Feedback of an EPDM geomembrane landfill cover 12 years after its installation

A. Guillaume Stoltz, Nathalie Touze-Foltz & Didier Croissant
IRSTEA, Antony, France

B. Bernat Amat
Firestone Building Products, Zaventem, Belgium

ABSTRACT: This study concerns the feedback of a synthetic rubber geomembrane EPDM that was installed 12 years ago for the landfill cell cover of Lann Hir. An inspection visit has been organized to assess the condition of the geomembrane and sealing details. Part of the covering soil has been removed to allow visual inspection and take samples of the geomembrane that were subjected to analysis. The publication presents the Lann Hir landfill, the specificities of installing an EPDM geomembrane landfill cover and the test results of the showing that twelve years after its installation, the mechanical characteristics of the EPDM geomembrane and its seams are nearly unchanged.

Keywords: [Geomembrane, EPDM, Durability, landfill cover.]

1 INTRODUCTION

The use of geomembranes on the bottom of and as covers for landfill sites is a very common practice. The follow-up period for a closed landfill cell, around 30 years, poses the question of durability of the materials comprising the "envelope" of the cell, notably the geomembranes. This study relates to the analysis of an EDPM geomembrane installed 12 years ago, serving as a cover at the Lann Hir municipal landfill.

EPDM geomembranes (Ethylene-Propylene-Diene terpolymer) are cured synthetic rubber geomembranes. Their highly cross-linked polymeric structure (carbon chains linked together by sulphide bonds) gives the material substantial flexibility and elasticity (> 300% elongation). Waste dumps usually present wide ranging compaction, in metric terms (Olivier, 2003), the flexibility of EDPM geomembranes may be considered for use as landfill covers.

Two studies examine on the use of this type of geomembrane in exposed conditions for hydraulic structures (Blanco et al., 2011 and Blanco et al., 2013). The Blanco et al. (2011) study concluded that the mechanical characteristics (tensile strength, resistance to static puncture) experienced only minor changes over time (12 years of use). A decrease in elongation at break under tensile stress is however observed. According to Blanco et al. (2011), this observation can be explained through the curing of the polymer.

The study on the EPDM geomembrane installed at the Lann Hir landfill site was conducted in several stages. After a visual inspection of the condition of the cover system and its details, samples were taken and sent to a laboratory for analysis. The tensile characteristics measured on the samples takes were compared against those from the virgin samples 12 years ago. The results obtained allow for an assessment to be made on the extent to which the EPDM geomembrane retains its mechanical performance after 12 years in use.

2 PRESENTATION OF THE LANN HIR LANDFILL

The Lann Hir landfill located in the municipality of Pont Scorff (Morbihan (56), Brittany) is a site of approximately 20 ha with authorisation since 1979 and currently in post-exploitation status. In 1999, the operator and owner of the land - GEVAL, a subsidiary of the VEOLIA Propreté group decided that an area of 7 ha which had been exploited between 1992 and 1996 would be subjected to redevelopment to reduce the quantity of leachates produced in the old exploitation cells (Figure 1).

The significant input of leachates was caused by the shallow gradient of the semi-permeable cover on the cells and localized mess caused by differential settling of the waste dump.

The redevelopment consisted of leveling the ground to achieve an overall gradient of more than 3%, installing a waterproof covering of 70,000 m², installing a degassing network and leachate pumping system and to finish off, covering the entire cell with a clay and topsoil layer.

The owner would like the location to return to its former forest usage. The specifications considered the compatibility of the waterproofing system with a sample of trees with a suitable root system. An access way was created above the waterproof covering and all the ditches (1500 ml) for this cover are waterproofed with EPDM geomembranes (Figure 2).

The project design was awarded to SICAA Etudes consulting engineers, the execution of the earth works to SOTRAMA and the waterproofing works to SODAF Géo Etanchéité.

The owner's selection of an EPDM geomembrane was an innovative choice at the time as it represented the first use of an EPDM geomembrane on a landfill site in France for both the owner and the geomembrane manufacturer. This selection can be explained by the significant waste settling expected, the consolidation rate of which was unknown and the assurances given by Firestone that the EPDM geomembrane was compatible with the type of root system envisaged.

