INTERFACE PARAMETER EVALUATION OF LANDFILL LINERS

Saravanan Mariappan[1], Masahi Kamon[2], Faisal Haji Ali[3],
Takeshi Katsumi[4], Toru Akai[5], Toru Inui[6], and Akira Matsumoto[5]

[1] Graduate Student, Graduate School of Global Environmental Studies, Kyoto University, Sakyo, Kyoto, 606-8501 Japan, Tel: +81-75-753-5114, Fax: +81-75-753-5116, e-mail: vanan.nexus@gmail.com
[2] Professor, Graduate School of Global Environmental Studies, Kyoto University, Yoshida Honmachi, Sakyo, Kyoto, 606-8501 Japan, Tel: +81-75-753-5114, Fax: +81-75-753-5116, e-mail: kamon@mbox.kudpc.kyoto-u.ac.jp
[3] Professor, Department of Civil Engineering, Faculty of Engineering, University Malaya, 50603 Kuala Lumpur, Malaysia, Tel: +603-7967-5341, Fax: +603-7967-5318, e-mail: fahali@um.edu.my
[4] Associate Professor, Graduate School of Global Environmental Studies, Kyoto University, Sakyo, Kyoto, 606-8501 Japan, Tel: +81-75-753-9205, Fax: +81-75-753-5116, e-mail: tkatsumi@mbox.kudpc.kyoto-u.ac.jp
[5] Senior Research Scientist, Technology Research Institute of Osaka Prefecture, 2-7-1 Ayumino, Izumi, Osaka 594-1157 Japan, Tel: +81-72-551-2734, Fax: +81-72-551-2529, e-mail: akai@tri.pref.osaka.jp and akimatumoto@tri.pref.osaka.jp
[6] Assistant Professor, Graduate School of Global Environmental Studies, Kyoto University, Sakyo, Kyoto, 606-8501 Japan, Tel: +81-75-753-5752, Fax: +81-75-753-5116, e-mail: inui@mbox.kudpc.kyoto-u.ac.jp

INTRODUCTION

Stability of landfills has been a major concern of the present environmental geotechnical engineering community. Failures at landfill sites can be minor, however the cost of rectifications are huge. As landfill sites generally used to contain solid waste of various kinds, which some cases can contaminate and harm the environment. Hence landfill failures could lead to serious environment pollutions. Engineers are required to be careful in not designing slope that exceeds the safe slope angle for liner components, internal properties and their respective interface parameters within the system. For example, an infinite slope consisting of cohesionless interfaces with no seepage, the factor of safety (F) is (Daniel et al. 1998) :

$$F = \tan \phi \ / \tan \beta \qquad (1)$$

Where, ϕ is angle of internal friction and β is slope angle. Strain incompatibility with municipal solid waste (MSW) could be another cause of stability failures. Example when failure occurs at first, in native soil, only a fraction of the MSW peak strength will be mobilized. Similar condition is also applied for geosynthetic interface and foundation soils because of their strain incompatibility with the adjacent materials in stability analysis (Hisham et al. 2000). Strain incompatibility could suggest the use of residual shear strength in stability analysis instead of peak shear strength. The soil-geomembrane interface acts as possible plane of potential instability of system under both static and seismic loading (Hoe et al. 1997). Hence environmental geotechnical engineers have strong concern about the potential instability caused by the waste containment liner system.

INTERFACE TESTING APPARATUS

The objective of this research is to study the interface shear strength of landfill liner materials. The list of interface test conducted dependent on the configuration and material used for landfill liner system and adopted for the research. The liner configuration used for research is shown in Fig. 1. The research configuration consists of both single and double composite liner system. The research is still under progress to study the interface performance under saturated condition for both single and double composite liner system. Fig. 2, 3 and 4 shows section of large scale shear box adopted for the research work for three different test conditions. Namely i) Case 1 – Interface testing between geosynthetic and geosynthetic, ii) Case 2 - Interface testing between geosynthetic and soil, and iii) Case 3 - Interface testing between soil and soil.

Bottom shear box size of 350 x 600mm and top box size of 250 x 500mm were used for the test. Larger 100mm bottom box was used to define test failure of 15 % to 20% relative lateral displacement of top box dimension. However, shearing surface contact areas were made to be similar for both top and bottom box of 250 x 500mm in size. Height adjustable bottom box base plate with spacer blocks were required to cater for variation in sample thickness and allowance for settlement or sample deformation during normal loading prior to shearing. Constant shearing speed of 1 mm/min was used for test normal loads of 100, 200 and 300 kPa for the interface tests. ASTM D3080 -98, ASTM D5321-02 and ASTM D6243-98 was referred for the modifications of the said shear box.

