EFFECTS OF ADDING 'SPIKES' AT THE NODES OF BIAXIAL GEOGRID ON ITS PULLOUT RESISTANCE IN SANDY BACKFILL SOIL

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1 INTRODUCTION

The cost of geosynthetic reinforced soil retaining walls is mostly dependent on the backfill soil and amount of reinforcement required (Horpibulsuk et al. 2010). One way of lowering cost could be by reducing the length and/or increasing the spacing of reinforcement layers. However, the length and/or spacing is affected by many factors, including the reinforcement pullout resistance. In the case of geogrid reinforcement, several studies have concluded that its pullout resistance is a combination of friction between the surface of the ribs and the backfill soil particles, and bearing/passive resistance of the transverse ribs. Further characterization of this mechanism of interaction has also indicated that the passive resistance of the transverse ribs contribute significantly to the overall pullout resistance (Calvarano et al. 2013, Lopes et al. 1999, Palmeira et al. 1989). Hence, it would imply that increasing the passive resistance or skin friction of a geogrid may increase its pullout resistance. Moraci et al. (2006), noted that the node embossment of a geogrid contributes to the overall passive resistance. Li, et al. (2012), created 'strengthening nodes' on biaxial geogrid and reported increased peak pullout resistance with increase in height of 'strengthening nodes' but a loss in bearing resistance contribution to peak pullout resistance with increase in transverse member spacing.

This paper attempts to investigate the effects of attaching 'spikes' at the nodes of biaxial geogrid on its pullout characteristics without altering the original geometry but varying the spacing, location, number and height of the spikes.

2 GEOGRID PULLOUT TESTS

2.1 Apparatus, geogrid model and backfill material

The pullout-test equipment consisted of a steel box (70x40x50cm deep) into which the backfill material and geogrid models were laid, and a loading system (Fig. 1a). The front wall of the box (near the clamp) had a slot of height 46.5mm for pulling out the geogrid, but this height was reduced using two 20mm strips of sponge to prevent the backfill sand from pouring out. The loading system comprised of a motor with variable pull-out rate up to 10mm/min, tensile load cell with a load capacity of 49kN and accuracy of 98N, and linear variable differential transformers (LVDTs). The loading system was connected to an automatic data logger.

The tests consisted of three (3) Tensar® SS1 biaxial geogrid models (test size 40x32.5cm wide). Two of the models had 16 plastic 'spikes' (Fig. 1b) each, of total height, H = 23 and 41mm (H = h1+h2 as shown in Fig. 2) respectively, heat-welded at their nodes. The spikes with H = 23mm were of equal heights (h1=h2=11.5mm) on either side of the geogrid node, while the 41mm spikes were unequal (h1=12mm and h2=29mm).

Silica sand No. 5 with mean particle size, D_{50}, 0.67mm, coefficient of uniformity 1.49, coefficient of curvature 0.92, minimum density 1.30 and maximum density 1.54 was used as the backfill soil.

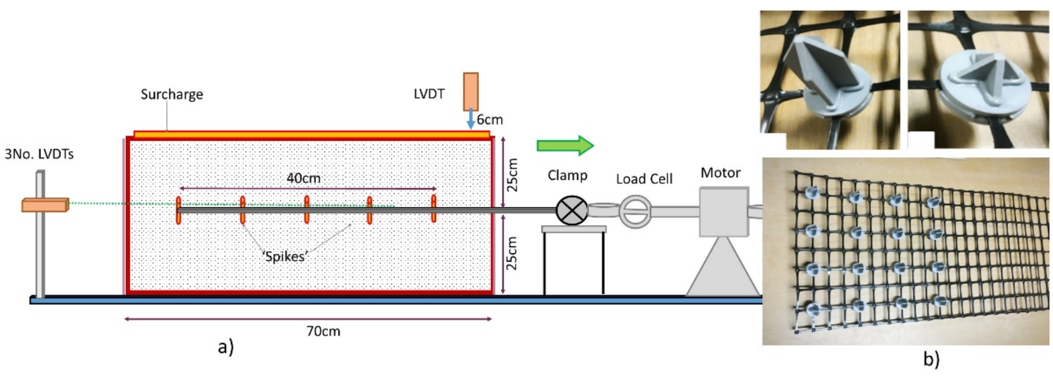

Fig. 1: a) Schematic of geogrid sample setup in pullout box; b) Spike connection to geogrid

