

Landfill Engineering

Naue Fasertechnik



www.naue.com



Landfill Engineering



Illegal dumping of waste in the seventies.

In landfill engineering, basal linings and caps are designed in two different manners to maximise containment of potential pollutants. Basal lining systems incorporate geosynthetic sealing and drainage components to contain the fluids and contaminants that may leach from the waste as well as direct these fluids to a collection point for treatment.

»Brown field« industrial sites that require remediation may also benefit from the use of geosynthetic sealing systems. By using complete geosynthetic solutions, industrial sites can be redeveloped for new use at a fraction of the cost of soil treatment and decontamination.



1988, shear strength transferring Secudrän® drainage systems were more widely used in landfill caps.



1995, landfill caps were sealed with Carbofol® geomembranes and Bentofix® geosynthetic clay liners.

Geosynthetic landfill caps utilise sealing and drainage layers to prevent precipitation from penetrating into the landfill body, minimising the generation of leachate in closed facilities.

Complete geosynthetic solutions from Naue Fasertechnik protect the environment from the potential contamination of pollutants.



1991, the composite lining system in the landfill base became state-of-the-art.

The full range of products are durable and ensure a long service life. Compared to conventional construction methods, they are also typically more economical, consume less space, save resources, and reduce installation costs. ■

Geosynthetic Functions



Sealing

Acting as liquid and gas barriers, geomembranes have become a fundamental component in civil engineering, due to the heightened need for groundwater protection. High density polyethylene (HDPE) geomembranes, specifically those with a certification by government regulators and thickness' of more than 1.5 mm, are most commonly used. Personnel from those companies that have been approved by the certifying agency, are employed to both deploy and weld the geomembranes where an area needs to be sealed.

For sealing purposes in road construction and environmental protection, HDPE geomembranes and geosynthetic clay liners are gaining use due to the importance of a quality seal.



Protection

Geomembranes, structures, coated materials as well as related construction elements must often be protected from potential mechanical damage. Without suitable protection, damage may occur from sharp-edged objects such as stones, from the unevenness of the subsoil or even by the cover material. Mechanically bonded needle-punched nonwovens as well as composite materials manufactured from polypropylene (PP) are commonly used for protection layers. Specific to nonwoven geotextiles, the protection function is directly related to the thickness and mass per unit area, as a heavier and thicker nonwoven is more likely to provide better protection.



Drainage

Drainage materials are required for the surface collection of precipitation, the subsurface collection and diversion of groundwater, as well as the general collection of fluids and their discharge into a drainage system. Drainage systems are typically designed with individual material layers or in combination with other components to create pre-formed composite drainage elements. Composite drainage elements consist of at least one filter layer and one percolation layer. The percolation layer is required for the flow and discharge of fluids at a collection point, without the build-up of pressure. Single and multiple component geosynthetic drainage systems made from high density polyethylene as well as polypropylene, often replace the conventional thick mineral drainage layer.



Erosion Control

Single component geosynthetic layers and three-dimensional multi-component composite materials are used to prevent surface erosion.

By preventing soil particles from being washed off slopes or channels, rapid vegetation is ensured when erosion control mats are employed.



Reinforcement

Geosynthetics are installed beneath or between soil layers to improve the mechanical properties of soil layers by assuming the tensile forces and minimising deformation. Geotextiles, geogrids and composite synthetic materials are used in applications such as retaining structures according to the principles of "reinforced soil", slope stabilisation or for foundation reinforcement of earthen dams where the subsoil exhibits poor bearing capacity. The use of geosynthetics for reinforcement applications minimises expensive constructive measures, can reduce soil intermixing and eliminate the need for additional soil layers.



Separation

As a separation layer, geotextiles are used to prevent adjacent soil layers or fill materials from intermixing.

Synthetic nonwovens that exhibit an elongation capacity, are the materials of choice in most applications. The selection of a suitable product is dependant upon the base course grain size and the operational loads to be expected. The main use of separation nonwovens are road and railway construction, hydraulic and landfill engineering, and sport fields.



