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Long-term flow capacity of geocomposites

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ABSTRACT: The most common method to predict the water flow capacity of a drainage geocomposite at the end of the service life is based on the assumption that the flow capacity is directly dependent on the thickness whereas the thickness is predicted by the extrapolation of compressive creep tests. To take into account the influence of the deformations of surrounding soil a reduction factor for intrusion of the geotextile is calculated, based on short-term water flow measurements. The deformation of the surrounding soil is reflected in different test set ups with stiff or flexible loading or support conditions. Direct measurements of the water flow capacity at different support conditions have shown that the real decrease in flow capacity is sometimes much higher than taken into account by short-term generated reduction factors for geotextile intrusion.

Little attention is given to the compression behaviour and failure mode of geocomposites when the long-term flow capacity is predicted. So-called incompressible geospacers can collapse at higher load-levels or in long-term. Even if there is only a little decrease in flow capacity over a longer period a sudden acceleration of compression or collapse can occur resulting in a tremendous decrease in flow capacity. To be able to make safe predictions of the long-term flow capacity the compression behaviour has to be analysed and a collapse failure mode must not take place within the service life.

1 INTRODUCTION

The determination of the water flow capacity of drainage geocomposites is carried out according to EN ISO 12958 after a pre-loading of only 6 minutes at every load level. Such a value is sufficient as an index value. But usually the index value differs considerably from the long-term flow capacity which is influenced essentially by the intrusion of the geotextile into the drainage core in contact with soil, the compressive creep of the drainage core, chemical clogging and biological effects. First design recommendations (Koerner 1994) have taken such effects into account by reduction factors. Typical values for local deformation are RF_{IN} = 1.0–1.5 and for creep RF_{CR} = 1.2–1.4. But already Zanzinger and Gartung (1999) have shown that based on compressive creep tests the reduction factor RF_{CR} can come up to 3.0. Jarousseau und Gallo (2004) found reduction factors for creep between 1.1 and 4.2 for different types of drainage cores.

The determination of the reduction factor creep can be carried out indirectly by measuring the residual thickness of the geocomposite after a defined period and extrapolation to the required service life. The flow capacity related to that calculated thickness is measured at virgin samples. This method includes a few uncertainties, because the test conditions differ from those in situ. The compressive creep tests have to be carried out between rigid support plates, otherwise a precise determination of the thickness is not possible. In reality in most of the cases the support conditions are rigid/flexible.

The type of support system chosen in the test will influence the deformation and compression behaviour of the drainage core, by hindering the free movement of the drainage core in case of a soft and flexible support. Furthermore it has to be proven that a time dependent decrease of the flow cross-section by intrusion of the geotextile does not occur.

2 EXPERIMENTAL PROGRAMM

2.1 *Test description*

To be able to answer the raised questions various geocomposites have been installed in a specially designed compressive creep box. (Figure 1). The samples are loaded by means of pressure bags which are placed in the top and bottom part of the box. By

Figure 1. Compressive creep test box.

air-pressure loads between 20 kPa and 400 kPa can be applied. A flexible support is realized by direct contact of the samples with the membrane, a rigid support is realized by metal plates put between the samples and the membrane.

An overview of the geocomposites tested is given in Table 1.

Table 1. Types of geotextiles and geospacers tested.

GTX	M	Mechanically bonded 200 g/m2
GTX	T	Thermally bonded 125 g/m2
GSP	R	Random array of monofilaments
GSP	V	V-shaped array of monofilaments
GSP	N	Geonet
GSP	C	Cuspated sheet
GCO	MRM, TRT, MVM, TVT, TNT, TC, ……	

In this paper results of tests on various types of Enkadrain products are reported. Many long-term tests have been executed on other type of drainagemats with e.g. cuspated cores or different non wovens. The samples have a dimension of 20 × 30 cm which is identical with the size necessary for the flow tester. To determine the residual flow capacity the samples are taken out at regular intervals and tested at the same load and support conditions as they are present in the compressive creep box. The flow capacity is determined according to EN ISO 12958.

2.2 *Test results of support conditions on water flow*

Figure 2 shows the flow capacity of a drainage geocomposite, consisting of a geospacer with a random array of monofilaments, which is combined on both sides with a thermally bonded geotextile (TRT). The normal stress applied is 20 kPa, whereas all three support conditions have been realized.

