PROJECT SUMMARY REPORT

0-7001: Utilizing Steel Fiber Reinforced Concrete as a Substitute Reinforcement for CIP-PCP Bridge Deck

Background

The CIP-PCP bridge deck, comprising cast-in-place slabs atop stay-in-place precast concrete panels, is widely used in North American bridge construction. This method offers several advantages, including reduced formwork requirements and enhanced durability compared to traditional cast-in-place bridge decks. While extensive research has been conducted to optimize reinforcement details and improve structural integrity, there is a notable lack of studies exploring steel fiber reinforced concrete (SFRC) use in the cast-in-place component to reduce the need for reinforcement without compromising integrity. Addressing these research gaps has the potential not only to expedite the construction process of CIP-PCP bridge decks but also to enhance costeffectiveness in construction practices.

What the Researchers Did

To fill these knowledge gaps, the research team conducted a comprehensive review of previous studies and design codes relevant to CIP-PCP bridge decks and the utilization of SFRC as a bridge deck material. Building upon the literature review findings, the team formulated SFRC mixes suitable for deployment as CIP material. Subsequently, utilizing the identified SFRCs from the material selection phase, two experimental programs were devised to establish the most effective reinforcement layout for CIP-PCP bridge deck construction incorporating SFRC.

At the outset, the team conducted an extensive laboratory investigation on SFRC. Three distinct types of steel fibers were individually assessed at three varying dosages and combined with different cementitious mixtures to create fiber-reinforced concrete aligning with TxDOT Class S Concrete standards for bridge decks. The study includes a detailed presentation and discussion of the concrete's fresh and hardened properties and an examination of its durability when incorporating these fibers.

The first structural investigation evaluated the behavior of predetermined SFRCs in the flexural deck strip specimen. This task aimed to compare the performance of different types of SFRC design, which varied in fiber type and fiber volume fraction. The load-resisting capacity and crack control assessment were performed on ten deck strip specimens.

Utilizing the results obtained from the deck strip test, a nonlinear finite element analysis was executed. The comparison between the model and test results served to validate the modeling approach. Following this validation, a parametric study was conducted to refine reinforcement iteratively and SFRC properties for further optimization.

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Another structural experiment was conducted using a full-scale bridge deck specimen. The specimen underwent testing in eight different regions, encompassing two girder joint tests, two panel joint tests, and four overhang tests, each featuring distinct reinforcement layouts—specifically, #4 reinforcement at 18-inch spacing and configurations without reinforcement.

What They Found

Derived from the test outcomes, the investigators established several vital findings, outlined as follows:

1) Following the material testing protocol, various binder compositions were evaluated with three different fibers. In the context of employing steel fibers for bridge decks, it was determined that a 1 percent volume fraction of steel fibers effectively enhanced key concrete properties and was satisfactory for significant reductions in the required amount of reinforcing steel in bridge decks.

2) The results from tests conducted in the interior regions revealed that when the residual strength of SFRC surpasses 120 psi, areas without additional reinforcement can sufficiently support traffic loads and concurrently withstand excessive cracking.

3) The validation of yield-line analysis through the overhang region test indicated that an SFRC overhang, reinforced with transverse bottom and longitudinal top and bottom reinforcement, utilizing #4 bars at 18-inch spacing (0.135 in^2/ft), along with an additional need for #4 bars at 4.5-inch spacing for the top transverse reinforcement, can effectively serve as a viable alternative to the existing TxDOT overhang reinforcement.

What This Means

The results offer valuable insights for integrating SFRC into CIP-PCP bridge decks. According to the findings, SFRC can effectively replace all the reinforcement in the interior region and 31% of the reinforcement in the overhang region when an ample quantity of steel fibers is introduced to achieve the necessary residual strength in the concrete mix. The reduction in reinforcement can substantially enhance cost-effectiveness and expedite the construction process of CIP-PCP. It is suggested that additional field-testing protocols may be necessary to validate the proposed design when in service.

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