Use of multi-linear drainage geocomposites for CCP disposal units final cover

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ABSTRACT

In the event that a final cover is used to close a CCP disposal area, the cover system has to meet or exceed the EPA requirements. Regarding the drainage layer component, the use of Multi-Linear Drainage Geocomposite (MLDG) permits to collect and evacuate the infiltration water. MLDG like Drain Tube have embedded corrugated perforated mini-pipes regularly spaced between two non-woven geotextile layers. They enable water to be evacuated at a higher rate than an homogeneous drainage layer (Del Greco et al., Politecnico di Torino, Italy, 2012) even if the drainage slope is zero. Because differential settlement over time is one of the main concerns for CCP Landfill and Impoundment closures, Drain Tube will drain efficiently water and limit its accumulation even if differential settlements occur thanks to its directional behavior (drainage in the direction of the mini-pipes).

The effective drainage capacity of the Drain Tube geocomposite which is a function of the distance between the mini-pipes in the product, is determined using GRI GC15 and ASTM D4716 standards. After Blond et al., 2010 and as per ASTM D7931 standard recommendation, the long-term drainage capacity of tubular drainage geocomposites is not affected by creep in compression nor geotextile intrusion when confined in soil. These two reduction factors RF_{CR} and RF_{IN} must be taken equal to 1.0 in the design of the drainage layer with a MLDG such a Drain Tube. This leads to a cost reduction and a higher factor of safety for the drainage layer.

INTRODUCTION

Covers on CCP disposal area are required to minimize the infiltration of precipitation into the CCR and limit the volume of leachate to be treated. Even if an impermeable layer (soil or geosynthetic) is required, a good drainage system on top of it is also essential to limit water infiltration through the cover.

Multi-Linear Drainage Geocomposites (MLDG) have been used for decades in civil and environmental applications. This paper presents a series of studies conducted to assess their performance in CCP Landfill and Impoundment closures. The efficiency of a MLDG to remove infiltration from the topsoil even under very low slopes and its behavior regarding differential settlements will also be presented.

GEOCOMPOSITE DESCRIPTION AND INSTALLATION

Drain Tube MLDG is described on Figure 1. It includes the following components:

- A non-woven geotextile, which acts as a filter. This layer is typically selected with consideration to the gradation and properties of the overlying material, with opening sized ranging from 44 µm to 200 µm or more;
- A series of corrugated, perforated polypropylene tubes. The number of tubes per unit width can be adjusted to fit specific project's needs. These tubes provide most of the drainage capability of the product;
- Another non-woven geotextile, which is selected as a cushion, to protect the underlying geomembrane from puncture when exposed to coarse, angular gravels. This layer may also provide a secondary drainage medium.

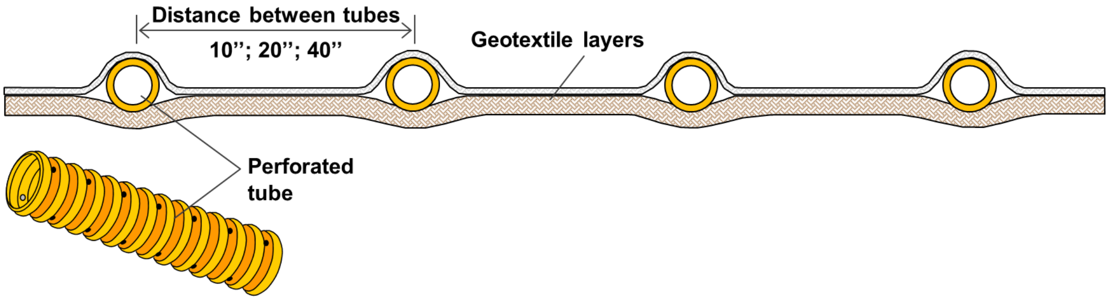

Figure 1. Drain Tube MLDG

Drain Tube MLDG is unrolled directly on the lining system (figure 2) and connected down the slope to a collector trench or a ditch.

Figure 2. Drain Tube installation

Backfill is then put into place on the geocomposite (figure 3).

Figure 3. Drain Tube backfilling

BEHAVIOR OF DRAIN TUBE MLDG COMPARED TO A HOMOGENEOUS DRAINAGE LAYER

A field study has been conducted with the University Politecnico di Torino in Italy to compare the behavior of a Drain Tube MLDG to a homogeneous drainage layer, in that case, a 500 mm (20 in.) thick gravel layer (coarse clean gravel 1/3 to 1-1/2 in.). Two test pads have been constructed with the same size, 10 m (33 ft.) long and 4 m (13 ft.) wide. The two pads with gravel layer and MLDG are presented in the figure 4. Both having a slope angle of 5%. Rainfall was simulated.

