Repair of Corroded Steel H-Piles Using Performance Material

Executive Summary

Many bridges in the Midwest of the United States were constructed using steel H-piles as substructures. A steel H-pile carries a large load while occupying a relatively small cross-sectional area. Inspection of many of these bridges revealed severe localized corrosion damage due to aggressive environmental conditions and/or repetitive dry-wet cycles in a variable level of the water table. Therefore, there is an urgent need to assess the residual axial capacity of the corroded piles and to repair these piles using new techniques that have better durability.

This presentation summarizes an experimental work and finite element modeling that were conducted to evaluate: 1) the remaining axial capacity of steel H-piles having different corrosion severity and extension levels, and 2) the performance of repaired corroded steel H-piles. The research consisted of 32 short steel H-piles (10 × 42) encased in different types of concrete, including conventional concrete, high strength concrete, high-early strength concrete, UHPC, and geopolymer concrete. Different embedment lengths and shear studs were used. Thirteen long steel H-piles (10 × 42) were milled to represent the loss of a cross-sectional area associated with corrosion. The milling included a reduction of 70% in the web, 50% in the flanges, a 152 × 95 mm (6 × 3.75 in.) cut in the web, and/or a 152 mm (6 in.) diameter half-circle cut in the flanges. Both corroded and repaired piles were tested under concentric axial load. The capacities of the corroded piles were predicted analytically using three different existing design approaches: AASHTO (2014), AISC (2017), and AISI (2012).

Findings & Outputs

According to the obtained and observed results from the test, the axial capacity of the concentrically loaded corroded H-piles decreases as the corrosion severity increases. Both the FEMs and experimental work showed that the buckling load is more susceptible to corrosion in the flanges. For less than 25% reduction in the thickness of the flanges and 50% reduction in the thickness of the web, the axial capacity remained approximately constant, as the failure was due to global buckling. For less than 25% reduction in the thickness of the web and 50% reduction in the thickness of the flanges, the axial capacity decreased by up to 20% of the axial capacity of the uncorroded pile, as the failure was due to flange local-buckling. Beyond that, local buckling of the flanges and webs controlled the behavior, and the strength of the corroded piles significantly decreased, reaching up to 30% of the capacity of the uncorroded pile. Furthermore, the length of the corroded region had an insignificant effect on the axial load capacity. Increasing the corroded region length up to 304 mm (12 in.) decreased the axial load capacity for different corrosion scenarios. Beyond 304 mm (12 in.), the length of the corroded region did not affect the axial load capacity.

Implementing different concrete jacket types was successful in recover the full axial strength of the corroded piles. Push-out tests showed that using the CFRP jackets without headed studs slightly increased the bond stress between the concrete jackets

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and steel piles. Using headed studs and CFRP jackets increased the bond strength between the jackets and steel piles by a range of 580% to 1,130%, compared to the reference specimen. AASHTO_LRFD (AASHTO 2012) and Eurocode-4 (Standardization 2004) underestimated the shear capacity of the headed studs for concrete jackets with a CFRP confinement ratio higher than 0.21.

Impacts & Benefits

Corrosion of steel H-piles is a pressing issue in many states. For example, Missouri has about 700 bridge featured steel H-piles that require some pile maintenance. Of those, 300 bridges have piles with different degrees of section losses that require repair. This project addresses two crucial issues: 1) determine the remaining capacity of the corroded piles, and 2) propose a repair option. Addressing these issues will have DOTs to have safe bridges for commuters.

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For More Information:

Phase I: http://matc.unl.edu/research/research_project.php?researchID=528
Phase II: http://matc.unl.edu/research/research_project.php?researchID=561

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About MATC

Since 2006, the Mid-America Transportation Center has been designated as the US DOT Region VII University Transportation Center composed of Iowa, Kansas, Missouri, and Nebraska.

Research priority: Increase safety with an emphasis on reducing the number of incidents involving hazardous material transport and improving emergency response.

Education priority: Increase the number of students from underrepresented groups in STEM education and transportation-related careers