Effect of particle size of backfill on seismic resistance of geo-synthetic-reinforced soil retaining walls

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ABSTRACT: In this study, the effect of the particle size of the backfill material on the seismic performance of geosynthetic-reinforced soil retaining walls was investigated. For this purpose, a series of shaking table model tests were performed, with conventional geogrids and the newly developed square-shaped geocell as soil reinforcements. Based on the model tests, it was found that the square-shaped geocel reinforced soil retaining wall showed a higher seismic resistance than both conventional gravity type retaining wall and geogrid reinforced retaining wall regardless of the backfill particle size.

Key Words : *geocel, geogrid geosynthetic reinforced soil, shaking table test, seismic performance*

1. INTRODUCTION

Geosynthetic-reinforced soil retaining walls (GRS RW) have shown higher seismic performance during major earthquakes than conventional gravity-type retaining walls (Tatsuoka et al. 2007). However, the use of larger particle backfill materials would result in a reduction in the friction along the interface between the geogrid and the backfill material. Therefore, in order to investigate the effects of the particle size of the backfill material on the seismic performance of GRS RWs, a series of shaking table model tests on a new type of geocell (Han et al., 2014: Mera et al., 2014), namely square-shaped geocell, and geogrids were conducted with different particle size backfills.

2. EXPERIMENTAL OUTLINE AND METHODOLOGY

To analyze the influence of the particle size of the backfill on the seismic performance of a GRS RW, eight shaking table model tests were conducted separately using three different types of reinforcements, embedded in silica sand No.7 (D_{50}=0.25 mm) and gravel No.5 (D_{50}=14.2 mm). The reinforcements used in this study are summarized in Table 1. For the geogrid RS-RW, two different types of geogrids were used with different aperture sizes. Note that the dimensions of the aperture of the small geogrid were 6.3mm×6.3mm, which is smaller than D_{50} of gravel No. 5 and larger than that of silica sand. The small geogrid model is the same as that used in the field, while for the geocell model a scale factor of 1/6 is assumed. The GRS RWs models had a full-height rigid (FHR) facing, 50 cm in height, assuming a scale factor of 1/10. For comparison purposes, a gravity-type retaining wall with no soil reinforcement was tested. Refer to Han et al. (2014) for further details about the large geogrid and square-shaped geocell, the shaking table model and boundary conditions.

Table 1 Reinforcement materials used in this study

Reinforcement type	Size W × L (mm)	Aperture size (mm)	Type of material
Gravity-type	-	-	-
Small geogrid	350 × 360	6.3 × 6.3	Polypropylene (PP)
Large geogrid	350 × 360	35 × 35	Phosphor bronze strips (longitudinal member) and mild steel bar (transverse member)
Square-shaped geocell	350 × 360	60 × 50 (H=25)	Polyester (PET)

3. TEST RESULTS AND DISCUSSION

Basically, the predominant failure pattern of the reinforced walls was overturning, which is linked with the bearing capacity failure of the subsoil layer, along with a small component of base sliding. On the other hand, the failure mode of the T-shape gravity-type RW was predominantly associated to sliding. In the cases of silica sand backfill, the T-shape gravity-type RW showed brittle failure during a base acceleration of 488 gal. For the geogrid-reinforced soil RWs (small and large aperture size) and square-shaped geocell-reinforced soil RW, similar ductile failure patterns were observed at base accelerations of 790gal, 845gal and 888 gal, respectively, indicating that the square-shaped geocell reinforced soil RW has a higher seismic performance than geogrid-reinforced soil RWs, as well as to T-shape gravity-type RW. In the cases of gravel backfill, the T-shape gravity type RW showed similar brittle failure during a base acceleration of 427 gal, while geogrid-reinforced soil RWs (large and small aperture size) and square-shaped geocell-reinforced soil RW showed similar ductile failure patterns at base accelerations of 799gal, 713gal and 902, respectively.

Figures 1 to 6 show the representative residual displacements of the walls in terms of base sliding (d_s), overturning angle (θ), and settlement at the top of the backfill, against the base acceleration (α_b), which were plotted after each stage. It can be seen that both types of geogrids and square shape geocell show similar deformations until a base acceleration value of around 400 gal. However, as the base acceleration increases, the residual displacements of the T-shape gravity-type RW drastically developed. On the contrary, the geogrid-reinforced soil RWs and square-shaped geocell-reinforced soil RW show considerably smaller deformations with an increase of the base acceleration.

From the results shown in Figs. 1 to 6 it can be noted that the seismic performance of reinforced retaining walls with gravel backfill is slightly higher than that of silica sand backfill. However, for the geogrid reinforced RWs, the trend of deformations with an increase of the base acceleration are different between silica sand and gravel backfills. As shown in Fig. 1, the small geogrid shows a higher seismic resistance than the large geogrid for the silica sand backfill, while it is the opposite for the gravel backfill. It seems that the ratio of particle size to aperture of the geogrid has a substantial effect on the seismic resistance performance of the GRS-RW system.

