Developing a waterproofing geocomposite for railway platforms in evolving materials area

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ABSTRACT
As part of the building of new high-speed lines in France and Morocco (Tanger-Kenitra), a waterproof geocomposite has been developed to answer time, space and money constraints of these particular worksites. This new geocomposite has been designed to meet the technical standards of French National Railway company (SNCF); it protects the railway platform against water infiltrations in sensitive-to-water areas.

1. INTRODUCTION

Railways platforms are the support of high speed lines and their structure must be protected from any type of possible damage.
The Moroccan high-speed line goes through pelitic areas which are sensitive to water and likely to swell in contact with rainfall water infiltrations.
The classic solution to protect the platform consists in laying a protection geotextile, then a bituminous geomembrane and another protection geotextile. An all-in-one solution has been developed by Afitex to ease the installation and be less expensive, following a request from French National Railway Company (SNCF).

2. DESCRIPTION OF THE GEOCOMPOSITE SOLUTION

2.1 A built-to-suit solution

In various applications, the geocomposite solution has several advantages and especially:
- Saving time on worksite thanks to an easier installation
- Saving money thanks to a less expensive solution and reduced installation costs.

However the geocomposite solution needs to be at least as performing as the traditional solution in order to be considered.

In this context, a waterproofing geocomposite for railway platform has been thought to replace the bituminous geomembrane and the two protection geotextiles on both sides.

2.2 Composition and manufacturing

Geocomposite Protecterre PF (Figure 1) is made of three components associated together by cold gluing:
- A 500g/m² non-woven needle-punched geotextile on the upper side
- A 1mm-thick HDPE geomembrane
- A 300 g/m² non-woven needle-punched geotextile on the lower side.

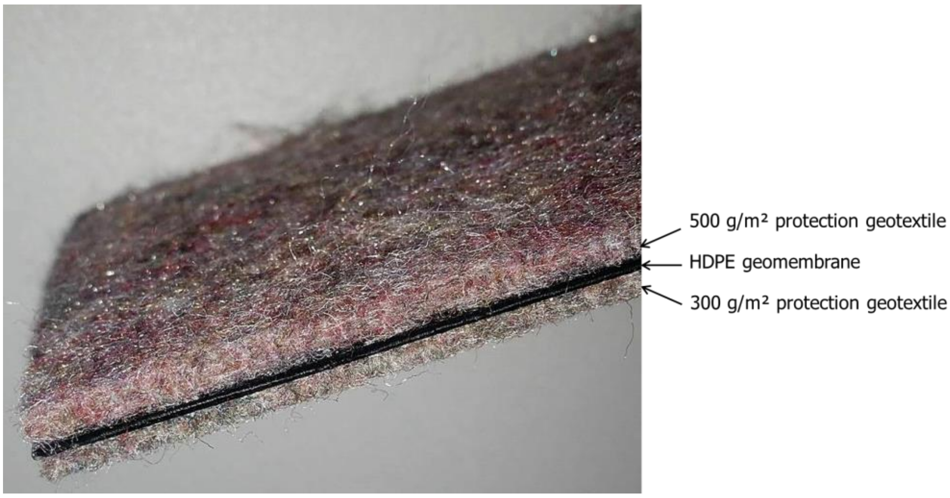


Figure 1: Detail picture of geocomposite Protecterre PF

The two geotextiles aim at protecting the associated geomembrane against puncturing and consequently at avoiding damages of the waterproofing system.

The association process (Figure 2) combines three particular steps:

- powdering of LDPE glue on the whole area of geomembrane. This process permits to guarantee:
  - a homogeneous association of the geotextiles with the geomembrane
  - good flexibility to ease the installation
- light heating of LDPE glue by IR radiations
- cold-gluing of the geotextiles on geomembrane by cold calenders.

