Joint Transportation Research Program

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Fiber Reinforced Polymer Bridge Decks

Introduction

A number of researchers have addressed the use of Fiber Reinforced Polymer (FRP) deck as a replacement solution for deteriorated bridge decks made of traditional materials. The use of new, advanced materials such as FRP is advantageous when the bridge is load-rated and much of the weight of the superstructure can be reduced with installation of a new deck without replacing the beams thus providing a quick and economical solution. Studies have shown that the use of fiberglass decks can reduce the life cycle cost of a bridge from 10% to 30% over the design life of the bridge, due to less traffic impact during construction and reduction in maintenance (e.g., corrosion resistance). These advantages were a motivation for this study of the use of FRP as a possible solution for the replacement of deteriorated bridge decks.

The overarching goal of this study was to perform a comprehensive evaluation of various issues related to the strength and serviceability of FRP deck panels. Specific objectives were to establish critical limit states to be considered in the design of FRP deck panel, to provide performance specifications to designers, and to develop evaluation techniques for the FRP bridge deck panels in service. Results of the study were applied to rehabilitation of a Tippecanoe County bridge with an FRP deck.

Findings

- Serviceability criteria, or deflection limits, govern the design of FRP decks. However, the limits typically used for bridge decks may not be applicable to FRP decks because of their relative light weight, low stiffness, and resulting difference in vibration response. A couple of side studies were conducted on this issue of deflection limits, as well as a small literature review. One side study investigated the development of an alternative criterion based on the dynamic response of the FRP decks. Another investigated a hybrid GFRP-steel solution, providing a deck with much higher shear stiffness in the core. Meanwhile, one suggestion made later in the project for the actual case study bridge was a deflection limit between girders of span/500, based on expected strains in the deck and wearing surface and an attempt to minimize cracking of the wearing surface in the negative moment region over girders.

- The case study bridge, CR 900 E. over Sugar Creek, was studied for use of a fiber reinforced polymer (FRP) deck for bridge rehabilitation and deck widening. The 2% cross slope on the deck was to be built into the FRP deck installation; the crown connection was one of a number of concerns that were studied experimentally. The FRP deck was installed on the Sugar Creek Bridge in November 2009.

- The FRP deck was subjected to a number of tests, primarily to evaluate any issues with the crown connection. Test results demonstrated that a special joint would be needed at the crown to prevent moisture ingress. Results also demonstrated that the deck design was adequate. The ultimate failure mode, at a factor of safety of approximately 5, was web buckling.

- A number of non-destructive evaluation methods were considered for monitoring of the FRP deck in service. Of the various technologies, acoustic emission appeared to be the most promising. Passive tests on damaged specimens, acoustic emission tests on FRP deck specimens as they were loaded, and acoustic emission tests on FRP coupons as they were loaded showed different frequencies, amplitudes and durations for different failure modes and proximity to damaged locations. However, some limitations to acoustic emission include the inability of the acoustic waves to traverse joints between FRP deck panel sections, as well as the connection between the top plate and bottom section of the FRP deck. Therefore, use of acoustic emission would be labor intensive, requiring measurements at regular and frequent intervals along the deck, between deck joints.

- Infrared thermography also appeared to be promising for identifying delamination between the wearing surface and the FRP top plate. However, use of the infrared thermographic camera would also be labor intensive, requiring heating of small sections of deck at a time and then quickly taking the thermographic image. Furthermore, results would show variability with amount of heating and cooling before the image is acquired.

- Meanwhile, a traveling truck deflection measurement method was developed. This procedure was tested on the FRP deck after installed on the Sugar Creek Bridge. This method showed some promise, but also showed variability and sensitivity to small variations in the surface of the deck. It is believed that this method would be successful at locating severe damage of the webs, as deflection measurements would show marked increases local to the damage. However, further validation and baseline measurements on the FRP bridge deck with the wearing surface are required if this method is to be pursued.

Implementation Recommendations

Items to be implemented include design procedures as related to deflection limits, crown connection details, and guardrail details. Inspection and monitoring procedures may also be implemented.

INDOT design and inspection personnel are recommended to be involved in the implementation of the findings of this study.

References

Rodriguez-Ver, R. E., N. J. Lombardi, M. A. Machado, J. Liu, and E. D. Sotelino. Fiber Reinforced Polymer Bridge Decks. Publication FHWA/IN/JTRP-2011/04. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2011. doi: 10.5703/1288284314242