STRESS-DEFORMATION CHARACTERISTICS OF GEOCELL REINFORCEMENTS CONSIDERING THE EFFECT OF GEOMETRY BY PULLOUT TESTS

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1. INTRODUCTION

For the last two decades, geosynthetic-reinforced soil retaining walls (GRS RWs) with a stage-constructed full-height rigid (FHR) facing have been constructed for railways, highways and other facilities and have shown greater seismic resistance than conventional retaining wall structures (Tatsuoka et al., 2009). Geotextiles are commonly used as planar reinforcements to tensile-reinforce the backfill of RWs, embankments and other soil structures. Geocell, as a three-dimensional soil confinement system, has more attractive features than other planar geosynthetic reinforcements. However, the application of geocell as tensile reinforcement to these soil structures is relatively new due to the lack of related research. Ling et al. (2009) investigated the seismic performance of several soil RWs having a geocell facing by shaking table tests. The results showed that walls having a geocells facing are flexible exhibiting much better seismic performance than conventional type RWs. In addition, the performance of a RW with the backfill reinforced with geocell layers was better than a RW with the backfill reinforced by geogrid layers.

In the present study, in order to check whether geocell can be worked as tensile reinforcement, two types of geocell which have diamond-shaped cells and square-shaped cells were evaluated by pull-out tests.

2. EXPERIMENT OUTLINE

Figure 1 shows the schematic diagram of pullout test apparatus that was developed at IIS, the University of Tokyo. The tests were carried out on plane-strain condition. The pullout test apparatus was rectangular in shape and made of steel. The dimensions of inner soil box were 700mm (length) ×400mm (width) ×500mm (height). Leads shots were applied on the crest of the backfill to provide a surcharge of 1 kPa and a flexible top boundary, which was preferred for the purpose of measuring dilatancy of soil. The front displacement (d_0) was monitored by laser. The displacements along the geocell, for example, the locations at distances of 60 mm (d_{60}), 180 mm (d_{180}), 300 mm (d_{300}), and 540 mm (d_{540}) from the face of front wall were measured with Linear Variable Displacement Transducers (LVDTs). The vertical displacements at distances of 60 mm (V_{60}), 300 mm (V_{300}), and 540 mm (V_{540}) from the face of the front wall were also measured with three LVDTs. The tests were conducted by pulling out the geocell at a constant displacement rate of 5 mm/min using a precision jack driven by a motor.

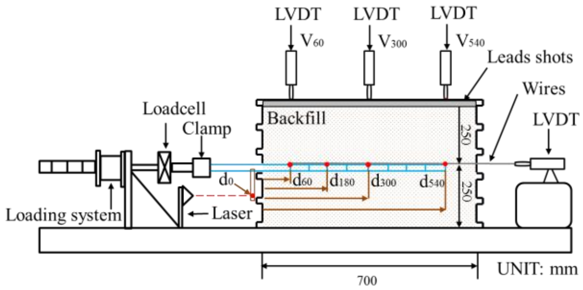
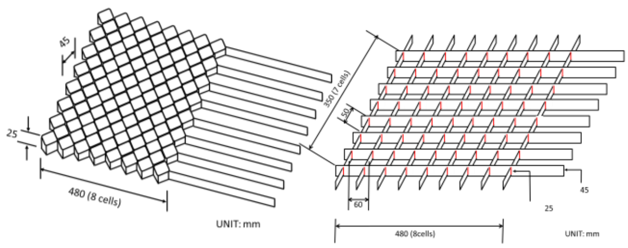


Fig.1 Schematic diagram of pullout test apparatus



(a) (b)

Fig.2 Geometry characteristics of: (a) diamond-shaped geocell and (b) square-shaped geocell

The backfill soils used in this study were poorly graded sub-round gravelly soils-Gravel No.1. The particle sizes were 3~5 mm. As shown in Fig. 2, two types of geocell reinforcements were prepared: diamond-shaped geocell and square-shaped geocell. The diamond-shaped geocell reinforcement was 480 mm (length) × 360 mm (width) × 25 mm (height), having eight diamond-shaped cells in both longitudinal direction and transverse direction. The square-shaped geocell reinforcement was 480 mm (length) × 350 mm (width), having eight square-shape cells in the longitudinal direction and seven square-shape cells in the transverse direction. The transversal members have a common height (25mm) which is 20mm lower than longitudinal members. Both types of geocell reinforcements were made of polyethylene terephthalate (PET) covered with PVC for protection, having a thickness of 1 mm. The ultimate tensile strength of the material is 56 kN/m at a strain of 20%.

