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PROPERTIES OF GEOTEXTILES DEPENDENT UPON MANUFACTURING PARAMETERS

MATERIAL- UND KONSTRUKTIONSABHÄNGIGE EIGENSCHAFTEN VON GEOTEXTILIEN

CARACTERISTIQUES DES GEOTEXTILES DEPENDANT DU MATERIEL ET DE LA CONSTRUCTION

The data sheets published in the Swiss Geotextile Manual, which are the object of this examination, have been compiled from identical tests. The aim of this paper is to give information on the one hand, to a manufacturer, as to how a product can be changed to achieve a certain property, or on the other hand, to show a user which properties a geotextile has and the standard reached today.

The properties of different non-woven textiles have been put side by side and with the help of a few examples it can be clearly shown what influence the material used or the construction has. This paper is however not complete, nor of lasting validity. Only a few of the geotextiles traded world wide have been included and they are improving continually.

INTRODUCTION

In the past, and sometimes today, geotextiles were only choosen by weight. That this is incorrect must be obvious to every specialist. In this paper some correlations between material/construction and the most important utility properties are shown. The weight often plays an important part when the same geotextile is considered in different weight classes, there are however vast differences between the various products.

The data used here were taken from the Geotextile Manual published about 1 year ago by the Swiss Association of Geotextile Specialists. In the Appendix of this manuel the data of the geotextiles commercially available in Switzerland can be found. All geotextiles have been tested under identical conditions.

This paper pursues two aims: Firstly it should give the manufacturer information on what to change at his geotile to obtain a certain property and secondly the user can see which properties are common to a certain geotextile and which properties are technically achievable today.

This examination handles only non-woven textiles. In this short paper it is impossible, unfortunately, to show all direct and indirect dependencies. Therefore only a few special exemples are shown.

Furthermore, it must be pointed out that the status involved is 1984. It is certainly possible with a concentrated effort to change single properties up to a certain point.

MATERIALS EXAMINED

60 non-woven textiles from 11 manufacturers were involved in the examination. A characterisation with some property ranges is shown in table 1:

	Number of samples	Mass g/m^2
Polyolefine continuous, thermically bonded	16	65...423
Polyolefine continuous, needled	11	121...437
Polyolefine staple, needled	3	200...344
Polyolefine staple, needled/thermically bonded	3	111...241
PES continuous, needled	21	122...572
PES staple, needled	2	190...245
PES staple, needled/chemically bonded	4	146...405
All together	60	65...572

In fig. 1 the ranges of individual properties of different non-woven textiles are shown.

