DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Improving the Design of Earth-Retaining Walls

New geotechnical and structural design procedures enhance the longevity and safety of retaining wall structures

Seismic

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Project Title:
Improved Guidelines for Earth-Retaining Structures

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WHAT IS THE NEED?

Retaining walls are an essential element in highway construction, but earlier seismic design guidelines, based on the Mononobe-Okabe (M-O) equations, do not address passive pressures, which determine the resisting force at the toe of standard, semi-gravity retaining walls and at the wall face for pile-supported cantilever walls. More sophisticated limit-equilibrium methods for determining the passive pressures for general cohesion and friction backfills exist, but they do not take inertial effects into account. New design criteria that incorporate backfill inertia and cohesion into an accurate model are needed to mitigate the potential for retaining wall failures during an earthquake.

WHAT WAS OUR GOAL?

The goal was to develop updated design guidelines for earth-retaining structures, incorporating new safety and serviceability standards to address known shortcomings.

WHAT DID WE DO?

Caltrans, in partnership with the University of California, Los Angeles Department of Civil and Environmental Engineering, incorporated a Log-Spiral-Rankine Model, which is based on the log-spiral limit equilibrium approach for building earth-retaining structures. A physics-based, mathematically rigorous model, the Log-Spiral-Rankine Model offers a more complete picture of the problem than previous limit equilibrium models. The researchers incorporated backfill inertia and cohesion into the model, verifying the accuracy of those extensions using advanced numerical finite-element methods and existing centrifuge and field test data.

A wide variety of earth-retaining systems exist. This effort focused on semi-gravity retaining structures, which include reinforced concrete, cast-in-place, and cantilever retaining walls. Structural behaviors of non-gravity cantilever and anchored retaining walls were also investigated. If the native soil is weak, it is recommended to add piles to meet the bearing and overturning demands. If native soils have adequate bearing capacity, or seismic demand is low, a shear key provides ample restraint against lateral sliding.

WHAT WAS THE OUTCOME?

The Log-Spiral-Rankine Model explicitly accounts for the magnitude of earthquake acceleration, structure height, backfill soil properties, such as internal friction angle and cohesion, and the mobilized interface friction angle between the backfill and earth-retaining structure.

Step-by-step design procedures, including two examples for the design of cantilever retaining walls supported by a spread footing and a pile foundation, were developed. New safety guidelines specify how to design earth-retaining structures to withstand lateral earth and water pressures, the effects of surcharge loads, self-weight of the wall, and earthquake loads. Serviceability requirements are also addressed, including adequate structural capacity with acceptable movements, adequate foundation capacity with acceptable settlements, and the overall stability of slopes adjacent to walls.

WHAT IS THE BENEFIT?

Earth-retaining structures are an important component of California's transportation infrastructure. To repair, replace, or retrofit these structures can be costly and labor intensive. These new guidelines provide a more comprehensive and rational design approach to improve earth-retaining structure performance during a seismic event.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2013/final_report_65a0413_task_2270.pdf

IMAGES

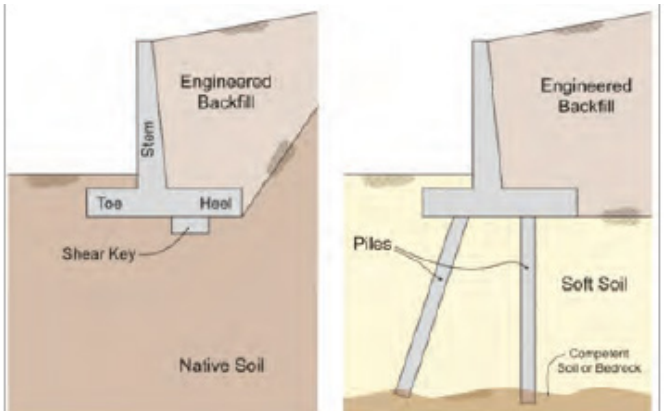

Figure 1: Caltrans cantilever reinforced concrete retaining walls are typically built with a shear key (left) or supported on piles (right).

Figure 2: Precast concrete crib walls