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PERFORMANCE EVALUATION OF SHEAR CONNECTORS EMBEDDED IN ULTRA-HIGH PERFORMANCE CONCRETE AS PART OF A BRIDGE REPAIR METHOD

ABSTRACT

Corrosion is one of the most dominant forms of deterioration in steel bridge girders. U.S. federal and state agencies spend billions of dollars annually on bridge rehabilitation as a direct result of corrosion. Even with these efforts, it is estimated that approximately $125 billion is needed to address the current backlog of structures in need of repair. Over time, corrosion leads to section loss of the critical load bearing components and hinders the structural integrity of the bridge. To strengthen weakened girders ends which suffer from section loss, a structurally efficient and easy-to-implement repair option has been developed. In this repair, headed shear studs are welded to the intact portion of the web plate, i.e. the region with no section loss, above the bearing. The studs are encased in a thin panel of Ultra-High Performance Concrete (UHPC), which is cast to the bottom flange. This creates an alternate load path to omit the weakened web plate, instead transferring the forces through the studs and into the UHPC panels.

However, the success of the proposed repair hinges on the interaction between the headed studs and UHPC cast and therefore must be thoroughly assessed. In this study, a five-phase approach is deployed to better understand the critical load-transfer mechanism as part of this repair. First, an extensive series of push-out tests was conducted to evaluate the mechanical behavior of the headed studs when welded on thin web plates and embedded in UHPC. Parameters such as load bearing capacity, strain transfer, and failure mechanisms are captured. Next, design considerations such as eccentric loading, cover for studs, concrete embedment material variations, concrete curing conditions, and welding are evaluated to aid engineers during field implementation. The third phase consisted of a high-fidelity finite element analysis to validate the experimental results. Through these simulations, further design parameters such as eccentric loading and stud-diameter-to-web-thickness ratios for various limit states were evaluated. In the fourth phase, a corrosion investigation was conducted to assess the durability of the headed studs when embedded in UHPC. Finally, alternate shear connectors such as threaded rods and UHPC dowels are evaluated experimentally to provide flexibility to the designer as an alternative option to headed studs. The results of this work are used to facilitate the field implementation of the proposed repair method by addressing critical design parameters. Further, the broader contribution of this work may be applied to general structural engineering concepts involving shear connectors embedded in UHPC.