Comparative monitoring of a Geocomposite Drainage and a draining mask : 2-year-data analysis and moving forward

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ABSTRACT: French site of one of the new high speed train line was equipped with temperatures and water content sensors, and with flow rate monitoring, in order to compare two techniques to ensure slope stability : traditional matter using granular materials and an alternative solution using a draining geocomposite. This paper presents the way the instrumentation was installed, and how this experimental site was monitored in order to follow the behavior of the geocomposite, the evolution of the flow during seasons, with respect to the traditional way, and to appreciate any potential clogging. Results show that both techniques project grounds below from rain infiltration and frost, that water occurrences are drained, with a distinction between the two techniques. In order to appreciate clogging and stability problems, the experiment must be followed with material improvement, such as increasing the battery life time or autonomous power supply.

1 INTRODUCTION

The construction of train or roads infrastructures generates slopes, which stability has essential stakes, such as people security, costs, including the price of potential repairs. Water is one of the cause of landslide, due to the increase of pore pressure and the lowering of shear strength. Allow water circulation thanks to draining masks, composed of granular materials will ease those pressures. This traditional technical matter uses a lot of natural resources and numerous vehicles movements, with CO_2 emissions. An alternative consists in using a geocomposite drainage (GCD) layer, covered by local materials, treated or not. This option is material-efficient, and reduces trucks traffic.
SNCF Reseau, in charge of the French train network, accepted to experiment a GCD solution, to monitor its draining capacity evolution, on a high-speed train line (LGV in French) site (Morhange, north Est of France). The selected geocomposite layer is constituted by a succession of a filtering blanket, a draining blanket, perforated mini pipes and another filtering blanket.
The construction site was equipped, with 25mm-diameter draining tubes, with 50cm space between them. Soil water content probes, temperature ones and water flow measurement devices were installed. The idea was to monitor water contents at the interface between the geocomposite and the ground, and to improve data safety (redundancy based a small tanks for water collection, and ultrasonic level probes with to cope with weak water flows). This will allow a better characterization of water occurences from the slope after a rainfall, and then their respective evolutions of flows in both drainage technical solutions. A water flow gauge

was installed downstream of the trench collecting water of the slope, with a threshold to ease measurements. Nine probes determining soil water content and temperature were located at the interface between the slope and the draining system (three right below small draining devices, three between them at three different depths, and three at specific locations such as identified incoming water points). A temperature probe was also installed within one small draining device, while another monitors atmospheric temperature.

The main objective is to control the stability of the system, and the hydraulic performances of this GCD solution. The whole system had been currently installed during the summer 2013.

This paper provides details about:

- the way the GCD was implemented with a cover of treated marls on a slope, partially high of clearing,
- the instrumentation setup,
- the 2-year results (evolution of the flows during seasons, of temperature and water contents at the soil/draining mask or GCD interfaces)
- the problems encountered,
- and the changes to ensure the safety of the acquisition devices, for future monitoring and analysis.

2 EXPERIMENTAL SITE AND INSTRUMENTATION DETAILS

2.1 *Description of the instrumented area*

For safety reason, the site with all instruments was selected far enough from the future tracks, in the upper part of the bank. The locations had to present enough water inlets to allow flow rates measurements. Such locations have to be homogeneous between each other to ease further comparisons of the results. The selected zone compliant with these conditions was bank DBT 529 of batch 35 of the high speed track (LGV Est), near Morhange. These areas had been identified by Eiffage TP as soon as February 2012, while outcoming water froze. General views of the studied site are illustrated in Figures 1 to 3.

Figure 1 : frozen water occurrences (source: Eiffage)

Figure 2 : general view in 2012 (source: Cerema)

Figure 3 : water occurrences (dark areas) in 2012 (source: Cerema)

2.2 *Principles of the instrumentation*

Probes installed on the selected site were dedicated to both soil and water temperature, along with the interface with the geocomposite. Other ones were meant to monitor water contents at the interface between the natural soil and the draining mask. Two bands 15 m-wide and 35 m-long each, one with a conventional solution with the draining mask, and one with a geocomposite, have been equipped with a specifically shaped water collection device to bring drained water. Water levels were then monitored with ultrasonic sensors and measurements recorded in a data acquisition system. They will be then used to calculated flow rates for both bands.

