Model tests to evaluate the performance of geosynthetic-reinforced soil wall subjected to rainfall

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INTRODUCTION

For years, global warming has been considered as one of the greatest threats to earth; it not only causes the rise of sea levels but also changes the pattern of precipitation. From a geotechnical engineering standpoint, the concentration level on the pattern of precipitation has dramatically increased since the extreme weather caused by global warming has been one of the major factors responsible for many slope failures.

Various methods have been taken to stabilize the slopes. Geosynthetic reinforced soil walls (GRS walls), having the advantages of eco-friendliness, high flexibility, and large tolerance of deformation, are considered as one of the best methods to stabilize the slope. However, the application of GRS structures has certain limitations. The use of good quality backfill with high permeability is indeed satisfactory. Nevertheless, for the cut down of the cost and the convenience of the construction, in-situ soil is often used as backfills. Additionally, in-situ soil was adopted to adhere to a local regulation in Taiwan which specifies that the excavated and backfilled soils at the construction site should be balanced. In-situ soil is usually referred to as marginal backfills and has little capacity for drainage. Loss of matric suction and soil shear strength due to the infiltration of rainfall has long been one of the main causes of the failure of GRS walls. The mechanism and a real case of a GRS slope failure triggered by rainfall are enunciated in Figure 1 and Figure 2.

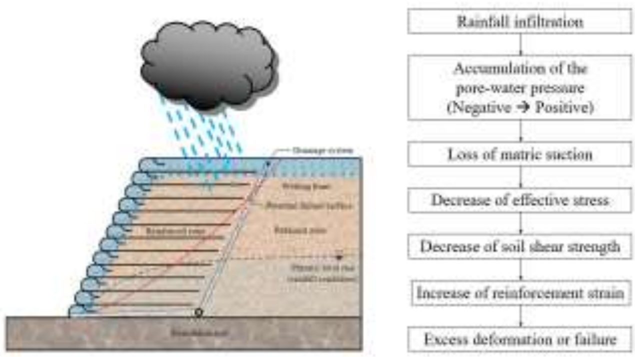


Figure 1. Failure mechanism of GRS structures under rainfall conditions

Figure 2. A GRS structure failure triggered by rainfall

Since intense rainfall had been identified as the most critical natural factor on slope stability (Wu et al., 2013), this study purports to investigate the performance of GRS walls with different reinforcement configurations under rainfall conditions.

TEST SETUP

A series of reduced scale model tests were carried out to investigate the performance of GRS walls under rainfall conditions. The target scale factor is 1/15. The failure mechanism and the effect of reinforcement layouts were also evaluated. In this study, polyester geogrids with a maximum tensile strength of 0.5 kN/m were used as reinforcement. Notably, a thin non-woven geotextile was stuck to geogrid in the facing portion to prevent soil particles coming out of geogrid openings. The GRS walls were constructed in a sandbox having the length, width, and height of 102 cm, 30 cm, and 90 cm. respectively. Vietnam quartz sand was compacted to a relative density of 70% as the backfill. The reinforced zone is 70% of the wall length while the wrap-around length is about 40% of the reinforcement length. In addition, the wrap-around length of the topmost layer was lengthened to prevent sloughing failure. Two pore water pressure transducers and three volumetric water content gauges were installed. Figure 3 shows the schematic view of the instrumentation.

