The Evaluation of Separation Function for Geotextiles

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ABSTRACT: The effect of the properties of geotextile on the separation function and the relationship between the reinforcement and separation function in road constructions were considered. The cyclic loads were applied on the surface of the pavement model in cylindrical mold. The tests consist of two type of series. In the first series, the effects of the properties of geotextiles on the quantity of the fine particles movement through the geotextiles are discussed. And the test results show that the unit weight of geotextile is applicable to estimate the separation function. In the second series, the interaction between the reinforcement and the separation function is considered. The reinforcement is a prime function when the ratio of the applied stress on the subgrade soil to the shear strength of the subgrade soil (σ / c_u) is high, however, the separation can be an important function when the ratio is low.

1 INTRODUCTION

The application of geotextiles for the construction of road on soft subgrade soil has become popular in the last decade. One of the important roles of a geotextile are as a separator between the sub-base and underlying soft subgrade soil. The geotextile must prevent the movement of fines from the subgrade into the sub-base course. The past studies about the separation are concerned with filtration (McMorrow, 1990 ,Floss and Laier, 1990) or short and long term strength of geotextiles to maintain their function (Werner, 1986). The earlier research on the filtration under dynamic loading was carried out by Bell(1982). He described particle movements depend on the loading number and the opening size (AOS) of the geotextile. However, there is large difference in the opening shape between the nonwoven and woven, and the filtration is furthermore related to the hydraulic property.

Many researches on the reinforcement function have been reported (Giroud, 1981), and they supposed the reinforcement is the prime function in the road construction. However, the boundary between the separation and the reinforcement is not clear ,and it is difficult to distinguish them from the usual model test.

In this study, laboratory simulation tests to evaluate the performance of some geotextile samples as separators were carried out. And the effects of the properties of the geotextiles on the separation and the relation between the separation and reinforcement were quantitatively considered.

2 APPARATUS AND TESTED MATERIALS

The model tests with cyclic loads in a circular mold with a diameter of 500mm and 500mm height were performed. The test mold and materials are shown in Fig.1.

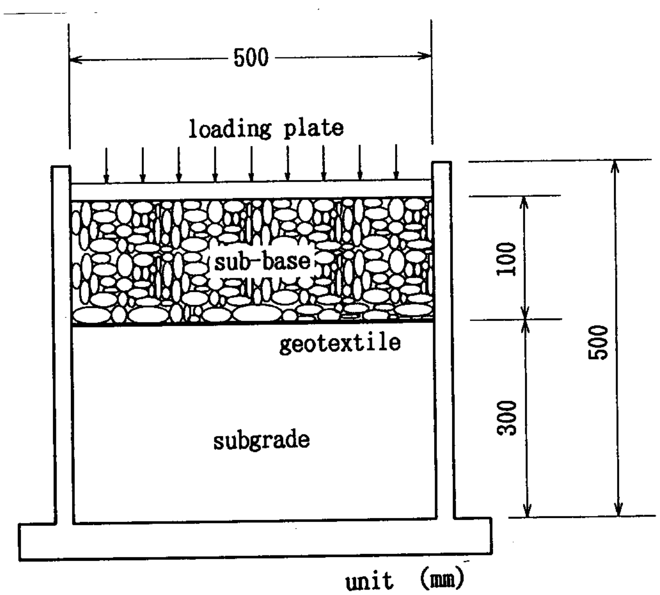

Fig.1 Test apparatus

Table 1 Properties of the geotextile samples

Samples	Method of manufacture	Thickness mm	Weight g/m2	Opening size mm	Tensile strength kN/m
HB-1	thermal	0.69	213	0.07	7.2
HB-2	bonded	0.58	113	-	7.8
HB-3	nonwoven	0.37	57	0.11	6.2
NP-1	needle	2.77	337	0.09	17.7
NP-2	punched	1.28	150	0.11	7.3
NP-3	nonwoven	2.46	322	0.10	16.7
MULT-1	multi-	0.53	346	0.14	57.3
MULT-2	filament	0.31	181	0.24	29.1
MULT-3	woven	0.56	352	0.014	51.1

The subgrade with 300mm deep was formed with kaolinite clay prepared at a required water content. The range of undrained shear strength of the soft subgrade clay by vane test were 2.0 and 5.0kPa. The sub-base layer with 100mm thickness was formed on the subgrade with gravel approximately 20mm diameter.

The geotextile was installed between the subgrade and sub-base layer without prestretching. The nine typical products were used for estimating the separation function, and their physical properties are listed in Table 1. The cyclic loads were applied by an air cylinder and their minimum and maximum cyclic stresses were 25kPa and 75kPa at frequencies of 1Hz, up to 30000 cycles.