3. RESULT AND DISCUSSION

Figures 3, 4 and 5 show different pullout characteristics of diamond-shaped geocell and square-shaped geocell. Fig. 3 exhibits the relationship between the pullout resistance (T) and the horizontal displacement (d_{60}) of diamond-shaped geocell and square-shaped geocell. Square-shaped geocell shows both higher peak pullout resistance and initial stiffness

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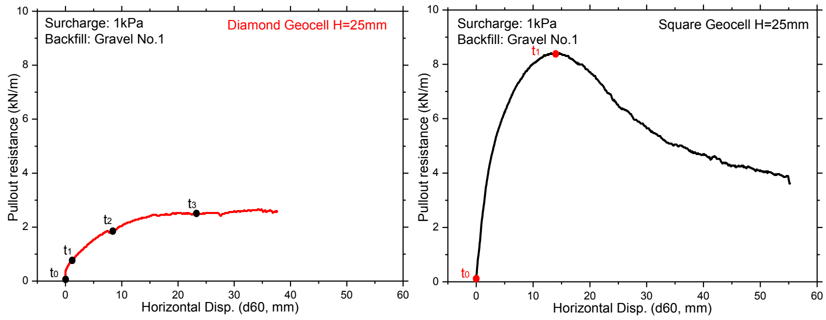
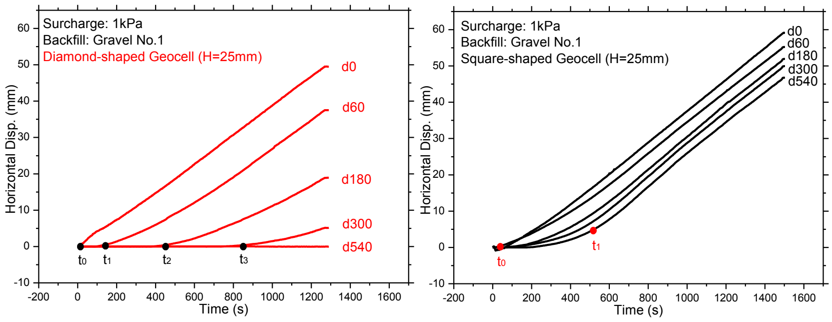
than diamond-shaped geocell. Diamond-shaped geocell starts obvious yielding at very small displacement (2mm) and exhibits strain-hardening behavior, while square-shaped geocell exhibits higher peak strengths at large displacements (16mm), followed by noticeable strain-softening. This difference is due likely to the different geometries of the geocell, in particular the shape of aperture (Fig. 2).

Figures 4 and 5 show the deformation characteristics of diamond-shaped geocell and square-shaped geocell subjected to a pullout force. In particular, the stress-deformation mechanism of diamond-shaped geocell is shown in Fig. 6. For diamond-shaped geocell (Figs. 4a, 5a and 6), from t_0 (initial state) to t_1 (the first stage), the first diamond cell starts to deform and provides corresponding pullout resistance (Fig. 3a and 6) until other cells reach the residual resistance state of the first cell. Afterwards from t_1 to t_2, the second and the third cells deform and provide their pullout resistances until the rest cells reach the residual state of them. This procedure repeats from t_2 to t_3 until all cells work in the pullout process. This deformation characteristic of diamond-shaped geocell can be described as progressive deformation, which would induce the soil surrounding the diamond-shaped geocell not fully mobilized, and therefore cause a lower peak pullout resistance and initial stiffness compared with the square-shaped geocell. However, as shown from Fig. 3b, Fig. 4b and Fig. 5b, the square-shaped geocell does not show or show slightly progressive deformation. From t_0 (initial state) to t_1 (peak state), almost all square cells work immediately, which can provide larger peak pullout resistance and higher initial stiffness than diamond-shaped geocell.



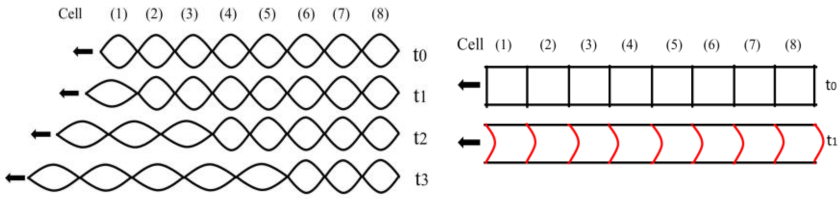
(a) (b)

Fig.3 Pullout resistance against horizontal displacements (d_{60}): (a) diamond-shaped geocell; (b) square-shaped geocell



(a) (b)

Fig.4 Horizontal displacement along the geocell reinforcements versus time history: (a) diamond-shaped geocell; (b) square-shaped geocell



(a) (b)

Fig.5 Schematic diagram of deformation status vary with time: (a) diamond-shaped geocell and (b) square-shaped geocell

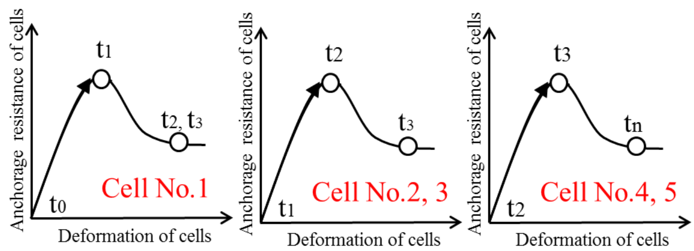


Fig.6 Schematic diagram of stress-deformation mechanism of diamond-shaped geocell

4. CONCLUSION

The effect of the geometry of geocell on pullout resistance and initial stiffness was evaluated by pullout tests. Two types of geocell show different pullout characteristics: the progressive deformation characteristics of diamond-shaped geocell and non-progressive deformation characteristics of square-shaped geocell. Due to this effect, the square-shaped geocell exhibits much higher peak pullout resistance and higher initial stiffness than the diamond-shaped geocell. However, the pullout behavior of different types of geocells may be different under larger surcharge, since other factors, the connection between cells, may govern the ultimate pullout resistance. Therefore, the tests should also be conducted under larger surcharge in the future.

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