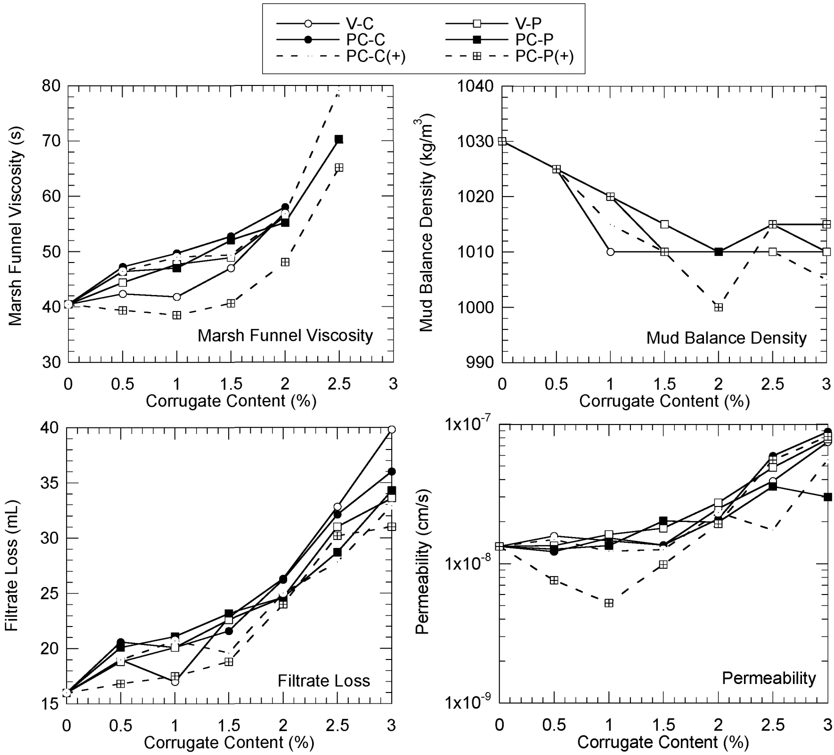

Fig. 2. Engineering Properties of Slurries

The additional blending time for the post-consumer samples had a more pronounced effect on engineering properties of the slurries containing pizza box fibers than the c-flute box fibers. The greater differences were attributed to the breakdown of greasy film on the pizza box allowing access to water and softening during the extended blending. In comparison, the c-flute fibers had already sufficiently broken down after 2 min. of blending and additional blending did not change the behavior significantly.

CONCLUSIONS

Tests were conducted to assess the feasibility of using corrugated board in slurry applications. Bentonite used in typical slurry mixtures was replaced by fiberized corrugated board at varying ratios. Properties of bentonite-corrugated board-water mixes were compared to baseline bentonite-water slurry mixes to evaluate the influence and practical limits of corrugated board addition to the mixes. The results indicated that the corrugated board could be used to replace 9 to 27% (corresponding to 0.5 to 1.5% corrugate content in a 5.5% mixture) of the bentonite used in the slurry mixes based on Marsh funnel viscosity, density, and filtrate loss tests. Corrugated board may be used to replace up to 36% of bentonite (2.0% corrugate in a 5.5% mixture) for specific site and construction conditions requiring high MFV. In addition, permeability of the mixes with corrugated board was similar to baseline bentonite-water mix permeability. The differences in engineering properties of the slurries containing corrugate content were attributed to the presence of a fibrous matrix that influenced viscosity and flow characteristics. Overall, slurry applications provide a new and viable beneficial reuse alternative for paper / paperboard products, which constitute the largest weight and volume fraction of municipal solid waste generated and disposed of in the U.S. as well as other countries.

ACKNOWLEDGMENTS

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Analysis on Tensile Force of Liner System with the Variation of Location of Roller Compactor in Landfill

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ABSTRACT: A liner system is installed on the bottom and the side slope of a waste landfill. Tensile forces can occur due to waste compaction which is transferred into the geosynthetics by friction. The long term design strength of the liner system placed on side slope in landfill may be determined by creep rupture strength, so it is very important to estimate the amount of tensile force created in the liner system, especially on the shoulder of liner system in the course of filling. In this research, centrifugal model experiments and FEM analyses are conducted to study the variation of tensile force created at the shoulder of liner system with the variation of roller compactor's location.