2.3 *Realization of the instrumentation*

Each of the experimental band was elaborated during April 2013 by Eiffage TP. Conventional band consisted in granular material over a 50 cm-thickness. The other band had a draining geocomposite blanket with 50 cm of marls treated on site over it. Ditches were dub at their basis to collect water. All these elements are shown in Figures 4 and 5, while the draining geocomposite section in Figure 6.

Figure 4 : traditional part (source: Cerema)

Figure 5 : GCD experimental part (source: Cerema)

Figure 6 : GCD section (source: Afitex)

2.4 *Types of probes*

So as to cope with requirements of the objectives of hydraulic performances of both draining techniques, each ditch at the bottom of the band drained the water which level was measured with ultrasonic sensor with a 0.5 mm-accurracy. Knowing the shape of the collection device, standardized approaches were used to calculate corresponding flow rates. The choice consisted in an Aquabac 4 (manufactured by Aqualyse), with a flow rate measurement range from 0 to 1.17 L/s (4.21 m^3/s) (Figures 7 and 8).
Water contents and temperatures variations at the interface between the natural soil and granular material, and between the geocomposite and granular material were measured with 5TM probes (from Decagon). These measurements were then correlated with pluviometry data recorded with a rain gage on site to compare flow rates and water contents evolutions over both bands. Data acquisition were connected to batteries to allow an autonomous recording system on the experimental site.

Figure 7 : temperature and water content sensors (source: Cerema)

Figure 8 : chamber with flow rate measurement (source: Cerema)

2.5 *Localization of the material and instrumentation devices*

A full map of different materials and instrumentation devices is presented in Figure 9. Temperatures and water contents probes were located at the respective interfaces with natural soil and granular material (1 to 3), and with natural soil and geocomposite (4 to 12). Probe 5 was dedicated to a dry area, while other were assigned to humid ones. Some probes were specifically located below draining pipes (6 to 8) or between the draining pipes (probes 4 and 12). Temperature probe A was installed within a draining pipe, and another one B within the device collecting water.

