# PARTIAL REPLACEMENT OF THE GRANULAR LAYER AT THE BOTTOM OF A LANDFILL: SHORT AND LONG TERM MONITORING OF DRAINAGE GEOSYNTHETICS

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**Abstract:** Landfill owners use more and more renewable resources by substituting the granular layer with a drainage geocomposite in landfill covers. A greater demand concerns the bottom of landfills where usually a layer of 50 cm of gravel should be placed. The paper presents an experimental study where the granular layer has been partially replaced by a geocomposite equipped with mini-pipes directly laid onto the geomembrane. The geocomposite aims at acting as a drain and also at protecting the geomembrane against puncture. In order to check the efficiency of the product used, a video inspection has been done during the reception of the waste up to about 15 metres height. A test pad has also been constructed to estimate the impact of the granular layer thickness reduction on geomembrane exposure to puncture damages. The present study highlights critical steps during the construction of the landfill bottom layers and suggests a methodology the drainage and puncture protection functions of the geosynthetics.

**Keywords:** leachate collection system, geocomposite drainage materials, hazardous waste, landfill, drainage, long-term behaviour.

## INTRODUCTION

The partial replacement of the gravel layer with geosynthetics at the bottom of landfill sites allows the saving of granular materials that are more and more difficult to find and lead to important delivery costs. For environmental purposes, it also allows optimisation of the storage capacity of the cell and reduction of truck traffic.

The design of the geocomposite has to be realised specifically for this type of application because the geocomposite will be under high pressures and in an aggressive environment due to leachate.

In this type of application, a factor of safety of 10 on the drainage capacity is generally considered to take into account the biologic clogging of the filter. But what about the factor of safety due to hard mechanical conditions when the granular layer is putting into place just on the geocomposite or when the height of waste reaches several metres?

## LEGAL REQUIREMENTS IN WASTE STORAGE CENTRES

The national legislation for hazardous waste storage centres defines the leachate collector system at the bottom of the cell as a granular layer with collector pipes. The thickness of the granular layer is 0.50 m with a coefficient of permeability not inferior to $10^{-4}$ m/s. The maximum admissible height of leachate at the bottom of the cell is 0.30 m.

The last 0.20 m of gravel above the maximum height of leachate acts therefore as a security layer. Replacing this 0.20 m of gravel (and the protecting geotextile) with a specific designed geocomposite with higher drainage capacity permits to optimize the operating of the waste storage centre without infringing the leachate collection principle defined in the legislation.

## SITE PRESENTATION

The experiments have been conducted on a hazardous waste landfill during 7 months. A geocomposite with incorporated mini-pipes has been laid directly on the geomembrane, continuously welded with hot air to avoid displacements during backfilling and covered with 0.30 m of crushed gravel material 20/40 mm (Figure 1).

**Figure 1.** Putting into place of gravel on the geocomposite

Typical cross section of the bottom of the cell is presented in Figure 2 and the structure of the geocomposite is presented in Figure 3.

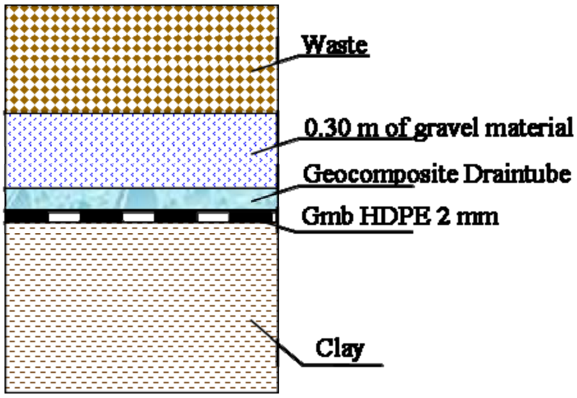


**Figure 2.** Typical cross section

Geocomposite results of the association by needle punching of the following elements (from bottom to top):

- Non woven needle-punched polypropylene drainage layer,
- Polypropylene mini-pipes, perforated at regular intervals on two alternate axes at 90°,
- Non woven needle-punched polypropylene filter layer.

The lateral spacing of mini-pipes in the geocomposite is of 0.50 m.