The works took place in 9 stages between 2000 and 2008.

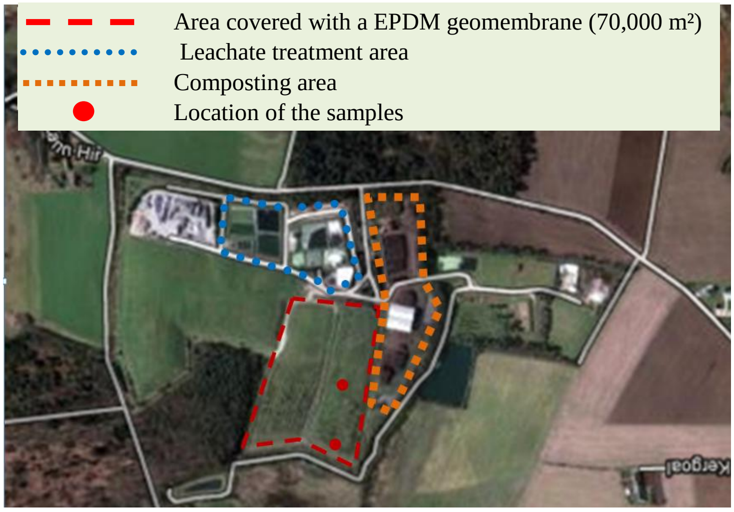


Figure 1. Arial view of the Lann Hir landfill during covering work

Figure 2. Peripheral ditch at the foot of the mound lined with EPDM geomembrane and current state of the landfill

3 COVER CHARACTERISTICS AND INSTALLATION DETAILS

3.1 *Description of the Lann Hir landfill cover*

To reduce the amount of leachates generated by the landfill cells at Lann Hir, it was decided to install impermeable covers to prevent rainwater from getting into the waste. Additionally, the impermeable cover affords better conditions for collecting biogas by the collector system and thereby prevent dispersal into the atmosphere.

The cross section illustrated in Figure 3 shows the cover system installed at the Lann Hir landfill. From bottom to the top, the following elements are noted:

- domestic waste;
- a reprofiling layer intended to level out and homogenise the ground and facilitate the installation of the cover;
- a gas drainage system connected to the degassing wells. The drain geocomposite is made from a filtration geotextile on the lower surface and a drainage core on the upper surface (Figure 4);
- a protective, heat bonded, 300 g/m² geotextile made from recycled fibres;
- the Asqual certified, 1.1 mm thick EPDM geomembrane (Figure 5);
- a protective, heat bonded, 300 g/m² geotextile made from recycled fibres (Figure 6);
- a protective soil layer, 0.45m thick, made up of clayey soil (Figure 7);
- 0.4m of topsoil with the aim of encouraging the growth of vegetation to help with integration into the surroundings and protect against erosion

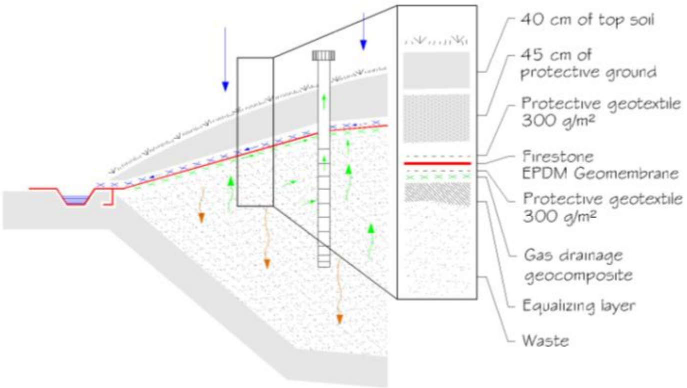


Figure 3. Schematic diagram of the Lann Hir landfill cover

Figure 4. Gas drain geocomposite.

