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Geocomposite drains in paper-pulp landfill covers

Methods for countering cover erosion

During the course of our careers, we have had the opportunity to work on a wide variety of landfills. The easiest to design were the hazardous and mixed-waste facilities that contained essentially soil like wastes. The hardest to design were those for the paper-pulp industry, where wastes ranged from boiler ash to a type of sludge lovingly referred to as "spooge." The latter may have an almost fluid consistency and typically requires bulking with sands or sawdust to pass the paint filter test. Such wastes are low in permeability and don't freely drain. As such, seeps and slope blowouts are common. This paper describes two uses of drainage composites that are somewhat unique to landfill final covers for this type of waste.

Side slope seepage control

While not unique to paper-pulp landfills, side slope seepage can be very destructive to earthen final covers and perimeter berms. **Photo 1** shows slumps and erosion rills that developed on a steep (2H:1V) perimeter berm in a landfill that contains up to an 80-ft. (24.4 m) depth of unbulked sludge spooge. The spooge waste has a water content greater than 80% and drains slowly through the perimeter berms.

The site's problem was exacerbated by the presence of a clayey berm within the footprint of the silty-sandy berm vertical expansion. **Figure 1** shows a section of the berm and the general flow pattern of seepage. The presence of the clayey berm forces the phreatic surface of the seepage to daylight high on the slope of the silty-sandy berm. Where the seepage daylighted, slumps would form within days of regrading and the first moderate rain would produce large rills. The lack of effective confining stress on the surface sands reduced their ability to tolerate seepage forces without essentially liquifying. Stability analyses indicated that while the berm was stable, continued erosion of the surface would lead

***Photo 1**. Slumps and erosion rill on a 2H:1V slope of a paper mill sludge landfill.*

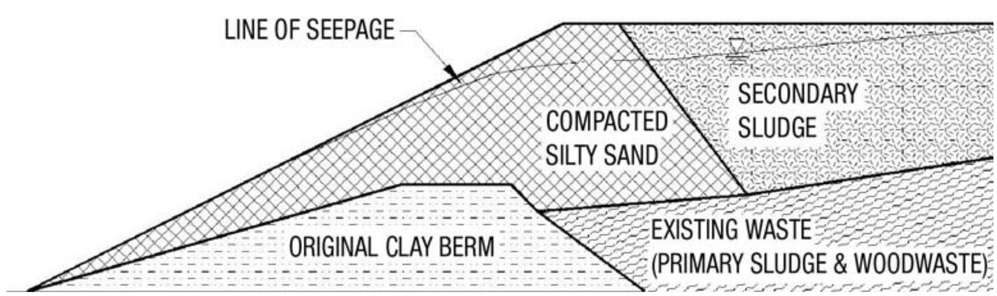

***Figure 1**. Cross section of the berm shown in Photo 1.*

quickly to a potentially unstable condition.

The mill initially attempted to control the seepage by installing sock-wrapped perforated pipe within the zones of maximum seepage. While installing the pipe required heroic efforts by the contractor, the pipe failed to control seepage. Vertical wells were also tried. However, the vertical wells produced a very limited radius of influence even after months of operation. The silty-sands proved to be much harder to locally drain than anticipated.

Earthen dams control such seepage flows by installing vertical chimney drains within the berm or with layers of granular drainage media applied to the surface of the dam. Our initial reaction to the ongoing seepage damage was to recommend a 3 ft. thick surface layer of riprap placed over a heavy nonwoven geotextile. This system maintains both a positive effective stress- and erosion-resistant surface where the seepage exits the silty-sands. While easy to construct, the presence of the seeps high on the slopes would have required covering nearly two thirds of the surface of the berm's slopes. Unfortunately, with the mill being located near the Carolina coast, rip-rap can cost more than $80 per cubic yard installed. Once this option was priced, the mill asked for alternatives.

While drainage composites have become essential to final covers on slopes that must include a geomembrane barrier, they are rarely used without the geomembrane. However, for this particular application, geocomposite drains offer an alternative means of placing a stable veneer over the seepage zones. The proposed alternative involved removing 2 ft. of soil from the slopes at and below the seepage zones. A double-bonded drainage composite (geotextile on both faces) was then placed on the slopes and tied into a French drain located at the toe of the slope. Next, 2 ft. of a soil having more organic matter was placed over the drainage composite, graded and seeded. **Photo 2** shows a dramatic demonstration of the success of this system. The slump shown in the photo occurred between portions of the slope having the geocomposite underdrain installed. The contractor felt this area was "dry" and failed to install the geocomposite underdrain in this location. In all locations where the geocomposite underdrain system was installed, surface seepage problems disappeared and surface slumps were nonexistent. A combination of eliminating seepage, more organic soil, and erosion control matting significantly minimized surface erosion.