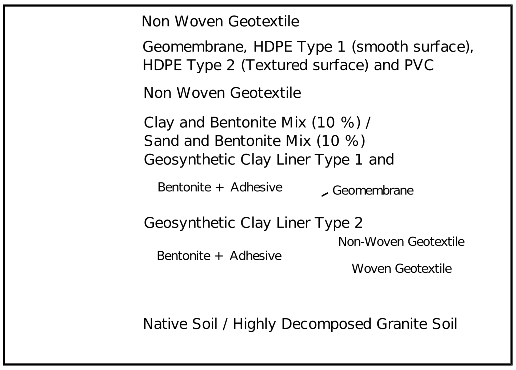

Fig. 1 : Landfill liner configuration used for the research

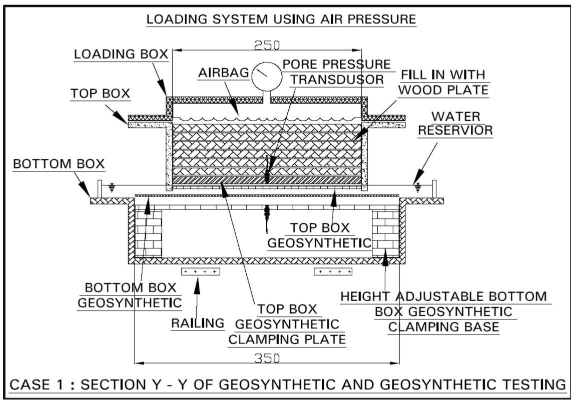

Fig. 2 : Case 1 – Modification adopted for geosynthetic and geosynthetic testing

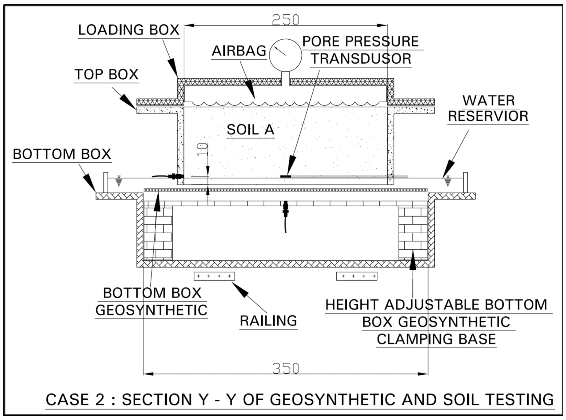

Fig. 3 : Case 2 – Modification adopted for geosynthetic and soil testing

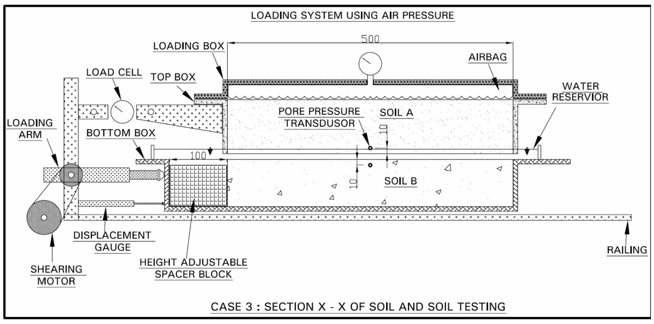

Fig. 4 : Case 3 – Modification adopted for soil and soil testing

TEST RESULTS AND DISCUSSIONS

1. Geotextile Interfacing With Geomembrane And Geosynthetic Clay Lines (GCLs)

Using peak shear stresses within 8% strain, geotextile interfacing with PVC and bentonite side of bentonite glued GCL Type 1, found to have high cohesion and frictional resistance. This could be due to plowing kind of effects created during shearing. The performance of HDPE was dominated by textured surface of HDPE. The weakest was between geotextile and both geotextile sides of needle punched GCL Type 2 and smooth HDPE Type 1. Details of test results are presented in Table 1 and Fig. 5. In Fig. 5 it shows clearly that smooth HDPE Type 1 stand out of the group as the lowest interface. Hence designers should avoid direct interface between smooth HDPE Type 1 and geotextile, and also geotextile of both woven and non woven sides of needle punched GCL Type 2 with geotextile.

