DESICCATION OF A COMPACTED CLAY LINER IN A COMPOSITE LANDFILL LINING SYSTEM

Clay desiccation of an existing landfill composite lining system was observed during the expansion of the landfill. The existing bottom liner consisted of a 60-mil HDPE geomembrane overlying a 12-inch compacted clay liner. During the original construction, the bottom of the cell was covered with at least 2 feet of drainage sand while the side slopes were left with the HDPE surface exposed. Drainage sand was placed on the side slopes as landfilling proceeded. The landfill was designed to be constructed in two phases with the new composite liner to be tied into the existing composite liner. When the existing geomembrane was removed to expose the clay on the slopes, the existing clay was found to be highly desiccated. The clay along the cell bottom was in good shape.

The main theory for the phenomenon involves relative humidity fluctuations beneath the geomembrane liner on the slope. During the summer, daily liner surface temperatures may reach or even exceed 150º F, causing the exposed liner to become highly wrinkled. Water vapor pockets form between the geomembrane and the clay surface as moisture evaporates from the clay surface. When the liner cools at night the relative humidity of the trapped vapor increases, and liquid condenses on the bottom of the liner. Water then migrates to low spots in the liner system. Continued heating and cooling cycles would eventually desiccate the clay from the top down.

Source: *Geotechnical Fabrics Report.*

800.527.9948 Fax 847.577.5566

BY CURT BASNETT and MARTIN BRUNGARD

The clay desiccation of a landfill composite lining system

Editor's note: The following article is an observation by two geotechnical engineers on the clay desiccation of an existing landfill composite lining system. The authors request you send your theories on this subject to Geotechnical Fabrics Report (GFR). GFR will publish submitted papers. All papers are subject to GFR's paper reviewing process. The intent of this new Solutions column is to provide engineers the opportunity to learn from each other's experiences.

We have observed what may be a unique phenomenon during the expansion of a landfill. The existing bottom liner consists of a 60-mil HDPE geomembrane overlying a 12-inch compacted clay liner. The clay liner was constructed with rigid QA/QC procedures and was observed to have permeabilities ranging from 10-7 to 10-8 cm/sec. The cell cross-section is shown in Figure 1. The bottom of the cell was covered with at least 2 feet of drainage sand. The side slopes were left with the HDPE surface exposed. Heavy rainfall in the region makes retaining sand on the 3:1 slopes difficult. However, drainage sand is placed on the side slopes as landfilling proceeds.

The existing landfill was designed to be constructed in two phases. Figure 1 shows a plan view of the landfill. The new clay liner for the cell expansion is to be feathered into the existing clay liner. When the liner was removed to expose the clay on the slopes, the existing clay was found to be highly desiccated.

This desiccation was quite severe, with cracks averaging 1/2 inch to 1 inch

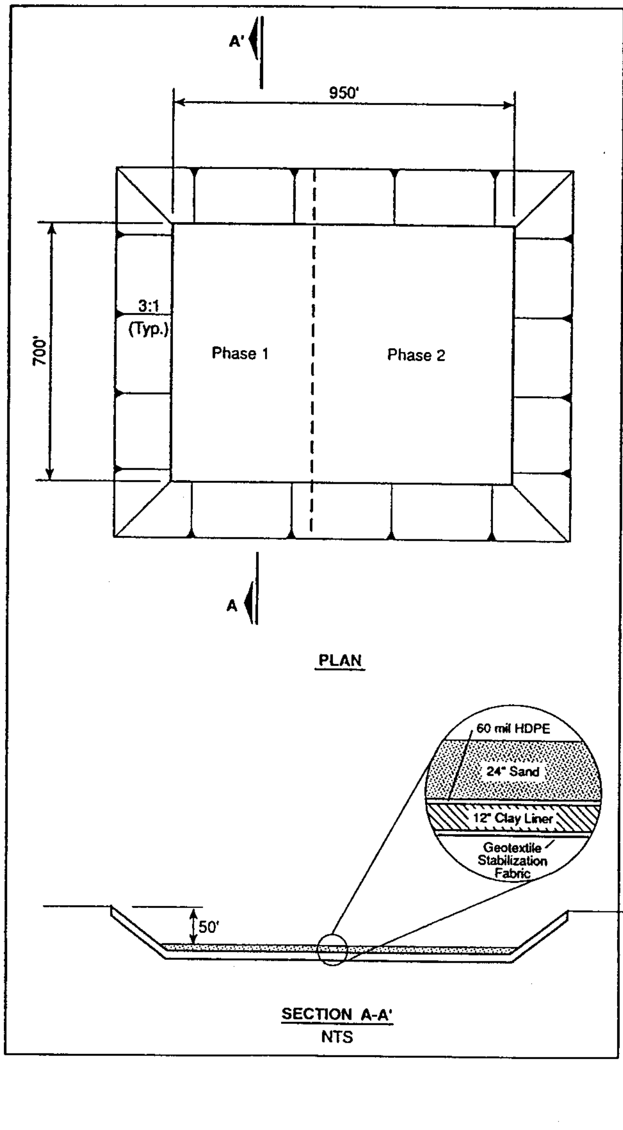
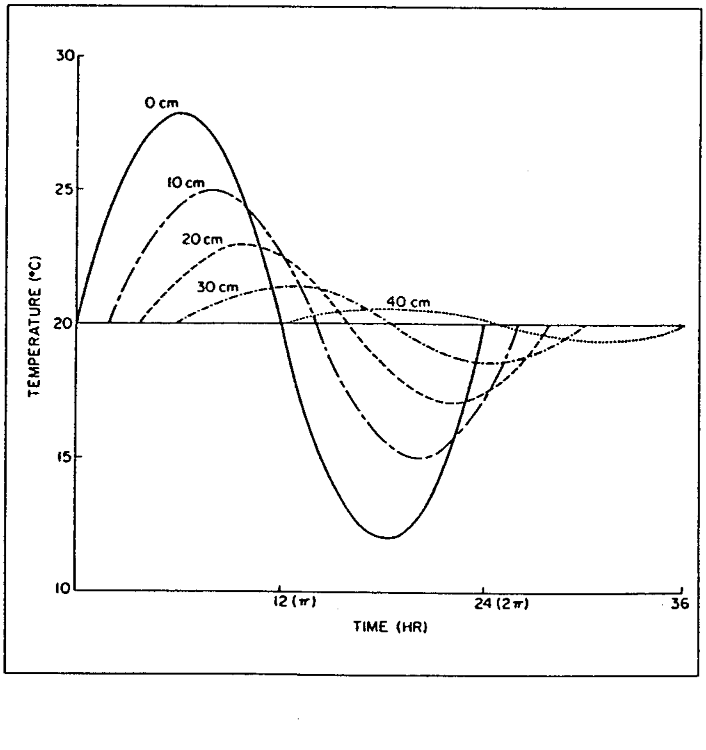


