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Research Notes

Geotechnical/ Structures

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Project Title: Evaluation of Soil Plug Geotechnical Resistance in the Design of CISS Piles

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Evaluation of Soil Plug Geotechnical Resistance in the Design of CISS Piles

This research will evaluate various soil plug thicknesses and assess their impact on the geotechnical resistance.

WHAT IS THE NEED?

The California Amendments to American Association of State Highway and Transportation Officials Load and Resistance Factor Design Bridge Design Specifications require a design procedure by the American Petroleum Institute (API, 2000) for the design of Cast-In-Steel Shell concrete (CISS) piles larger than 18-inch in diameter. The use of the soil plug in the API design procedure doesn't correspond well with the California Department of Transportation (Caltrans) practice of cleaning out the soil and backfilling with concrete and steel reinforcement. This research will evaluate various soil plug thicknesses and assess their impact on the geotechnical resistance of the pile and how it correlates with the API design procedure.

WHAT ARE WE DOING?

Drive three 36-inch diameter test piles with 8 reaction piles to specified tip elevations. The three test piles will be instrumented with vibration wire strain gauges and distributed fiber optic strain sensors. Three stages of static load tests will be performed:

1. Load the test piles to the specified nominal resistance after driving and before removal of the soil plug. (Suggest a waiting period, say 5 days after driving before loading the piles).
2. Remove the soil plug inside the three test piles to a specific depth for each test pile. The remaining soil plug thickness inside the CISS piles will be a function of diameter (e.g. 1D, 3D, 7D) for each load test. Load the test piles to the specified nominal resistance.
3. Place seal course on the top of soil plug, let set to

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specified time, then place concrete up to the pile cutoff for all three Test piles, load the test piles to the specified nominal resistance and/or geotechnical failure.

From the measurement data, the shaft and base soil-pile interaction diagrams will be developed at different stages of construction. The level of uncertainty for each stage will be examined. Such data will be used to assess how the actual performance correlates with the API procedures.

WHAT IS OUR GOAL?

The objectives of this research are as follow:

- Evaluate the soil plug contribution to the geotechnical resistance of the pile for variable thicknesses of soil plug.
- Evaluate the Caltrans practice of placing concrete and steel reinforcement on top of the soil plug and its effect on the geotechnical resistance of the pile.
- Evaluate the API design procedure in predicting the geotechnical capacity of the CISS pile.

WHAT IS THE BENEFIT?

The research will address the uncertainty and reduce the geotechnical risk that exists when designing CISS piles. The CISS pile foundation is the most expensive foundation that geotechnical designers can recommend because it uses both a thick steel, driven shell that is backfilled with concrete and steel reinforcement. It is used commonly when large lateral pile capacity is required to resist seismic forces. There have been a number of Caltrans projects where the calculated geotechnical resistance was not met during construction due to uncertainty in the design method, and costly change orders were required. The research will help refine and better predict the geotechnical resistance of the soil plug and therefore yield more cost-effective designs with less risk.

WHAT IS THE PROGRESS TO DATE?

Contractor has completed driving the CISS test piles and performing all planned static load tests. Measured capacities were significantly higher than the anticipated failure loads, so additional load tests with higher target loads were conducted, and supplemental Cone Penetration Tests (CPTs) were performed to refine the site stratigraphy and soil parameters.

The research team is currently evaluating the soil plug effect on the geotechnical resistance and load transfer behavior of the CISS piles. Using continuous strain measurements obtained from distributed fiber optic cables, the load transfer behavior (t–z and q–z curves representing shaft and base response) is being derived for different soil plug conditions and compared with API design predictions. In parallel, a 2D axisymmetric finite element model simulating the field conditions has been developed and is being calibrated through back-analysis; this model will be used to quantify the contribution of the soil plug under varying plug thicknesses.