International bridge study on New Jersey reference bridges

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1. Introduction

In June 2010 the US Federal Highway Administration (FHWA) Long-term Bridge Performance (LTBP) Program initiated an International Bridge Study (IBS) to formulate and demonstrate best practice guidelines for the integration and application of technology to diagnose, perform prognosis, and design treatments to mitigate performance deficiencies of bridges. As part of this program, a steel stringer bridge was selected in northern New Jersey for a round robin study as it displayed a number of performance deficiencies which are relatively common for the large population of steel bridges older than 25 years. The University of Tokyo team visited the bridge and made observations, conceptualized its performance, and hypothesized potential root causes of any indentified deficiencies. In this paper, the visual inspection results as well as a series of experimental studies (including dynamic monitoring and image recognition) within the context of structural identification are described.

2. Tested bridge description

The object bridge is located in Wayne County New Jersey of US. It is a highway bridge that supports the interstate I-23. The bridge consist of four spans, where each span consists of two separate bridge connected at the support. In each span, the girder is supported by several stringers made of I-shaped beams and connected laterally by bracings. Each bridge span is simply-supported either by moveable or fixed connection at one of its ends. The bridge ends are placed on concrete pier caps and supported by concrete cylindrical columns.

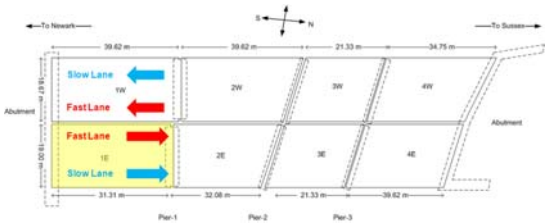

Figure 1. View and layout of tested bridge

3. Visual inspection

In the latest 12th cycle inspection report given by New Jersey Department of Transportation, this bridge is in overall fair condition (minor section loss of primary structural elements) due to the condition of the superstructure. The rating is 5 in 0-9 ranking system, in which 0 means failed condition and 9 stand for excellent condition.

The visual inspection in this paper is totally followed the periodic inspection manual of roadway bridges published by Japanese Ministry of Land, Infrastructure, Transport and Tourism. In Japanese national inspection manual, there is no global damage and countermeasure index to evaluate the whole bridge like US. The periodical inspection manuals mainly focused on preventive maintenance to avoid severe damage. So when severe damages are inspected, the detailed investigation with some kinds of measurements, loading tests and structural analysis will be carried out. The judgment or evaluation of the global structural performance is out of scope of periodical inspection manuals.

Japanese team found that the condition of the bridge after visual inspection is better than anticipated from the records. Deficiencies are mainly situated in dewatering and in the actual vibration intensities. However this assessment still indicated immediate or short-team countermeasure is necessary for some local members, which are shown in Figure 2.

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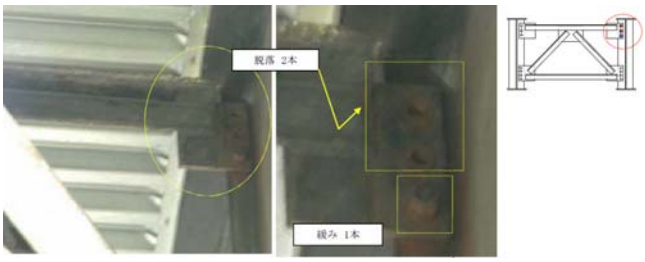
The damaged location shown in Figure 2(a) has not been recorded in the inspection report from US side. It has been observed that the moveable bearings are cyclically moved by the vibration, shown in Figure 2(b). The modes contain considerable transverse elements providing additional stress to the bearings. Furthermore the response analysis below also indicates that the bearing has completely lost the movable function.



(a) Drop of high-strength bolts

(b) Unmovable bearing

Figure 2. Local damage area

4. Image recognition

The cracks of the concrete columns and piers were identified using the image recognition technique. As shown in Figure 3, Crack width is detected approximately based on the width corresponding to 1 pix in the photo.

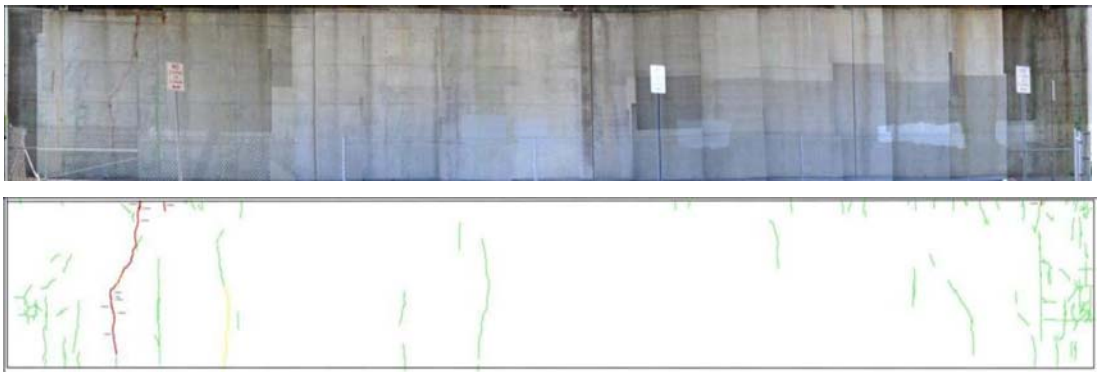


Figure 3. Width of concrete crack (Green: <0.5mm, yellow: 0.5mm～0.7mm, red: >0.7mm)

5. Response analysis

To capture the responses near the bearing pair of sensors is placed on the girder and on the column at each bearing. For the bearing shown in Figure 2(b), the longitudinal movement ability of the bearings has been lost completely. This is indicated by the almost similar acceleration (both in amplitude and phase) of the girder and column sensors in Figure 4.

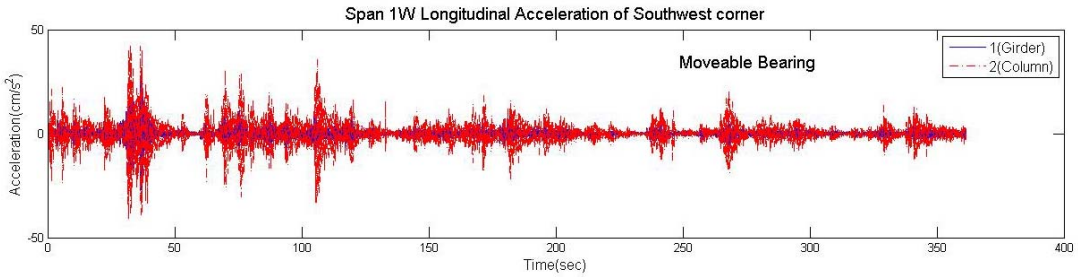


Figure 4. Comparison of acceleration results in the bearing

6. Concluding remarks

The outcome of this study will be part of an internationally developed database of recommendations of best practices for the application of technology to bridges. It will be very helpful to study the socio-cultural differences between the approaches and compare the results among different countries.

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