



## Florida Department of Transportation Research

### The Repair of Damaged Bridge Girders with Carbon Fiber Reinforced Polymer “CFRP” Laminates

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The Federal Highway Administration reports that collisions with a vehicle or vessel are the U.S.’s third leading cause of bridge collapse. Many collisions cause damage, not collapse, but together, collisions cost millions of dollars, plus costs in terms of traffic delays and rerouting.

Bridge collisions are increasing, and studies are needed on assessing structural damage, suitability of repair material, optimum repair method, and repair configuration. For promising new repair materials, such as carbon-fiber-reinforced polymer (CFRP), full characterization of properties and investigation of application details are needed.

University of North Florida researchers applied CFRP to repair laterally damaged prestressed concrete (PSC) girders and mitigate debonding. Though widely accepted to restore or enhance performance of reinforced concrete and PSC bridge girders, CFRP’s effectiveness in repairing collision-damaged PSC girders requires study.

Researchers tested repair configurations of CFRP laminates based on longitudinal strips and U-wrapping on full-scale (40-ft) and half-scale (20-ft) PSC girders. Impact damage as seen in the field was mimicked by concrete damage and prestressing force reduction by cutting some of the prestressing strands. Repair systems were designed to restore original flexural capacity.

In addition to static load tests, some girders were tested under fatigue loading for two million cycles to simulate traffic conditions. Lessons learned from the fatigue testing of the half-scale beams included covering the damaged section with transverse and longitudinal CFRP strips to restrain crack opening and propagation. Full-scale AASHTO prestressed beams repaired using CFRP laminates withstood over 2 million cycles of fatigue loading with little degradation.

The study also suggested the optimum repair configuration: longitudinal CFRP laminate applied



*A technician works on wet layup application of CFRP fabric laminate on a prestressed concrete girder.*

to the girder soffit along with U-wrapping anchored with a longitudinal CFRP strip at the top ends of U-wraps. This configuration restored and increased girders’ load-carrying capacity. Details for optimum application were also described. Evenly spaced transverse U-wrappings provided an efficient configuration to mitigate debonding.

Based on their results, the researchers formulated a system for assessing the degree of damage to bridge girders after collisions and then correlated this with repair options. The scope and level of detail considered by the researchers resulted in a comprehensive guide for the application of CFRP laminates to collision-damaged bridge girders.

Overall, test results confirmed that CFRP systems can be designed to restore lost flexural capacity and maintain desired failure mode. The capacity of repaired girders often exceeded the capacity of controls in both strength and ultimate displacement. Experimental results were examined analytically using standard models. The ability to restore and possibly enhance the original capacity of a collision-damaged bridge girder using non-prestressed fabric CFRP repair applications offers an effective, timely, economical procedure.