# Behaviour of Non-woven Geotextiles for Drainage of Buildings

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ABSTRACT: The filter behaviour of nonwoven geotextiles was investigated. For this purpose three different geotextiles were combined with three selected problem soils. The results of the tests showed, that a line of stabilization occurs. This is faster in the case of thick, needle punched nonwoven geotextiles than in the case of thin, heat bonded nonwoven geotextiles. In all the tests the permeability normal to the plane (permittivity) decreased by approximately 50%. Comparable results were also obtained in the field tests.

## 1 INTRODUCTION

The permeability of a nonwoven geotextile is an important characteristic to be considered for its application for the drainage of buildings. The very fine soil particles, which penetrate into the geotextile via the inflowing water, lead to a decrease in the free area of the discharge section. The aim of the research work was to examine the behaviour of the formation of silt from soil fines (stability of the filter) for the geotextiles used for step filters, installed under problem soils depending on the permeability and the load duration. It had to be determined, as to whether the earth matter is taken up or whether it settles in the nonwoven geotextiles, and how the corresponding permeability changes. The permeability in relation to the installation time, as well as in relation to the soil penetration, was taken as a criterium, as shown in figure 1. It had to be established, as to whether, after a certain length of time, stabilization occurs - or whether the permeability continues to decrease, so that stabilization is doubtful. Furthermore, it had to be clarified, as to whether a possible stabilization occurs relatively quickly (weeks) or whether it takes place over a longer period of time (years).

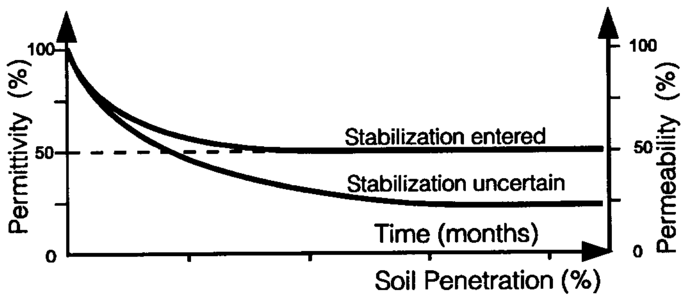


Figure 1 Decrease in the permeability in relation to soil penetration and time

## 2 PROBLEM SOILS

From a technical point of view with regard to filters, soils are described as being problem soils, when they contain considerable portions of silt and fine sand and only have slightly cohesive characteristics. It can then be assumed that there will be a high mobility of the single grains under flow pressure. According to the stipulations in the Swiss

Table 1 Soil properties of the test soils

| Proberty | Soil A | Soil B | Soil C |
|---|---|---|---|
| Curvature Index | 2,25 | 2,60 | 1,00 |
| Uniformity Coefficient $C_u$ | 4,0 | 5,4 | 10,0 |
| Plasticity Index $I_P$ (%) | 5 | 7 | 2 |
| Porosity n (%) | 0,404 | 0,404 | 0,404 |
| Portion of Clay (%) | 2,5 | 5,0 | 0 |
| Portion of Silt (%) | 80 | 68 | 55 |
| Coefficient of Permeability k (m/s) | $1{,}1 \cdot 10^{-7}$ | $8{,}0 \cdot 10^{-8}$ | $1{,}0 \cdot 10^{-6}$ |

Table 2 Filter properties of the test soils

| Criterium | | Parameters | | |
|---|---|---|---|---|
| | | Soil A | Soil B | Soil C |
| Particle diameter | $d_{10}$ | 0,01 mm | 0,004 mm | 0,013 mm |
| | $d_{50}$ | 0,035 mm | 0,03 mm | 0,05 mm |
| | $d_{60}$ | 0,04 mm | 0,04 mm | 0,07 mm |
| | $d_{90}$ | 0,08 mm | 0,18 mm | 1,3 mm |
| Silt grain d < 0,06 mm ⇓ and uniformity coefficient $U_c$ | | pesent ⇓ 4 < 15 ⇒*f* | present ⇓ 10 < 15 ⇒*f* | present ⇓ 5,4 < 15 ⇒*f* |
| Coarse clay + fine sand 0,02 mm < d < 0,125 mm | | 73% > 50% ⇒*f* | 54% > 50% ⇒*f* | 47% < 50% ⇒*nf* |
| Clay + coarse clay d < 0,06 mm | | 83% > 40% ⇒*f* | 73% > 40% ⇒*f* | 56% > 40% ⇒*f* |
| $\frac{\text{Clay content (d < 0,002)}}{\text{Coarse clay content (0,002 < d < 0,06)}}$ | | 0,038 < 0,5 ⇒*f* | 0,074 < 0,5 ⇒*f* | 0 < 0,5 ⇒*f* |

