route 'ADL-PKU-HLZ' of SER.

4.1.2 Subsequently operation of 22.32t axle load at 40 kmph was allowed on this bridge. Further on 03.11.2022, 22.9t axle load at 40 kmph was allowed on 23.12.2022.

4.1.3 As per the data given by Zonal Railway the average annual GMT from 1966 to 1995 was 30 GMT. From 1995 to 2023 the annual GMT increased from 33.43 GMT to 86.82 GMT.

4.1.4 Therefore it is observed that axle load and GMT on the bridge have increased enormously since commissioning of the bridge in 1966. Steel Girder Bridges are subjected to heavy fluctuating stress causing fatigue in steel. With increased axle loads, GMT and speeds, the bridge are subjected to cycles of higher stress ranges and fatigue life of members/components are consumed early.

4.2 Sectional adequacy of member U1-M1/U13-M13

4.2.1 In the subject truss shown above, upper verticals UM are primarily subjected to tensile stresses. The magnitude of tension is maximum at U1-M1 and it keeps on reducing in upper verticals located towards centre of span. In all these upper verticals from U1-M1 to U7-M7, same cross sectional area has been provided. Therefore the first member from either side i.e. U1-M1 and U13-M13 become the most critical upper vertical members.

4.2.2 The table below shows the comparison of actual stresses vs. permissible stresses for checking the structural adequacy of member U1-M1 for 22.9t axle load (BOXNS) at 40 kmph (allowed on the bridge)-

Member	SPAN (m)	AREA OF ILD	CDA (125 kmph)	CDA (60 kmph)	D.L. (t/cm)	D.L. (t)	L.L. (t/cm)	L.L. (t)	I.L. (t)	DL+LL+IL	Cross Sectional Area (cm^2)	Actual Stress (Kg/cm^2)	Permissible Stress (Kg/cm^2)	Stress Ratio	Remarks
U1 - M1	93.80	2181.0	0.230	0.074	0.026	56.706	0.045	97.790	7.202	161.698	83.360	1939.756	2130.00	0.911	OK

From above table it can be seen that under 22.9t axle load at 40 kmph, the upper vertical U1-M1 is subjected to a stress of approx. 194 N/mm^2 which is within the permissible stress of 213 N/mm^2.

4.2.3 For analyzing the member from fatigue point of view, the detail category for the member U1-M1/U13-M13 can be taken as 80 as per table G-II.1 construction detail 8. The permissible stress from fatigue point of view shall be 80/1.15 = 69.57 N/mm2 without applying damage factors. Therefore, it can be seen that although permissible stress considered for finding section U1-M1 was 213 N/mm2, the actual governing fatigue stress was much below that i.e. 69.57 N/mm2 only. Based upon the simplified approach as given in Annexure-G of IRS Steel Bridge Code, fatigue life of member U1-M1/U13-M13 has been calculated for 25t loading, 125 kmph, for various GMTs as below –

25T LOADING AT 125 KMPH

Detail category = 80N/mm^2

γ_{mf} = 1.15

Member	Stress Range (N/mm2)	Loaded Length (m)	Loading factor λ 1	Annual Traffic in GMT Corresponding average route GMT factor (λ2) Design Life(years) respectively						
				5	10	20	30	40	50	87
				0.721	0.830	0.956	1.038	1.101	1.152	1.289
U1-M1	143.2470	93.80	0.760	55.24	27.73	13.92	9.30	6.99	5.60	3.23

4.2.4 As elaborated above, although section adopted was safe from normal stresses point of view but there was very little margin available for fatigue. It can be seen that member U1-M1 has very low fatigue life i.e. 9.3 to 7 years only even at 30-40 GMT. The provided section was almost one third of the section required from fatigue requirements point of view.

4.2.5 The simplified approach may be used for analyzing various members from fatigue point of view based upon the criteria as given in Annexure-G of IRS Steel Bridge Code. Stepwise procedure to be followed has been explained later in the recommendations section.