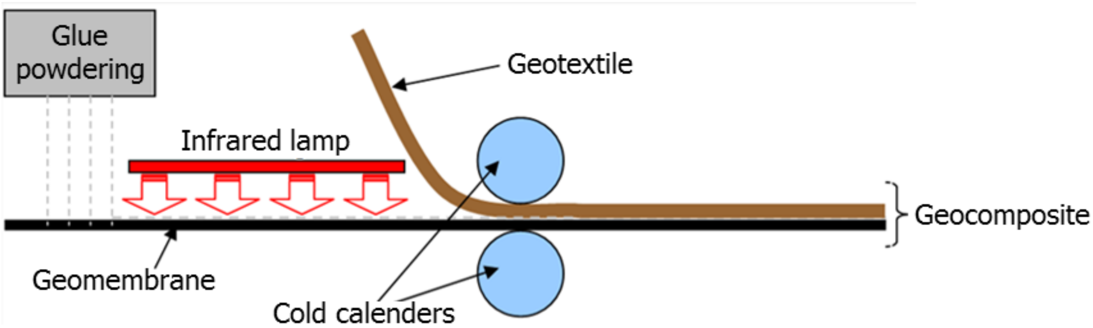


Figure 2: Association process of Protecterre PF

The geotextiles are never heated, which avoids any degradation of their mechanical properties.

The association process on the edge of the geocomposite can be specifically adapted to each worksite to facilitate longitudinal joints.

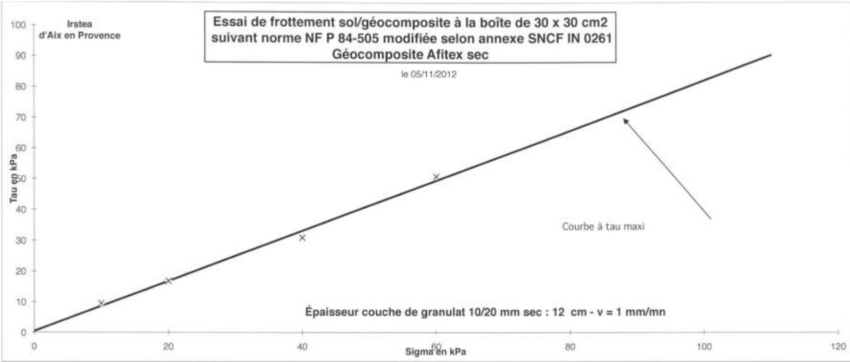
2.3 Technical validations

The waterproofing geocomposite has been specifically developed to meet the technical requirements of National French Railways Company SNCF (Société Nationale des Chemins de Fer). So, it has been tested under two French standards of IN 0261:

- Friction angle
- Resistance to perforation by ballast.

2.3.1 Friction angle

IRSTEA laboratory has carried out the measurements. This test aims at determining the friction properties of the whole geocomposite in contact with a 10/200 mm gravel under 10, 20, 40 and 60 kPa in dry condition (Figure 3) and wet condition (Figure 4). The friction angle is measured with box shear apparatus following two French standards: NF P 84-505 modified to SNCF standards (IN 0261) and NF P 94-097.

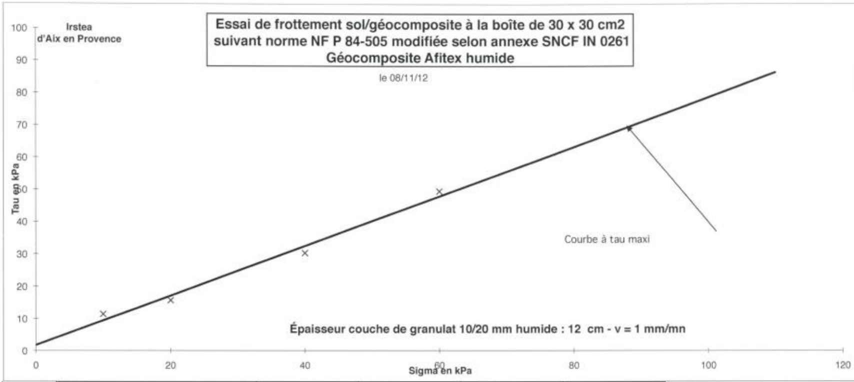


Sigma (kPa)	10,0	20,0	40,0	60,0	
Tau maxi (kPa)	9,5	16,8	30,9	50,8	
Tau (kPa) à 10 %	10,2	16,7	29,9	49,9	à 30 mm
Tau (kPa) à 3 %	9,9	12,2	27,6	42,9	à 10 mm
Tau (kPa) à 1%	7,9	7,5	19,7	26,7	à 3 mm
Poids vol. sec initial grave	11,6	11,6	11,6	11,6	en kN/m3

	tg Phi	c (kPa)	Phi	
A tau maxi	0,82	0,4	39,2 degrés	
A Delta l/L = 10%	0,79	1,2	38,1 degrés	à 30 mm
A Delta l/L = 3 %	0,69	0,9	34,4 degrés	à 10 mm
A Delta l/L = 1 %	0,41	2,0	22,5 degrés	à 3 mm

Figure 3: Angle friction results on waterproofing geocomposite in dry condition (NF P 84-505 modified following SNCF standard IN 0261)

The friction angle in dry condition is 39.2°.