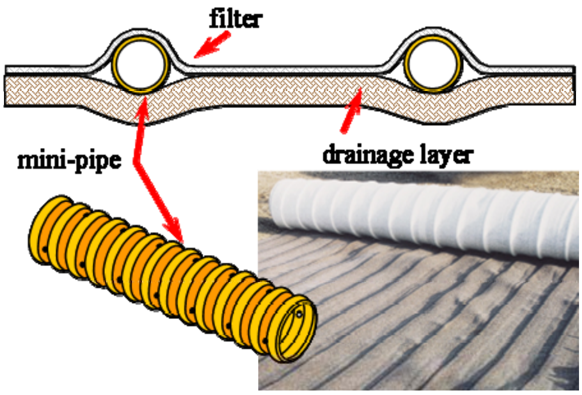


**Figure 3.** Structure of the geocomposite

## EXPERIMENTAL PROTOCOL

The experiments consist of introducing an endoscope video camera into the mini-pipes of the geocomposite and check if there is any damage on them. The camera allows also to see the leachate drainage by the geocomposite.

The test pad is 12 m wide and 20 m long as shown in Figure 4. There are 6 rolls of geocomposite and a total of 48 mini-pipes.

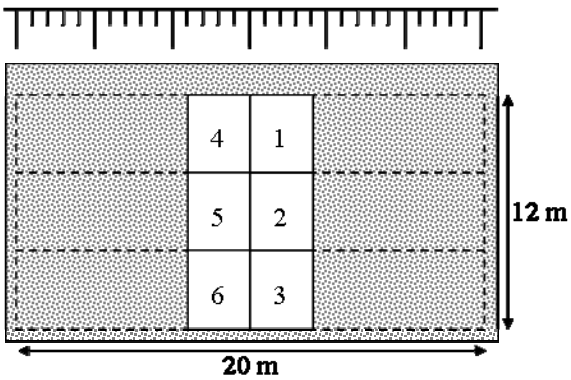


**Figure 4.** Test pad

The test has been conducted while landfill was in operation (filled up with waste). The video inspection has been divided in to 3 stages:

- Stage 1, just after putting in place the granular layer on the geocomposite,
- Stage 2, under about 5 meters of waste,
- Stage 3, under about 15 meters of waste.

The access to mini-pipes was possible thanks to an open space left in the middle of the waste as shown in Figure 5.


**Figure 5.** Filling with waste around the test pad

Video inspection has been conducted by a third party inspector. Viewing inside mini-pipe is possible thanks to an arc lamp on the endoscope camera. The endoscope has a diameter of 8 mm (see figure 6). Video is seen directly on a screen during the inspection.

**Figure 6.** Insertion of the endoscope into the mini-pipe

Observed punctures on the mini-pipes have been divided in two categories:

- Deformation of the mini-pipe from 0% to 30%: considered as free of damage (see figure 7),
- Deformation of the mini-pipe superior or equal to 30%: mini-pipe damaged (see figure 8).

**Figure 7.** Mini-pipe free of damage

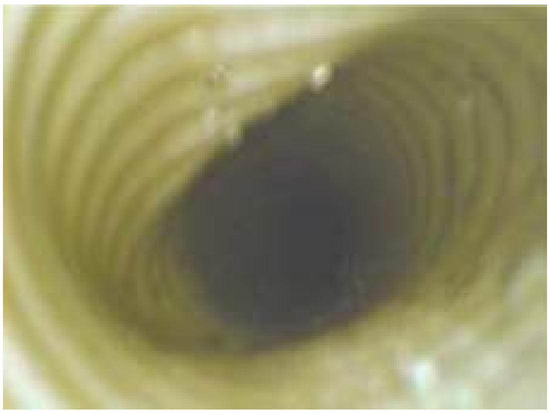

**Figure 8.** Mini-pipe damaged

If one puncture with a deformation superior than 30% was observed on the mini-pipe, the whole length of mini-pipe was considered as damaged.

## RESULTS

### Stage 1

Inspection on stage 1 has been done after putting in place the 0.30 m gravel layer on the geocomposite. Figure 9 presents the observed damages and their positions in the mini-pipes.

