FIGURE 1 Multi-linear drainage geocomposite under railway embankment

Case Studies

Improving railway drainage with multi-linear geocomposites

The authors assert, through three illustrative cases studies, that significantly improving railway drainage is possible using multi-linear drainage geocomposites.

By Stephan Fourmont and Mathilde Riot

In civil engineering, drainage systems are traditionally made with granular material layers and perforated collector pipes. The use of drainage geocomposites became more common 30 years ago with the development of products that met the specific requirements of each application. Moreover, the geocomposite is cheaper than the granular material (but provides the same performance) in most applications. Drainage geocomposites are faster to install, require less machinery and reduce the greenhouse gas (GHG) emissions of the project (Durkheim et al. 2010). As with any engineering solution, engineers must carefully select and design drainage geocomposites to function for a specific site's conditions. In railway infrastructure, engineers stipulate using specialized geocomposites for lateral drainage on vertical wick drains under preloading embankments and directly under the tracks, to increase the drainage capacity of the ballast, and in cuttings, to intercept high water tables.

Drainage geocomposites with mini-pipes are used in civil engineering and, more specifically, in earthworks projects (**Figure 1**). DRAINTUBE is a multi-linear drainage geocomposite (terminology as per ASTM D4439) composed of nonwoven geotextiles that are needlepunched with perforated, corrugated polypropylene mini-pipes evenly spaced inside and running the length of the roll. The mini-pipes have two perforations per corrugation at 180° and alternating at 90° (**Figure 2** on page 22).

The number of mini-pipes within the geosynthetic drives the drainage capacity of such geocomposites (**Figure 3** on page 22). The distance in between the mini-pipes and the transmissivity of the overall product

Stephan Fourmont is business development manager at AFITEX-Texel Geosynthetics Inc. in Sainte-Marie, Que., Canada.

Mathilde Riot is technical and R&D manager at Afitexinov Geosynthetics in Champhol, France.

All figures courtesy of the authors.

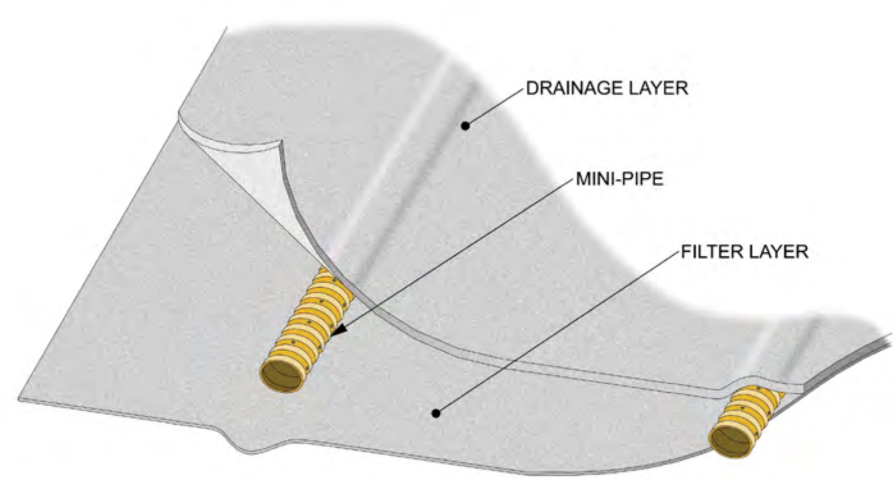

FIGURE 2 Diagram of DRAINTUBE multi-linear drainage geocomposite

FIGURE 3 Unrolling of the DRAINTUBE geocomposite

(Blond et al. 2013 and GRI GC15 2017) have a linear relationship. From Saunier et al. (2010), it has been shown that the flow capacity of a drainage geocomposite is not load or time sensitive when confined in soil. **Figure 4** shows hydraulic transmissivity test results (per ASTM D4716) that have been carried out on top of the product when compressed under a load of 50,000 psf (2,400 kPa), which correlates to a 390 foot (120 m) high soil embankment.

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 multi-linear drainage geocomposite is made with adapted short staple fiber geotextiles, from 3 ounces per square yard to 26 ounces per square yard (100 to 900 g/m^2) or higher. The elongation at break of the geocomposite is always greater than 50% (ASTM D4632), making it flexible enough to provide a good connection with the subgrade soil when installed. The mini-pipes have a pipe stiffness at 5% deflection over 435 psi (3,000 kPa) (ASTM D2412).

