MECHANICAL PROPERTIES OF GEOGRID-REINFORCED GRAVEL IN TRIAXIAL TESTS

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I. INTRODUCTION

The use of geogrids in road and railway projects is becoming an important practice all around the world for solving many design and construction problems. Reinforced granular material is a composite material which combines two different materials in such a way to improve its mechanical properties. However, there is still a lack of the understanding how the geogrids contribute to the observed increase of the load bearing capacity. To allow for better assessment of the composite behaviour, a series of large-scale triaxial tests were conducted on unreinforced and reinforced gravel specimens of 50 cm in height and 23 cm times 23 cm in cross-section, using an apparatus developed at the Institute of Industrial Science, University of Tokyo (Anh Dan et al. 2006). In addition to the variation of the cell pressure, the test series also includes the variation of geogrid types.

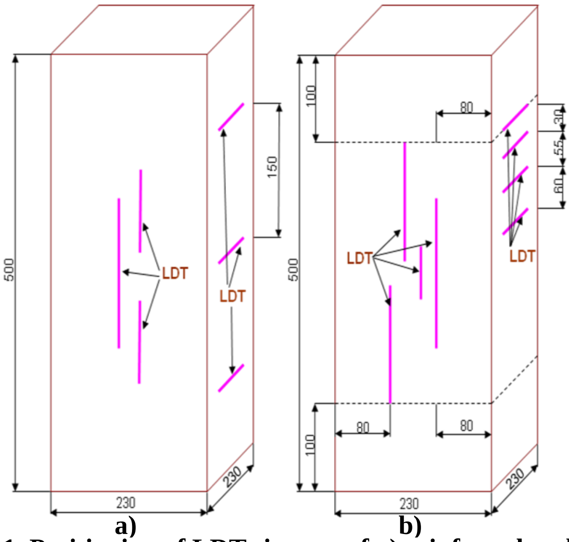
II. TESTING APPARATUS AND MATERIALS

The purpose of this study is to examine the effect of geogrids on the peak strength and the small strain stiffness of large prismatic specimen of gravel by conducting triaxial compression tests.

For unreinforced tests, axial strain (ε_1) was measured by three pairs of vertical local deformation transducers (V-LDTs). Lateral strains in two directions (ε_3) were measured by another three pairs of horizontal local deformation transducers (H-LDTs). For in the reinforced tests, axial strain (ε_1) and lateral strains (ε_3) were measured by four pairs of vertical and horizontal local deformation transducers in each side of the specimen, respectively. The schematic diagrams showing the location of all LDTs over the specimen for both types of tests are shown in Fig.1. The mean of data measured with three or four pairs LDTs was used for each direction of local strain measurement for the analysis of test results.

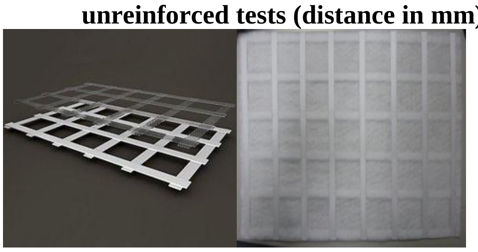
The testing material was a well-graded crushed stone, called Tochigi gravel. It consists of angular to sub-angular particles with a coefficient of uniformity C_u=32 and specific gravity G_s=2.68. The optimum moisture content and the maximum dry density were defined by modified Proctor as w_{opt}=4.0 % and ρ_d=2.168 g/cm^3, respectively.

