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Case Study: **Empire Landfill Perimeter Down-Chute Channel Protection Using a Cellular Confinement System with Concrete Infill**

Empire Landfill is located in Taylor, PA, northeast of Scranton, and is situated on a 600-ac. site, with 203 ac. currently under permit for waste disposal. In anticipation of current and future environmental concerns, the management of Empire Landfill Inc. has ensured that the landfill currently exceeds today's design and operational guidelines.

Empire Landfill features double-lined cells, with a "geosynthetic sandwich" of geotextile, two 100-mil HDPE liners, and stone aggregate atop a clayey soil sub-base. A complete stormwater management system for surface run-on and runoff includes a series of channels, with high erosion potential in the diversion and interceptor channels.

Interceptor channels follow the landfill toe, with a gradient ranging from 2% to 16%. These channels are in a trapezoidal configuration, with an 8 ft.-wide bottom and 2:1 sideslopes. In the past, 18 in.-thick, rock-filled baskets or shot rock were being employed to protect the interceptor channels from erosion. Alternate hard armor systems were considered in an attempt to enhance the stormwater management system, and to minimize labor and site disturbance required with the installation of the 18-in. baskets.

An alternate channel armament system was chosen, which consists of a 4 in.-thick cellular confinement system underlain with a nonwoven geotextile, and infilled with concrete. The cellular confinement technology was originally developed in the late 1970s in cooperation with the Army Corps of Engineers. Cellular confinement technology is based on confine-

ment principles of granular materials in a cellular system. The cellular confinement system is an engineered expandable, polyethylene, honeycomb-like cellular structure.

Introduction

Empire Landfill receives approximately 4,000 to 5,000 tpd of municipal solid waste from the n-state area. The landfill itself features tomorrow's technology today. It is built with a double-lined construction, offering the highest degree of quality control in an environmental-

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ly sound landfill. Both the primary and secondary liners are made of a minimum of 100 mil-thick, high-density polyethylene. This thickness far exceeds state requirements. Consistent with this quest for quality, Empire



goes beyond normal requirements relative to stormwater management.

Project Background

Empire Landfill was originally opened in 1987. Over the past several years, Empire has continued to prepare a new cell as one cell is being filled and another cell is being constructed. In 1995, Martin & Martin, an engineering consulting and design firm, was retained to design the construction and closure of the landfill. This design was to include all the necessary components of an effective, cost-efficient, and long-lasting system to protect the facility and surrounding area from accelerated erosion, while accommodating the flows from a 100-year, 24-hour storm.

Empire Sanitary Landfill Inc. was designed and constructed as a state-of-the-art waste containment site with all phases of the construction to meet or exceed current design guidelines. As an example, Pennsylvania requires the primary liner to be 50-mil HDPE and the secondary liner to be 30-mil HDPE. Empire has and continues to use 100-mil HDPE in the construction of the primary and secondary liner systems. The site is being constructed in phases. New cells are constructed as required, and the filled cells are capped.

The Problem

Current EPA, Subtitle D, and Pennsylvania Department of Environmental Protection Chapter 273 Regulations require that stormwater management systems be designed to accommodate 100-year, 24-hour storm events for run-on control, and 25-year, 24-hour events for runoff management. These systems include both run-on diversion and runoff interceptors around the site perimeter, as well as channels and down-drains from the terraced landfill area. On the landfill footprint, regulations require a geomembrane cap system, thereby maximizing runoff that the stormwater system must accommodate.

Martin & Martin engineers were very familiar with methods of accomplishing the task of stormwater management on the landfill site, and especially the removal of stormwater front diversions, interceptors, and from each capped cell. In the past, rock-filled gabion baskets and or riprap-lined channels had been used to construct a series of channels to remove surface rainwater. While these systems are effective, Empire was interested in pursuing more cost- and time-efficient alternatives that would adequately handle the flows and be easy to maintain.

The Solution

Empire and Martin & Martin worked with ACF Environmental Inc., looking for some potential alternate means of constructing the perimeter stormwater channels. Empire, in analyzing the cost of gabion baskets and the stone to place in the baskets, realized that substantial excavation required to fit the 0.457 m- (18 in.-) thick gabion baskets into the trapezoidal configuration.

An important fact in considering any alternate product was that it had to meet the requirements of the State Department of Environmental Protection. ACF Environmental Inc. suggested that a product called Geoweb, a cellular confinement system, be evaluated for this application.