PROJECT HIGHLIGHTS

RAILWAY DRAINAGE WITH SOFT SOILS

OWNER
RFF/SNCF

LOCATION
France

GENERAL CONTRACTOR
Razel

ENGINEERS
Terrasol

GEOSYNTHETIC PRODUCT
DRAINTUBE FTF2 D20

GEOSYNTHETIC MANUFACTURER
Afitexinov Geosynthetics

Case study: Railway drainage with soft soils

One of the high-speed lines (in French, “Ligne à Grande Vitesse [LGV]”) constructed in France in 2008 (LGV Rhin-Rhône) crossed numerous compressible areas and 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 25 feet (7.5 m) high and more than 130 feet (40 m) wide. The subgrade was composed of loess in the first 13 feet (4 m), sandy soil from 13 feet (4 m) to 21 feet (6.5 m), then clayey soil from 21 feet (6.5 m) to 36 feet (11 m).

Engineers estimated settlements to be between 1.5 and 3.5 inches (40 to 90 mm). The length of the vertical drains was set at 36 feet (11 m) with a square grid of 4 × 4 feet (1.2 × 1.2 m).

After removing the topsoil layer, crews drove vertical wick drains into the ground. Workers subsequently unrolled the drainage geocomposite perpendicularly to the railway line while also overlapping the wick drains (**Figure 5**). The geocomposite's mini-pipes have a diameter of 0.8 inch (20 mm) and a spacing of 20 inches (510 mm) center-to-center. The geocomposite collects the water from the wick drains and drains it to ditches on each side of the embankment. The backfill was placed directly on the drainage geocomposite to the final level.

Monitoring settlements

Engineers monitored the embankment subbase using profilometers to measure settlements over time and to choose the right moment to remove the overload.

The measured settlements did not exceed 1.6 inches (40 mm), which was lower than the estimated limit; in addition, the effective consolidation time was about three months. The use of a multi-linear drainage geocomposite for horizontal drainage instead of a granular layer offered consistent performance and reduced the cost of the preloading embankment construction, as granular material would have been extracted and transported to the site, resulting in heavy truck traffic in and around the worksite. In comparison, one full truck can carry enough of the drainage geocomposite material to cover an area of approximately 108,000 square feet (10,000 m^2);

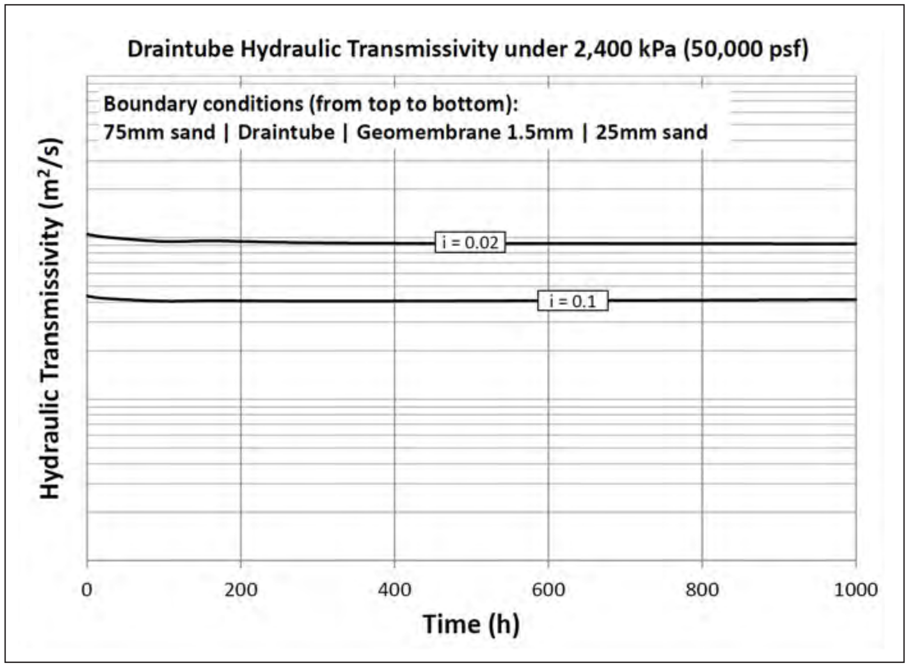

FIGURE 4 Graph of hydraulic transmissivity of the geocomposite under load over time

