New Concepts in Waste Disposal: Improved by Geosynthetics

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ABSTRACT : Geosynthetics are widely used in lining systems of wastes disposals. This paper describes other uncommon applications of geomembranes and geotextiles designed in the case of three french landfills, to improve the safety of the work and to make easier daily working.

1 INTRODUCTION

The use of geosynthetics in landfill applications is growing for two decades. First, lining systems with geomembranes were introduced and added to the natural clay layer to decrease transferts between the wastes and the surrounding environment (air, water, soil), i.e. leachates and gaz migration. The use of geomembranes is generally completed by geotextiles for protection, and eventually by geocomposite clay liners in substitution of an insufficient natural clay liner.

For the drainage layers of landfills (leachate at the bottom, or gaz and rainfall at the cover), other families of geosynthetics have been gradually employed : geonet or geocomposite drain for the drainage function, geotextiles for the filtration function.

Near these now common uses, it was found that geosynthetics can have other applications in wastes disposals. This paper presents the case of three french landfills, owned by the waste management company France-Déchets, were new solutions with geosynthetics have been developped. All these solutions refer to stability or mechanical problems of the soil or of the wastes themselves. They were designed by Bidim Geosynthetics in coordination with the owner and the engineering company FD-Conseil. All the products mentionned in this paper belong to the range distributed by Bidim Geosynthetics.

2 GEOMEMBRANES AS A VOLONTARY SLIDDING SURFACE : CASE OF THE VILLEPARISIS LANDFILL (F)

This case history presents a marginal function of the geomembrane, compared to the usual fluid barrier function.

The Villeparisis landfill is one of the nine french landfills for industrial and toxic wastes (Class 1) managed by this company. It is located over a thick geological clay layer of very good quality. A part of the site contains deep levels of municipal wastes with a very high water content deposed here in the past. The new use of the landfill required to separate these old organic wastes from the industrial one by 5 m of compacted clay. Over this clay liner has been designed a drainage system including an HDPE geonet and two polypropylene needle-punched non-woven geotextiles for filtration.

As indicated in Fig. 1, the new waste induces an increasing compressive load on the deep level of organic wastes, what produces loss of internal water and sinking of the clay liner separating the two kinds of wastes. The reduction of volume was estimated to at least 20 - 30 %. This displacement can create critical strengths in the geosynthetics of the drainage structure, especially at the junction between the embankment and the compacted clay liner where the maximum deformations occur.

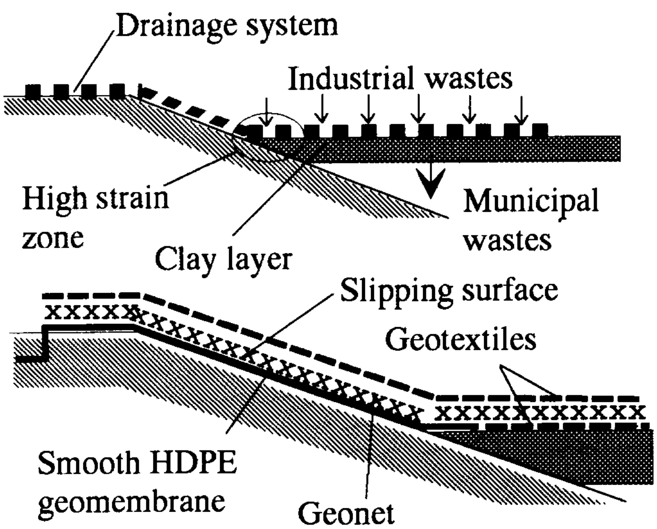

Figure 1 : Vertical section of the cell of the Villeparisis landfill to be drained.

This problem was solved by "disconnecting" the drainage structure from the clay of the embankment with a thin smooth HDPE geomembrane anchored in the slope with steel clamps. This geomembrane doesn't act as a lining componant, but only as a low friction interface. Thus, when the organic wastes are consolidating, the low friction angle between the geonet and the geomembrane (less than 10°) compared to the one between the geotextile and the soil (more than 30°) let the whole drainage structure slid on the slope over the geomembrane accompaging the clay liner movement.

3 SOIL REINFORCEMENT WITH GEOTEXTILES : CASE OF THE TORCY LANDFILL (F).

Geotextiles are commonly used in earth works as reinforcement structures to increase the slope of embankments. This application can also be useful in landfills to save storage capacity or to take into account new conditions of waste management.

This technique was applyed to the external dyke of the Torcy landfill. The municipal waste stored in this site is compacted in cubic bales of about 1 m. The original solution consisting in a classic dyke with a slope 2h/1v (Fig. 2) would have create a lot of problems : a) the installation of these blocks of waste on an inclinated plane is not easy; b) a lot of space between the blocks remains empty; c) the two previous points are detrimental to the stability of the wastes near this crucial zone near the geomembrane (slidding).

