INFLUENCE OF PARTICLE SIZE AND GEOMETRY ON THE PULLOUT TESTS OF GEOCELL EMBEDDED IN SOIL

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1. INTRODUCTION

Geocell, a three-dimensional interconnected geosynthetic, can be used as tensile reinforcement in the backfill of earth structures (Ling et al., 2009). The important benefit of geocell is to confine large particles in the three dimensional cells and respective cells have a large anchorage capacity when pull laterlly. Kiyota et al. (2009) conducted pullout tests with diamond-type geocells, which shows the strain hardening behavior in the load and displacement curve. Kuroda et al. (2012) examined the effect of particle size of backfill soil on the pullout resistance and initial stiffness of diamond-type geocells, which shows that pullout resistance becomes larger as the particle size becomes larger. However, the progressive deformations of geocells in the direction of pullout and a lower initial stiffness have been found. To increase the initial stiffness and pullout resistance of geocells, square-type geocells (SG-1, SG-2, and SG-3) were tested in this study.

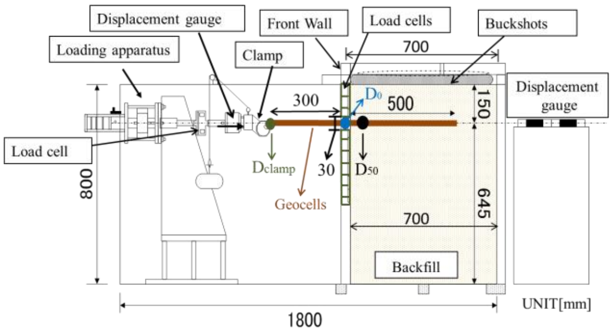
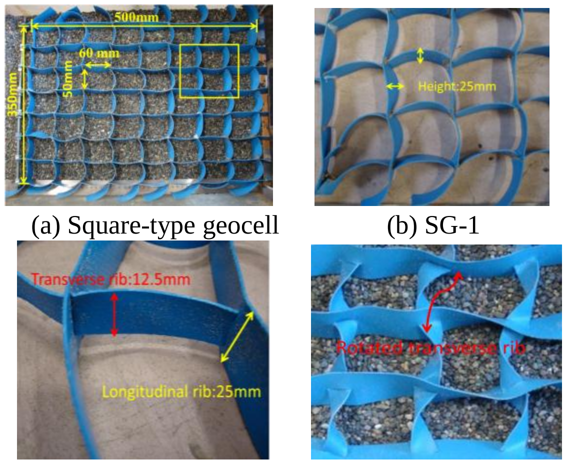


Fig.1 Schematic diagram of pullout test apparatus

2. EXPERIMENT OUTLINE

Figure 1 shows the schematic diagram of pullout test apparatus. The tests were carried out on plane-strain condition. The pullout displacements of geocells (D_{clamp}) and the displacements of the geocells away from the wall 50mm (D_{50}) were measured by displacement gauges. The surcharge of 1kPa was applied by buckshots. The tests were conducted by pulling the geocell out at a constant speed of 5mm/min using a jack driven by a motor. The pullout force was measured using a load cell.

Soils used in this study were Toyoura sand and Gravel No.1. The particle size of Toyoura sand is 0.1mm~0.2mm, and the relative density is 90%. The particle size of Gravel No.1 is 3mm~5mm. Three types of model geocells are shown in Photo 1. The model geocells reinforcement is 500mm (length) ×350mm (width) ×25mm (longitudinal height), having 8 cells in longitudinal direction and 7 cells in transverse direction. The model geocells were made of polyethylene terephthalate (PET) covered with PVC materials for protection, having square aperture opening size of 60mm (length) ×50mm (width), longitudinal height of 25mm(1/6 of the practical projects), thickness of 1mm, ultimate tensile strength of 56kN/m, and 20% strain at ultimate tensile strength. The square-type-1 geocells (SG-1) were prepared with full height of transverse ribs (25mm), the square-type-2 geocells (SG-2) were made with half height (12.5mm) of transverse ribs of SG-1, and the square-type-3 geocells (SG-3) were fabricated with half height of rotated transverse ribs of SG-1.



(a) Square-type geocell (b) SG-1

(c) SG-2 (d) SG-3

Photo.1 Geometry characteristics of square-type geocells

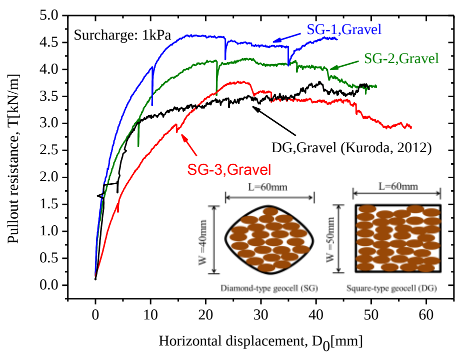


Fig.2 Pullout resistance-displacements Relationships

3. RESULT AND DISCUSSION

3.1 Effects of geometry of geocell

Figure 2 shows the pullout resistance (T) against the displacement of geocell (D_0) for square-type geocells and diamond-

