DIAGNOSIS OF A LANDFILL COVER FAILURE. THE RELEVANCE OF PROPER INSTALLATION PROCEDURES.

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ABSTRACT: Geosynthetics applications in landfills are of current use all over the world. The confidence in the use of such materials on this kind of structures has been increasing due to all the research work done concerning this issue throughout the past years, being plenty the cases of successful performance. In order to obtain a correct performance of these materials on this type of use it is very important to have a proper definition of construction details, as well as of the care needed in the installation of geosynthetics, being very important to be aware of the possible property degradation that may occur due to a careless installation or an incorrect handling. The case study presented in this paper deals with a USW landfill in the North of Portugal in which several localized failures in the cover system's geocomposite drain have occurred. In this paper a description of the problem will be done, as well as its diagnosis based on site observations and on laboratory tests of the chemical composition of the leachate and of the tensile behaviour of the geocomposite drain.

1 INTRODUCTION

The case study that will be presented is fully described in Lopes *et al.* (2003) and refers to a USW landfill located in the North of Portugal, serving an area where shoe industry is of the utmost relevance.

In the beginning of 2003, during an abnormal rainy winter, several localized failures were identified in the lower slope of the landfill cover system (Figure 1).

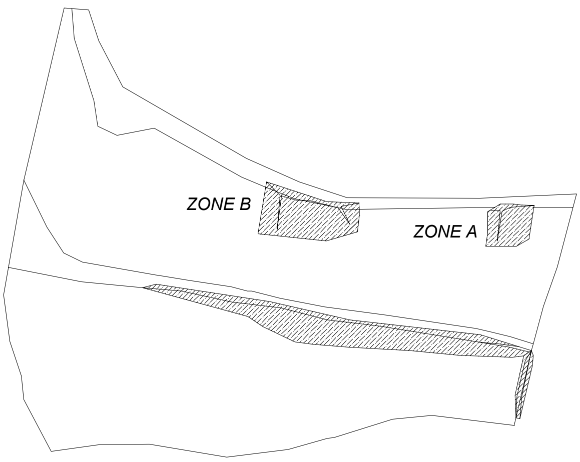

Figure 1 Cover system failures location.

In the site it was observed, not only the slippage of the cover soil, but also the rupture of geocomposite drain constituents of the cover system. Moreover, it was confirmed the presence of leachate nearby the failure areas.

An overview of the failures is shown in Figure 2, and a quite elucidative picture of the leachate percolation along the landfill cover can be found in Figure 3.

Figure 2 Failure overview.

Figure 3 Leachate percolation along the landfill cover.

2 DIAGNOSIS OF THE PROBLEM

The constitution of the cover system, presented in Figure 4, is:

- Soil regularization layer over waste;
- HDPE geomembrane;
- Geocomposite drain (HDPE geonet + PP non-woven geotextile);
- 0.60m thickness soil cover layer.

The cover slope is 1(V):3(H).

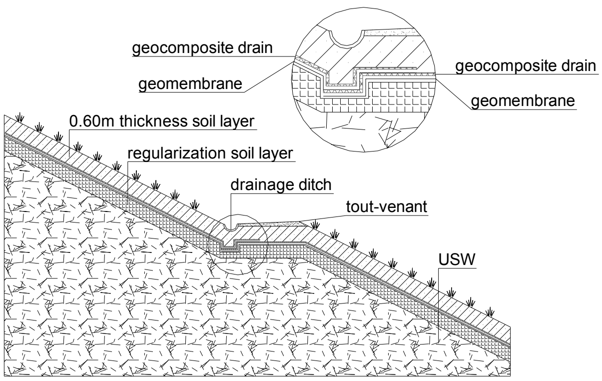

Figure 4 Landfill cover system detail.

As shown in Figure 1 failures took place on the lower slope of the landfill cover, and the presence of leachate was observed nearby. In fact, the percolation of this solution along the geocomposite drain (GCD) is, probably, the major reason for the ruptures, as its chemical aggressiveness can change the mechanical properties of the geosynthetics and prone them to failure.

But, how was the leachate percolation possible on the cover GCD?

Mainly because the sealing requirements between the upper and the lower slope's geomembranes were not assured. In fact, as shown in Figure 4, geomembranes are overlapped, but not welded.

Other circumstances could prone cover to failure, namely the improper compaction of the cover soil.

In short, the failures of the cover system were probably due to:

- Reduction of tensile resistance of the geosynthetic and of the interfaces resistance, caused by the presence of leachate;
- Reduction of the soil friction angle, caused by improper compaction.

3 EXPERIMENTAL APPROACH

Apart from the diagnosis of the problem based on site observation it was considered of the utmost importance to support it by an experimental approach. This approach consisted in the performance of laboratorial tensile tests of exhumed GCD from two zones of the landfill:

- Zone A (see Figure 1), which was the failure area where heavy concentration of leachate was found;
- A stable area of the cover, without the presence of leachate.

The objective of these tests was to compare the tensile strength of the material placed at the same time in similar conditions, having part of it failed *in situ*, and part performed properly.

Beyond the tensile tests of the GCD, performed in accordance to EN ISO 10319, a chemical characterization of the leachate solution took place.

3.1 *Chemical characterization of the leachate*

The objective of the chemical characterization of the leachate was the definition of its aggressiveness.

The samples of the solution were obtained from a well placed near the toe of the lower slope of the landfill cover.

Table 1 shows the more relevant characteristics of the leachate.

