# FILTER CHARACTERISTICS OF SYNTHETIC FABRICS

By

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## 1. Introduction

In the recent two decades, economical and technological considerations as well as shortage in natural filter materials enhanced the importance of synthetic fabrics as filters for gravity soil drainage. These filters are expected to satisfy the specified requirements.

Water passing through the boundary surfaces of soil masses of different permeabilities undergoes a rapid change of the hydraulic gradient, and may apply flow pressure likely to scour fine-grained soil. Seepage may induce grain migration inside the soil masses, a phenomenon likely of obturating the drain. Suffosion and erosion due to seepage can be eliminated by constructing a filter layer.

In dimensioning filters for gravity drainage, two contradictory requirements have to be satisfied. On the one hand, the pores of the filter material must be small enough not to let pass the soil grains to be filtered out. This property of the filter is the mechanical filtering capacity. On the other hand, the filter pores should be large enough to transmit the seeping water in order to keep the hydraulic efficiency of the filter.

Tests on the filtering abilities of some nonwoven fabrics made in this country are discussed below. The chosen fabrics were to be built in as filter layers 8 to 12 m deep constructed by the slurry trench wall technology.

Brands and principal rated characteristics of the fabrics tested in the laboratory are shown in Table 1. The different fabrics were made by similar production technologies. Terfil-I is a fleece of isotropically arranged, cut polypropylene fibres stratified on a pneumatic production line to the desired weight per area ($g/m^2$) of controlled thickness. The material is pre-strengthened by passing through a quilter, then it is heat-treated on a calender with heated cylinders.

Polyamide fabrics F 601, F 601-pp and F-607 received a polypropylene fabric insert. The felt material was produced as above, but without heat treatment. The fabric F 610 had a reinforced polyamide backing of loop sewn malimo cloth.

Similar to heat treatment, the insertion in the nonwoven fabrics serves to increase their strength. The reinforcing insertions are irrelevant to measurement characteristics.

Kenderfonó és Szövőipari Vállalat (The Hemp Spinning and Weaving Industrial Enterprise) actually applies no cloth insertion in its fabrics.

Table 1

| Type | Producer | Production method | Material | Nominal thickness mm | Spec. mass g/m² |
|---|---|---|---|---|---|
| Terfil-I | Temaforg | Nonwoven, quilted, heat-treated | Polypropylene | 2–3 | 250 |
| F 601 | Szegedi Kenderfonó | Nonwoven, quilted insertion | Polyamide polypropylene | 5 | 500 |
| F 601-00 | Szegedi Kenderfonó | Nonwoven, quilted insertion | Polypropylene polypropylene | 5 | 500 |
| F 607 | Szegedi Kenderfonó | Nonwoven, quilted insertion | Polyamide polypropylene | 3 | 350 |
| F 610 | Szegedi Kenderfonó | Nonwoven, quilted 100p-sewn malimo insertion | Polyamide polyamide | 5 | 500 |

## 2. Laboratory tests and results

### 2.1 *Determination of fabric pore sizes*

Fabric-type materials have regular pores of fairly identical sizes — inherent in their production method. Pore size and distribution are determined by optical measurement with good results.

The examined nonwoven fabrics have a wider range of pore sizes than have woven fabrics. Because of the entangled, non-directional isotropic fibre arrangement, also the pores consist of entangled interlocked interstices and very small canals. Cross-sectional dimensions critical for soil grain filtration can be determined indirectly, e.g. by sieving materials of known grain size through the fabric.

In these experiments a vibro-mechanic water flush screening equipment was applied. The fabric was put between big-mesh screens (36 and 45 mm) irrelevant to permeability, soil of known grading poured over it, vibrated and water flushed till only pure water flowed through the fabric. Then the gradings of the soil passing through, and residual on the fabric were determined. For the tests two kinds of fine-grained soils were used, with grading compositions of 60% sand and 40% sand flour, and 60% sand and 40% sand flour + silt, respectively. Test results are plotted in Fig. 1.

