CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6909: Designing for Deck Stress Over Precast Panels in Negative Moment Regions

Background

Precast concrete deck panels (PCPs) are commonly used on simply supported prestressed concrete girder bridges in Texas. However, with recent advances on the use of spliced-concrete girders and the potential to use of PCPs on steel girder systems, deck design in the negative moment regions of continuous girder systems is of interest. However, there is currently inadequate guidance on reinforcing requirements for the cast-in-place portion of bridge decks constructed using PCPs in negative moment regions. There is significant variability and ambiguity in the deck reinforcement recommendations for concrete and steel girder systems in the AASHTO LRFD Bridge Design Specifications when applied to bridge decks constructed with PCPs, and the justification for some of these provisions is not clear.

Developing appropriate deck reinforcing requirements is critical for ensuring acceptable deck cracking behavior and to avoid long-term maintenance problems. The purpose of this study was to understand the cracking behavior of reinforced concrete bridge decks with precast concrete panels in the negative moment regions of continuous girders under service loading and to develop guidelines for reinforcing steel details. A major focus of the study was the influence of the reinforcing details on the control of deck crack width.

What the Researchers Did

The experimental protocols developed in project The research study included field monitoring, laboratory testing, and parametric analytical and finite element analyses. The work resulted in a proposed design methodology to control deck cracking in the negative moment region of continuous prestressed concrete and steel girder systems. The work was conducted at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin. The following major tasks were completed on this project:

1. Four bridges were instrumented during construction to capture the behavior of the concrete bridge deck immediately following construction and for several months as the concrete continued to cure. The bridges were also monitored during controlled live load tests with loaded dump trucks and after the bridges were opened to traffic. The tests provided valuable field data on the deck cracking performance of the bridges under actual environmental and traffic conditions in the field.
2. The deck reinforcing was varied in three composite steel tub girders in the laboratory to obtain data on the behavior during curing and load testing within the service range and up to ultimate strength testing on the girder

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systems. The tests provided data on the deck cracking and reinforcing steel stress on girders in a controlled environment to better understand the behavior.

3. Direct tension tests were carried out on concrete specimens with a variety of reinforcing bar sizes and curing conditions to obtain a measure of relationship between crack widths and reinforcing steel stresses.
4. Parametric studies were carried out using analytical and finite element models. The studies demonstrated the influence of key variables on the relationship between deck cracking and reinforcing steel stresses as a function of concrete shrinkage, temperature changes, and live load-induced stresses.
5. A design methodology was developed for deck reinforcing requirements considering practical ranges of geometry and environmental conditions for Texas bridges. The methodology allows the designer to establish deck cracking limits based upon exposure conditions and to properly size and detail the reinforcing steel to meet the design criteria.

What They Found

1. Although cracking of the concrete bridge deck is caused by a variety of sources of applied loading and environmental conditions, the primary factor influencing the cracking is early-age volumetric shrinkage in the concrete.
2. The primary factor that influences deck cracking is the reinforcement ratio. The reinforcement ratio should be based upon the volume of the cast-in-place (CIP) concrete. The design of the deck steel should be based upon the maximum rebar stress, which can be determined from the average rebar stress using tension stiffening models that estimate the reinforcing stress at the crack locations. For a given reinforcement ratio, crack width is a function of several factors; however larger crack widths will develop with increases in the thickness of the CIP layer, and increases in the concrete strength.
3. The proposed design methodology allows the designer to proportion and detail the deck steel to achieve control over the widths of cracks to satisfy specific durability requirements for variable exposure conditions.
4. Providing a deck reinforcement ratio of 1% based upon the volume of cast-in-place concrete is satisfactory for most Texas bridges utilizing PCPs that are not subjected to deicing agents. Larger reinforcement ratios will likely be necessary for bridges exposed to deicing agents.

What This Means

The results of this research provide definitive guidance on the design of longitudinal deck reinforcement in the negative moment regions of continuous prestressed concrete and steel girder bridges when the deck is constructed using PCPs. This will be of assistance to bridge designers and will also will also help enable the more widespread use of PCPs for continuous girder bridges, including the negative moment regions.

For More Information

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