INTRODUCTION

Waste landfill should be designed that no leachate that may include hazardous materials flows into the surrounding ground and water over its design life. A liner system is installed on the bottom and the side slope of a waste landfill to prevent the leachate from infiltrating into surrounding ground and polluting groundwater (Wang and Wang 2004). The liner system is considered to experience various forces, such as tensile force induced by settlement of base ground (Knipschild. 1984), thermal stress due to decrease of temperature (Imaizumi et al. 1999), lifting force by the wind (Zornberg and Giroud 1997), tensile force by compaction work of disposed waste (Xu and Imaizumi 2003). The long term design strengths of the liner system are usually controlled by creep rupture within the design life. Creep strain would occur if the tensile forces of the liner system remain constant over a sufficiently long period of time, and it can lead to creep rupture if the strain exceeds the limit strain (Ingold et al. 1994), so it is very important for the design of the liner system to determine the tensile force induced in components of the liner system, especially on the shoulder of HDPE geomembrane with the location of roller compactor (Hullings and Sansou 1997). But it is not clearly understood how the tensile force acting on the liner system due to the compaction work varies with the location of the roller compactor in landfill. In this paper, the variations of tensile force created at the shoulder of the liner system with the location of roller compactor are studied.

INTERFACE FRICTION CHARACTERISTICS

The characteristics of the studied geosynthetic materials at 20℃ are listed in Table 1. Incinerated ash from municipal waste is used to represent disposed waste in landfill, its cohesion and friction angle are 8 kPa and 36.5°, respectively. Water content of the incinerated ash is 41%.

Table 1. Mechanical Properties of Geosynthetics.

Material	Thickness (mm)	Tensile strength (MPa)	Elastic modulus (MPa)
HDPE geomembrane	1.5	35.3	484
Non-woven geotextile	10	1.4	6.5

The interface friction angles between the incinerated ash and non-woven geotextile, HDPE geomembrane and non-woven geotextile are 12.5° and 19.7°, respectively.

CENTRIFUGAL MODEL TESTS

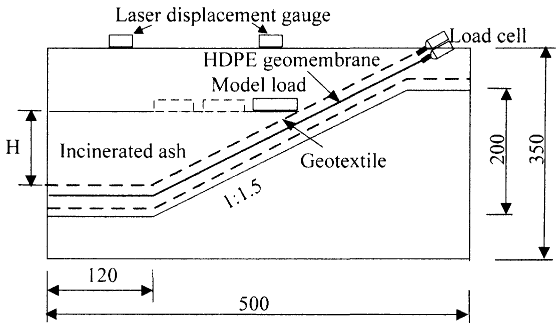

FIG.1. Configuration of the centrifugal model.

The model landfill as shown in Fig.1 is placed in a steel container having a length of 500 mm, a width of 260 mm and a depth of 350 mm. The foundation and slope of the model landfill are made of gypsum. The slope of the model landfill is 1:1.5(V:H) with a height of 200 mm. Non-woven geotextile is then glued to the surface of the model landfill which is then covered by an HDPE geomembrane with a thickness of 1.5 mm. A protective layer of non-woven geotextile is spread over the HDPE geomembrane which is then covered on the surface by incinerated ash. The model is accelerated to about 37 g in the centrifuge. The tensile forces induced within the top non-woven geotextile and HDPE geomembrane are measured through load transducers of 196 N and 490 N which are fixed at the top of the slope.

Incinerated ash is poured into the model landfill. Its wet density is approximately 820 kg/m^3. Acceleration of the centrifuge is increased at a rate of 5 g/min to a maximum of 37 g(g is gravitational acceleration and equals to 9.8m/s^2), a 150 mm height in the model is equivalent with a 5 m height of waste landfill in the prototype. The tensile forces of HDPE geomembrane and non-woven geotextile and the acceleration are recorded by computer at each 5 g interval in acceleration.

To evaluate the influence of the location of roller compactor on tensile force of liner system for constant height of incinerated ash, the model load of 47.4 kPa (37g) is applied on the surface of incinerated ash to simulate the roller compactor. The distance from the model load to the slope liner system is also varied at 0, 70, 140 mm.

RESULTS OF TESTS

The measured tensile forces created at the shoulder of HDPE geomembrane and non-woven geotextile with model load applied on the surface of incinerated ash are shown in Fig.2 and Fig.3.It is found that the tensile forces of HDPE geomembrane and non-woven geotextile increase significantly, and as the distance from model load to slope liner system becomes larger, the tensile forces of HDPE geomembrane and non-woven geotextile decrease. For example, the tensile force of HDPE geomembrane increases from 0.26 kN/m to 0.72 kN/m when the model load is applied on the surface of incinerated ash, the increment of tensile force is larger than that of tensile force created by incinerated ash. The tensile force of non-woven geotextile also increases from 0.25 kN/m to 0.47 kN/m. But the tensile forces of HDPE geomembrane decrease from 0.72 kN/m to 0.63 kN/m when the distance increases from 0 mm to 140 mm.