FIGURE 5 Installation of the vertical wick drains followed by DRAINTUBE

FIGURE 6 Drainage geocomposite installation on slope

PROJECT HIGHLIGHTS

RAILWAY DRAINAGE OF CUT SECTIONS

OWNER
RFF/SNCF

LOCATION
France

GENERAL CONTRACTOR
Roland/Eiffage Group

ENGINEERS
SNCF Reseau Ingenierie et Projets

GEOSYNTHETIC PRODUCT
DRAINTUBE FTF2 D25

GEOSYNTHETIC MANUFACTURER
Afitexinov Geosynthetics

it requires more than 300 dump trucks to cover the same area with a 1 foot (300 mm) thick gravel drainage layer.

Case study: Railway drainage of cut sections

Cut sections involve massive, tall slopes designed to maintain stability and avoid landslides. In case of the presence of groundwater, drainage masks using granular material require large amounts of materials. The use of a multi-linear drainage geocomposite for subsurface drainage reduces that need for copious granular material.

The drainage geocomposite is unrolled directly on the subgrade with the mini-pipes in the direction of the slope (**Figure 6**). 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 (**Figures 7 and 8**). The drainage geocomposite does not provide additional strength resistance for the stability of the slope. But due to the nonwoven needlepunched geotextile layers of the product, the geocomposite/ soil interface angle is approximately the same as the internal friction angle of the soil in contact.

Monitoring and results

On a new high-speed line constructed between 2010 and 2016 in France (LGV Est), engineers monitored two drainage methods for the cut sections: a drainage layer made with granular material and one made with a multi-linear drainage geocomposite. The engineers monitored two areas of 5,650 square feet (525 m^2) each with temperature sensors, water content gauges at the interface and flowmeters (Heili et al. 2014).

It is observed that the water content remained stable between 20% and 40% at the gravel/soil interface and between 20% and 27% at the geocomposite/soil interface. These results show that both drainage systems perform well: They keep the soil unsaturated even during rain events.