4.2.6 Using this simplified approach similar exercise was done for other members also and results are as follows-

25T LOADING AT 125 KMPH

Detail category = 80N/mm^2
γ_{mf} = 1.15

Member	Stress Range (N/mm^2)	Loaded Length (m)	Loading factor λ 1	GMT						
				5	10	20	30	40	50	87
				Average route GMT factor λ2						
				0.721	0.830	0.956	1.038	1.101	1.152	1.289
				Corresponding Fatigue life in years for above GMT & corresponding λ2						
U1-M1	143.24	93.8000	0.760	55.24	27.73	13.92	9.30	6.99	5.60	3.23
M1-L1	69.59	83.3800	0.767	1799.14	903.23	453.45	303.02	227.65	182.36	105.14
U1-M0	104.48	93.8000	0.760	257.88	129.46	65.00	43.43	32.63	26.14	15.07
M1-L2	136.90	86.5800	0.763	67.61	33.94	17.04	11.39	8.55	6.85	3.95
U4-U5	126.95	93.8000	0.760	99.62	50.01	25.11	16.78	12.61	10.10	5.82
L4-L5	125.15	93.8000	0.760	106.80	53.62	26.92	17.99	13.51	10.83	6.24

4.2.7 Fatigue life of above members was also calculated for 25t loading at 60 kmph and the results are appended below –

25T LOADING AT 60 KMPH

Detail category = 80N/mm^2
γ_{mf} = 1.15

Member	Stress Range (N/mm^2)	Loaded Length (m)	Loading factor λ 1	GMT						
				5	10	20	30	40	50	87
				Average route GMT factor λ2						
				0.721	0.830	0.956	1.038	1.101	1.152	1.289
				Corresponding Fatigue life in years for above GMT & corresponding λ2						
U1-M1	135.56	93.800	0.760	72.31	36.30	18.23	12.18	9.15	7.33	4.23
M1-L1	64.41	83.380	0.767	2625.13	1317.91	661.64	442.14	332.16	266.08	153.42
U1-M0	98.87	93.800	0.760	337.59	169.48	85.09	56.86	42.72	34.22	19.73
M1-L2	129.26	86.580	0.763	89.48	44.92	22.55	15.07	11.32	9.07	5.23
U4-U5	120.13	93.800	0.760	130.42	65.47	32.87	21.97	16.50	13.22	7.62
L4-L5	119.19	93.800	0.760	135.55	68.05	34.16	22.83	17.15	13.74	7.92

4.2.8 For 25t loading and 40 kmph the results are as appended below –

25T LOADING AT 40 KMPH

Detail category = 80N/mm^2
γ_{mf} = 1.15

Member	Stress Range (N/mm^2)	Loaded Length (m)	Loading factor λ 1	GMT						
				5	10	20	30	40	50	87
				Average route GMT factor λ2						
				0.721	0.830	0.956	1.038	1.101	1.152	1.289
				Corresponding Fatigue life in years for above GMT & corresponding λ2						
U1-M1	133.19	93.800	0.760	78.80	39.56	19.86	13.27	9.97	7.99	4.61
M1-L1	62.81	83.380	0.767	2966.92	1489.49	747.78	499.70	375.41	300.72	173.39
U1-M0	97.14	93.800	0.760	367.89	184.69	92.72	61.96	46.55	37.30	21.50
M1-L2	126.91	86.580	0.763	97.86	49.13	24.66	16.48	12.38	9.92	5.72
U4-U5	118.04	93.800	0.760	142.12	71.35	35.82	23.94	17.98	14.41	8.31
L4-L5	117.35	93.800	0.760	146.22	73.41	36.85	24.63	18.50	14.82	8.54

4.2.9 As seen from above result it is found that not only the failed member U1-M1, but also other members have outlived their fatigue life. This is only when the girder has been considered new but in present instance the girder is already in service for more than 58 years. So the girder has outlived its fatigue life despite being safe from normal stresses point of view. The girder survived so long due to running of lesser load than the load at which above analysis has been done. Also there is always certain factor of safety in design which prolongs occurrence of cracks at the end of fatigue life.

4.3 Instrumentation study

4.3.1 As per the report provided by Railway, a third party audit of this bridge was done by AIMIL in Jul-Aug 2021. The report was duly vetted by IIT, Guwahati. Girders of all the 11spans (mentioned as girders G1 to G11) of UP, DN and MID lines were instrumented for recording accelerations of girders, strains of girders, longitudinal displacements of girders, tilt of piers & vibration frequencies of girders. Vertical deflections were recorded for only two girders namely G3 & G4 of UP, DN and MID lines. One of the recommendations particularly related with the girders from the report is reproduced below in verbatim-

4.3.2 “During Goods train passes through 57 DN Line, the maximum deflection obtained from measurement is 30.505mm w.r.t. the FEM calculation of 42.868mm. It is quite below the deflection obtained from FEM model. However, the Load vs Deflection recovery time is almost 2 minutes as mentioned in the observation. This may be due to fatigue loading of the Girder."

