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Caltrans Division of Research, Innovation and System Information

Research Results

Interaction of MSE Abutments with Bridge Superstructures under Seismic Loading

Six shaking table tests were performed on mechanically-stabilized earth (MSE) bridge abutments to understand the impacts of reinforcement spacing, reinforcement stiffness, bridge surcharge stress, and shaking direction on the seismic response..

Geotechnical Structures

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Project Title:
Interaction of MSE Abutments with Bridge Superstructures under Seismic Loading

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WHAT IS THE NEED?

In recent years, mechanical-stabilized earth walls have been used as bridge abutments where the bridge beam load is applied as a surcharge to the top of a reinforced soil mass via a shallow footing. This concept offers significant cost and construction time savings in comparison to traditional pile-supported bridge abutment designs and can reduce differential settlements between the bridge and approach roadways. Many studies have shown that the MSE bridge abutments have acceptable deformations under service load conditions in terms of bridge settlement, abutment compression, and differential settlement. However, a concern regarding the use of MSE bridge abutments is that vertical settlements and facing displacements during a major earthquake are uncertain. Therefore, while MSE bridge abutment technology offers substantial cost- and time-savings for construction, there are concerns that need to be addressed regarding the use of this technology in high seismic areas like California and little information is available to validate numerical simulations that can be used to guide designers on how to improve the seismic response of these structures. Due to the limited information on the seismic performance of MSE bridge abutments in the field and in previous shaking table tests, more experimental testing and evaluation are needed to understand the potential issues and for impacts of different design variables on the performance characteristics of MSE bridge abutments.

WHAT WAS OUR GOAL?

The overall purpose of this project was to investigate the seismic response of MSE bridge
abutments with various configurations and loading conditions through physical testing. A

secondary is to develop a database of instrumentation results from the shaking table experiments that can be used to validate numerical simulations of MSE bridge abutments, which can then in turn be used to refine design recommendations for these structures.

WHAT DID WE DO?

A total of six shaking table tests were performed on half-scale MSE bridge abutments with a significant amount of embedded instrumentation to monitor the vertical bridge seat settlement, lateral facing displacements, lateral accelerations, bridge seat-bridge beam contact stresses, reinforcement tensile strains, and vertical and lateral soil stresses. The testing program was configured to understand the impacts of reinforcement spacing, reinforcement stiffness, reinforcement type, bridge surcharge stress, and direction of shaking on the seismic response of MSE bridge abutments.

WHAT WAS THE OUTCOME?

In general, the seismic deformation responses of all of the MSE bridge abutments evaluated were reasonable, with vertical and lateral permanent displacements that were small enough that major damage to the bridge structure would not be expected. The following major conclusions were drawn from evaluation of the shaking table test results:

- For shaking in the direction longitudinal to the bridge beam, reinforcement spacing and stiffness were observed to have the most significant effects on the seismic performance of MSE bridge abutments. Specifically, facing displacements and bridge seat settlements increased with increasing reinforcement spacing and decreasing reinforcement stiffness.
- The bridge surcharge stress also played an important role in the seismic performance of the MSE bridge abutment. Although greater bridge surcharge stresses were observed to lead to larger facing displacements and bridge seat settlements for static loading conditions, greater bridge surcharge stresses were observed to lead to smaller values of lateral facing displacements and bridge seat settlements for seismic loading conditions. This observation is attributed to the increase in backfill soil stiffness with confining stress.
- For shaking in the direction transverse to the bridge beam, large reinforcement strains were observed near the facing block connections, indicating that the reinforcement-block connection stress-displacement relationship should be considered in design.
- Contact between the concrete bridge seat and bridge beam was only observed in some of the earthquake motions. However, the scaled horizontal contact forces were not large enough to create damage to the concrete elements, but were large enough that they should be considered in the seismic design of MSE bridge abutments.

WHAT IS THE BENEFIT?

This study provided valuable experimental data that can be used for calibration of numerical models of MSE bridge abutments under dynamic loading. These validated models are useful when refining the seismic design guidelines for MSE bridge abutments.