3.2 *Initial Characteristics of the EPDM geomembrane*

The average thickness and tensile strengths for the 15% and 250% deformation ratios of a new membrane, measured between 1999 and 2000 on 5 samples machine direction and 5 samples ross machine direction, are listed in Table 1.

Table 1. Average characteristics of 5 new EDPM geomembranes measured between 1999 and 2000

Characteristics	Standards	Values	
		SP*	ST**
Functional thickness (mm)	NF P84-515	1.13	
Tensile • Resistance to 15% deformation (kN/m) • Resistance to 250% deformation (kN/m)	NFP 501	0.75 6.43	0.72 5.88

The standards NF P84-515 and NFP 501 have since been replaced respectively by EN 1849-2 and EN 12311-2; the thicknesses and tensile characteristics, measured according to the new standards on the new sample in 2007, are detailed in Table 2.

Table 2. Characteristics of a new EDPM geomembrane measured in 2007

Characteristics	Standards	Values	
		SP*	ST**
Functional thickness (mm)	EN 1849-2	1.09	
Tensile • Resistance to 15% deformation (kN/m) • Resistance to 250% deformation (kN/m)	EN 12311-2	0.84 6.86	0.77 6.39

3.3 *EPDM geomembrane installed at the Lann Hir site*

Between 2000 and 2008, 70,000 m² of EPDM geomembrane was installed in nine phases (from 4,000 m² to 10,000 m²) by the company Sodaf Géo. The geomembranes used were for the most part 15.25 m x 61 m or 30 m x 61 m when they were assembled in advance in the workshop. The installation team was made up of 10 people (2 Asqual certified welders and 8 laborers) and had an installation pace of 10,000 m² per two weeks (installation of the protective geotextile and realization of details included).

The various panels were assembled on site using self-adhesive tape made from synthetic rubber, and a primer made from solvents and EPDM (Figure 5). The seams were systematically subject to visual inspection, vacuum chamber (individual points) and destructive tests (shearing, peeling). It is also possible to test the taped seams along their length with an air lance system (ASTM D 4437) which consists of directing high pressure air onto the seam.

For the Lann Hir project several geomembranes were pre-assembled in the workshop to reach panels 2,000 m² in size. Consequently, more than half of the seams were realized in ideal conditions in terms of temperature, humidity and quality of the support. The decrease in the number of seams to be realized on site reduces the risks attached to the installation and how dependent the assembly is on climatic conditions.

Figure 5. Installation of the EPDM geomembrane. Creating a seal using self-adhesive tape

Figure 6. Installation of the peripheral ditch and high protection geotextile

3.4 *Installation of the soil cover*

The installation of the soil cover requires exceptionally strict installation rules to be observed given that heavy machinery needs to move around on the areas which have already been waterproofed with the geomembrane.

At the Lann Hir site, the lorries were authorised to move around on access ramps 80 cm thick. The levelling of the material was done from the ramp, using a caterpillar track vehicle, authorised to move around on a layer at least 40 cm thick.

Figure 7. Installation of the soil cover

3.5 *Connection of the geomembrane to the biogas collection wells*

Considering that household waste is largely composed of biodegradable elements, even if they are correctly compacted during use, it is inevitable that some differential settling will occur over time. This can pose problems for the impermeable connection between the geomembrane and the degassing wells given that the wells will not follow the same patterns of movement as the waste.

To ensure that this detail does not become strained over time, which may risk compromising the impermeability, the flexibility of the EPDM geomembranes allows for a "safety pleat" to be made outside the soil on the degassing wells (Figure 8 and 9). Then, when the soil around the well settles, the excess geomembrane provided at the well (0.6 m at Lann Hir) means that the geomembrane is not put under strain. The advantage of this feature is that it can be adapted to any diameter and the excess geomembrane can be adjusted to the anticipated differential settling.

