Monday 3/13/2017

2–3:30 p.m.

MSE Retaining Walls 1

Chairs: Christopher Meehan, University of Delaware; Mike Adams, Federal Highway Administration

V-Shaped Failure Surfaces in Bearing Capacity Type Limit Equilibrium Analyses

Daniel VandenBerge, Tennessee Tech

Limit equilibrium is often used to evaluate global stability of retaining walls. The critical failure surfaces tend to be "V-shaped" with distinct active and passive regions separated by an abrupt point. The validity of these failure surfaces is explored in this study through comparison with bearing capacity theory and finite element analysis. V-shaped surfaces are similar to lower bound bearing capacity solutions, imply a discontinuity in stress orientation, and tend to have conservative factors of safety. The amount of conservatism depends on the accuracy of the limit equilibrium method used and the side force assumptions. Other factors, such as the bearing pads often placed below MSE walls, can also affect the accuracy of limit equilibrium global stability analyses. The factor of safety can be checked using bearing capacity theory. The proposed method produces factors of safety within 5% of finite element results for undrained conditions.

A Case Study on Evaluating the Performance of Geosynthetic Reinforced Soil–Integrated Bridge System (GRS–IBS)

Murad Abu-Farsakh, Milad Saghebfar, Allam Ardah, and Qiming Chen, Louisiana State University; Benjamin Fernandez, Louisiana Department of Transportation and Development

The Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS) is an alternative design method to the conventional bridge support technology. This new technology has a number of advantages including reduced construction time and cost. This paper presents a case study on instrumenting and short-term performance monitoring of the first GRS-IBS project in Louisiana. The monitoring program consisted of measuring bridge deformations, settlements, strains along the reinforcement, vertical and horizontal stresses within the abutment, and pore water pressures. Measurements from the instrumentations also provide valuable information to evaluate the design procedure and the performance of GRS-IBS bridges. The instrumentation readings showed the overall performance of the GRS-IBS was within acceptable tolerance in terms of measured strains, stresses, settlements and deformations. The magnitude and distribution of strains along the reinforcements vary with depth. The locus of maximum strains in the abutment varied by the surcharge load and time.

Passive Force-Deflection Behavior of Geosythetically Reinforced Soil (GRS) Backfill Based on Large-Scale Tests

Amy Fredrickson, AECom; Kyle M. Rollins, Brigham Young University; Jennifer Nicks, Federal Highway Administration

A correct understanding of passive force-deflection response is important for lateral load evaluations of bridges during extreme events such as earthquakes and during in-service conditions resulting from thermal expansion and contraction of the superstructure. The goal of this study was to better understand this behavior for abutments backfilled with both gravel and geosynthetic reinforced soil (GRS). Large-scale testing was performed with non-skewed and 30° skewed abutment configurations. Two tests were performed at each skew angle, one with gravel backfill and one with GRS backfill. The test abutment backwall was 3.35 m wide, non-skewed, and 1.68 m high and loaded laterally into the backfill. Both backfills exhibited greater passive resistance than sand backfills owing to increased internal friction angle and unit weight. Skew angle reduced the passive force in both cases by about 40%. The GRS backfills had reduced initial stiffness and only reached 79% to 87% of the passive force developed by the unreinforced gravel backfill. This reduction was considered to be a result of reduced interface friction at the geotextile-backwall interface due to wrapping. Reduced stiffness may be favorable for abutment configurations because it allows thermal movement without developing excessive induced stresses in the bridge superstructure.

Numerical Study of Compaction Effect on the Static Behavior of Geosynthetic Reinforced Soil-Integrated Bridge System

Yewei Zheng, University of California, San Diego; Patrick Fox, Pennsylvania State University; John McCartney, University of California, San Diego

This paper presents a numerical study on the effect of backfill compaction on the static response of Geosynthetic Reinforced Soil-Integrated Bridge System (GRS-IBS). The numerical simulations were performed in stages to simulate the construction process, and considered soil-geotextile, soil-block, geotextile-block, and abutment-bridge interactions. Backfill compaction was simulated using a temporarily-applied uniform vertical stress to each lift during construction. Simulation results of the GRS-IBS behavior corresponding to various levels of compaction effort are presented and discussed, including lateral facing displacements, settlements, and maximum tensile forces in the reinforcement layers. Results indicate that greater backfill compaction leads to smaller bridge seat settlement and backfill compression, but also results in larger lateral facing displacements.

3D Deformation Behavior of Geosynthetic-Reinforced Soil Bridge Abutments

Wenyong Rong, Yewei Zheng, and John McCartney, University of California, San Diego; Patrick J Fox, Pennsylvania State University;

Although 2-dimensional (2D) design methods have been shown to work well in defining the longitudinal reinforcement layout in geosynthetic-reinforced soil (GRS) bridge abutments, three-dimensional (3D) effects may play a role in the design of the side walls and the associated transverse reinforcement layout. The objective of this study is to understand the deformation behavior of GRS bridge abutments considering 3D boundary effects, using finite difference analyses to simulate the deformation behavior of a hypothetical GRS bridge abutment expected during construction. Soil-concrete and concrete-concrete interactions were simulated using interface elements and soil-geogrid interactions were simulated using geogrid structural elements. Analyses were performed in stages to simulate the abutment construction process with different reinforcement vertical spacing and length. The results presented in this paper provide insight into the lower wall lateral facing displacements in both the longitudinal and the transverse directions, as well as bridge seat settlements at different sections. This information is a useful component in the development of comprehensive design guidance for GRS bridge abutments.

Experimental Design for Half-Scale Shaking Table Test of a Geosynthetic-Reinforced Soil Bridge Abutment

Zheng Yewei, Andrew Sander, Wenyong Rong, John McCartney, and P. Benson Shing, University of California, San Diego; Patrick J. Fox, Pennsylvania State University

This paper presents an experimental study on the seismic performance of a half-scale geosynthetic-reinforced soil (GRS) bridge abutment. Experimental design of the scale model followed established similitude relationships for shaking table testing in a 1 g gravitational field. This involved scaling of model geometry, reinforcement and backfill stiffness, bridge load, and characteristics of the earthquake motions. The GRS abutment was constructed using well-graded sand, modular facing blocks, and uniaxial geogrid reinforcements with a vertical spacing of 0.15 m in both the longitudinal and transverse directions. The bridge deck was placed on the GRS abutment at one end and supported by a concrete wall resting on a sliding platform off the shaking table at the other end. The table was connected to the base of the support wall with steel beams to transmit the table motions. The measured lateral facing displacements and bridge seat settlements during application of a series of earthquake motions in the longitudinal direction are presented and indicate good seismic performance of the GRS bridge abutment.