2 Silt Bentonite Mixture (100 : 10) Interfacing With Geotextile And Geomembrane

The performances of silt bentonite mixture (100 : 10) with geotextile and geomembrane were relatively consistent with interface test results within narrow range of differences. Only fictional contribution was exhibited without cohesion. The performance of geotextile and smooth HDPE Type 1 was the lowest with fiction angle of 15° degrees. Textured HDPE Type 2 and PVC provide high and relatively consistent frictional resistance. Details of the test results are presented in Table 2 and Fig. 6 respectively. Eventhough smooth HDPE Type 1 and geotextile had low frictional resistance, the interface values are higher as compared to direct interface between geotextile and smooth HDPE Type 1. Hence it is proposed to sandwich smooth HDPE Type 1 or geomembrane in general within compacted clay liner (CCL) , shown in Fig. 7, rather than placing on top of geotextile, as shown in Fig. 8. Precautions are required to avoid damages on geomembrane during installation of compacted clay liner (CCL) due to direct contact. It is recommended to allow for some sacrificial thickness on geomembrane to resists major or microscopic puncture.

Table 1 : Test results of geotextile interfacing with geomembrane

Test	Interface Parameters	Cohesion (kN/m^2)	Friction Angle (^{O})
Interface Parameters Between Geotextile and HDPE, PVC, GCLs			
Test 1A	GEOTEXTILE & HDPE Type 1	0.0	7.6
TEST 2A	GEOTEXTILE & HDPE Type 2	3.2	21.1
TEST 3A	GEOTEXTILE & PVC (Rear Side)	11.1	18.7
TEST 3C	GEOTEXTILE & PVC (Front Side)	25.7	17.1
TEST 4A	GEOTEXTILE & GCL Type 1 (Bentonite side)	12.1	17.1
TEST 4C	GEOTEXTILE & GCL Type 1 (HDPE Side)	0.0	21.8
TEST 5A	GEOTEXTILE & GCL Type 2 (Non Woven Site)	1.5	15.1
TEST 5C	GEOTEXTILE & GCL Type 2 (Woven Side)	10.5	14.8

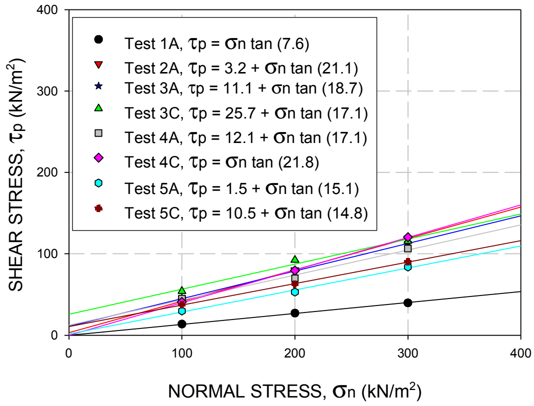

Fig. 5 : Summary of peak failure envelopes for geotextile interfacing with geomembrane.

Table 2 : Test results of silt bentonite (100 : 10) interfacing with geosynthetics

Test	Interface Parameters	Cohesion (kN/m^2)	Friction Angle (^{O})
Interface Parameters Between Geosynthetic and Silt Bentonite Mixture (100 : 10) CCL			
TEST 12A	GEOTEXTILE & SILT BENTONITE Mix(100 : 10)	0.0	15.3
TEST 13A	HDPE Type 1 & SILT BENTONITE Mix (100 : 10)	0.0	15.4
TEST 14A	HDPE Type 2 & SILT BENTONITE Mix (100 : 10)	0.0	24.2
TEST 15A	PVC (Rear Side) & SILT BENTONITE Mix (100 : 10)	0.0	22.2
TEST 15C	PVC (Front Side) & SILT BENTONITE Mix (100 : 10)	0.0	20.0

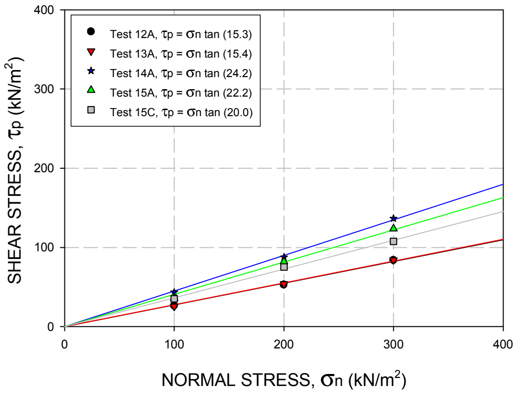

Fig. 6 : Summary of peak failure envelopes for Silt bentonite mixture (100 : 10) interfacing with geotextile and geomembrane

