Understanding different options for creating corrosion-resistant bridge pilings will support county engineers in designing sustainable bridges that perform for their intended life spans.

RESEARCH SOLUTIONS

New methods to protect steel bridge pilings from corrosion

Steel pile foundation systems need to perform over a bridge's service life, making corrosion an important consideration in the design and upkeep of these systems. Iowa DOT pursued options to combat steel's natural process of corrosion when exposed to moisture, oxygen, and soil properties. New research indicates that galvanized and painted galvanized steel pilings are highly corrosion-resistant. But another solution — increasing the the pile section size — allows for section loss from corrosion while still providing the required design strength. Considering the costs of steel and galvanizing practices, larger piles are the economical solution.

THE NEED

Preventing the steel components of a bridge from corroding is a priority for bridge engineers to achieve an extended structural service life. Deterioration of steel pile foundations, which occurs naturally because of exposure to moisture, oxygen, and various soil properties, can reduce the pile's cross-sectional area and structural capacity. Predicting rates of deterioration can be difficult because of changing environmental conditions and variations in surrounding soil composition.

Concrete-encased steel pilings are commonly used to protect against corrosion and have historically performed well. But pile corrosion and concrete deterioration aren't uncommon. To enhance bridge pile service life, Iowa DOT and county engineers wanted to explore the performance and cost-effectiveness of protective coatings on steel pilings to prevent corrosion.

RESEARCH APPROACH

A multifaceted exploration into the viability of galvanized and painted galvanized pile bridge foundations started with a comprehensive literature review of steel pile corrosion in air, water, and soil; testing methods; ways to protect steel from corrosion; and other related topics.

In the laboratory, researchers accelerated the corrosion process to evaluate the long-term performance of painted and unpainted galvanized steel piles. Nine test specimens included variations of bare steel,

(continued)

"This research gives county engineers a greater understanding of bridge piling options so they can choose the most cost-effective solution for their particular needs."

— **LEE BJERKE,**
Iowa County Secondary Roads Research Engineer

scratched and unscratched galvanized steel, and damaged and undamaged galvanized painted steel. The samples were subjected to cyclic salt and moisture conditions for 600 days to simulate an in-service environmental exposure of 100 years.

Next, a bridge project in Buchanan County provided an opportunity to observe pile performance over time. A painted galvanized pile system, installed in 2018, supports a bridge over Buffalo Creek. Because the creek's water level varies with significant rain, the piles are frequently exposed to varying air and water conditions. Investigators monitored the coating thickness in 10 locations on the bridge piles for over two years.

Lastly, results from lab experiments and field observations informed a life-cycle cost analysis and comparison among uncoated steel, galvanized, and painted galvanized piles. Investigators also compared the costs of increasing the pile size, an accepted method to address corrosion. The rate of pile thickness loss measured in the lab allowed researchers to calculate the needed magnitude of a "sacrificial" layer such that the remaining pile thickness meets design values.

WHAT IOWA LEARNED

Galvanized and painted galvanized steel performed well over the test period in the lab, which represented bridge design life. Paint layers eventually degraded from the galvanized steel but provided an estimated 10-year increase in life span. Galvanized steel with only small scratches remained protected. Similarly, the observations of Buffalo Creek Bridge revealed no corrosion of piles with painted galvanized coatings within the first two years of the bridge's service life.

The economic analysis, however, indicated that while galvanized and painted galvanized steel piles performed well in resisting corrosion, the initial higher cost may be prohibitive. Using data and estimates from the Buffalo Creek Bridge, investigators calculated costs per linear foot for each option:

- Bare steel piles: $36.
- Galvanized steel piles: $65.40.
- Painted galvanized steel piles: $85.
- Larger-sized bare steel piles: $47.

Of the three options that protect against corrosion — galvanized, painted galvanized, and increased thickness steel piles — the larger steel piles were the most cost-effective option in this scenario. Researchers noted that each project is different and the market price of steel varies, so this finding may not apply to all projects

PUTTING IT TO WORK

Investigators will continue monitoring pile thickness at the Buffalo Creek Bridge for several years. If galvanizing or painting and galvanizing steel piles becomes a more common strategy to resist corrosion, the costs will likely decrease. For any bridge project, county engineers will benefit from the increased options resulting from this project.

ABOUT THIS PROJECT

PROJECT NAME: Galvanized and Painted Steel Piling
Final Report | Technical Brief

PROJECT NUMBER: TR-766

REPORT DATE: September 2022

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