Sigma (kPa)	10,0	20,0	40,0	60,0	
Tau maxi (kPa)	11,4	15,7	30,3	49,4	
Tau (kPa) à 10 %	11,1	13,8	29,1	47,4	à 30 mm
Tau (kPa) à 3 %	10,6	12,2	23,9	38,0	à 10 mm
Tau (kPa) à 1%	7,8	9,7	19,1	23,1	à 3 mm
Poids vol. sec initial grave	11,6	11,6	11,6	11,6	en kN/m3

	tg Phi	c (kPa)	Phi	
A tau maxi	0,77	1,7	37,5 degrés	
A Delta l/L = 10%	0,75	1,1	36,7 degrés	à 30 mm
A Delta l/L = 3 %	0,56	2,8	29,5 degrés	à 10 mm
A Delta l/L = 1 %	0,33	4,3	18,1 degrés	à 3 mm

Figure 4: Angle friction results on waterproofing geocomposite in wet condition ((NF P 84-505 modified following SNCF standard IN 0261)

The friction angle in wet condition is 37.5°.

2.3.2 Resistance to perforation by ballast

SNCF laboratory has carried out this fatigue test.
The dynamic load on the geocomposite is applied by the following device:

- the tie
- 12m-long rails
- An eccentric vibrator which loads the tie vertically thanks to the rails and a load distribution beam.

The experimentation cell consists in (from the bottom to the top):

- A first 5cm-thick ballast layer
- The geocomposite
- A second 20cm-thick ballast layer
- The dynamic load device.

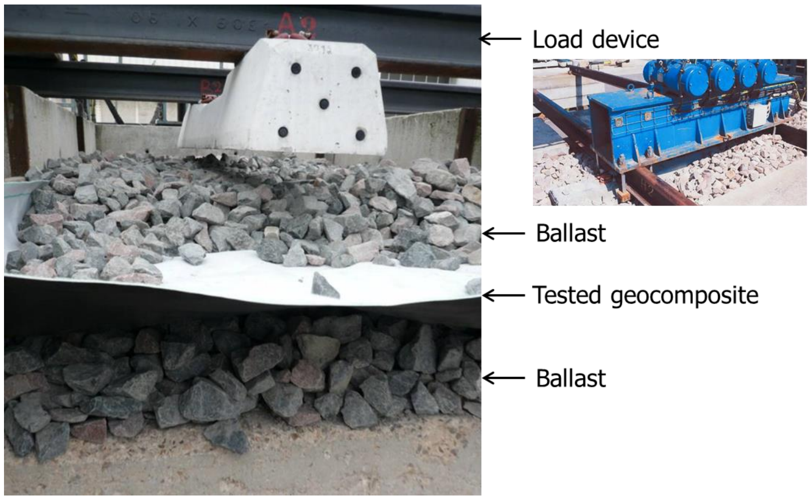


Figure 5: Experimentation cell determining the resistance to perforation by ballast of a geocomposite

The fatigue test has been performed with a reference frequency of 50 Hz during 18.10^6 cycles.
At the end of these cycles the geocomposite has been examinated: it shows lots of small impacts but no tear.

2.3.3 Conclusion

The results of these two tests are summarized in the following table and compared to the French standards.

Table 1: Mechanical properties of waterproofing geocomposite in comparison with IN0261 standards

Characteristics	Standard IN0261	Protecterre PF
Friction angle	40° dry	40° dry (-3%)
	36° wet	36° wet (-3%)
Resistance to perforation by ballast	25 kN	30 kN

These laboratories results led to the geocomposite validation by SNCF and its installation on a first worksite: East European high-speed line in France. However, the values of these tests are specific to a ballast as defined by the SNCF.

3. INSTALLATION ON MOROCCAN HIGH SPEED LINE BETWEEN TANGER AND KENITRA

3.1 Presentation of the worksite

The Moroccan high-speed line covers 200 km from Tanger to Kenitra (Figure 6) and will be ready in 2018. It will join up with the existing railway line connecting Kenitra to Rabat and Casablanca (AFD, 2013).

