MEMBER REPLACEMENT BASED MAINTENANCE STRATEGY FOR RIVETED RAILWAY BRIDGES

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Introduction

Most of the member replacement strategies are especially based on rating factors against failure. However, maintenance strategies, which are based on remaining fatigue life, illustrate more assurance than rating factor based policies for the railway bridges. Here, the Miner's rule is utilized as the damage model for remaining fatigue life estimations. But past researches have highlighted that Miner's rule is unable to take account of loading sequence effect preciously in variable amplitude loading. To overcome this problem to some extent, this study proposes an essential maintenance strategy for riveted railway bridges based on an accurate remaining fatigue life estimation technique.

Proposed Maintenance Strategy

The proposed strategy consists of two major parts viz. identification of critical members/ connections and member replacement/ strengthening scheme (Figure 1).

The critical members are identified based on the remaining fatigue life of each member which is calculated using recently proposed approach. The members which have the lowest remaining fatigue life of each member set (set of members which has the same load capacity) is called the "critical members" and the connections which are joining these critical members are termed as "critical connections". To capture the effects of stress concentration at the connections, the detailed class based code given *S-N* curve has been used for the critical member identification. However, various environmental attacks change the real stress distribution at the connections. As a result, replacement of members based on previously determined remaining lives may not be appropriate. Therefore, it is more

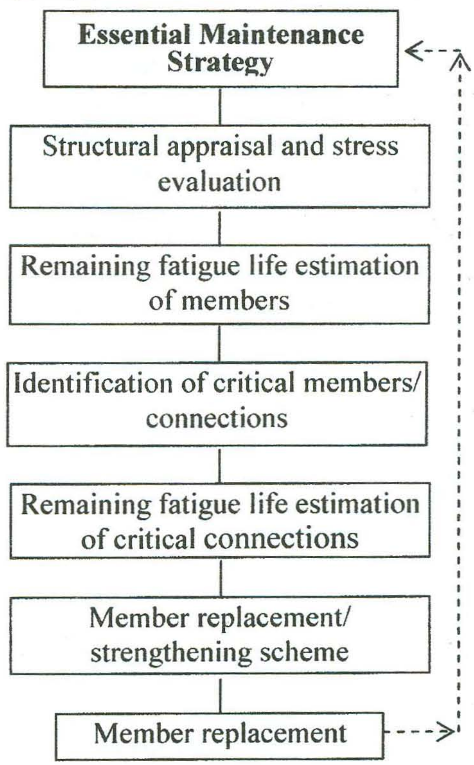


Figure 1. Flow chart of maintenance strategy

Table 1. Comparisons of member replacement schemes

Designation of test specimen	Experimental (Marciniak et al., 2008)		Previous strategy (Caglayan et al., 2009)		Proposed strategy	
	Service life (sec)	Sequence	Service life (sec)	Sequence	Service life (sec)	Sequence
NWL 4	42795	1	67502	4	49628	1
KWL 4	90705	2	22265	1	78239	2
KWL 2	98948	3	44579	2	116975	4
KWL 8	123275	4	45314	3	109076	3
NWL 1	130630	5	159770	5	123568	5

appropriate to replace the members based on fatigue lives of critical connections. Initially all critical connections should be investigated non-destructively to determine the current condition. The remaining fatigue lives of the connections, which have not been subjected to significant deviation from the initial condition, is finalized as same as the lowest remaining fatigue life calculated before. The remaining fatigue lives of other connections, where the conditions have been significantly changed, are calculated based on recently developed grain scale based approach (Siriwardane et al., 2009).

Once the age of the bridge reached the lowest fatigue life (when bridge life becomes zero), it is advisable to replace the corresponding critical members by new members with longer fatigue lives. At the same time, the associated connections are also recommended to strength. The future sequence of replacement is obtained following same procedure (Figure 1).

Verification of Proposed Strategy

To verify the accuracy of proposed strategy, the experimental (real) failure life based member replacement sequence is compared with the proposed strategy predicted scheme (Table 1). This verification reveals the validity of the proposed strategy in variable amplitude proportional loading conditions.

Case Study: Member Replacement Scheme for a Railway Bridge

The considered bridge is one of the major railway bridges in Sri Lanka (Ranaweera et al. 2002). The details of critical member identification procedure have been clearly stated in the previous study of this bridge (Ranaweera et al., 2002). Detailed examination showed that connections have not been subjected to severe changes. However, to illustrate the methodology of new strategy, the clamping force of TB 3 connection is assumed to have significantly disappeared. The considered geometry and FE mesh are shown in Figure 2, and the fatigue life of this connection is calculated. The member replacement sequences are shown in Table 2.

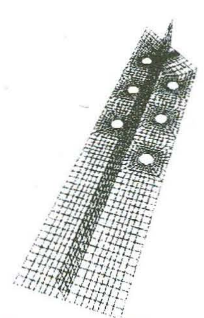
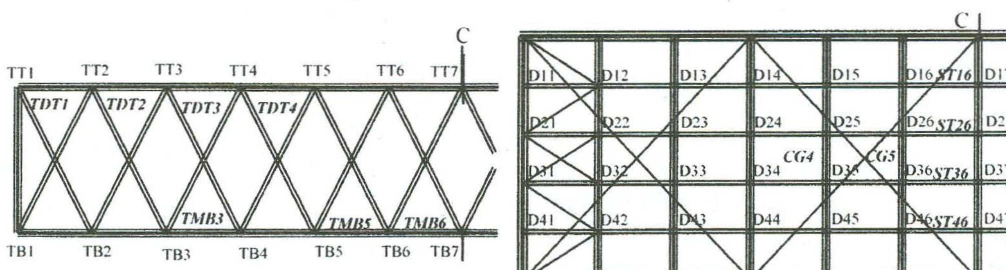


Figure 2. FE mesh

Table 2. Comparisons of member replacement schemes of the railway bridge

Member should be replaced	Corresponding critical connections	Previous strategy (Caglayan et al. 2009)			Proposed strategy		
		Service life	Replac-ement years	Seque-nce	Service life	Replac-ement years	Seque-nce
TMB3	TB4	305	300	5	323	320	6
TMB5	TB6	156	150	3	165	160	4
TMB6	TB7	157	150	3	169	160	4
CG4-5	D15,16,25,26, 35,36,45,46	20	20	1	12	12	1
ST16-46	D17,27,37,47	24	20	1	13	12	1
TDT1	TT1,TB2	179	170	4	45	45	3
TDT2	TT2,TB3	168	170	4	171	170	5
TDT3	TT3,TB4	131	130	2	24	20	2
TDT4	TT4,TB5	132	130	2	162	160	4



(a). Main truss girder

(b). Horizontal bridge deck

Figure 3. Designations of members and connections (Italic letters for members)

The designations of members and connections are shown in Figure 3.

Conclusions

It may be concluded that the proposed strategy gives a safer member replacement scheme for riveted railway bridges where detailed stress histories are known. Further verifications of proposed strategy are currently under way.

References

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