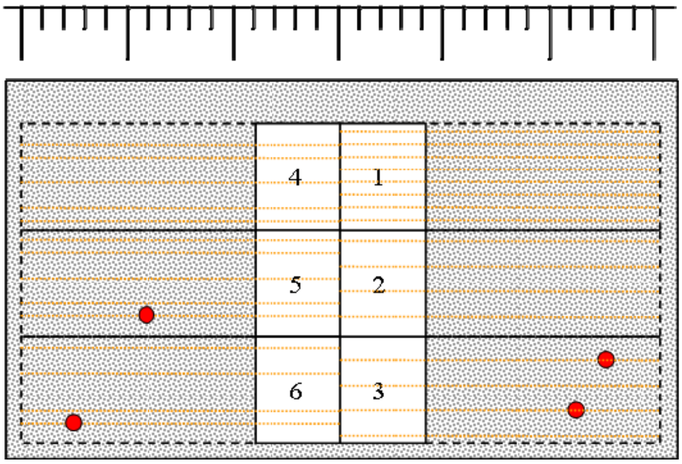


**Figure 9.** Observed damage locations (red dots) on stage 1.

### Stage 2

Inspection on stage 2 has been done after putting into place about 5 metres of waste on the granular layer. Figure 10 presents the observed damages and their positions in the mini-pipes.

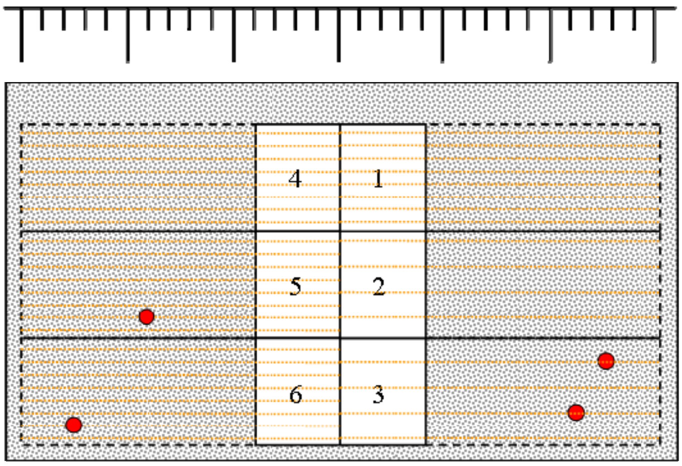


**Figure 10.** Observed damage locations (red dots) on stage 2

No further damages have been detected between stage 1 and stage 2. Some punctures have been found with a deformation less than 30%.

**Stage 3**

Inspection on stage 3 has been done after putting into place about 15 metres of waste on the granular layer. Figure 11 presents the observed damages and their positions in the mini-pipes.

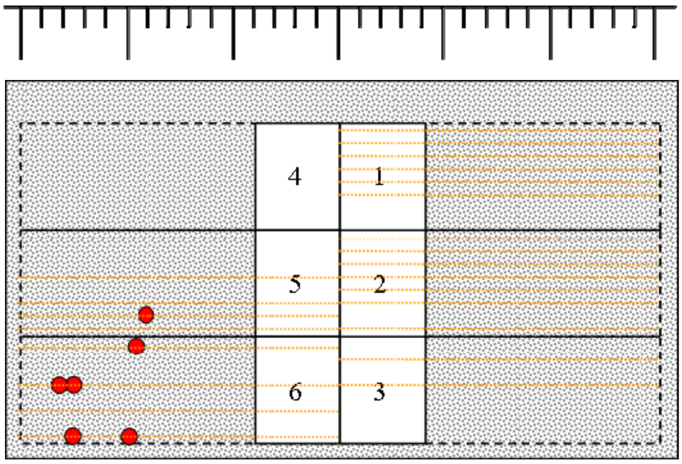


**Figure 11.** Observed damage locations (red dots) on stage 3

At the stage 3, some damages observed at the previous stages have not been detected because some mini-pipes were not accessible anymore.

## RESULTS ANALYSIS

### Global results

Table 1 presents the total length of mini-pipes inspected at each stage and the length of mini-pipes damaged. If a mini-pipe has one or more damages, the total length of this mini-pipe will be considered as damaged. The results are illustrated with the figure 12.

**Table 1.** Data collected during the 3 stages.

| | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|
| **Total length of mini-pipes inspected $L_T$** | 234.5 m | 361.1 m | 145.1 m |
| **Total observed damages** | 4 | 4 | 6 |
| **Length of mini-pipes with one or more damages $L_D$** | 36 m | 36 m | 31.5 m |
| **$L_D$ / $L_T$** | 15 % | 10 % | 22 % |

