LONG-TERM PERFORMANCE BY REDUCTION FACTORS OF GEOSYNTHETICS FOR WASTE LANDFILLS BEFORE/AFTER INSTALLATION

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Abstract

Six type geosynthetics were used - geocomposite(4 t/m design strength) and five geogrids(4, 6, 8, 10, 15 t/m). Installation damage tests were performed at various fill thickness (20, 30, 40, 60, 80 and 100cm) and the tensile testing was performed to evaluate both damaged and undamaged geosynthetics samples before/after installation. Tensile strength of all the geosynthetics were decreased about 2 30%. Creep strain of the damaged geosyntheticss were about 1 2% higher than the undamaged geosynthetics at the same loading conditions. From the result of estimated partial factors, long-term performance of geosynthetics was determined to account for the construction-induced damage and creep deformation.

Introduction

When the geosynthetics are used in soil structure, compaction is required and some damages would be occurred as a result of compaction. These damages by the compaction result in the unexpected changes of short and long-term properties of the structure. There exist no standard test method for the installation damage not yet, and the test method that now being examined doesn't consider carefully about the construction site, aggregate type and installation condition. So in the case of index test, there are some problems to the exact evaluation on the installation damage. Therefore, to the more definite evaluation on the installation damage of geosynthetics, the real site installation damage test is encouraged.

In this study, in order to evaluate the changes the geosynthetics tensile and creep property, two types of geosynthetic reinforcement material were installed in the various test sites. Then the geosynthetics are tested about the tensile and creep properties. To evaluate the long-term performance of geosynthetics, the GRI GG-4 test method was used. The long-term performance of geosynthetics due to installation damage, creep deformation before/after installation was determined by reduction factors.

Theoretical Background of Long term performance

Reduction factors, which affect the long-term performance of geosynthetics, are written in the equation (1).

$$T_{allow} = T_{ult}[\frac{1}{\prod RF}] \qquad (1)$$

$$= T_{ult}[\frac{1}{RF_{ID} \times RF_{CR} \times RF_{CD} \times RF_{BD}}]$$

where, T_{ult} = Ultimate tensile strength
T_{allow} = Allowable tensile strength
RF_{ID} = Reduction factor for the installation damage
RF_{CR} = Reduction factor for the creep deformation
RF_{CD} = Reduction factor for the chemical degradation
RF_{BD} = Reduction factor for the biological degradation

Installation damage

Geosynthetics are installed with various installation methods according to application condition. The strength history that applied to the geosynthetics is very different during the installation. General geosynthetic installation damages are occur at the time that the true strength exceeds the design strength. Factors influencing the damage mechanism are grain size, subsoil angularity, construction equipment and fill thickness.

There are number of laboratory tests relevant to the evaluation of damage susceptibility. However no single laboratory test has so far been developed which is capable of giving a complete basis for damage evaluation. Because failure form of material shows various with each condition, the test, which considered the primary function of the geosynthetic is recommended. In other words, if the primary function of the geosynthetic is reinforcement, the tensile property will be compared in pre and post installation. If the primary function is filtration, the AOS or permittivity test should be used to evaluate the installation damage reduction factor.

Experimental

Sample preparation

There were five kinds of geogrid and 1 geocomposite used in this study. The installation damage test and creep test were performed. Table 1 shows the physical properties of the samples. Sample A is woven type geogrid and sample B~E are knitted type geogrids. In the case of geocomposite, the PET high strength yarn knitting method was used to make sure the shape of geocomposite.

Table 1: physicals properties of the various samples

Geosynthetic	Law materials	Manufacturing type	Confining Load(t/m)	
			MD	CD
A	PET yarn +PVC coating	Woven type geogrid	4	2
B	PET yarn + PVC coating	Warp knitted type geogrid	6	3
C	PET yarn + PVC coating	Warp knitted type geogrid	8	3
D	PET yarn + PVC coating	Warp knitted type geogrid	10	3
E	PET yarn + PVC coating	Warp knitted type geogrid	15	3
F	PET yarn+PP onwoven geotextile	Geocomposite	4	4

Field installation test

To estimate the damage of geosynthetics according to various fill thickness, total 6 step increments (20~100cm) of fill thickness were applied.

Wide width tensile test

Wide width tensile tests are generally performed both in the machine and cross machine direction of the geosynthetics, using the standard test method ASTM D 4595. The tensile test was used to evaluate the effects of damage, e.g. after installation trials for 6 kinds of geosynthetics. And then the installation damage reduction factors were calculated.