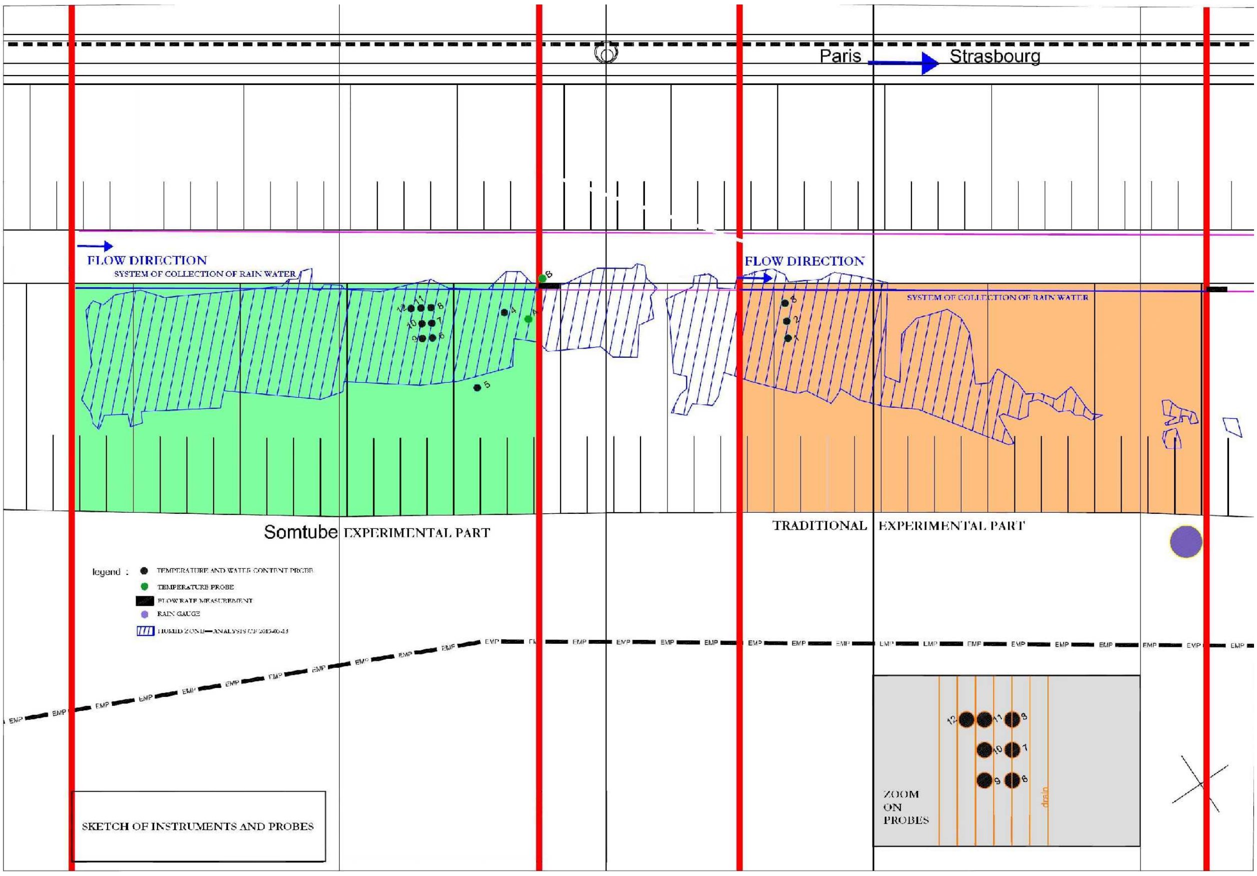

Figure 9 : instrumentation implantation

3 RESULTS. DISCUSSION

Once completed, the first measurements were obtained in September 2013, and lasted over nearly a 5-month period. Some disruptions in data acquisition were unfortunately observed because of power supply issue, along with some flooding of data acquisition devices (Figure 10). A solution was brought to this specific one placing the whole acquisition system in a dedicated flood-proof chamber (Figure 11).

Figure 10 : chamber with water (source: Cerema)

Figure 11 : new data logger chamber (source: Cerema)

3.1 Water contents

Many measurements were available over several periods (19 September 2013 to 31 January 2014, 17 November 2014 to 20 December 2014, and 20 January 2015 to 13 March 2015), provided in Figure 12 and 13. Water contents recorded over the conventional draining solution are presenting nearly constant values whatever the rain events.
Two different behaviors were observed:
- a first one with constant values, or with weak variations (C01, C02, C03, C04, C06, C08, C09, C10);
- a second one with quick and sudden variations related to rain data variations, with similar profiles (C05, C07, C11 and C12). Two hypothesis could then be raised, either a defect on probes or the presence of granular material near the probes. Important variations over time were observed on C05 probe. It is almost constant till January 2014 with a water content near 19%, and the large variations between November 2014 and March 2015, with a water content ranging between 48% and 58%.