These problems were canceled by designing a vertical wall facing the wastes reinforced by 7 layers of needle-

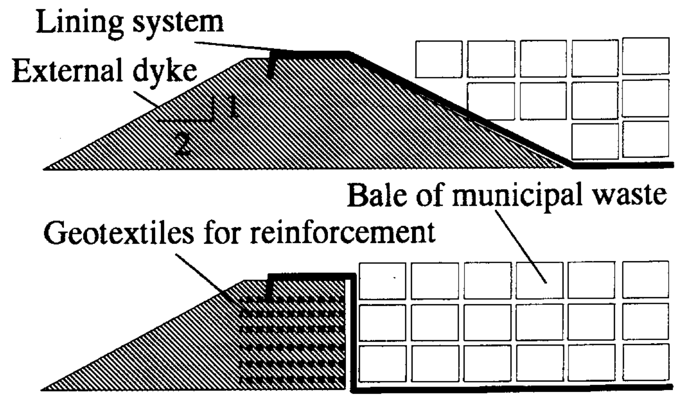

Figure 2 : Basic and new solutions for the external dyke of the Torcy landfill

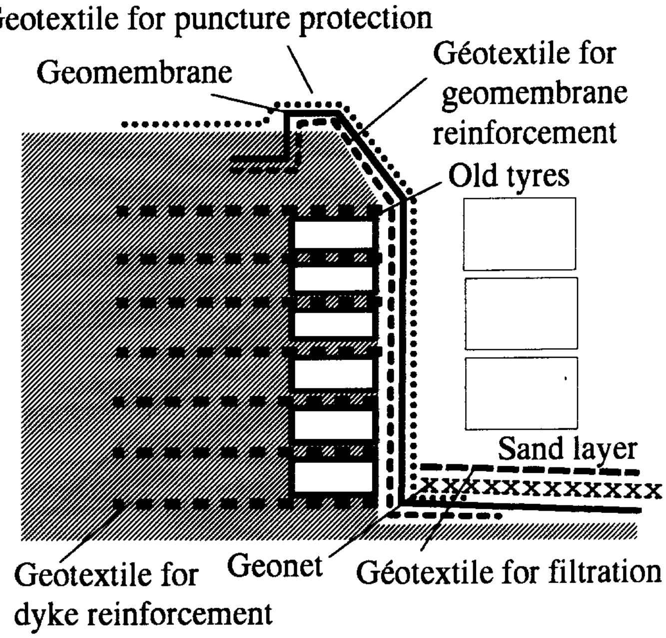

Figure 3 : Cut of the external dyke of the Torcy landfill .

punched non-woven polyester geotextiles. The facing of the wall has been buid up with old tyres of trucks as indicated in Fig. 3.

The advantages of this new design are the following : a) saving of storage space (about 11 m3/m of dyke); b) economy of soil material not available on the site; c) ease of installation of the bales of waste; d) use of old tyres (found in big quantity in landfills) as construction material instead of waste.

In spite of a higger quantity of geosynthetics used, an economical study shows that this solution is very interessant for high cost wastes (industrial), but also for municipal wastes depending on local considerations.

The 2 mm thick HDPE geomembrane covers the wall vertically and is anchored in a trench at the top of the dyke. It is protected against puncture from the wastes by a very resistant non-woven neddle-punched kN) and a sand layer. On the other side, a high modulus geotextile (stiffness at 5% strain : 60 kN), which is a non-woven reinforced by polyester yarns, is interposed to avoid excessive deformation of the geomembrane inside the holes between the tyres due to the horizontal pressure of the waste induced by sinking. The maximum permissible strain was fixed to 5 % and design in spherical deformation.

4 WASTE REINFORCEMENT WITH GEOTEXTILE FOR INTERNAL SEPARATION : CASE OF THE PONTAILLER LANDFILL (F)

A classic waste management method consists in exposing the smallest area of waste to rainfall, so that to minimize leachate production. This maximum area is about 2500 m² in France. Separation dykes are usually built with soil material to part a wide cell into smaller work zones. Theses dykes are often made with compacted clay. But this solution is economically not good, because a lot of storage volume is lost. A more judicious solution consists in building theses separation walls with wastes.

A very positive test was carried out in the Pontailler landfill where industrial waste is stored. The working zone is delimited by the wastes themselves which are reinforced with layers of geotextiles to obtain an almost vertical wall as indicated in Fig. 4. The waste used in this test is a bad material with a very high water content which is not bearing and difficult to compact when wetted. The hypothesis of design were the following : density of wastes : 1, internal friction angle : 20 °, cohesion : 0 kPa. Due to these bad conditions, the reinforced waste was treated as an abutment. The geotextile designed is a non-woven neddle-punched polyester geotextile which combines high resistance (40 kN/m) and good transmissivity (6 10^{-6} m²/s under 50 kPa) to drain interstitial leachate from the waste and to contribute to stabilise the wall.

