Florida Department of Transportation Research

Degradation Mechanisms and Service Life Estimation of Fiber Reinforced Polymer (FRP) Concrete

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Current Situation

Polymers reinforced with either glass or carbon fibers have emerged as valued construction materials for new construction, replacement, or reinforcement. With its proven track record of superior performance in strength, durability, resistance to corrosion, and versatility of fabrication, fiber-reinforced polymers (FRP) provide attractive options for engineers. However, a better understanding of these materials is needed. Despite their impressive performance at high strains, they can rupture at low strains; not enough is known about glass-FRP (GFRP) behavior in the highly alkaline environment inside concrete; and additional work is needed on carbon-FRP (CFRP) as prestressing strands.

Repairs made with GFRP concrete reinforcing bars to the sea walls along the Sunshine Skyway Bridge Rest Area will reduce the need for future repairs.

Research Objectives

University of North Florida researchers investigated the physical and mechanical properties, durability, and resistance to alkali of GFRP reinforcing bars and CFRP prestressing strands. They studied the structural behavior of concrete beams prestressed with CFRP beams.

Project Activities

The researchers extensively reviewed the state of practice for use of CFRP and GFRP in construction. They also reviewed research into the mechanical and physical properties of both types of FRP. These materials have been used extensively, and the researchers examined the history of structures that incorporate FRP, such as Japan's Shinomiya Bridge (CFRP) and highway bridge structures (GFRP).

In four experimental tasks, the researchers examined FRP materials under specific conditions. The first two tasks examined CFRP prestressing strands and GFRP reinforcing bars subjected to sustained loads in high alkali environments at elevated temperatures. High alkali simulates the fluids that FRP materials are exposed to when embedded in concrete. The elevated temperatures simulate an accelerated aging process. The experiments had two objectives: first, to determine the most appropriate means of testing FRP products and, second, to determine how much tensile strength FRP would be predicted to retain at a 100-year design life. The researchers found that the tested CFRP and GFRP materials were expected to retain 82% and 74%, respectively, of their guaranteed tensile strength at 100 years.

In the third experimental task, the researchers examined the component materials of FRP in more detail. FRP is composed of fibers in an epoxy resin matrix. The researchers quantified the degradation of resin and fiber separately in high alkali environments. Three resins used in the manufacture of FRP were studied. In the final experimental task, concrete beams made with CFRP were exposed to environmental conditions and loaded to 50% of their design strength for 18 months. The tested beams showed no degradation at the end of the testing.

Project Benefits

A full understanding of the behavior of FRP materials, especially in Florida's hot, humid environment, will allow designers to take advantage of FRP's many useful qualities.

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