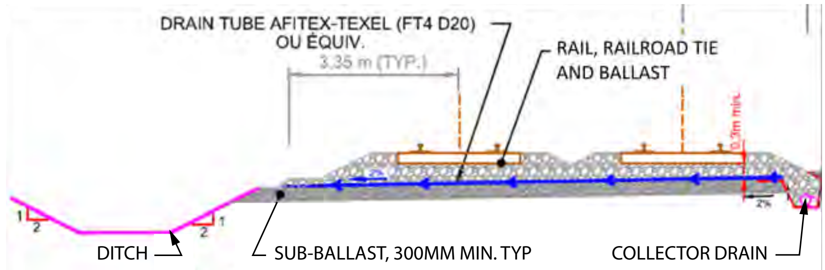

FIGURE 7 Typical cross section

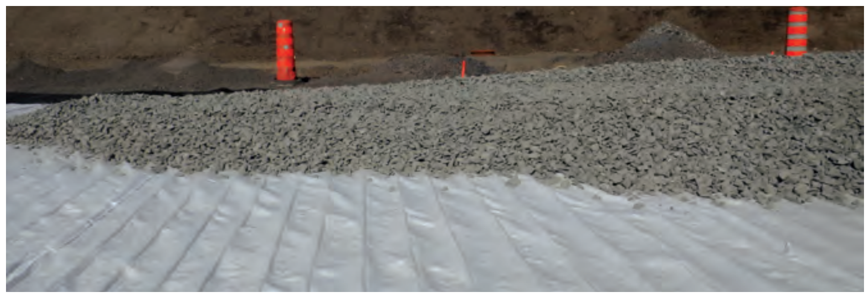

FIGURE 8 Installation of the geocomposite and backfilling with ballast

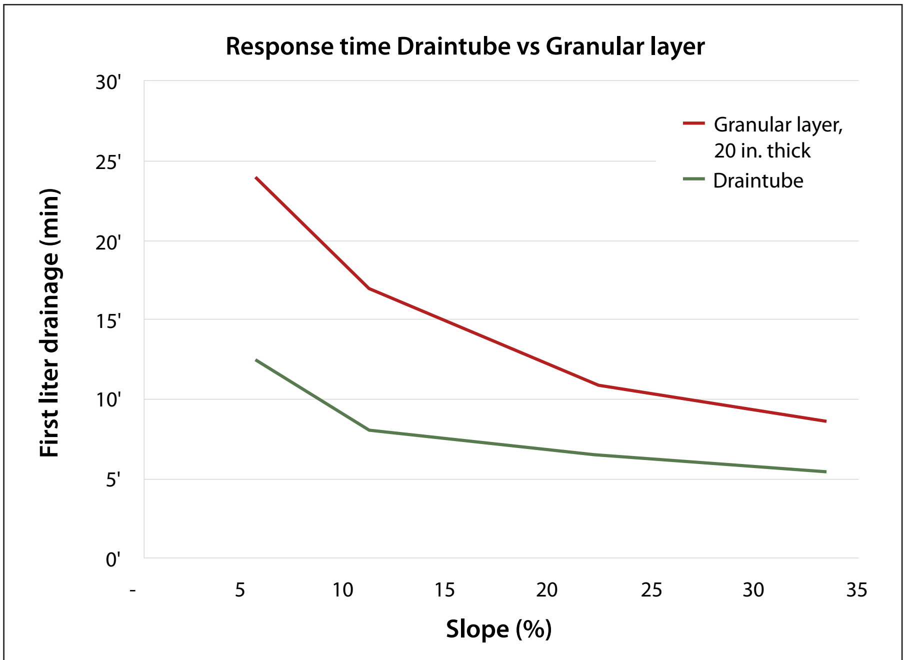

FIGURE 9 Drainage response time DRAINTUBE versus granular layer

Case study: Drainage improvement under tracks

Within the scope of work for some track reconfigurations, engineers must design alternative drainage systems because of the limited space available in certain track corridors. A multi-linear drainage geocomposite with mini-pipes can be used to efficiently evacuate the water below the tracks. The mini-pipes carry water flow to a ballast drain or an open ditch.

In 2016 a Canadian National Railway Co. project in Quebec required two tracks to be drained into either an open ditch or a ballast drain installed 3 feet (1 m) below track level. Without a proper system, potential drainage problems and a shortened life for the ballast would occur. The geocomposite with mini-pipes was placed directly under the ballast (**Figure 9**). The mini-pipes in the product had a diameter of 0.8 inch (20 mm) and a spacing of 10 inches (254 mm) center-to-center.

Construction crews unrolled the multi-linear drainage geocomposite perpendicular to the tracks directly on the MG-56 subgrade soil. Afterward, they installed the ballast in two layers of 5.9 inches (150 mm) each.

Engineers designed the multi-linear drainage geocomposite to evacuate rainfall of 26 inches per day (661 mm/day) with the mini-pipes remaining unsaturated (Ruel et al. 2018). The 100 years return period rainfall in Quebec is 6.1 inches per day (156 mm/day). Assuming only the geocomposite drains all rainfall, its drainage capacity is more than four times greater than required, considering the long-term hydraulic behavior of the geocomposite under the critical conditions of the application.

From Del Greco et al. (2012), using an 8.2 foot (2.5 m) long and 6.6 foot (2 m) wide inclinable open box with rainfall simulator on top, it was shown that a multi-linear drainage geocomposite enables rainfall to evacuate faster than a granular drainage layer. This is due to the directional aspect of the product. The water is drained into the mini-pipes even in situations where the slope is zero.

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

PROJECT HIGHLIGHTS

DRAINAGE IMPROVEMENT UNDER TRACKS

OWNER
Canadian National Railway Co.

LOCATION
Quebec, Canada

GENERAL CONTRACTOR
KPH Inc.

ENGINEERS
Journeaux Assoc.

GEOSYNTHETIC PRODUCT
DRAINTUBE 500P TF4 D25

GEOSYNTHETIC MANUFACTURER
AFITEX-Texel Geosynthetics Inc.

Conclusion

DRAINTUBE multi-linear drainage geocomposites with mini-pipes have been used successfully on many earthworks projects, including railway construction projects. Depending on the project and the design considerations, the geocomposite is used either for embankment and subsurface drainage on cut slopes as a replacement for granular layers or for drainage improvement under railway tracks.

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