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THE SEPARATION FUNCTION OF GEOTEXTILES

UNTERSUCHUNG DER TRENNWIRKUNG ALS KERNFUNKTION VON GEOTEXTILIEN UND DEREN KRITERIEN

LE ROLE FONDAMENTAL DE SEPARATEUR DES GEOTEXTILES ET SES CRITERES

Summary

A specially developed test rig was used to study the effects of dynamic loading on a two-layer system (two different soils). This two-layer system as well as four three-layer systems containing different geotextiles were subjected to dynamic loading. In order to simulate practical conditions as closely as possible the load was applied by two adjustable wheels moving on a circular track over the soil specimens. After a given number of load cycles the changes in the two- and three-layer systems were evaluated. The results obtained with the four types of geotextiles were compared with each other as well as with those obtained for the layer system without geotextiles. The results also suggest optimum geotextile properties.

1. Introduction

The effectiveness of geotextiles in civil engineering is generally accepted by experts. Thanks to their undeniable success in practical applications geotextiles have gained a rightful place in soil mechanics and have been used in civil engineering for more than 30 years, primarily as an auxiliary material in combination with the soil conceived as a building material. Opinions differ, however, about the optimum characteristics of geotextiles. While some authors attach the greatest importance to tensile strength, others lay stress on a high degree of flexibility in order to prevent damage to the geotextile. In principle, geotextiles fulfil a variety of functions at the same time.

2. Soil layer separation

In order to study this function Chemie Linz AG have developed a test rig which simulates, in particular, the stresses and strains occurring in roads. In this way valuable information can be obtained with regard to dynamic stresses and the load bearing capacity of geotextiles.

3. Test set-up

As shown in Fig. 1, the test rig is a rotary apparatus with two adjustable wheels driven by a geared motor via bevel wheels (cyclical loading test). They move on a circular track, the diameter of which may be varied down to a minimum of 60 cm. The maximum load per wheel is 2.0 kN, the maximum inflation pressure is 3.0 bars. The speed of the wheels may be varied between 8 and 25 rpm. The section to which the dynamic load is to be applied rests on a watertight tank receiving the soil specimens to be tested. The entire test rig is permanently mounted and vertically adjustable (variable H_1). Uniformity of the perpendicular load over the entire track is achieved by vertical adjustment of the wheels.

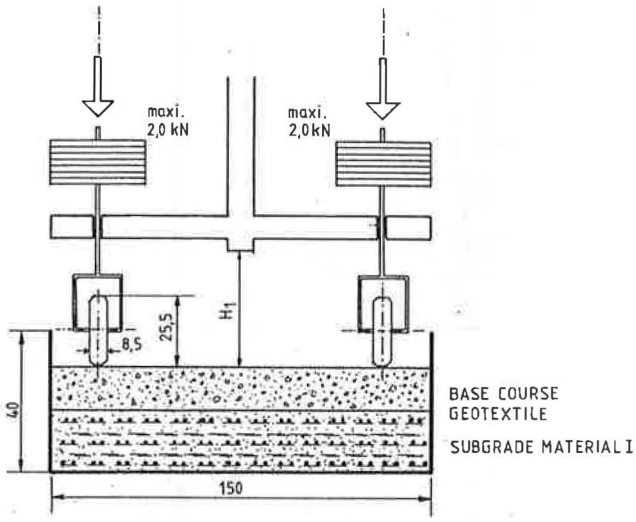


Fig. 1 Rotary apparatus

3.1 Test materials

3.1.1 Soils

Fig. 2 shows the grading curves of the soils tested. In order to obtain useful results, comprehensive preliminary trials had to be undertaken to find the most suitable soils.

