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New Jersey Department of Transportation
Bureau of Research

Technical Brief

Bridge Deck Cracking and Composite Action Analyses

This report looked at the possible contribution of common practice structural design of bridge decks and superstructure bearing fixity to concrete deck cracking. In particular, the study evaluates the AASHTO criteria for composite design with respect to the requirements for shear connectors, the effects of designing for deflection control as well as using higher concrete strengths on deck stiffness and stresses.

Background

Many State Departments of Transportation (DOTs) expend significant effort and resources on the construction of durable concrete bridge decks. Existing data and current research indicate that specific modifications to construction procedures, materials, and design details can significantly reduce the degree of cracking in bridge decks, thus reducing the exposure of reinforcing steel to the corrosive effects of deicing chemicals and freeze-thaw damage. A great deal is known about the factors that affect cracking in bridge decks, however, there is a need to monitor deck performance and fully understand the effects of various design parameters on bridge cracking behavior. Figure 1 shows Route 18 over Albany Street Bridge that was instrumented and monitored for cracking using vibrating wire strain gages (VWSG).

Figure 1 – Route 18 over Albany Street Bridge and VWSG installed in concrete deck

Research Objectives and Approach

The main objective of this study is to evaluate the cracking behavior of concrete bridge decks and explore the cause of the cracking related to design procedures. Using the 3-D Finite Element (FE) Method as an analysis tool coupled with field observations, the study identifies the design procedures and parameters that most directly relate to the severity of cracking in bridge decks. The evaluation process was implemented in five tasks: (1) literature search, (2) evaluation of LFD and LRFD design procedures for composite action, (3) development of a detailed FE model that incorporates field measurements, environmental conditions (such as temperature and differential expansion between steel and concrete), and shrinkage behavior of concrete material based on actual data or laboratory testing, (4) deflection requirements, and (5) concrete compressive strength. Data from field measurements was used to validate the FE model. Figure 2 shows typical strain data collected from VWSG that were installed in concrete bridge deck.

Findings

The following conclusions and recommendation are made from this study:

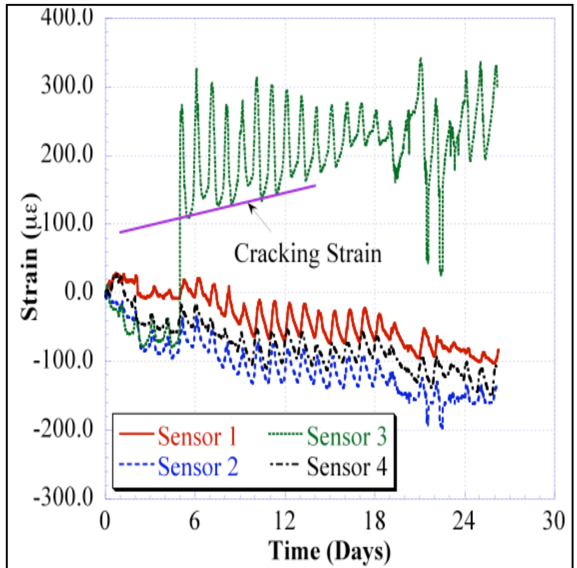

Figure 2 – Typical strain data collected from Route 18 over Albany Street Bridge used in assessing deck cracking.

- Shear studs, design concrete strength, and rebar locations do not contribute to bridge deck cracking.
- There is a higher potential for cracking at the end restraints, specifically at the fixed end and bridge piers for simple and continuous spans, respectively.
- Concrete cracking can be attributed to four important factors: (i) concrete shrinkage, (ii) thermal loads, and (iii) preliminary construction loads as well as (v) live load. Bridge designers should take all these effects into account to ensure that the concrete deck will not crack.
- The NJDOT deflection requirements should be retained at a minimum of $\frac{L}{800}$ to control the bridge deck flexibility (and thus any increase in concrete strains) when higher strength steel, i.e., Grade 70 and 100, is used.

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A final report is available online at: http://www.state.nj.us/transportation/refdata/research/. If you would like a copy of the full report, send an e-mail to: Research.Bureau@dot.state.nj.us.

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