The use of Draintube drainage geocomposites under railway infrastructures

Stephan Fourmont[1], Mathilde Riot[2]

[1] Afitex-Texel, 1300, 2e Rue Parc Industriel, Sainte-Marie QC G6E 1G8, Canada
`sfourmont@afitextexel.com`
[2] Afitexinov, 13-15 Rue Louis Bleriot, 28300 Champhol, France
`mathilde.riot@afitex.com`

Abstract. Railway construction involves substantial earthworks (embankments and cuttings). Cuttings may reach the water table, and embankments may need preloading when on soft soils. Even during operation of the railway line, the ballast put into place under the railways undergoes densification and degradation over time which reduces the hydraulic conductivity of the material. This phenomenon may affect the durability of the structure if the ballast is not able to evacuate the water during heavy rainfall, flooding or snowmelt. Drainage systems for soil water were traditionally made with granular material layers and perforated collector pipes, one of the main reasons being the ability of that system to support heavy loads over time. As their flow capacity is not load or time sensitive when confined in soil, drainage geocomposites with mini-pipes Draintube are often used instead of the granular drainage layers. At the different stages of the railway construction, it protects the cuttings against high water table, decreases the time for consolidation on soft soils and increases the overall drainage capacity of the system under ballast. It also allows the use of Hydraulically Bound Materials (HBMs) on top of it.

This publication presents a case study for each application, along with the related laboratory study or on-site monitoring. Drainage geocomposites with mini-pipes have been successfully used for 30 years; the product is designed for each project function of the specific site conditions. It requires less machinery to install and reduces the Greenhouse Gas (GHG) emissions compared to a granular material solution.

Keywords: drainage, geocomposite, railways.

1 Introduction

Dainage systems for soil water were traditionally made with granular material layers and perforated collector pipes. The use of drainage geocomposites becomes more common with the development of products that meets the specific requirements of each application. Moreover, the geosynthetic solution is cheaper than the granular material (for the same performances) in the majority of applications. It is faster to install, requires less machinery and reduces the Greenhouse Gas (GHG) emissions of the project [1]. Like any engineering solution, drainage geocomposites must be well selected and designed to function for specific site conditions. In railway infrastructures, drainage geocomposites with mini-pipes are used as lateral drainage on vertical wick drains under preloading embankments, directly under the tracks to increase the drainage capacity of the ballast or in cuttings to intercept high water tables. These three applications will be developed in the following paragraphs based on case and laboratory studies.

2 Multi-linear drainage geocomposites

2.1 Geocomposite description

Drainage geocomposites with mini-pipes Draintube are used in civil engineering and more especially in earthworks projects for the past 30 years. They are multi-linear drainage geocomposites (terminology as per ASTM D4439 [2]) composed of non-woven geotextiles that are needle-punched together with perforated, corrugated polypropylene mini-pipes regularly spaced inside and running the length of the roll (see Fig. 1).

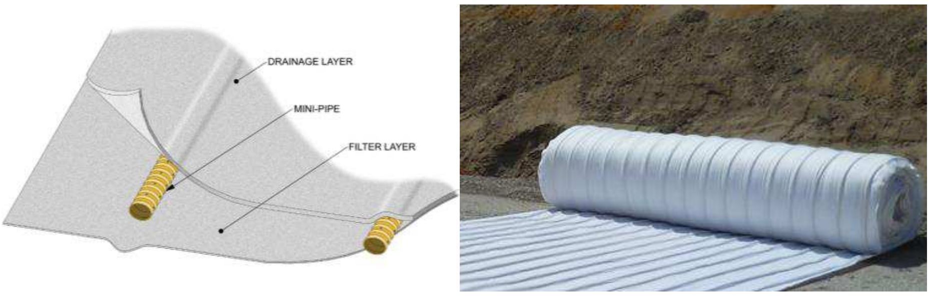

Fig. 1. Geocomposite description

2.2 Hydraulic characteristics

The drainage capacity of the product is driven by the number of mini-pipes within the product. There is a linear relationship between the distance between the mini-pipes and the transmissivity of the overall product [3], [4]. It has also been shown that the flow capacity of the multi-linear drainage geocomposite is not load or time sensitive when confined in soil [5]. Fig. 2 shows shows results of hydraulic transmissivity tests (ASTM D4716 [6]) carried out on the product compressed under a load of 2,400 kPa (50,000 psf) which represents a 120 m (390 ft.) high soil embankment.

