LOAD RATING ON CORROSIVE MEMBERS IN TWIN I-STEEL RAILWAY GIRDER

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1. INTRODUCTION

Twin I-steel girder, shown in Fig. 1, comprises of about 80% steel bridge population over Indian Railways (IR). About 75% of these bridges are more than 60 years old. Local corrosion is one of the biggest challenges in maintenance of these old steel bridges. Present maintenance approach in IR is based on assigning a Condition Rating Number (CRN) after visual inspection of bridge and based on this CRN the decision of maintenance effort (e.g. monitor, repair, rebuild or replace) is done.[2] But CRN based approach is qualitative as decision is based on only physical condition of corroded part. Moreover, there might be problem of individual bias in the decision of CRN and prioritization of corrosion damage in the same category of CRN.

2. CORROSION PRONE LOCATION ON I-GIRDER

Corrosion can occur in any part of the I-girder depending on its exposure to environment but there are some locations on the I-Girder which are more prone to local corrosion in IR case.[2] Fig. 1 shows four categories of corrosion: a) Top flange of girder below rail sleepers b) Bottom flange of girder where water pockets forms with vertical stiffeners c) End area of girder near supports where dirt accumulates near bearing area d) Junction of web plate and bottom flange.

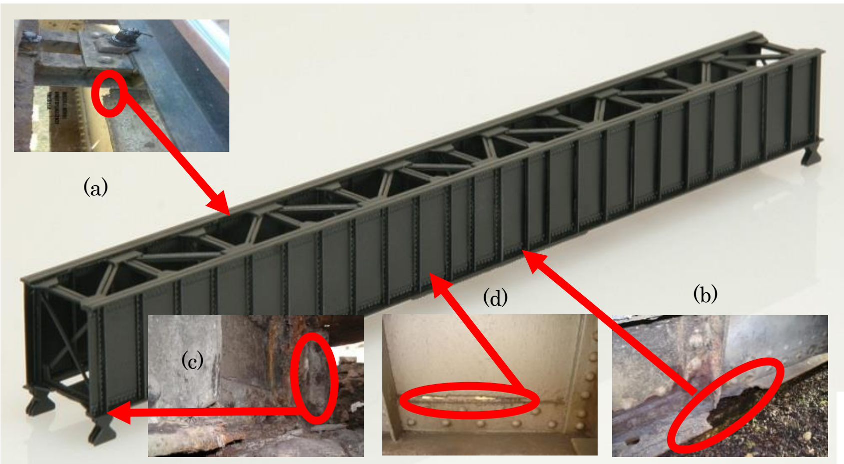

Fig. 1 Corrosion prone locations on I-Girder

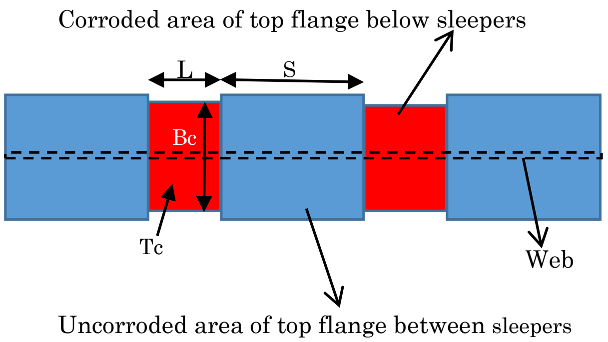

Fig. 2 Plan view of corroded top flange corrosion pattern at mid-span

3. CRITICAL CORROSION PATTERN FOR TOP FLANGE CORROSION CASE

A critical corrosion pattern has been identified for top flange corrosion shown in Fig. 2. Basis for such selection of critical corrosion pattern is the most adverse effect on load carrying capacity of girder out of most frequent corrosion patterns observed at this location. The capacity of girder and load effects is evaluated by parametric analysis on the degree of corrosion. Geometric parameters to describe the corrosive dimensions are Tc (Remaining thickness of top flange in corrosion affected area) and Bc (Width of top flange in corrosion affected area) as shown in Fig 2.

4. LOAD RATING OF BRIDGES

Load rating concept has been used to evaluate the condition of bridges. AASHTO has been one of the pioneers in suggesting the use of load rating of bridges. This concept has evolved from Allowable Stress Rating (ASR) to Load and Resistance Factor Rating (LRFR) as there is evolution in design concept from Allowable Stress Design (ASD) to Load and Resistance Factor Design (LRFD).[1] In this paper, ASR has been used as rating philosophy as the present steel bridge design code [4] in IR is based on ASD concept. If Rating Factor (RF) < 1, then bridge is not considered safe for carrying live load for particular extent of corrosion at that location.[1] So decision about maintenance effort for corrosion at particular location will be proposed to be done based on RF. For better monitoring of corrosion at top flange the effect of variable parameters (e.g. Tc, Bc) of corrosion on RF are studied.

