DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Seismic Performance of Mechanically Stabilized Earth Bridge Abutme

Numerical modeling shows minimal seismic impact of bridge abutment structures consisting of geosynthetic-reinforced soil

Seismic

JANUARY 2016

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

Task Number: 2493 & 2298

Start Date: January 9, 2012

Completion Date: November 30, 2014

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WHAT IS THE NEED?

Mechanically stabilized earth (MSE) walls have been successfully used for decades across the United States primarily as retaining walls that support on-ramps. Their popularity is due to low construction and maintenance costs, rapid construction, and good overall performance. More recently, many states are constructing bridge abutments using MSE techniques. In these applications, the bridge superstructure is supported by a small footing that bears directly on the MSE embankment structure. Compared to typical abutments that rely on driven or drilled piles for bearing support, the MSE abutment offers substantial savings due to simplified construction and the elimination of deep foundations. Geosynthetic-reinforced soil (GRS) is the next step, which reduces the concrete footing required and modifies the MSE embankment to take more of the bridge load directly from the deck. GRS bridge abutments have performed well under static loading conditions. However, to implement this technology in seismic-prone regions, research is needed to evaluate their performance, including vertical settlement during shaking. This study was partially funded by Transportation Pooled Fund (TPF) 5(276) to offset the cost of near-full-scale shake table testing and numerical simulation.

WHAT WAS OUR GOAL?

The goal was to determine whether GRS abutments are viable in regions prone to strong earthquakes by conducting numerical modeling simulations to investigate the seismic performance.

WHAT DID WE DO?

Caltrans, in partnership with the University of California, San Diego School of Engineering, conducted numerical studies using FLAC-2D (finite difference) and ABAQUS (finite element) software. The researchers validated FLAC-2D for static analysis using published field measurements for the Founders/Meadows GRS bridge abutment in Denver, Colorado. The team then conducted numerical simulations using FLAC-2D and ABAQUS to predict settlement and lateral displacement for a GRS abutment subjected to the Newhall Station ground motion record from the California 1994 Northridge earthquake. Results from the two programs showed good agreement. The researchers also compared numerical simulation results with measured data for seismic tests of a full-scale MSE wall on the UC San Diego large outdoor shake table, funded via TPF-5(276). Numerical results for this latter study indicated that FLAC-2D overestimated wall displacement measurements for this large-scale test.

The researchers then conducted numerical simulations using FLAC-2D to study the seismic response of GRS abutments supporting a 150-foot bridge for the Northridge record with ground motion applied in both the longitudinal and transverse directions. The team performed parametric studies to investigate the effects of several design parameters, including reinforcement spacing, reinforcement stiffness, reinforcement length, soil cohesion, soil friction angle, bridge load, earthquake ground motion record, and bearing pad friction coefficient on the seismic response of GRS abutments in the longitudinal direction. They also evaluated the effectiveness of soil shear keys to reduce seismic-induced lateral movement of a bridge seat in the transverse direction.

WHAT WAS THE OUTCOME?

GRS bridge abutments could be a viable option for single-span bridges in California. The numerical results indicated that seismic-induced settlements of a bridge seat on a GRS abutment are small—about 0.65 inches—for the Northridge-Newhall Station ground motion record. Corresponding seismic-induced lateral displacements of the bridge seat were 2.5 inches or less. Reinforcement stiffness and soil cohesion had a large influence on these displacements. Soil shear keys were shown to be effective in reducing lateral displacement of the bridge seat in the transverse direction. Based on these numerical results, the next step is to conduct shake-table testing to further evaluate the seismic performance and support the development of design guidelines.

WHAT IS THE BENEFIT?

GRS abutments can be built in weeks instead of months, due to the ease of construction and the use of readily available materials and equipment. A reduced construction schedule translates into less exposure around work zones, improving safety. They also provide environmental advantages, because less steel and concrete are needed.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2015/CA15-2493_FinalReport.pdf

IMAGES

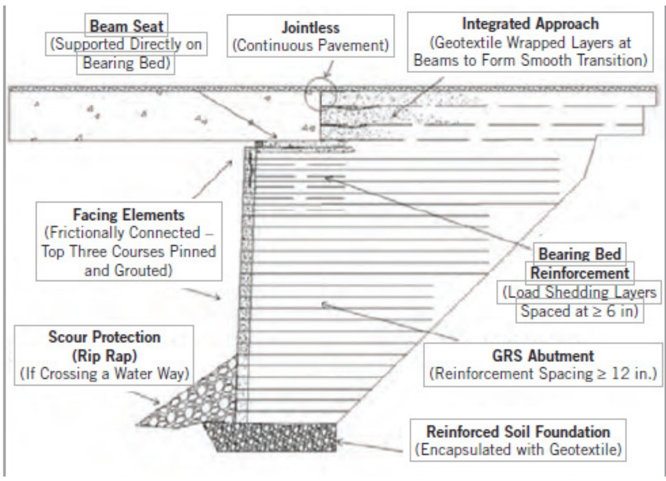

Figure 1: Example cross-section of a GRS bridge abutment