3 PERFORMANCE OF GEOTEXTILE ON SEPARATION

3.1 Test procedure

In this test series, the effects of the properties of geotextile on the quantity of the fine particles movement through the geotextile were investigated. The cyclic load were applied on the full surface of the road model as shown in Fig.1. The pressure gage was installed in the subgrade soil to analyze the drain function of the geotextiles under cyclic load. This test simulates the condition that the soil particles are washed out or squeezed through the geotextile. After the cyclic loading test, the contaminated areas of geotextile were cleaned and the weight of the soil mass which had accumulated was measured.

3.2 Test results

Figure 2 shows the effect of opening size of geotextiles

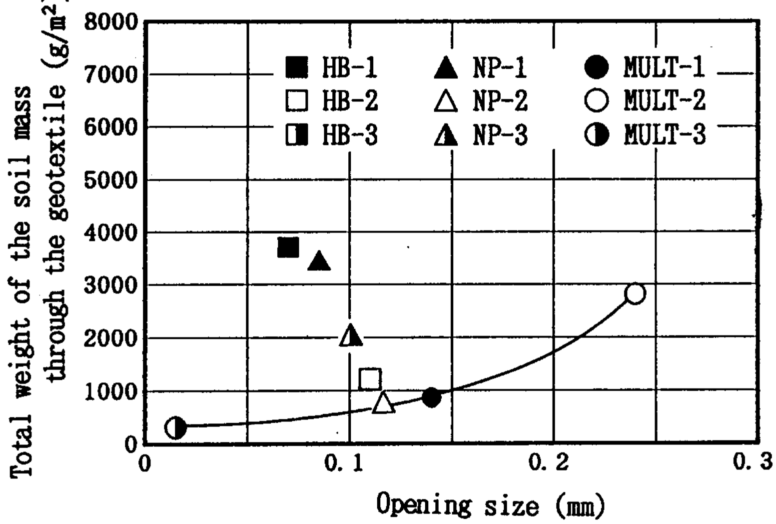

Fig.2 Effect of opening size on separation function

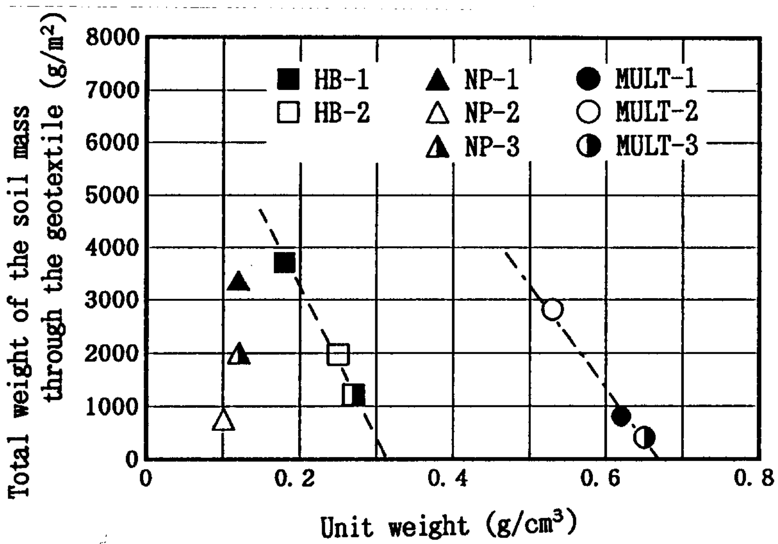

Fig.3 Effect of unit weight of geotextile on separation function

on the total weight of soil mass which were transported into the sub-base layer. Although the distinct relation can be seen on the results of the woven geotextiles, the relation on the nonwoven is unclear. The nonwovens have three dimensional structure and their opening sizes are not uniform. And the all nonwovens have approximately equal values of AOS of 0.1mm. So, it is difficult for the nonwovens to estimate the separation function by their opening size.

Figure 3 shows the rearrangement of the data to make clear the separation function by the unit weight of the geotextile. The relation on the result of each nonwoven appears clearly comparing the relations represented by opening size. It seems that the fiber density of the geotextile has remarkable influence on the separation function. The fiber densities of the nonwovens which are manufactured by the same method of production are

