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Empirical Deck for Phased Construction and Widening

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Current Situation

The most common method used to design and analyze bridge decks, termed the traditional method, treats a deck slab as if it were made of strips supported by inflexible girders. An alternative – the empirical method – treats the deck slab as a unit that resists load primarily through internal arching action. The mechanics of the empirical method are more complex, but the design process is simpler, and it offers advantages in economy and constructability – e.g., the empirical method requires much less internal reinforcement. A few states allow the empirical method; however, in Florida, this method awaits verification testing for phased construction and widening situations before it can be allowed in the design guidelines.

The full-scale test setup with simulated widening edge on the right is shown.

Research Objectives

University of North Florida researchers tested the efficacy of the empirical method for bridge deck design, in a widening situation using a full-scale bridge deck and support structures.

Project Activities

The complexity and expense of creating a full-scale test specimen required extensive preliminary design work. Finite element (FE) methods were used to develop a hypothetical bridge of which the test slab would be a part. Assorted FE models, using a variety of slab thicknesses and beam spacings, were developed to study the differences between slabs designed using traditional and empirical methods. Additional FE models were developed to represent phased construction and widening scenarios – plausible scenarios for which AASHTO guidelines disallow the empirical method. These models were used again after testing was completed, when results were available to refine the models according to actual slab behavior.

The fabricated deck specimen had a length of 47 feet, a width of 18.5 feet, and a thickness of 8 inches. It was reinforced with two layers of No. 5 rebar spaced at 12 inches in both directions. The slab was supported on two prestressed, 36-inch-deep Florida I-Beams with a 14-foot spacing. Numerous embedded and surface strain gauges were applied to the deck. Displacement transducers also recorded deflection throughout the service load tests.

A series of loads were applied to the deck using a hydraulic jack. Multiple locations of the deck successfully withstood repeated service loads of approximately 21 kip of force with little to no cracking. These locations were later tested to failure loads ranging from 80 kip at the edge to over 200 kip at midspan, all displaying a punching shear style failure. Extensive analysis of the collected data are presented in the final report. Researchers also provided recommendations for changes to Florida's design standards to include the empirical method.

Project Benefits

This research demonstrated the suitability of the empirical method for designing concrete bridge decks subjected to phased construction or widening. Compared to the traditional method, the large reduction in required reinforcement will make decks following the empirical method more economical and simpler to construct, while still satisfying service limits, and providing substantial ultimate strength.

For more information, please see www.fdot.gov/research.