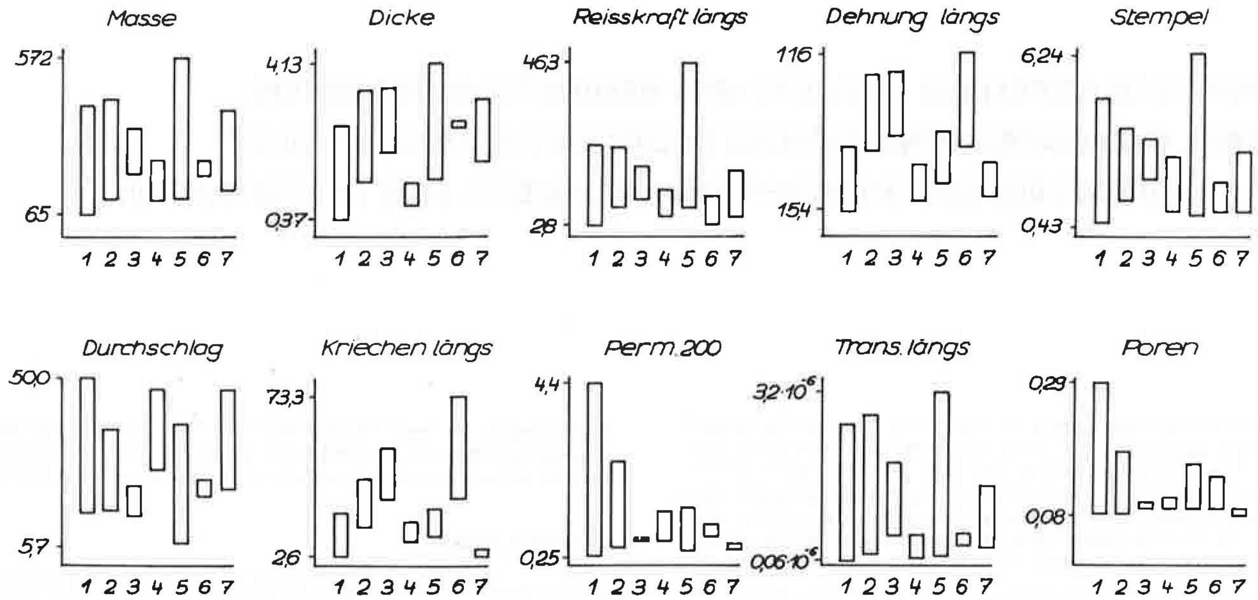

Fig. 1: Ranges covered by the 60 non-wovens (1 = polypropylene thermically bonded; 2 = polypropylene continuous fibres needled; 3 = polypropylene staple fibres needled; 4 = polypropylene staple fibres needled and thermically bonded; 5 = polyester continuous fibres needled; 6 = polyester staple fibres needled; 7 = polyester staple fibres needled and chemically bonded)

TEST METHODS

The tests have been carried out according to the standard (SN 640550), valid in Switzerland and described in the Geotextile Manual. Only the characteristic data shall be repeated hereafter:

Size : on large specimens
Thickness : at 2, 20, 200 kPa, 25 cm^2 area
Breaking strength/elongation: with templets, 10 cm wide, 20 cm long
Tearing strength : trapezoid method, small specimens (ASTM 1117-77)
Plungar Puncture resistance: 180 cm^2 - specimens; stamp 5 cm Ø
Resistance to penetration: 180 cm^2 - specimens; 1 kg cone from a heigh of 500 mm
Creep : with templet, 25 % of the breaking strength
Permittivity : multi-layer, load: 20, 200 kPa
Transmissivity : single layer, load: 20, 200 kPa
Pore opening : wet sieving (method Franzius)

RESULTS

1. General

When comparing the properties of the 7 materials the following can be said

- polypropylene continuous and thermically bonded behaves the same as polypropylene staple, chemically bonded, with the exception that with otherwise similar criterions, the thermically bonded polypropylene has a 1,5 fold higher tear strength.
- needled polypropylene made out of continuous fibres behaves the same as polypropylene with staple fibres.

  Exceptions for continuous fibres are:

  smaller cross strain
  somewhat smaller tendancy to creep
  tends to have smaller resistance to penetration

- a non-woven continuous fibre of needled polyester with the usual, similar construction and with stapel fibres, has the following characteristics.

  The continuous fibres show higher longitudinal breaking strength, puncture-strength and longitudinal tear strength: the creep of staple fibres is greater after 500 hours. On the otherside the residual creep measured between 1 and 500 hours, is about the same.

  In general the elongation at break is considerably smaller with continuous fibres.

- a comparison between the needled and the bonded non-woven textiles show the following picture for the needled ones.

  they are thicker and tend to have a higher strain
  they tend to have a higher transmissivity
  they tend to creep more.

  Otherwise all the properties are comparable.

2. Dependencies of mass, thickness, fibre fineness

The fineness of fibres in the non-woven textiles presented, lie between 15 and 53 microns, have an influence mainly on the elongation behaviour in the lower strength range: The finer the chosen fibres are the greater the elongation at 20 % of the breaking strength. At the upper range the dependency seems rather inverse, i.e. finer fibres give a lower elongation at break (see fig. 2). From this follows a principally different strength-elongation behaviour.

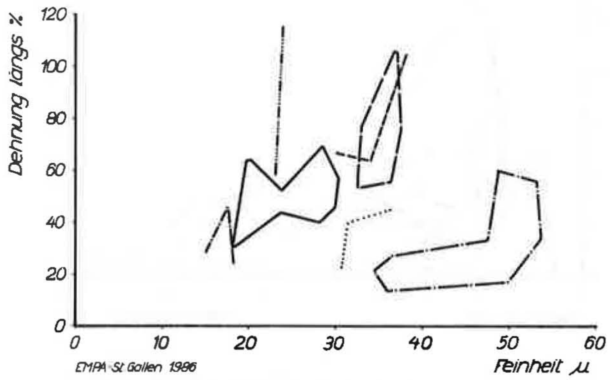

Fig. 2: Dependency of the longitudinal elongation on the fiber fineness (also valid for the following figures): This means

- polyolefine continuous thermically bonded
- polyolefine continuous needled
- polyolefine staple needled
- polyolefine staple needled/thermically bonded
- PES continuous needled
- PES staple needled
- PES staple needled/chemically bonded

Furthermore the creep tends to get smaller with increasing fibre thickness.

Because thickness and mass for each product category correlates relatively well, only the dependency of the mass is considered.