As expected the flow capacity at rigid/rigid support is the highest, followed by rigid/flexible support. Remarkable is the nearly parallel course of the curves. A reduction of the flow cross section as a result of the intrusion of the geotextile occurs immediately. The difference in the flow capacity between the various support systems does not change in time.

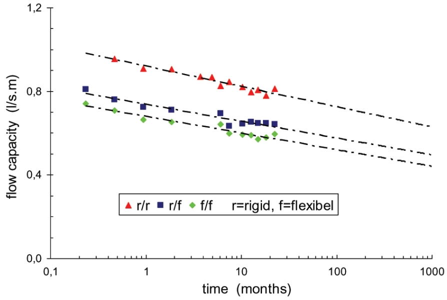

Figure 2. Influence of support on flow capacity of TRT-GCO at 20 kPa loading.

Figure 3 shows the influence of the geotextile (mechanically bonded versus thermally bonded) and the support on the flow capacity of a R-GSP. The difference in the flow capacity between the various geotextiles and support systems keeps constant in time.

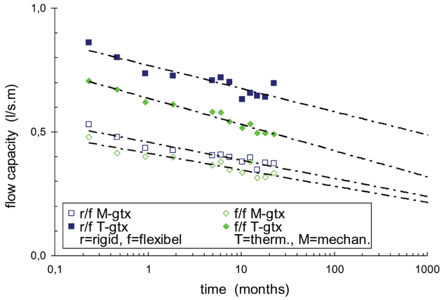

Figure 3. Influence of support and GTX on flow capacity of R-GSP at 20 kPa loading.

Figure 4 shows the influence of the support at load levels of 50 kPa and 100 kPa on the flow capacity of a MVM-geocomposite. The difference in the flow capacity between the various support systems does not change in time. But if the same V-GSP is combined with thermally bonded geotextiles a distinct decrease

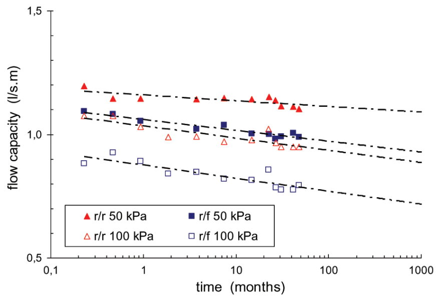

Figure 4. Influence of support on flow capacity of a MVM-GCO at 50 kPa and 100 kPa loading.

in flow capacity with rigid/flexible support becomes visible in time compared with rigid/rigid support conditions (Figure 5).

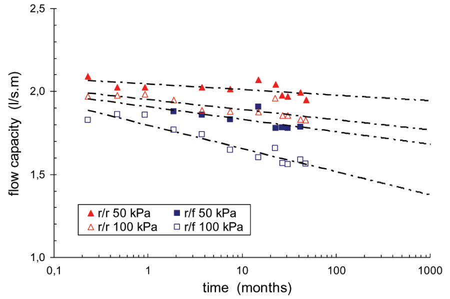

Figure 5. Influence of support on flow capacity of a TVT-GCO at 50 kPa and 100 kPa loading.

With another V-GSP in combination with a thermally bonded geotextile the influence of the support on the flow capacity is much more visible (Figure 6). Within the test period of 6 years the flow capacity at rigid/flexible support decreases with an additional 25% compared with rigid/rigid support conditions.

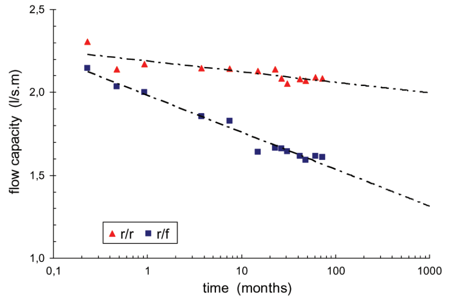

Figure 6. Influence of support on flow capacity of TVT-GCO at 50 kPa loading.

2.3 *Test results on compressive creep behaviour*

Figure 7 shows the time dependent flow of a MVM GCO at load levels between 20 kPa and 200 kPa. Within the test period of 8 years there is an absolute linear relation between the flow capacity and the logarithm of the time up to load levels of 100 kPa. Even at 200 kPa loading the decrease in flow capacity is linear up to 2 years test duration. After two years loading an accelerated decrease in flow capacity becomes visible and the residual flow capacity drops to very low values. The rapid decrease in flow capacity is linked to an increasing compression of the geospacer.