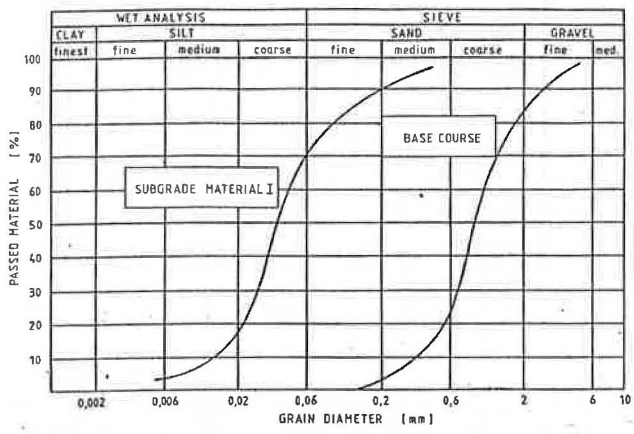


Fig. 2 Grading curves soils

It is essential that the test soils used should be frequently found in practice. Special attention was paid to the subgrade material I, which showed a CBR of less then 1.0 %.

3.1.2 Geotextiles

The four geotextiles studied are specified in Fig. 3.

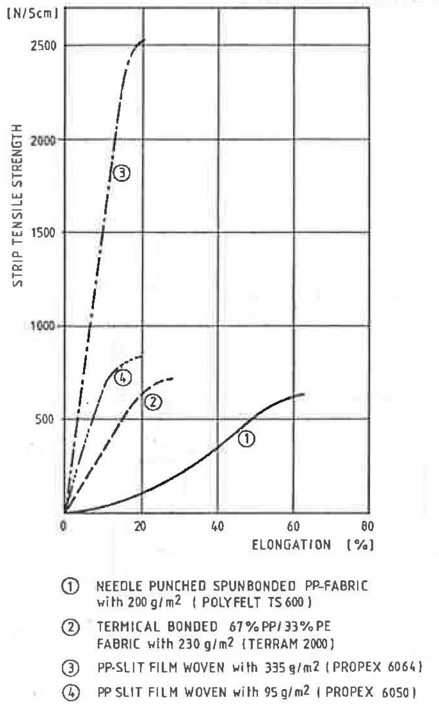


Fig. 3 Stress-strain behavior of the geotextiles

The four geotextiles studied were found to have the permittivities kn/d (s^{-1}) shown in Table 1. Gradient i amounted to 2, the load applied to the geotextile was 0.02 bar.

TYPE of GEOTEXTILE	Permittivity kn/d (s^{-1})
Product 1	1,20
Product 2	0,20
Product 3	0,15
Product 4	0,04

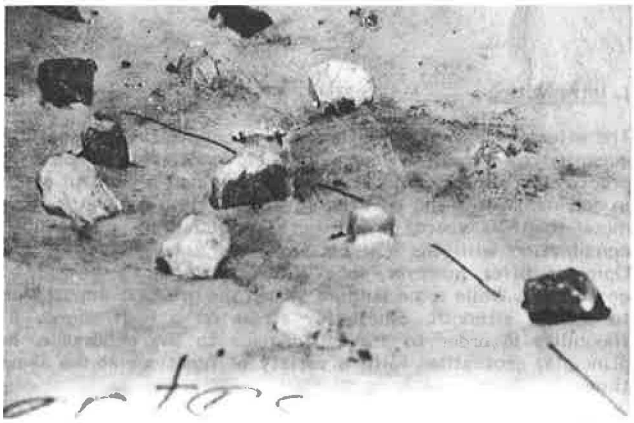
Tab. 1

The object was to determine the stress-strain charactistics of the three-layer system consisting of the base course, the geotextile and the subsoil. In order to simulate practical conditions as closely as possible, the dynamic impact rupture strength of the geotextile was studied by means of a "dropping pyramid" test. For this purpose a triangular pyramid weighting 1.5 kg was used, the angle between the lateral edges being 45°. The dropping test was performed directly on the geotextile placed on subgrade material I. At a height of fall of 40 cm the following results were obtained (Table 2).

TYPE of GEOTEXTILE	dropping pyramid 1,5kg hole diameter [mm]
Product 1	0
Product 2	30-40
Product 3	0
Product 4	5-15

Tab. 2 Drop test

The damaged products 2 and 4 were "crammed" with sharp-edged stones (photograph 1) in order to find out whether such damage has negative effects on the construction project and impairs the function of the geotextile. Products 1 and 3, which had not been damaged by the dropping test, were subjected to the "cyclical loading test" in intact condition. For reference, the base course/subsoil combination was in all cases tested under the same conditions. A comparison of the test results yields highly valuable information as to the relative properties of the materials tested, though it is always problematic to translate the results of small-scale tests directly into-building practice. There can be no doubt, however, that the trends observed are closely related to practical conditions.



