enka®solutions

TECHNOTE

# GUIDELINES FOR DISCHARGE CAPACITY ASSESSMENT AND SPECIFICATION

## FOR APPROPRIATE LONG-TERM DESIGNS USING DRAINAGE GEOCOMPOSITES

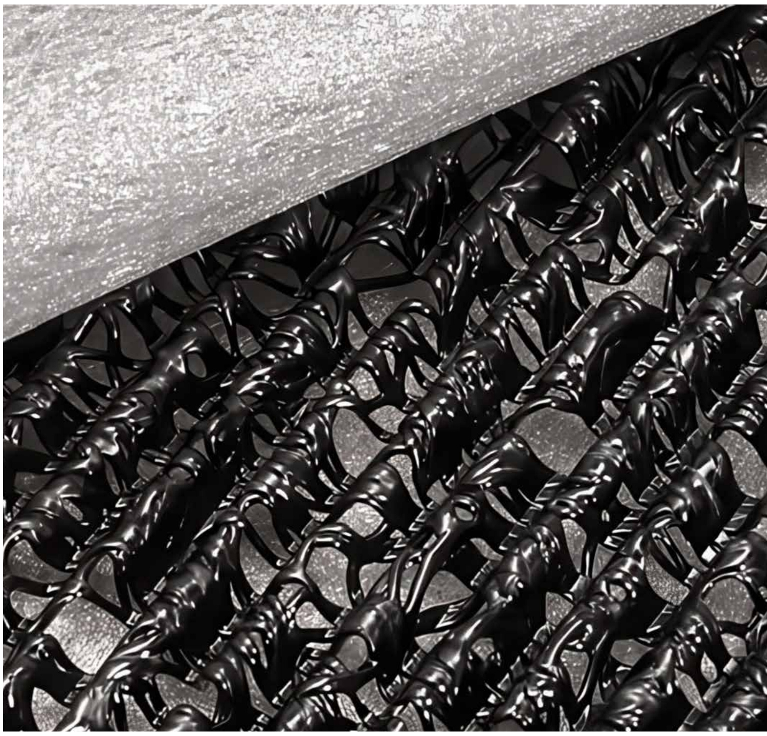
**Some stakeholders in projects using geosynthetics are not experts in the geosynthetics they only use from time to time and therefore do not perceive some design details that are important for the proper functionality of the structure.**

**In the case of drainage geocomposites, the end user has a very wide range of products on the market with very diversified technologies, especially concerning the drainage core. As their structures are sometimes not comparable, the designer has, first of all, to check that the proposed product is suitable for the application, taking into account the actual site conditions. For this purpose, he makes a design on the basis of the relevant performance of the product, i.e. performance measured under test conditions that are correct for the intended use.**

### In-plane flow capacity tests

Up to now, the in-plane flow capacity of a drainage geocomposite was measured according to the test standard EN ISO 12958. With the recent update of this standard, which now contains two parts, two tests can be carried out: an index test EN ISO 12958-1 for quality control and product comparison and a performance test EN ISO 12958-2 for the design and justification of drainage geocomposites for specific projects.

The EN ISO 12958-1 test is very similar to the previous EN ISO 12958 test in order not to change the in-plane water flow capacity values currently stated by the manufacturers. It is a very short term test (a few minutes) which measures an in-plane flow capacity between two standardized contact surfaces: a rigid plate or a foam layer. According to EN ISO 12958, a drainage geocomposite should be tested between two foam layers, except in the case where it is designed to be laid on a rigid surface, i.e. when the geocomposite consists of a drainage core and a filter fleece on one side only. In this case, the geocomposite has to be tested with a standard foam layer to simulate the soil in contact with the filter fleece and a rigid plate in contact with the drainage core. Since this clause is not properly applied on the market, it is no longer mentioned in the EN ISO 12958-1. This means that an in-plane flow capacity of a drainage geocomposite measured according to EN ISO 12958-1 can be obtained from a test carried out on specimens located either between two rigid plates (R/R), or between a rigid plate and a standard foam layer (R/F) or between two foam layers



Tightened V-shape profile of EnkaDrain Wide core

(F/F). It is therefore essential that manufacturers clearly mention the option considered on their technical data sheets and that users take it into account for quality control and product comparison.