Figure 1 A plan view of the landfill.

Figure 2 Idealized variation of soil temperature with time for various depths

Note that at each succeeding depth the peak temperature is damped and shifted progressively in time. Thus, the peak at a depth of 40 cm lags about 12 hours behind the temperature peak at the surface and is only about 1/16 of the latter. In this hypothetical case, a uniform soil was assumed, with a thermal conducitivity of 4 X 10^{-3} cal/cm sec deg and a volumetric heat capacity of 0.5 cal/cm^3 deg. *From: Fundamentals of Soil Physics, Hillel*



wide, extending the full depth of 12 inches.

Further investigation revealed that desiccation extended at least 100 feet to 150 feet back from the temporary end beneath the HDPE liner.

The clay located farther away from the temporary end of the liner appeared to be in worse condition than clay near the temporary end of the lining.

The clay along the cell bottom was in good shape. All clay had been in place about three years. The water table in the vicinity is approximately 25 feet below the landfill bottom. Subgrade soil is poorly graded sand with a permeability of 5 x 10-3 cm/sec.

Two theories are hypothesized for the clay desiccation. The first theory assumes drying occurred from contact with the atmosphere. In this case the clay condition could be expected to improve as you go farther back from the liner edge. This was not observed in the clay. It is possible the desiccation had extended well away from the edge of the cell because of the amount of time that had passed (three years).

The second theory involves relative humidity fluctuations beneath the liner. During the summer, daily liner surface temperatures may reach or even exceed 150 F, causing the exposed liner to become highly wrinkled.

Air or gas pockets form between the HDPE and clay surface. This solar-heated air or gas becomes highly humid, extracting moisture from the clay.

When the liner cools at night, the relative humidity of the trapped air or gas increases to 100 percent. Liquid then condenses on the bottom of the liner and on the clay surfacex. If the liner and clay are horizontal, the condensed moisture would simply drip back to rehydrate the clay. However, on sloped surfaces the liquid would tend to migrate to the bottom of the slope. This phenomenon agrees with what has been observed in the field. Since the liner was initially placed, liquid has been observed pooling under the liner at the toe of the landfill slopes.

Continued heating and cooling cycles could eventually desiccate the clay from the top of the slope down. This theory seems to most closely fit the conditions observed for this landfill. This phenomenon is probably more active in hot climates, but we expect that it will occur anytime there is a temperature cycle above freezing.

It appears that a soil cover over the liner is one solution to this problem. The soil surcharge will press the liner into intimate contact with the clay. This may prevent free liquid from migrating down the slope. The soil also serves as an insulating media to dampen the temperature variation.

Figure 2 shows the effect of soil thickness on temperature damping. The soil parameters modeled in the figure are roughly analogous to the characteristics of a drainage sand.

The authors are currently looking at various solutions to this problem. If you have any experiences or theories concerning this condition please write GFR, 345 Cedar St., Suite 800, St. Paul, MN 55101 USA; fax 612/222-8215. ◘

About the authors; Curt Basnett and Martin Brungard are geotechnical engineers with CH2M Hill, Gainesville, Fla.