Photograph 1 "Cram" of a geotextile

3.2 Test conditions

The layer thicknesses of the soils placed in the test rig are shown in Fig. 4.

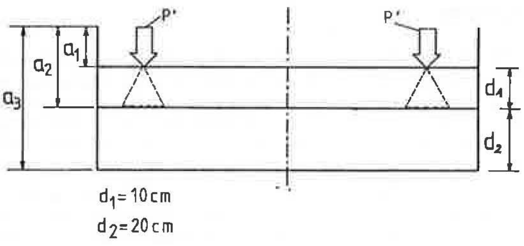


Fig. 4 Layer thickness of the soils

The individual soil layers were separated by the geotextiles under investigation. In all tests special attention was paid to the maintenance of uniform conditions as regards water content and compaction energy. Subgrade material I had a water content of w = 25.5 % and was placed in the tank withput compaction. The geotextile was placed on top and the base course material spread on it by hand and compacted for seven minutes with a lightweight (10.5 kg) tamper (three passages). Subsequently, the test specimen was subjected to the dynamic load test at a wheel speed of 10 rpm.
The inflation pressure was 2.1 bars, the absoulte load 0.66 kN per wheel. At a 10 cm thickness of the base course the average perpendicular load applied to the geotextile amounted to 2.2 N/cm². A lorry with a wheel load of 20 kN will impart an average perpendicular load of 4.0 - 5.0 kN/cm² on a geotextile covered with a 40 cm base course, which is approximately twice the load applied in our test. In order to achieve useful results load conditions have to be as carefully optimised as the soil materials selected.

4. Evaluation

The following parameters determined at a number of measuring points were evaluated after 23, 85, 110, 520 and 2 600 load cycles:

4.1 Particle-size distribution
4.2 Water content
4.3 Deformations (base course and geotextiles)

4.1 Particle-size distribution

The particle-size distribution in the base course was determined directly below the whell track after 2 600 load cycles. Fig. 5 shows the variations as a function of the geotextile used.

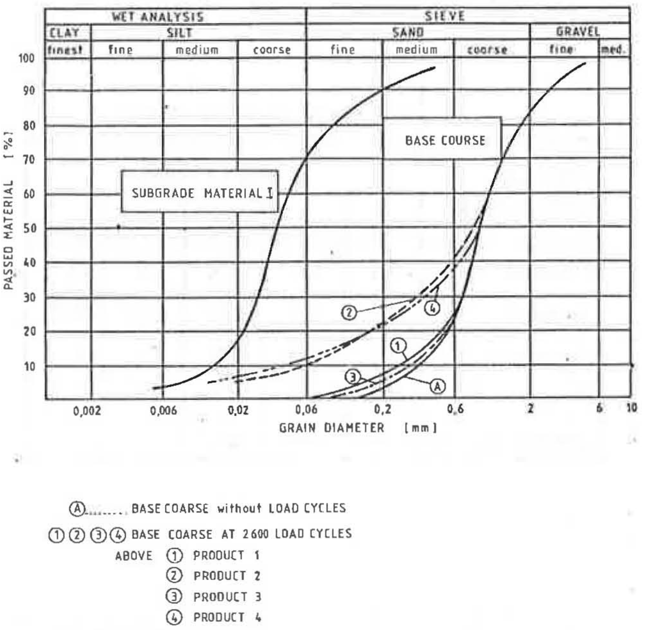


Fig. 5 Grading curve base course

In the tests without geotextiles a zone of base course/subsoil material I interpenetration of an average thickness of 2.5 - 5.0 cm was observed below the wheel track. The zone borders were visually determined and measured. These tests were discontinued after only 200 load cycles, when external changes (deformations) were found to be considerable.

4.2 Water content

The water contents of both subsoil material I and the base course were determined after the load cycles indicated above. The base course material was sampled from below the wheel track (layer d_1 in Fig. 8). The subsoil I specimen was sampled from the same location down to 5 cm below the geotextile. In tests without geotextiles the material samples were taken from outside the zone of interpenetration. Fig. 6 shows the increase of the water content in the base course.