The EN ISO 12958-2 test is a test with a much longer seating time than Part 1, it is agreed between the parties according to the purpose of the test. However, the standard mentions a usual seating time of 100 hours under the required stress before the measurement of the in-plane water flow capacity. The contact surfaces should be as close as possible to those of the project, a standard reference soil conforming to EN 196-1 is defined in Annex B to provide generic information on the flow capacity in the plane of a drainage geocomposite in contact with soil. The specimen under test can include the specific elements of a multi-layer sealing system.

FREUDENBERG
PERFORMANCE MATERIALS

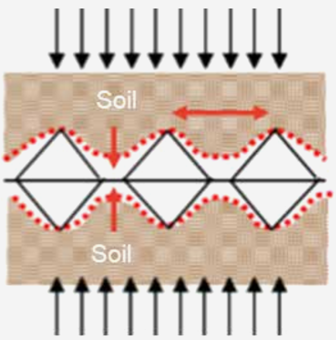
The test report shall include particularly the accurate description of the tested system with the specific soil properties. A performance value referring to this test standard should therefore be declared with, in addition to the hydraulic gradient and compressive stress, the seating time and the type of contact surfaces, Rigid/Soil (R/S) or Soil/Soil (S/S) and any specific information to enable the designer to properly use the stated performance. For products combining two parts with distinct in-plane flow directions, e.g. drainage composites with discrete draining elements, both parts shall be tested accordingly. Some geocomposites include an impermeable drainage core (e.g. symmetrical cuspated sheet) that does not allow the water collected on one side of the product to be drained over the entire section of the product. Performance test shall be carried out by plugging one of the both side of the drainage core, except for narrow strips when they are intended to be used with lateral water collection. Laboratories and manufacturers have to take care that there's no risk of confusion for the designer in both cases.

This performance test EN ISO 12958-2 will now provide the basis for the evaluation of long term in-plane water flow capacity of the drainage geocomposite.
Whatever the type of product considered, the EN ISO 12958-1 and EN ISO 12958-2 tests shall be carried out on the finished product.

### Boundary conditions

The drainage core structure, the filter fleece properties, the soil type and the compressive stress level are the main parameters which lead to more or less filter creep into the flow section of the drainage core, known as the intrusion phenomenon (Fig.1).

(fig. 1) Intrusion phenomenon of the filter fleece into the drainage core




Several studies were published, particularly Touze Foltz (2014) and Stoltz (2016) which compare this phenomenon on various drainage geocomposite structures and show the effect on their water flow capacity.

### Short term

The study presented by Touze Foltz (2014) provides the evolution over seven days of the performance ratio achieved for four geocomposite structures subjected to an in-plane water flow capacity test with the F/F boundary conditions under a compressive stress of 200 kPa, compared to the results obtained with more favorable test conditions using one or two rigid contact surface(s) R/R and R/F.
The drainage structure (geospacer) of the drainage geocomposites tested was as follows:

- Three-dimensional monofilament structure between two thermobonded non-woven filters with a seam in the central part of the specimen (EnkaDrain V-shape)
- Cuspated structure covered (not bonded) on both sides by a thermobonded non-woven filter
- Symmetrical thermoformed sheet covered (not bonded) on both sides by a thermobonded non-woven filter
- Geonet bonded on both sides to a thermobonded non-woven filter

Measurements of the flow rate were performed at 8, 15, 30, 60 minutes, 2, 6, 24 hours, 2, 3, 4 and 7 days.

Figure 2 shows that, for the tested geocomposites and testing conditions, the in-plane flow capacity measured after 8 minutes of seating time between two foam layers is in the range of 49% and 74% of the flow capacity measured between two rigid plates, and between 62% and 84% of the performance measured between a rigid plate and a foam layer. This graph shows how important it is to state the contact surfaces considered on the technical data sheets of drainage products.

