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Advantages of the secondary textured high density polyethylene geomembrane in a sanitary landfill

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ABSTRACT: The secondary textured High Density Polyethylene (HDPE) geomembrane is manufactured through a secondary texturing process on smooth HDPE geomembrane. Due to the specialty of the secondary texturing process, it is the only manufacturing process of textured product without sacrificing the properties of the smooth base material. As a result, the secondary textured HDPE geomembrane combines the superior mechanical properties (such as tensile strength at break and elongation at break) of the smooth HDPE geomembrane and the enhanced interfacial frictional properties of textured surfaces, which make it an excellent liner candidate for engineering applications with large settlements and concerns on the interfacial stability of a multilayered liner system. This paper introduces the advantages of the secondary textured HDPE geomembrane, quality assurance, and its application in a large municipal sanitary landfill in China.

1 INTRODUCTION

This paper describes the application of 1.5 mm secondary textured HDPE geomembrane of more than one million square meters for the Laogang municipal sanitary landfill Phase IV project over soft ground in Shanghai, China.

The Laogang Landfill Phase IV project site is located at Laogang Town, along the beach of the Eastern Sea, and it is at the eastern side of the existing Laogang Landfill. The site is located on the tidal zone and vegetation consists of bulrushes and grasses. The site measures about 4,200 m from south to north and approximately 810 m from east to west (Zhao and Zhu 1999).

The physiognomy of the Laogang Landfill site belongs to tide flat category. The foundation soils consist of sediments which are mainly comprised of saturated clays, silts and sands. The foundation soils in the depth of 30 meters can be classified into three major layers, namely, alluvial fill (up to 3.0 m thick), grey sandy silt and silty clay (about 7.0 m thick, permeability about 1.0×10^{-4} cm/s), silty clay interbedded with a few thin silty sand layers (about 20.0 m thick, clay permeability about 1.0×10^{-7} cm/s) (Zhao and Zhu 1999). The water content of soils range from 30% to 51%, generally with higher water content at the shallower depth.

2 THE LINING SYSTEM DESIGN

Since the permeability of subsoils immediately under the landfill is higher than the required 1.0×10^{-7} cm/s, an artificial liner system is required according to the landfill liner regulation in China (CJJ 17 1989). A composite liner system with HDPE geomembrane as the primary liner component to prevent the leachate from a landfill has been proved to be a cost-effective and widely accepted design in modern landfill construction (US EPA 1991). As a large scale municipal landfill close to some surface water bodies and with permeable soil layers at site, it is crucial to have a secured liner system to contain the leachate inside the landfill in order to prevent the environmental impact in the long term. As a result, a double geomembrane liner is designed for this purpose. The components of the liner system from top down are geotextile filter, granular layer for primary leachate collection and removal, geotextile protection layer, 1.5 mm textured HDPE geomembrane as the primary liner, geocomposite drain layer as the leachate detection and removal layer, 1.5 mm textured HDPE geomembrane as the secondary liner, geotextile cushion, granular layer to remove underneath water and geotextile filter, as illustrated in Figure 1.

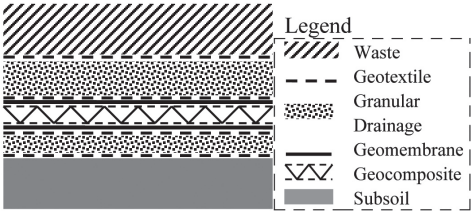

Figure 1. The bottom liner and drainage system.

3 CHARACTERISTICS OF SECONDARY TEXTURED HDPE GEOMEMBRANE

HDPE geomembrane is made from polyethylene resin with a small amount of carbon black and antioxidants. It is a liner material to barrier the flow of liquors and gases in containment applications. There are two common manufacturing processes to produce HDPE geomembranes, one is Flat Cast Extrusion Process, and the other is Round Die Co-extrusion Process (Koerner 1997). Both processes can produce smooth and textured geomembranes (You 2002). The mechanical properties of smooth geomembranes from the two processes are approximately same. But there are some significant differences in mechanical properties of their textured products. Table 1 is a comparison of the typical mechanical specification values between these two types of 1.5 mm textured HDPE geomembranes. As shown in Table 1, the tensile strength at break of secondary textured HDPE geomembrane is more than twice that of the round die product, elongation at break is four times, and the puncture resistance is more than 10% higher.

Table 1. Comparison of mechanical properties between two textured 1.5 mm HDPE geomembranes.