Filtration

In filtration applications such as hydraulic engineering and drainage systems, nonwoven geotextiles are employed to retain soil particles while allowing the vertical passage of liquids through the filter media. There are two aspects to filtration that should be evaluated when designing. The mechanical filter efficiency (does the fabric have sufficient soil retention capacity) and the hydraulic filter efficiency (does the water discharge without a hydraulic pressure build-up).

As with mineral filter layers, the geotextile thickness directly benefits the long-term mechanical and hydraulic efficiency of the filter. ■



1 Subgrade

2 Sealing with Bentofix®

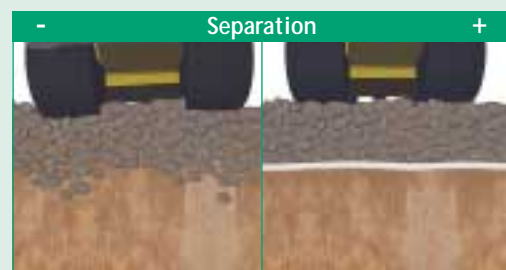
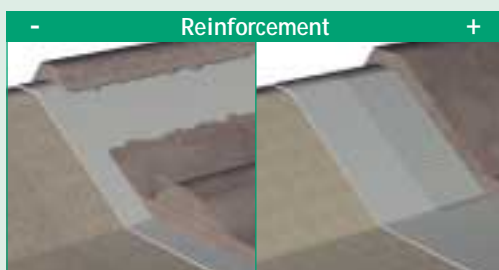
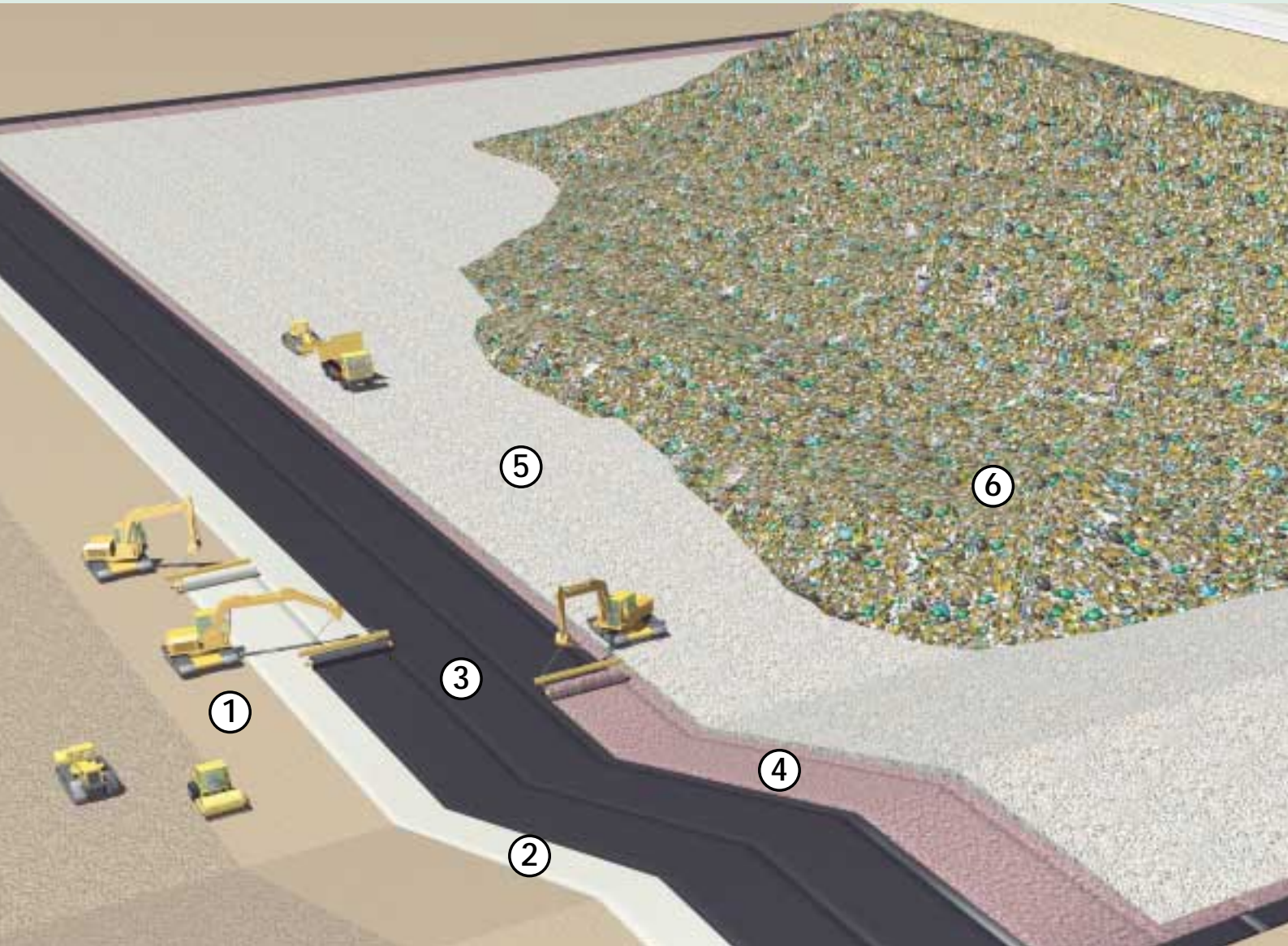
3 Sealing with Carbofol®

