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Application of geosynthesis on Tianziling landfill and correlated geotechnical problems

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ABSTRACT: The first Tianziling landfill is located in a valley in hills some 20 kms to the north of Hangzhou City, The new Tianziling landfill is constructed in the same valley, with its dam far away about 400 m from the first refuse dam, and will cover the existing landfill. For protecting the around environment and minimizing the potential groundwater contamination, geosysthetics liner systems will be applied; it is very important to solve the correlated geotechnical problems about the liner systerm, including stabilization and non-uniform settlement on the first landfill. Since the existing landfill slope will be the new landfill foundation, it is also neccary.

1 INTRODUCTION

The first Tianziling landfill in Hangzhou is is located about 20 kilometers north to the downtown in a valley named Qing Long. Tianziling landfill is the only landfill in use in Hangzhou. The landfill is a typical valley one and was entered into use at April, 1991. It disposes 600 tons of MSW per day and has been in serve over 13 years. The second Tianziling landfill will be constructed in the same valley, with its dam about 400 m far away from the first refuse dam, and will cover the existing landfill. Its' bottom level is 50 meters and the final top level will reach up to 165 meters. It will be permitted for 22,020,000 m^3 of waste placement with 24.5 years service life. The deepest vertical depth will reach nearly 100 meters. The section of the landfill is designed in terrace shape and showed in Fig. 1. The total investment is 36,028,750 dollars. Now the bottom geosynthetics system is carried on construction, as shown in Fig. 2.

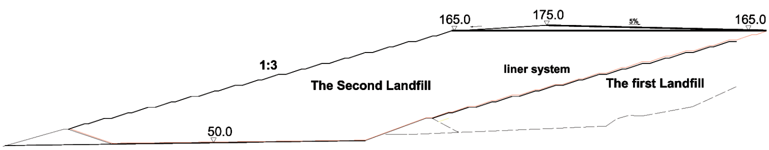

Figure 1. Cross-section of the second Tianziling landfill.

Figure 2. Construction of bottom geosynthetics system.

2 DESIGN OF THE LINERR SYSTEM

Waterproof technique is a key to MSW sanitary landfills. Leachate or gas produced during fill process must be prevented from polluting surrounding environment, and reducing the amount of leachate. The impermeable effect and the engineering construction investments depend on the configuration of the liner system directly.

According to the hydrology and geography environment of Tianziling, and the temporal economic condition and local techniques, an technique named vertical cement grouting was adopted in the first landfill, which is popular used as waterproofing technique in foundation pit. Through the run of more than ten years, slightly pollution was monitored in the downstream groundwater, the impermeable effect is not very successful. In order to reduce the water resources pollution, a combined method which mean both geosynthetic liner system and vertical cement grouting are adopted together in the second landfill.

Liner system with HDPE as the core liner and the GCL as the accessorial one are adopted for the second landfill. Three liner systems used on different surface are designed as follows:

2.1 *Bottom liner system*

The composite liner system used under the base of the second landfill is generally as shown in Fig. 3. The foundation of the base is compacted clay (30 cm thick) which comes from construction. The geomembrane is a HDPE liner, one of which is rough and the other is smooth.

2.2 *Slope liner system*

Surface of the slope can be classified as soil and rock. A liner system similar to bottom shown in Fig. 3 is used on the side slopes, with the following exceptions:

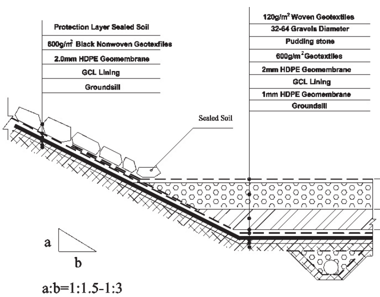

Figure 3. Bottom and slope liner systems.

The 40 cm gravel drainage layers are not included. The protective pudding stone does not extend up the slope.