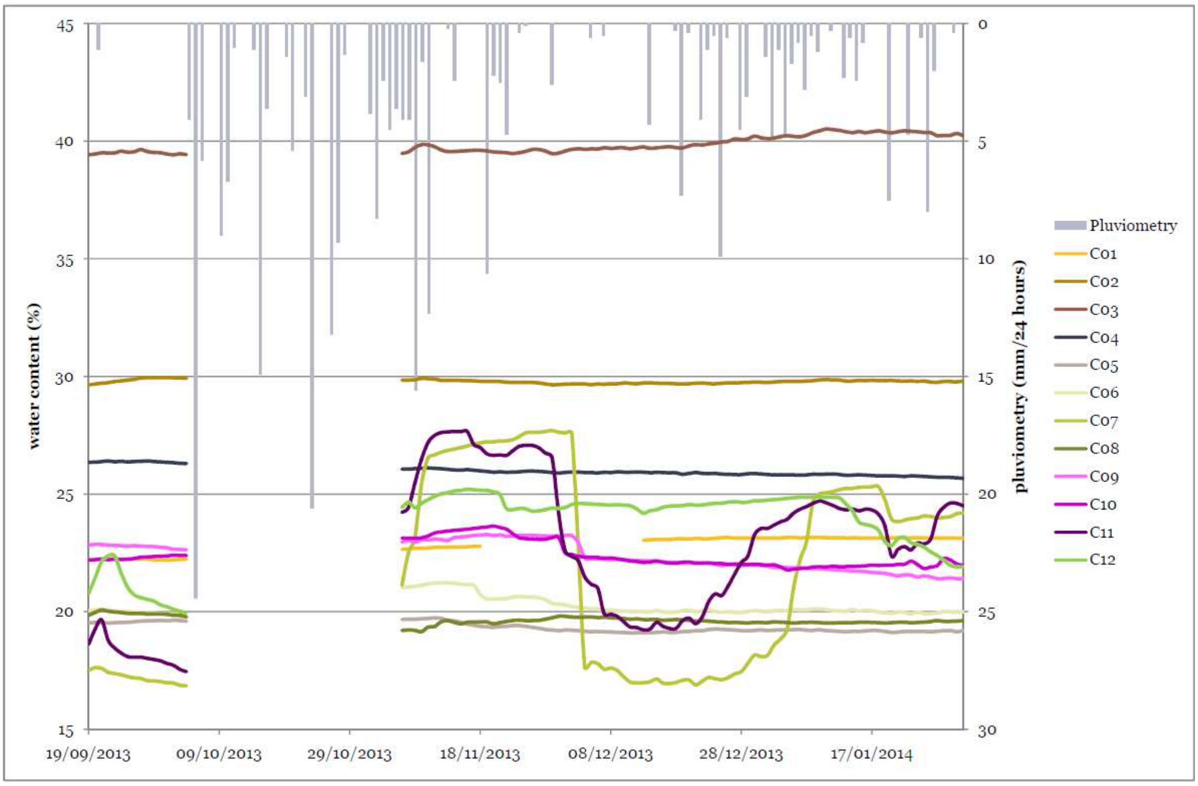

Figure 12 : water content - period from 19/09/2013 to 31/01/2014

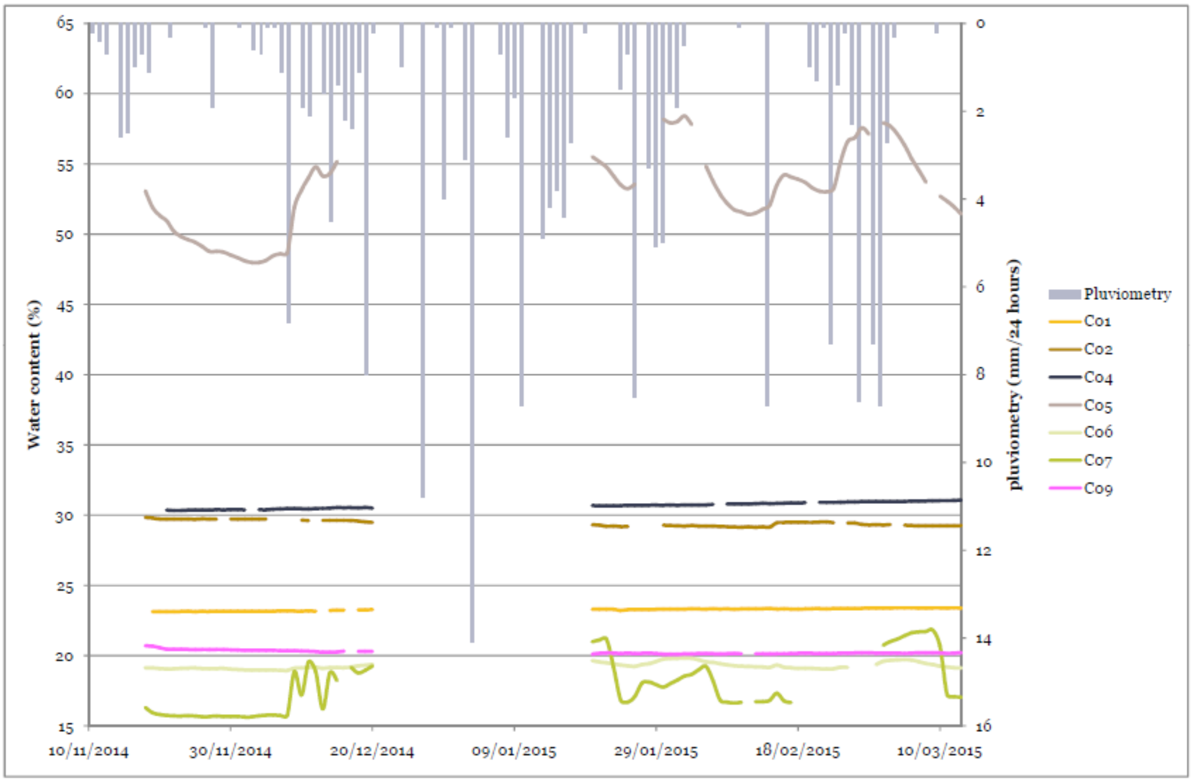

Figure 13 : water content - period from 17/11/2014 to 13/03/2015
with lack of acquisition on C03, C08, C10, C11 and C12

3.2 *Flow rates*

Data were here available between 21 November 2013 and 31 January 2014, between 15 December 2014 and 13 March 2015 for the band with conventional draining material. In the case of the geocomposite, the periods with available data were 19 September 2013 and 31 January 2014, between 15 December 2014 and 13 March 2015 too. Flow rates results are illustrated in Figure 14 and 15.

Flow rates were greater during rain events. They were in phase in the case of the conventional granular material. some delay was observed with the presence of the draining geocomposite. A maximum value of 0.0864 m^3 was not overtaken between November 2013 and January 2014. Some modifications were then performed over the data acquisition system to overcome this difficulty.

Flow rates were greater with the geocomposite with respect to granular materials. Here again, two hypothesis were raised. Either water volumes were greater for the band equipped with the geocomposite, or all the water from the conventional band did not reach as expected the measurement device. It is indeed easier to collect a set of draining pipes to a ditch than to avoid water leakage under granular materials.

