Florida Department of Transportation Research

Hybrid Prestressed Concrete Bridge Girders Using Ultra-High Performance Concrete

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Project Managers
William Potter
FDOT Structures Office

Principal Investigator
H. R. Hamilton
G. R. Consolazio
University of Florida

Current Situation

Concrete is a remarkably strong material against compressive forces, but very weak against tension forces. Reinforcing steel bars embedded in concrete improve overall strength against these tension forces considerably, but a process called prestressing takes it even further. In prestressing, concrete is poured around tightly stretched steel cables called tendons. When the concrete hardens, the tendons are released, and they try to shorten inside the concrete, which causes compression in the concrete, greatly improving its resistance to tension forces. Prestressed girders can span farther than reinforced girders, providing better economy and pleasing appearance.

One challenge of fabricating prestressed bridge girders is the tendency for the concrete to crack at the end of the girder due to the high forces applied by the prestressing tendon. This cracking is not a safety issue, but it can result in construction delays, repairs, additional costs, and compromise long-term durability. A number of techniques have been used to control this cracking, but they are not always effective.

Prestressing allows concrete girders to be longer, lighter, and stronger, saving time.

Research Objectives

University of Florida researchers tested prestressed girders for which ultra-high performance concrete (UHPC) was used in the end regions of girders made otherwise with conventional self-consolidating concrete (SCC).

Project Activities

Three 20-foot long mock-up girders were constructed at a precast concrete plant using UHPC only; two more 20-foot mock-ups were constructed with half UHPC and half SCC. UHPC-only girders were made with reduced end-region steel reinforcement to investigate UHPC behavior. Mock-ups were instrumented to measure strain during the prestressing process and monitored for one year. In periodic visual inspections during this time, cracks in the SCC and UHPC were to identified and measured. SCC ends showed crack widths up to four times greater than those of UHPC. Crack widths on UHPC ends did not exceed 0.003 in. independent of the amount of end region reinforcement.

Two 50-foot mock-ups were built with SCC in the middle and UHPC at both ends. Load tests indicated that girder shear strength was much higher than comparable SCC girders. The load test results indicated that the UHPC-SCC construction joint had sufficient strength, which validated the construction method.

Computer simulations complemented the girder tests and enhanced the understanding of UHPC behavior. Material models were evaluated and calibrated using material testing results. Simulations of both the mock-ups and the shear test specimens were conducted using the calibrated material model. Parametric studies were then conducted using the knowledge gained from the simulations to extend the understanding of UHPC behavior. These analytical results confirmed that UHPC is a promising approach to controlling end region cracking.

Project Benefits

This project introduces a promising new technique for constructing prestressed concrete girders in which end cracking will be reduced.

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