Michigan Department of Transportation RESEARCH Administration

FACT SHEET

Evaluating Long Term Capacity and Ductility of Carbon Fiber Reinforced Polymer Prestressing and Post Tensioning Strands

PROJECT TITLE

Evaluating Long Term Capacity and Ductility of Carbon Fiber Reinforced Polymer Prestressing and Post Tensioning Strands

STUDY TIMELINE

October 2013 – September 2019

INVESTIGATORS

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FURTHER RESOURCES

https://www.michigan.gov/documents/mdot/SPR-1690-FinalReport_663701_7.pdf

Introduction or Problem Statement

Since 2001, MDOT has successfully used carbon fiber reinforced polymer (CFRP) in place of steel as a prestressing and reinforcement material in the design and construction of several bridges across the state. CFRP components have tensile strength similar to steel, and their resistance to corrosion means they are anticipated to require less maintenance over time. Now, after six years of extensive research, MDOT's bridge designers have the technical information and specifications they need to predict how CFRP components will perform under a variety of conditions – and the design tools for future bridge projects.

Concrete beams prestressed with CFRP strands were subjected to fire/loading tests to evaluate their fire endurance.

Methodology or Action Taken

Through a research partnership between MDOT and Lawrence Technological University, a variety of experiments were conducted to evaluate the short- and long-term performance of prestressed CFRP strands. They also examined samples of scaled-down pretensioned T-beams (a combination bridge deck and I-beam) under various loading and environmental scenarios. Over the course of six years, the CFRP samples were subjected to 300 freeze-thaw cycles as well as combined fire/loading events and were exposed to severe weather conditions. These and other tests allowed investigators to calculate maximum tensile strength, guaranteed strength, environmental reduction factors, relaxation, creep rupture strength, short- and long-term prestress loss, and performance at high temperatures.

Conclusions or Next Steps

The research resulted in design criteria, design guidelines and recommendations to help make MDOT's design and construction of highway bridges using CFRP components more efficient. Additionally, researchers prepared four design examples using Mathcad software that can serve as a valuable design tool and reference for bridge designers. For ease of use, the design guidelines are modeled after AASHTO's Load and Resistance Factor Design Bridge Design Specifications.

Potential Impacts and Benefits

The guidelines and detailed design examples developed from this research are already providing value to MDOT engineers. For instance, after calibration and testing, the Mathcad calculations were used in 2017 in the design of an I-75 bridge in Metro Detroit. Armed with previously unavailable empirical data about the performance of CFRP, MDOT engineers can continue to design and construct corrosion-resistant highway bridges that are structurally reliable. With this material, MDOT's goal of building a bridge with a minimum 100-year service life is even closer to becoming a reality.