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Influence of geotextile filters on the discharge capacity of geocomposite drainage materials in long term tests with soil contact

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ABSTRACT: It is well known that creep on drain cores has an important impact on discharge capacity over time. A previous study reported in 2004 has shown also that the stress-strain behaviour of the geotextile filter has a crucial impact on the short-term discharge capacity of geodrains. New investigations were started in order to study the impact of the filter creep on the long-term discharge capacity of different geodrains. Creep tests on composites and on the geotextile filters have been made for quantifying these effects. The tested samples with different soils have been filled under load with epoxy resin so that the deformations and the shape of the different sags could be analyzed.

1 INTRODUCTION AND STATE OF THE ART

The longterm behaviour of drainage composites must be well known in applications of high service life duration, especially landfills, e.g. landfill covers. In the past, the creep behaviour of the geospacer between the filter layers was thought to be the most important factor for the longterm discharge capacity. In former publications Müller-Rochholz et al. [2000] (Fig. 1) have shown a nomogram to determine longterm discharge capacity regarding creep.

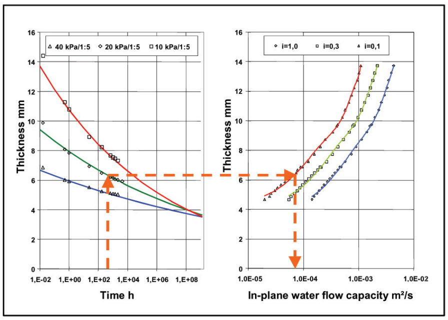


Figure 1. Longterm discharge capacity nomogram (creep tests with horizontal: vertical load 1:5).

The deformation of the filters seemed to be less important and was regarded by a "system factor" which was estimated as less than 2. Intensive work on creep of drainage materials and consequently testing of discharge capacity showed a significant influence of the boundary conditions in the discharge test EN ISO 12958 [1999] with soft and rigid platens. We have underestimated the influence of the deformation of the filter, as the standard tensile tests give misleading results as the preload disguises the deformation under 1% of load.

In a previous study Müller-Rochholz et al. [2004] have shown a clear correspondence between the stiffness of the filter and the discharge capacity under different loads. Higher stiffness or higher initial modulus of the geotextile filter results in higher retained discharge capacity. Out of the tested filters, 2 nonwoven products of similar weight but different stress-strain behaviour have been selected for testing the long-term behaviour (Fig. 2).

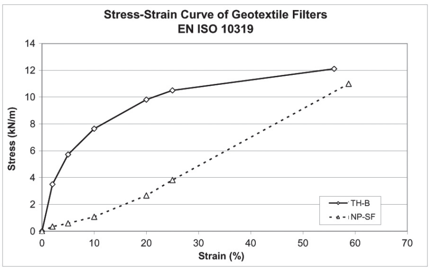


Figure 2. Stress-strain behaviour of geotextile filter.

For short term tensile tests on nonwovens this relation could be shown by Müller-Rochholz et al. [2004]. For a description of the longterm behaviour solutions were searched for. Only some old creep tests on nonwoven were available.

2 OBJECTIVE OF THE INVESTIGATION

The objective of the investigation was to quantify the influence of the soil pressure on the deformation of the filter and on the drainage capacity of the geodrain over time.

3 EXPERIMENTAL APPROACH

Drainage composites were put between rigid boxes 200 mm × 300 mm filled with 2 different soils (1: artificial clay known as Glyben, which is manufactured by mixing a sodium-bentonite clay and glycerine. This material simulates soft clay and gives excellent repeatability during testing. 2: fine sand, d_{max} = 1.2 mm). The system was then loaded for 28 days with a constant pressure of 40 kPa (Fig. 3 and Fig. 4).

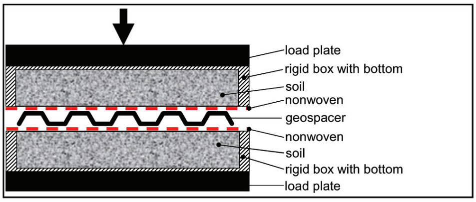


Figure 3. Sketch of creep test with soil.

Figure 4. Drainage composite between soil boxes.

After the creep time the complete loaded specimen (2 soil boxes + drainage composite) was transferred to the discharge measurement device where the discharge capacity at 40 kPa was measured.

As a reference value, the initial discharge capacity of the same drainage composites according to EN ISO 12958 [1999] with soft/soft structure was determined. After the discharge capacity measurements, the specimens and the boxes with soil were dried, loaded with 40 kPa and filled with epoxy resin (Fig. 5). The specimens were then cut and the cross sections were measured (Fig. 6 and Fig. 7).

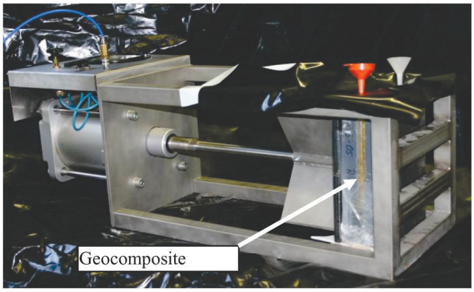


Figure 5. Filling the specimen and soil with epoxy resin.

