Abstract

Use of tensile reinforcement for improving the seismic stability of retaining walls has gained considerable attention in recent times and has become a very common practice. Compared to planar geosynthetic materials, geocells offer higher restraint to the shear deformations in the soil due to their higher stiffness and strength. Also, the locking effect of geocells, which ensures the soil to be confined within the pockets, further provides better resistance to shear deformations, making them more suitable for retaining walls which can be subjected to seismic ground shaking conditions.

Though the studies on retaining walls reinforced with geosynthetics are numerous, literature on geocell retaining walls is limited. Very few studies are available on the seismic response of geocell retaining walls. Since geocell retaining walls substantially differ with retaining walls reinforced with planar geosynthetics in their mechanism of interaction with soil and strain restraint effects, these aspects and their variation under the influence of various ground motion parameters and reinforcement configurations need careful consideration and evaluation. This thesis work is motivated by this need. The objective of the present work is to study the response of geocell retaining walls during seismic shaking conditions, through shaking table model studies. Scope of the work includes understanding the effect of geocell stiffness, configuration of geocells including facing thickness and slope inclination, infill type, extended basal layer and surcharge pressure on the seismic response of geocell retaining walls under varying base shaking acceleration and frequency of shaking to bring out some important conclusions that can help designing geocell retaining walls with better seismic response.

Initially, interface direct shear tests were carried out to study the interface shear behavior of sand- geocell and sand-geonet interfaces. These tests helped in the selection of geocell material, cell dimensions and infill for the shaking table model tests. Shaking table model tests were carried out on model geocell retaining walls scaled to 1:10 (model to prototype), changing the acceleration amplitude (0.2g and 0.3g) and frequency of base shaking (1-7 Hz). The need to downscale the strength and stiffness of geocells in shaking table model studies to represent typical field geocells through similitude laws necessitated the use of weaker geosynthetics (geonets and PVC sheet) for making geocells in this study. Geocells of 100 mm pocket size and aspect ratio (height to diameter ratio) of 1.0. Tests with different wall configurations were carried out by changing the facing thickness and inclination of the facing. Effects of geocell stiffness, extended basal reinforcement layer, geocell infill properties and surcharge pressure on the crest were studied in detail through systematic series of shaking table model tests.

Data from shaking table model tests on geocell retaining walls was analyzed in terms of lateral deformations, acceleration amplifications and crest settlements at various locations to draw conclusions on the overall wall performance. Results showed that retaining walls with geocell facing undergo overturning kind of failure during seismic shaking, with their top portions deforming laterally, because their wider base filled with soil provides excellent resistance to sliding. Wall deformations increased by several orders of magnitude with increase in acceleration amplitude and frequency of shaking. Results showed that geocell facing with thickness equal to 30% of wall height is adequate to sustain very high level seismic shaking even when the backfill was not reinforced. Walls with a battered facing are found to be undergoing lesser lateral deformations and acceleration amplifications. Use of geogrids/geonets as retaining wall resulted in excessive deformation of the facing and settlement of the crest and also cavities behind the facing due to flow of backfill materials into the wall facing units during seismic events. It is found that monolithic geocells with adequate drainage considerations are best suited for wall facings. Extended basal geosynthetic layer helped in moving wall as a whole and in reducing deformations and acceleration amplifications even under strong ground shaking conditions. With the addition of surcharge pressure and its increase, lateral deformations of the wall reduced because of mobilization of higher tensile strength in geocells under the additional confinement effect of surcharge. The increase in deformations by replacing gravel with sand in half of the geocells towards the backfill side is not very significant. Results from the present study can be extended to compute the deformations and acceleration amplifications of field walls subjected to earthquakes using the similitude laws presented in the thesis.