Long Term Behaviour of Trench Drains in the Alps

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ABSTRACT: Within the context of stabilization works in mountainous regions, kilometers of trench drains are constructed each years in the Alpes. These trench drains are filled with clean gravels and are protected from the fill–in (clogging) of the site soil by means of a geotextile filter. An investigation campaign was started in order to analyse the behavior of the filter and of the trench drain. The methodology used and the first results are presented:
– following up the behavior of two ten years old trench drains of about 4 m depth: piezometers have been bored and the water flow has been measured;
– opening and observations of six years old trench drains (1.3 and 1.7 m depth) with or without a geotextile filter. The role of the geotextile and the influence of the contact between the soil and the non–woven filter are shown.

1 DRAINAGE FOR STABILIZING LANDSLIDES:

The region of Trièves, in the south of the Departement of Isère, is indisputably a part of the French Alpes which presents a very large display of landslide risks, with relative districts where more than 50% of the territory has proven declared or potential movement due to the presence of massive deposits (more than 100m of thickness at different points) of quaternary glacio–lacustrian clays.

The distinct drainage systems like trench drains (fig.1), counterfort drains, are very often used for the shallow drainage (1 to 5 m depth) of sliding zones. Indeed, they perform very well in order to intercept water flows circulating along preferential ways in these surface layers. The purpose of this trench drains is to catch the water circulating in this shallow layer in order to prevent it infiltrating deeper.

But, in these particular drainage conditions, where one looks to intercept the preferential water ways, the flows are strong and continuous. There is therefore a risk of putting particles of soil in suspension, and thus increasing the risk of clogging.

These critical filtration conditions are not actually taken into account in the filtration criteria. A specific and adapted research programme was elaborated by the University of Grenoble (IRIGM) and the RTM Services (Land Restoration in the Mountains of Forest and Agricultural Services of Isère Departement) including:
– the follow up of drainage works in existence for several years and the opening of some drain trenches;
– to carry out experimental in–situ trench drains in order to compare different filter systems (with or without geotextile) in real work conditions.

In this paper, only the results of the first part (Farkouh 1994) of the programme are presented. The experimental in–situ trench drains were constructed in September 1993 and the follow up is just beginning.

2 BEHAVIOR OF EXISTING TRENCH DRAINS

It has been chosen to follow up, more particulary, two sites where trench drains were constructed close to ten years ago: at Corps (Isère) in 1982 and at Avignonet (Isère) in 1984. The objective is to know if the trench drains, constructed using a geotextile as a filter, are performing their expected role, concerning the landslide stabilisation and the piezometric level in the vicinity of the trench.

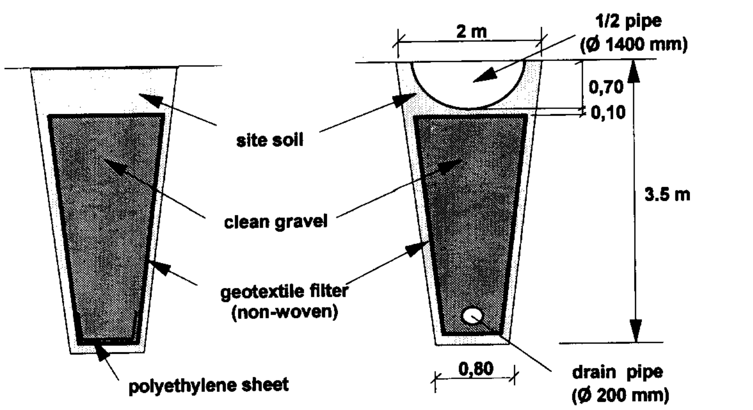
2.1 Trench drain at Corps (Isère):

On this site two herringbone trench drains were joined at their lowest point (at depth of 4m) to a connecting manhole. The site soil consists of approximately an heterogeneous soil made of a relatively permeable layer (silty and sandy clay of about 4 m thickness) above the clayey level. The trench is filled with gravel surrounded with a non–woven geotextile filter. A polyethylene sheet is laid at the bottom of the trench (fig.1.a) in order to collect the water (there is no drain pipe).

The west part of the trench, of length 114m with an average slope of 10%, has been instrumented: 9 piezometers have been put in place uphill, and 2 downhill. On the uphill slope there is a ditch always filled with water which gives a reference level (fig.2 and fig.3). The measurement of the flow in the manhole has not been easy because the main collector pipe ends just at the bottom of the manhole. It was necessary to introduce a small diameter pipe surrounded by an inner tube (ensuring watertightness with the main collector pipe).