Key words: Geogrid, spikes, passive resistance, compaction degree, pullout resistance
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2.2 Test procedure

Silica sand no. 5 was laid and compacted in ten (10) layers of 5cm each by tamping a predetermined mass of sand corresponding to a target relative density. The geogrid sample was laid on the fifth layer of sand (mid height of box). One end of the geogrid was connected to the clamp outside the box as shown in Fig. 1a. Three (3) LVDTs placed outside at the back of the pullout box were connected to nodes of the geogrid model at 6, 18 and 36cm from the front wall using inextensible wires encased in rigid plastic pipes. A 1kPa surcharge of lead shots was placed on top of the sandy backfill soil. The pullout tests were conducted at a constant displacement rate of 5mm/min and data from the LVDTs and load cell was collected at three (3) seconds log interval.

2.3 Results

Fig. 2 shows the plot of pullout force against displacement of the first line of spikes (closest to the front wall) tested in loose (Dr 47%) and medium dense (Dr 71%) sand backfill. It was observed that the pull-out resistance generally increased with increase in the height of the spikes, both in loose and medium dense sandy backfill. However, there was a marked difference in the peak and residual strength between test in the both backfills. The peak pullout strength of geogrid in medium dense sandy backfill almost doubles that in loose backfill for all samples and also the residual strength in medium dense backfill falls steadily after the peak unlike in loose backfill where there is no clearly defined residual strength.

Also noticeable, was the gradual attainment of peak strength at large displacement in loose backfill, while in medium dense backfill, the peak strength was achieved at short displacement. This may imply that for seismic resistance, the requirement for good compaction is still important even though spikes are used. The difference between peak resistance for the short (H=23mm) and long (H=41mm) spikes in medium dense sand was small yet the short spike is half the height of the long one. It was thought that this could probably be due to the unequal size of the spikes on either side of the geogrid for the long spike configuration. The unbalanced height to could have caused a tilt of the longer spike due to its stronger anchorage while the shorter spike moved forward during pullout. However, this will be investigated further in subsequent tests.

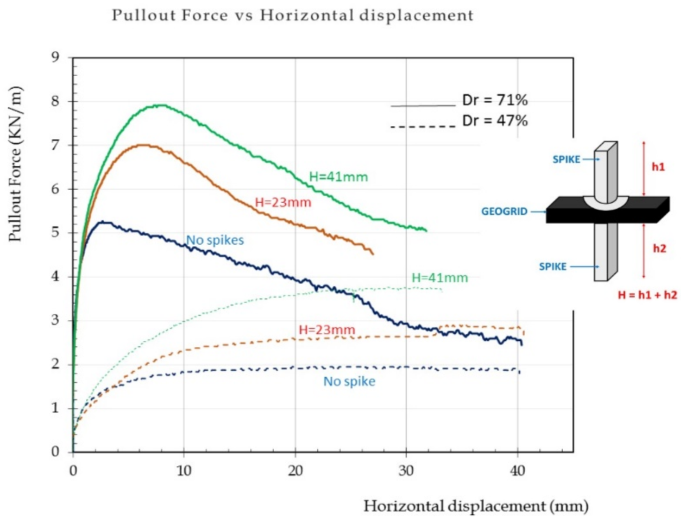

Fig. 2; Pullout - horizontal displacement curves

3 CONCLUSION

From the tests, was observed that;

- Addition of rigid spikes at the nodes of biaxial geogrid leads to increased pull-out resistance. This may be attributed to the additional passive resistance as a result of increased bearing surface area at the face of the spike, as demonstrated by general increase in pull out resistance with increase in the height of the spikes.
- The pull-out resistance increased with increase in density of the sandy backfill. However, at low density, the peak strength is mobilized at large displacement for both standard biaxial geogrid and geogrid with spikes, a condition which is not suitable for seismic stability, meaning with the current configuration of spikes, the need for good compaction of backfill material is important.

4 REFERENCES

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