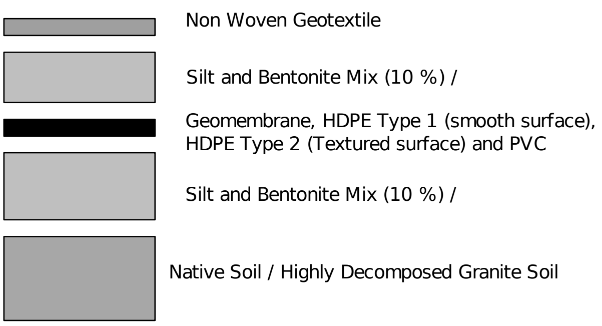

Fig. 7 : Single composite liner configuration

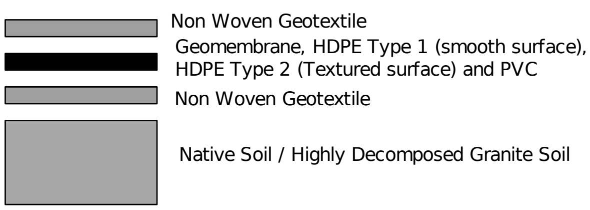

Fig. 8 : Single membrane liner configuration

3 Native Soil Interfacing With Geotextile And Geomembrane

The performances of native soil with geotextile and geomembrane were covered in wide range of friction angle. Only fictional contribution was exhibited without cohesions. The performance of geotextile, smooth HDPE Type 1 and rear side of PVC were the lowest with fiction angle of 15° to 19° degrees. Textured HDPE Type 2 provides high frictional resistance. Details of the test results are presented in Table 3 and Fig. 9 respectively. By comparing sand bentonite mixture (100 :10) (CCL) and native soil, the interface of geotextile and smooth HDPE Type 1 contribute higher interface property with native soil as compared to CCL of sand bentonite mixture (100 : 10). Lower interfaces were observed for textured HDPE Type 2 and rear side of PVC with native soil as compared to CCL of sand bentonite mixture (100 : 10). These could be higher damages created by native soil especially on texture HDPE Type 2.

Table 3 : Test results of native soil interfacing with geosynthetics

Test	Interface Parameters	Cohesion (kN/m^2)	Friction Angle (^{O})
Interface Parameters Between Geosynthetic and Native Soil (HW Granitic Soil)			
TEST 26A	GEOTEXTILE & NATIVE SOIL	0.0	17.8
TEST 27A	HDPE TYPE 1 & NATIVE SOIL	0.0	15.6
TEST 28A	HDPE TYPE 2 & NATIVE SOIL	0.0	23.1
TEST 29A	PVC (Rear) & NATIVE SOIL	0.0	18.7

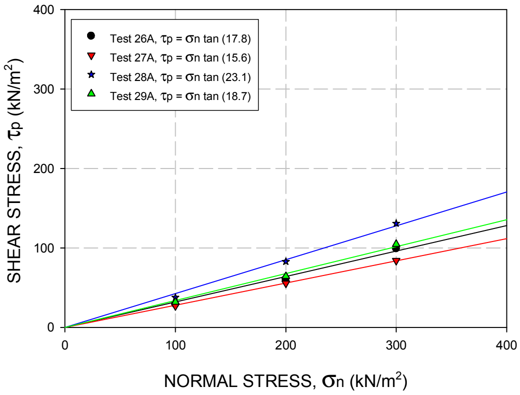

Fig. 9 : Summary of peak failure envelopes for native soil interfacing with geotextile and geomembrane

CONCLUSIONS

By analyzing further the interface strength parameters, example in the case of single member liner there were different in failure strain between geotextile, geomembrane and native soil. As HDPEs are commonly used in landfill liners, the findings from this research conclude the following recommendations to improve HDPE, namely (1) Softer HDPE material, however firmer or harder than PVC, (2) HDPE with ability to mobilize larger strain before preliminary peak forces are reached, and (3) Imprint textured HDPE is proposed against blowed film texture HDPE (textured HDPE Type 2) since the film is sheared easily during interface shearing even with geotextile. Imprint texture of zigzag pattern having 0.2 to 0.5 mm height and 2 mm width is recommended to be imprinted on both sides of HDPE during manufacturing. It is also recommended to apply minor tension within elastic deformation of HDPE before the zigzag patterns are imprinted. Data from the interface test results obtained from this research could be analyzed further by engineers case by case to improvise liner design. The information obtained will be useful in selecting suitable landfill liner configuration without compromising on landfill stability and hydraulic conductivity prior to detailed design.

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