The puncture-strength replaces here the strength test. Its dependancy upon the mass per area unit is shown in fig. 3. The figure shows the following: 1) A clear correlation between these two properties. 2) The materials differ somewhat from each other. 3) The breaking strength can be kept in limits during the manufacture with the same manufacturing process.

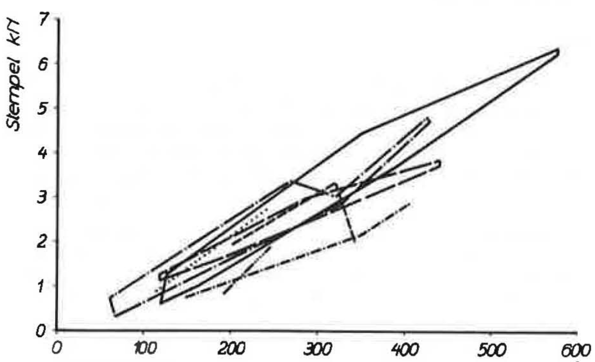

Fig. 3: puncture-strength dependent upon the mass. The individual non-woven types are shown in fig. 2

The creep is practically independent of the mass. Only the material and manufacturing process play a role here.

Whereas the permittivity decreases with increasing mass, the transmissivity increases distinctly with the mass and is largly independent of the material.

The pore width ist hardly influenced by the mass. In addition to the correlations this has been proved on different geotextiles by determining the pore width on 1 to 4 layers. The pore width did not decrease or only slightly. The pore width ist variable to a greater extent only on very light geotextiles. Over 150 g/m^2 the pore widths are between 0.09 and 0.15 mm.

3. Mechanical properties

These are, due to natural circumstances, strongly dependant on each other. The correlation coefficients, of the different materials, between the breaking strength longitudinal, puncture strength and resistance to penetration are about 0.9 and higher. A typical picture is shown in fig. 4. No great difference between the individual materials is visible here.

When the elongation and the creep behaviour are examined one observes that the creep tends to increase parallel to the elongation at break (fig. 5). On the other hand the residual creep behaviour (= difference between creep after 500 hours and 1 hour) might be much more important. In this respect the different materials show a completely different behaviour (fig. 6).

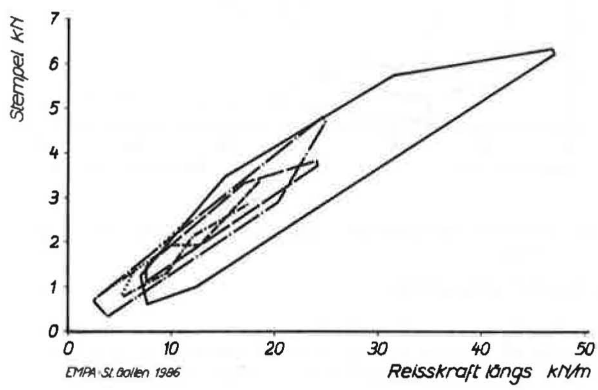

Fig. 4: Correlation between the puncture strength and the breaking strength.

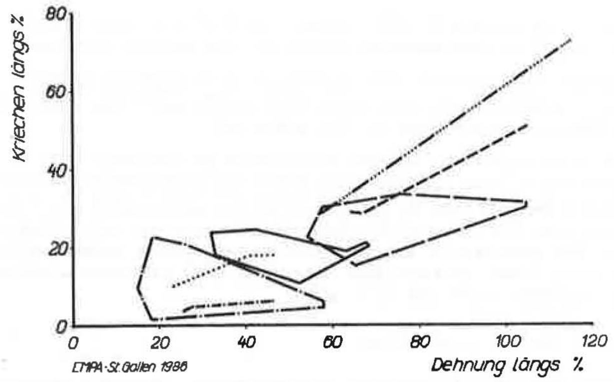

Fig. 5: Correlation between elongation and creep after 500 h.

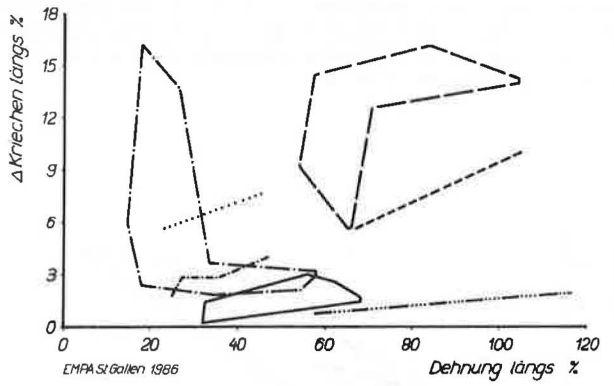

Fig. 6: Correlation between elongation and the residual creep.