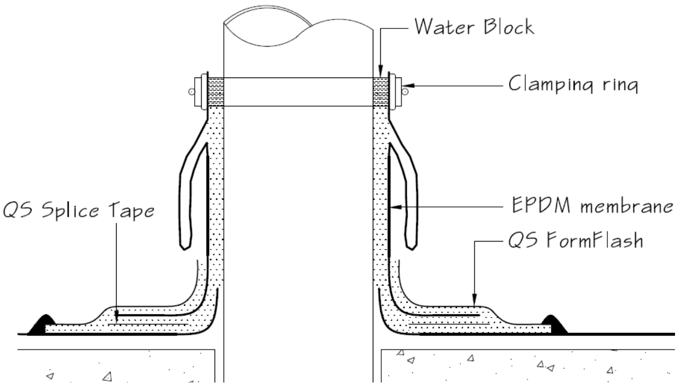


Figure 8. Schematic diagram of the "safety pleat" on the biogas collection wells

Figure 92. Degassing well before and after the addition of a safety pleat

4 SAMPLING AND INITIAL OBSERVATIONS

4.1 *Sampling technique*

On 14 June 2012, that is to say, 12 years after installation, two geomembrane samples were taken from the first cell covered with EPDM geomembrane in 2000. The first sample was taken from the top of the mound and the second at the foot of the slope, where it meets the seam.

To begin with the soil cover was excavated using a mini digger (Figure 10). The last centimetres were removed using a scoop so as not to damage the impermeable geomembrane system.

Samples sized at approximately 1.0 m x 1.0 m were cut using scissors (Figure 11).

Figure 10. Starting the excavation to take the samples

Figure 11. Taking samples of the EPDM geomembrane

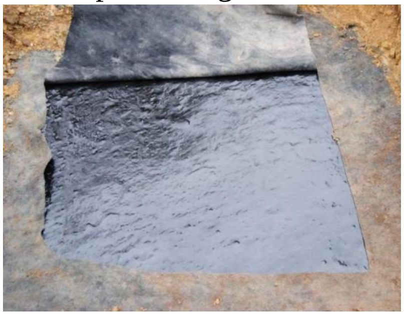
4.2 *Carrying out repairs*

After taking the samples, the sample area was repaired by an Asqual certified welder. The existing geomembrane had been carefully cleaned using a naphtha based solvent. A new piece of EPDM has been cut to the dimensions and fitted to the geomembrane on site using a self-adhesive tape.

New pieces of protective geotextile were placed above and below the geomembrane. Finally, the soil cover was put back.

4.3 *Observations made during sampling*

The pieces of geomembrane taken as samples did not present any visible fault or perforation. The protective geotextiles (above and below) were also in very good condition. It should be noted that the upper geotextile showed substantial coloration (the origin of which has not been determined) while the lower geotextile had retained its original color (Figure 12). This observation shows the role of the geomembrane in preventing infiltration.



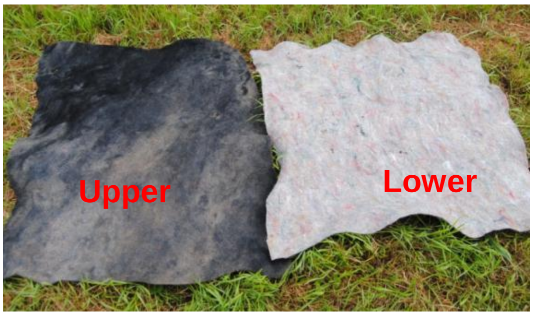


Figure 12. EPDM geomembrane and color difference between the upper and lower geotextile

We were also able to observe that the thicknesses of the soil cover had been respected (85 cm). The excavation showed that roots of the vegetation planted on the cover remained in the top 40 centimeters of the topsoil.

The gas drain geocomposite located under the geomembrane and lower protective geotextile was still in a very good condition (Figure 14). No clogging was observed in the drain area.

Figure 13. Location of the root zone

Figure 143. Protective geotextile and gas drainage placed under the geomembrane

The foot of a biogas collection well had also been cleared in order to inspect the condition of the detail. A well was selected where the safety pleat had been clearly unfolded, a sign of a significant differential settling in that area.