(fig. 2) F/F performance ratio at seating time 8 min vs R/R & R/F performances

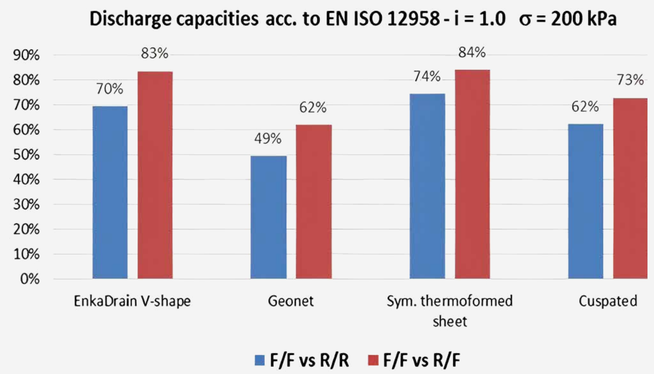
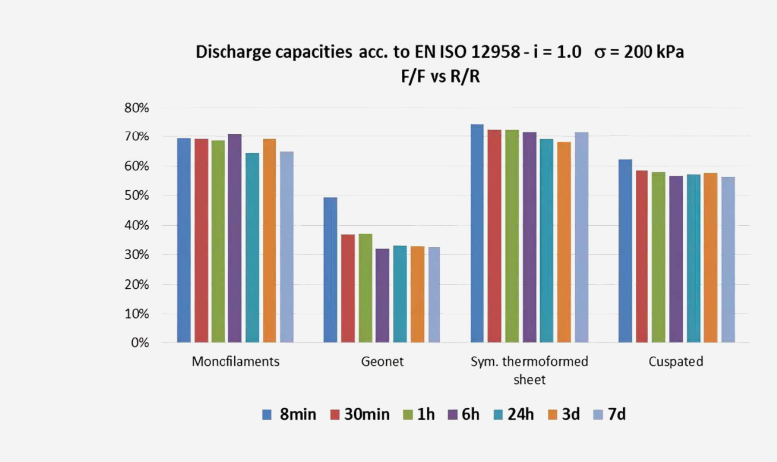



Figure 3 shows the ratio obtained from 8 min to 7 days seating time for the four specimens tested between two foam layers (F/F option) vs measurements between two rigid plates (R/R option). R/R values only account for a reduction due to the compressibility of the product, property which is measurable in creep testing EN ISO 25 619-1. F/F values include the effect of the compressibility of the geocomposite and the filter intrusion in the core.




(fig. 3) Tab. 1 - F/F performance ratio vs R/R at seating time from 8 min to 7 days

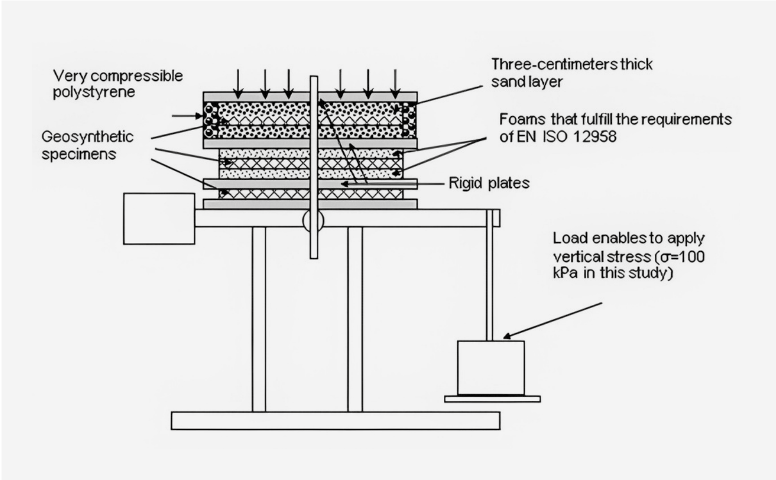
| Product families | EnkaDrain V-shape | Geonet | Symmetrical thermoformed sheet | Cuspated |
|---|---|---|---|---|
| 8 min | 70% | 49% | 74% | 62% |
| 30 min | 69% | 37% | 73% | 58% |
| 1 h | 69% | 37% | 73% | 58% |
| 6 h | 71% | 32% | 72% | 57% |
| 24 h | 64% | 33% | 69% | 57% |
| 3 days | 69% | 33% | 68% | 58% |
| 7 days | 65% | 32% | 72% | 56% |

The performance ratio between the in-plane flow capacity measured between two foam layers and that measured between two rigid plates is decreasing with time, more or less depending on the product. Table 1 gives the values of this performance ratio for the 4 products tested between 8 min and 7 days of seating time. The minimum performance ratio varies from 32% to 68%.