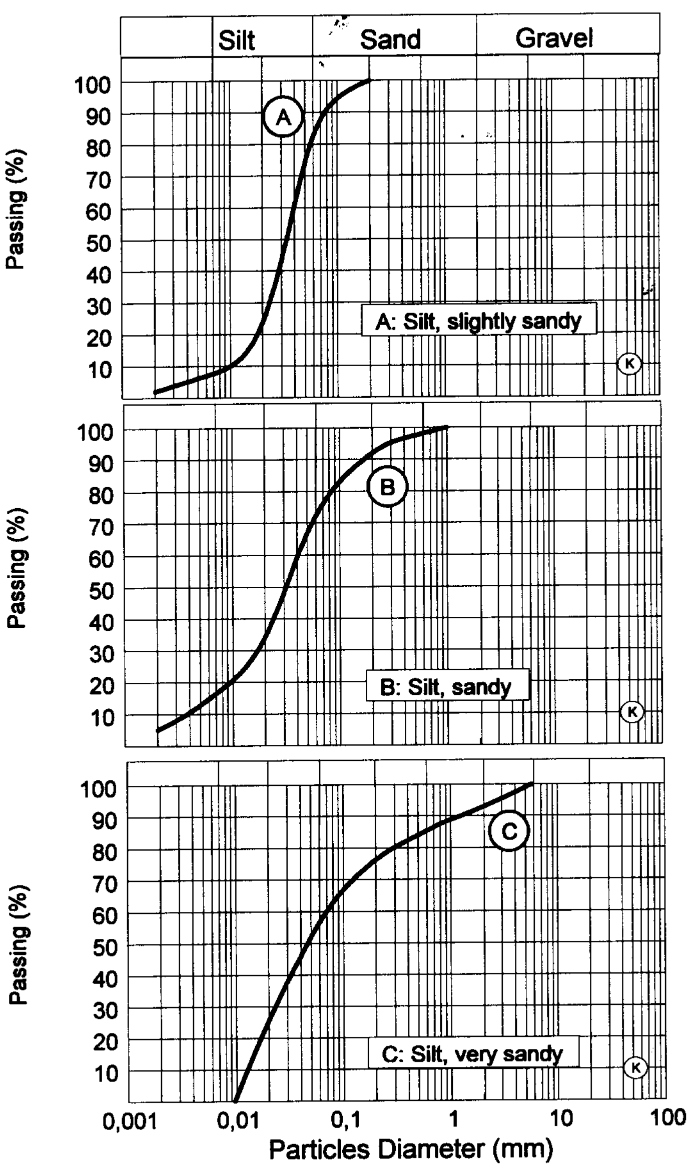


Figure 2 Gradation curves of the test soils

standard specification for filter materials (SN 670125 a) three types of soil (figure 2) were selected from the range of soils causing filter technical problems. The properties of these soils are given in table 1, their filter properties are listed in table 2 (criterium fulfilled = *f*, not fulfilled = *nf*).

## 3 NONWOVEN GEOTEXTILES FOR FILTERING

For testing purposes two thermically compacted nonwoven geotextiles (X,Y) and one mechanically needle punched nonwoven geotextile (Z) were investigated. The properties of these geotextiles are listed in table 3.

Table 3 Properties of the investigated geotextiles

| Nonwoven Geotextiles | X | Y | Z |
|---|---|---|---|
| Fibre | polypropylen | 70% polypropylen 30% polyethylen | polyester |
| Bonding | heat bonding | heat bonding | needled |
| Mass per unit area $\mu$ | 115 $g/m^2$ | 140 $g/m^2$ | 310 $g/m^2$ |
| Thickness t | 0,4 mm | 0,7 mm | 3,52 mm |
| Coefficient of permeability k | $2{,}3 \cdot 10^{-4}$ m/s | $1{,}67 \cdot 10^{-3}$ m/s | $7{,}5 \cdot 10^{-3}$ m/s |
| Opening size $O_n$ | 0,13 mm | 0,13 mm | 0,11 mm |
| Filter length $m = t/O_n$ | 3,0 | 5,5 | 32 |

The most important properties for the application of nonwoven geotextiles as filters is the filtration opening size $O_n$, which must be suited to the soil in question. A further property is the filter length as a ratio between the thickness and the filtration opening size.

The properties of nonwoven geotextiles vary greatly according to the method of fabrication. Thus there are considerable differences in the mass per unit area (figure 3) as well as in the thickness t (table 4), which should be taken into consideration in hydraulic calculations.

