Revision of “Specifications for Highway Bridges”

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INTRODUCTION

NILIM routinely reviews nation-wide bridge inspection data and also conducts the field survey of damaged structures. These are required to feedback the findings to technical specifications and standards and identify what should be done by NILIM in research. One of the recent good examples is the revision of the Japanese Specifications for Highway Bridges in 2012. The revision had been the first time in almost ten years. Following the adoption of durability design in the previous revision such as chloride ingress in concrete members for a design service period of 100 years, the present revision incorporates the latest knowledge and experience that have been obtained for the last ten years in the broader sense of bridge maintenance such as the deterioration and seismic damage to existing structures.

Lessons learned from recent experience in bridge maintenance

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Firstly, the bridge inspection data has reconfirmed that fatigue cracks continue to develop in steel members such as deck plates of bridges carrying a busy / heavy traffic. However, as it turns out, the design guidance for fatigue in steel bridges published in 2002 can cover typical damage types that were observed in the bridge inspection. Damage due to chloride ingress to concrete bridges also shows that the 2002 Specifications for Highway Bridges is still effective to prevent damage due to chloride ingress during the design service life.

Secondly, there were several serious damage cases in truss bridges in the U.S and Japan. The I-35W Mississippi River Bridge, in Minneapolis, Minnesota, the United States, suddenly collapsed in 2007. In Japan, the failure in a truss bar which was embedded through the deck concrete occurred at two national highway bridges on major routes and ceased traffic. These bridges were inspected under their periodic inspection programs but these accidents were not staved off. NILIM conducted field surveys for all these events and analyzed the causes of these collapse and failures. We learned the importance in designing more redundant structures against partial collapse in structural members. For example, the AASHTO design specifications have load modifiers in terms of redundancy and a concept of fracture critical members. In addition, the bridge inspection data obtained in national highway bridges has indicated that the rate of deterioration changes with different members as well as difference portions / zones even within a member. The visual inspection and present deterioration curves cannot completely detect all damage and hidden failure such as corrosion of steel inside concrete. Rapid development of existing damage sometimes appears between the every-five-year inspections unexpectedly.

Thirdly, the Great East Japan Earthquake occurred in 2011. The emergency inspection was conducted by highway administrators and NILIM also backed up them when evaluating the condition of bridges damaged seriously. However, they had difficulty approaching to some portions of the bridge or bridges thereof to check if they were o.k. in such urgent situations. They also had difficulty conducting emergency repair work at such inaccessible portions to open the service of the bridge for emergency vehicles.

KEY ITEMS INTRODUCED IN THE REVISION REGARDING MAINTAINABILITY

The lessons above brought the following major revisions in the 2012 Specifications for Highway Bridges regarding bridge maintenance:

1) The chapter of fatigue design is incorporated into the Specification which was formerly guided in a different design guidance book. The chapter shows design equations and the classification in fatigue strength of

welded joints.

2) The minimum thickness of steel deck plate is increased to 16 mm based on NILIM's experimental study.

3) The following items must be considered in design and specifically described in design reports and drawings.

- Details to secure so-called load-path redundancy, structural redundancy, and internal redundancy
- Installation of bridge inspection facilities from the beginning of service
- Details to make it easy to replace the identified structural members that are supposed / planned to replace during the design service life, such as the installation of mounts for jacks and the pre-reinforcement of associated structural members for the future jack-up etc.
- Elimination of portions that are not accessible from the inside such as a narrow portion of box cross-section

4) Description of expected failure modes or deterioration prone portions / zones and the associated inspection and maintenance strategy in design documents and drawings.

5) Preservation of all drawings such as project drawings, shop drawings, working drawings, record drawings, as-build drawing etc. that will be needed in maintenance.

It is worth mentioning that the design for chloride ingress in concrete members remained unchanged from the 2002 Specifications for Highway Bridges based on the findings shown above.

REMARKS

NILIM has also been working to upgrade the Specifications for Highway Bridges into a partial design factor format and develop repair / reinforcement design specifications particularly for existing structures. The reliability theory can give more reasonable load and resistance factors for existing structures that can consider the present traffic condition and structural condition of the particular bridge on a particular site. The related findings can be seen elsewhere soon.

Reference

Bridge and Structures Division HP (Related papers posted)
http://www.nilim.go.jp/lab/gcg/index. htm