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Florida Slab Beam Bridge with Ultra-High Performance Concrete Joint Connections

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Current Situation

Many bridges are constructed using concrete beams. The design of these beams has been refined over decades to create types and technologies that designers can choose depending on a bridge's length, width, and other specifics. While engineering marvels like the Sunshine Skyway Bridge receive more attention, most bridges are more modest and span small creeks or other roadways. In Florida, the beam of choice for these bridges is the Florida Slab Beam (FSB), a precast, prestressed, steel-reinforced concrete slab that is 12 to 18 inches thick, 4 to 6 feet wide, and up to 60 feet long. Currently, construction methods using these slabs lay them side by side. A lip at the bottom of each slab creates a channel between slabs into which a steel reinforcing cage is placed and concrete is poured, forming a joint between slabs. Once the channel concrete is cured, a 6-inch concrete deck is poured over the entire bridge. This has generally been very successful, but longitudinal cracks have developed in some bridges, and the amount of concrete pouring at the site is expensive and time-consuming.

Steel protruding from adjacent FSB slabs and a steel cage form a joint between slabs when concrete is poured.

Research Objectives

Florida International University researchers investigated changes to FSB geometry and the use of ultra-high performance concrete (UHPC) for slab joints as well as omitting the final deck pour.

Project Activities

The researchers conducted a literature review and documented a variety of concrete short-span bridge designs, including joint designs, joint materials, deck overlays, and other design details. They reviewed the original development of the current FSB design standard, with special attention to the FSB joint.

In the main project task, modified FSB designs were tested using new geometry for overall slab design as well as channel profiles and steel reinforcement patterns. Four joint details with two different slab thicknesses were investigated using numerical models and small-scale experimental testing to evaluate the weight-bearing capacity and ensure the integrity of the joints under strength and fatigue testing.

The best performing joint was tested for service, fatigue, and ultimate strength in two-beam and four-beam large-scale configurations. The beams in all full-scale systems reached their estimated ultimate flexural strength without any joint debonding or distress. No damage was observed in the joint or system in these specimens up to four million cyclic loads. To allow the developed FSB system to be constructed in a widely used bridge design system called "simple for dead load, continuous for live load" (SDLC), construction details were developed and evaluated using nonlinear finite element analysis.

The developed FSB design allows spans of 32 feet (12 inches thick), 44 feet (15 inches thick), and 55 feet (18 inches thick). To determine if a 75-foot span beam was feasible, beams of this length were analytically developed using several possible cross-section designs. Among these, three designs – modified slab beam, pre-topped IT beam, and box beam – are viable options at this length."

Project Benefits

The methods developed in this project can lead to reductions in construction time and cost for short-span bridges while increasing durability.

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