Table 4 Thickness t of the nonwoven geotextiles (n = 36)

| Nonwoven Geotextiles | Thickness (mm) | | | | |
|---|---|---|---|---|---|
| | $t_0$ | $t_{min}$ | $t_{max}$ | $t_{mean}$ | $\pm\sigma$ |
| X | 0,40 | 0,42 | 0,60 | 0,49 | 0,050 |
| Y | 0,70 | 0,88 | 1,24 | 1,04 | 0,120 |
| Z | 3,52 | 3,49 | 3,96 | 3,73 | 0,124 |

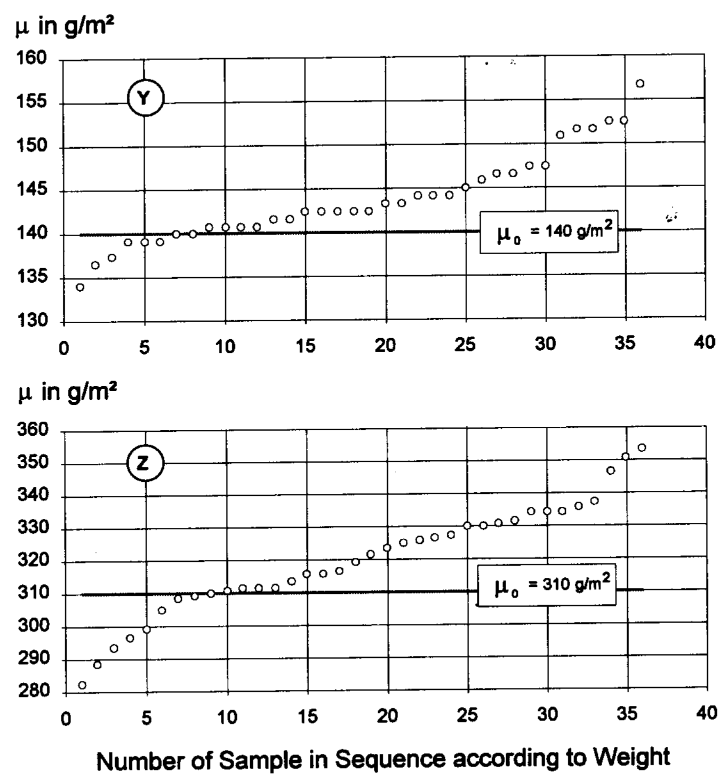


Figure 3 Differences in the mass per unit area μ (g/m²)

## 4 TEST PROCEDURE

In the test tanks (figure 4), the soils (A,B,C) were placed on top of the geotextiles (X,Y,Z). The rain test was carried out by sprinkling 3,5 l/(h·m²), which corresponds to approximately 30% of the infiltration rate for clay soil. The sprinkling was simulated for 1 week up to 520 weeks, which corresponds to up to a 10 year load.

After extracting the nonwoven geotextiles, the mass per unit area was ascertained as well as the permeability via the coefficient k of the permeability and the corresponding permittivity ($\psi = k/t$). The permeability, expressed by the permittivity, and the mass per unit area after soil penetration depend on the initial condition of the samples investigated. As soil penetration increased, the permittivity of all the samples examined decreased down to a certain limit. However, it had to be taken into account, that the permittivity of the zero sample (new and unused) already fluctuated within wide limits.

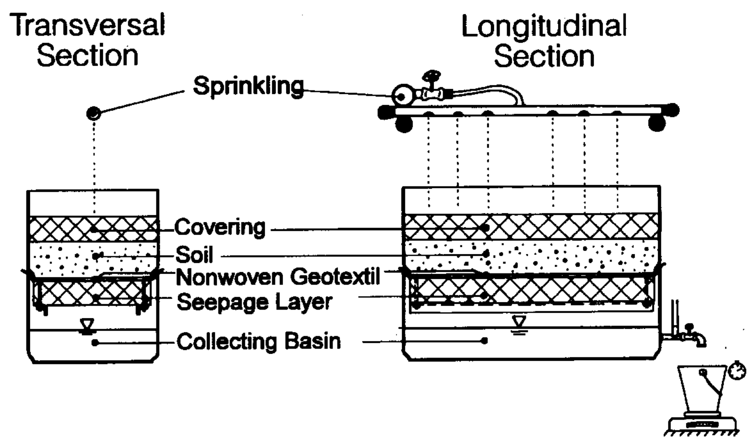


Figure 4 Model of the test tanks

## 5 RESULTS

The permeability, expressed by the permittivity, and the mass per unit area after soil penetration depend on the initial condition of the samples investigated. As soil penetration increased, the permittivity of all the samples examined decreased down to a certain limit. However, it had to be taken into account, that the permittivity of the zero sample (figure 5) already fluctuated within wide limits.

The lower limit of the permittivity was independent of the nonwoven geotextile and the soil used. Based on the lowest permittivity of the zero sample, the decrease amounted to between 50% and 65% in the thermally compacted nonwoven geotextiles and to 25% in the mechanically bonded ones.