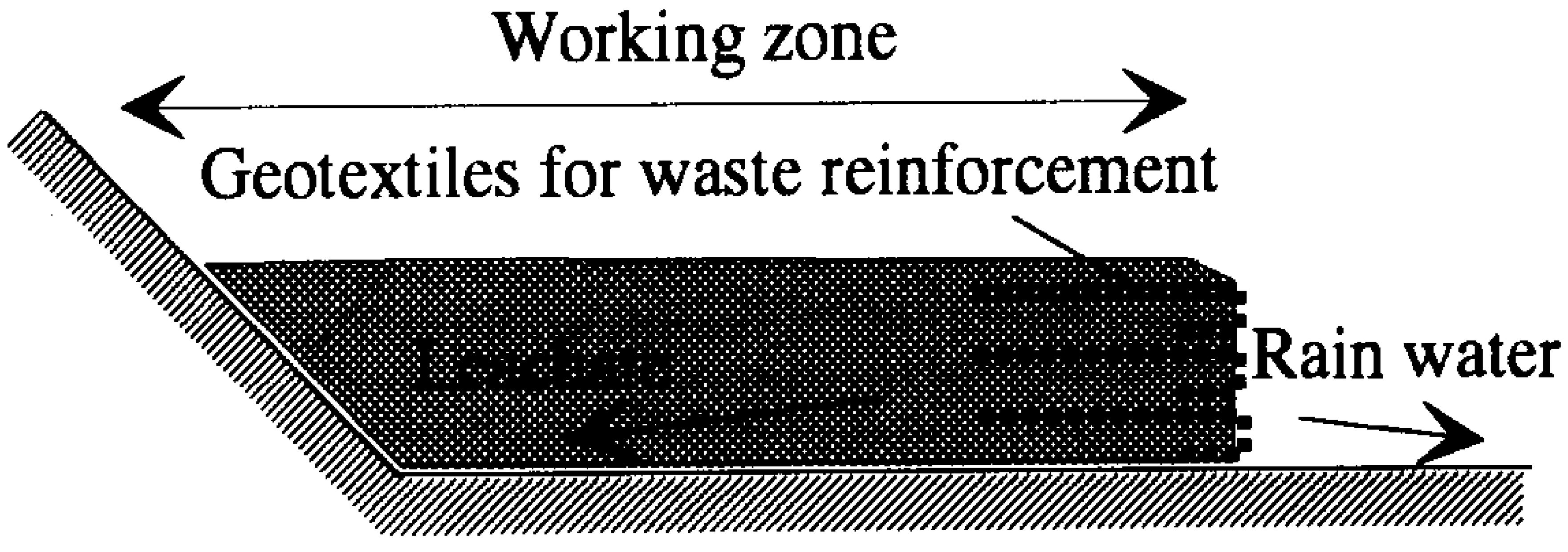

Figure 4 : Internal separation dyke with wastes reinforced by geotextiles at the Pontailler landfill.

5 WASTE REINFORCEMENT WITH GEOTEXTILES TO INCREASE STABILITY AND STORAGE CAPACITY : CASE OF THE TORCY LANDFILL.

One type of failures, the global failure along the lining and the drainage systems, was observed on several sites, landfills or not. It is very important to be aware of this specific aspect, because lining and drainage systems often introduce low friction interfaces due to the supperposition of geosynthetics layers. If this phenomenon is evident over embankments (cf. § 2), it can also occur even if the lining slope is small, for exemple at the bottom of the landfill.

A numerical study (Delmas et al., 1993; Artières et al., 1994) was undertaken to evaluate the influence of several parameters (bottom slope, height of wastes, type of friction interface, water level in the waste) on the stability of the wastes over a typical lining system : {clay - HDPE geomembrane - nonwoven needle-punched geotextile - gravel - wastes}. It shows that: a) the most critical interface corresponds to the lower friction angle (here between geomembrane and geotextile); b) the efficiency of the drainage over the geomembrane is of great importance on the stability; c) a lower slope of wastes increases the stability of the embankment, but its influence is rather low (the slope without reinforcement must be so flat that it is practically and economically not possible).

The use of geotextiles to reinforce the body of wastes either near the lining system, or inside the wastes is a solution which allows on one hand an increase of the global stability during a period corresponding to the improvement of the geotechnical characteristics of the wastes (these characteristics tend to increase when domestic wastes are consolidating), and on the other hand, a design of the landfill closer to the specific constraints of the site : better adjustment to the local topography (variable slopes of the embankment are possible), increase of the stored waste for a given land area, etc...