Therefore, in the case of application where the drainage geocomposite is used between two soil layers under an actual compressive load of 200 kPa, the designer could overestimate the actual discharge capacity by a factor 1/32% = 3 by using the thickness reduction only in a long term hydraulic design.

Stoltz (2016) considered a sand/sand configuration in addition to the Rigid/Rigid and Foam/Foam configurations (Fig.4). The sand is a mixing of three sands, that fulfills the opening size test requirements EN ISO 12956.

Fig. 4 - Compression creep test combining three contact surfaces (Rigid/Rigid ; Foam/Foam ; Sand/Sand)




The specimens are extracted from the compressive creep test device several times during the test duration to measure, under 100 kPa, their in plane water flow capacity in accordance with EN ISO 12 958 for hydraulic gradient i = 1 with Foam/Foam option for all specimens. Specimens are reinstalled in the compressive creep test apparatus after each water flow capacity measurement. Drainage core aperture size being a main parameter to define the sensitivity of a drainage core to fleece intrusion, three types of drainage structures with similar filter fleeces but various draining core aperture sizes were tested:

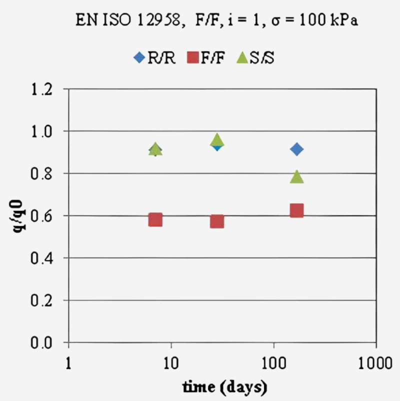
1. Uniform 3D monofilament structure, aperture size ~ 4 mm, with needle-punched geotextile 110 g/m$^2$
2. Geonet, aperture size ~ 10 mm, with needle-punched geotextile 120 g/m$^2$
3. Heterogeneous 3D monofilament structure max. aperture size ~ 20 mm with needle-punched geotextile 120 g/m$^2$.

1. 2. 3.

Figures 5, 6 and 7 give for each product the ratio q/q0 as a function of time up to 6 months, where q is the discharge capacity at the considered time, and q0 is the initial discharge capacity at t=0, both measured between two foam layers. Not all the geocomposites behave in the same way depending on the compressive creep contact materials.

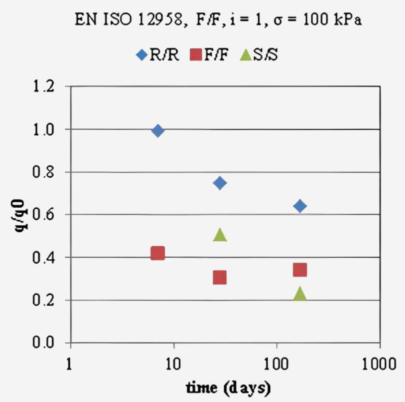
(fig. 5) Water flow capacity decrease of uniform 3D monofilament structure, aperture size ~ 4 mm. (EnkaDrain 5004F/5-2s/M110PP)

- Residual F/F water flow capacity due to compressive creep S/S (79%) higher than F/F (63%) and lower than R/R (91%).
- S/S values equal or close to R/R values mean the tightened Vshape profile allows arching effect in the soil and optimal discharge capacities.



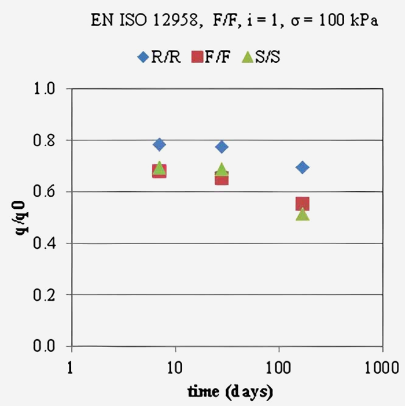

(fig. 6) Water flow capacity decrease of geonet, aperture size ~ 10 mm.