Figure 6: Satellite view of North Morocco with new high-speed line (doted orange line) and existing main rail lines departing from Rabat (full lines) (modified from Google Earth)

The estimated cost of the project is 1.8 thousand million euros.
This project has been developed by the National Moroccan railway company (ONCF) which is the contracting authority.
Systra and Egis Rail are the two project managers involved in the design of the high-speed line.
The building of this new railway line is the first part of a much bigger project, the Atlantic Moroccan high-speed line.

3.2 An installation depending on the geology of the sectors

The waterproofing geocomposite has been validated and installed on three sectors in the north part of the railway line, in pelitic areas. It represents 145,000 m².

Figure 7: Installation of waterproofing geocomposite on railway platform near Larache (Sector 3)

It was laid at the base of pelitic cuttings to prevent rainfall water from infiltrating into pelites and also to keep infiltration water from rising into the structure layers by capillarity. Indeed, pelites are fine-grained sedimentary rocks sensitive to water (Foucault and al., 2010) because of their shrink-swell capacity.

The geocomposite is almost always installed on the top of subgrade surface.

3.3 Installation procedure

Protecterre PF is provided in 3.90m-wide rolls and its length has been adapted for some worksites. The subgrade needs to be smoothed and cleared out from sharp elements before starting the installation.

Geocomposite is unrolled perpendicularly to the axis of the platform in the direction of slope so that water will not penetrate into the subgrade by longitudinal joints (Figure 8).

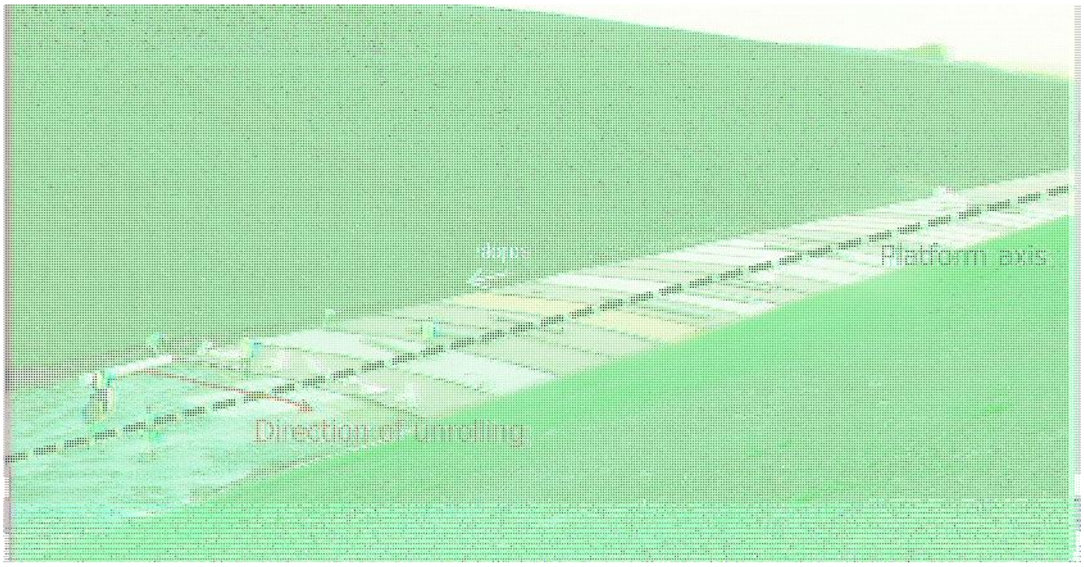


Figure 8: Direction of installation depending on the slope of the platform

Transversal joints must be avoided, this is the reason why the length of rolls can be adapted to the width of the platform.

The geocomposite can be either welded or simply overlapped. The association between the two geotextiles and the geomembrane is adapted to ease installation and particularly longitudinal joints.

3.3.1 Overlapping

Simple overlapping is required when there is no need for perfect watertightness, for example on areas where pelites are found with sandstone beds. Then the upper geotextile is not associated to the geomembrane on about 35 cm on both edges. Thus the two geomembranes are overlapped and covered by protection geotextiles (Figure 9).

