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Experimental Study on Performance of Multi-Tiered Reinforced Soil Retaining Walls

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ABSTRACT: In reinforced soil walls, if the wall divided into several sections (here called tiers) it can be called multi-tiered reinforced soil retaining walls (MRSRW). These walls are considered to be a good solution especially if the wall's height need to increase. The main objective of the study was finding the effects of tiers horizontal distance, offset distance between adjacent tiers and number of tiers on the lateral deflection of the wall facing as well as ultimate bearing capacities of a strip footing located at top of the wall. In this study, a small scale experimental programme on MRSRW were carried out where a total of 12 experiments were performed under static loading condition. The results showed that by increasing the tiers' width and number of tiers in MRSRW, the horizontal deflection and settlement of footing on the crest of the wall was considerably reduced. Besides, when the tires' width increased, the lateral deflection along the wall height was significantly reduced, especially at top of the wall. The result indicated that in order to attain the highest interaction between the top and bottom sections of the MRSRWs, having four reinforcement layers and one tier (with tier's width/wall's height ratio equal to 0.35) can provide the best result in regard to both lowest lateral deflection and highest bearing capacity of footing installed at top of the wall.

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1- Introduction

In reinforced soil walls, if the wall divided into several sections (here called tiers) it can be called multi-tiered reinforced soil retaining walls (MRSRW). These walls are considered to be a good solution especially if the wall's height need to increase. The main objective of the study was finding the effects of tiers horizontal distance, offset distance between adjacent tiers and number of tiers on the lateral deflection of the wall facing as well as ultimate bearing capacities of a strip footing located at top of the wall. There are few studies on the subject of MRSRWs. In previous works the positive effect of tiers has been well described [1-3]. The implementation of the tier wall reduces the thickness of the wall, the volume of the embankment behind the wall and settlement the soil backing of the wall. The tier walls showed a beautiful view [1-3]. However, most of the above studies were based on the finite element modelling (FEM) and very few of the explored influential parameters in the stability of MRSRWs was based on the laboratory evaluation [4]. Yoo et al., investigated the two-width tiers wall using finite element analysis [5-7]. Yang et al. (2014) examined the performance after construction of reinforce soil wall with a height of 17 meters in full scale [8]. Hence, the main objective of current research was finding the effect of tires (e.g., distance of each tires and tiers number) on the MRSRWs stability based on laboratory testing.

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2- Material and Method

For the soil material that was used in the experiments, a poorly graded sandy soil (air dried before to be used as the backfill) was prepared. For the reinforcement material, geogrid was selected to be embedded into the backfill soil material i.e., as called reinforced soil. The geogrid reinforcement layers were embedded along the wall height. According the FHWA report, the geogrid length was selected to be 0.7 of the wall's height (H). Note that in MRSRWs, the length of geogrids in tier's location was set to be higher than 0.7 H since the tier's distance need be also considered in calculation of the geogrid length. For the wall facing, the several attempts were made to make the small scale modeling of the wall as more reliable as possible. This is because of this fact that in the laboratory scale, the wall stiffness can hardly be calculated with commonly used formulas. For instance, the low weight of small scale materials led to wall collapse even before the wall subjected to any loading step. As a final decision on selecting proper material for the wall facing, a series of specific light concrete cubic boxes with the size of 50×50×50 mm and with the unit weight of the 14 kN/m3 were selected. In order to conduct the tests in the laboratory, a small scale loading frame was constructed and a box made from Plexiglas with the 10 mm thickness was provided. The loading frame was consist of a pneumatic jack with the capacity of applying load to a maximum of 7.8 kN vertically. In the present study all of the MRSRWs were constructed with the height of 0.40 m, length of 0.8 m and width of 0.49 m. They were built on a rigid ground body in order to present any unexpected settlement due to the vertical loading. In this study, a small scale experimental programme on MRSRW were carried out where a total of 12 experiments were performed under static loading condition.

3- Results and Discussion

In this research, the effect of parameters like the width of the stairs and the number of retaining walls stairs on the wall deformation, bearing capacity and foundation settlement on the top of the retaining wall were studied. As the width of the stairs increased, the horizontal deformation of the wall was significantly reduced, especially in the lower part of the wall, mainly due to the higher resistance of the layers of the reinforce in the upper row of the wall. In cases where the width of the stairs is low, the horizontal deformation in the tier wall and the vertical wall is not significantly different. Accordingly, a suitable stair width can be defined. In this study, D/H = 0.35 was approximately the appropriate width (D = stair width and H = wall height). By increasing the stair width, the upper and lower walls were acted independently, and the upper wall was applied by lowering the load.

In Figure 1, the maximum horizontal deformation ratio of the wall in stair wall to vertical wall (RMD) is shown in front of the width of the one stair wall and two stairs wall. According to the results obtained in a stair wall, suitable width (D/H = 0.35), the maximum variation in the wall versus the vertical wall decreased by 41% and for the two-stairs walls at D/H = 0.35, the maximum wall decreases by about 68% relative to the vertical wall, which indicates the proper functioning of the wall tiered.

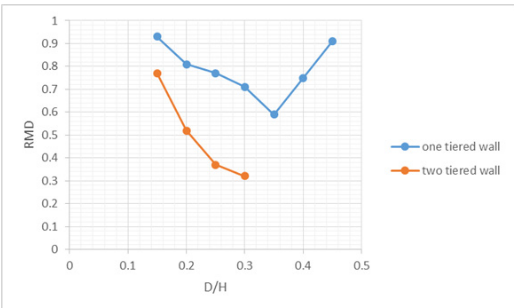

Figure 1. RMD variations versus D/H in stair wells

On the other hand, in the walls of a stair with increasing stair width, the strip foundation settlement was decreaseed and with the increase in the width of the stair more than the suitable width, the strip foundation settlement was increased. As shown in Figure 2, increasing the width of the stair, the bearing capacity of strip foundation in the stair walls increases and then decreases. By increasing the stair width more than the suitable value, the performance of the upper and lower stairs of the wall is independent and bearing capacity is reduced. An increase of 30% in the bearing capacity of the strip foundation in a stair wall of an appropriately sized relative to the vertical wall was observed.

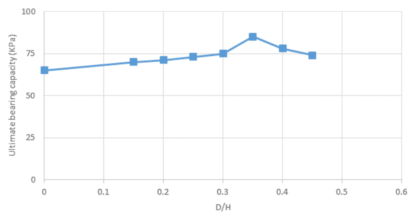

Figure 2. Load bearing capacity chart-Stair width in a stair wall

Also, in the stair wall with increases the number of stairs, decreases due to the fact that the layers of the reinforcement in the upper and lower walls distribute smaller vertical loads in a larger area. In the stair wall, with a stair width of 0.3H, the increase in bearing capacity was about 15% and in the wall of two stairs with a width of 0.3H each, the increase in bearing capacity was 36%, which demonstrates the proper applying of the stairs walls.

4- Conclusions

The results clearly showed that in MRSRW by increasing the tiers' width and number the horizontal deflection (e.g., horizontal displacement along the all height) and settlement of footing on the crest of the wall was considerably reduced. Besides, when the tires' width increased the lateral deflection along the wall height, especially at top of the wall, was significantly reduced. The result indicated that for attain the highest interaction between the top and bottom sections of the MRSRWs, having four reinforcement layers and one tier (with tier's width/wall's height ratio equal to 0.35) can provide the best result in regard to both lowest lateral deflection and highest bearing capacity of footing installed at top of the wall.

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