The specimens were prepared by manual compaction at nearly optimum moisture content (Table 1). Specimens were compacted in 10 layers with a thickness of 5 cm for each layer. Before placing the material for the next layer, the surface of the previously compacted layer was scrapped to a depth of about 2 cm to ensure a good interlocking between vertically adjacent layers. The compaction was applied with an aim to reach dry density of specimen as close as possible to the one defined by Proctor test. In reality approximately 95% of the maximum density was reached on average. The confining pressure (σ'_3) was applied by vacuum and by positive cell pressure and kept constant during testing. Two geogrid layers have been placed in the reinforced specimens leading to a vertical reinforcement spacing of nearly 0.3m. Test results presented in this paper are obtained from specimen reinforced with a biaxial polypropylene and biaxial combi-polypropylene geogrids as shown in Fig.2 with a nominal strength of 40kN/m and welded, pre-stretched flat bars. The aperture size of the grid was 31mm x 31mm and the tensile force at 2% strain 16kN/m, as given by the manufacturer .



a) b)

Fig. 1. Positioning of LDTs in case of a) reinforced and b) unreinforced tests (distance in mm)



a) b)

Fig.2. Figure of a) PP geogrid and b) Combi-PP geogrid, respectively

Table 1. Test conditions

Test name	Reinforcement	σ'_3 (kPa)	ρ_d (g/cm^3)	e	ω (%)
IIS-0E	Unreinf	25	2.053	0.305	3.73
IIS-0G	Unreinf	150	2,096	0.278	2.41
IIS-2D	Geogrid	150	2.089	0.283	3.81
IIS-2E	Geogrid	25	2.066	0.297	2.53
IIS-COM-C	Combi-grid	25	2.112	0.269	2.25
IIS-COM-D	Combi-grid	150	2.080	0.288	2.11

Keywords: geogrids, geogrid reinforcement, large scale-triaxial, confining pressure, stiffness, peak strength.
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III. TETS RERULTS

Stress-strain curves of tests with unreinforced and reinforced samples compacted to 95% proctor density are given in Fig. 3 for two types of geogrids at two different confining pressures of 25kPa and 150kPa. The increase of the peak strength due to the reinforcements can be seen clearly.

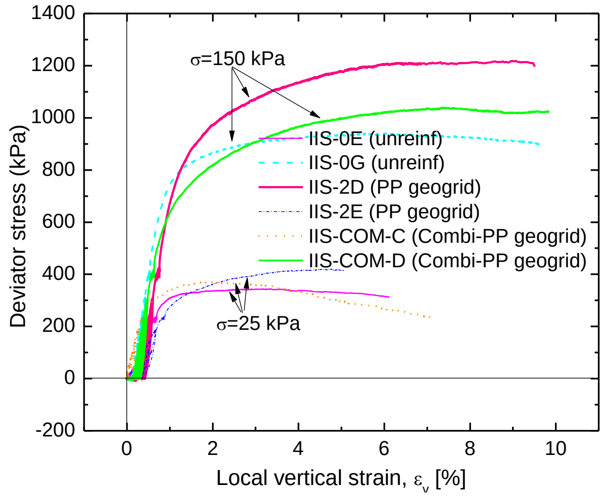

Fig.3. Stress-strain relationship

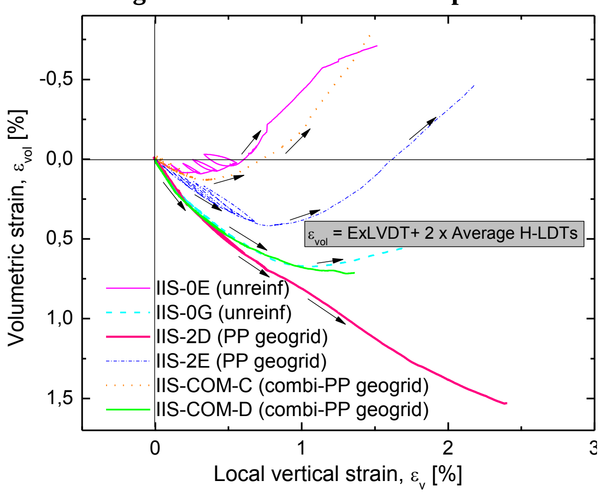

Fig.4. Volumetric strain of unreinforced and reinforced tests

However, the initial stiffness of unreinforced and reinforced specimens seems to be similar to each other for vertical strains up to 0.3%. This is in accordance with the volumetric strains calculated from the radial and vertical strains, indicating almost pure compaction at the beginning of the tests (Fig. 4).

