JOINT TRANSPORTATION RESEARCH PROGRAM

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Link Slab Details and Materials

Introduction

This report contains the findings of a synthesis study on the use of link slabs to eliminate intermediate joints in Indiana bridges. Major findings were limitations in current design approaches, the effect of support conditions, and observed cracking, in particular, in Indiana where the design detail used lacks a debonded zone and is particularly susceptible to early cracking in the link slab. Further investigation is needed to examine the appropriate method for considering temperature effects and support conditions.

Findings

This section summarizes the findings from the study under each heading category, Literature Review and Analysis of Indiana Bridge.

1. Literature Review

The literature review on the state of practice about link slabs included (1) State Departments of Transportation (DOT) experience; (2) previous research studies; (3) design specifications and construction practices; and (4) Indiana DOT implementation experience. Following are the salient findings.

1.1 State Department of Transportation Experience

(a) Approximately 30% of the states responding had experience with the use of link slabs, and approximately two-thirds of the reported agencies had performed research or implemented the link-slab system in the field.

(b) The reported cases of implementation of link slabs were mainly in the rehabilitation of steel girder bridge superstructure.

(c) One-third of the agencies having reported experience with the system had design provisions or standard details. A standardized geometry and detailing has not been achieved across the DOTs. North Carolina, Michigan, Virginia, and New York were identified as key DOTs in the use of link slabs.

1.2 Previous Research

Studies focused on development more durable materials for use in link slabs, with few studies addressing improvements on design and detailing standards.

(a) *Materials:* Four advanced concrete materials for link slabs have been reported: latex modified concrete (LMC), fiber-reinforced engineering cementitious composite (ECC), ultra-high-performance concrete (UHPC), and hybrid fiber-reinforced concrete (HyFRC). Common features between these materials are higher tensile strength and lower permeability.

(b) *Types:* Three different types of link slabs were identified: haunched, flexible, and debonded. Currently, the debonded link slab detail is the most commonly used in the United States and Canada.

(c) *Key Performance Factors:*

i. *Temperature gradients:* Aktan et al. [2008], using design detail by Caner and Zia [1998], concluded that cracks in the link slabs are due mainly to hydration thermal loads and drying shrinkage.

ii. *Support conditions:* Caner and Zia [1998] concluded that support conditions do not affect the behavior of link slabs because the measured reactions, strains, and deflections remained the same for all support cases in the elastic range. Later work with numerical studies by El-Safty and Okeil [2008], Aktan et al. [2008], and Aktan and Attanayake [2011] showed that link slabs are affected by the support conditions and subjected to both axial tension and bending.

iii. *Length of debonding:* Numerical analysis performed by El-Safty and Okeil [2008] observed that a debonded length of 5% increased the load-carrying capacity of the beam by about 11.6% when compared to that of an unbonded beam. Aktan et al. [2008] observed that link slab moment decreases with increasing the debonded length but remains constant after a debonding of 5%.

1.3 Design Specifications and Construction Practices

To date, this is the first broad survey of highway agencies that documents the state of practice on link slabs. The review of the specifications and the proposed AASHTO guidelines for accelerated bridge construction in this study revealed that the majority of the states reporting use the following. (a) The design methodology proposed by Caner and Zia [1998] in North

Carolina. Accordingly, the girder end rotation due to live load and the AASHTO crack limit are used as design criteria. It must be noted that none of the states consider thermal effects in the design of the link slab. (b) A debonded length of 5% to 7% at each span. No transition zone is specified by the states. (c) Full-depth link slabs. Only the state of New York indicates the use of a partial-depth configuration. (f) Specified concrete materials by North Carolina, Virginia, and New York are Class AA Concrete, Low Shrinkage Class A4 Modified Concrete, and UHPC, respectively.

1.4 Indiana DOT Implementation Experience

The findings in this section are based on the study of the inspection reports and the drawings of the bridges analyzed in Indiana. (a) Link slabs mostly follow the haunched type detail, i.e., deeper than the deck. In this detail, the link slab is fully bonded to the adjacent slabs as well as the girders with no debonding. (b) All link slabs analyzed were constructed using conventional normal strength Class C concrete. (c) Most of the examined bridges experienced cracking within the first year of the link slab construction.

2. Analysis of Indiana Bridge

The bridge (#68-65-5213A) crossing the State Road 68 over the Interstate 64 was modelled numerically. The findings of the analysis described in reference to loading, type of superstructure, and bridge support conditions are as follows. (a) *Live load:* link slabs reduced compressive stresses at midspan of the deck as a result of the continuity provided. Link slabs themselves experienced tensile stresses that can be maximized by fully loading the adjacent spans. (b) *Thermal loads:* The magnitude of the stresses was almost 50% of the magnitude of stresses induced due to live loads. A uniform decrease in temperature induced tensile stresses in the link slab, while a uniform increase in temperature induced compressive stresses. (c) *Bridge support conditions:* Stresses in the link slabs due to live loads decreased with less restraints at the girders supports. Stresses due to uniform decrease in temperature in the deck of the concrete spans in the approach slab model were twice as much as those stresses in the all-rollers model.

Implementation

Based on the study conducted, the following recommendations are presented for consideration and possible implementation. (a) Use 5% debonding length and detailing recommend by Caner and Zia [1998], with the additional transition zone into the existing deck proposed by Li et al. [2003], to minimize the overall longitudinal tensile stresses in the link slabs. (b) Investigate the use of high tensile materials for the link slabs. The literature addresses this issue extensively and provide better alternatives such as UHPC, ECC, and FRP. The use of these materials alone may not guarantee un-cracked link slabs without further consideration of thermal loading and the detailing of the link slab. (c) Investigate improved reinforcement details and material specifications to address construction issues and enhance long-term performance.

References

Aktan, H., & Attanayake, U. (2011). *High skew link slab bridge system with deck sliding over backwall or backwall sliding ober abutments* (Report No. RC-1563). Lansing, MI: Michigan Department of Transportation.

Aktan, H., Attanayake, U., and Ulku, E. (2008). *Combining link slab, deck sliding over backwall, and revising bearings* (Report. No. RC-1514). Kalamazoo, MI: Michigan Department of Transportation.

Caner, A., & Zia, P. (1998). Behavior and design of link slabs for jointless bridge decks. *PCI Journal*, *43*(3), 68–80.

El-Safty, A., & Okeil, A. (2008). Extending the service life of bridges using continuous decks. *PCI Journal*, *53*(6), 96–111.

Li, V., Fischer, G., Kim, Y., Lepech, M., Qian, S., Weimann, M., & Wang, S. (2003). *Durable link slabs for jointless bridge decks based on strain-hardening cementitious composites* (Report. No. RC-1438). Lansing, MI: Michigan Department of Transportation.

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