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Feedback on long-term integrity of Multi-linear drainage geocomposites installed on landfill final covers after 10 and 12 years of operation

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Abstract. The use of drainage geocomposites in landfill final covers facilitates surface water drainage, contributing to long-term stability. However, validating their durability beyond accelerated laboratory aging tests remains a challenge. The most direct method involves exhuming geocomposites after prolonged field exposure and analyzing their mechanical and hydraulic properties. This study presents two case studies involving multi-linear drainage geocomposites installed in landfill final covers, one exhumed after 10 years in France and the other after 12 years in Canada. The samples underwent laboratory analysis to compare residual properties with original specifications, providing insights into long-term performance.

1.Introduction

Multi-linear drainage geocomposites have been widely used for more than 30 years for liquids drainage (water, leachate, etc.) and gas collection (LFG, Radon, VOCs, etc.).

While laboratory studies provide insights into long-term behavior, field exhumations offer direct validation of durability. This paper presents two exhumation case studies assessing the integrity of multi-linear drainage geocomposites used in landfill final covers as surface water drainage layers. The first exhumation conducted at Lapouyade Landfill in France, examined a geocomposite installed for 10 years. The second, at Vancouver Landfill, Canada, investigated a geocomposite in service for 12 years.

The two multi-linear drainage geocomposites are representative of the range of products used in landfill final covers. The product used at the Lapouyade landfill has embedded perforated mini-pipes with a diameter of 20 mm, while the product used at the Vancouver landfill has perforated mini-pipes with a diameter of 25 mm.

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2 Lapouyade Landfill, France

Lapouyade Landfill in France has been receiving only non-hazardous waste since 1996. It is located in the north-east of the Gironde department, in the Nouvelle Aquitaine region, 50 km from Bordeaux. The site is operated by Veolia, a long-established landfill operator with many sites in France and around the world.

The Lapouyade landfill covers an area of 105 hectares and has a treatment capacity of 430,000 tonnes of waste per year. Waste comes from local authorities and industry of the region. Once each cell has been closed, Veolia will provide 30 years of post-operational monitoring to ensure that the site's environment is controlled and protected.

2.1 Final cover design in 2004

Each 5,000 m² compartment is filled and then gradually closed, before being landscaped. This allows the various landfills to be gradually revegetated. All the leachate and biogas collection systems put in place during the operation of the landfill continue to be collected, monitored and/or recovered.

The landfill cell n°3 presented in this paper has been closed for 20 years. The landfill cover consists of a semi-impermeable clay layer, followed by a multi-linear drainage geocomposite and a cover layer of 0.80 m of topsoil. The geocomposite replaces a traditional 0.30 to 0.50 m thick layer of granular drainage material.

The figures below show the installation of the geocomposite multi-linear drainage system on the site in 2004 and the vegetated and monitored cover (Fig.1).

Fig. 1. Placement of topsoil over multi-linear geocomposite drainage and final vegetation cover.

This typical cross section (Fig.2) has been used on several of the site's landfills since 2004.

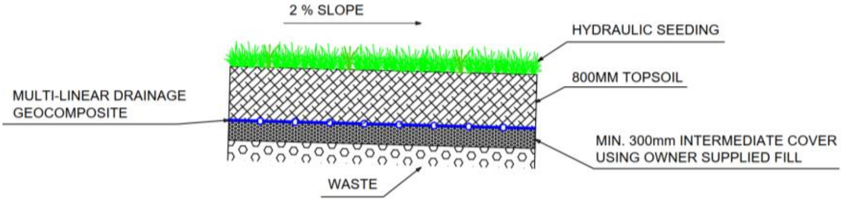

Fig. 2. Lapouyade Landfill – Cross Section of the final cover design.

2.2 Exhumation of the drainage geocomposite in 2014

In order to determine whether the multi-linear drainage geocomposite has retained its mechanical and hydraulic characteristics after 10 years of operation, a 1.50 m by 2.00 m sample was taken in-situ to carry out test controls.

The 800 mm topsoil was gently removed without damaging the drainage geocomposite (Fig.3).

Fig. 3. Removal of the topsoil on top of the multi-linear drainage geocomposite.