$$\text{Rating } Factor = \frac{(Capacity\ of\ \text{girder}\ - Dead\ load\ \&\ permanent\ load\ effect)}{Live\ load\ effect\ including\ impact} \quad \text{------} \quad (1)$$

Keywords: Load Rating, Corrosion, Railway I-Girder

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5. METHODOLOGY

RF has been calculated for the twin I-girder system as a whole for corrosion patterns with varying different variable parameters (e.g. Tc, Bc). The calculation of capacity and the effects of various loads in top flange corrosion case for calculation of RF is done by Finite Element Modeling (FEM). ABAQUS model of twin I-girder system of span 19.4 meter with track has been adopted as shown in Fig.3. All parts are three dimensional deformable homogeneous solid with density of 7850 kg/m^3 and Young's Modulus 210 GPa. Moving wheel loads have been simulated by applying patches of pressure load on rail top, changing its location on rail top across different steps of analysis. All analysis steps are static general. Interaction between different part instances ensured by tie constraints. Boundary condition applied on ends of bottom flange as one end pinned and other end roller. Meshing has been done by using C3D8R element. Corrosion represented by reducing the thickness (Tc) and width (Bc) of area under middlemost eight railway sleepers as shown in Fig.3. Value of Tc and Bc are changed to represent extent of corrosion for each analysis. Results of analysis indicate that visual examination is not enough to decide about the maintenance effort. For example in case of top flange corrosion with reduction in Tc only and no reduction in Bc under eight middlemost railway sleeper, the reduction in RF is about 25% only even if the reduction in top flange thickness is 60% as shown in Fig. 4. By visual examination this is considered far worse situation as compared to results of analysis. In this case if decision about maintenance effort is done by CRN approach[2)] it would have been much more conservative and more costly as compared to the decision based on RF approach. Thus RF eliminates subjectivity and provides a logical decision for maintenance effort based on structural evaluation of bridge.

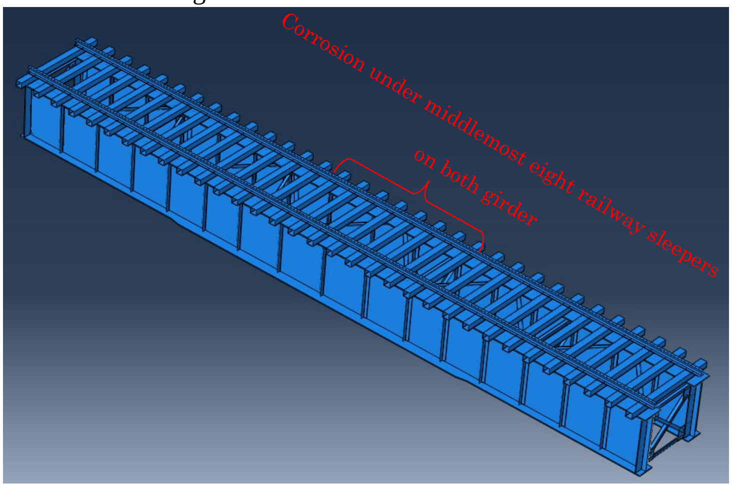

Fig. 3 ABAQUS model assembly of twin I-Girder system

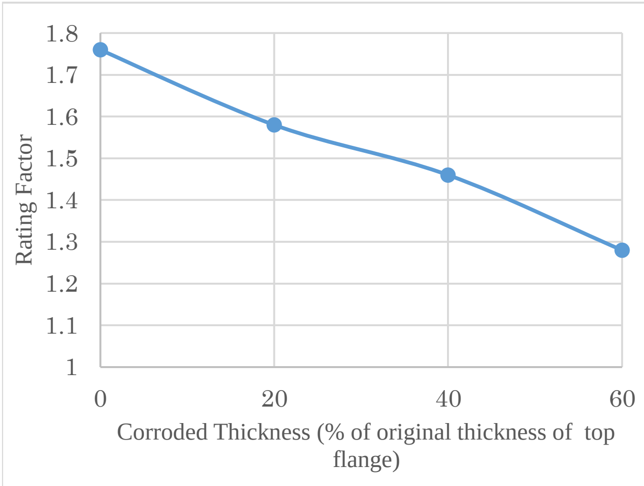

Fig. 4 RF reduction vs Tc for Top flange corrosion without reduction in Bc

5. CONCLUSION AND FUTURE TASK

Rating Factor based approach for maintenance of corrosive twin I-steel girder is much more quantitative than CRN based approach as it combines the visual inspection of bridge with its structural evaluation. Future task involves RF calculation vis-a-vis different variable parameters of corrosion for the critical corrosion pattern identified at remaining three locations shown in Fig. 1. Then apply simplified theoretical approach based on allowable stress as per provisions of IR standards for capacity calculation [4)] and loads specified in IR standards for load effect calculation [3)]. Compare the results of simplified theoretical approach vis-à-vis FEM calculations to verify its applicability as it is difficult to do FEM modeling for all inspected bridges.

REFERENCES

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