UTC Project Information	
Project Title	MPC-456 – Performance of Steel Girders Repaired with Advanced Composite Sheets in a Corrosive Environment: A Multi-Physics Approach Leading to Practical Design Recommendations
University	University of Colorado Denver
Principal Investigator	Dr. Yail Jimmy Kim
PI Contact Information	Associate Professor Department of Civil Engineering University of Colorado Denver Phone: (303) 352-365 Email: jimmy.kim@ucdenver.edu
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Brief Description of Research Project	The issue of infrastructure management and rehabilitation is one of the primary interests in the civil engineering community. Constructed bridge members deteriorate because of aging, corrosion, increased service load and traffic volume, use of deicing salts, and collision of heavy trucks (Kim et al. 2008; Harries 2009; Kim and Yoon 2010). Over $180 billion is required to address structurally deficient or functionally obsolete bridges in the United States (ASCE 2005). Of particular interest are steel bridges that account for more than 43% of the substandard bridges in the nation (Tavakkolizadeh and Saadatmanesh 2003). Steel bridges are susceptible to corrosion. Structural repair of damaged members provides a viable alternative to replacement, reducing downtime and cost. Traditional repair techniques for steel bridges include use of steel plates bolted or welded to damaged girders. Although the performance of such repaired girders is generally acceptable, the repairs themselves may introduce new potential problems associated with increased dead load, corrosion (crevice and galvanic corrosion), and the introduction of fatigue-sensitive details at the junction of existing and repair materials (Lenwari et al. 2006). The application of carbon fiber reinforced polymer (CFRP) composites is proposed as an alternative to steel-plating repair methods. The advantages of CFRP materials include their non-corrosive characteristics, high stiffness- and strength-to-weight ratios, ease and rapidity of erection, and reduced long-term maintenance expenses (Bakis et al. 2002). A significant advantage of CFRP systems is that they are typically adhesively bonded, rather than mechanically connected, to the substrate steel, resulting in mitigation of the additional stress raisers associated with bolt holes or welds. Although CFRP

	composites have primarily been used for repairing concrete structures (Teng et al. 2003), there are relatively limited data available on strengthening damaged steel members using CFRP (Schenerch and Rizkalla 2008, Shaat and Fam 2008, Harries et al. 2010). Nonetheless, this body of work clearly indicates the promise of this technique for strengthening damaged steel members subject to monotonic loads. Cadei et al. (2004) provides significant guidance for such applications. Notwithstanding the foregoing, very limited information is available on the behavior of steel structures repaired with CFRP composites subjected to corrosive service environments. There has been no attempt to understand the progression mechanism of corrosion for steel members repaired with CFRP, which will be a crucial issue to develop design guidelines. Research Objectives The objectives of the research are: • To understand the mechanism of corrosion progression in CFRP-repaired steel bridge girders exposed to a corrosive service environment • To examine the effect of corrosion damage on the performance of repaired steel girders in terms of load-carrying capacity and ductility as well as CFRP-steel interfacial behavior • To develop practical design guidelines for bridge engineers who are interested in repairing in-situ bridge girders with CFRP materials
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	The consequences of corrosion damage are physically and chemically characterized, including electric potential, mass loss, corrosion current density, corrosion rate, load-carrying capacity, interfacial strain development, failure mode, and infrared spectroscopy. Design recommendations are proposed to facilitate the use of CFRP-strengthening techniques based on the fact that the accelerated test protocol reasonably represented the deterioration mechanism of constructed steel bridges, which is a typical assumption in durability research, and thus the model is intended to guide practitioners rather than to accurately quantify the extent of corrosion damage.
Impacts/Benefits of Implementation (actual, not anticipated)	This research provides new experimental data required to understand the corrosion-induced deterioration mechanism of CFRP-strengthened steel girders and suggests design guidelines for practitioners. The approaches used influence multiple disciplines such as corrosion science, structural engineering, chemistry, and interface physics.
Web Links • Reports • Project Website	http://www.ugpti.org/resources/reports/details.php?id=876