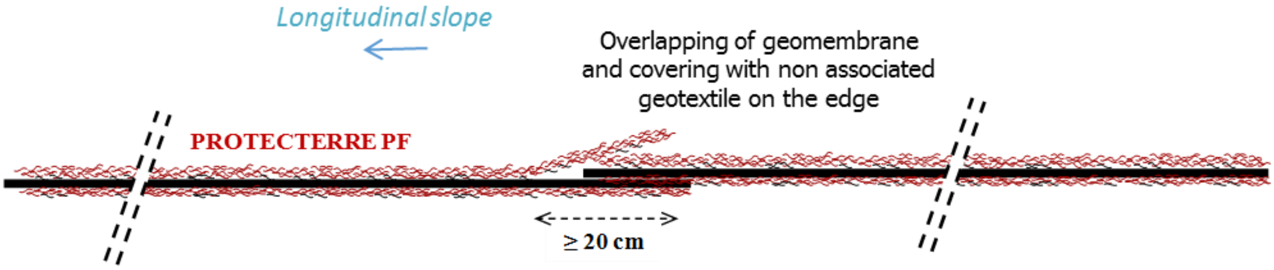


Figure 9: Drawing showing the overlapping between two rolls of geocomposite

3.3.2 Welding

If a perfect watertightness is asked, for example in highly sensitive areas, the two protection geotextiles are treated in different ways:

- the upper geotextile is not associated to the geomembrane on about 20 cm on both edges
- the geomembrane is not covered by lower geotextile on about 20 cm on both edges.

This permits to easily weld the geomembrane. The seam is then protected by a strip of geotextile on the lower side, and by the upper geotextile on top (Figure 10).

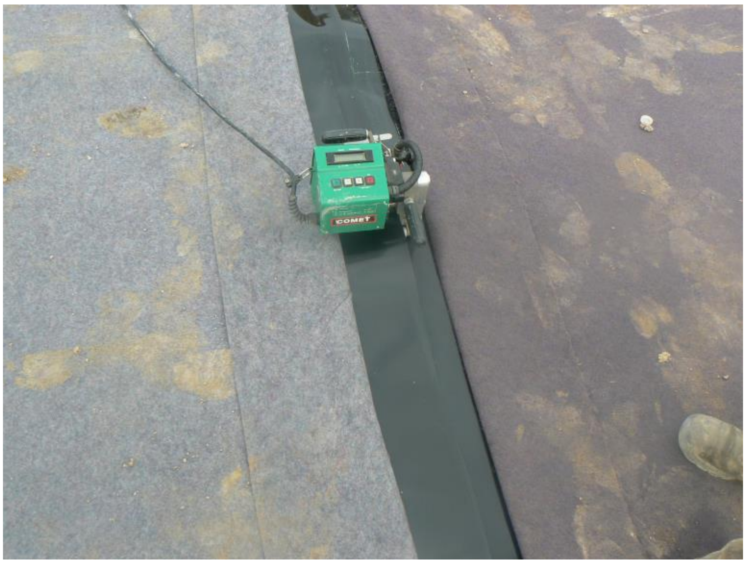


Figure 10: Longitudinal welding of Protecterre PF between two rolls.

Conclusion

The use of the PROTECTERRE PF on the TANGER-KENITRA worksite has allowed to get rid of constraints due to pelitic areas shrink-swell capacity.

According to the sensibility of pelites, a perfect watertightness solution can be chosen (welding) or an impermeable solution (overlapping).

The behaviour of the geocomposite regarding the puncturing induced by the railway ballast (validated by the SNCF tests), allowed to confirm the thicknesses and the masses per unit area of both of the anti-puncturing geotextiles, in association with the 1 mm HDPE geomembrane.

REFERENCES

Agence Française de Développement (2014). Contribuer à la réalisation de la 1ère ligne à grande vitesse du Maroc entre Tanger et Kenitra [en ligne]. Disponible sur : http://www.afd.fr/webdav/site/afd/shared/PORTAILS/PAYS/CMA1133%20LGV%20Tanger-K%C3%A9nitra.pdf

Foucault, A., Raoult J-F. (2010). *Dictionnaire de géologie*, 7e ed., Dunod, Vottem, Belgique.

IN 0261. Référentiel Infrastructure, Document d'application. Emploi des géosynthétiques (Géotextiles, géogrilles, géomembranes). Spécifications des géosynthétiques utilisés dans les assises ferroviaires, *SNCF*, France