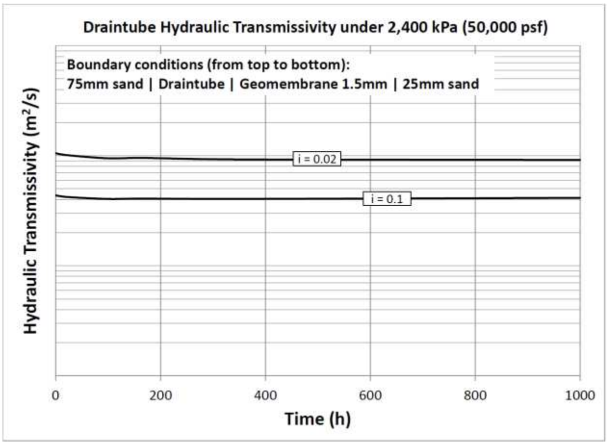

Fig. 2. Drainage capacity of the multi-linear drainage geocomposite over time

2.3 Mechanical characteristics

Mechanical properties of the drainage geocomposite must be selected as a function of the drainage application, the installation conditions and the soil in which the product is in contact. The tubular drainage geocomposite is made with adapted short-staple fibers geotextiles, from 200 g/m2 (6 oz/sy) to 900 g/m2 (26 oz/sy) or above. The elongation at break of the product is always greater than 50% (ASTM D4632 [7]), making the product flexible to provide a good connection with the subgrade soil when installed. The mini-pipes have a pipe stiffness at 5% deflection over 3,000 kPa (435 psi) (ASTM D2412 [8]).

3 Drainage under embankment on soft soils

3.1 Project description

One of the High-Speed Lines (HSL) constructed in France in 2008 (LGV – Rhin Rhône), crossed numerous compressible areas as well as bridges that required the construction of preloading embankments in conjunction with surcharging to accelerate the expected settlements of the subgrade. These preloading embankments included vertical wick drains with a multi-linear drainage geocomposite on top as a horizontal drainage base layer. The major preloading embankments were 7.5 m (25 ft.) high and more than 40 m (130 ft.) wide. Subgrade was composed of loess on the first 4 m (13 ft.), sandy soil from 4 m (13 ft.) to 6.5 m (21 ft.) then clayey soil from 6.5 m (21 ft.) to 11 m (36 ft.).

Expected settlements were estimated to be from 40 to 90 mm (1-1/2 to 3-1/2 in.) from geotechnical identification of the subgrade soil layers. The length of the vertical drains was set at 11 m (36 ft.) with a square grid of 1.2 m x 1.2 m (4 ft. x 4 ft.). The multi-linear drainage geocomposite was unrolled directly on the wick drains.

3.2 Completion of works

After the removing of the topsoil layer, the vertical wick drains were driven into the ground as required as depicted in Fig. 3 below.

Fig. 3. Installation of the vertical wick drains

The multi-linear drainage geocomposite was unrolled perpendicularly to the railway line and overlapped the wick drains (Fig. 4). The mini-pipes of the product have a spacing of 0.50 m (20 in.) center-to-center. The geocomposite collects the water from the wick drains and drains it to ditches on each side of the embankment. Backfilling soil was placed directly on the drainage geocomposite to the final level.

Fig. 4. Drainage geocomposite installation

3.3 Monitoring and results

The sub-base was monitored using profilometers to measure settlements over time and choose the right moment to remove the overload. Examples of settlement measurement values are indicated in Fig. 5.