The recording piezometric levels were carryed out during the year 1993, in the course of which it had alternated rainy and drought periods. A certain stability of the piezometric levels was observed, (fig.4) surely due to the presence of the uphill ditch being continuously full of water. On the other hand the flow was sensible to rainfall: from 0.25l/s to 1.25l/s, probably because of the existence of points of water observed at the uphill extremity of the trench (zone without piezometer) during its excavation. Nevertheless, it can be noted that, as the flow is varying, the piezometric level is quiet constant near the drain trench, and not far from it.

The trench, on the instrumented uphill part, drives down the water table efficiently (fig.3). Owing to the fact that the trench width is badly known, it can be considered wider than its supposed width because of the crumblings quoted in the execution reports. The network of equipotential lines could be estimated from the piezometric measurements, fig.2 and it shows clearly a reorientation of the flow perpendicular to the trench axis. The geotextile seems to perform correctly its filter function: the water is clear at the exit and the water table is well driven down.The landslide movements are stabilized.



a) Trench drain at Corps b) Trench drain at Avignonet

Fig. 1 Typical schemes of trench drain

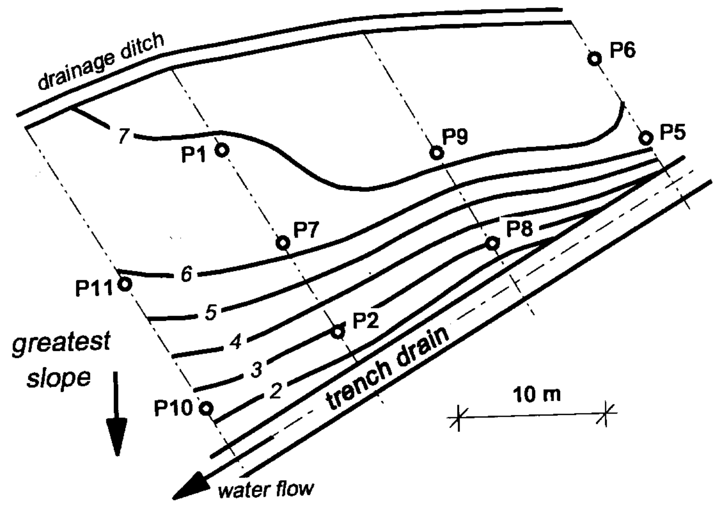


Fig. 2 Plan view and equipotential lines at Corps

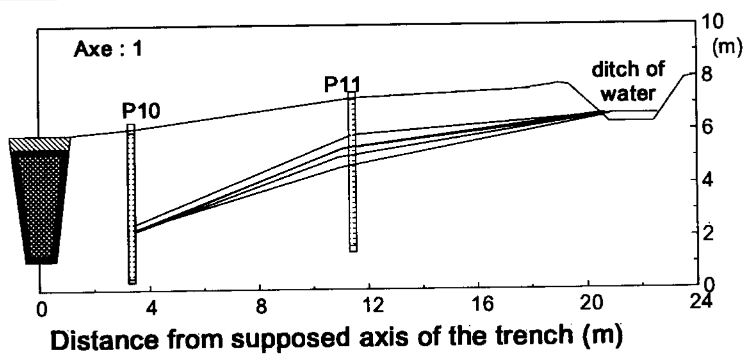


Fig. 3 Piezometric levels at various times (Corps)