Soil bags are layed as protective liner and leachate collection system. The rock slope is put on the cement sand evenly.

2.3 *Interval liner system between the old and new landfill*

The first landfill covers will become the bottom of the second landfill. In order to reduce the leachate yield, the old landfill will be covered up with internal liner systerm. To prevent the leachate from the 2nd landfill entering, then the leachate of the old landfill only comes from the MSW biodegradation. The liner system is also HDPE and geocomposites. The form of the interval liner system between the old and the new landfill are shown in Fig. 4.

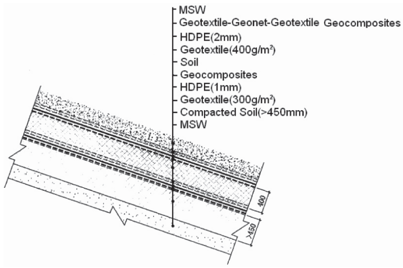

Figure 4. Interval liner system between the old and new landfill.

3 NON-UNIFORM SETTLEMENT OF GEOSYSTHETICS ON THE FIRST LANDFILL

It's not difficult to understand that considerable settlement as well as non-uniform settlement of this liner system will occur under the pressure of upload. And it is essential to calculate the settlement to help the design of this liner system.

According to test results and records (Chen, Ke 2001), the parameters for Tianziling landfill can be defined. And the settlement and non-uniform settlement of the first landfill are calculated (Chen, Ke 2001). It can be seen from the result (Fig. 5) that considerable settlement and deformation will occur in the first landfill's cover system under the upload pressure and decomposition effects. The curvature of the final cover is especially high at the site vertical to the toe of the dam. This condition may lead to the tearing of HDPE, so the anti-ooze effects of the cover system will be reduced greatly.

4 THE LANDFILL STABILITY ANALYSIS

This paper adopts Reame and Lizheng software which are both based on the simplifid Bishop method are

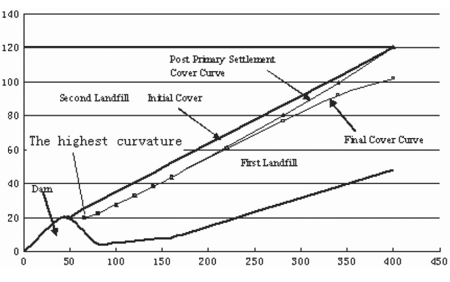

Figure 5. Non-uniform settlement of geosysthetics on the first landfill.

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used to analyze the two landfills stability. Analytical process and results are as follows:

4.1 *Static stability analysis of the two landfills*

According to the indoor experiment result (Chen, Ke 2001) and the geotechnical reports, the cross section of the 1st landfill and the 2nd landfill are shown in the Fig. 6 and Fig. 7 respectly. The phreatic surface of the 1st landfill is measured on site and two phreatic surfaces (one is higher and the other is lower) are supposed for calculation.

The safety factor calculated by Reame is 1.399, and 1.457 by Lizheng.

According to the analysis, the results calculated by the two softwares are generally in accordance and the first landfill is safe.

The parameters of the second landfill are the same as the first. The safety factor of Reame and Lizheng are both 1.960 at the low water level shown in Fig. 7. But the minimum safety factor for the high water level is 1.230. Generally speaking, the stability of the landfill was greatly influenced by the position of water level. The landfill will be in danger when the height of the phreatic line surpass the high level.

4.2 *The liner system stability*

Laboratory shear testing results indicate that many common interfaces between components in the waste containment system exhibit strain-softening behaviour. Peak shear strength decreases and soon approaches a residual value. The difference between peak and residual strength is sometimes great, for example the interface strength between HDPE and geotextile, from 32.0° to 14°. The interface strength tests of the liner system have not been taken on in this paper, and the results done by other scholars were refered as shown in Table 2. The lowest interface strength is the smooth HDPE-geotextile interface above the slope and the interface between smooth HDPE –clay on the bottom in this system.

