DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Improving Pile Capacity Estimation in the Design Phase

Reusable test pile instrumentation provides an alternative to expensive static load tests

Geotech/ Structures

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Project Title:
Instrumentation Strategies for Improved Pile Capacity Estimates

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WHAT IS THE NEED?

Driven piling is used extensively in California to support bridges and other structures. The foundations constructed have been reliable and performed well, but have often been conservatively designed to compensate for uncertainty in assessing soil capacity. The methods available for predicting the axial capacity of driven piles do not accurately capture the complexity of site-specific soil properties, particularly for piles driven in soil consisting of sand or gravel. The lack of reliable capacity estimation procedures has lead to conservative approaches that can increase construction costs.

Engineers can get slightly improved capacity estimates by taking dynamic measurements of strain and acceleration at the top of the pile during driving using the Case Pile Wave Analysis Program (CAPWAP). However, CAPWAP estimates are available only in the construction phase, where deviation from the original plan reduces potential savings and may threaten the schedule. The most accurate method for determining pile capacity is to perform a static load test of an installed pile, but these tests can be expensive and have similar drawbacks of cost increases and schedule delays.

WHAT WAS OUR GOAL?

The goal was to develop a mobile pile testing device that enables improved prediction of pile capacity in the design phase of a project, resulting in more cost-efficient foundations and fewer construction delays.

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Davis Department of Civil and Environmental Engineering, developed a prototype of a reusable test pile (RTP) device that can be used

at the site prior to construction to evaluate the load capacity. The RTP device is a modular system that can be taken to the field, assembled, driven into ground with a Becker-hammer rig, load tested, removed, and then reused. To manage costs, the RTP was designed to be compatible with Becker-hammer driving equipment and pipe string, which is commercially available and can be contracted as needed, minimizing the need for additional personnel and equipment purchases.

The RTP device consists of a series of instrumented pipe sections that can be easily assembled. Each load module fits in a standard (6.625-inch diameter) Becker hammer pipe and is constructed of a special steel alloy known for strength and toughness. Each section has a down-hole computer that records and processes sensor data before transmitting it to the surface. A separate, above-ground data acquisition system measures vertical pile displacement and Becker-hammer performance.

The load modules measure axial strain up to 8,000 Hz and store the information in onboard memory. Each module is connected to a single, shared communication cable that extends from the top of the pile to a field laptop that can quickly process stored measurements.

WHAT WAS THE OUTCOME?

Five load test modules, each 2 feet in length, were developed and tested at an Oakland site that has a common stratification of surficial fill, young bay mud, and sand. The system is in the process of being deployed at locations that have had static load tests to use as a basis of developing a methodology for converting test pile measurements into capacity predictions for various types and sizes of piles.

The RTP instrumented modules are capable of measuring axial resistance, temperature, acceleration, pore pressure, and inclination. The measurements can be obtained during driving, load testing, and setup. The multiple instrumentation clusters along the RTP pile length will provide insight into driving dynamics, installation energy required, tip-to-shaft bearing proportions, load transfer distribution along the pile shaft, end-bearing capacity, and pile setup.

WHAT IS THE BENEFIT?

When designing foundations for bridges, the RTP device allows engineers to not rely on conservative design assumptions or wait until project construction to perform expensive load tests. Instead, engineers can reduce costs and time by performing load tests during a project's design phase. This information can then be used by piling contractors in the bidding process and assess the type of equipment that would be suitable for the job. Engineers can also use the data to optimize the foundation design as well as provide an early alert to potential construction problems, such as difficult driving conditions.

IMAGES

IMAGE 1: Drill ring with driving hammer in upward position