Secutex®

gotextile introduction
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 cramped 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 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 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®.

Filter properties

Needle-punched nonwovens are also well suited to filtration applications due to the typical thickness (d) and opening size ratio (O90,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

\[ d_{\text{geotextile}} \geq (25 \text{ to } 50) \ast O90,w,select \]

- 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 O90,w,select is closest to the largest allowable value O90,allow (e.g. 0.8 to 1.0 \ast O90,allow). Under no circumstances should this value be less than 0.2 \ast O90,allow as a colimation (deposition of fine soil particles on the geotextile surface) could occur. Allowing a selected opening size O90,select in the low range of \( \geq 0.2 \ast O90,allow \) may only be excepted if a colimation 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 (\( \eta = 0.02 \text{ to } 0.01 \)). Long-term performance is assured if the nonwoven geotextile water permeability coefficient (kN), when reduced by \( \eta \) is still greater than or equal to the permeability coefficient of the soil to be filtered (k_s).

Hence:

\[ \eta \cdot k_N \geq k_s \]

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

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 \( \tan \theta / \tan \pi \) between the geotextile filter and the soil can be assumed, as illustrated in figure 10 (\( \delta = \text{interface friction angle between soil and geotextile; } \pi = \text{friction angle of the soil} \)).

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 or 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.

<table>
<thead>
<tr>
<th>Property</th>
<th>Mechanically Bonded Nonwoven</th>
<th>Thermally Bonded Nonwoven</th>
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</thead>
<tbody>
<tr>
<td>Water Permeability</td>
<td>high, due to the open uncemented structure</td>
<td>low, due to the dense cemented structure</td>
</tr>
<tr>
<td>Filter Performance</td>
<td>good, due to large filter length (thickness)</td>
<td>poor, due to small filter length (thickness)</td>
</tr>
<tr>
<td>Elongation</td>
<td>high, no fibres are fixed</td>
<td>low, fibre junctions are rigidly bonded</td>
</tr>
<tr>
<td>Adjustment to Soil Asperity or Unevenness</td>
<td>good, due to high elongation characteristics</td>
<td>poor, due to low elongation characteristics</td>
</tr>
<tr>
<td>Drainage Performance</td>
<td>high, due to large pore volume</td>
<td>low, due to small pore volume</td>
</tr>
<tr>
<td>Protection Performance</td>
<td>high, due to thick structure</td>
<td>low, due to thin structure</td>
</tr>
<tr>
<td>Puncture Resistance</td>
<td>high, elongation characteristics</td>
<td>low, low elongation characteristics</td>
</tr>
<tr>
<td>Shear Behaviour</td>
<td>high, due to rougher surface structure</td>
<td>low, due to compressed flat surface structure</td>
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</tbody>
</table>

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

References

2. NAUE GmbH & Co.KG; “Civil Engineering”, Stand 03/2006
5. "Eigenschaften von mechanisch und thermisch verfestigten Wiesstoffen"; Hoechst High Chem, 0392/042
6. SVG Schweizerischer Verband der Geotextilfachleute; "Das Geotextil-Handbuch", 2000