4 Protection with Secutex®

5 Leachate Collection System

6 Waste

7 Leveling Layer



8 Drainage with Secudrän®

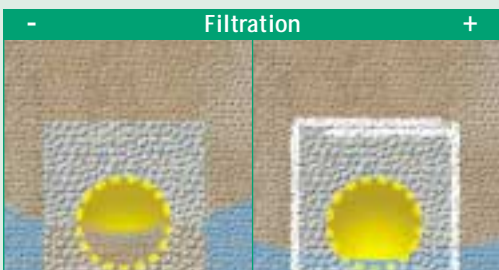
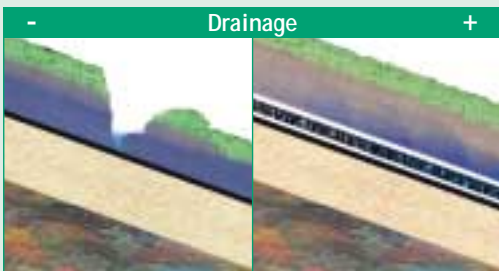
9 Sealing with Bentofix®

10 Sealing with Carbofol®

11 Drainage with Secudrän®

12 Reinforcement with Secugrid®

13 Top Soil



Landfill Base Lining

Figure 1
Welding of Carbofol®
geomembranes (land-
fill Xingfeng, China).



Both the US Environmental Protection Agency (EPA) Federal Regulations as well as the European Council Directive on the Landfill of Waste describe prescriptive cross sections for hazardous and non-hazardous waste landfill base lining systems. With complete geosynthetic solutions from Naue, the minimum base lining standards can be easily fulfilled while the performance obtained can be significantly improved.

Sealing

The base lining is designed to prevent the escape of contaminants from landfilled waste into underlying soils. A properly constructed liner system should also allow for the controlled collection and removal of landfill leachate for subsequent treatment.

In regions where local soils are not suitable for the construction of hydraulic barriers, Bentofix® geosynthetic clay liners (GCLs) can be used to protect the hydrogeological resources by providing an effective barrier against potential risks to the environment. Typical compacted clay liners (CCL) are difficult as well as expensive to build. In many cases, they are subjected to installation conditions that can cause desiccation cracking and create preferential flow paths. Bentofix® GCLs can replace or augment the typical CCL in most designs to minimise the effects of desiccation. Once covered, Bentofix® GCLs quickly hydrate with existing soil moisture to form a low permeable barrier. The quick and easy installation methods used for Bentofix yield substantial cost and time savings when compared to expensive construction methods typical for CCLs.