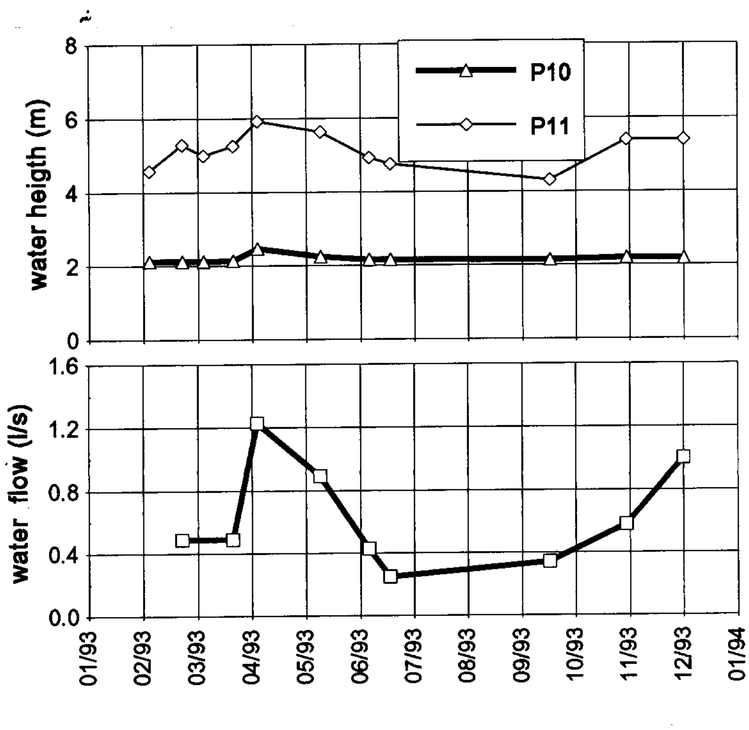


Fig. 4 Piezometric levels, from manhole bottom, and water flow rates for 1 year (Corps)

2.2 Trench drain at Avignonet (Isère):

The studied trench drain is situated in the top part of the moving zone. It was constructed in 1984, as a consequence of an important land movement affecting a housing development in construction. Like on the site of Corps (§2.1), the soil is composed of a superficial layer (a clayey moraine), of thickness 4 to 5 m depending on the place, of weak mechanical resistance. Below is a thick layer of compacted clay. This superficial layer is a silty clay of soft average plasticity.

The trench drain has a depth of 4m and a length of 180m. It consists of a drain pipe of 200 mm diameter placed at the base of a mass of appropriate gravel 3.5 m in height. All is surrounded by a non–woven geotextile filter. The upper part is recovered with a site soil layer and a watertight semi–pipe collecting superficial water flows (fig. 1b). Only the uphill part of the trench, the first 72m up to the first manhole, has been followed up.

9 piezometers were installed on the uphill slope (fig.5). The measured water flow is about 0.08 l/s in dry period, but it is a lot higher in rainy periods (0.86 l/s). However important runoffs were observed during rainy days (like April 7th ,1993, fig.6) and were penetrating the trench drain under the semi–pipe. Water is clear at the drain pipe exit.

The variations of the piezometric levels as function of time (fig.7) are clearly following the variations of the water flow, as well near the trench as far. Analysis of the piezometric profile, fig.6, perpendicular to the trench axis, does not allow us to suppose that an effective lowering of the water table occurs; and during rainy days, the water table rises to the same level as the soil surface. The network of equipotential lines (fig. 5) does not show a reorientation of the flow towards the trench (it stays approximately orientated in the direction of the slope) and the flow stays parallele to the soil surface. It would be tempting to believe that the filter is clogged, but it must be noted that:

– the soil is a lot less permeable than at Corps and probably more homogeneous (no silty sand zone), but maybe with an anisotropy of permeability, larger in the direction of the slope,

– if we look at the piezometric level along the largest slope line (P9, P5, P1), about 10.5%, there is effectively a lowering of the water table around the manhole, which works like a draining well. Consequently at important crumblings occured during excavation, the site soil had been replaced by an important volume of gravel surrounding the manhole.

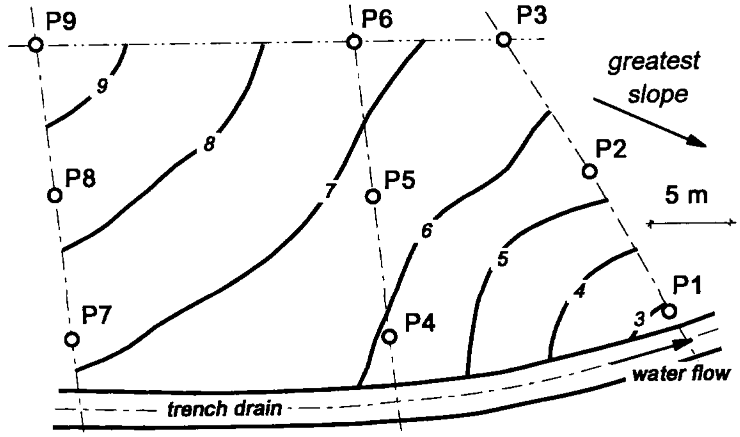


Fig. 5 Plan view and equipotential lines at Avignonet

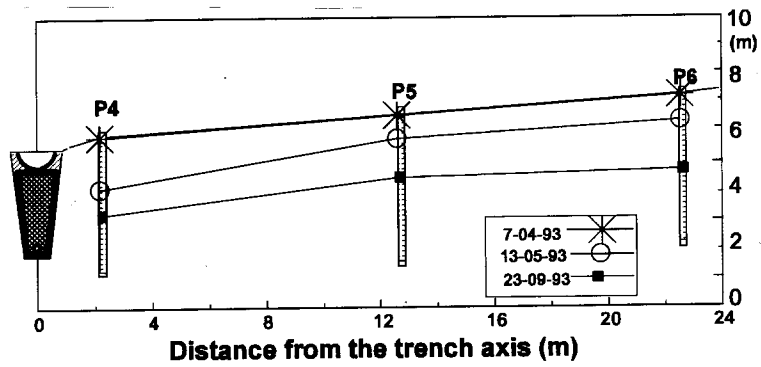


Fig. 6 Piezometric levels (Avignonet)