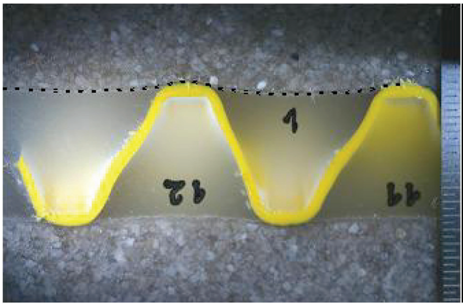


Figure 6. Cross section of specimen with TH-B, sag of the filter = dotted lines.

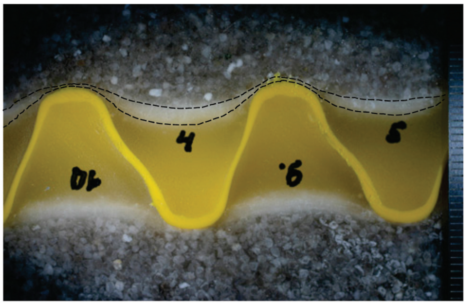
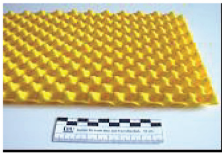


Figure 7. Cross section of specimen with NP-SF, sag of filter = dotted lines.

4 PRODUCTS

The products used in this investigation are:

2 drainage geospacers
Geospacer 1. A symmetrical thermoformed sheet of high density polyethylene (HDPE). The cuspa-ted studs are formed on both sides of the product, thickness at 2 kPa–16.3 mm (Fig. 8)



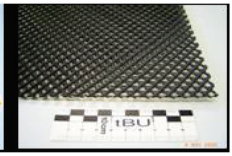


Figure 8. Cuspated core. Figure 9. Geonet.

Geospacer 2. HDPE extruded geonet, thickness at 2 kPa -4.9 mm (Fig. 9).

Geotextile filters

- TH-B: Polypropylene nonwoven, thermally bonded, continuous fibres, nominal 190 g/m^2 (Table 1).
- NP-SF: Polypropylene nonwoven, needle-punched, staple fibres, nominal 200 g/m^2 (Table 1).

Table 1. Properties of geotextile filters.

Property	Unit	TH-B	NP-SF
Mass per unit arearea	g/m^2	192	196
Thickness at 2 kPa	mm	0.59	2.82
Thickness at 200 kPa	mm	0.50	0.98
MD Tensile Strength	kN/m	13.1	8.0
CMD Tensile Strength	kN/m	11.2	18.5
MD Strength at 5%	kN/m	6.1	0.5
CMD Strength at 5%	kN/m	5.4	1.0
MD Elongation	%	53.0	68.7
CMD Elongation	%	57.8	44.1

5 RESULTS

5.1 *Discharge capacity tests*

The results are shown in Fig. 10 and Fig. 11.

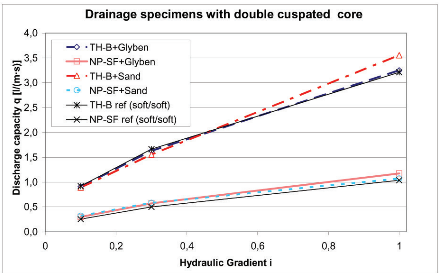


Figure 10. Discharge capacity with cuspated core.

The discharge capacity measured with sand contact consists of the water flow through the geocomposite and through the adjacent sand. With glyben, the water can only flow between and through the geofilters. **Cuspated core**. The water flow through the sand is extremely low compared to the flow through the geocomposite. (Factor sand/glyben up to 1.09 for all specimens and gradients, see Table 2).

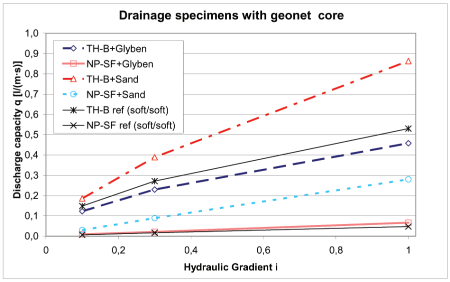


Figure 11. Discharge capacity with geonet.

Table 2. Relation of discharge capacity of geodrain between sand and between glyben (q_{sand}/q_{glyben}).

Hydraulic	Cuspated core		Geonet	
Gradient i	TH-B	NP-SF	TH-B	NP-SF
0.1	0.98	0.93	1.5	3.3
0.3	0.95	0.98	1.7	4.2
1.0	1.09	1.09	1.9	4.2

Geonet. In this case, the water flow through the sand compared to the whole discharge capacity is remarkably higher. (Factor sand/glyben for TH-B between 1.5 and 1.9 and for NP-SF between 3.3 and 4.2, see Table 2).

5.2 *Evaluation of visual deformations*

The results of sag in the middle between the studs and the tensile strain of geofilters with double cuspated core are indicated in Table 3.