Properties	Test Method	Round Die Textured	Secondary Textured
Tensile properties	ASTM D 6693		
Break strength	Type IV	16 N/mm	37N/mm
Yield strength		23 N/mm	23N/mm
Break elongation		150% 13%	600% 13%
Yield elongation			
Tear resistance	ASTM D 1004	187N	187N
Puncture resistance	ASTM D 4833	480N	530N

Concerning a large settlement and/or differential settlement can be expected at the landfill subsoil since the soft ground of the landfill base is to be strengthened by Prefabricated Vertical Drain (PVD), a large tensile strength and elongation at break value is essential for the textured geomembrane product to accommodate the excessive settlement induced from the soft ground improvement. **GSE HD Friction Flex**, a secondary process textured HDPE geomembrane with smooth

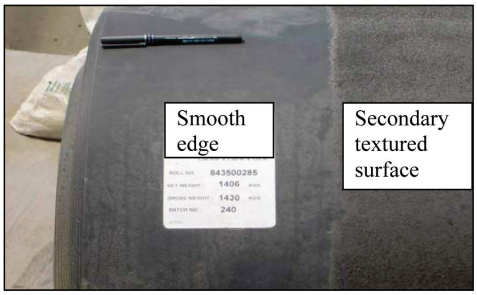

Figure 2. Secondary textured HDPE geomembrane with smooth welding edge.

edges (as shown in Figure 2 taken at the jobsite) was selected as the liner material for the project. Due to the specialty of the secondary texturing process, it is the only manufacturing process of textured product without sacrificing its properties. So its outstanding tensile properties at break are ideal to accommodate the potential large settlement of the landfill base. The smooth edges on both sides of the roll are convenient for the field seaming of geomembrane panels.

These differences in mechanical properties are caused by the differences in the manufacturing process of texturing. In the Round Die Co-extrusion Process, the texture is formed simultaneously while the melted resin is extruded from a multilayer die. In contrast, the secondary texturing process of HDPE geomembranes is a two-step procedure, the first step is to independently produce the smooth product, and second is to apply a textured surface on the smooth geomembrane to form a rough surface. Figure 3 shows the manufacturing process of secondary texturing, where the smooth geomembrane is unrolled, then moved over the texturing header. The texturing header applies melted atomised resin on the smooth surface of geomembrane to form a textured surface.

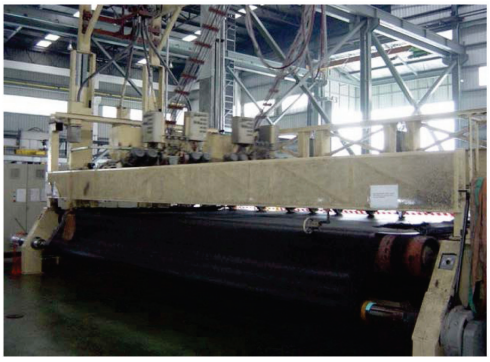

Figure 3. Secondary textured manufacturing process.

The most significant advantage of the textured HDPE geomembrane over the smooth is the greatly increased interfacial frictional angle between the

geomembrane and the underlying or overlying geosynthetic or soil layer. So, secondary textured HDPE geomembranes incorporate the advantages of large tensile properties of smooth HDPE and enhanced frictional properties of textured HDPE geomembranes.

4 THE LINER QUALITY ASSURANCE

The quality assurance of the geomembrane product begins from raw materials (virgin polyethylene resin and masterbatch) used, which have to meet the geomembrane manufacturer's strict raw material specifications and have to pass the acceptance conformance tests conducted on each lot of shipment.

A strict and thorough quality assurance program for the geomembrane products is implemented in accordance with both the manufacturer's consistent quality assurance program and the project specification in this regard. The quality assurance program is essentially including two phases for the geomembrane products. The first phase is the online manufacturing quality control, including thickness measurement and sparking test. The data acquired are used to establish the minimum, maximum and average thickness values for each roll and are verified by the thickness testing upon sampling of the finished goods. Meanwhile, an electrical spark detector is online to provide immediate notification of pinholes in the finished product. Rolls containing a hole are rejected from the standard quality product.

