INTERFERENCE BETWEEN TRANSVERSAL MEMBERS OF SQUARE-SHAPED GEOCELLS EMBEDDED IN SANDY BACKFILL SOIL

Institute of Industrial Science, University of Tokyo, Student Member ○ Zelong XU
Ditto KIYOTA, T., OLOYA, S. R., SENEVIRATHNA, K. and KATAGIRI, T.

1 INTRODUCTION

Geosynthetic Reinforced Soil (GRS) structures have been widely constructed and exhibited larger seismic stability and cost-effectiveness than conventional unreinforced structures (Tatsuoka et al., 2007). A newly-developed square-shaped geocell consisting of longitudinal and transversal members, as three-dimensional soil confinement system, exhibits higher pullout resistance, compared with the planar tensile reinforcements (Han et al. 2012). The primary interaction mechanisms regarding the pullout resistance of the square-shaped geocell embedded in backfill soil are the skin friction between soil particles and geocell member surfaces and the passive bearing resistance that develops against transversal members. If transversal members are close to each other, a disturbed region (softened region) will form behind each member that moved by the pullout force, which will affect the maximum passive bearing resistance of the following transversal members, namely the interference (Palmeira, 2004). In the previous geocell study, the effect of the height of transversal members of geocell and backfill soil particle size on pullout resistance have been investigated by Han et al. (2013) and Mera et al. (2013). However, the interference is not investigated yet. This paper aims to study the interference between transversal members of the square-shaped geocell embedded in sandy backfill soil.

2 PULLOUT TESTS

The pullout test apparatus is shown in Fig. 1. The geocell models were embedded in the sandy backfill soil inside soil container (700×400×500mm). The geocell models were pulled out through the opening of the front wall of soil container by the loading system, which comprised of a motor and a load cell. The pullout force was measured by the load cell. To measure the local horizontal displacements of the geocell model, four linear variable differential transformers (LVDTs) at four different locations in the horizontal axis corresponding to D_0, D_{60}, D_{180}, and D_{360} were used. The vertical displacement of the backfill crest at distances V_0, V_{60}, V_{180} and V_{360} were measured by LVDTs too. The Teflon panel was installed on the front wall to minimize the influence of friction on the front wall.

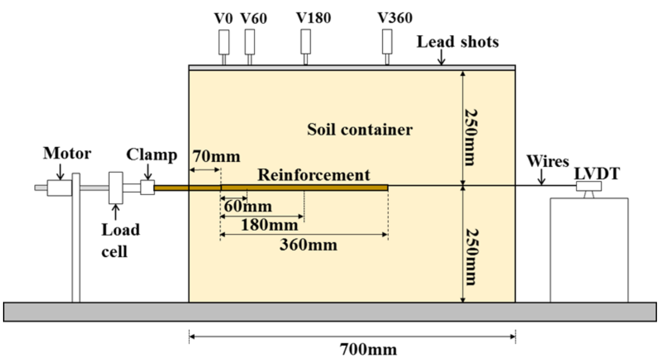

Fig. 1: Schematic diagram of pullout apparatus

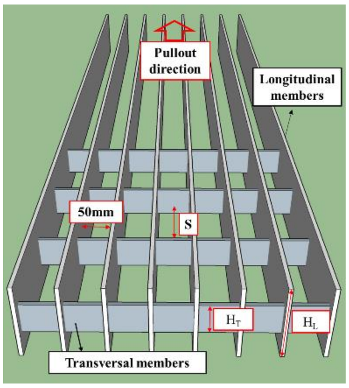

Fig. 2: Square-shaped geocell model (S=120 mm)

Table 1. Square-shaped geocell reinforcement used (H_T=40 mm)

Case	S (mm)	S/H_T	Number of cells in longitudinal member direction	Number of transversal members	Peak pullout resistance (PPR) (kN/m)	D_0 responding to PPR (mm)
1	(Special one)	(N.A.)	0	1	7.32	4.9
2	360	9	1	2	10.57	5.8
3	180	4.5	2	3	9.31	7.0
4	120	3	3	4	9.59	7.2
5	60	1.5	6	7	8.93	7.3

The geocell model was shown in Fig. 2. There are eight longitudinal members and the spacing between two adjacent members is 50 mm. The height of longitudinal members (H_L) is 60 mm and the height of transversal members (H_T) is 40 mm. The spacing (S) between transversal members is 30, 60, 120, 180 and 360 mm respectively. There is also a special geocell model without backward transversal members which only has eight longitudinal members and the first transversal member. The geocell used in this study was shown in Table 1. All geocell members were made of polyethylene (PE). The

Keywords: Square-shaped geocell, transversal members, interference, pullout resistance
Contact address: Be206, Institute of Industrial Science, University of Tokyo, 4-6-1 Komaba, Meguro-Ku, Tokyo, 153-8505, Japan, Tel:+81-35452-6143

distance from the first transversal member of all geocell models to the front wall of soil container is 70 mm. Silica sand No. 5 (D_{50}=0.64 mm, U_C=1.49, ρ_{dmax}=1.47) was used as the backfill material.

The Silica sand No. 5 was prepared in ten layers, 5 cm each, and each layer was compacted to the target compaction degree (Dc). The geocell model was laid on the fifth layer and in the middle height of soil container, and the front end was connected to the clamp. A surcharge of 1kPa was applied by lead shots on the top surface of the backfill. The geocell model was pulled out at a constant displacement rate of 2.5 mm/min driven by the motor. The measured data from LVDTs and the load cell was recorded by a data-logger.