Prior to sampling, observation of the top filter layer of the product showed no area of clogging, despite the sandy-clay nature of the topsoil. The bottom section of the drainage geocomposite also appeared to be very clean, as did the underlying clay layer (Fig.4).

Fig. 4. Manual exposition of the two faces of the geocomposite.

The uniform surface condition showed that there was no seepage over this area and that the infiltrated precipitation has been completely drained away by the multi-linear drainage geocomposite. The perfectly clean area of the lateral overlap (> 150 mm) between two rolls confirmed that there was no contamination of the product from the sides and through the overlap (Fig.5).

Fig. 5. Observation of a lateral overlap of product.

The exhumation has been repaired using another piece of the same product, connecting the mini-pipes with couplers before backfilling again.

2.3 Comparative testing in the laboratory

In addition to a visual inspection and photos of the product before sampling, tests were carried out in the laboratory. A sample of the original geocomposite, stored in the laboratory for 10 years, was compared with the sample taken on site.

2.3.1 Visual observations on the virgin geocomposite and the geocomposite exposed on site

The visual appearance of the two products was very similar, only the mini-pipes looks dirtier without being clogged or crushed (Fig. 6 and 7). The durability of the drainage geocomposite was visually validated after a 10-year period of use as a landfill cover.

Fig. 6. Visual inspection of the virgin geocomposite (geotextile layers and mini-pipes).

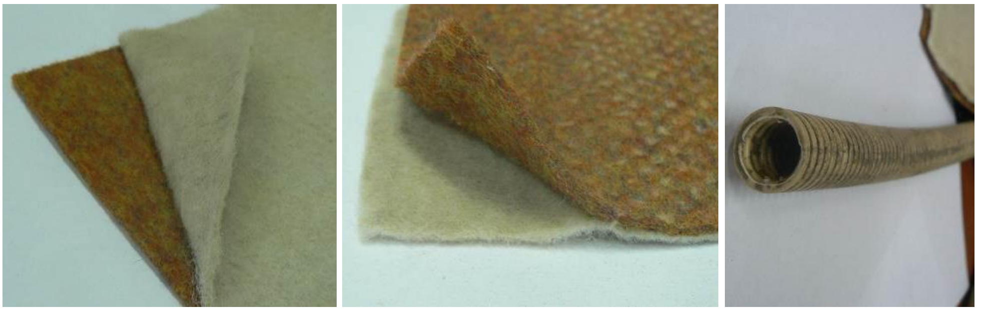

Fig. 7. Visual inspection of the exposed geocomposite (geotextile layers and mini-pipes).

2.3.2 Testing in the laboratory

The tests were carried out in accordance with the standards applicable to geotextiles and related products. The benchmarks are current AFNOR standards and the ASQUAL "Geotextile and related product test method data" 2014 version.

The exhumed product was tested for mechanical and hydraulic properties. The results were compared with the original values tested on the product before installation. As shown in Table 1, after 10 years the product shows no evidence of rapid degradation or any sensible change in its original properties.

Table 1. Comparison of the residual values with the initial values.

	Characteristic	Standard	Ratio Residual/Initial	Unit
Geotextile layers	**Mass per Unit Area**	NF EN 9864	**197%**	g/m²
	Thickness under 20 kPa	NF EN 9863-1	**98%**	mm
	Tensile Strength (MD)	NF EN 10319	**92%**	kN/m
	Elongation	NF EN 10319	**69%**	%
Geocomposite	**In-Plane flow capacity** Hydraulic gradient i=1 Normal load = 20 kPa	NF EN ISO 12958-1	**84%**	m²/s
	In-Plane flow capacity Hydraulic gradient i=1 Normal load = 100 kPa	NF EN ISO 12958-1	**92%**	m²/s
Filter	**Opening size**	NF EN ISO 12956	**100%**	micron

The properties tested on the products are the most important mechanical and hydraulic properties for the function of the geocomposite on this landfill cover. Thickness and tensile strength properties are related to the behaviour of the product under long term compression, flow capacity is related to the drainage function and the opening size of the filter to prevent clogging. All these properties are maintained after 10 years of use of the geocomposite as a drainage layer on the final landfill cover.