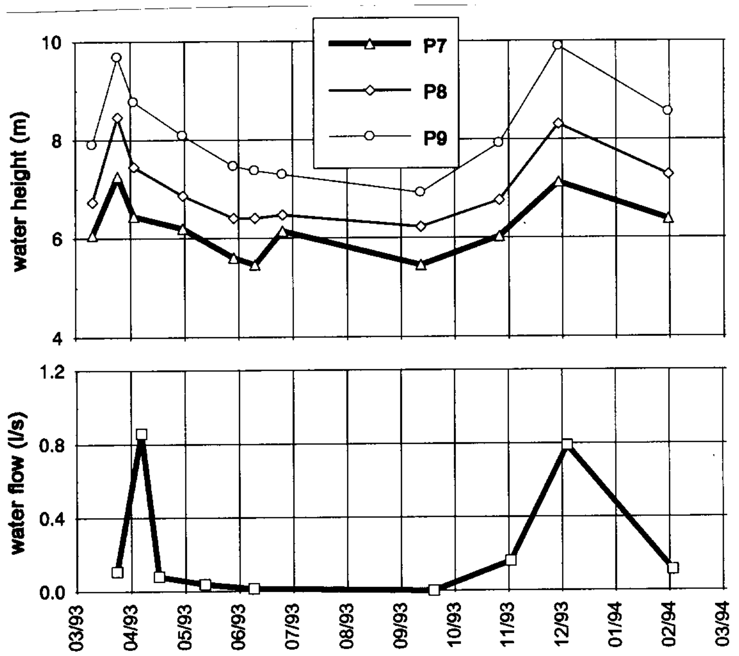


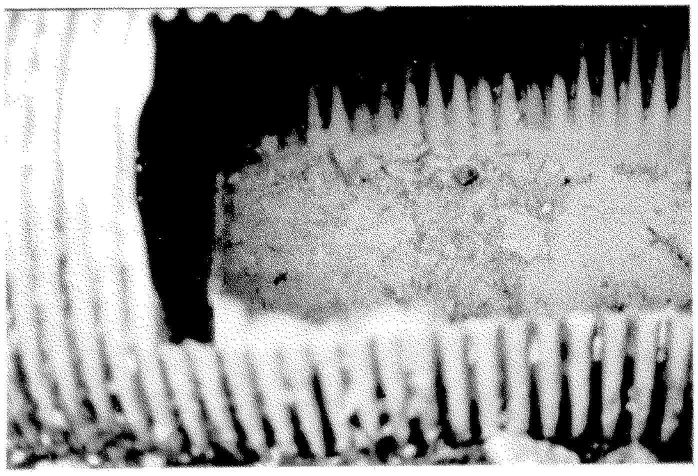
Fig. 7 Piezometric levels, from manhole bottom, and water flow rates for 1 year (Avignonet)

3 OPENING OF TRENCH DRAINS:

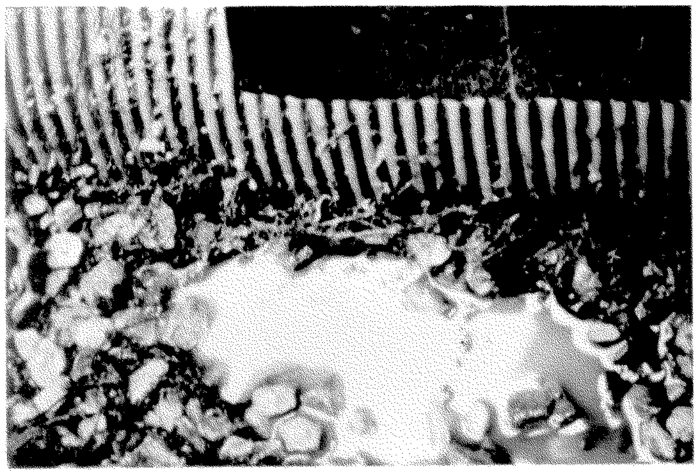
Two trench drains have been opened in order to observed their state after functionning for 6 years. They were constructed in 1987 and were opened in 1993.

