Behavior characteristics of geogrid-reinforced soil with improved soil surface by laboratory tests

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ABSTRACT: The wall surface of the geosynthetic reinforced soil wall is preferably as flexible as possible in order to cope with deformation of the foundation ground and backfilled soil during construction, but it is preferable that the rigidity is as large as possible after completion.. In RRR construction method, reinforced soil block would be constructed in advance, and after the deformation of the ground soil and backfill soil of the reinforced soil block was almost finished, wall surface (relatively thin concrete wall) are constructed. This construction method for geosynthetic reinforced soil have been used for roadbed of high-speed railway in Japan. However, problems with the connection between the rigid wall surface and the soft reinforced backfill soil are still being discussed. In this study, a series of laboratory and finite element analysis were performed to solve the above mentioned inconsistency by replacing wall surface to the soil wall reinforced by ground improvement material named N-soil. The greatest advantage of this replacing method is that the front wall and the backside reinforced soil block are integrated, which eliminates the above mentioned inconsistencies and there is no limit to the order of construction. The composite reinforced soils showed a horizontal movement of less than 1/2 of the geogrid reinforcement soil at failure load, and exhibited the behavior characteristics within the allowable range similar to that of the block type reinforced soils. The possibility of the role of improved soil surface was confirmed from the above written content.

Keywords: Improved Soil Surface, Geogrid-reinforced Soil, Horizontal movement, Foundation settlement

1 INTRODUCTION

Both the steep slope reinforced embankment and reinforced soil wall structures have been highlighted so far as follows. The first is the fact that the earth pressure does not work to the wall very well, so it is easy to construct a wall surface compared with concrete retaining wall. Secondly, the pile foundations are unnecessary because there are sufficient deformability corresponding to deformation of foundation in surface wall. These advantages have resulted in significant reductions in construction costs and construction periods, which have begun to gain prominence in various construction projects. By a lot of research on the role of a wall surface and a reinforced soil wall, the benefits above are beginning to be recognized as follows. When the equal sized earth pressure to the active earth pressure work on wall surface, the deformability is resulted in small and strength grow bigger. This is because the comparative large confined pressure add to the backfill soil. And according to recent studies, the wall surface of reinforced soil wall is preferably as flexible as possible in order to cope with deformation of the foundation ground and backfill soil during construction. But it is preferable that rigidity is as large as possible after completion. In order to solve such inconsistence, In RRR method (Reinforced Railroad with Rigid facing method), reinforced soil block would be constructed in advance, and after the deformation of the ground and backfill soil of reinforced soil block was almost finished, wall surface (relatively thin concrete wall) are constructed(Tatsuoka, 1993). This construction method for reinforced soil wall have been used for roadbed of high-speed railway in Japan. But, problems with the connection between the rigid wall surface and the soft reinforced backfill soil are still being discussed. In this study, a series of laboratory model test were performed to solve the above mentioned inconsistency by replacing wall surface to the soil wall reinforced by ground improvement material named N-SOIL.

2 USED MATERIALS AND COMPRESSIVE STRENGTH

2.1 *Used materials*

2.1.1 *Backfill soil*

In order to perform the laboratory model test, soil from Jeonju area in Korea was collected and used as backfill soil of reinforced soil wall. Table 1 shows physical properties of soil. Figure 1 shows particle size distribution curve of backfill soil and Figure 2 shows result of compaction test.