4.3.3 The above observation/recommendation is about the Girder No. G3 of DN line for 25t axle loading. However, no remedial action seems to be taken as per details provided by Railway.

5 CONCLUSION

5.1 It is observed that GMT on the bridge has increased many folds since commissioning of the bridge in 1966. Steel Girder Bridges are subjected to heavy fluctuating stress causing fatigue in steel. With increased axle loads, GMT and speeds, the bridge was subjected to cycles of higher stress ranges/ more stress cycles and fatigue life of members/components got consumed early. Members were not adequate to sustain this much fatigue life.

6 RECOMMENDATIONS

6.1 Indian Railways is having a large no. of old steel bridge. As per BMS, the total no. of steel bridges more than 50 years old is 2752 nos. Most of these steel bridges are carrying/ have carried a larger load than they were originally designed for.

6.2 At the time these bridges were designed, the effect of fatigue due to cyclic loading was often neglected and if such an effect was taken into account, it was based on limited understanding and knowledge of the phenomenon.

6.3 Therefore in the light of above discussion and instructions issued by Railway Board vide letter no. 2023/48/CE-III/BR/3000MT (E-3448988) dated 04.06.2024 and 14.05.2024, Zonal Railways should take up assessment of residual fatigue life of steel bridges. Action for regirdering/ rebuilding/ repair to be planned based on outcome of the assessment and distress condition of the bridge.

6.4 Approximate assessment of residual fatigue life of such bridges can be done based upon Simplified Approach as given in Annexure-G of IRS Steel Bridge Code as illustrated above by performing the calculations for each type of bridge member. Following steps may be followed for this purpose –

Step 1: Considering the bridge as new one on present date calculate fatigue life (N years) based upon current / intended GMT (G) for various components of bridge.

Step 2: The fatigue life of the bridge component as on date is (GxN) GMT years.

Step 3: Based upon the past traffic data which actually passed over the bridge (available with Zonal Railways), (g)GMT (n)years (for various year brackets) passed so far over the bridge since its commissioning shall be calculated say –

g.n= g1xn1+g2xn2+g3xn3…….

Step 4: Residual life left = (G.N-g.n) GMT years.

Such exercise allows us to identify members which are critical from fatigue point of view. This will help in identifying those members of OWG, whose fatigue life is governing the fatigue life of the entire bridge.

6.5 If the fatigue life is found inadequate, following options are available:

i. Authenticity of traffic data considered may be reviewed.

ii. Instrumentation of critical members can be carried out to obtain the actual stress ranges and the residual fatigue life can be re-calculated.

iii. Improve track conditions over the bridge to reduce impact. This will help in reducing the stress ranges coming over the bridge and the fatigue life can be extended.

iv. Restrict axle load/volume of traffic over the bridge and institute periodic inspections of those particular details that restricted the fatigue life to ensure adequate safety without other changes.

v. Modify the bridge to improve its fatigue strength by either retrofitting the particular detail that controlled the fatigue life or add extra steel to cross sections to reduce the stresses.

6.6 For the purpose of instrumentation following is recommended –

i. Inspection and monitoring the fatigue effects is evitable requirement of old bridges where heavy axle load is under operation. Owing to the difficulty and constraints of manual inspections, necessary instrumentation should be employed to detect fatigue damages, assess the structural adequacy for the load being operated, structural integrity and residual fatigue life of member of girders. RDSO guidelines for instrumentation of bridges (BS-106-R-2) may be referred for planning of the instrumentation schemes. Alarm based long term continuous structural health monitoring system may also be installed for real time monitoring of bridges.

ii. In riveted bridges, the fatigue crack normally originates from the edge of the rivet hole and is initially hidden by the rivet head, thus making it impossible to detect the crack visually. The only method to detect theses cracks in riveted structure is ultrasonic testing. RDSO Guidelines on Non-destructive testing of bridges (BS-103) may be referred.

iii. Damage assessment (though only qualitatively) is possible through Acoustic Emission (AE) technique as the AE activities are functions of parameters such as stress level in the crack Zone. AE activity can be related to fracture mechanics parameters which can be further related to crack growth rate and fatigue failure. This system may also be utilised for long-term continuous monitoring. However, this AE based system is not suitable for riveted structures. Further, this AE system can only qualitatively gauge the damage, so, use of other NDT methods like ultrasonic tests are necessary to obtain quantitative results about size, depth, and overall acceptability. RDSO guidelines on use of Acoustic emission Technique (AET) on Railway Bridges (BS-104) may be referred.

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