3 Vancouver Landfill, Canada

Vancouver Landfill, located in Delta, serves as a regional waste disposal site. Operated by Metro Vancouver, it is the region's largest landfills. In 2012, Sperling Hansen Associates, the engineer of record, incorporated multi-linear drainage geocomposites into the final cover to replace gravel drainage layers, initially as a pilot project.

3.1 Landfill Cover Design (2012)

To reduce environmental impact, maximize landfill capacity, and minimize construction costs and time, engineers implemented multi-linear drainage geocomposites as a substitute for gravel in the surface water collection system of the final cover. Starting in 2012, the geocomposite was installed on a section of the north slope of Phase 2 and monitored for several years. This pilot project informed the subsequent large-scale application on the Western 40 cover, which took place a couple of years later.

The geocomposite effectively managed rainwater drainage (above the geomembrane) and landfill gas (LFG) collection (below the geomembrane) following the W40 construction implementation in 2017, 2018, and 2019.

The Draintube multi-linear drainage geocomposite is represented in blue in Figure 8.

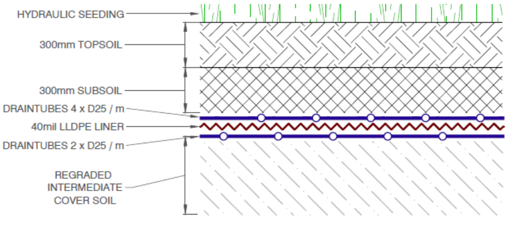

Fig. 8. Vancouver Landfill: Typical cover system including multi-linear drainage geocomposites

3.2 Phase 5 final cover (2024)

Recently, as part of the conceptual design of Phase 5, Sperling Hansen Associates explored the option of extending the use of multi-linear drainage geocomposites beyond the crest areas, where they had been successfully implemented and operated in the W40 phase, to the landfill slopes. This provided an ideal opportunity to assess the material's condition after 12 years of continuous use. As a result, the exhumation of the geocomposite installed on the slope of Phase 2 in 2012 was planned and scheduled for May 2024

3.3 Exhumation Process (2024)

A multidisciplinary team, including geosynthetics manufacturers (Afitex-Texel), the site engineer of record (Sperling Hansen Associates), geosynthetics installer (Western Tank and Linings) and independent laboratories (Sageos CCT Group), oversaw the exhumation. The process involved:

- Careful soil removal to avoid damaging the underlying geomembrane.
- Manual exposure and sampling of the geocomposite.
- Endoscopic inspection of mini-pipes, revealing no clogging or deformation.

Fig. 9. Location of the exhumation and removal of the soil on top of the geocomposite.

Fig. 10. A large sample is collected to be sent for laboratory testing.

Preliminary inspection showed that while some roots were present in the geotextile layer, none had penetrated the mini-pipes. The liner remained clean after 12 years, with no clogging in the mini-pipes.

Fig. 11. Exposition of the geocomposite and the liner. Endoscopic inspection of the mini-pipes.

An endoscopic camera was inserted into each mini-pipe to assess internal conditions, confirming no deformation, root intrusion, or debris accumulation. The geocomposite maintained stable flow conditions, demonstrating the effectiveness of its geotextile filter.

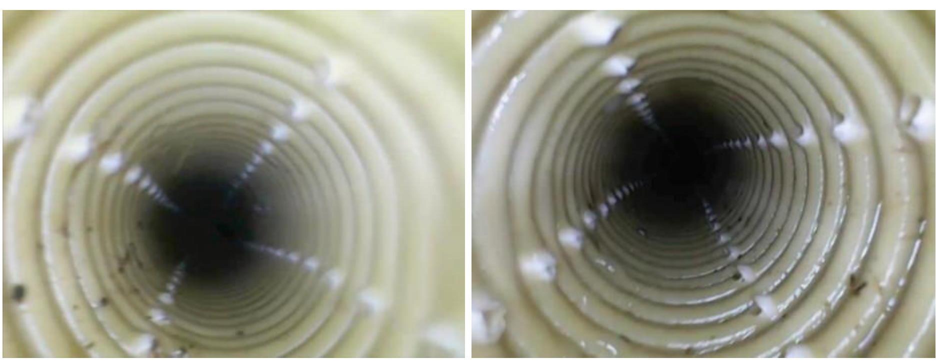

Fig. 12. Inspection of the mini-pipes up-grade (left) and down-grade (right).