2.1 Trench without geotextile filter:

This trench drain is also in Avignonet, in a lower part of the sliding zone than the previous one (§2.2). It is 1.30 m depth and only an horizontally layed geotextile was placed



b: particles accumulated below the removed roots carpet



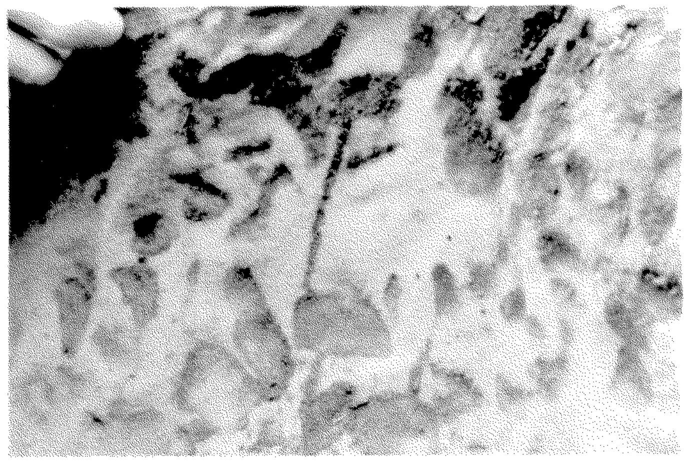
a: roots blocking the openings of the drain pipe
Fig. 8 Trench without geotextile

in the upper part of the trench to prevent soil infiltration from the covering soil. We observed that:

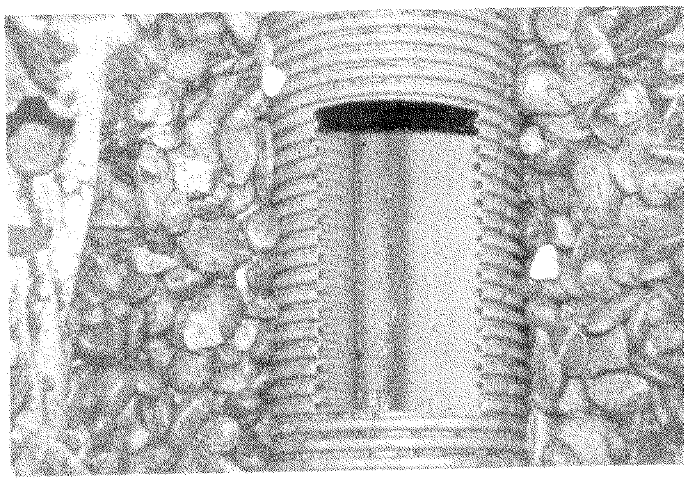
- gravels are not clean, fines particles are mixed with roots. These roots block the drain pipe openings (fig.8a);
- inside the pipe, a 40 mm thick carpet of roots is holding up the water flow (50 mm water height in the pipe) and a lot of particles are accumulated below the roots carpet (fig.8b). In spite of this, the water flow is varying from 0.225 l/s to 1.7 l/s (rainy days).

2.2 Trench with a geotextile filter around the gravels:

The second trench, located near S[t]. Sebastien (Isère), is 1.70 m depth. When removing the upper geotextile layer, the gravels below are clean (fig.9a) and at the bottom of the drain pipe, only few particles are collected. On the non–woven face on the side of the soil, marks of runnings are visible where there is not a good contact with the soil. On the gravels side, water pass through the filter where a pebble well confines the geotextile, and then it is running down along the nonwoven (fig.9b). At the base of the trench, the filter is saturated and the water flows in the gravels to the pipe.



b: geotextile face in contact with the gravels



a: gravels and pipe free of roots and of fines particles
Fig. 9 Trench with geotextile

4 CONCLUSION

The first measured results are not sufficient enough to answer the questions that has been set down by the works manager. More subtile investigations are necessary, to find out the determination of the free surface of flow at the near vicinity of the trench (seeping height) and a better understanding of the site soil: permeability, stratification.

Without geotextile, the gravel and the drain pipe can be clogged by roots and soil particles. But the geotextile has to be well in contact with the soil to allow the flow to pass through the geotextile otherwise water run along it and penetrates in the trench only at its bottom.

The comparison of the measured piezometric levels with theoretical ones and the partial dismantling of the trench to examin the state of the geotextile filter in the situ experimentation will be full of interest.

REFERENCE

Farkouh, B. (1994) : Les filtres géosynthétiques dans les ouvrages de drainage: Essais de laboratoire et observations in situ, *Thesis University of Grenoble (to be published).*