Table 1. Physical properties of backfill soil

ω	Gs	LL	PL	USCS
16.08%	2.745	30.41%	N.P	SM

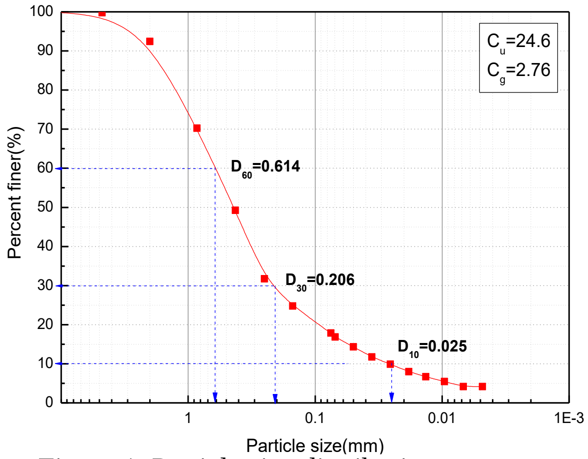


Figure 1. Particle size distribution curve

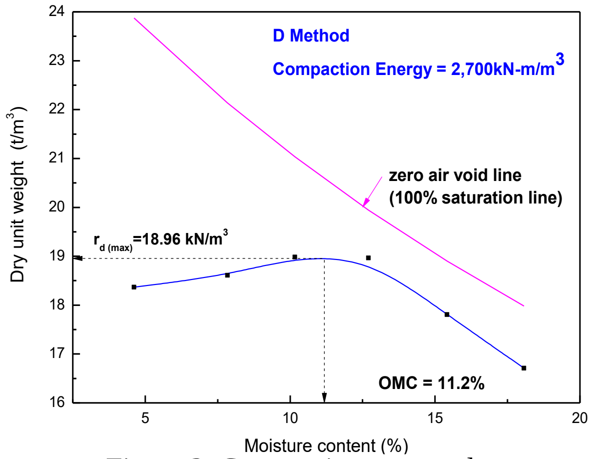


Figure 2. Compaction test result

2.1.2 *Ground improvement material*

In this study, a ground improvement material named N-SOIL was used which can react with fly ash as a main material and react with backfill soil to induce pozzolanic reaction sufficiently. Table 2 shows chemical composition of N-SOIL.

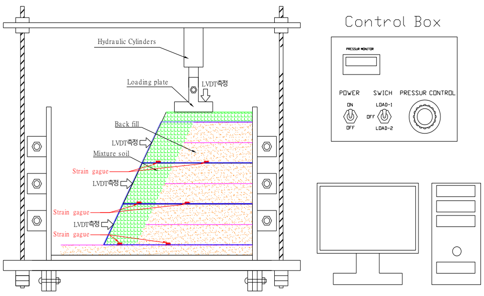
Table 2. Chemical composition of N-SOIL

Material	Component (%)									
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	TiO_2	K_2O	Na_2O	Ig
N-SOIL	30.0	13.2	1.44	33.4	6.48	5.59	0.98	0.39	0.57	7.6

3 LABORATORY MODEL TEST AN RESULTS

3.1 *Laboratory model test apparatus*

To perform the laboratory model test, chamber with width(B) of 0.5m, height(H) of 1.5m, length(L) of 2.0m was made. Figure 2 is shown diagram and apparatus of laboratory model test chamber.



(a) Diagram (b) Laboratory model test apparatus

Figure 2. Diagram and laboratory model test apparatus

3.2 *Procedure of laboratory model test*

In order to perform the laboratory model test, the soil as the maximum dry unit weight was put in the chamber and compaction was carried out. The strain gage attached geosynthetic was installed on the top of compaction soil, and the above procedure was repeated to complete the model of the reinforced soil wall. In the model of the finished reinforced soil wall, a cylinder for applying load and LVDT for measuring an amount of deformation at the wall surface were installed. Figure 3 shows this test procedure.

(a) Preparation

(b) Installation of strain gage

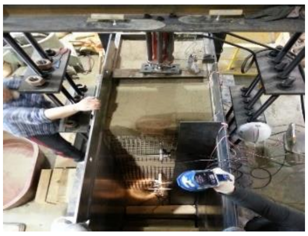
(c) Put soil in chamber

(d) Compaction

(e) Geosynthetic

(f) Installation of cylinder

(g) LVDT



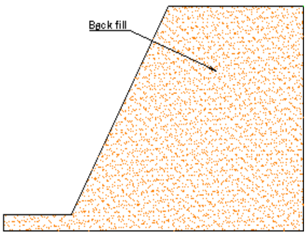
(h) Perform the test

Figure 3. Procedure of laboratory model test

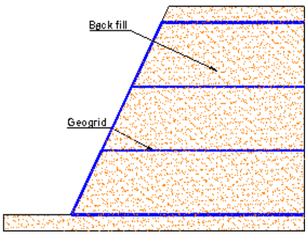
3.3 *Test result*

3.3.1 *Test method of laboratory model test*

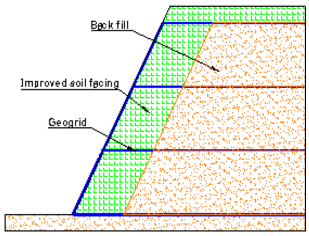
In this study, laboratory model test were performed for 3 cases as shown in figure 4. Case 1 is composed only backfill materials, and case 2 is composed backfill material with geogrid reinforcing per 40cm in height. In case 3, the backfill material mixed with 6% of ground improvement material named N-SOIL constituted the wall surface with a depth of 40cm on the wall surface of reinforced soil wall, and geogrid was installed in the same as Case 2.