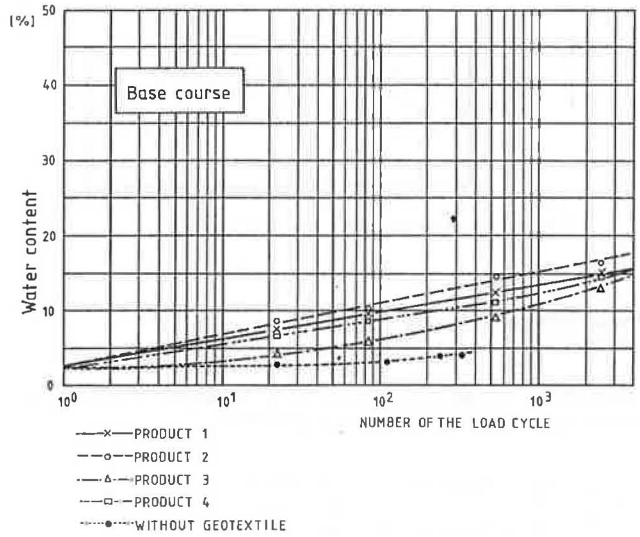


Fig. 6 Water content base course

Initially, products 1, 2 and 4 showed a more rapid increase in base course water content than product 3. After 85 load cycles the base course water content found in the test with products 1, 2 and 4 was twice as high as with product 3. Most significantly, the water content increased only slightly in the tests without geotextiles suggesting a very low level of drainage. This is confirmed by the change in subsoil water content as shown in Fig. 7.

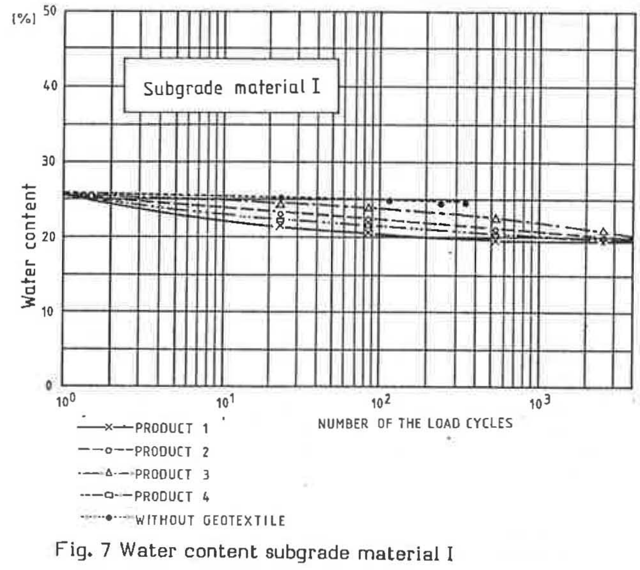


Fig. 7 Water content subgrade material I

Product 1 was found to show the best subsoil drainage properties. After only 85 load cycles the degree of drainage was already as high as it was after approximately 2 600 load cycles with product 3. Where no geotextile was used subsoil drainage was lowest.

4.3 Deformations

Along with water content changes, deformation (formation of wheel tracks) was recorded (Fig. 8).

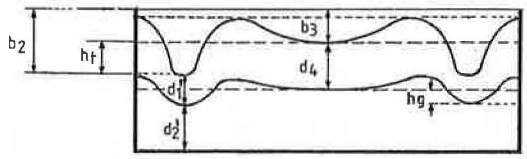


Fig. 8 Deformation after the load cycles

These findings were broken down as follows:
- deflection of geotextile and base course (h_g, h_t)

Deflection of the base course (Fig. 9) show no significant variations among the four geotextiles tested.