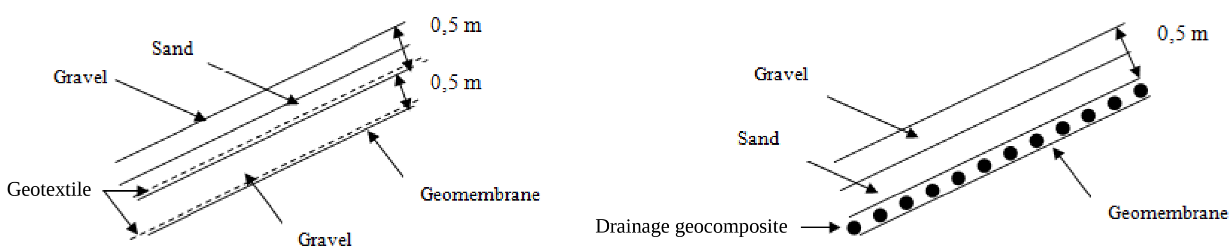

Figure 4: Test pads description

At the toe of each slope, the flow rate and the total volume of water collected were measured. The Drain Tube MLDG in place had a spacing between tubes of 1 m (40 in.). The soil cover above the drainage layer was composed of 250 mm (10 in.) of gravel and 250 mm (10 in.) of sand, these layers didn't take any part in the water evacuation but acted as infiltration layers. Steps of the construction if the pads are shown in Figures 5 and 6.

Figure 5: Geomembrane installation

Figure 6: Rainfall simulation

Rainfall was simulated with an irrigation system equipped with 6 nozzles. The rain intensity was 22 l/min, corresponding to an effective rainfall of 33 mm/h.

The irrigation system simulated a rainfall of 33 mm/h for 6 hours. Two series of tests were completed. The first, just after the construction of the test pads with the cover material being dry and the second one after a few weeks when the cover material was partially saturated. During the tests, no runoff was observed. The time for the initial flow to reach the bottom of the drainage layer was measured as well as the amount of flow drained over time. Table 1 shows the abbreviations that will be used to present the results.

Table 1. Definition of the abbreviations

Drainage layer	Hydraulic conditions	
	Dry	Partially saturated
Gravel	G_d	G_{ps}
Drain Tube	$MLDG_d$	$MLDG_{ps}$

The time for the water to reach the end of the drainage layer was measured under 4 different configurations (cf. Table 2). Regardless of the initial hydraulic conditions, the Drain Tube MLDG had a faster response time than the gravel drainage layer.

Table 2. Time for the initial flow to reach the end of the drainage layer

Test pad	Time (min)
G_d	77
$MLDG_d$	54
G_{ps}	45
$MLDG_{ps}$	30

The flow rate was measured for the 4 configurations (figure 7). Drain Tube MLDG always drained with a higher flow rate than the homogeneous drainage layer. That has also been observed in small scale tests especially for mild slopes (Del Greco et al., 2012). The tubes of the MLDG collect and evacuate the fluid in one given direction (the direction of the tubes) even if the slope equals to zero. This directional aspect of the MLDG helps to reduce the impact of differential settlements that will occur on a cover and causes reverse slopes. A homogeneous drainage layer will drain in the direction of the reverse slope into the land subsidence whereas the MLDG will drain the water in the direction of its tubes to the collector trenches or ditches.

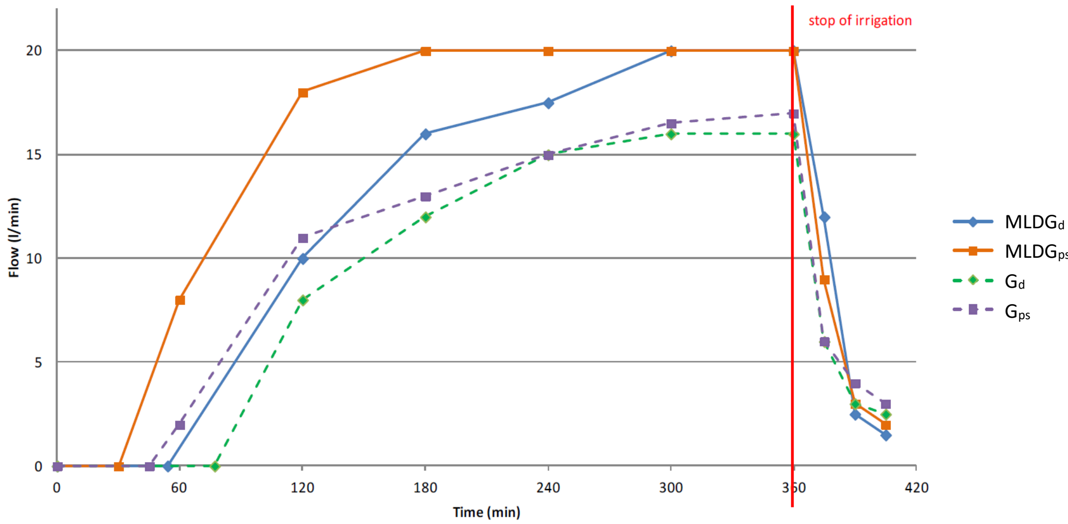

Figure 7: Flow rate over time

As shown in the Figure 7, the total amount of drained water was greater with Drain Tube MLDG. Indeed, the gravel drainage layer retained between 20% and 25% more water than the MLDG. The water remaining into the gravel layer may increase the infiltration rate into the CCR through any defect in the geomembrane or though the low permeability layer.

