

## Optimum maintenance strategy for bridges using reliability approach

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This paper presents different aspects of development of maintenance strategy for bridges. It has been known that high expenditure in bridge maintenance is a burden for most countries in the world. In addition, most of bridge maintenance strategies are based on human visual inspections that have larger uncertainties. To solve this difficulty, there is a need to implement a probability based maintenance strategy for bridges that use both theoretical considerations and practical visual and human experiences.

Depending on the type of bridge, failure modes are proposed considering critical failure modes of the concerned bridge.

$$M_i = Z_{R_i} - Z_{S_i} \quad i = 1, 2, \dots, n \quad (1)$$

Where  $M_i$  is the safety margin for  $i^{\text{th}}$  mode of failure of the concerned bridge.  $Z_{R_i}$  is the strength variable and  $Z_{S_i}$  is the load variable. The reliability index ( $\beta_i$ ) and failure probability ( $P_{f_i}$ ) for  $i^{\text{th}}$  failure mode can be expressed as,

$$\beta_i = (\mu_{Z_{R_i}} - \mu_{Z_{S_i}}) / \sqrt{(\sigma_{Z_{R_i}}^2 + \sigma_{Z_{S_i}}^2)} \quad (2)$$

$$P_{f_i} = -\phi\left[(\mu_{Z_{R_i}} - \mu_{Z_{S_i}}) / \sqrt{(\sigma_{Z_{R_i}}^2 - \sigma_{Z_{S_i}}^2)}\right] \quad (3)$$

According to Equation 3, for each failure mode ( $i = 1, 2, \dots, n$ ), elementary reliability index and elementary failure probability can be calculated. Assuming all failure modes are combined with a series system, it is possible to calculate the system failure probability ( $P_F$ ) from simple bound as shown in the Equation 4.

$$\text{Max}_{i=1,2} P_{f_i} \leq P_F \leq 1 - \prod_{i=1}^n (1 - P_{f_i}) \quad (4)$$

$$\text{Then, } \beta_S = -\phi^{-1}(P_F) \quad (5)$$

As outlined above, for each type of bridge, it is possible to calculate the system reliability index ( $\beta_S$ ) at different time. Overall bridge reliability index reduces with time. Once it reaches target reliability index, bridge maintenance can be carried out. By adopting as mentioned a maintenance strategy, unnecessary resources expenditure can be minimised and such a methodology is useful for a developing country like Sri Lanka.

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