Three different assumptions regarding interface strength were adopted: (1) peak strength along the entire sliding interface; (2) peak strengths along the base of landfill and residual strengths on the back slope; (3) residual strengths along the entire sliding interface.The result of these analysis is shown in Table 3.

The analysis results reveal that when smooth HDPE is applied to the interface, the safety factor for the entire interface (shown in Fig. 8) is 1.083, or say,

Talbe 1. The minimum safety factor under static instance.

	The first landfill		The second landfill	
	Reame	Lizheng	Reame	Lizheng
static	1.399	1.457	1.960	1.960

Table 2. Interface strength in liner system of the 2nd lanfill.

	Peak		Residual	
	C (kpa)	δ°	C (kpa)	δ°
Textured HDPE-nonwoven GCL	0	23.7	0	15
Smooth HDPE-Geotextile	0	18	0	14
HDPE-Geocomposites	0	25	0	15
Smooth HDPE-Clay	0	10.4	0	8

Table 3. Results of interface stabilization analysis.

Analysis method	Interface strength Base	Back slope	Safety factor
Reame	Peak (10.4°)	Peak (18°)	1.305
Reame	Peak (10.4°)	Residual (14°)	1.212
Reame	Residual (8°)	Residual (14°)	1.083

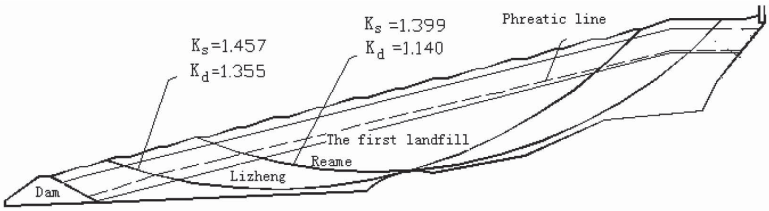

Figure 6. The calculation cross section of the first landfil.

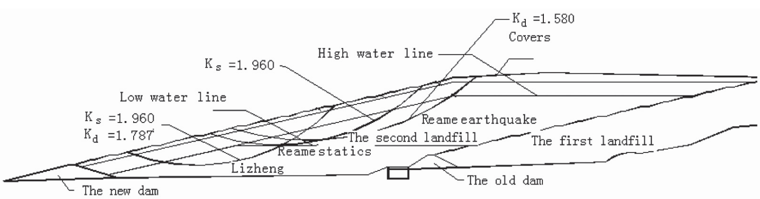

Figure 7. The calculation cross section of the second landfil.

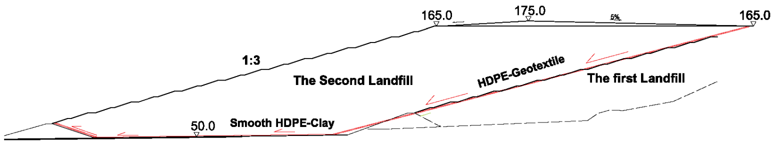

Figure 8. Slippage surface of the liner system.

stability failure may occur when the MSW is filled to the designed maximum level.

5 CONCLUSION

This paper introduces the liner systems used in the 2nd landfill, the bottom liner system, including the slope liner system and the interval liner systerm. HDPE geomembrane and GCL are used as the main liners.

Considerable settlement and deformation will occur in the first landfill's cover system under the upload pressure and decomposition effect. According to the result of non-uniform settlement, HDPE would be teared at the site vertical to the toe of the dam.

This paper adopts Reame and Lizheng software to analyze the two landfills stability. The first landfill satisfied the need for static stability. But the stability of the 2nd landfill is upon the head of the phreatic line greatly. As much as effort should be put into dropping the height of water level by means of effective measure of design and construction; The lining system is a potential failure surface for the second landfill and smooth HDPE shouldn't be used in the lining system, especially the interfaces between the two landfills and those abut on clay.

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