Creep deformation test

Creep deformation test was performed on both damaged and undamaged samples to evaluate the creep reduction factor. The GRI GS10 test method used in this study. The temperature steps were 26, 40, 54, 68 and 82 ^{o}C. The loading level was 60% of the ultimate tensile strength of all the geosynthetics.

Results and Discussion

Decrease of tensile strength by he installation damage

Table 2 shows the reduction factors determined for all the geosynthetic samples according to the fill thickness. A decrease of the tensile strength was observed. In here, the PVC coated geogrids' tensile properties decrease less than the geocomposite. In the case of geocomposite, the environmental factors, e.g., size of soil, compaction equipment, worker, etc. directly affected to the geosynthetics, such that the tensile properties decreased more than the coated geogrids. Also, there are no trends according to the fill thickness in the all geogrids and geocomposite. Therefore, during the installation of the geosynthetics, to reduce decrease in strength, the construction quality control should be carefully managed.

Table 2: Installation damage reduction factors of the each geosynthetics

Geosynthetic	Installation Depth					
	20cm	30cm	40cm	60cm	80cm	100cm
A	1.14	1.12	1.18	1.19	1.21	1.14
B	1.09	1.05	1.10	1.09	1.05	1.05
C	1.06	1.08	1.04	1.04	1.04	1.07
D	1.03	1.01	1.03	1.06	1.11	1.03
E	1.02	1.04	1.03	1.09	1.19	1.07
F	1.34	1.63	1.49	1.51	1.42	1.49

Creep behaviour by installation damage

Figure 1~3 show the creep deformation curves of the geosynthetic samples A, D, F with the fill thickness. The creep deformations of the damaged were decreased to the undamaged geosynthewtic samples. The creep strain change to be occurred in the same loading levels were about 0.5~1%.

Figure 1: Creep strain curves of geogrid A with fill thickness at loading level 60%

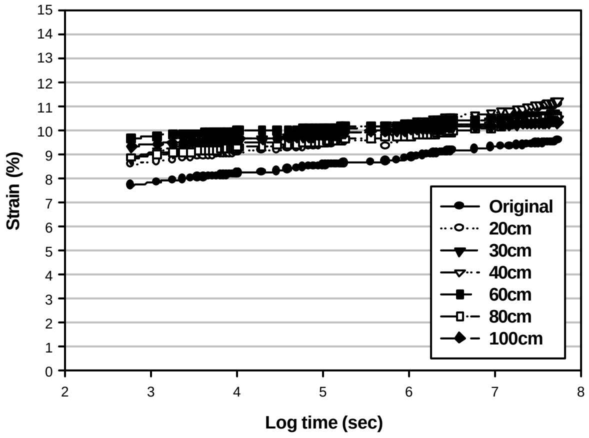


Figure 2: Creep strain curves of geogrid D with fill thickness at loading level 60%

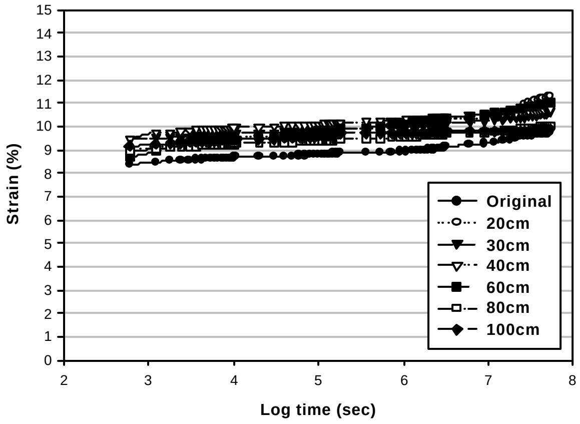
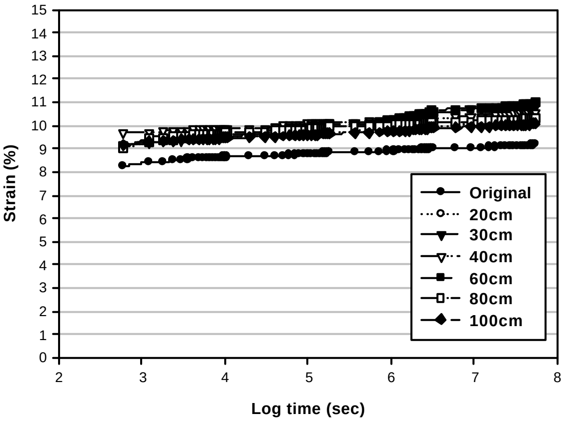