Cellular confinement of soil, aggregate, or concrete infill materials has been used successfully since its development in the late



Connecting adjoining Geoweb sections with a pneumatic stapler

1970s by the Army Corps of Engineers and Presto Products for:

- Protection and stabilization of steep slope surfaces;
- Protective linings of channels and hydraulic structures;
- Static and dynamic load support on weak subgrade soils;
- Multilayered earth retention structures.

For this project a 100-mm (4-in.) concrete-filled textured Geoweb system with tendon and J pin anchorage was able to satisfy all of the design objectives and requirements. The textured Geoweb maximizes the mechanical bond between the concrete and cell walls, locking the concrete infill into the individual cells of the system. High-strength, LDPE-coated polyester tendons inserted through the Geoweb provide a connection element for the J pin anchors. The function of the 170 g/m² (6 oz./yd.²) was to provide drainage and soil filtration.

The Design Solution

Martin & Martin and Empire's internal design staff worked with Presto Products' consultant InterSol Engineering to determine the flow conditions in each channel section. The following project parameters were used to determine the type of Geoweb lining system required:

- Maximum Bed Slope = 16.2%

- Discharge = 6.0 m³/sec. (210 ft³/sec.)
- Velocity = 7.22 m/sec. (23.7 ft./sec.)
- Critical Interface Friction (soil/geotextile) = 280
- Factor of Safety Downstream Sliding = 1.3

A channel analysis program developed by InterSol Engineering was used to analyze the stability against sliding due to drag forces of the Geoweb channel lining system. The program calculates downslope and downstream driving and resisting forces, and calculates a resultant factor of safety for each element of the channel cross-section. Elements are the components (i.e. invert sideslopes, flood plains) of a single cross-section defined by the user.

Considerable testing has been carried out on various block systems to establish the limiting velocities in relation to block weight and system flexibility. The findings of a number of such tests have been published by the US Department of Commerce² and CIRIA³ together with recommended maximum flow velocities as follows:

1. Blocks with face-to-face contact length less than 75%. Maximum design velocity: 6 m/sec. (20 ft./sec.).
2. Blocks with face-to-face contact length greater than 75%. Maximum design velocity: 8 m/sec. (26 ft./sec.).

A minimum superficial mass of 125 kg/m² (28 lb./ft.²) is also required.

The selected 100 mm- (4 in.-) thick, con-

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Concrete fill is placed by backhoe in the Geoweb cells and given a raked finish.

crete-filled Geoweb lining system meets the requirements of the higher limiting velocity due to its 100% face-to-face contact, and a superficial mass of 238 kg/m² (49.5 lb./ft.²).

The Geoweb extended up the channel sideslopes a distance of 1.2 m (4 ft.). It was determined that J pin anchors 13 mm by 600 mm (0.5 in. by 24 in.) would be required at 812-mm (32 in.) by 488 mm (19.2 in.) centers in conjunction with the three tendons per section to anchor the system. This not only facilitates the placement of the Geoweb, but ensures intimate contact with the ground surface prior to and during the filling process, and during peak flow conditions.

Construction

Installation of the Geoweb system was completed by a three-man crew (one equipment operator and two laborers). The total area protected was 2,839 m² (20,560 ft²), which resulted in a channel length of 582m (1,910ft.).

The sequence of construction was to first excavate the channel and place the nonwoven geotextile. The nonwoven geotextile was temporarily pinned in place to prevent movement while expanding the Geoweb sections. Tendons were then cut to measured lengths that included the length of the expanded Geoweb sections, with an allowance for

knots to be tied at either end. The tendons were inserted through the factory-drilled holes in the Geoweb sections. Knots were tied at either end to hold the tendons in place while the Geoweb sections were expanded into position. The Geoweb sections were then expanded longitudinally down the channel invert. Adjacent sections were then mechanically attached by interweaving the ends of outside cells and stapling with a pneumatic stapler. Then the expanded Geoweb sections were anchored into position with the J pin earth anchors. Each J pin was hooked over a tendon at the specified spacing, and driven flush with the ground surface. Concrete was placed into the Geoweb using a 0.8 m³ (1 yd.³) track backhoe and filled level with the top of the cells. The concrete was then given a raked finish.

Conclusion

Empire Sanitary Landfill Inc. continues to operate a state-of-the-art landfill in northeastern Pennsylvania. With innovative solutions to problems such as the removal of stormwater with the concrete filled Geoweb lined channels, it continues to lead the industry into the twenty-first century. The Geoweb has handled the stormwater during one of the wettest summers on record in the east.

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