CFRP REPAIR OF IMPACT-DAMAGED BRIDGE GIRDERS

VOLUME I: STRUCTURAL EVALUATION OF IMPACT DAMAGED PRESTRESSED CONCRETE I GIRDERS REPAIRED WITH FRP MATERIALS

PROBLEM STATEMENT

The Florida Department of Transportation (FDOT) currently uses fiber-reinforced polymer (FRP) composites to repair prestressed concrete bridges that have been damaged by vehicle impact. The Chaffee Road Bridge over Interstate 10 in Jacksonville is an excellent example of a bridge on which this type of repair has been used. This bridge was severely damaged by an over height vehicle on July 6, 2001, and FRP composites were used successfully in an emergency repair of the bridge. At that time, however, FDOT had limited or no experience with many of the FRP systems manufacturers that were used to perform this type of emergency repair.

OBJECTIVES

The FDOT Structures Research Lab tested six Type II AASHTO girders, strengthened with FRP, to determine the post-repair behavior and capacity. There were two primary objectives of this research: (1) evaluate and report the behavior of the FRP repair systems during the load test (cf. Volume I), and (2) use infrared thermography (IRT) to inspect the FRP composites before, during and after the load tests (cf. Volume II). Infrared thermography is a non-contact remote sensing technique that can be used to determine if FRP systems are properly bonded to the concrete substrate.

FINDINGS AND CONCLUSIONS

Six full-scale AASHTO girders were repaired and loaded to failure at the FDOT structures research facility in Tallahassee. Two of the girders served as control specimens (one with no damage and one with simulated impact damage at the girder's midspan). Simulated impact damage was imposed on the remaining four girders, which were then strengthened in flexure with different FRP systems and tested as shown in Figure 1.

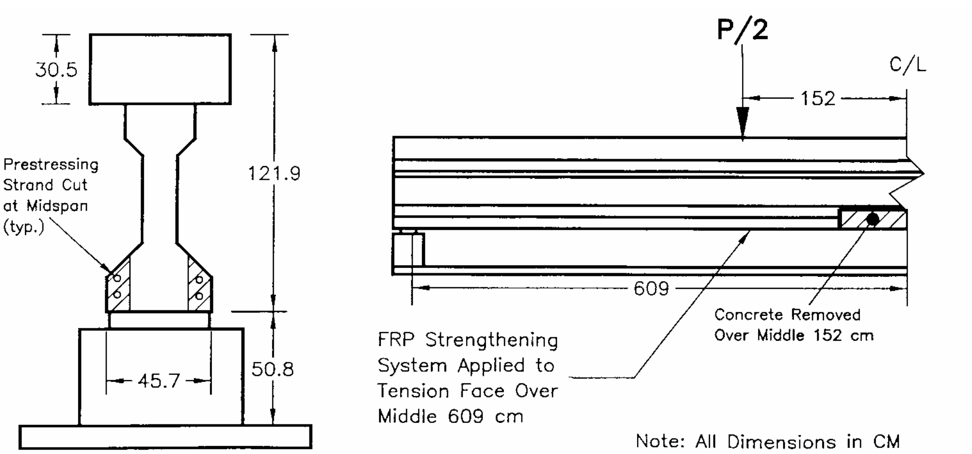

Figure 1: Test-setup and specimen dimensions

Testing focused on the moment and shear capacities, as well as the deformation and ductility behavior of the undamaged, the damaged, and the repaired girders. Researchers experimentally and analytically compared the behavior of the repaired girders to the behavior of the undamaged girder, and then structurally evaluated the FRP systems with respect to their ability to restore the undamaged shear and moment capacity of the prestressed concrete girder, i.e., the type of failure mode that occurred.

The FRP system applied to each girder was installed by the manufacturer or its representative(s), respectively, as follows: Girder 3 – RJ Watson, Girder 4 – Air Logistics, Girder 5 – Magnum Venus Products (MVP)/University of Florida, Girder 6 – Edge Structural Composites.

The following summarizes the results obtained for each of the girders that was strengthened with FRP composite materials:

1. **Girder 3** failed prematurely due to end-peel of the FRP composite system. In spite of this premature failure, it still regained 91% of the experimental capacity of Girder 1.

2. **Girder 4**, repaired with carbon fibers and a polyurethane adhesive, failed prematurely due to adhesive failure followed by FRP rupture. The test specimen regained 92% of the experimental capacity of Girder 1.

3. **Girder 5** failed due to FRP rupture and regained 95% of the experimental capacity of Girder 1. The FRP system for this girder was applied using a spray-up technique, by which a mixture of chopped E-Glass fibers and polyester resin was sprayed onto the tension face of the girder. The desired thickness of the spray FRP was 0.50 in., although only an average thickness of 0.27 in. was achieved.

4. **Girder 6** because of an FRP anchorage failure that allowed the longitudinal FRP to slip between the anchorages. The test specimen still exceeded the experimental capacity of Girder 1 by a factor of 1.07.

These load tests have shown that FRP systems can be used to restore a significant portion of the moment capacity that may be lost during a vehicle impact event. A critical observation made during the study was that FRP system performance is highly dependent upon proper detailing at the termination points of the composite on the tension face. Specifically, it is necessary to provide additional FRP stirrups at the termination points to avoid high end-peel stresses and premature failure of the FRP system.

BENEFITS

Since most FRP repair methods are proprietary to a company, the FDOT realized the need for approved alternatives. A quality products list, which would enable qualified companies to be certified by FDOT to perform emergency repairs to vehicular damaged bridge girders using FRP materials, was not developed. However, issues important in considering these types of repair did emerge and can be used to educate Department personnel.

The research reported in Volume I was conducted by Perry S. Green, Ph.D., and Andrew J. Boyd, Ph.D., P.E., of the University of Florida. For more information, contact Marc Ansley, Project Manager, at (850) 414-4291, marc.ansley@dot.state.fl.us