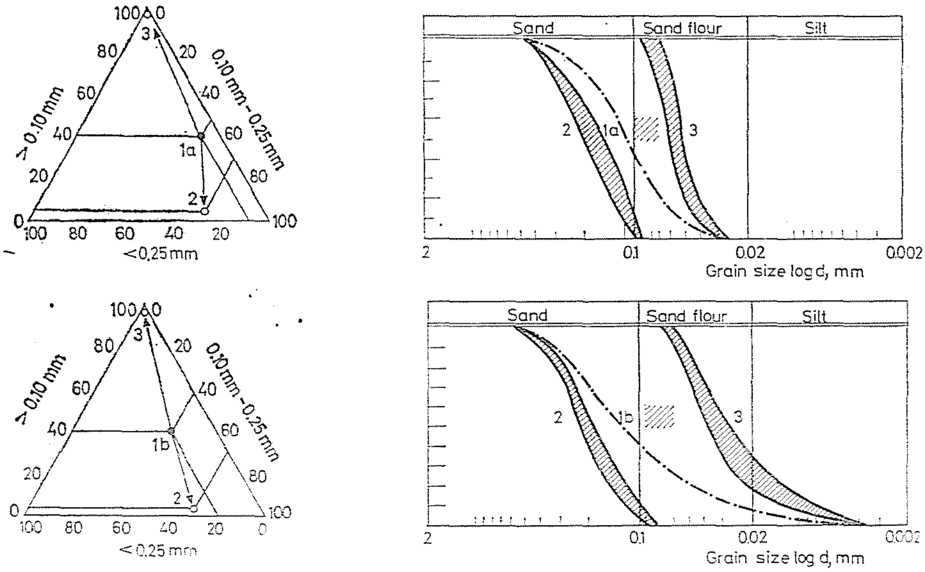


*Fig. 1.* Vibration-water flushing test results on fabrics. 1/a, 1/b. Grain size distribution curves of the original soil. 2. Range of grain size distribution of the fabric residue. 3. Range of grain size distribution curves of the passing material

The ranges of grain size distribution curves divided by the fabric — as a screen of given mesh size — show well the nominal mesh size of the fabrics or better the range of size distribution. Tests showed the void size of the fabrics to range from 0.06 to 0.10 mm. During the test an important quantity of soil grains of the nominal pore size got trapped within the fabric. The fabrics exert their filtering effect together with the trapped grains; they form together a spatial filtering system.

## 2.2 *Permeability of fabrics*

The surface of the soil-bedded fabric is acted upon by a load approximately proportional to the top layer. Under load the fabric is deformed, its thickness, mechanical and hydraulic characteristics change. Therefore first the compressibility of the fabric under load normal to its surface was tested. Superposing 4 to 6 layers of the fabric in an oedometer to make up a total thickness of about 20 mm, the deformation under load was measured. Up to a load of 100 kN/m$^2$, the thickness of the fabrics decreases section-wise ($\varepsilon = 40$ to 50%), further load causes a smaller decrease; the compression curve tends to a horizontal tangent (Fig. 2).

For the permeability tests an apparatus of constant water head has been constructed. The load was applied on the fabric by a loading device

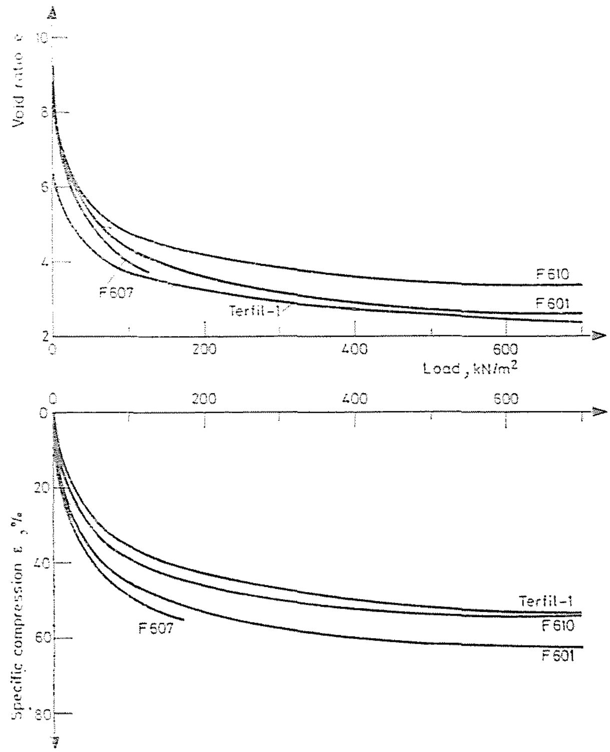


*Fig. 2.* Compression curves of fabrics

acting through a level gear. The load was distributed by a pure sifted gravel layer 50 mm deep (Photo 1). Permeability of the gravel layer was by two orders higher than that of the examined fabrics.

The permeability was determined by measuring the water quantity $Q$ seeping through the fabric during time $t$ at constant head. Permeability coefficient of the fabrics can only be approximated, namely their thickness cannot be defined exactly for hydrostatic calculations. Permeability coefficients of the tested five products did not differ substantially: $k = 2.8 \times 10^{-4}$ to $6 \times 10^{-4}$ m/sec.

In Fig. 3, permeabilities of fabrics Terfil-1 and F 601 vs. load are seen. The fabrics became compressed under load, the loose elementary fibres forming the nonwoven material got closer to each other, the size of the "voids" decreased. Increasing the load up to about 50 kN/m², the passing water quantity hence the permeability remained practically unchanged. Compression reduced the fabrics' permeability by about 40%. The decrease value did not impair the applicability of the fabric, the hydrostatic efficiency remained essentially inaffected.