The geocomposite drain was designed to accommodate a unit gradient inflow from the silty-sandy soil beneath the drain and the organic soil above the drain. This is an adaptation of the analysis method first proposed by Thiel and Stewart (1993) and presented by Richardson et al. (2002). This is very conservative based on flow-net evaluations. Fortunately, the low normal loads in this application allow high transmissivities in available composite drains.

Installing the geocomposite underdrain proved to be very simple and quick. The contractor was cautioned to protect the core of the geocomposite drain from fouling with soil. To accomplish this, he provided a geotextile seal at the ends of the composite and sewed the upper geotextile together at the sides. We had anticipated having to stake the drainage composite in place during placement of the cover

***Photo 2**. Surface slump on a section of the cover without the drainage composite installed. The drainage composite was placed on either side of the slump, but not beneath.*

soil, but this was not required. Installation of the geocomposite underdrain actually took less time than was previously spent installing sock-wrapped drainage pipes.

Geocomposite drain to reduce infiltration

In redesigning the closure for a clay-lined (12 in. of 1 x 10-7 cm/sec) paper-pulp landfill in Virginia, the design parameters were more traditional than the previous example. A leakage rate of 2.5 in./yr. (6.4 cm/yr.) was estimated using Darcy's law and assuming a 12 in. maximum head over the clay liner. This mill landfilled significant quantities of boiler ash and smaller amounts of sludge. Historically, significant side slope seeps and blowouts had occurred during or after heavy rains. State regulators wanted a final cover placed quicker but had expressed concerns regarding the ability of the previously permitted 1 x 10-7 cm/sec clay cover to be properly constructed and survive.

Placing a conventional geosynthetic Resource Conservation and Recovery Act (RCRA) cover and underdrain system over the 4H:1V side slopes of the landfill would triple the cost of closure for the mill. With an eye to reducing this cost, we re-evaluated the performance required of and system alternatives for the final cover. State regulators indicated that the final cover would simply have to limit the infiltration to a level less than the leakage from the liner system, standard fare for RCRA facilities. As reflected in Subtitle D, this does not mean that the liner system components are simply replicated in the final cover. Evapotranspiration mechanisms benefit the final cover but have no impact on liner leakage. Thus, the portion of the landfill with a 1 x 10-7 cm/sec clay liner would not necessarily need a clay barrier cap of equal or lower permeability.

A parametric study of final cover leakage was performed using the Environmental Protection Agency's (EPA) HELP model. Three final cover systems were evaluated:

- One, the current 1 x 10-7 cm/sec clay final cover;
- Two, a more permeable soil cover that incorporates a drainage composite above a 1 x 10-6 cm/sec soil barrier layer and below the vegetative support soils; and
- Three, a final cover system that includes a geomembrane barrier.

The third's final cover is appropriate for future geomembrane-lined cells that will incorporate a geomembrane in the cover system. Total HELP annual leakage through the three final covers is as follows:

- One, clay liner leakage rate of 1.4 in./yr. (3.6 cm/yr.);
- Two, drainage composite enhanced final cover leakage rate of 1.3 in./yr. (3.3 cm/yr.); and
- Three, geomembrane leakage rate of 0.002 in./yr. (0.005 cm/yr.).

In that the drainage composite enhanced final cover has a leakage rate less than the leakage through the clay liner and is comparable to the leakage through the previously approved clay cover, the clay-lined portion of the landfill is now permitted to close with the drainage composite enhanced final cover.

Summary

Geosynthetic drainage composites are typically used in conjunction with a geomembrane to limit head build up on the membrane. This may be required for stability on slopes or may be done to limit potential infiltration through the geomembrane. The examples presented here demonstrate the use of a drainage composite by itself within a final cover. These roles may not be practical for all wastes. For example, municipal solid waste (MSW) landfills are now as concerned with landfill gas emissions as with potential infiltration. In such applications, the geomembrane limits gas emissions and we are not yet sure it can be eliminated. However, where landfill gas emissions are not of concern, use of the drainage composite by itself should not be overlooked by the designer.

The authors would like to thank Perry Vyas of Skaps Industries for supplying sample rolls of composite used to convince a wary client of the merits of such applications.

References

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