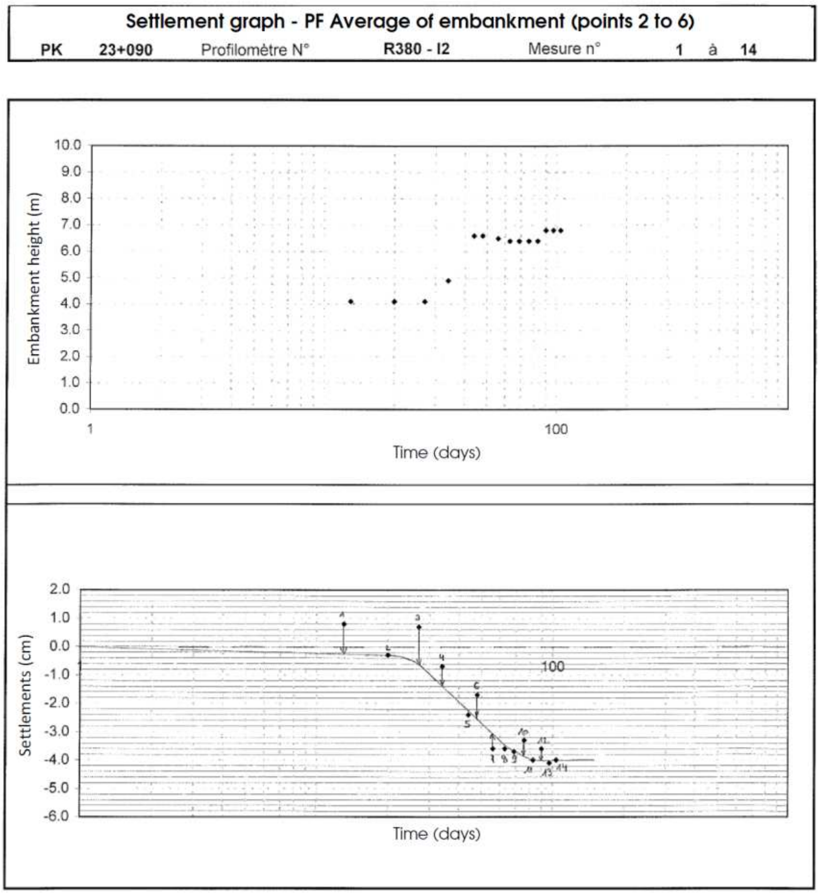

Fig. 5. Example of the subgrade settlements over time

The measured settlements did not exceed 40 mm (1-1/2 in.), which was lower than the estimated limit, and the effective consolidation time was about 3 months.

The use of a multi-linear drainage geocomposite for horizontal drainage instead of a granular layer offered consistent performances and reduced the cost of the preloading embankment construction as granular material should have been extracted and transported from the carrier to the site resulting in a heavy truck traffic in and around the worksite. In comparison, one full truck can carry enough multi-linear drainage geocomposite to cover an area of approximately 10,000 m^2 (approx. 100,000 sf).

4 Cut sections

Cut sections involved large and high slopes to get stability and avoid landslides. In case of groundwater infiltrations or high water table, the use of drainage masks with granular material implies to carry and install a large amount of materials. The use of a drainage geocomposite for subsurface drainage reduces that need of granular material.

4.1 Installation

The drainage geocomposite is unrolled directly on the subgrade with the mini-pipes in the direction of the slope. It is anchored on top of the slope and connected to a French drain at the toe. The backfill is then placed on top of the product from the bottom to the top (Fig. 6).

The drainage geocomposite does not provide additional strength resistance for the stability of the slope. But due to the non-woven needle-punched geotextile layers of the product, the geocomposite/soil interface angle is generally the same as the internal friction angle of the soil in contact.

Fig. 6. Drainage mask construction with drainage geocomposite

4.2 Monitoring and results

On a new HSL constructed from 2013 in France (LGV Est), monitoring has been conducted to evaluate the two solutions: drainage layer made with granular material and made with multi-linear drainage geocomposite. Two areas of 525 m^2 (5,650 sf.) each have been monitored with temperature sensors, water content gauges at the interface, and flowmeters [9]. Details are shown on the Fig. 7. The mini-pipes of the product have a spacing of 0.50 m (20 in.) center to center.

The water content monitoring for both solutions is shown on the Fig. 8 and Fig. 9. It can be observed that the water content remains stable between 20% and 40 % at the gravel/soil interface and between 20% and 27% at the geocomposite/soil interface. Both drainage systems perform well, keeping the soil above unsaturated even during rain events.

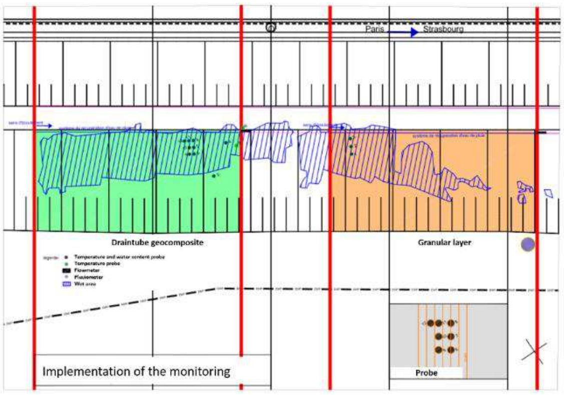

Fig. 7. Probes implementation (plan view)

