SYSTEM RELIABILITY MODELING OF RIVETED WROUGHT IRON RAILWAY BRIDGES

P.A.K. KARUNANANDA AND P.B.R. DISSANAYAKE

Department of Civil Engineering, Faculty of Engineering, University of Peradeniya

This paper proposes a methodology to predict the remaining service lives and estimation of the condition of riveted wrought iron railway bridges based on structural reliability theory. Fatigue and corrosion are two of the most vulnerable forms of damages in these bridges. In this study, how to model both of these processes in terms of remaining service lives of steel bridges is considered.

When a member in a bridge is subjected to cyclic loading in a repetitive manner, it is liable to fail in fatigue, with the operating stresses well below the yield stress. For such a member, the failure can be modeled by the reliability approach as shown below,

$$M_1 = N_f - N_n \tag{1}$$

where M_1 is called the safety margin and it is the criterion used to express how close the element to failure; N_f is the total number of stress cycles that can be applied to the bridge material; N_n is the number of stress cycles that has been applied up to now.

For corrosion, the proposed failure mode is as follows,

$$M_2 = (A_s)_{current} - (A_s)_{required} \tag{2}$$

where M_2 is the safety margin, $(A_s)_{current}$ is the effective steel area present at the time of consideration and $(A_s)_{required}$ is the steel area required to carry the load. From fundamentals of reliability theory, failure probability for the first mode of failure is (P_{f_1}) and that of the second mode of failure (P_{f_2}), and these can be found as follows,

$$P_{f_1} = -\phi[(\mu_{N_f} - \mu_{N_n}) / \sqrt{(\sigma^2_{N_f} + \sigma^2_{N_n})}]$$

And
$$P_{f_2} = -\phi[\mu_{(A_s)current} - \mu_{(A_s)required}] / \sqrt{[\sigma^2_{(A_s)current} + \sigma^2_{(A_s)required}]}\},$$

If the total failure probability is P_f , it can be mathematically represented as follows;

$$P(M \le 0) = P[M_1 \le 0 \cup M_2 \le 0].$$

Since
$$P_{f_1} = P[M_1 \le 0],\ P_{f_2} = P[M_2 \le 0],\ P_{f_3} = P[M_1 \cap M_2 \le 0]$$

$$P_f = P_{f_1} + P_{f_2} - P_{f_3} \tag{3}$$

Hence, total failure probability can be found if three components of failure probabilities are known. With a target value of failure probability, remaining service life and the current condition of the bridge can be determined. As a case study, nine spanned riveted wrought iron railway bridge has been selected and first component of failure probability has been found while others are currently being done.

Authors of the paper like to express their sincere acknowledgement to the National Science Foundation of Sri Lanka (research grant no: RG/ 2002/E/01 and NSF/SCH/2005/02).