Secutex®

geotextile introduction

NAUE

Introduction

Since the early 1960's, nonwoven geotextiles have been used in various fields of civil engineering for separation, filtration, protection and drainage applications. Since then, numerous national and international guidelines have been published that enable project-specific specifications and product selection, based on established performance requirements.

Nonwoven geotextile manufacturing

The basic characteristics of a nonwoven geotextile can be categorised by the geotextile structure, the bonding method and the raw material - the most prevalent of which are polypropylene (PP) and polyester (PET). Nonwoven geotextiles are manufactured by bonding loose, randomly orientated short staple fibres or continuous filament layers (fleece). Depending upon the desired or required civil engineering characteristics, the bonding of these fibre layers into a finished product can be a mechanical (needlepunching) or thermal (by cohesion) process. Regardless of the bonding process, the finished nonwoven geotextile product is wound onto cores and supplied in rolls.

Needlepunching/mechanical bonding

This process (figure 2) involves forcibly entangling layers of loose staple fibres or filaments into a three-dimensional structure (figure 1) by alternately punching and pulling out "beds" of barbed needles. Using select

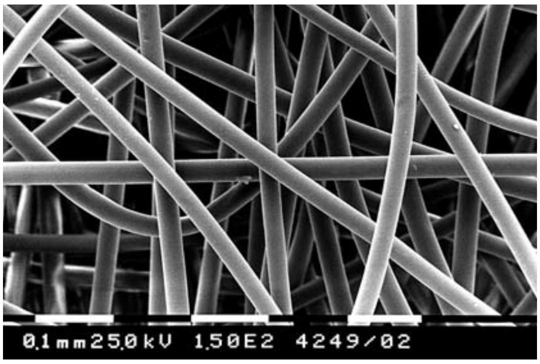


Fig. 1 Magnified mechanically bonded nonwoven

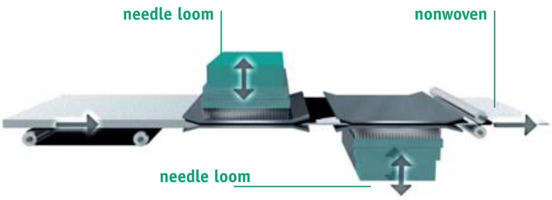


Fig. 2 Needle-punched nonwoven process

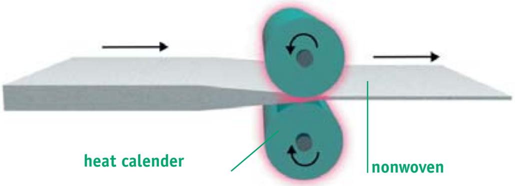


Fig. 3 Thermally bonded nonwoven process

crimped staple fibres in our nonwoven products, Secutex® and Terrafix® are produced with a firm interlocking bond and exhibit high abrasion resistance. With needlepunching strong yet flexible and comparably thick nonwovens are produced. Some Secutex® products are additionally calendered.

Thermal/cohesive bonding

During this nonwoven production method (figure 3) the junctions of the loose fibres or filaments are thermally bonded together (figure 4) or "calendered" when the

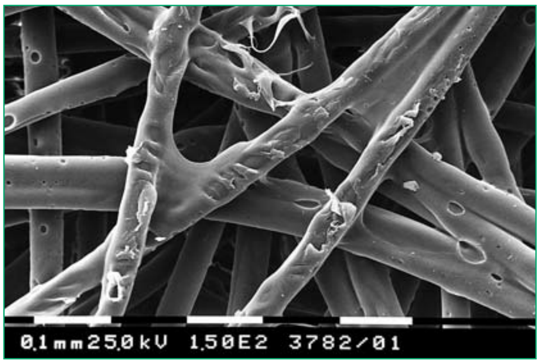


Fig. 4 Thermally bonded nonwoven

fleece surface is compressed with heated rollers (drums). Occasionally low melt temperature fibres are incorporated into the fleece. The thermal bonding method creates a relatively thin, less flexible nonwoven with a comparably flat, smooth surface and lower elongation characteristics than needle-punched nonwovens.

