ABSTRACT

Geosynthetic reinforced soil (GRS) walls and slopes have become important applications of retaining structures in earthquake prone areas such as Taiwan and Japan in Asia. In this paper, the authors present a numerical model that is capable of simulating seismic response of GRS structures. Results of GRS slope shaking table tests that were conducted in University of Washington were then utilized to verify the developed model. Moreover, a selected modular block faced GRS wall, which failed during the 921-Chi-Chi earthquake, was carefully analyzed with the developed model using real earthquake records. Seismic performance such as deformation history, reinforcement strain distribution, as well as failure mechanism of the studied case was examined in this paper. Additional efforts were also made to examine the influence of seismic design factors such as peak ground acceleration, duration, and frequency via a preliminary parametric study. Conclusion of presented research was hoped to be helpful to improve the understanding of seismic behavior and the design of GRS structures.

KEY WORDS: Geosynthetics Reinforced Soil Retaining Structures, Performance Analysis, Numerical Modeling.

INTRODUCTION

Because of the well performance in sustaining seismic loading, geosynthetics reinforced soil (GRS) structures, including slopes and walls, have gradually become the mainstream of important applications of retaining structures in earthquake prone areas such as Taiwan and Japan in Asia. Although many efforts have been put in researches in analyzing seismic performance of GRS structures in the past few years, little progress was made due to limited performance data and calibrated numerical models. Moreover, present seismic design of GRS structures like walls and slopes are mostly based on the pseudo-static limited equilibrium concept. Usually, only horizontal ground acceleration is taken into consideration. Other earthquake characteristics, such as frequency and duration, are not well discussed for their influences on seismic performance of GRS structures.

In an effort to improve understanding of seismic behavior of GRS structures, the authors developed a series of numerical models which are capable of simulating seismic performance of GRS structures; as well as excelling “multi-interfaces” problems that generally occurred in modeling seismic performance of rigid faced GRS structures such as modular block walls. The authors first presented the details of developed numerical models in this paper. Test measurements of large scale GRS slope shaking table tests, which were conducted in University of Washington, were then used to verify the developed model. It was found that the developed model was able to simulate the shaking table test results within a reasonable agreement. Other than the verification using laboratory test data, a modular block faced GRS wall that failed during the 921-Chi-Chi earthquake was selected as a study case for analyzing seismic performance of GRS structures. Seismic performance such as deformation history, reinforcement strain distribution, as well as failure mechanism of the studied case was carefully examined in this paper as well.

Finally, in order to improve incompetence of present seismic designs of GRS walls, a preliminary parametric study was also carried out in this study. Total ten ground motion records that cover a good range of peak ground accelerations, dominant frequencies, and durations were used to examine influences of various seismic design factors on seismic behavior of GRS structures. Progress of offered study is hoped to be helpful in gaining understanding of seismic performance of GRS structures.

NUMERICAL MODEL

Numerical models of this study were developed using the finite difference method computer program FLAC. Models used in this study were modified from the numerical models developed by Lee (2000). In the developed models, backfill materials were modeled using Mohr-Coulomb material elements coded with hyperbolic soil modulus model. Geosynthetic reinforcements were modeled using the structural cable elements (Lee, 2000). Input soil module were calculated based on the in-situ SPT-N values, and coefficients of hyperbolic soil modulus model were adapted from triaxial test results of similar material reported by Duncan et al (1980).

In order to avoid instability of the many interfaces between different