LONG TERM PERFORMANCE OF DRAIN TUBE MLDG

Due to their structure, Drain Tube MLDG maintain their transmissivity (the volumetric flow rate per unit width of specimen per unit gradient in a direction parallel to the plane of the specimen; see ASTM D4716 and GRI GC15 standards) under significant normal stresses (Blond et al., 2010) in large part because they do not experience geotextile intrusion into the primary high-flow components: their tubes.

Therefore, for most of the applications, the applied combined reduction factors (intrusion of the geotextile into the drainage core RF_{IN}, creep of the drainage core RF_{CR}, chemical clogging of the drainage core RF_{CC} and biological clogging of the drainage core RF_{BC}) for Drain Tube MLDG are almost half of those applied to standard geonet geocomposites (Maier, et. al., 2013). In other words, for the same index transmissivity, Drain Tube MLDG offers almost two times higher long-term flow capacity than a geonet geocomposite. ASTM D7931 provides recommendations to determine the allowable flow rate of drainage geocomposites including MLDG.

Figure 8 presents a schematic of a transmissivity testing device. Figure 9 provides transmissivity test results for a Drain Tube MLDG composed of 25-mm diameter tubes placed every 250 mm (10 in.) width of product, after 1,000 hours under 2,500 kPa (50,000 psf).

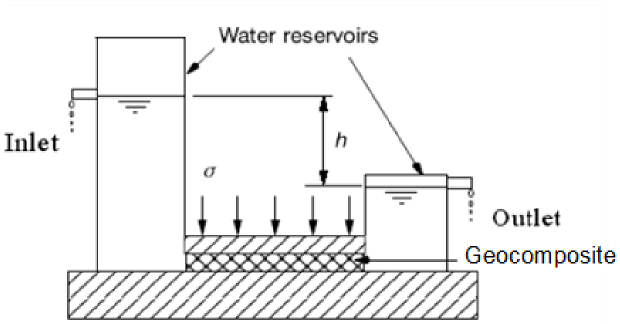

Figure 8: Transmissivity test device

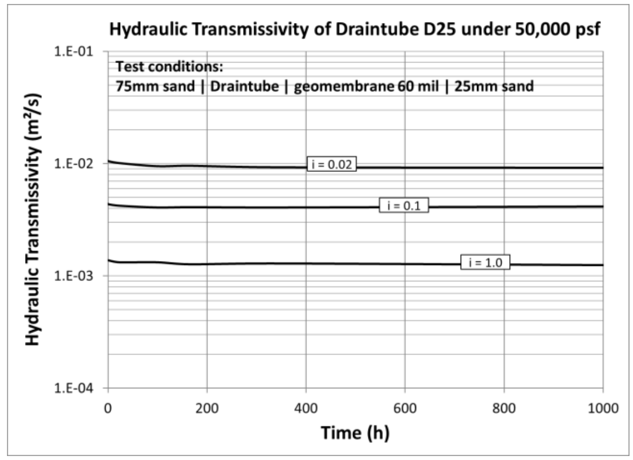

Figure 9: Transmissivity test results

The performance of a Drain Tube MLDG has been investigated in a waste cover test pad located north of Montreal (Quebec) over a three-year period (Chappel, et al., 2013). The study showed that the average annual infiltration to the geocomposite was 45% of precipitation. The capillary break formed by the pore size and texture differences between the topsoil and the geotextile held water in the topsoil and evapotranspiration eliminated most of the infiltration through the cover system during summer time. The Drain Tube MLDG performed as designed (calculated maximum rate of infiltration was 7.5×10^{-7} m/s) when required to drain water from fall to spring, during periods when the cover system was not frozen. They suggested that the local rate of evapotranspiration should be considered when designing a cover system to understand the volume and time periods when a drainage geocomposite is utilized. This would help to optimize costs and materials while designing the cover system.

CONCLUSIONS

The use of a Drain Tube MLDG in CCP Landfill and Impoundment closures as drainage layer decreases the time the water is in contact with the underlying impermeable layer and reduces water retention in the drainage layer. These benefits should be taken into consideration, especially for mild slopes and when the underlying impermeable layer is made of soil.

The directional drainage characteristic of the product reduces the impact of differential settlements of the cover over time compared to a homogeneous drainage layer.

Also, by using Drain Tube MLDG it is possible to reduce the reduction factors associated to the drainage core (i.e., reduction factor for intrusion of the geotextile in the drainage core RF_{IN}, and reduction factor for creep RF_{CR}). Both reduction factors can be taken equal to 1.0. This leads to a cost reduction and a higher factor of safety for the drainage layer.

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