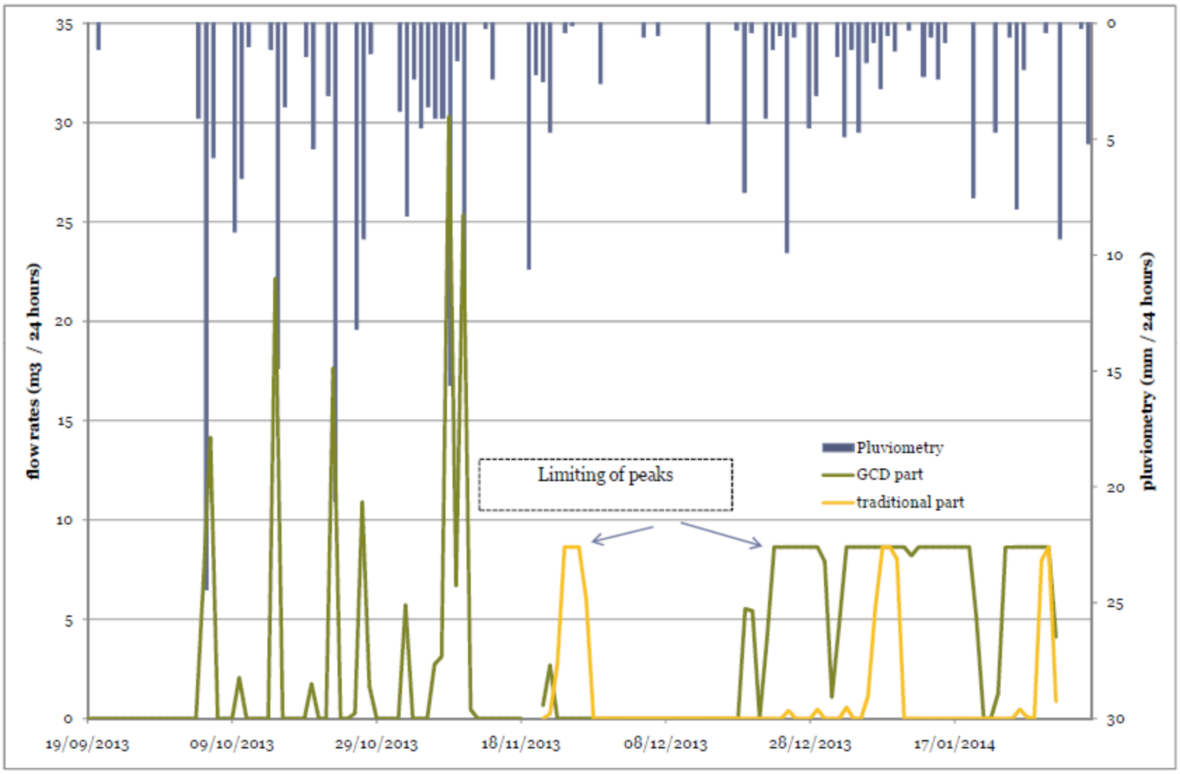

Figure 14: flow rates collected on each part - period from 19/09/2013 to 31/01/2014

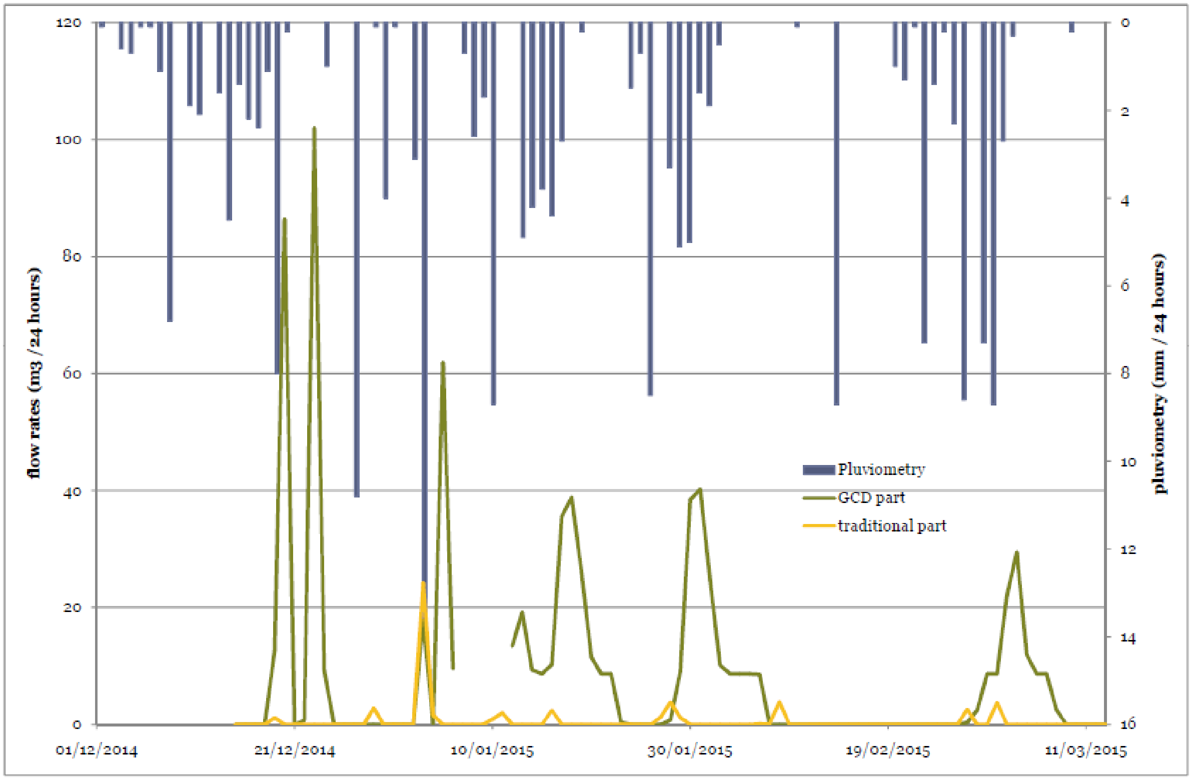

Figure 15: flow rates collected on each part - period from 15/12/2014 to 13/03/2015

3.3 *Temperatures*

Measurements were available between 19 September 2013 and 31 January 2014, between 17 November 2014 and 13 March 2015, with some disruption in the data flow in January 2015. As illustrated in Figures 16 and 17, temperatures on the band and within the draining pipes (probe A) were above 0°C. Variations were similar for both the conventional granular material (probes 1 to 3) and the draining geocomposite (probes 4 to 12). Only data from probe B indicated negative temperatures, in agreement with negative ambient ones.