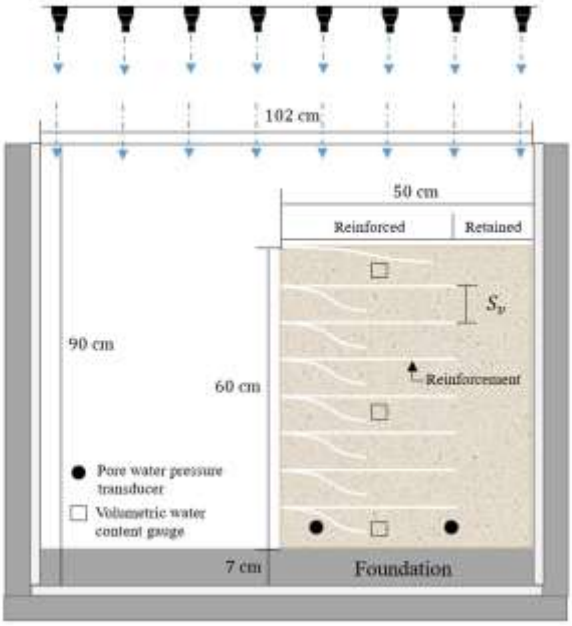
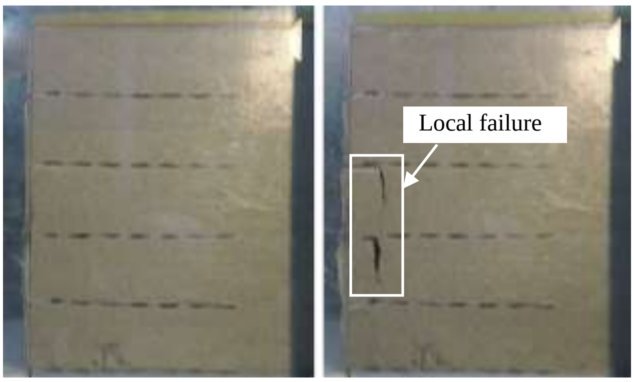


Figure 3. Instrumentation of the model test

An irrigation system was installed over the GRS wall after its construction to simulate rainfall. The system includes a water pump and two series of fine spray nozzles. In this study, the rainfall intensity is much higher than the permeability of the backfill soil. The effect of reinforcement configurations was investigated by varying the spacing of the reinforcement. A standard spacing of 6 cm and a large spacing of 12 cm were compared A picture of the model test is presented in Figure 4(a). The results are discussed in terms of pore water pressure, volumetric water content, reinforcement strain, and wall displacement.

RESULTS

This study presents the preliminary results of laboratory investigation of the behavior of GRS walls subjected to rainfall. The comparison of the wall displacement concerning different reinforcement spacing is given in Figure 5. The results indicate that GRS walls with granular backfill are generally stable; this is because of the high drainage capacity of the soil.



(a) (b)

Figure 4. Picture of the reinforced model wall a) before test (b) after test

Wall displacement was hardly found in the case with standard spacing. However, though there was no failure found in the case with larger spacing, local interlayer failure near the face of the wall and larger wall displacement commenced.

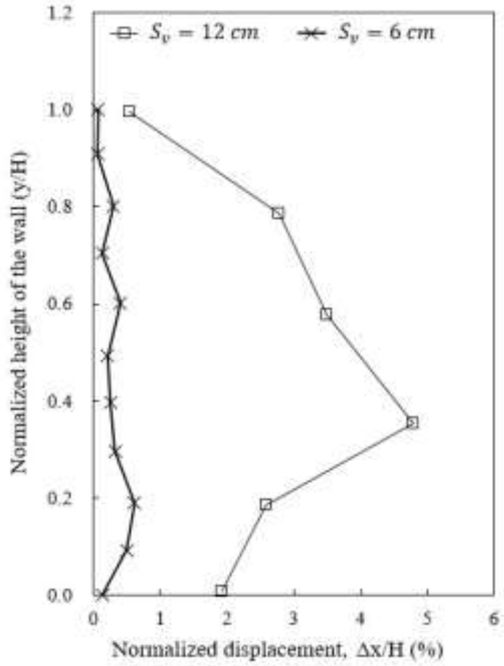


Figure 5. Comparison of wall displacement with different reinforcement spacing

CONCLUSIONS

Generally, geogrids can provide effective reinforcement to the soil wall under extremely torrential rainfall. The local interlayer failure of the wall was relatively minor since the global stability of the wall was remained. Further study should be done to propose the most effective reinforcement layout for granular backfills; the stability of the interlayer should also be taken into account upon designing.

ACKNOWLEDGEMENT

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