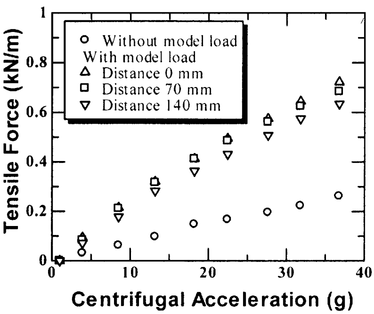

FIG. 2. Measured tensile force. (geomembrane).

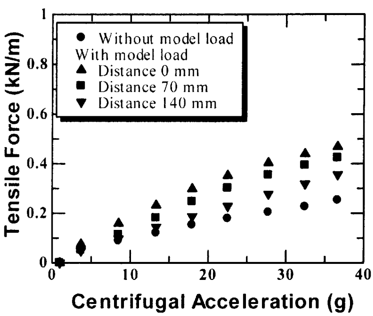

FIG. 3. Measured tensile force. (geotextile).

FEM ANALYSIS

The finite element meshes and boundary conditions are shown in Fig.4. It is possible to displace freely between incinerated ash and steel container in the vertical direction, and the HDPE geomembrane and non-woven geotextile at the shoulder are fixed. The quadrilateral element and triangle element are used to model the incinerated ash, and the geosynthetics were modeled by quadrilateral element. The interfaces between different materials are modeled by joint element to simulate the transfer of frictional stresses through them.

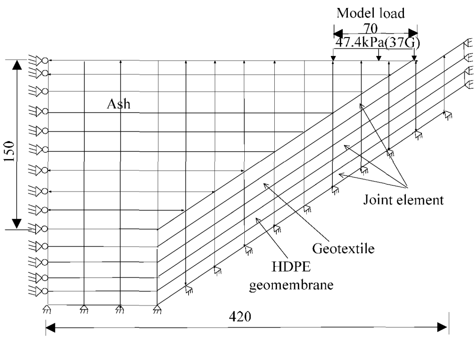

FIG. 4. Finite element mesh.

The stress-strain response of the incinerated ash is modeled by Duncan-Chang model (Duncan and Chang 1970). The tangential modulus can be expressed

$$E_t = \left(1 - \frac{R_f(1-\sin\phi)(\sigma_1 - \sigma_3)}{2c\cos\phi + 2\sigma_3\sin\phi}\right)^2 kP_a\left(\frac{\sigma_3}{P_a}\right)^n \tag{1}$$

Where σ_1 and σ_3 are maximum and minimum principal stresses, respectively; R_f is failure ratio; c and ϕ are cohesion and friction angle, respectively; P_a is atmospheric pressure; k and n are experimentally determined constants according to direct shear tests. The friction angle and cohesion of the incinerated ash are 19.7° and 1.3 kPa, respectively.

The HDPE geomembrane and non-woven geotextile are treated as a linear elastic materials and secant modulus at a strain of 1% (Table 1) is applied in the analysis.

The shear stiffness K_{st} of interface ahead of the peak shear stress can be expressed as follows

$$K_{st} = \left(1 - R_f\frac{\tau}{\tau_f}\right)^2 k\gamma_w\left(\frac{\sigma_n}{P_a}\right)^n \tag{2}$$

Where, τ and σ_n is shear stress and normal stress at the interface; τ_f is shear stress at failure; γ_w is unit weight of water.

The interface shear strength τ_f can be expressed as a function of the normal stress by Mohr-Coulomb failure criterion.

Beyond peak value, the interface shear stress is assumed to be constant. The parameters of interfaces used in the analysis are shown in Table 2.

Table 2. Analysis Parameters.

Interface or materials	k	n	R_f
Incinerated ash-geotextile	11.65	1.06	0.82
HDPE geomembrane-geotextile	3.90	0.84	0.78
Incinerated ash	63.2	0.83	0.81

The calculated tensile forces of HDPE geomembrane and non-woven geotextile are shown in Fig.5. Irrespective of distance from model load to slope liner system, the calculated values of HDPE geomembrane are smaller than the test values, about 0.76-0.90 of the test values.

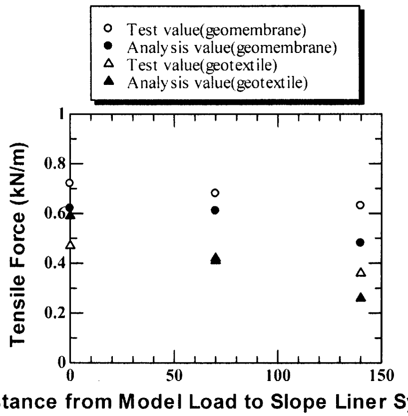

FIG. 5. Relationship between calculation and test values.

