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LATERAL CAPACITY OF CORRODED PILE BENTS

PROBLEM STATEMENT

Florida's long coastline and subtropical climate make substructure elements that are exposed to wet/dry tidal cycles vulnerable to corrosion. Corrosion is particularly prevalent in piles that are exposed to the splash zone (i.e., within two to six feet of the water line). The combination of the deposition of salt on the pile surface and alternate dry/wet cycles due to tidal changes provides ideal conditions for corrosion in steel.

Depending on the extent of the damage, piles are patch repaired or repaired using fiberglass jackets. Knowledge of the *residual* capacity of the piles under axial and lateral loads provides an ideal basis for prioritizing such repairs. Although finite element analysis can provide a suitable framework for such a determination, its predictions need to be carefully calibrated against experimental results before it can be used with confidence.

In 1996, the University of South Florida conducted a two-year study to assess the residual capacity of corroded piles under concentric and eccentric loading. In the study, one-third-scale models of corroded piles were tested and the results were used to calibrate nonlinear finite element analyses. This study, initiated in 1999, is a continuation of the earlier study. In the investigation, one-third-scale models of corroded pile bents were tested under lateral and axial loads, and the residual capacity was determined.

OBJECTIVES

The objectives of this study were threefold:

1. To conduct scale-model tests on representative pile bents to determine the effect of damage on lateral capacity.

2. To examine the correlation between predictions from finite element analysis and the test results.

3. To conduct parametric studies to extend the results of the laboratory tests to larger piles.

FINDINGS AND CONCLUSIONS

A two-year experimental study was conducted to investigate the effect of corrosion on the lateral capacity of corroded pile bents. One-third-scale models of corroded pile bents were fabricated and tested. Their capacity reduction was assessed through comparison with an identical uncorroded control. Surveys of characteristic corrosion damage in pile bents were carried out to establish the geometry of the pile bent and the location of the damage. Soil restraint was modeled so that it reproduced the axial load and bending moment distribution in the damaged portion of the piles from the point of inflection.

Corrosion damage was simulated using a constant current system and stainless steel counter electrodes. The system developed was very successful in achieving targeted metal loss in strands and ties, in a predictable time frame, and in reproducing damage that was typically observed. Gravimetric testing was carried out to establish actual metal loss in the test specimens. Three different metal loss levels were examined - 10%, 30%, and 50%. Lateral capacity was determined under sustained axial loads corresponding to 90 kips per pile in the prototype. A five pile bent was selected for testing, and the piles were spaced at 6.5 times the pile size; all five piles were corroded. The center of the corroded region was located at a distance of *0.15 x pile length* from the underside of the pile cap. All model bents were heavily instrumented with load cells, shear cells, strain gages, LVDTs, a pressure transducer, and string line transducers to assess the performance during testing. An MTS controller and hydraulic actuator was used to apply and measure the lateral load, and five hydraulic jacks mounted on a trolley were used to simulate service loads during testing. All data was recorded using an acquisition system.

The results indicated that ultimate capacity was not severely compromised by high levels of corrosion. Compared to the controls, the reduction in the lateral load in specimens corroded 10%, 30% and 50% were, respectively, 1%, 23%, and 30%. Failure occurred in the pile cap in the controls and in the 10% corroded bents but in the corroded zones in the 30% and 50% metal loss levels. Analysis of the strain data indicated that the top and bottom ends of the piles, assumed fixed, did not exhibit full fixity throughout the test. Researchers also found that axial load predictions from approximate portal frame analysis did not corroborate measured axial loads throughout the entire test. Finite element analyses were conducted to extend the test results. Reductions in prototype pile bents were predicted to be greater when the damage was located at the pile cap. For five pile bents with 18 inch piles, reductions ranged from 11% (single pile in benicorroded) to 56% (all five were corroded).

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