This relative decrease should be compared with the absolute decrease, which in each case reached a limit of 1,0 $s^{-1}$. The results are given in table 5.

In all tests a straight line of stability occured; the load time amounted to between 4 weeks and 12 weeks, which corresponds to a surface rain fall of 60 mm (l/m²) up to 180 mm.

Table 5 Permittivity of Nonwoven Geotextiles before and after test implementation

| Non-woven | Permittivity ($s^{-1}$) | | | |
|---|---|---|---|---|
| | before test implementation | | | |
| | max $\Psi_0$ | min $\Psi_0$ | $\Delta\Psi_0$ | $\Delta\Psi_0$ (%) |
| X | 2,75 (2,72) | 1,50 (1,64) | 1,25 (1,08) | 45,5 (39,7) |
| Y | 3,00 (2,86) | 2,00 (2,04) | 1,00 (0,82) | 33,3 (28,7) |
| Z | 2,00 (1,95) | 1,50 (1,53) | 0,50 (0,42) | 25,0 (21,6) |
| | after test implementation | | | |
| | $\Psi_E$ ($s^{-1}$) | | max $\Delta\Psi_E$ (%) | min $\Delta\Psi_E$ (%) |
| X | 1,00<br>1,25 | | 63,6<br>54,5 | 33,3<br>16,6 |
| Y | 1,00 | | 66,6 | 50,0 |
| Z | 1,25 | | 25,0 | 0 |

The permittivity of the geotextiles covered with soil is mainly in the same range as that of the zero samples. Figure 5 illustrates this by showing the results of the tests with geotextiles Y and Z under soil B.

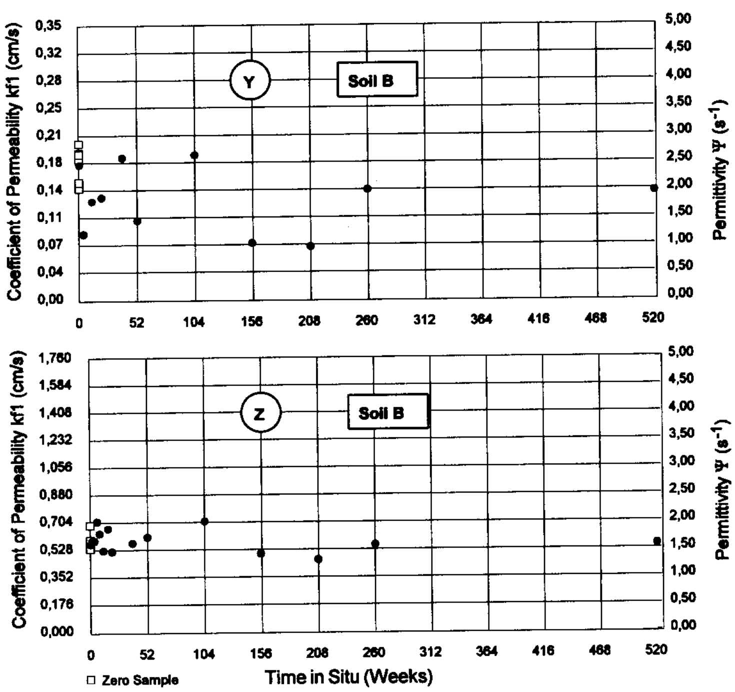


Figure 5 Permittivity of Nonwoven Geotextiles depending on time

The in situ tests (Muth 1993) over a period of up to 10 years showed the same results. The decrease in the permeability of the nonwoven geotextile was also about 50% here.

The results of the tests can be generalised under the condition:

$$k_{\text{nonwoven geotextile+soil}} \geq 0{,}5 \cdot k_{\text{nonwoven geotextiles}}$$

When constructing a natural area filter applies:

$$k_{\text{nonwoven geotextile}} \geq 10 \cdot k_{\text{soil}}$$

Thus, for the permeability of the nonwoven geotextile in relation to the permeability of the soil the following results:

$$k_{\text{nonwoven geotextile}} \geq 2 \cdot k_{\text{nonwoven geotextile+soil}} \geq 10 \cdot k_{\text{soil}}$$

Then the permittivity could also become greater; from the tests a limit of 50% can be given. The applied experimental set-up is also suitable for testing nonwoven geotextiles.

In addition, the tests have shown that it is sufficient to examine an adequate number of zero samples of the geotextile to be investigated, in order to be able to assess its behaviour under soil contact.

## REFERENCES


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## ACKNOWLEDGEMENT


This research was supported by the Ministry of Civil Engineering and Construction Works of the Federal Republic of Germany. Funds were made available for constructing the test equipment as well as for carrying out the tests.