The second phase of the quality assurance program is to conduct onsite laboratory tests. Every roll is sampled for quality assurance tests as per the test frequency stipulated in the project specification, as well as in compliance with the manufacturer's established minimum test frequency requirements. Every roll is tested on thickness as per ASTM D 5994, shown in Figure 4 is the thickness profile of geomembrane roll. All the quality assurance test results are documented in the manufacturer's product database and reported in the form of Manufacturer Quality Certificate for each roll which is despatched with the shipped products to the customer. Table 2 shows that all the laboratory test results for each roll of the finished geomembrane product meet or exceed the project specification agreed by both parties.

5 CONSTRUCTION

The construction work of this sanitary landfill project started at the end of 2004, and the installation work of the liner system is contracted to an experienced geosynthetic installer in China. The soft ground underneath the landfill is intended to improve through the Prefabricated Vertical Drain (PVD) under the landfill load. Therefore, prior to the liner installation,

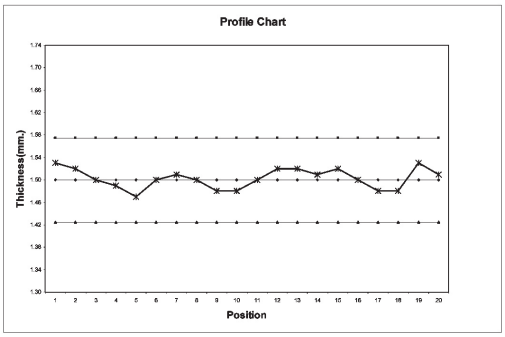

Figure 4. Thickness profile of a geomembrane roll.

Table 2. Design Properties of Textured HDPE Geomembrane.

Properties	Test method	Test result
Thickness (average)	ASTM D 5994	≥1.425 (mm)
Thickness (minimum)		≥1.275 (mm)
Asperity height	GRI GM12	≥0.25 (mm)
Density	ASTM D 1505	≥0.940 (g/cc)
Tensile properties	ASTM D 6693	
Break strength	Type IV	≥16 (N/mm)
Yield strength		≥22 (N/mm)
Break elongation		≥100 (%)
Yield elongation		≥12 (%)
Tear resistance	ASTM D 1004	≥187 (N)
Puncture resistance	ASTM D 4833	≥400 (N)
Carbon black content	ASTM D 1603	2~3 (%)
Carbon black dispersion	ASTM D 5596	Of 10 readings, 9 in Cat 1 & 2 and 1 in Cat 3

the ground is prepared and installed with PVD. The pore water from the soft ground is collected and channelled out through the drainage layer under the liner system. As shown in Figure 5, once the PVD installation is completed post the excavation earthen work, a geotextile filter is installed and a gravel drainage layer is subsequently constructed.

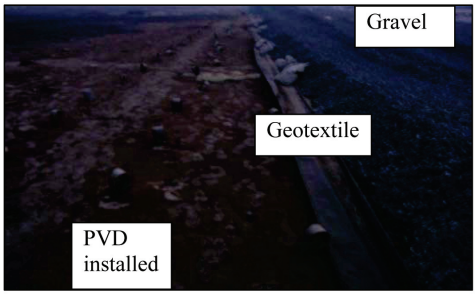

Figure 5. Base preparation at the landfill site.

Upon completion of the engineering work required by the PVD program on the landfill base, the liner installation is immediately preceded in the sequences of geotextile cushion, secondary liner of 1.5 mm

secondary textured HDPE geomembrane which is seven meters wide and the seam is hot-wedge welded, geocomposite leachate detection layer, the primary liner of 1.5 mm secondary textured HDPE geomembrane, geotextile protection layer, primary gravel leachate collection and removal layer, and finally a geotextile filter. Figure 6 shows a landfill cell where the entire liner system installation is completed.

Figure 6. A landfill cell completed liner system installation.

6 CONCLUSIONS

In this paper, the differences in mechanical properties are described between the secondary textured HDPE geomembrane and the Round Die Co-extrusion textured HDPE geomembrane. Due to the specialty of the secondary texturing process, its tensile properties at break are not sacrificed during texturing process, so the secondary textured HDPE geomembrane is an ideal combination of the superior mechanical properties of smooth geomembrane and the increased frictional properties of textured surfaces. In addition, the secondary textured HDPE geomembrane can easily leave smooth edge for the convenience of field seaming without the need of smoothing the rough surfaces to ensure high quality field welding.

Giving these superior properties of secondary textured HDPE geomembrane, this product in the thickness of 1.5mm is selected for a large sanitary landfill in the quantity exceeding one million square meters. Consequently, the manufacturer's quality assurance program and field construction are briefed.

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