Following exhumation, repairs were conducted by installing a new section of multi-linear drainage geocomposite, reconnecting mini-pipes using couplers before backfilling the area.

3.4 Laboratory Testing

A comparison between the exhumed and original geocomposite revealed:

- Mechanical properties (tensile strength, puncture resistance) remained stable (≥95%).
- Mini-pipe stiffness increased (142%), indicating no loss of structural integrity.
- Flow capacity retained 105% of original values.
- Filtration properties remained intact, preventing soil intrusion.

These findings demonstrate the geocomposite's resilience under real-world landfill conditions.

Table 2. Comparison of the residual values with the initial values.

	Characteristic	Standard	Ratio Residual/Initial	Unit
Geotextile layers	**Mass per Unit Area**	ASTM D5261	**100%**	g/m²
	Grab Tensile Strength	ASTM D4632	**95%**	N
	Grab Elongation	ASTM D4632	**100%**	%
	Puncture Resistance	ASTM D6241	**102%**	N
Mini-pipes	**Outside diameter**	ASTM D2412	**100%**	mm
	Pipe Stiffness at 5%	ASTM D2412	**142%**	
Geocomposite	**Transmissivity** i=0.1; Normal load = 480 kPa; Seating time = 100h	ASTM D4716	**105%**	m²/s
Filter	**FOS**	CAN 148.1 No 10	**114%**	micron
	Permittivity	ASTM D4491	**109%**	s^{-1}

4 External Stresses Performance

Multi-linear drainage geocomposites have been extensively used for over 30 years for liquid drainage (water, leachate) and gas collection (LFG, Radon, VOCs). Their performance under external stresses such as soil load, extreme temperatures, chemical exposure, and biological clogging has been investigated in multiple studies. Below is a summary of key findings.

4.1 Load Resistance

Multi-linear drainage geocomposites retain their drainage capacity over time and under load. Figure 13 shows the transmissivity of the product measured for loads up to 2400 kPa and the variation over time of the transmissivity of the geocomposite under 2400 kPa for 1000 hours, for several gradients.

It can be observed that the product is not load sensitive when confined between a geomembrane and a soil layer. They demonstrate resistance to creep compression, with a reduction factor for creep (RF_{CR}) of 1.0 when confined in soil under loads up to 2400 kPa. Laboratory tests show no significant reduction in transmissivity over extended periods.

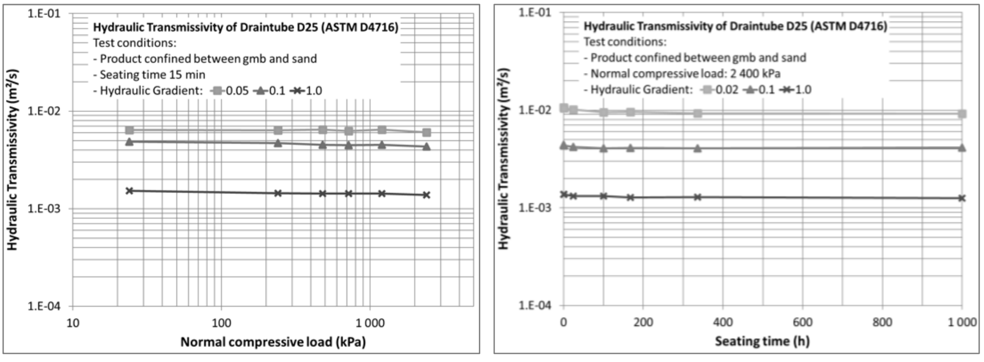

Fig. 13. Hydraulic transmissivity of the geocomposite function of load intensity and time.

4.2 Cold Temperature Performance

Multi-linear drainage geocomposites are made with polypropylene corrugated perforated mini-pipes as drainage conduits. Unlike HDPE, polypropylene is not sensitive to environmental stress cracking.