The visual inspection showed that the connection between the well and the geomembrane had not suffered differential settling. Visually, the geomembrane has not been under strain and there is still a significant amount of surplus geomembrane to withstand any possible future settling.

5 ANALYSES CONDUCTED ON THE SAMPLES AND DISCUSSION OF RESULTS

The analyses conducted on the samples taken are set out in Table 3. The types of analyses were chosen in order to be able to compare the condition of the geomembrane 12 years after its installation with the values in Table 1 measured 12 years ago. It should be noted that these tests were not conducted by the same laboratory, which could entail some variations.

We can also note that the tensile tests according to the standard EN 12311-2 and static puncture test according to the standards NF P 84-507 and EN ISO 12236, could not be carried out on the sample taken from the foot of the mound due to a lack of material.

By comparing the values of the thicknesses and tensile strengths for the 15% and 250% deformation ratios given in Tables 1 and 3, a slight change in these characteristics can be seen after 12 years. The slight increases in the values could be attributed to slight stiffening of the geomembrane following the continuation of the carbon chain cross linking which causes a decrease in molecular mobility. The environmental conditions and site location have therefore not had a significant impact on the mechanical properties of the geomembrane. We note that this comparison is made based on the values measured according to the standards which were replaced, which may be the reason behind this slight skewing. Table 2 shows that this skewing is not significant.

As a comparison, in exposed conditions, the evolution over time of the mechanical properties of thermostable materials is essentially characterised by a decrease in elongation at break following an increase in the number of links between carbon chains (Blanco et al., 2013). In the case of the El Golfo water reservoir located in the Canary Islands (Blanco et al., 2011), after 12 years' exposure in demanding climatic conditions (temperature, UV), elastic elongation of the EPDM geomembrane was between 320 and 360%. In covered conditions, the samples taken at Lann Hir 12 years after installation had elongation at break values of between 450 and 510%. In all likelihood, this difference is explained by the fact that the average yearly temperature of the geomembrane is less in unexposed conditions, temperature being an accelerating factor in the ageing process of geomembranes. We can therefore conclude an increase in the durability of EPDM geomembranes in covered conditions compared to exposed conditions.

The mechanical properties of the seam tested showed that it was in a very good condition. The values for resistance to peeling and shearing are relatively high for EPDM seams made with the self-adhesive tape and primer system.

Table 3. Results of analyses conducted on the samples 12 years after installation

Characteristics	Standards	Declared value	Top of mound		Foot of mound	
			SP*	ST**	SP*	ST**
Functional thickness (mm)	EN 1849-2	1.1	1.14			
Mass per unit area (g/m²)	EN 1849-2	1288	1321			
Tensile resistance to 15% deformation (kN/m) resistance to 250% deformation (kN/m)	EN 12311-2	0.7 5	0.92 6.96	0.85 6.39		
Strength at break, (N/mm²)	EN ISO 527	9	10.6	10.0	11.2	10.0
Deformation at break (%)	EN ISO 527	≥ 300	452	454	512	457
Static puncture Resistance (N) Displacement (mm)	NF P 84-507	115 33	142.7 35.44			
Static puncture (CBR) – (kN)	EN ISO 12236	0.7	> 0.7***			
Foldability at low temperature (ºC)	EN 495-5	≤ -45	≤ -45		≤ -45	
Shore A – hardness (Shore A units)	ISO 7619:2011		64		67	
Seam resistance by tensile-shear, (N/50 mm)	EN 12317-2				325	
Seam peel resistance, (N/50 mm)	EN 12316-2				88	

* along the grain
** across the grain
*** the equipment reached its maximum displacement without achieving break (> 151 mm)

6 CONCLUSIONS

This study was a review of the condition of the EPDM geomembrane used as landfill cover following 12 years in use. The approach consisted of taking samples on site while simultaneously collecting a maximum number of visual observations on the state of the cover. The samples taken clearly showed a good general condition of the entire impermeable geomembrane system comprising the cover. The tests showed that the mechanical properties (tensile strength for the 15% and 250% deformation ratios) remained stable after 12 years of use. This study therefore shows some elements concerning the durability of mechanical properties of EDPM geomembranes in unexposed conditions. Further studies would be useful to determine the evolution of hydraulic, chemical and physico-chemical properties over time.