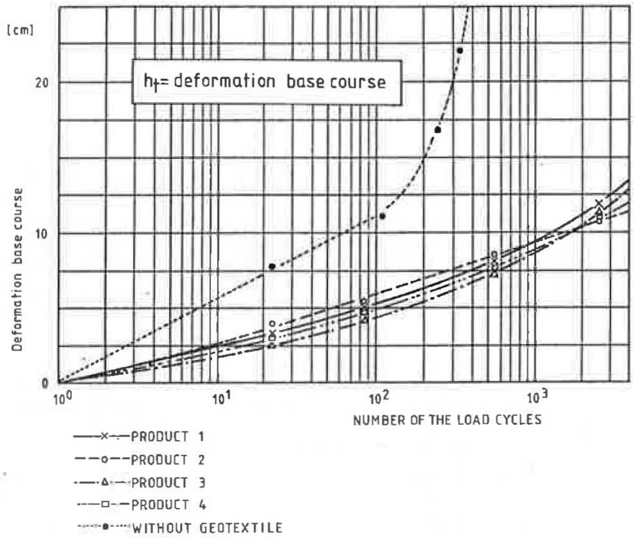


Fig. 9 Deflection base course

In the absence of geotextiles base course deformation was considerable. After 100 load cycles approximately twice as high as in the presence of geotextiles.
In the presence of geotextiles indentations after 2 600 load cycles were approximately as deep as they were after 100 load cycles in the absence of geotextiles. A 26-fold improvement due to the use of geotextiles.

The different geotextiles used did not vary significantly in terms of deflection (Fig. 10).

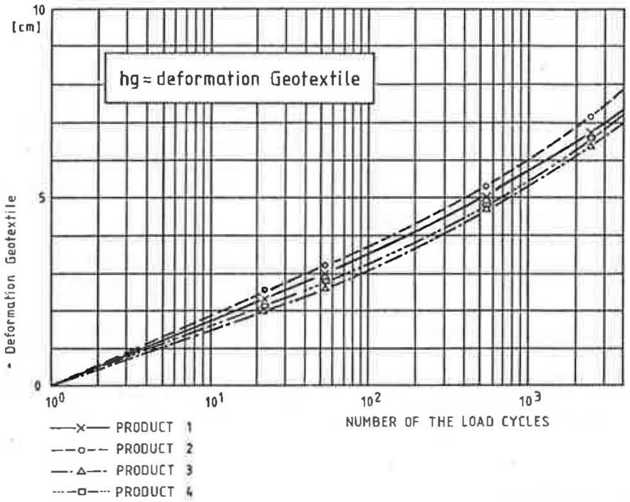


Fig. 10 Deflection geotextile

A general review of the deformations of the base course and the geotextile shows that the stress-strain properties of geotextiles have no significant influence upon the overall deformation behaviour of the structure. Neither did the differences in the initial moduli of the geotextiles result in significant differences in the initial deformation of the base course.

One important deformation parameter is the deflection (Table 3).

	Deformation base course				
TYPE of GEOTEXTILE	LOAD CYCLES				
	23	85	110	550	2600
Product 1	3,3	5,0	5,5	8,0	11,7
Product 2	4,0	5,5	6,0	8,5	10,7
Product 3	2,5	4,3	4,5	7,2	11,3
Product 4	2,7	4,5	5,0	7,7	11,5
without Geotex	7,8	10,7	11,0	-	-

Tab. 3

Table 3 shows the "deflection" as observed in our tests. Significant differences were observed only between the test with and those without geotextiles, not between the different geotextiles used.

The results can be summarised as follows (Table 4):

CRITERIA	PRODUCT				WITHOUT GEOTEXTILE
Separation (grading curve)	⊗	⊖	⊗	⊖	⊖
Filteration (grading curve)	⊗	⊖	⊗	⊖	⊖
Drainage (water content)	⊗	⊗	⦶	⊗	⊖
Deformation (rutting)	⊗	⊗	⊗	⊗	⊖

⊗ optimal property
⦶ suitable
⊖ less suitable

Tab. 4

5. Conclusion

The studies reveal the following tendencies:

- A geotextile used as separating layer may under certain subsoil and base course conditions reduce deformation upon dynamic loading.
- The initial modulus of a geotextile has no significant influence on base course deformation.
- If the geotextile is damaged during installation its separating and filtering performance under dynamic load is reduced. "Cramming" of the damaged geotextile was not found.
- The drainage capacity of mechanically bonded countinuous filament non-wovens is a multiple of that of the other products under investigation.