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Risk-Based Approach for Improving Concrete Bridges' Inspection Planning

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1 Introduction

Routine bridge inspections are essential for maintaining information, damage status and proper prioritization of bridge maintenance measures. According to the available information on bridge maintenance and current inspection procedure at the Norwegian Public Road Authority (NPRA), it is revealed that over half of the bridges in Norway, the visual inspection has not been performed at each year. NPRA estimated in 2017 that it is a lag in maintenance and improvements for bridges and quays, which have a cost of NOK 15 billion (Statens vegvesen, 2017). Therefore, it is vital to improve the existing inspection procedure to optimize the available budget. This paper proposes the use of Risk Based Inspection for the planning of inspections, which will help to optimize and increase the efficiency of the inspection procedure carried out by the NPRA.

2 The Existing Inspection Procedure in NPRA

To be able to improve the existing inspection procedure in NPRA, it is necessary to get an overall understanding about the procedure. In the inspection program, once a bridge is needed to be inspected, visual inspection combined with non-destructive/destructive testing are performed to assess the condition and safety of the bridges. Then, the damages or deficiencies in structural members (i.e. location) in a bridge should be recorded in a database. The list of possible damages/deficiencies (i.e. corrosion, cracks, spalling, discoloring, etc.) in bridges are given in NPRA handbook (Vegdirektoratet, 2000) with a representing number. Moreover, the NPRA has established a bridge management system called 'Brutus' to input all the information about all bridges in Norway. Therefore, the Brutus (i.e. bridge inspection data base - BIDB) consists of the historical inspection data of the bridges.

3 Group Technology Concept to Improve Inspection Planning

3.1 Bridge Families and Representative Bridges

In order to develop optimal inspection procedures, group technology concept has been used as it has a potential to increase the efficiency of the inspection procedure (Rachman and Ratnayake, 2019). The group technology concepts are based on creating families of bridges with similar characteristics such as building materials, degradation mechanisms and condition, and for each bridge family, a representative bridge is designated. The representative bridge should have all the characteristics of the remaining bridges in each bridge family. Initially, based on building material the bridges are grouped into primary families; reinforced concrete, pre-stressed concrete and steel. The secondary families group the bridges primarily by location and exposure.

3.2 Selection of Representative Bridge

The representative bridges should have features of all the damages (i.e. corrosion, leakage, spalling etc.). To assure this, the study compares the damage frequencies, as well as other characteristics like age, length and structural integrity for the individual bridges to the bridge family as a whole. This is information that is available in NPRA's database Brutus. The study therefore involves a damage frequency analysis, and this is the decisive factor when appointing representative bridges. It could be seen that the analysis shows that crack, spalling/RF corrosion and leakage are the most typical damage modes. Based on frequency of each damages, representative bridges have been assigned for each bridge group. For example, based on the damage and frequency analysis of reinforced concrete bridges in coastal area, "Kongsbrua" are chosen as representative bridge for reinforced concrete bridges in coastal climate in Rogaland, Norway.

3.4 Modification of the Existing Inspection Planning Process

The existing inspection procedure can be modified by implementing group technology concept and risk/based inspection planning process. However, it is vital to develop risk matrixes to assess the severity considering consequences and repairing costs. According to repair cost comparison, cost for repairing spalling/RF corrosion is very high. Therefore, the risk matrix has been developed to assess the severity of spalling/RF corrosion. Illustrative case study is shown in the paper how to use the developed risked matrices.

4 Conclusions

The existing NPRA inspection procedure shows how bridge in Norway prioritize inspections and utilize their budgets. It can be seen that current inspection procedure does not utilize the allocated inspection budget efficiently. To improve the existing method, and to increase the efficiency of both the inspection procedure and the resource allocation in NPRA, group technology concept is proposed. The proposal to group the bridges into families according to different properties, and then to designate representative bridges for each bridge family is a new way of working that will increase both efficiency and safety.

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