- Residual F/F water flow capacity due to compressive creep S/S (23%) lower than F/F (34%) and a lot lower than R/R (64%).




(fig. 7) Water flow capacity decrease of heterogeneous 3D monofilament structure, max. aperture size ~ 20 mm.

- Residual F/F water flow capacity due to compressive creep S/S (51%) close to F/F (55%) and lower than R/R (69%).




Of course, in all cases, compressive creep performed between two rigid plates leads to in-plane flow capacity performances more or less significantly higher than those measured after compressive creep performed between sand or foam layers. In the case of the uniform 3D monofilament structure, aperture size ~ 4 mm, residual F/F water flow capacity after compressive creep phase carried out between sand layers is higher than the one measured after compressive creep phase carried out between foam layers. Standard foam layers are in this case conservative boundary conditions for the assessment of long term performances.

## Long term

The evaluation of the long term in-plane flow capacity is currently carried out on the basis of the short-term water flow capacity test EN ISO 12958 combined with a compression creep test. Ideally, the compressive creep test should be carried out with the contact surfaces close to field conditions to allow the filter intrusion phenomenon to develop, if necessary over the long term.

However, the soil can be replaced by the natural rubber membrane of air pressure bags installed in a compressive creep test box for long term testing process as described by Böttcher (2006). Regarding the water flow capacity measurements, it is considered in this testing process that the best way to reproduce the residual thickness that is reached with the appropriate contact surfaces at a given time and load in the compressive creep test box is by applying the same load to the same specimen within few minutes after its withdrawal from the box. The water flow capacity being the final performance to assess in order to define the appropriate reduction factor for long-term designs, a direct extrapolation of water flow capacities values seems more justified and realistic.

FREUDENBERG
PERFORMANCE MATERIALS

Experts are of the opinion that the deformation of foam layer as used in EN ISO 12958 could amplify unrealistically the fleece intrusion phenomenon because an arching effect may sometimes take place in a soil layer. In the case of simulation of soft contact surfaces by membrane with air pressure as used in these compressive creep test boxes, the risk to get conservative values is existing as well because this potential arching effect is not taken into account.

EnkaSolutions compressive creep test boxes for long term (>10 years) tests, 20-400 kPa loads.

Another method consists of first carrying out a compressive creep test according to EN ISO 25619-1, i.e. with the specimen tested between two rigid plates. This test provides the thickness variation of the product over time. The long-term behaviour of the geocomposite is then defined by its residual thickness at the end of the service life extrapolated from this test, which does not allow the phenomenon of filter intrusion.

The corresponding residual in-plane flow capacity is currently measured according to EN ISO 12958 with the required contact surfaces (R/R, R/F or F/F) under the compressive stress read from the previously established stress/product thickness curve. In the case of compressible products, this procedure can lead to apply high stress during the in-plane water flow capacity test to reach, in a very short term, the residual thickness of the geocomposite at the end of the service life. Therefore, there is a risk of irrelevant results with regard to the long-term intrusion phenomenon: it may be overestimated on compressible products due to this very high compressive stress compared to the reality of the phenomenon in the long term under the actual service stress.

On the contrary, since the reduction in thickness of a collapsible product is usually smaller, the compressive stress applied during the in-plane flow capacity test to reach the residual thickness may not compensate for the actual long-term intrusion phenomenon (fig. 5, 6, 7) which is not taken into account by the EN ISO 25619-1 compressive creep test carried out between two rigid plates. In this case, intrusion phenomenon is considered only the time of the in-plane flow capacity test with a seating time of only a few minutes according to EN ISO 12958. However, the long-term variation of the free cross section area of a collapsible drainage geocomposite for the in-plane water flow is also linked to the intrusion of the filter.

The test according to the new EN ISO 12958-2 will improve, if carried out with the appropriate seating time, the taking into account of the intrusion phenomenon in the long term performance of the products.

