RESEARCH NOTES

Contract: 59A0650

September 2011

Full-Scale Shake Table Test of Retaining Walls with and without Sound Wall

RESULTS: In testing retaining walls with and without sound wall, wall with sound wall performed differently from the wall without sound wall. However, both walls were able to withstand the subjected excitations with no collapse occurring.

Background

The objective of this research is to develop improved and validated rational guidelines for seismic design of retaining walls with/without sound wall to overcome the main drawbacks in the existing design specifications and tools. One key component in designing retaining wall systems is predicting the active lateral earth pressure, which becomes more complicated and difficult to predict with earthquake loading. The existing method to find the earth pressures exerted on retaining walls during earthquakes is based on the well-known Mononobe-Okabe method, which has several inherent limitations.

Why We Pursued This Research

Hundreds of miles of retaining wall systems exist in the western United States. Many private and public engineering sectors have practiced a routine design for static applications of these retaining wall systems. However, seismic design of these walls has not been extensively developed with a lack of accurate and reliable guidelines in the existing design codes and specifications.

What We Did

Office of Earthquake Engineering from Engineering Service Center contracted with University of California, Davis to test two specimens that are constructed based on the Caltrans retaining wall design specifications. The walls are backfilled with Caltrans specified soil and supported on flexible foundation in a soil box to be placed on the NEES Large High-Performance Outdoor Shake Table at the Englekirk Structural Engineering Center of the University of California, San Diego. One of the specimens is a 1.83 m (6 ft) Type 1 Semi-Gravity Reinforced Concrete Cantilever Wall itself. The other specimen is identical to the first wall but has a 1.83 m (6 ft) tall sound wall connected to the top. The soil container is subject to excitations with high and low frequencies on the shake table.

Research Results

The results of the tests with and without sound wall had similar behavior in the backfill during the ground motions. Greater acceleration was at the top of the compacted soil compared to the bottom of the soil container in both tests. Slightly higher acceleration and displacement in the soil was near the wall because of the translation (lateral displacement) of the wall. More heaving was seen near the wall for the two tests with little settlement. However, significant behavioral differences between the two tests were seen from the displacements and dynamic pressures measured on retaining wall with and without sound wall as described below.

- Along the height of the stem, the wall without sound wall had the lateral dynamic pressure linearly increasing from the top to the bottom of the stem similar to the trend seen in the Mononobe-Okabe method. The addition of the sound wall caused more dynamic pressure towards the top of the stem compared to one without sound wall due to the reverse thrust effect from the backfill on the wall. This created a non-linear pressure distribution for wall with sound wall.
- The wall with sound wall did not displace as much as wall without sound wall in the less intense shakes. Though more bending was measured in the wall with sound wall, the wall without sound wall had more sliding and thrusting in the more intense shakes.
- The stem of the wall without sound wall was more rigid than the one with sound wall, especially experienced at the top of the stem from bending.

Recommendations

From this study, concrete cracking along the joint between the footing and stem was observed in both test specimens. This was the same location where the rebar was failing in tension. Also, in the test with sound wall, there was mortar cracking seen along the seam between the retaining wall and the sound wall. These appear to be the critical areas that may need to be examined in the design, especially under high intensity earthquakes where significant amount of bending is expected in the retaining wall and sound wall.

Based on the results of this project, the retaining wall with sound wall shall not be designed the same way as the retaining wall without sound wall because of the different pressure distributions between the two tests. The pressure trend of the retaining wall without the sound wall has a similar pressure trend as the Mononobe-Okabe method, so the active resultant of pressure acts at one-third the height of the stem, which is the same location as the theoretical resultant based on the Coulomb and Rakine theories. The resultant of the active pressure for wall with sound wall does not act at one-third the height but at a taller height on the stem in this project.

Reference

E. Mock, L. Cheng: "Full-Scale Shake Table Test of Retaining Walls with and without Sound Wall", Final Report, June 2011, 841 pp.

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