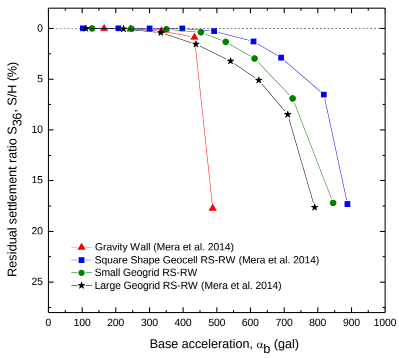

Fig. 1 Sand backfill residual deformation: settlement

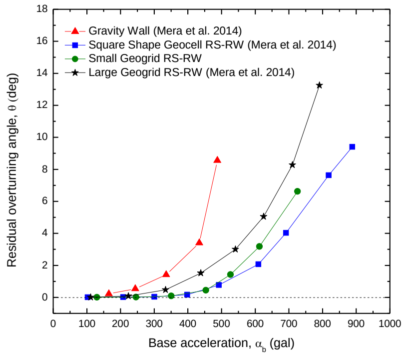

Fig. 2 Sand backfill residual deformation: overturning angle (θ)

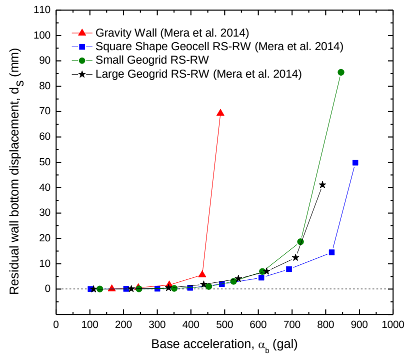

Fig. 3 Sand backfill residual deformation: wall bottom displacement (d_s)

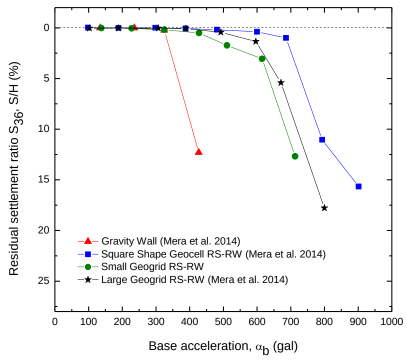

Fig. 4 Gravel backfill residual deformation: settlement

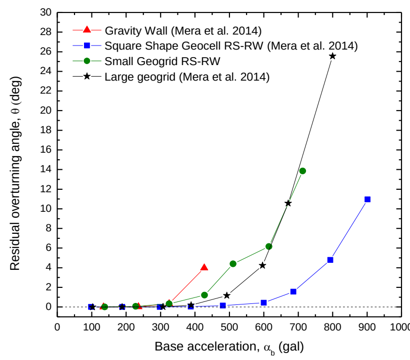

Fig. 5 Gravel backfill residual deformation: overturning angle (θ)

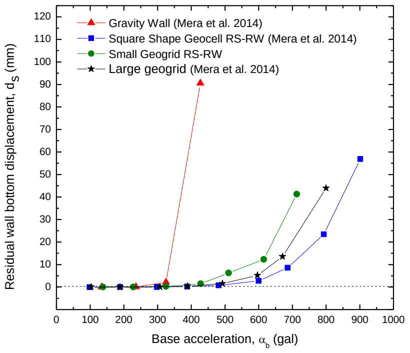

Fig. 6 Gravel backfill residual deformation: wall bottom displacement (d_s)

CONCLUSION

A series of shaking table model tests on square shape geocell-RS RW, geogrid-RS RWs (different aperture size) and gravity-type RW, backfilled with silica sand No. 7 and gravel No. 5, were performed. It was found that the square-shaped geocell-RS RW exhibited higher seismic performance than geogrid-RS RWs and gravity-type RW regardless of the soil particle size. This conclusion is based on the analysis of the residual sliding displacement of the wall facing, residual overturning angle of the wall facing and settlement of the backfill. Moreover, it is important to mention that for the geogrid-RS RWs, the seismic resistance would decrease when the aperture size of geogrid is smaller than backfill material due to loss of friction between the soil material and the surface of geogrid reinforcement.

REFERENCES

1) Tatsuoka F., Tateyama M., Mohri Y., Matsushima K.: Remedial treatment of soil structures using geosynthetic-reinforcing technology, Geotextiles and Geomembranes, 25, 204-220, 2007.
2) Han X., Mera T., Kiyota T.: Influence of reinforcement on the seismic response of reduced-scale reinforced soil retaining walls, Proc. of the 16th JSCE International Summer Symposium, 74-75, 2014.
3) Mera, T., Han, X., Kiyota, T., Katagiri, T. and Harata, M.: Shaking table model test son geo-syntenthetics-reinforced soil retaining Wall with a new-type of geocell embedded in Sandy and gravelly backfills, Proc. Of the 34th JSCE Earthquake Engineering Symposium, 2014.