Research Brief

Wisconsin Highway Research Program
Project 0092-16-03
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Corrosion Rates of Bridge H-Piles in Aggressive Subsurface Environments

Research Objectives

- Study the corrosion performance of steel in different soils
- Develop methods to more accurately evaluate potential pile corrosion for bridge projects

Research Benefits

- Developed more accurate models for evaluating and predicting corrosion activity and potential in steel in different soils

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Background

On September 24, 2013, Pier 22 of the Leo Frigo Bridge sagged nearly two feet due to a loss of structural support in one of its steel H-piles. Steel H-piles are commonly used in bridges to resist vertical and lateral loads; however, they can be susceptible to corrosive interaction with soils due to factors such as soil type, moisture content, position of the water table, soil resistivity, soluble ion content, soil pH, oxidation-reduction potential and the role of micro-organisms in the soil. In the Pier-22 event, the pile was exposed to high levels of moisture, sulfate and chloride ions, and the porosity of the industrial fly ash fill around it facilitated oxidation-reduction.

The objective of this research was to evaluate the corrosion activity of the steel used in the H-piles in soils with different physicochemical parameters and to develop guidelines for future investigation procedures for evaluating potential pile corrosion in the project design stage.

Buckled H-pile in corrosive conditions

Methodology

Soil samples were collected from nine locations across Wisconsin. The following physicochemical parameters of each soil were measured: moisture content, pH, resistivity, chloride content, sulfate content, sulfide content and mean total organic carbon. Steel specimens with chemical composition similar to typical steel H-piles were constructed. Soil samples with-as received specimens as well as steel embedded in mortar specimens were subjected to corrosion potential, Linear Polarization Resistance (LPR), Tafel, cyclic polarization and Zero Resistance Ammetery (ZRA) testing in each soil. As-received carbon steel specimens were sandblasted and subjected to the same tests. In addition, the galvanic corrosion between new steel specimens and old steel specimens retrieved from the bridge was evaluated. Specimens were embedded in soil for over one year. Further testing was performed on as-received and steel-mortar specimens to determine the impact of soil chloride content on corrosion. In these tests, chloride content was increased to three percent of soil weight.

"This research provides additional information for the understanding of steel pile corrosion in Wisconsin."

– Jeff Horsfall, WisDOT

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Final report is available at: [WisDOT Research website]

Results

Steel-mortar specimens and as-received specimens showed comparable corrosion activities in both as-received soils and soils with elevated chloride content. Corrosion potential values of all specimens remained relatively stable, both before and after the addition of chlorides, while the corrosion current densities were higher after the addition of the chlorides.

The galvanic corrosion was also observed between steel in soils with the same chemistry but different chloride contents. Old steel specimens retrieved from the bridge showed higher corrosion activity compared to the new as-received steel. The results of electrochemical experiments also showed significant improvement in corrosion resistance of sandblasted specimens compared to the as-received specimens.

Recommendations for implementation

The Generalized Regression Neural Network (GRNN) model and experimental measurements showed high correlation between corrosion potential values and corrosion current densities in sampled soils. The model was used to predict the corrosion current densities and corrosion potential values of the steel specimens ahead of the actual experimental measurements, and the results showed that the model is highly capable of predicting these values.

This brief summarizes Project 0092-16-03,
"Evaluation of H-pile Corrosion Rates for WI Bridges Located in Aggressive Subsurface Environments"
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