# Florida Department of Transportation Research

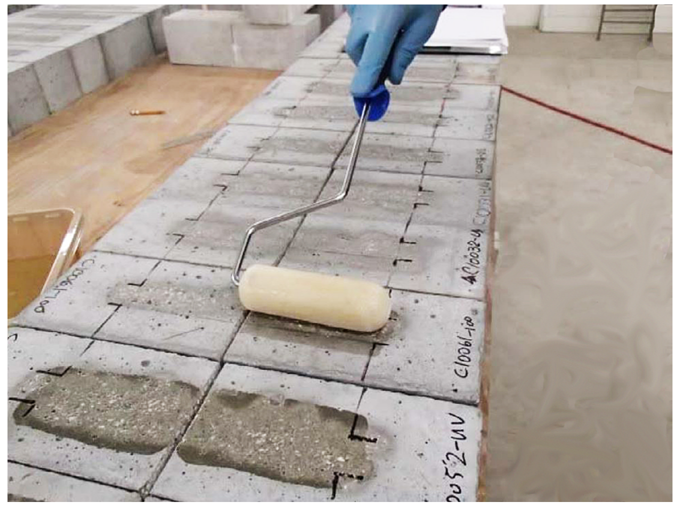
## Highly Accelerated Lifetime for Externally Applied Bond Critical Fiber Reinforced Polymer (FRP) Infrastructure Materials

BDK75-977-45

The Florida Department of Transportation (FDOT) uses fiber-reinforced polymer (FRP) composites to repair bridges and strengthen bridge decks. Proven mechanical characteristics make FRP composites cost-effective in extending the life span of bridges or improving their functionality. However, despite confidence in the application of FRP composites, how they will perform over the 50-year-plus lifespan of a bridge cannot be known in advance; instead, this must be predicted, usually through tests that accelerate aging of composites using elevated temperatures, stress levels, and concentrations of corrosive media. While standardized, these tests generally do not take into account the fundamental science of the cement/FRP/epoxy system. In this project, University of Florida researchers investigated the underlying chemical and physical processes of epoxy-cement bonding and FRP degradation to provide a basis for designing better and more predictive conditioning protocols.

The researchers first investigated the epoxy-concrete bond. Several small-molecule analogs of the epoxy molecule were adsorbed onto cement paste particles to simplify analysis. Infrared (IR) spectroscopy showed no indication of bonding between cement and these small molecules. Solid state NMR experiments showed weak interaction between one epoxy analog and cement, suggesting the presence of hydrogen bonding.

The second part of this work focused on accelerated aging of two epoxy systems. Mechanical testing was performed along with IR spectroscopy and diffusion modeling to determine changes in properties and mechanisms of degradation. A decrease in tensile strength and modulus of elasticity and an increase in strain to failure were found with higher exposure temperatures. Three degradation mechanisms were identified, depending on exposure conditions: water absorption at low exposure temperatures; oxidation for exposure to UV radiation; and hydrolysis for combined water and UV exposure.



*Concrete test beams are primed to receive FRP strips adhered with epoxy.*

Based on these results, accelerated aging conditions were identified and tested on five different FRP systems bonded to small-scale concrete beams. The acquired data were grouped with data from a previous study that used the same FRP-reinforced concrete specimens, providing over 900 test results. Data were rigorously analyzed to determine the distribution of data with respect to multiple variables.

The method used to experimentally determine a characteristic design value for adhesive anchors (ACI 355.4-11) was adapted to quantify the loss in bond capacity following accelerated conditioning. However, for this durability factor to enter the design standards, the findings from this study must to be confirmed with large-scale specimens and full-scale structural elements.

Better scientific understanding of the long-term behavior of epoxy/FRP/systems will allow broader application of cost-effective and efficient FRP composite repair systems.

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For more information, visit http://www.dot.state.fl.us/research-center