Strength properties

Needle-punched nonwovens have high elongation characteristics due to the "flexible", non-brittle fibre junctions created by the manufacturing process. Due to

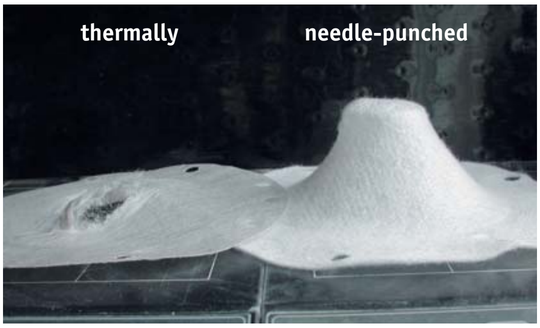


Fig. 5 Typical behaviour of 200 g/m² needle-punched and thermally bonded nonwovens in the plunger puncture test (simulation of a stone puncture)

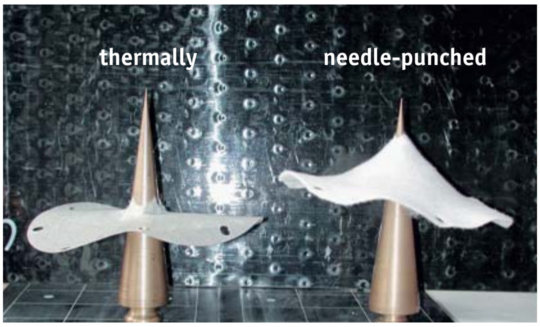
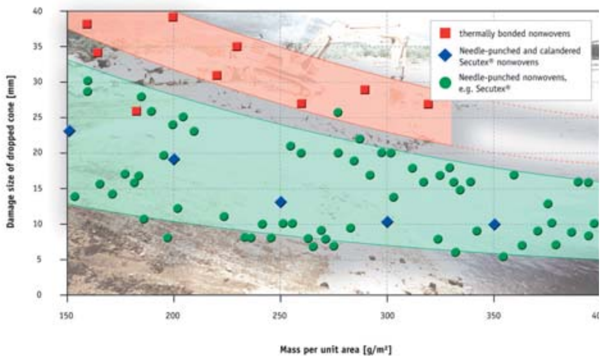


Fig. 6 Typical behaviour of 200 g/m² needle-punched and thermally bonded nonwovens in the cone drop test (simulation of a puncture load)

their superior high elongation characteristics, needle-punched nonwovens are more capable of accommodating soil irregularities, and are more resistant to puncture from imbedded stone (figure 5) or similar potentially damaging sources (figure 6) than geosynthetic products with low elongation properties, such as thermal bonded nonwovens or woven geotextiles.

Figure 7 illustrates and compares the cone drop behaviour of several thermally bonded and needle-punched nonwoven geotextiles from the Geotextile Manual of the SVG (Swiss Association of Geotextile Experts) as well as several other NAUE nonwoven products such as Secutex® and Terrafix®.

Fig. 7
Cone drop behaviour (according to EN 918) of thermally bonded and needle-punched nonwovens



Filter properties

Needle-punched nonwovens are also well suited to filtration applications due to the typical thickness (d) and opening size ratio ($O_{90,w,select}$) (figure 8), as required in several national filtration calculations.

Unique to the manufacturing process, needle-punched nonwovens can be produced in greater thicknesses than other bonded nonwovens. Hence they can be produced in compliance with the recommended minimum thickness (d) according to the "DVWK guidelines, Vol. 221/1992" (page 5) where

$$d_{geotextile} \geq (25 \text{ to } 50) * O_{90,w,select}$$

- thereby ensuring the long-term filter effectiveness of the nonwoven.

The highest possible hydraulic efficiency of the Secutex® filter nonwoven geotextile is achieved when the selected opening size $O_{90,\ sel}$ is closest to the largest allowable value $O_{90,\ allow}$ (e.g. 0.8 to 1.0 • $O_{90,\ allow}$). Under no circumstances should this value be less than 0.2 • $O_{90,\ allow}$ as a colmation (deposition of fine soil particles on the geotextile surface) could occur. Allowing a selected opening size $O_{90,\ sel}$ in the low range of ≥ 0.2 • $O_{90,\ allow}$ may only be excepted if a colmation of the geotextile filter as well as soil settlement in the drainage system does not effect the performance of the design. Another advantage of mechanically bonded Secutex® nonwoven geotextiles is that the effective opening size will change only slightly when subjected to elongation stresses. Consequently, the filter dimensioning is also valid, even if a coarse grained material causes nonwoven geotextile deformation when being installed on a soft subgrade.

To minimise soil pore water pressure, national guidelines recommend that nonwovens have a water permeability coefficient which is at least 50 to 100 times higher than the soil to be drained (η = 0.02 - 0.01). Long-term performance is assured if the nonwoven geotextile water permeability coefficient (kN), when reduced by η is still greater than or equal to the permeability coefficient of the soil to be filtered (k_s).

