8th National Congress on Civil Engineering, 7-8 May 2014
BabolNoshirvani University of Technology, Babol, Iran

Numerical modeling of Mechanically Stabilized Earth Walls

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Abstract

This paper describes the numerical modeling details of an example full-scale physical steel reinforced soil wall taken from a series of structures constructed at the FHWA Reinforced Soil Project site at Algonquin, Illinois. In this research, numerical analyses were performed with the finite difference based computer program FLAC (Fast Lagrangian Analysis of Continua). Details of the numerical model and constitutive modeling of the component materials are described. The modeling results are presented and compared to the field measurements from case histories to assess the accuracy of the numerical approach. Example parametric analyses are carried out using the verified numerical code to investigate the influence of internal stability design factors on Earth Pressure Coefficient of a theoretical wall of 7.6 m height. The lessons learned here are of value to modelers who wish to: (a) explore the mechanical behavior of these systems; (b) generate data to fill in the gaps in performance data from the limited number of monitored structures reported in the literature; and (or), (c) carry out parametric analyses.

Keywords: reinforced soil, numerical analyses, Earth Pressure Coefficient, FLAC

1. Introduction

A recent study by Allen et al.[1] and Bathurst et al. [2] of the design, analysis, and performance of instrumented reinforced soil walls constructed in the field has demonstrated that limit equilibrium-based analysis methods (AASHTO 2002) over-estimate reinforcement loads under operational conditions (on average) by a factor of 2 to 3. As the emphasis shifts to prediction of reinforced soil walls under operational (serviceability) conditions the demand for improved and more accurate design models for these systems increases. Furthermore, the need to develop calibrated serviceability limit states design models for design engineers requires data that are difficult to obtain due to the limited number of monitored field structures.
Useful reviews of geosynthetic reinforced soil wall numerical modeling efforts can be found in the papers by Bathurst and Hatami [3], and Hatami and Bathurst[4]. This paper describes the numerical modeling details of an example full-scale physical metallic reinforced soil wall from a series of structures constructed by FHWA at Algonquin, Illinois.
The numerical model is first validated against measured results from instruments. The validated model is then used to investigate the influence of internal stability design factors on Earth Pressure Coefficient of this type of walls. Four different backfill unit weight, six different thickness for facing panels, six different value for soil friction angle, four value for vertical spacing of reinforcement, five different wall face batter and six different Reinforcement length to wall height ratio were included in the study to examine their respective influences on the predicted Earth Pressure Coefficient of the wall.

2. Physical model

1.2. Wall configurations

The Federal Highway Administration (FHWA) built a series of full-scale instrumented test walls 6 m high at Algonquin, Illinois. These test walls were constructed as part of a FHWA study to investigate the behavior of mechanically stabilized earth (MSE) walls [5].
Five of the walls utilized the same precast concrete facing panels. One of these sections (Wall 1) used Reinforced Earth Company (RECO) steel strips. The control structure (Wall 1) was constructed with 8 layers of reinforcement at a 0.76 m vertical spacing and extending 4.1m into the backfill soil. The performance of