Figure 3: Creep strain curves of geocomposite F with fill thickness at loading level 60%



Creep reduction factor of undamaged and damaged geosynthetics

The reduction factor of creep deformation follows with this equation (2).

$$RF_{CR} = \frac{T_{ST}}{T_{LT}} \qquad (2)$$

where, RF_{CR} = Creep reduction factor, T_{LT} = 10 year design life strength of the geogrid in sustained ASTM D 4595 or sustained GRI GG-1, or ASTM D 5262 testing at which curve becomes asymptotic to a constant strain line, of 10 percent or less, T_{ST} = Short term strength of the geogrid in ASTM D 4594, GRI GG-1 or GG-2 testing whichever is comparable to the long term creep test, i.e., wide width, single rib or through the junction test.

The reduction factor for creep deformation is determined fom the 10,000 hours curves as being the load at which the creep deformation curve becomes asymptotic to a constant strain line, of 10 percent or less. This value of strength is then compared to the short-term strength of the geogrid in ASTM D 4594, GRI GG-1 and GG-2.

Table 3 shows the creep reduction factor values of the undamaged and damaged geosynthetic samples. This shows the creep reduction factors of damaged geosynthetics are higher than the undamaged geosynthetics. Also, there are no significant trends with the fill thickness in the all geosynthetic samples. And the reduction factor value of the geocomposite, F is lower than the other samples. And since the results of the warp density of the geocomposite, F are higher than geogrids A~E, so the applied load was distributed effectively in the geocomposite, F.

Table 4 shows the total factor of safety of the undamaged and damaged geosynthetics. This shows the similar trends as the creep reduction factors and the damaged geosynthetics have the higher value than the undamaged geosynthetics. Table 5 shows the long-term design strength of the undamaged and damaged geosynthetics and it is seen that this shows the similiar trends as the total factor of safety and the creep reduction factors

Table 3. Creep reduction factors of the each undamaged and damaged geosynthetics

Geosynthetic	Installation Depth						
	0	20cm	30cm	40cm	60cm	80cm	100cm
A	1.67	2.0	2.0	2.0	2.0	2.0	2.0
B	1.67	1.67	1.81	1.81	1.81	1.67	2.0
C	1.67	2.0	1.67	1.67	1.67	1.67	2.0
D	1.67	2.0	1.81	2.0	2.0	1.67	1.67
E	1.67	2.0	2.0	1.67	1.67	1.67	1.81
F	1.42	1.81	2.0	2.0	2.0	1.81	1.67

Table 4. Total factor of safety of geosynthetics after installation

Geosynthetic	Total Factor of Safety						
	0	20cm	30cm	40cm	60cm	80cm	100cm
A	1.67	2.28	2.24	2.36	2.38	2.42	2.28
B	1.67	1.82	1.90	1.99	1.97	1.75	2.10
C	1.67	2.12	1.80	2.08	1.74	1.74	2.14
D	1.67	2.06	1.83	1.86	2.12	1.85	1.72
E	1.67	2.04	2.08	2.06	1.82	1.99	1.94
F	1.42	2.43	3.26	2.69	3.02	2.57	2.49

Table 5. Long-term design strength of geosynthetics after installation

Geosynthetic	Long-Term Design Strength						
	0	20cm	30cm	40cm	60cm	80cm	100cm
A	1.75	1.75	1.79	1.69	1.68	1.65	1.75
B	3.29	3.29	3.16	3.01	3.04	3.43	2.86
C	3.77	3.77	4.44	3.85	4.59	4.59	3.74
D	4.85	4.85	5.46	5.38	4.72	5.41	5.81
E	7.35	7.35	7.21	7.28	8.24	7.54	7.73
F	1.65	1.65	1.23	1.49	1.32	1.56	1.61

Conclusion

1) The results of the tensile test show that strength decreases are both warp and weft directions of all the geosynthetics.

2) There are decreases of the tensile properties due to installation damage and this is not related to the soil filling thickness.

3) The decreases of the creep deformation were occurred after installation, and the reduction factors of creep deformation were decreased for all the geosynthetics.

4) In the designing with the reinforcement geosynthetics applied to the reinforced structure, decreases of properties should be carefully considered in accordance with total factor of safety.

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