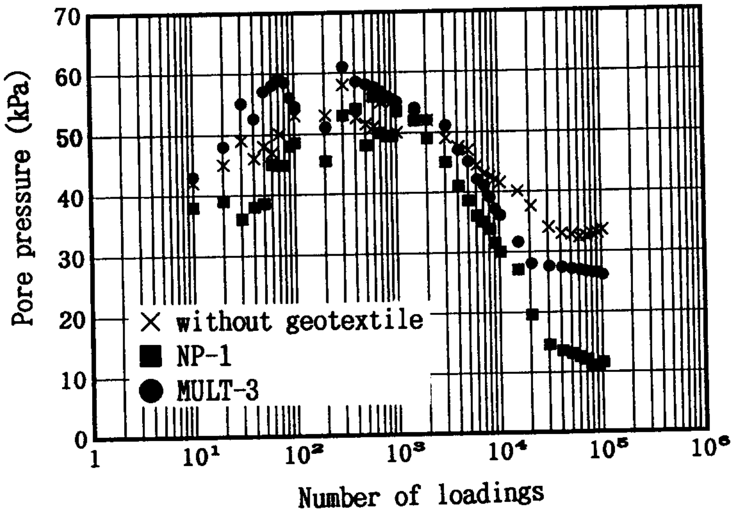

Fig.4 Pore pressure in subgrade soil under cyclic loading

approximately equal. So, the thickness and the unit weight of geotextile is available to the estimation of the separation function.

The measured results from the pressure gage installed in the subgrade soil are shown in Fig.4. The excess pore pressure in each case increases as the number of loading increase. Then the pore pressures decrease when the loading are in range beyond 1000 times, and the drainage effect of the geotextile appears gradually. It is clear from these test results the drainage function of the geotextile is effective for the stabilization of the soft subgrade soil. The problem of the clogging of geotextile is important, however it is unclear from this test results.

4 RELATIONSHIP BETWEEN THE SEPARATION AND REINFORCEMENT FUNCTION

4.1 Test procedure

The separation and reinforcement work simultaneously on the stabilization of the pavement systems. These two functions should be separated quantitatively to estimate each function.

The cyclic loads are locally applied at the center of the test models with 170mm diameter, and the load intensity and cycles are the same as the former series. The tests are carried out under the two kindsof placing area of the geotextile as shown in Fig.5. The geotextile sample of NP-3 shown in Table 1 is used in this test series.

In the first case, the geotextile is placed on the full surface of the subgrade soil shown in Fig.5(a). The reinforcement function is performed as the tensile force is developed in the geotextile and also the separation is simultaneously performed.

In the second case, the circular sample of geotextile with

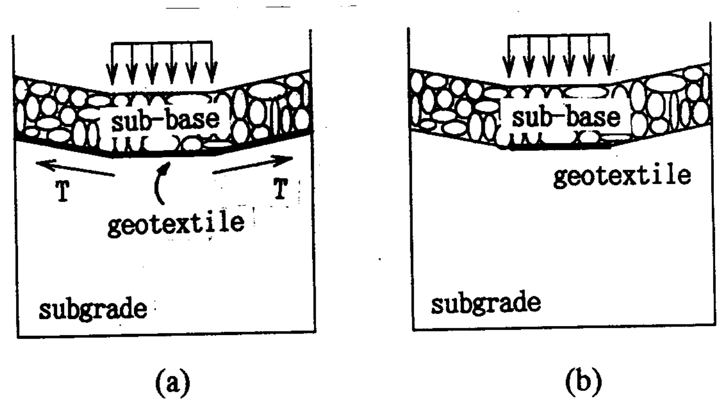

Fig.5 Two test cases for estimating the separation and reinforcement function separately (a) Both of separation and reinforcement are generated. (b) Separation only is generated.

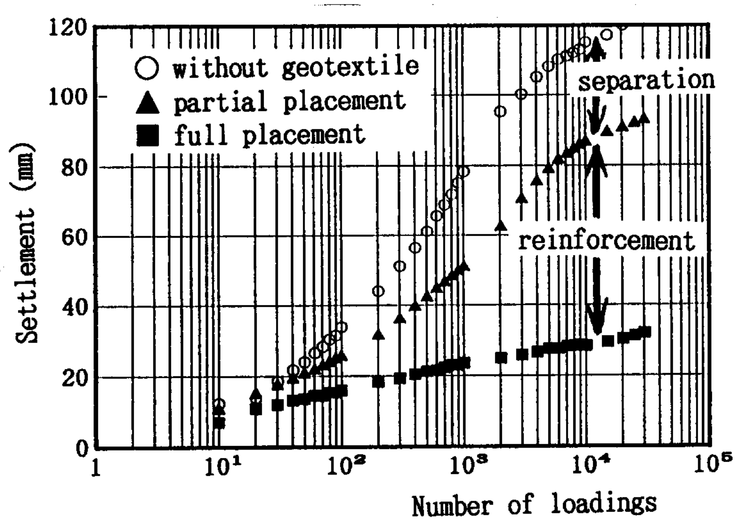

Fig.6 Settlement of test model at loading point

200mm diameter was partially placed on the center of the subgrade soil shown in Fig.5(b). The tensile force does not developed in this condition, and the consentrative movement of the soil particles occurs at the location under the loading area. So, it can be assumed that the reinforcement is absent and the separation only performed.