### Tender text specifications

As a result of the replacement of EN ISO 12958 by the two tests EN ISO 12958-1 and EN ISO 12958-2, the specifications of the tender texts should now be based on EN ISO 12958-1 for quality control and on EN ISO 12958-2 for the technical justification of the product. On top of the design flow rate and the project geometry, the specifications for the in-plane flow capacity should therefore define the following parameters:

- The hydraulic gradient of the flow: usually, we consider a flow without water pressure above the drainage geocomposite, this water pressure could e.g. affect the stability of the overlying soil. The hydraulic gradient is therefore defined by the slope of the substrate only (ISO TR 18228-4 p20). Adding a water pressure in the soil above the drainage geocomposite is a way to increase the flow capacity in the plane of a product by increasing the hydraulic gradient of the flow, if applicable, this has to be justified.

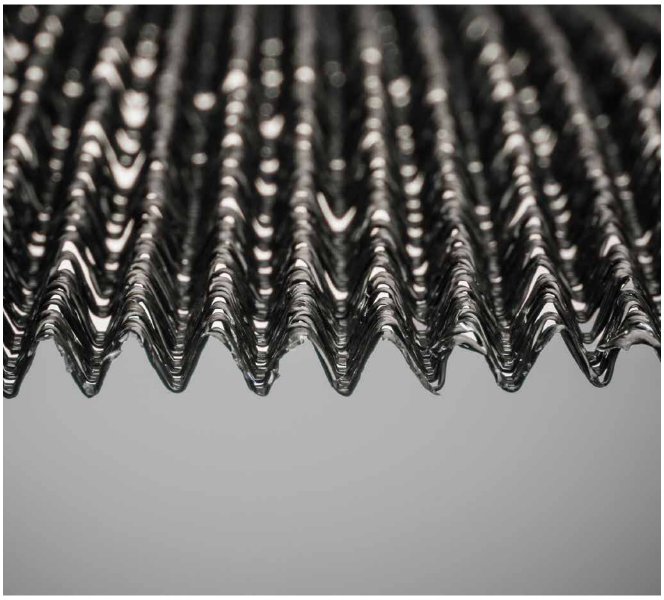
- The actual compressive stress to which the drainage geocomposite will actually be subjected: both, the product performance and the grade of the product to be used depend on the actual compressive stress. Overestimating the actual compressive stress can lead to the use of an inappropriate product in a product range and a product that is more expensive than needed. Specifying the correct compressive stress is a win-win solution for all parties involved.

- Contact surfaces/testing boundary conditions: when the product is laid on a HDPE geomembrane or a rigid support, performances measured between a foam layer and a rigid plate (R/F) should be specified according to EN ISO 12958 12958-1 for quality control, and performances between a rigid plate and a representative soil (R/S) should be specified according to EN ISO 12958 12958-2 for project specific design. Only leakage drainage between two HDPE geomembranes can justify a test between two rigid plates (R/R). Other interfaces, e.g. drainage geocomposite laid on soil or over a geosynthetic clay liner (GCL), should be tested with a foam layer in the EN ISO 12958-1 test and a soil layer or, ideally, the contact material itself in the EN ISO 12958 12958-2 test.

- The service lifetime of the structure: this is essential for assessment of the long long-term performance of the drainage geocomposite. National annex of EN 1997 1997-1 (Eurocode 7) can help to define the appropriate service lifetime of the structure.

## Conclusion

The only criterion of residual thickness at the end of the service life is not enough to define the long long-term behavior of a drainage geocomposite. The test according to the new EN ISO 12958 12958-2 will better take into account, if it is carried out with a sufficient seating time, the filter intrusion phenomenon and the actual decrease of the cross section of the water flow in the drainage geocomposite. On top of that, a project project-specific design of a geocomposite requires the correct and accurate description in the tender texts of the actual working conditions of the geocomposite. In that way, technically and financially optimal and safe solutions can be defined by contractors and manufacturers.



EnkaDrain Wide core consists of a unique V-shaped zigzag structure, making it optimally pressure resistant for even up to 120 years.

TN_ENG_guidelines long-term design_2751031_12/2024

China +86 519 6858 5555
France +33 1 74 90 00 13
Germany +49 6022 812020
Hungary +36 23 610 870
The Netherlands +31 85 744 1300
U.S.A. +1 828 665 5000



FREUDENBERG
PERFORMANCE MATERIALS