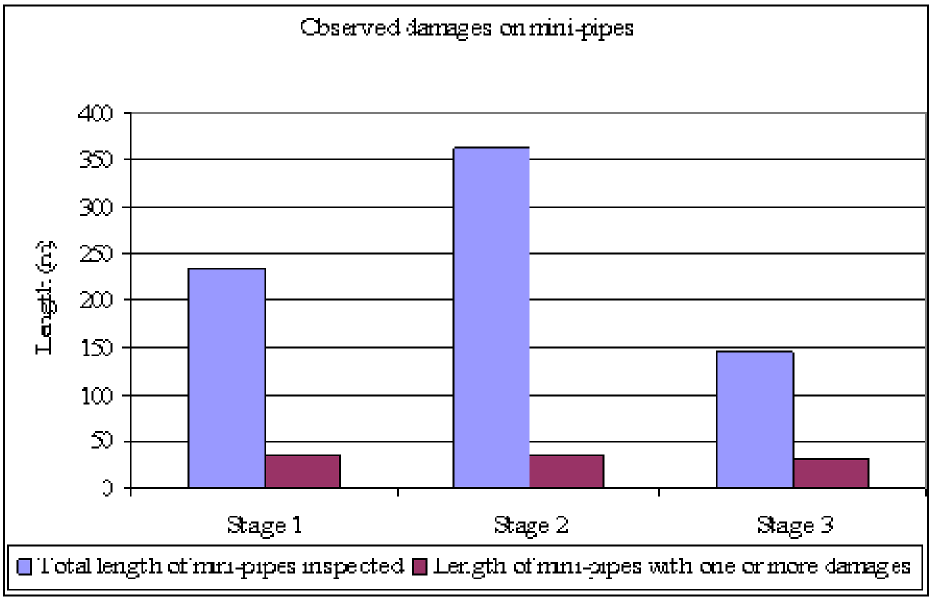


**Figure 12.** Total linear observed and damaged on the 3 stages

Inspections on stages 1 and 2 reveal that the placing of granular layer damages the geocomposite. The damage impact is found equal to 10% of inspected mini-pipes. Indeed, the inspection on stage 2 is more relevant than the one on stage 1 because the length of inspected mini-pipes is more important than the previous stage.

On stage 3 under 15 meters of hazardous waste (about 230 kPa), the damage impact is found equal to 22%.

**Impact of waste height on mini-pipe damage**

In order to measure the waste height impact on mini-pipe damage, the behaviour of mini-pipes has been followed up during the 3 stages on the same identified products.

Table 2 presents the total length of mini-pipes observed during the 3 stages. Although the same mini-pipes are considered in this table, the actual video inspection has not been possible on the same length due to technical constraints (no visualisation because of leachate, stop of the inspection due to bends, etc.).

**Table 2.** Data collected during the 3 stages on the same mini-pipes

| | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|
| **Total length of mini-pipes inspected $L_T$** | 94.7 m | 105.8 m | 95.8 m |
| **Total observed damages** | 2 | 2 | 7 (*) |
| **Length of mini-pipes with one or more damages $L_D$** | 18 m | 18 | 25.5 |
| **$L_D$ / $L_T$** | 19% | 14% | 27% |

(*) On stage 3, damage observed on the previous stages on the roll 3 has not been detected; it has been added to take it into account in results analysis.

Table 2 shows that the installation of the granular layer leads to about half the total damages on the geocomposite (14% at the beginning against 27% under 15 meters of waste).

The influence of the waste thickness on the damage of the geocomposite has to be taken into account for heavy loads. Indeed, no more damages have been found between stages 1 and 2 even though 5 meters of waste have been putting into place.

## CONCLUSIONS

A drainage geocomposite with mini-pipes placed at the bottom of a hazardous waste storage centre in replacement of the protecting geotextile and 0.20 m of granular material has been monitored during 7 months from the start of the operation up to a height of waste of 15 meters on the top of it.

This study shows that the installation of 0.30 m of gravel just above the geocomposite is responsible of about half the damages observed on geocomposite. The other damages appear for an important height of waste (about 15 meters). Under 15 meters of waste, damaged mini-pipes represent less than 25 % of the total length of mini-pipes.

Added to the factor of safety of 10 generally considered for the hydraulic design to take into account biologic clogging of the filter and leachate drainage, another factor of safety of 1.25 can be considered for mechanical stress on the geocomposite during operating of the cell.

Further tests are conducted to estimate the impact of granular layer thickness reduction on geomembrane exposure to puncture damages and the effect of the drainage mat thickness on mini-pipe protection. The experimentation on this test pad has not yet been done; the results will be compared to the previous similar studies (A. Budka, 2007).

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