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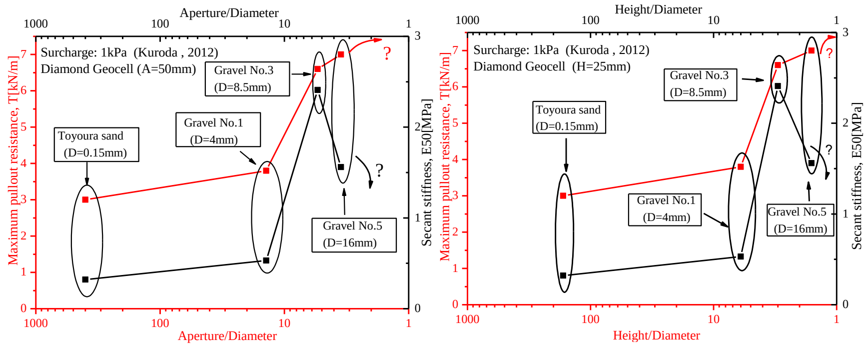
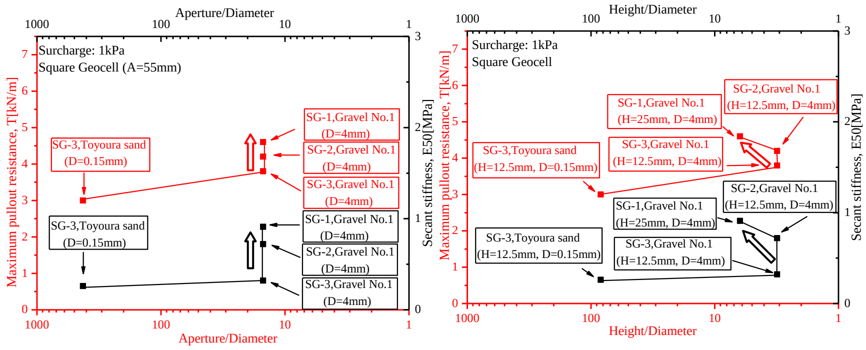
type geocells (DG) (Kuroda, 2012) with the same height of SG-1, which were conducted on the same test condition. D_0 was estimated by interpolation method depending on the strain between D_{clamp} and D_{50}. For square-type geocells (SG-1, SG-2, and SG-3), the strain-softening behavior is apparent; and for diamond type geocells (DG), the strain-hardening behavior is apparent. SG-1 not only has a higher pullout resistance than DG, but also has a higher residual pullout resistance. But SG-1 shows similar initial stiffness compared with DG.

Among the square-type geocells, the pullout resistance and initial stiffness of SG-1 are higher than that of SG-2 and SG-3. This is due to the difference of transverse ribs, which can be seen from Photo 1. According to the mechanism of pullout resistance of reinforcement embedded in the backfill (Kiyota et al., 2009), when the particle size of backfill soil with respect to the height of geocell reaches a certain level, the anchorage force induced by passive pressure would determine the total pullout resistance, as a result, the pullout resistance would decrease as the decrease of the height of geocell.



(a) (b)

Fig.3 For diamond-type geocells: (a) Relationship between A/D and pullout resistance (and initial stiffness); (b) Relationship between H/D and pullout resistance (and initial stiffness)



(a) (b)

Fig.4 For square-type geocells: (a) Relationship between A/D and pullout resistance (and initial stiffness); (b) Relationship between H/D and pullout resistance (and initial stiffness)

3.2 Effects of particle size of backfill

The particle size effect can be represented by the value of A/D and H/D (A: average size of single cell, A= (L+W)/2; H: the height of geocells; D: average diameter of soil particles). Figure 3 summarizes pullout test results of diamond-type geocells (Kuroda et al. 2012) , which shows that the pullout resistance increases as the value of A/D (and H/D) decreases and reaches its maximum value (7.0kN/m) when A/D is 3.5 (and H/D is1.6). Yet, the initial stiffness rises to its peak value (2.41MPa) when A/D is 5.4 (and H/D is 3), and then the initial stiffness falls to 1.56MPa when A/D is 3.5 (and H/D is1.6). Figure 4 compares the particle size effect on square-type geocells (SG-1, SG-2, and SG-3). From Figure 4 (a), for the same A/D, the difference of geometry and height of the square-type geocell will influence the pullout resistance and initial stiffness. As can be seen from Figure 4 (b), as the height of geocell increases, the pullout resistance and initial stiffness increase.

4.CONCLUSION

Square-type geocells show strain softening behavior, while diamond-type geocells show strain hardening behavior under the surcharge of 1kPa. Square-type geocells have higher pullout resistance and similar stiffness compared with diamond-type geocells with the similar aperture and the backfill of Gravel No.1. And also, for square-type geocells with the backfill of Gravel No.1, as the height of transverse ribs decreases, the pullout resistance and initial stiffness decrease.

The value of A/D (and H/D) can represent particle size effect. For diamond-type geocells, as the value of A/D (and H/D) decreases, the pullout resistance increases. Yet, there is an optimum value of A/D (and H/D) on initial stiffness. However, different types of geocells may show different relationships between A/D (and H/D) and pullout resistance (and initial stiffness). Therefore, more tests are needed, for example, the backfill with larger particles, to describe the relationship between A/D (and H/D) and pullout resistance (and initial stiffness) for different types of geocells.

REFERENCES

Kiyota, T., Soma, R., Munoz, H., Kuroda, T., Ohta, J., Harata, M., and Tatsuoka, F. (2009). “Pullout behaviour of geo-cell placed as reinforcement in backfill.” Geosynthetics Engineering Journal 24(0), 75-82. (In Japanese).

Kuroda, T., (2012). “Evaluation of static and seismic stability of bridges with reinforced backfill and integrated structural (New type and Rehabilitated type bridges) by model tests.” Master thesis, Department of civil engineering, Tokyo University of Science. (In Japanese).

Ling, H.I., Leshchinsky, D.,Wang, J.P., Mohri, and Y., Rosen, A. (2009). Seismic response of geocell retaining walls: experimental studies. ASCE Journal of Geotechnical and Geoenvironmental Engineering 135, 515-524.