7 BIBLIOGRAPHY

ASTM D 4437 (2012) Standard Practice for Non-destructive Testing (NDT) for Determining the Integrity of Seams Used in Joining Flexible Polymeric Sheet Geomembranes. Vol 4.13.

AFNOR (2001) NF EN 495-5. Feuilles souples d'étanchéité Détermination de la pliabilité à basse température Comité européen de normalisation, Bruxelles.

AFNOR (2012) NF EN ISO 527. Plastiques Détermination des propriétés en traction. Comité européen de normalisation, Bruxelles.

AFNOR (2001) NF EN 1107-2. Feuilles souples d'étanchéité Détermination de la stabilité dimensionnelle. Comité européen de normalisation, Bruxelles.

AFNOR (2010) NF EN 1849-2. Feuilles souples d'étanchéité Détermination de l'épaisseur et de la masse surfacique. Comité européen de normalisation, Bruxelles.

AFNOR (2006) NF EN ISO 12236. Essai de poinçonnement statique (essai CBR). Comité européen de normalisation, Bruxelles.

AFNOR (2010) NF EN 12311-2. Feuilles souples d'étanchéité - Détermination des propriétés en traction - Partie 2 : feuilles d'étanchéité de toiture plastiques et élastomères. Comité européen de normalisation, Bruxelles.

AFNOR (2000) NF EN 12316-2. Feuilles souples d'étanchéité - Détermination de la résistance au pelage des joints - Partie 2 : feuilles d'étanchéité de toiture plastiques et élastomères. Comité européen de normalisation, Bruxelles.

AFNOR (2010) NF EN 12317-2. Feuilles souples d'étanchéité - Détermination de la résistance au cisaillement des joints - Partie 2 : feuilles d'étanchéité de toiture plastiques et élastomères. Comité européen de normalisation, Bruxelles.

AFNOR (2010) NF ISO 7619-1Caoutchouc vulcanisé ou thermoplastique - Détermination de la dureté par pénétration - Partie 1 : méthode au duromètre (dureté Shore). Comité européen de normalisation, Bruxelles.

AFNOR (2000) NF EN 12316-2. Feuilles souples d'étanchéité - Détermination de la résistance au pelage des joints - Partie 2 : feuilles d'étanchéité de toiture plastiques et élastomères. Comité européen de normalisation, Bruxelles.

AFNOR (1996) NF P 84-507. Essais des géomembranes - Détermination de la résistance au poinçonnement statique des géomembranes et des dispositifs d'étanchéité par géomembranes - Cas du poinçon cylindrique sans support. BNSR/GTX-GMB.

AFNOR (1998) NF P 84-515. Mesure du niveau d’étanchéité conventionnel des géomembranes. BNSR/GTX-GMB.

AFNOR (1992) NF P 501. Géomembranes-Dispositif d’étanchéité par géomembranes (DEG) Détermination des caractéristiques en traction. BNSR GMB.

Blanco M., Aguiar E., García F., Vara T., Soriano J., Castillo F. (2011) État de la géomembrane en EPDM de la retenue d’ “El Golfo” dans l’île d’El Hierro (Îles Canaries). Proc. 8eme Rencontres Géosynthétiques 283-293. Tours.Blanco M., Touze-Foltz N., Amat B., Castillo F., Aguiar E. (2013) Comportement d’une géomembrane EPDM 18 ans après son installation dans la retenue d’El Boqueron (Tenerife, Espagne). Proc. 9èmes Rencontres Géosynthétiques. Dijon.

Frobel R., Gilligan T., Kalbas J. (1999) EPDM geomembrane caps commercial landfill. First United States permitted landfill using EPDM proves successful. GFR magazine, volume 17, number 8.

Olivier, F. (2003) Tassements des déchets en CSD de classe II : du site au modèle, Thèse de
doctorat, Université Joseph Fourrier de Grenoble, 305 p.