(a) Case 1(Non-reinforced)



(b) Case 2(Geogrid)

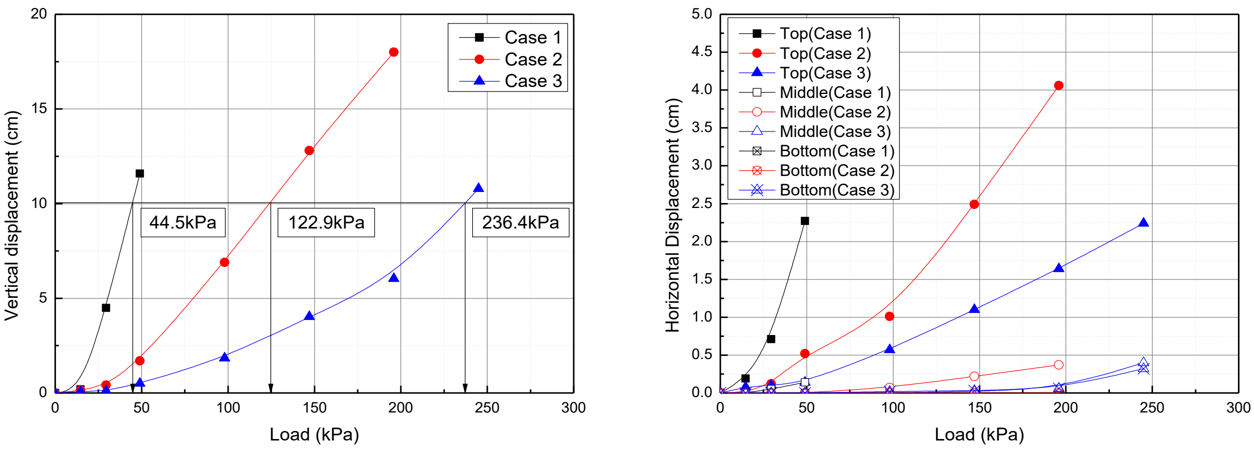


(c) Case 3(Improve soil and Geogrid)

Figure 4. Test model in this study

3.3.2 *Test result of laboratory model test*

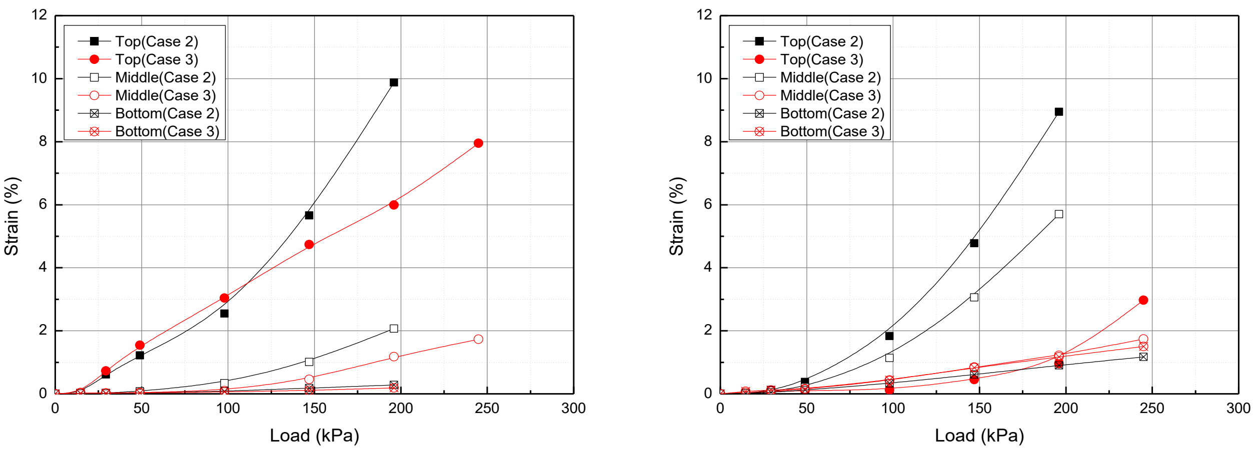
Figure 5(a), (b) shows the variation of the vertical and horizontal displacement due to load through the laboratory model test. As results of the test, the failure occurred at 49kPa for Case 1 and 196.1kPa for Case 2, and in Case 3, the load applied to the maximum cylinder capacity of 245.2kPa. Based on the vertical settlement of 10cm that began to break down, the load of each case was 44.5kPa for Case 1, 122.9kPa for Case 2 and 236.4kPa for Case 3. These results show that Case 3 has a reinforcing effect about 5 times that of Case 1 and about twice that of Case 2. In other words, it is shown that the reinforcement of the geogrid to the embankment increases the load strength about three times, and the load strength again doubles by the modified wall surface construction. Also, comparing the amount of vertical displacement at the load stage where failure occurs in Case 1, vertical displacement of Case 1 was 11.59cm, Case was 1.7cm and Case 3 was 0.5cm. Especially, Case 3 had about 5 times higher failure load than Case 1, but vertical displacement was smaller than that of Case 1. As a result of measuring the horizontal displacement, the displacement at the top of each case is the largest, and the displacement at the bottom is little or very small. Also, as the reinforced soil wall was reinforced, the displacement occurred to the lower part. In a typical reinforced soil structure, the maximum horizontal displacement occurring after construction is estimated to be 0.9 to 1.5% of wall height(Christopher, et al., 1990). In case 2, 2.7% of the wall height is 2 times larger than the above value, but in Case 3, it is about 1/2 of this value, which shows the validity as reinforcement method.