3 RESULTS AND DISCUSSION

Fig. 3 shows the relationship between the pullout resistance and the horizontal displacement. Based on the modified punching shear failure mode (Bergado et al., 1996), the possible failure mechanism is presented in Fig.4. In the shear failure zone caused by transversal members, the length (L_0) of triangle zone (ABC) can be defined by $L_0 = \frac{H_T}{2}\tan(45° + \frac{\phi}{2})$, which is about 35 mm in this study. Reportedly, the length (L_1) of shear failure zone is about $10H_T$ which was concluded from test results (Zhou et al., 2012). The L_1 could be affected by normal stress levels.

For Case 1, the pullout resistance is fully mobilized at D_0=4.9 mm, which is smaller than other cases (Table 1). This could be explained that the pullout resistance in Case 1, which has only one fore transversal member, was mainly determined from the skin friction between longitudinal members and the backfill soil.

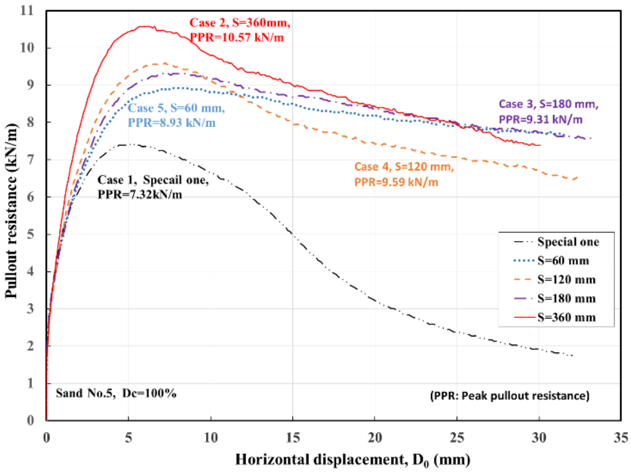

Fig. 3: Pullout resistance- Horizontal displacement curve

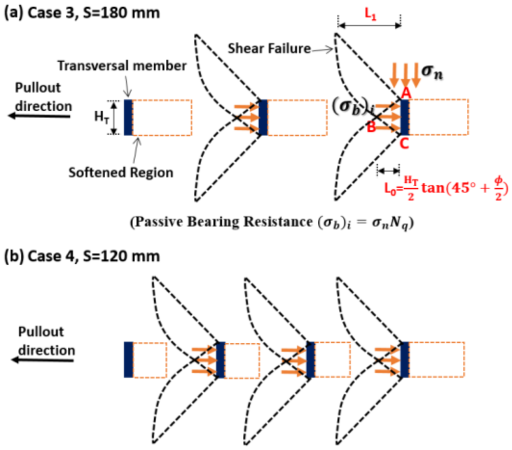

Fig. 4: Possible Failure mechanism

For Case 2 (S=360 mm), initially, the pullout resistance sharply increases with displacement and gradually increases until failure at 5.8 mm. Its initial stiffness probably resulted from the skin friction resistance. As mentioned before, the other primary interaction is passive bearing resistance. In this case, the passive bearing resistance was fully mobilized and there was no interference between the two transversal members, attributed to the S= 360 mm is much larger than the L_0 and the L_1 is considered to be less than 360 mm. The real L_1 could not reach to $10H_T$ (400 mm), because the geocell models were pulled out under lower normal stress in this study, compared to Zhou's (2012).

As S decreases, the pullout resistance might increase or decrease. It could be attributed to the increment of the transverse member and the interference effect, respectively. When the former effect is dominant, the more transversal members, the more total passive bearing resistance contributed to the PPR. When the latter effect is dominant, the interference leads to reduction in the passive bearing resistance against the transversal member. When S decreases from 360 mm (Case 2) to 180 mm (Case 3), the PPR decreases. It is probably because the interference effect is dominant (Fig.4a). When S decreases from 180 mm (Case 3) to 120 mm (Case 4), the PPR increases slightly. The former effect might be dominant (Fig.4b). As a further reduction in S, the interference effect may be negligible, while the smaller S for a given H_T may restrain the development of the failure domain, which may reduce the PPR. Therefore, when S decreases from 120 mm (Case 4) to 60 mm (Case 5), the PPR decreases. Additionally, there is an optimum value of S (Cases 3 to 5) which results in the largest PPR.

4 CONCLUSION

It could be concluded that: (1) When the transversal member spacing (S) of geocell model is 360 mm, the bearing resistance could fully mobilize and there is not interference; (2) There is an optimum value of S, between 60 mm and 180 mm, which results in the largest peak pullout resistance.

5 REFERENCES

Bergado et al. (1996), Soils and Foundations 36. Han, X. et al. (2012), Bulleting of Earth Resistance Structures 45. Han, X. et al. (2013), The 18th International Conference on Soil Mechanics and Geotechnical Engineering. Mera, T. et al. (2013), GeoKanto. Palmeira E.M. (2004), Geotext. Geomembrans 22. Tatsuoka, F. et al. (2007), Geotextiles and Geomembranes, 25. Zhou et al. (2012), Geosynthetics International 19.