Optimum Inspection Policy for Long Span Bridge Based on FTA with Visual Inspection Data

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Summary

This paper proposes a decision making methodology on an optimal inspection method/cycle for long span bridges, based on the two evaluation items: lifecycle cost and risk probability. The authors express the risk of the management limit in the visual inspection of a long bridge with a fault tree, and calculate the probabilities of events constituting the fault tree with the Markov transition probability. Then, it becomes possible to grasp the variation in risk probability due to the difference in inspection policies. Finally, the proposed method is applied to the actual case of determining an optimal inspection policy, to discuss its effectiveness empirically.

Keywords: fault tree analysis, visual inspection, long span bridge, optimum inspection policy, asset management

1. Introduction

This paper proposes a decision making methodology on an optimal inspection method/cycle for long span bridges, based on the two evaluation items: lifecycle cost and risk probability. The authors express the risk of the management limit in the visual inspection of a long bridge with a fault tree, and calculate the probabilities of events constituting the fault tree with the Markov transition probability. Then, it becomes possible to grasp the variation in risk probability due to the difference in inspection policies. Finally, the proposed method is applied to the actual case of determining an optimal inspection policy, to discuss its effectiveness empirically.

2. Fault tree Analysis

Figure.1 shows the fault tree of the long span bridge, which is used as an application case. The figure is composed of deterioration events of members, which have influence on maintenance

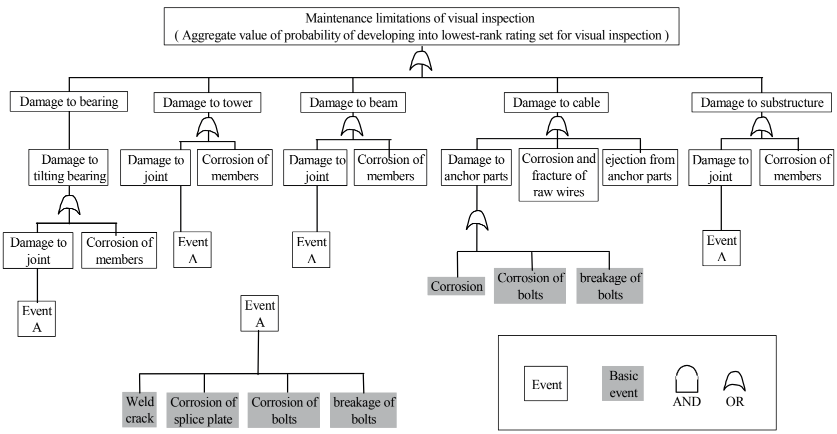

Fig 1: Fault tree of long span bridge A

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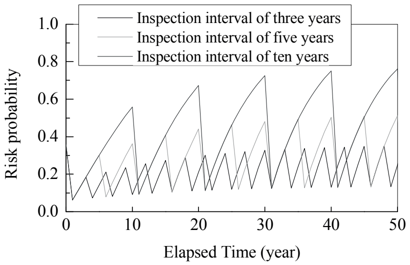

Fig 2: Probability of occurrence of maintenance limitation risk (top event)

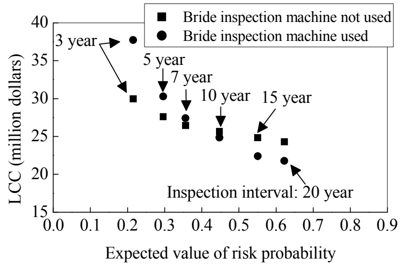

Fig.3: Relationship between LCC and risk

limitations, and explains the development process of maintenance limitation risk concerning regular visual inspection into the long span bridge. If the maintenance limitations of visual inspection are arranged as the top event, all the members that are targets of visual inspection will be included in lower events. In this study, however, only the events that are considered to have influence on the structural safety of the long span bridge eventually in the future are selected.

3. Case study

3.1 Outline and conditions of analysis

This study focuses on the long span bridge A (Steel cable-stayed bridge: two-pillar and two-cable boxgirder type with the span lengths of 170mm + 350mm + 120mm = 640mm, six lanes) managed by Hansin Expressway Co., Ltd, for the finalization of the optimal inspection policy, under the consideration of lifecycle costs and probability of maintenance limitation risk of visual inspection.

3.2 Results of FTA

Figure.2 shows the probability of the occurrence of the top event in the fault tree targeting the long span bridge A and the time variation of its probability. The probability of the occurrence of the top event constantly rises until the occurrence of visual inspection (therefore, the implementation of repair), and becomes 0 as repair have been done. This is because all the detected damage is repaired in this case as there are no limitations to a repair budget. Meanwhile, however, if attention is drawn, for example, to the peak value of each risk probability, it can be known that the peak value is on an upward trend over time, although the rise is gradual. Also, if three inspection intervals are compared, it can be reasonably known that the longer an inspection interval is, the larger the probability of the occurrence of the top event becomes.

3.3 Evaluation of optimal repair policy

Figure.3 shows the relationship between LCC and risk. In Figure 3, lifecycle costs are measured along the vertical axis and the expected value of risk probability is measured along the horizontal axis. The influence of differences in inspection methods (policies) and in inspection intervals on lifecycle costs and on the expected value of risk probability can be easily grasped.

As different administrators make a different judgment as to whether this margin of a reduction in costs can be considered significant from the standpoint of view of engineering knowledge, a decision cannot be made deterministically. Through repetitive discussion by engineers based on the above-mentioned methodology, the decision-making process can be refined, and knowledge about maintenance skills can be builds up.

4. Conclusions

This study proposes the methodology for determining the optimal inspection policy (repair policy) targeting special infrastructures such as long span bridges. More specifically, focusing on the long span bridge, this study explores inspection policies (inspection intervals and methods) that can minimize lifecycle costs and risk probability.