(a) Vertical displacement (b) Horizontal displacement

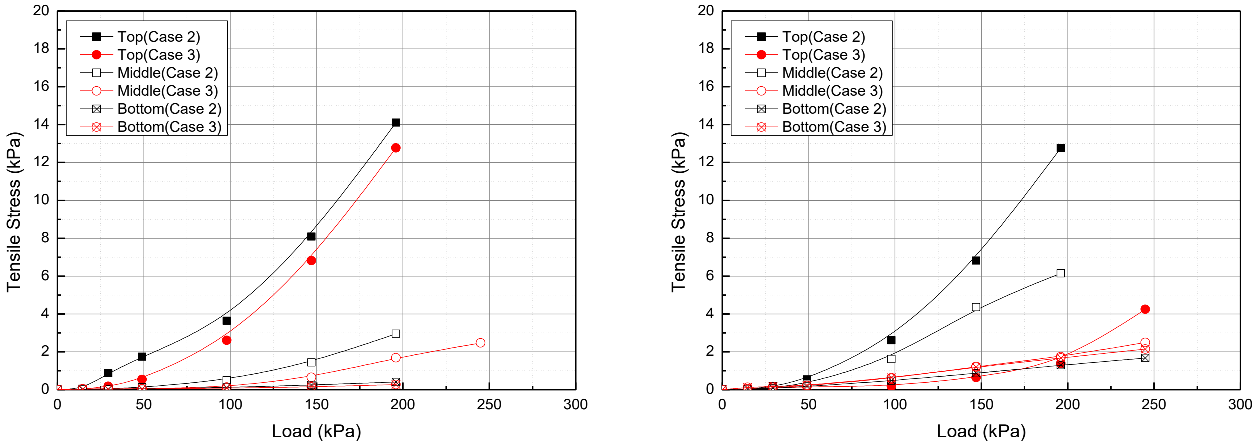
Figure 5. Variation of displacement due to load

Figure 6(a), (b) and Figure 7(a), (b) shows the variation of strain and tensile stress of geogrid due to load. As a result of the strain and tensile stress measurement, the largest strain and tensile stress occurred at the upper part and little strain and tensile stress occurred at lower part. Also, the geogrid installed in the backfill soil of Case 3 was less deformed than Case 2, and the tensile stress was less. Based on the above results, reinforcement at the wall surface can reduce the deformation and stress of the reinforced soil wall, which will contribute to securing the stability.



(a) Wall surface (b) Backfill soil

Figure 6. Variation of strain due to load



(a) Wall surface (b) Backfill soil

Figure 7. Variation of tensile stress due to load

4 CONCLUSION

1) Compared to geogrid reinforced soil without surface wall, the composite reinforced soil with the modified surface of the wall surface showed a reinforcing effect more than 2 times in the quantitative comparison in terms of vertical load, foundation settlement and horizontal displacement at fracture load.
2) The composite reinforced soils showed a horizontal movement of less than 1/2 of the geogrid reinforcement soil at failure load. Also, the strain and tensile stress of the geogrid are less than those of it. The possibility of the role of improved soil surface was confirmed from this.

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