The peak strength parameters for unreinforced and reinforced tests are shown using Mohr circles in Figure 5. As can be seen, in unreinforced tests, the cohesion and internal friction are less than those in reinforced tests.

The stiffness of the specimens derived from small cyclic loading is shown in Fig.6. As can be seen, the reinforcement does not largely affect to the small strain stiffness of the specimens under both low or high confining pressures.

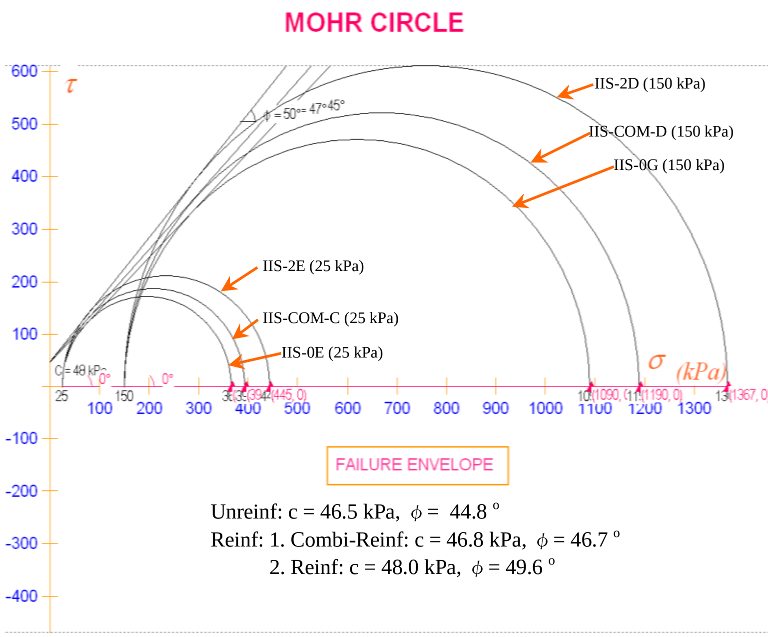

Fig.5. Mohr circles of unreinforced and reinforced tests

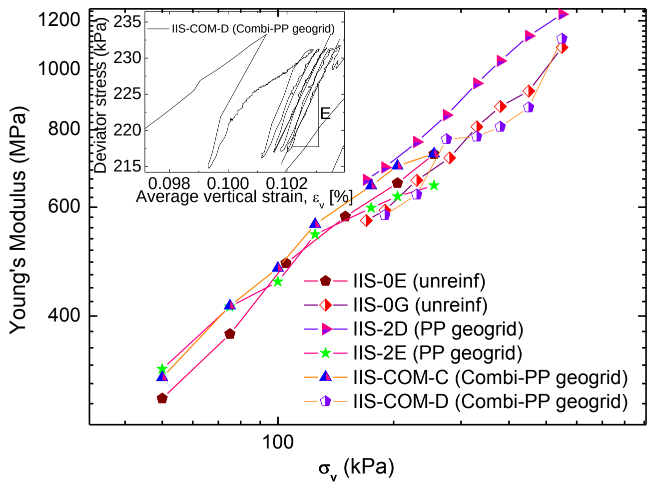

Fig.6. Stiffness of unreinforced and reinforced specimens

IV. CONCLUSIONS

Large-scale triaxial tests on reinforced and unreinforced specimens showed a significant increase of the peak strength due to the geogrids.

On the other hand, the stiffness and the volume change property of the specimen up to vertical strain levels of about 0.3% were not affected by the reinforcement.

References

1) AnhDan, L.Q., Koseki, J., and Sato, T. (2006): Evaluation of quasi-elastic properties of gravel using a large-scale true triaxial apparatus, Geotechnical Testing Journal, ASTM, Vol 29, No.5, pp 374-384.