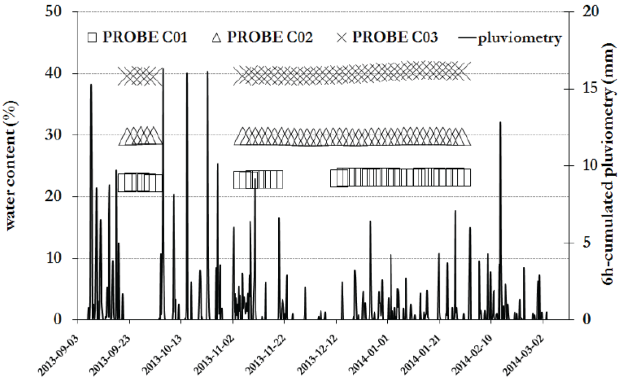

Fig. 8. Water content at gravel / soil interface

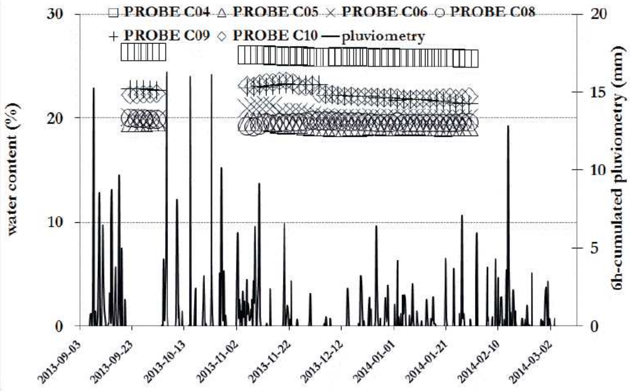

Fig. 9. Water content at geocomposite / soil interface

5 Drainage improvement under railways

5.1 Project description

Within the scope of work for some track reconfigurations, alternative drainage systems are used, given the limited space available in some track corridors. A drainage geocomposite with mini-pipes can be used in order to efficiently evacuate the water from below the tracks. The mini-pipes are brought to a ballast drain or an open ditch.

A Canadian National Railways project located in Quebec in 2016, required two tracks to be drained into either an open ditch or a ballast drain installed approximately 1 meter (3 ft.) below track level. Without a proper drainage system, potential drainage problems and a shortened life for the ballast would occur. The multi-linear drainage geocomposite was placed directly under the ballast (Fig. 10). The mini-pipes in the product had a spacing of 0.25 m (10 in.) center to center.

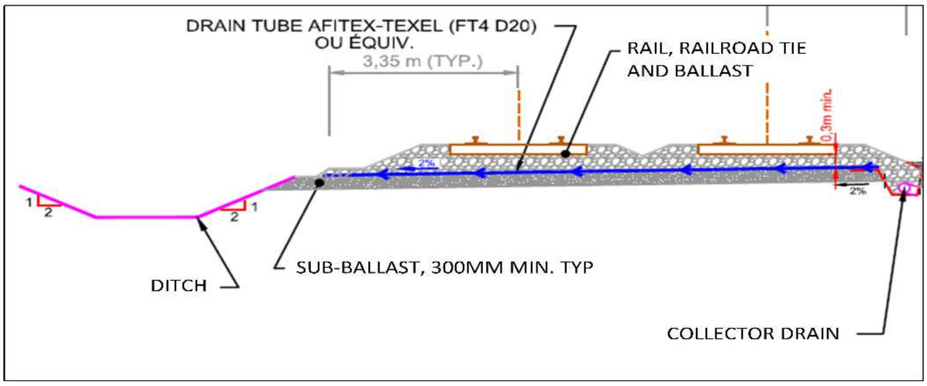

Fig. 10. Typical cross-section

5.2 Completion of works

The multi-linear drainage geocomposite was unrolled perpendicular to the tracks directly on the MG-56 subgrade soil (Fig. 11). After which the ballast was installed in two layers of 150 mm (6 in.) each (Fig. 12).

The product was designed to have the ability to evacuate rainfall of 661 mm/day with the mini-pipes staying unsaturated [10]. The 100 years return period rainfall in Quebec is 156 mm/day. The drainage capacity of the drainage geocomposite is more than 4 times greater than what is required, taking into account the long term hydraulic behavior of the geocomposite under the critical conditions of the application.