The relationship between temperature t and secant modulus $E_{1\%}$ of HDPE geomembrane can be expressed as:

$$E_{1\%} = 784 \cdot 10^{-0.0102t} \quad (3)$$

The elastic modulus of HDPE geomembrane used for FEM analysis is data of 20℃, but the test temperature is 14℃, so the elastic modulus of HDPE geomembrane used is smaller than the test value, the deviation between calculated values and test values is generated.

The calculated values of non-woven geotextile are about 0.72-1.25 of the test values.

The test values are larger than the calculated values except at 0 mm distance of model load to slope liner system.

CONCLUSIONS

This paper describes the influence of the location of roller compactor on tensile force creating at the shoulder of liner system. As the distance from model load to slope liner system becomes larger, the tensile forces of HDPE geomembrane and non-woven geotextile decreased. Effects of model load on the tensile forces of HDPE geomembrane and non-woven geotextile are significantly.The tensile forces of HDPE geomembrane and non-woven geotextile analyzed by FEM are consistent with those obtained by centrifugal model test in general. The calculated values of HDPE geomembrane are smaller than the test values, about 0.76-0.90 of the test values. The calculated values of non-woven geotextile are about 0.72-1.25 of the test values.

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pH Changes in Solidified Dredged Materials

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ABSTRACT: The cement-based solidification is recently considered as an alternative option to reuse the dredged materials as engineering fills. As the solidification involves hydration reactions, the pH value of the solidified soil can change which may affect the surrounding environment after its placement. Thus the pH value of the solidified dredged material is one of the key factors which govern its suitability as fill materials. In this study, the effects of the type of additive, curing method and curing time on the change in pH value of a solidified dredged material were investigated. Four different additives (cement, fly ash, gypsum and rice straw powder) were used. The solidified samples were cured under either humidity controlled or exposed conditions. The curing period ranges from 1 to 60 days. The test results show that among the four additives used in the study, cement gives a more substantial increase in the pH value than the other three additives. Regarding the curing conditions, samples cured under humidity controlled condition exhibit higher pH value than those cured under exposed condition.

INTRODUCTION

Dredging is commonly employed to improve water quality of rivers and lakes and ensure the ability of river for flood discharge and navigation. As a result huge amount of high water content and low strength dredged materials are produced (LUO Qing ji et al., 2005). Land and ocean disposal are the traditional methods for treating the dredged materials in China. Besides the disposal methods, cement-based solidification is recently considered as an alternative option to reuse the dredged materials as engineering fills (Zhu Wei et al., 2005). As the solidification involves hydration reactions, the pH value of the solidified soil can change which may affect the surrounding environment after its placement. Besides, the leachability of heavy metals (if any) entrapped in the solidified soil is significantly affected by the soil pH value (Sanchez et al., 2005). Thus the pH value of the solidified dredged material is one of the key factors which govern its suitability as fill materials.

Previous studies show that the additive was an important factor affecting the pH of mixture materials (M. Kimura et al., 2000; C.Q. Wang et al., 2004). Curing method, such as curing sealed or curing exposed to air, also affected the pH change of materials (R.E.H. Sweeney et al., 1999). In this study the effects of the type of additive, curing method and curing time on the change in pH value of a solidified dredged material were investigated. Four different additives (cement, fly ash, gypsum and rice straw powder) were used. The treated samples were cured under either humidity controlled or exposed conditions. The curing period ranged from 1 to 60 days. The objective of the study is, through the laboratory tests, to provide a scientific basis for controlling the pH of solidified soil used in practical engineering.

MATERIALS AND METHODS

Materials

The dredged material was taken from Taihu Lake, China and its main physical properties are summarized in Table 1. Four additives were used: Ordinary Portland cement (OPC), fly ash, semi-hydrated gypsum and rice straw material (drying below 60°C and grinding into powder).

Table 1. Physical properties of dredged material

Water content (%)	Density (g/cm^3)	Specific gravity	Void ratio	Organic matter content (%)	Plastic limit (W_P) (%)	Liquid limit (W_L) (%)	Plasticity index (I_P)	pH
104	1.48	2.64	2.7	4.7	18	33	15	6.89

pH test

First, the dredged material and additives were mixed thoroughly inside a mixer. Then some mixtures were sealed by polyethylene bags and cured at temperature around 20°C and humidity greater than 90%. The other mixtures were placed on the plexiglass plates and exposed to air. After curing for the target time, the pH of solidified soil was measured according to the methods specified by (ISO 10309: 2005). The mixture samples were first dried in an oven at 40°C, and pulverized to pass through a 2mm sieve. Then the powder samples were extracted at a liquid to solid (L/S) ratio of 5 ml/g in capped polypropylene bottles, stirred for 60 min, and the pH was measured by using a PHS-3C pH meter.

RESULTS AND DISCUSSION

Effect of additives

(1) OPC