The apparent modulus of elasticity of the mini-pipes have been tested as well as the unrolling test, under several temperatures. Table 3 shows the main results of tests performed with temperatures up to -70°C. The apparent modulus of elasticity is almost 3 times higher at -30°C compared to 23°C. That change has no consequence on the behavior of the mini-pipe when it is unrolled as demonstrated by the ASTM D5636 that simulates the unrolling of the mini-pipe around a 150 mm diameter mandrel. The test was performed at -70°C and no crack or any other failure was observed on the mini-pipe [1].

Table 3. Apparent modulus of elasticity of the mini-pipe

Temperature	**+23 °C**	**-30 °C**	**-70°C**
Apparent modulus of elasticity (Mpa) *ASTM D790*	8.99	24.54	-
Unrolling test - Mandrel diameter 150mm *ASTM D5636*	-	-	OK no cracks

4.3 Resistance to Biological Clogging

Since 2013, several field tests have been conducted using fresh leachate circulation systems to assess the long-term behavior of multi-linear drainage geocomposites in landfill leachate environments. One such study, carried out in Pennsylvania, USA, by the Geosynthetic Research Institute (GRI) over three years, compared multi-linear drainage geocomposites with biplanar geonet geocomposites.

The study concluded that "*the needle-punched nonwoven geotextile performed the best when placed over the tubular drainage composite. It is well designed with respect to the concrete sand's gradation to avoid piping and is open enough to resist long-term clogging. This is demonstrated by its ability to remain free-flowing with leachate as a permeant for over three years of testing.*" [2]

Figure 14 illustrates the system flow rate over time for four different geotextile configurations tested during the field study: NPNW (Needle-Punched Non-Woven geotextile), WM (Woven Monofilament geotextile), and HBNW (Heat Bonded Non-Woven geotextile).

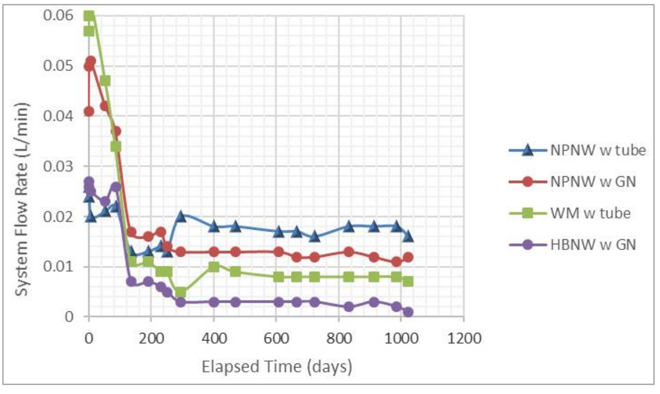

Fig. 14. Combined long-term flow curves for the four different geotextiles with two different drainage components

5 Design Considerations

During the system design process, engineers address the long-term behavior of geocomposites by applying Reduction Factors (RFs) to critical product properties. For drainage geocomposites, these reduction factors are typically applied to drainage capacity (in-plane flow rate or transmissivity).

Field measurements and laboratory studies enhance confidence in the product's performance and confirm the Reduction Factors currently in use for this type of product. Table 4 outlines the recommended reduction factors for multi-linear drainage geocomposites [3].

Table 4. Recommended RFs for multi-linear drainage geocomposites

Applications	Requirements			
	RF_{GI}	RF_{CR}	RF_{CC}	RF_{BC}
Landfill Leachate Collection	1.0	1.0	1.5 to 2.0	1.0* to 1.3
Retaining Walls	1.0	1.0	1.1 to 1.5	1.0 to 1.2
Sport Fields	1.0	1.0	1.0 to 1.2	1.0* to 1.3
Landfill covers	1.0	1.0	1.0 to 1.2	1.0* to 3.5

* In cases when using Draintube ACB, which contains a non-leachable, silver-based biocide treatment

6 Conclusions

The exhumation and analysis of multi-linear drainage geocomposites after 10 and 12 years confirm their long-term durability in landfill final covers. Key findings include:

- No clogging or significant degradation.
- High retention of mechanical and hydraulic properties.
- Resistance to root intrusion, bacterial clogging, and extreme temperatures.

These results, combined with extensive laboratory studies, reinforce the suitability of multi-linear drainage geocomposites as a reliable solution for landfill final covers. Future research should explore longer-term performance beyond 12 years..

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