Table 3. Deformation of the geofilters.

		TH-B		NP-SF	
		Sand	Glyben	Sand	Glyben
mean sag		0.7	1.6	2.8	2.8
max sag	mm	1.1	1.8	3.4	3.1
min sag		0.5	1.2	2.1	2.5
mean strain		0.5	1.8	5.2	5.1
max strain	%	1.1	2.2	7.2	6.1
min strain		0.2	1.2	3.2	4.4

Little or no sag of both geofilters was observed on the geonet (Fig. 12).

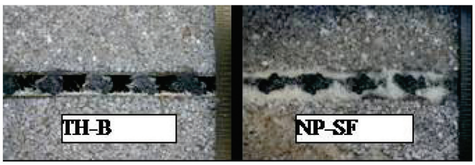


Figure 12. Cross sections of specimens with sand.

In this case the reduction in discharge capacity between the different geotextile filters is also due to the fleecy surface structure and the high compressibility of the thicker needlepunched structure (thickness: at 2 kPa – 2.82 mm, at 200 kPa – 0.98 mm). This effect reduces the flow cross section in the geonet and explains the reduced discharge capacity of NP-SF compared to TH-B by the factor of 13 at i = 0.1 and 7 at i = 1 (see Fig. 13).

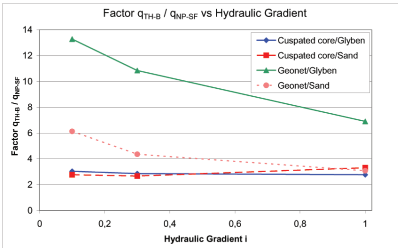


Figure 13. Relation between discharge capacity of geocomposite with thermally bonded filter TH-B and geocomposite with needle-punched filter NP-SF (q_{TH-B}/q_{NP-SF}).

6 ANALYTICAL APPROACH

To get a realistic assumption for the stress of the nonwovens between the peaks of the geospacer (drain core) a force-equilibrant form-finding – program EasyForm from technet GmbH was tested to estimate the tensile stresses in the nonwovens (Fig. 14) under real conditions. With a realistic load scheme, additional creep tests on nonwoven geotextiles can be started, in order to determine directly the real deformation of the filter stressed between the tops of the cuspations.

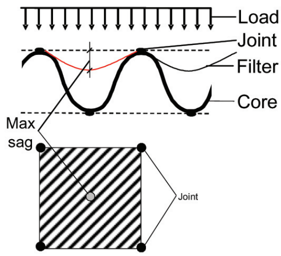


Figure 14. Sketch for the calculation of tensile strength in the filter.

Using a 2-dimensional calculation, a stress of ca. 8% for needle punched nonwoven NP-SF and 14% for a thermally bonded nonwoven TH-B was the result. Based on this calculated stresses, tensile creep tests on nonwovens were started. These tests without pre-load strain show deformations of ca. 32% for NP-SF and 4% for TH-B (Fig. 15).

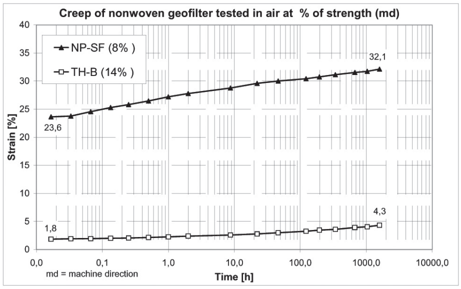


Figure 15. Creep of nonwoven filters.

The creep curves show a huge initial deformation difference (1.8% for TH-B, 23.6% for NP-SF). The increase vs. time (66 d) is 2.5% for TH-B and 8.5% for NP-SF. These deformations reduce the discharge capacity differently.

7 CONCLUSIONS

- The discharge capacity tests using a soft/soft structure according to EN ISO 12958 [1999] very well simulates the real behaviour with soil contact (provided that no water flow through the adjacent soil occurs, Fig. 10, Glyben compared to reference soft/soft)
- In granular contact zones a parallel water flow “bypass” can be seen (the flow outside the filter is enlarged if the spacer has higher water flow resistance)
- Nonwoven filter with low initial modulus and fleecy surface decrease the flow by deformation and surface structure
- The creep deformation of the filter decreases the volume and discharge capacity. The deformations in a creep test vs. 66 days of NP-SF are about three times higher than TH-B.

REFERENCES

Müller-Rochholz, J., Heerten, G. and von Maubeuge, K. “Long-term performance of geosynthetic drainage systems with filter components.” 3. International Conference on Filters and Drainages in Geotechnical and Environmental Engineering, Warschau, 06/2000.

Müller-Rochholz, J., Recker, Ch., Bronstein, Z. and Diederich, R. “Influence of Geotextile Filters on the Discharge Capacity of Geocomposite Drainage Materials. “4th International Conference on Geofilters, Stellenbosch, South Africa, 10/ 2004.

EN ISO 12958, Determination of water flow capacity in their plane 1999.

Müller-Rochholz, J. Geokunststoffe im Erd- und Straßenbau, Werner Verlag, 2005.