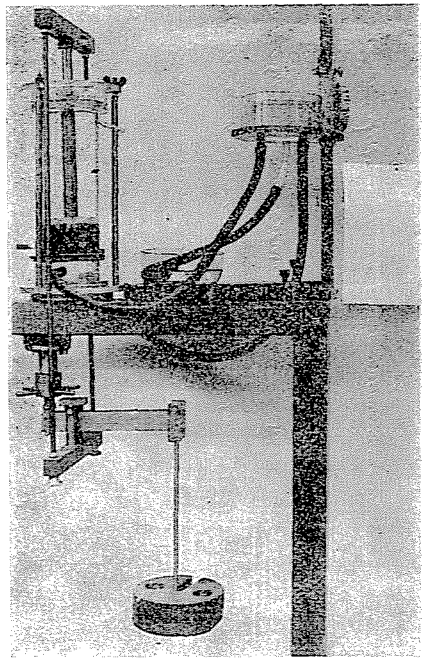

*Photo 1.* Constant head apparatus with the loading equipment

Subsequently, the impact of soil grains trapped in the material used as a filter on the permeability of the fabric was investigated. The same fabrics as used in the flush screening test for determining the void size were examined. The permeability test results have been plotted in Fig. 4. The range No. 1 contains inherent permeability characteristics of each fabric. Ranges No. 2 and 3 show flow-through characteristics of permeability for 60% sand and 40% sand flour and silt, respectively. The soil with a higher content in fines is seen to have more impaired the permeability, that is, more grains settled in the voids of the fabric. Again, the fabrics may be stated to have kept their hydrostatic efficiencies, water permeabilities, while acting as mechanical fibres.

Thereafter tests were made using soil samples taken from the area where it was planned to build in the fabrics. The samples were taken from the transition soil, among clays characteristic of the subsoil. The stratum waters of the area are seeping in these soils towards the valley. The catchwater drains to be constructed with these fabrics were expected to collect and drain the stratum waters.

The grain size distributions of the soil sample and of the sandy gravel material of the drain have been plotted in Fig. 5.