4.2 Test results

The settlement at the loading point under the cyclic loads in each case are shown in Fig.6. The difference between the case of the partial and the full placing can be taken as contribution of the reinforcement, and the difference between the case of partial placing and that without geotextile can be taken as the contribution of the separation. In this way, the each function is quantitatively expressed by the quantity of settlement.

Figure 7 shows the contributions of the reinforcement

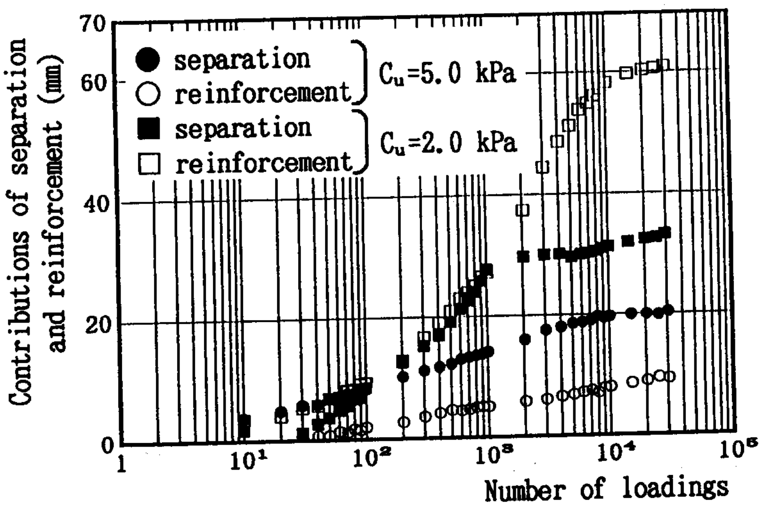

Fig.7 Contributions of separation and reinforcement function

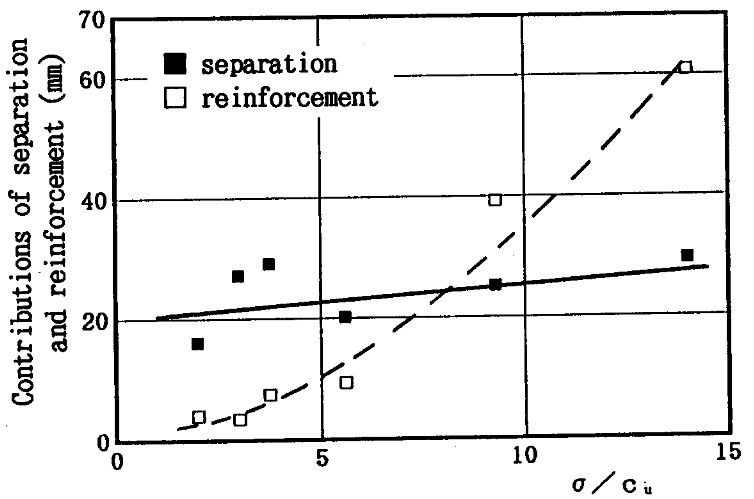

Fig.8 Relationship between the separation and reinforcement

and the separation function calculated separately according to the preceding method. The contribution of reinforcement increases as the number of loads increase when the subgrade soil has the low shear strength. The separation has a large effect comparing the reinforcement for the relatively high strength of the subgrade soil.

Figure 8 indicates the relationship between the strength of the subgrade soil and the contributions of the both functions. The abscissa is represent by the ratio of the vertical stress on the subgrade surface (σ) to the shear strength of subgrade soil(c_u). The stresses are calculated from the applied maximum load intensity by using Boussinesq's theory. The contributions of reinforcement and separation which are obtained from the settlement data at the loading cycles of 10000 are adopted in the ordinate. The contribution of the reinforcement increases rapidly with increasing of the ratio (σ /c_u). Namely, the reinforcement works as a prime function when the subgrade soil has a low shear strength. The separation is not influenced significantly by the ratio.

As seen from the Figure, the separation becomes the prime function in the region of σ /c_u<8 and reinforcement becomes the prime function in σ /c_u>8. It is possible to select the prime function for the stabilizing the pavement systems if the load intensity and the strength of subgrade soil are known. The reinforcement needs a large settlement to develop the effective function, however, it seems that the separation is basically independent to the settlement. So, the separation function of the geotextile is important for the design in both of common and temporary road.

5 Conclusion

The following results are revealed.

(1) Opening size of the nonwoven geotextile cannot be used to estimate the ability of the separation function. The unit weight of the nonwoven is available.

(2) The drain function of the geotextile under the cyclic loads can be anticipated over a long time.

(3) The reinforcement is a prime function when the ratio of the applied stress on the subgrade soil to the shear strength of the subgrade soil (σ /c_u) has a high value, however, the separation is a most important function when the ratio has a low value.

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