Figure 8 shows the time dependent flow capacity of a TCT-GCO. At 20 kPa loading this product has a very high flow capacity. But already at 50 kPa loading and rigid/rigid support the geospacer collapses within days resulting in a very low residual flow capacity. At rigid/flexible support and 50 kPa loading the flow capacity decreases within one year ending up at the same low level of flow capacity as the other samples.

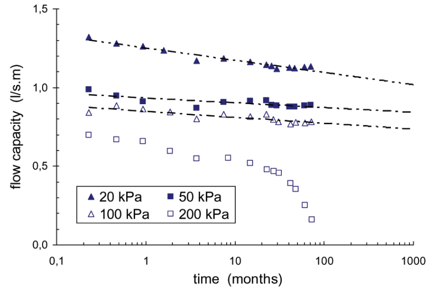

Figure 7. Changes in the flow model in time of a MVM-GCO at different loading at rigid/rigid support.

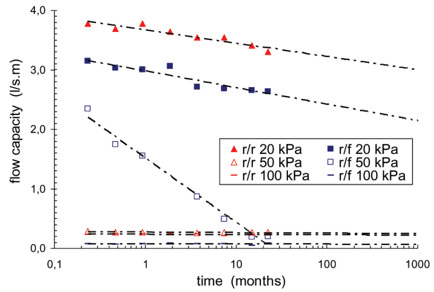

Figure 8. Changes in the flow model in time of a TCT-GCO at load levels between 20 kPa and 100 kPa.

3 DISCUSSION OF RESULTS

3.1 *Long-term influence of support on water flow*

An often applied method to determine the long-term flow capacity is using the residual thickness derived from creep tests. Based on creep tests of 1,000 of 10,000 hours the residual thickness of a geocomposite after x years is extrapolated. In a second step the water flow capacity is determined in a flow tester at that thickness and at rigid/rigid support.

E.g. the initial flow capacity of the geocomposite drain from figure 6 is 2.3 l/(s·m) at 50 kPa and rigid/rigid support. The residual flow capacity after 100 years derived from creep tests is 2.0 l/(s·m). The reduction factor for creep at rigid/rigid support is calculated to $RF_{CR} = 2.3/2.0 = 1.15$. The initial flow capacity at rigid/flexible support and 50 kPa loading is 2,15 l/(s·m). Compared with the flow capacity at rigid/rigid support the reduction factor for filter intrusion is calculated to $RF_{IN} = 2.3/2.15 = 1.07$. Both reduction factors combined result to $1.15 \times 1.07 = 1.23$. The calculated long-term flow capacity at rigid/flexible support is 2.3/1.23 = 1,87 l/(s·m). In contrast to that the residual flow capacity derived from the compressive creep box tests at rigid/flexible support at 50 kPa is only 1,3 l/(s·m). The difference in long-term flow capacity between these two methods is more than 40% and cannot be neglected. The common method to derive the long-term water flow capacity from thickness measurements in creep tests and to correct these data with a reduction factor RF_{IN} for filter intrusion can lead to an overestimation of the capacity of the geocomposite drain, if the reduction factor RF_{IN} has been calculated in short-term flow measurements applying virgin samples.

3.2 *Long-term influence of compression behaviour on water flow*

The different types of geospacers can be described by their compression behaviour and their failure mode. Geospacers with a low compression resistance tend to have a continuous load-compression curve. The decrease in flow capacity in time is somewhat higher compared with "incompressible" geospacers, but discontinuities in their long-term flow capacity haven't been observed so far.

Relatively stiff geospacers with a high compression resistance can undergo a rapid decrease in thickness, if their structure is susceptible for buckling or similar deformation modes. Such a rapid deformation can occur above critical load levels, but it can also occur at lower load levels in time.

4 CONCLUSIONS

It could be illustrated by direct measurements of the long-term flow capacity at rigid/rigid and rigid/flexible support conditions that the flow capacity of some drainage geocomposites will be reduced due to filter intrusion in the long-term much more, as it is taken into account by short-term tests respectively by reduction factors for filter intrusion determined in short-term tests only. It is advisable to carry out long-term tests to determine directly the influence of the support conditions on the flow capacity, apart from usual creep tests for determination of the residual thickness. Otherwise the real long-term flow capacity of some geocomposite drains can be overestimated.

Some drainage geocomposites tested show only a little decrease in flow capacity over a period of 8 years. Nevertheless the extrapolation of the flow data can be critical, when due to deformation modes like buckling such geocomposites can collapse. For geospacers with a discontinuous load-compression curve the allowable load-service life relation should be determined by stress-rupture tests.

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