Florida Department of Transportation Research

Macro Synthetic Fiber Reinforcement for Improved Structural Performance of Concrete Bridge Girders

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Current Situation

In prestressing, steel cables are placed in a form and stretched very tightly. Concrete is poured into the form, and when the concrete has set, the tension on the cables is relieved, and the cables are trimmed. Prestressing adds tensile strength to concrete's compressive strength and allows the creation of longer and stronger structural components, like bridge girders. While prestressing adds considerable strength to the concrete, it also induces cracking at the ends of the girders. This cracking does not influence the strength of the girder, but it may provide a path for moisture that can weaken the girder over time, leading to monitoring and maintenance issues.

Long slender girders like this are possible because of prestressing.

Research Objectives

University of Florida researchers studied the use of fiber-reinforced concrete to control cracking in the end region of concrete girders.

Project Activities

For the experimental phase, the researchers used self-consolidating concrete (SCC), often used in precast girders in Florida. Their first task was to develop fiber-reinforced SCC formulas that would meet state requirements for workability. Three fiber types were tested – macrosynthetic, basalt, and steel – at volume fractions ranging from 0.1% to 0.7%. Steel fibers were tested in plain, hooked-end, and crimped forms. Steel fibers provided the highest residual strength, and macrosynthetic fibers outperformed basalt fibers. Based on workability and residual strength, mixtures with hooked-end steel fibers at 0.3% and 0.7%, crimped steel fibers at 0.7%, and macrosynthetic fibers at 0.5% were selected for tests in full-scale girders.

Five precast prestressed Florida I-beams (FIB-78) were constructed. Each girder end was designed with different end region detailing to evaluate the effectiveness of fiber-reinforced SCC, combined with conventional FDOT reinforcement. Concrete and mild steel reinforcement strain was measured during prestressed transfer, and monitoring of end region cracks began immediately following prestress transfer and continued for 150 days. Results indicated that the use of fiber reinforcement can reduce end region crack widths. Steel fiber at a volume fraction of 0.7%, combined with reduced end region reinforcement, was found to be more effective than currently required end region reinforcement at maintaining crack widths smaller than 0.006 in.

The analytical phase of the project focused on creating a computer model that could predict end region cracking behavior. A smeared reinforcement approach calibrated against experimental data produced an accurate representation of the effect of fiber reinforcement on end region cracking. The model was used to simulate prestressed FIB-78 girders and showed good agreement between experimental and analytical results.

Project Benefits

Effective control of end region cracking in prestressed concrete girders will reduce maintenance issues and help ensure that girders perform as intended throughout their service life.

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