Hence: $\eta \cdot kN \geq k_s$

To demonstrate the superiority of needle-punched nonwovens for filtration, figure 9 compares a needle-

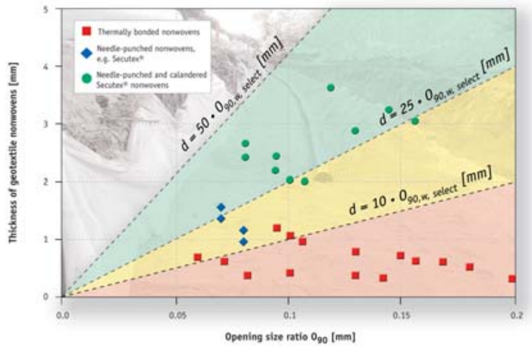


Fig. 8
Recommended opening size and thickness correlation for a filter geotextile (DVWK, Vol. 221/1992)

punched nonwoven to thermally bonded nonwovens. In this example similar the needle-punched nonwoven has a much greater thickness and a higher vertical water permeability - which are both important properties for maximising filtration behaviour. The substantial performance differences can be attributed to the benefits of the needle-punched bonding process.

As illustrated in figure 9, the water permeability coefficient of the needle-punched nonwoven and the needle-punched calendered nonwoven is significantly higher than that of the thermally bonded product. In general, the superior long-term water permeability performance permits the use of the needle-punched nonwoven (even additionally calendered) for a much larger range of soils than with the thermally bonded nonwoven.

Fig. 9
Comparison of needle-punched and thermally bonded nonwoven properties

	needle-punched (Secutex® R 201)	needle-punched and calendered (Secutex® R 201 GRK)	thermally bonded	
mass per unit area	200 g/m²	200 g/m²	190 g/m²	220 g/m²
thickness	2.2 mm	1.2 mm	0.57 mm	0.59 mm
pore value	90 %	82 %	46 %	60 %
vertical water flow rate H50	100 m/s	60 m/s	35 m/s	18 m/s

Shear properties

As a result of the multi-dimensional surface structure, needle-punched nonwovens will typically achieve a much higher interface friction angle to adjacent soils than is capable with thermally bonded products. In general, the transferable friction angle tan δ/tan π between the geotextile filter and the soil can be assumed, as illustrated in figure 10 (δ = interface friction angle between soil and geotextile; π = friction angle of the soil).

tan δ/tan π for:	needle-punched nonwoven	thermally bonded nonwoven/woven
clay	~ 0.92	~ 0.84
fine sand	~ 0.92	~ 0.80
coarse sand	~ 0.95	~ 0.83

Fig. 10
Comparison of predicted interface friction angles between geotextile and soil

While this discussion typifies the interface shear characteristics that can be expected, actual performance levels should be predicted through project and product-specific shear tests modelling the conditions of the application.

Conclusion

Needle-punched (mechanically bonded) nonwovens are robust geotextiles capable of withstanding harsh installation conditions and challenging construction loads. Their unique flexibility and elongation properties combine to provide high puncture resistance without sacrificing frictional of filtration properties. When properly selected, needle-punched nonwovens can provide superior long-term filtration and achieve higher interface friction angles than comparably weighted nonwovens manufactured through alternative processes. Needle-punched nonwovens can be employed in many geotechnical fields, including landfill, civil and hydraulic engineering as well as groundwater protection. Through years of research, testing and experience, needle-punched nonwovens have proven their capabilities in landfill engineering when employed for separation, filtration, drainage as well as protection applications. Figure 11 contrasts needle-punched and thermally bonded nonwovens for a number of other important geotextile properties.

	Mechanically Bonded Nonwoven	Thermally Bonded Nonwoven
Water Permeability	*high,* due to the open unconsolidated structure	*low,* due to the dense consolidated structure
Filter Performance	*good,* due to large filter length (thickness)	*poor,* due to small filter length (thickness)
Elongation	*high,* no fibres are fixed	*low,* fibre junctions are rigidly bonded
Adjustment to Soil Asperity or Unevenness	*good,* due to high elongation characteristics	*poor,* due to low elongation characteristics
Drainage Performance	*high,* due to large pore volume	*low,* due to small pore volume
Protection Performance	*high,* due to thick structure	*low,* due to thin structure
Puncture Resistance	*high,* elongation characteristics	*low,* due to low elongation characteristics
Shear Behaviour	*high,* due to rougher surface structure	*low,* due to compressed flat surface structure

Fig. 11 Comparison of needle-punched and thermally bonded nonwovens

References

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