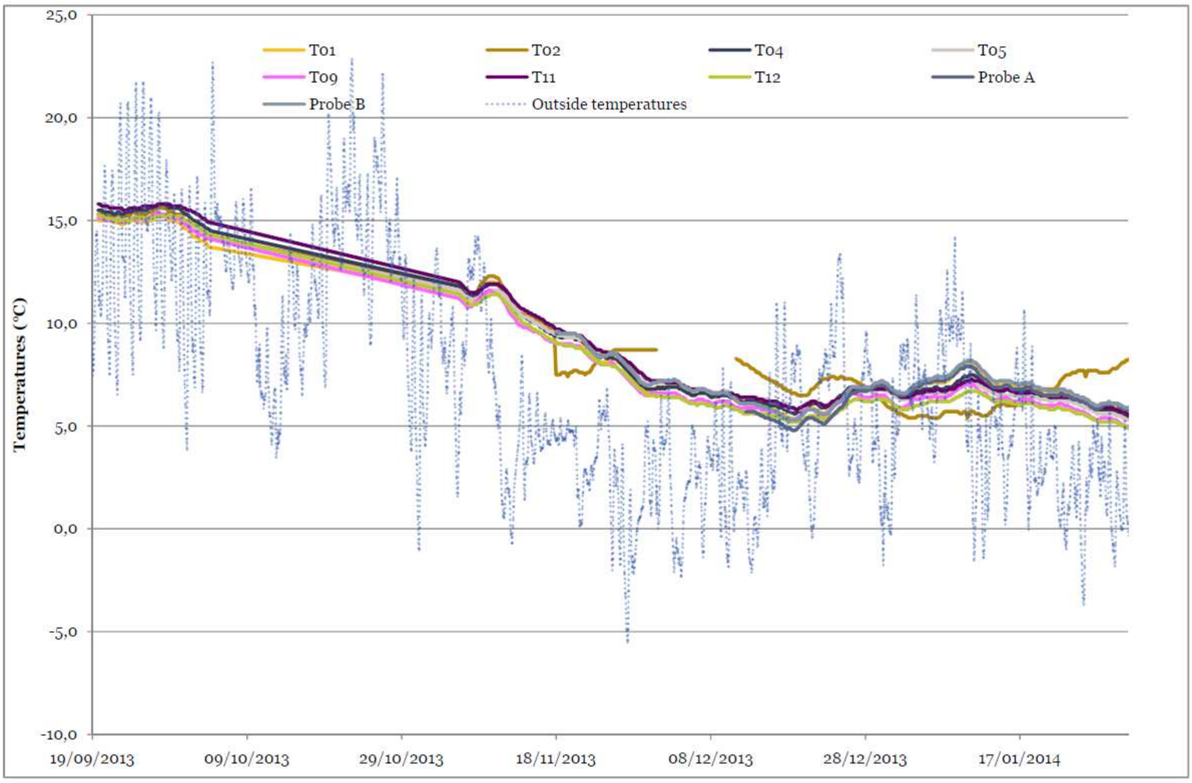

Figure 16: measured temperatures - from 19/09/2013 to 31/01/2014

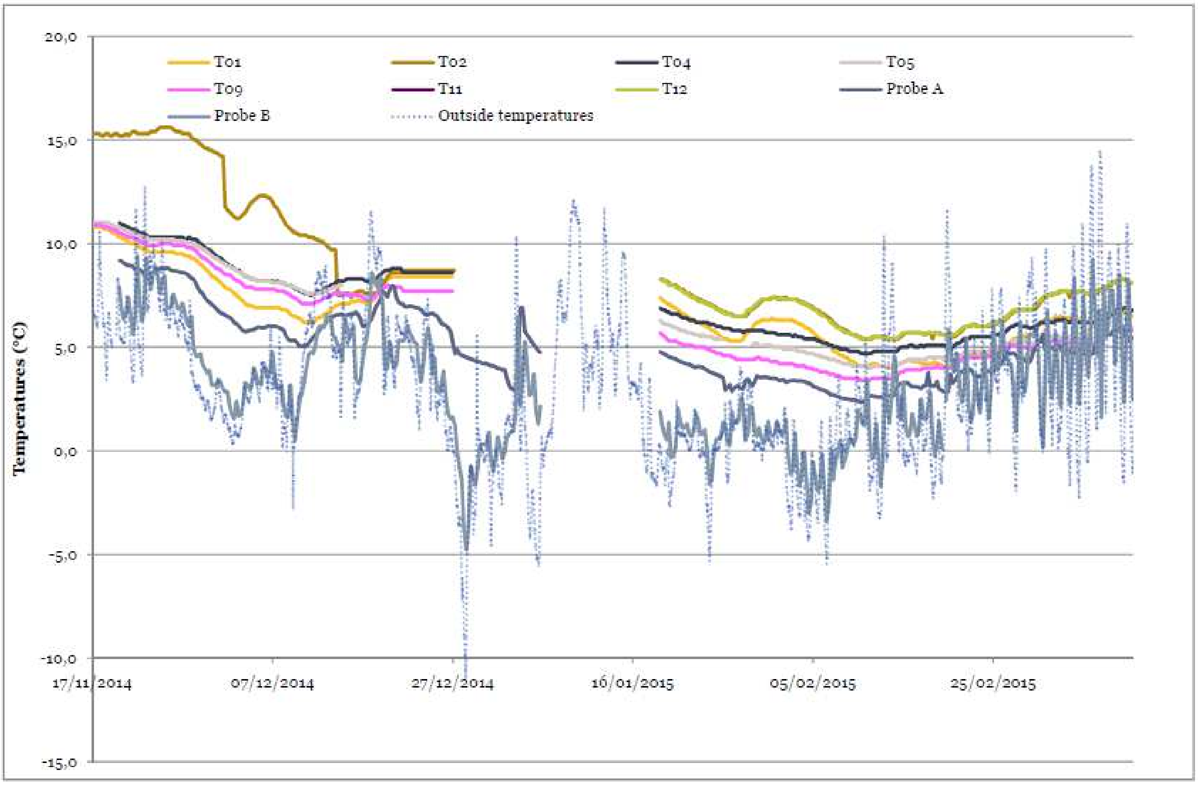

Figure 17: measured temperatures - from 17/11/2014 to 13/03/2015

4 CONCLUSION AND PERSPECTIVES

Both techniques were efficient to prevent natural soil from water infiltrations because of the absence of variations in water contents at the interface between it and the draining mask over a majority of measurement points. Observed variations could be related to the ones on incoming water. With respect to freezing protection, similar results were also obtained with the two solutions. Measurements appeared to be consistent with the places probes were installed. The one in the dry area presented the lowest values over weeks, while the ones at the bottom of humid areas have the largest values. Even the protection of the whole data acquisition system within a dedicated chamber away from public and precipitations did not avoid disruptions in the acquisition. Some improvements are still to be implemented to avoid data loss such as an autonomous power supply system (solar panel, Li batteries), or remote data collection with GPRS. Flow rates measurements indicated both technical solutions were able to evacuate water with a constant time and volumes of their own. Since incoming water volumes were not quantified nor comparable to each other, sole a qualitative analysis of the draining capacity will be conducted.

Missing data do not change the first conclusions. they need to be consolidated on the long run (evaluation of the performances of the geocomposite). The absence of any particular reduction in drained volume has to be confirmed in the two coming years.

As a conclusion, with respect to these first results, the draining geocomposite did answer to the requirements in terms of bank stability, drainage of the zone where it has been installed, and the protection to freezing.