Fig. 11. Installation of the geocomposite

Fig. 12. Backfilling of the product with ballast

5.3 Laboratory study

Using a 2.5 m (8 ft.) long and 2 m (6-1/2 ft.) wide inclinable open box with rainfall simulator on top (Fig. 13), it was shown that multi-linear drainage geocomposite Draintube enables rainfall to evacuate faster than a homogeneous drainage layer (Fig. 14) [11]. Due to the directional aspect of the product, the water is indeed drained into the direction of the mini-pipes even in the situations when the slope is zero.

That behavior is significant for low slopes, where the rainfall water must be evacuated rapidly before building up into the overlying layer or infiltrating into the subgrade.

Fig. 13. Inclinable open box with a rainfall simulator

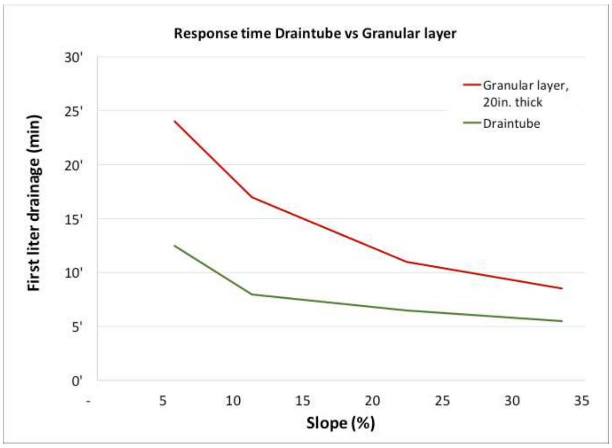

Fig. 14. Drainage response time Drain Tube vs granular layer

6 Conclusion

Multi-linear drainage geocomposites have been used successfully on many earthworks projects and more especially on railways construction projects. Depending on the project and the design consideration, it is used either for drainage under embankments and subsurface drainage on cut slopes as a replacement of the granular layers or for drainage improvement under railway tracks.

Its main useful characteristics, on an installation point of view, are its flexibility and robustness. Other advantages include its long term remaining drainage capacity, even under high loads, and its faster response time compared to a homogenous drainage layer. All this makes the Drain Tube geocomposite efficient and safe, given its designed performances.

REFERENCES

1. Durkheim Y. and Fourmont S.. Drainage geocomposites: a considerable potential for the reduction of greenhouse gas emission, 9th International Conference on Geosynthetics, Guaruja, Brazil (2010).
2. ASTM D4439. Standard Terminology for Geosynthetics, *American Society for Testing and Materials*, West Conshohocken, PA, USA.
3. Blond E., Saunier P., Daqoune T and Fourmont S.. Assessment of the effect of specimens dimensions on the measured transmissivity of planar tubular drainage geocomposites, GeoMontreal 2013, Montreal, Canada (2013).
4. GRI Test Method GC15. Determining the Flow Rate per Unit Width of Drainage Geocomposites with Discrete High Flow Components, *Geosynthetic Institute*, Folsom, PA USA
5. Saunier, P., Ragen, W. and Blond, E.. Assessment of the resistance of drain tube planar drainage geocomposites to high compressive loads. 9th International Conference on *Geosynthetics*, Guarujá, Brazil, Vol3 (2010).
6. ASTM D4716. Standard Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head, *American Society for Testing and Materials*, West Conshohocken, PA, USA.
7. ASTM D4632. Standard Test Method for Grab Breaking Load and Elongation of Geotextiles, *American Society for Testing and Materials*, West Conshohocken, PA, USA.
8. ASTM D2412. Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading, *American Society for Testing and Materials*, West Conshohocken, PA, USA.
9. Heili V., Benamu D., Gendrin P., Godon V., Thomas D.. Experiment of the use of geosynthetics for the drainage in place of draining masks – Hydraulic properties and sustainability, 10 ICG, Berlin, Germany (2014).
10. Ruel M., Rodger D., Fourmont S.. Drainage improvement under CN railways with the use of a multi-linear drainage geocomposite, GeoEdmonton 2018, Edmonton, Canada (2018).
11. Del Greco O., Fey A., Oggeri C., and Fourmont S.. Behaviour of drainage geosynthetics for landfill capping systems, 5th European Geosynthetics Congress, Valencia, Spain, 2: 114-118 (2012).