Summary of Final Report, BC386
December 2002

APPLICATION OF FIBER REINFORCED CONCRETE IN THE END ZONES OF PRECAST PRESTRESSED BRIDGE GIRDERS

PROBLEM STATEMENT

Prestressed concrete is a widely used material for bridge construction. Compared to its compressive strength, the tensile strength of reinforced concrete is limited. Consequently, prestressing becomes essential in many applications in order to fully utilize the compressive strength and, through proper design, to eliminate or control cracking and deflection. The high-technology advancements in the science of materials have made it possible to construct and assemble large-span prestressed concrete systems.

Precast post-tensioned girders are subjected to high concentrations of compressive stresses at the anchorage zone due to the transfer of prestressing force at the girder end through bearing plates and anchors. Most damage to anchorage zones in post-tensioned concrete structures occurs during construction, when large tendon stressing forces are applied to usually immature concrete. A considerable amount of spiral and skin reinforcement is required at the end zones of a prestressed bridge girder. Reinforcement congestion in the anchorage zone is a frequent cause for poor concrete consolidation, which results in failures caused by the crushing of the concrete ahead of the anchor. Congested anchorage zone details also complicate the placing of the reinforcement. Various reinforcement components used in close proximity cause congestion in the anchorage zone, which makes the placement of concrete, anchorages, and post-tensioning ducts difficult. Furthermore, producing and placing the secondary anchorage reinforcement is labor intensive.

Fiber reinforced concrete (FRC) possesses better properties, such as tension strength, compression strength, shear strength, bond strength, flexural toughness, and ductility, than conventional concrete. Therefore, it may be possible to utilize FRC in the end zones of prestressed bridge girders to reduce the amount of secondary reinforcement.

OBJECTIVES

The goal of this study was to investigate, theoretically and experimentally, the application of FRC for the aforementioned purpose. Specific objectives include the following:

- To establish various properties of FRC that are relevant to bridge design.
- To select adequate synthetic or steel fibers for application in anchorage zones.
- To experimentally determine the feasibility of reducing or eliminating the secondary reinforcement with synthetic or steel fibers for post-tensioned anchorage zones.
- To perform theoretical validation of the feasibility of FRC application in anchorage zones.
- To make a cost comparison between fiber reinforced and conventionally constructed girders, based on both material and labor costs.

FINDINGS AND CONCLUSIONS

The first phase of the test program involved the determination of the split tensile strength, the compressive strength, and the flexural toughness of FRC and of non-fibrous concrete. Two steel fibers and one synthetic fiber with volumetric dosage rates of 0.75% to 1.0% were utilized. Steel fibers enhanced the properties of concrete. The use of synthetic fiber; however, was not encouraging. In the second phase, the AASHTO Special Anchorage Device Acceptance Test was performed. Variations of spiral and skin reinforcement, with two levels of concrete strengths, were utilized to investigate the performance of the two types and various volumetric percentage amounts of steel fibers. The experimental results indicated that 1% steel fiber could be used to replace all the secondary reinforcement for a minimum concrete strength of 5900 psi (40.7 MPa), and that it could reduce a maximum of 79% of the secondary reinforcement for a minimum concrete strength of 4710 psi (32.5 MPa). Lower volumes of steel fibers may also result in a reduction of secondary reinforcements.

A finite element model of the AASHTO test block was also developed to validate the experimental results. Researchers found the theoretical and experimental strain values to be in agreement. Usage of steel fiber reinforced concrete in the anchorage zones will result in negligible change in the girder costs.

BENEFITS

This research demonstrated the feasibility of substituting or reducing the secondary reinforcement, such as spiral reinforcement and skin reinforcement, in the anchorage zones of precast post-tensioned bridge girders. It was shown that the secondary reinforcement could be completely eliminated through the use of 1% steel fiber in the anchorage zone. Secondary reinforcement is hard to fabricate and place, and it can cause substantial local steel congestion, which leads to difficulty in concrete placement and inferior quality concrete. This problem, in turn, may lead to premature concrete cracking and long-term durability issues. Utilization of steel fibers in the anchorage zone is convenient, and it can be achieved with negligible extra material and labor costs. This practice is expected to result in strong and durable concrete anchorage zone, as well as substantial economic savings.

This research was conducted by Nur Yazdani, Ph.D., P.E., and Lisa Spainhour, Ph.D., at the Florida A & M University – Florida State University College of Engineering. For more information, contact Dongzhou Huang, Project Manager, at (850) 414-4660, dongzhou.huang@dot.state.fl.us.