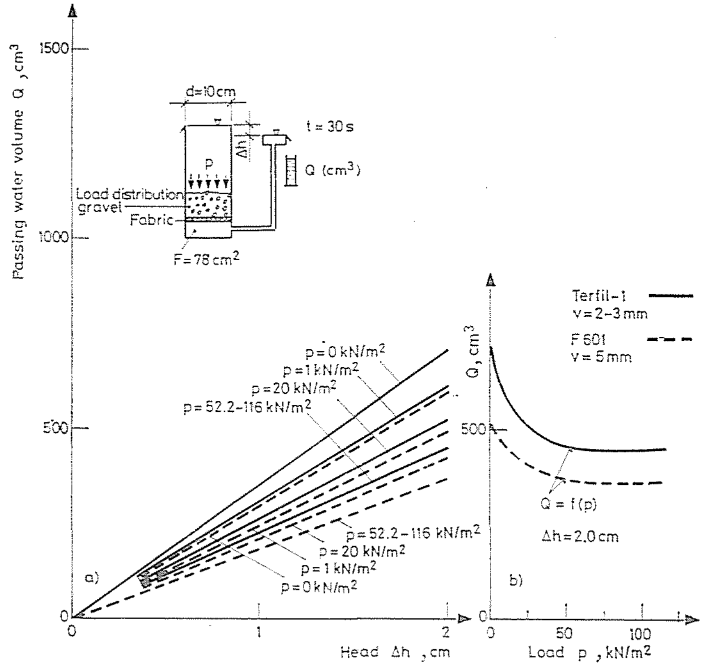


*Fig. 3.* Permeability change of fabrics vs. load

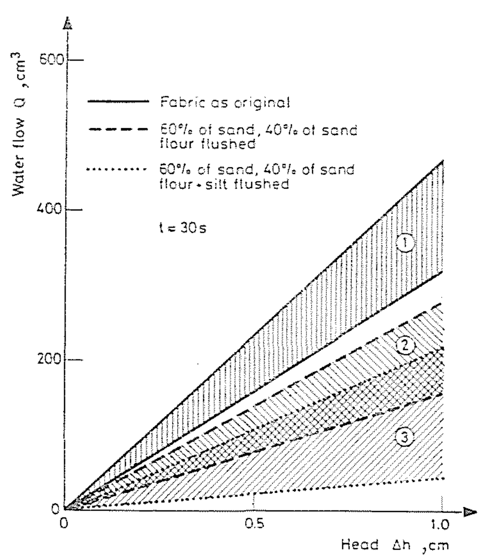


*Fig. 4.* Permeability change of fabrics due to the trapped soil grains

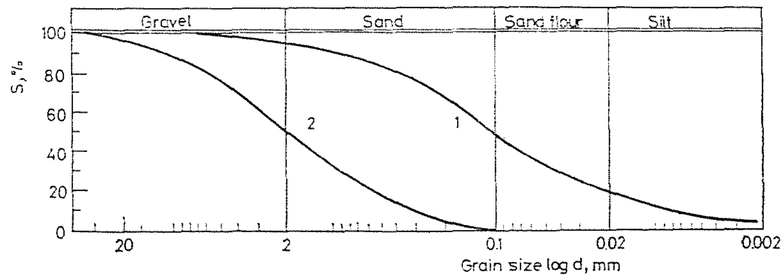


*Fig. 5.* 1. Grain size distribution of the soil sample taken from the site. 2. Grain size distribution of the catchwater drain material

The soil sample was spread over the fabric in a layer 8 cm thick. Response to seepage of this system was observed to see how the permeability of the fabric built in as filter layer changed in circumstances similar to those planned. Test results are shown by curve No. 1 in Fig. 6, with the water quantity $Q$ flowing through within 12 hours in ordinate, and the number of days of test repetitions in abscissa. After seven or eight repetitions, permeability of the system assumed a constant value $Q$, at approximately 50% of the initial permeability.

Permeability change of the system tested with the sandy gravel filter (curve No. 2) had a similar character at a lower specific permeability decrease. The soil grains displaced during seepage seem to have been better filtered by the fabric so that the fine grains piling on its surface enhanced the permeability loss.

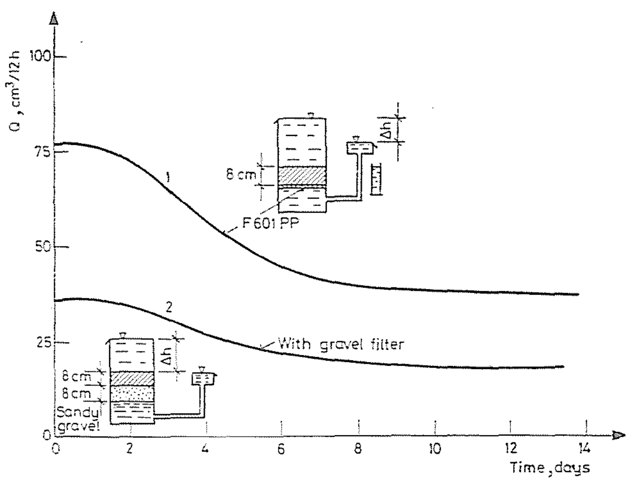


*Fig. 6.* Model test on soil taken from the site: 1. with fabric F 601; 2. with the drain material

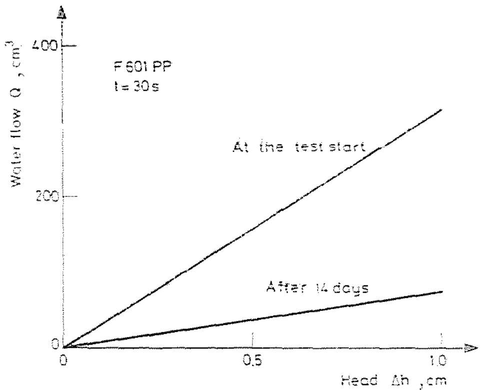


*Fig. 7.* Permeability change due to grains trapped in the fabric

The experiment ended by checking the permeability change of the built-in fabric due to the grains scoured during the seepage. Data characteristic of the permeability have been plotted in Fig. 6. Course of the change is in agreement with data in Fig. 3.

## 3. Conclusions

According to laboratory tests related to the construction of a drain, the nonwoven synthetic fabrics in Table 1 are characterized by the following:

- Nominal pore size of the fabrics determined under 2.1 ranges from 0.06 to 0.10 mm. The tested fabrics screen out completely any fraction over 0.1 mm.
- Compression of the fabric affects its permeability, causing a decrease by about 40%. Beyond a specific load of 50 kN/m² the permeability remains practically constant. This load limit corresponds to minimum 2.5 to 3.0 m of overburden.
- In seepage, the migrating soil grains intruding into the fabric reduce its permeability by one order at maximum. After the run-in period, the flushing effect settles, filter stability comes about. The fabric and the soil form together a spatial filter.

## Summary

Synthetic or geofabrics are increasingly applied for soil drainage. Conditions of economical application depend on several factors.

No filter rule vs. pore size can be given for the tested nonwoven fabrics else but after systematic tests and possibly, much of building experience. To then, incorporation of different fabrics has to be preceded by laboratory tests.

Conclusions drawn from tests and building observations made to now being positive, the use of synthetic fabrics for soil drainage works is promising, it is less labour consuming than the use of natural filter materials, and permits increased mechanization of building technologies.

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