4. Hydraulic properties

The transmissivity decreases between the loads 20 kN/m^2 and 200 kN/m^2 by the factor 5 to 15 depending on whether it is a thermically solidified or other non-woven textile.

With the permittivity the factor lies between 1 and 2.

There is in general a reciprocal correlation between the permittivity and the transmissivity: The greater the transmissivity the smaller the permittivity (fig. 7).

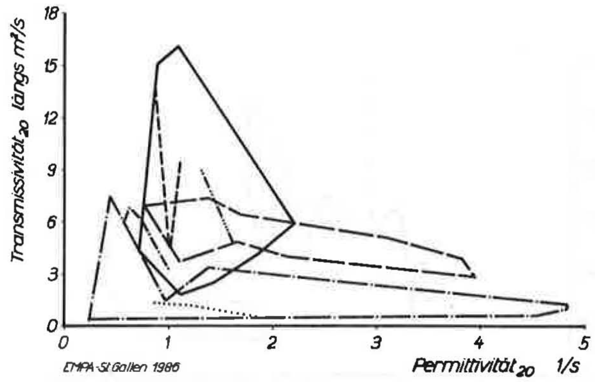

Fig. 7: Correlation between permittivity and transmissivity

Interesting - although indirectly given by the correlations with the mass - is the observation that a high breaking strength seems to exclude a high permittivity (fig. 8) or, vice-versa, that the transmissivity tends to give higher values with an increasing breaking strength.

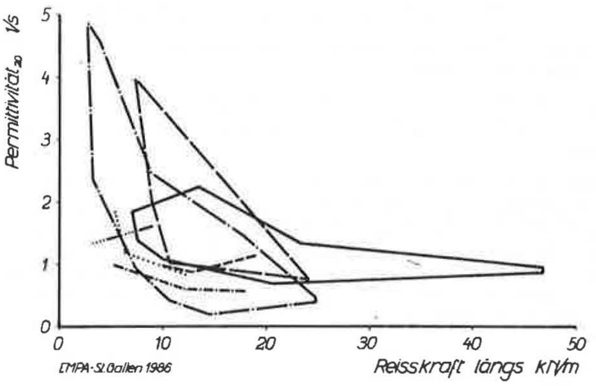

Fig. 8: Correlation between the breaking strength and the permittivity.

PROSPECTS

The present paper gives some tips on how correlations of different properties are partially given automatically and partially controlled by the technique of manufacture. The correlations and tendency-wise dependencies will certainly be obsolete, at least partially, in a few years; the industry is intensively working on new developments.

Further interesting multiple correlations, which would however go beyond the scope of this paper, can be traced using the data in the Geotextile Manual. Finally we take only one example of needled polyester non-wovens made of continuous fibres. The breaking strength can be predicted, with great accuracy (s = 1.3 kN/m; this is approximately the reliability of the mean value) with second order correlation, based on fineness, the density at 2 kN/m^2, thickness at 200 kN/m^2 and the square of the mass and the thickness at 200 kN/mm2 (fig. 9). It is:

breaking strength in kN/m =

$$= 7.23 - 0.214\ \text{fineness} - 0.0497\ \text{density}_2 + 19.0 . \text{thickness}_{200} + 0{,}000204\ \text{mass}^2 - 12.7 . \text{thickness}_{200}^2$$

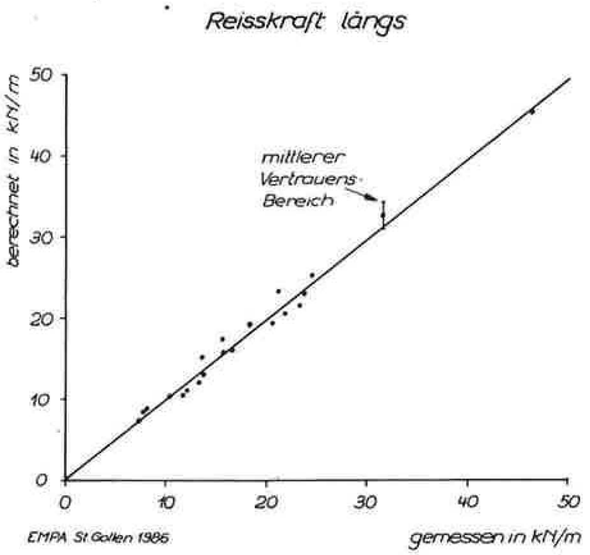

Fig. 9: Correlation between measured and the calculated longitudinal breaking strength from the construction data. (21 PES-continuous-non woven textiles, needled, from 3 manufacturers).