This solution was designed in the case of the Torcy landfill. The bottom lining system is described in Fig. 5. Due to local topography, the maximum height of wastes is planed to be 40 m with an external slope of 45°. The slope of the lining system is 1 % in this direction.

In the Torcy case, the sliding surface passes through the waste and follow the lining system between the geomembrane and the geonet. The two materials have the lower interface friction angle of all the structure. The global tensile force which is necessary to obtain a

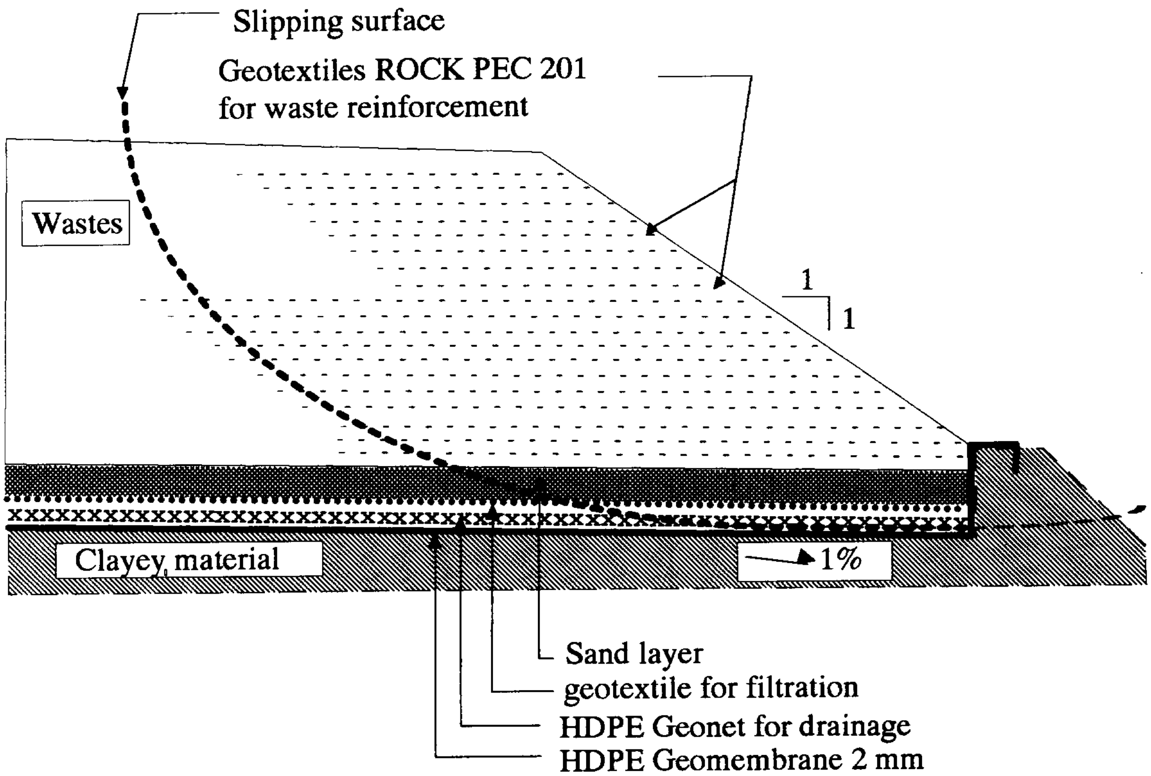

Figure 5 : Cross section of the Torcy landfill.

safety factor of 1.2 is about 2800 kN for 1 m width of the embankment in the short term case.

The reinforcement structure designed with the CARTAGE program consists of 31 layers of high strength (200 kN/m) and high stiffness (1400 kN/m at break) geotextile. The space between the layers is 1 m with a length between 25 and 70 m. The geotextile ROCK PEC 201 is the association of a needle-punched nonwowen polypropylene geotextile, knitted with polypropylene yarns. The yarns give the tensile properties, when the non-woven placed above the yarns protects them against mechanical damage due to puncturing by the waste or by the traffic. This particular point allows to lower the safety factor on the product according to the french standardization on geotextiles for soil reinforcement.

Polypropylene offers the best chemical compatibility geotextile-leachate, particularly at high pH values. Partial safety factors tacke into account durability and possible degradation of the product.

It must be noticed that the assumptions on the wastes shear characteristics were chosen on the safe side and induce a high level of reinforcement. More precise evaluation will certainly allow a reduction of the reinforcement costs, and will be more economic.

6 CONCLUSION

Near the common uses of geosynthetics in landfills, especially in lining systems, come into view new applications in which the wastes can be ranked as a construction material. The benefits of these applications are very interesting in the current working of the landfill. They are for instance able to solve a lot of stability problems induced by the specific behaviour of the wastes. They also often offer economically solutions, such as increase of storage capacity by reducing soil quantity or by increasing external slopes.

7 REFERENCES

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