Table 1 Leachate characteristics

pH	6.8
Oxide/reducer potential	+118 mV
Organic matter	0.09%
Chromium content	368 ppm
Copper content	62 ppm
Zinc content	18 ppm
Lead content	0.5 ppm
Total acidity *	481 mg/l
Oxygen content	< 15% of the saturation value
Solid residue	Mainly chromium oxide and heavy metal (Pb, Zn and Cu) sulphurets

* in terms of CH3COOH quantity

The leachate pH is moderately acid. Its total acidity is compatible with:

1 - an advanced anaerobic process;

or

2 - a landfill cover permeable to rainwater.

The first possibility is incompatible with the measured value of the leachate oxide/reducer potential, which corresponds to a heavy oxidative process, characteristic of the aerobic process.

It must be noted that, during the aerobic process the waste biodegradation produces CO2 and acid organic substances, which are responsible for the reduction of the leachate pH to values in the range of 5.5 to 6.5 for dry waste, and in the range of 6.0 to 7.0 for wet waste.

Attending to the mentioned it was assumed that the incoming of the rainwater in the waste body of the landfill was sufficient to dilute the “dry” leachate.

However, as the oxygen content of the leachate is low, the oxidative effect of the solution is not related with the dissolved oxygen, but with another oxidant chemical species, which was identified as chromium VI (Cr (VI)).

3.2 *Mechanical characterization of the GCD*

As it was referred before, the main target of the mechanical characterization of the GCD was to compare the tensile resistance of the material placed on the landfill with and without contact with the leachate. GCD_{DRY} will represent the material without contact with leachate, and GCD_{WET}, that with contact with the solution.

Specimens of the GCD_{DRY} and of the GCD_{WET} are shown in Figure 5. The behaviour of one of that specimens during a tensile test is presented in Figure 6.

The tensile strength, in the machine direction (MD) and in the cross machine direction (CMD), of the GCD_{DRY} and of the GCD_{WET} is presented on Table 2.

a)

b)

Figure 5 Specimens of the exhumed material: a) GCD_{DRY} ;b) GCD_{WET}.

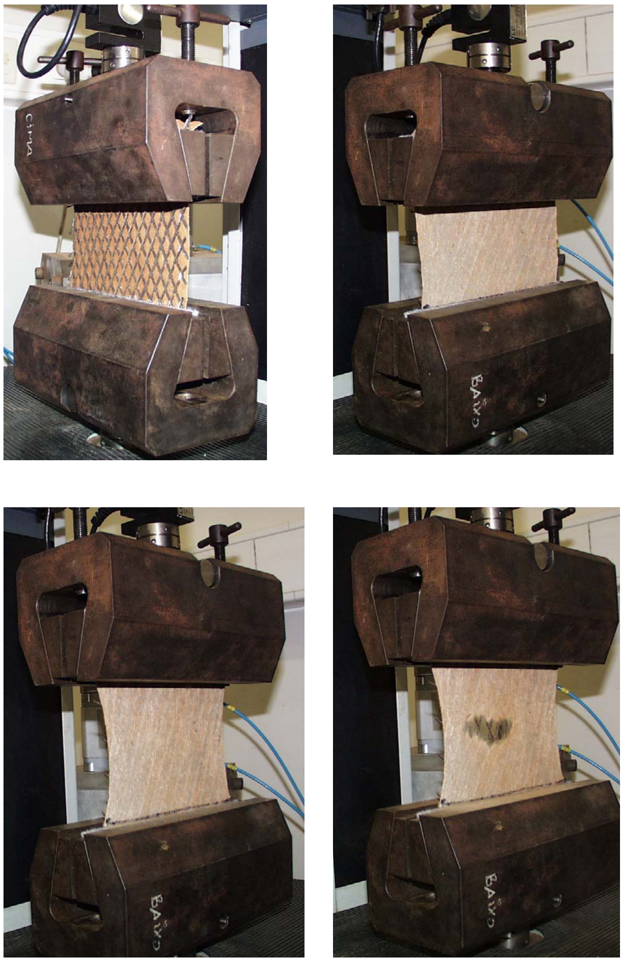

Figure 6 Tensile test of GCD_{WET}.

Table 2 Results from the tensile tests

Sample	Tensile Strength kN/m	
	MD	CMD
GCD_{DRY}	14.16	11.62
GCD_{WET}	7.53	11.95

The influence of the leachate in the tensile strength of the GCD in the cross machine direction was found meaningless. However, in what concerns that strength in the machine direction a strong influence of the geosynthetic contact with the leachate was found.

In fact, tensile strength in the machine direction reduces about 47% when the geocomposite drain had been in contact with the landfill leachate.

Probably, the heavy oxidant leachate, due to its high chromium content, partially oxides the main polymer constituent of the geocomposite drain (polyethylene), leading to reduction on the mechanical resistance of the geosynthetic.

As the geocomposite drain was placed in the landfill cover with its machine direction coincident with the direction of the main actions, the reduction observed on the mechanical properties of the geosynthetic is, for sure, the main reason of the failures of the cover system of the landfill.

4 FINAL REMARKS

The case study presented in this paper enhances the relevance of proper definition of landfill's cover systems construction details, as well as, of adequate installation and handling in order to avoid geosynthetics damage.

The landfill cover failures could have been avoided if the geomembrane junctions were welded and if the tightness of system, both against rainwater and leachate was effective.

There is a strong feeling that the geocomposite drain would behave properly if there were not any contact with leachate, as it should be, if the design and construction of the cover system had followed the most elementary principles for geosynthetics.

5 REFERENCE

Lopes, M. L., Silvano, R., Moura C., 2003: Landfill cover system failures – problem identification and analysis, FEUP Technical Report, 15p., Porto, Portugal.

ACKNOWLEDGEMENTS

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