When used in combination with Carbofol® HDPE geomembranes, Bentofix® GCLs can achieve the superior hydraulic per-

formance obtained with exceptional intimate contact, and can minimise lateral flow of leachate - in the unlikely event of a puncture. A composite liner system incorporating Carbofol® and Bentofix® as the independent sealing elements is extremely effective when containing both polar as well as non-polar contaminants.

As Bentofix® geosynthetic clay liners are needle-punched over their entire surface area, they are capable of transmitting shear forces on steep slopes as well as within base lining systems. Bentofix® products produced with mechanically bonded nonwovens on both outer surfaces can be used to achieve higher interface friction angles and shear strengths.

When constructing the base liner system of municipal or hazardous waste landfill, Carbofol® HDPE geomembranes can be used to protect and seal the subsoil from the release of potential contaminants. Smooth surfaced 2.0 mm thick HDPE Carbofol® geomembranes are well suited for the lining of landfill base seals with slopes up to 9h:1v, and are available in various structured or textured versions for more demanding conditions. Unique surface structures and textures are used to address different slope inclinations and loads.



Figure 2
Filling of waste in a
landfill with a
Secutex® protected
composite liner
(landfill in Spain).

A project specific analysis should be performed, including direct shear testing to confirm slope stability calculations. During the manufacturing process, surface textures and structures are added directly to the layer of pliable HDPE Carbofol® geomembrane by a molding or spraying process. This step creates a homogeneous structured geomembrane made from a single material or resin, maximising the product shear strength characteristics.

Design Cross sections Details

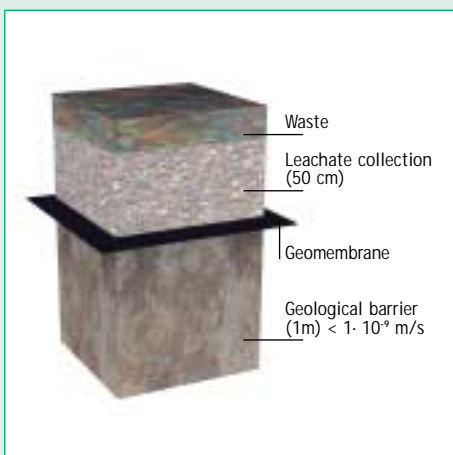


Figure 5: EU directive for base seals (non hazardous)

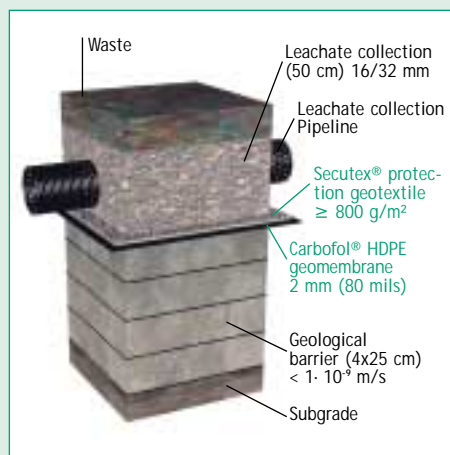


Figure 6: EU directive, state-of-practice for base seals (non hazardous)

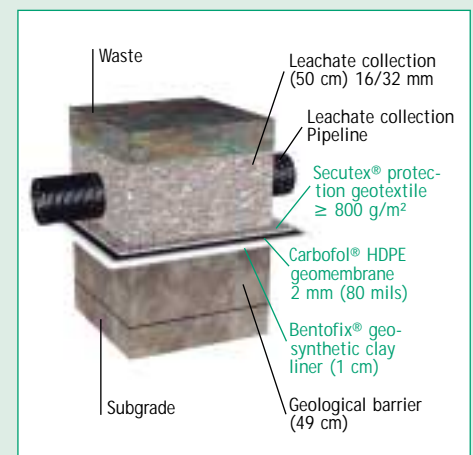


Figure 7: Naue base seal complete solution

Protection

High quality protection geotextiles limit geomembrane damage and deformation during installation as well as during subsequent operational use.

When properly selected, Secutex® needle-punched polypropylene (PP) nonwovens are capable of preventing the puncture of Carbofol® geomembranes under the most demanding conditions.

Depending on the nature of the landfill cover layer, the grain size as well as the shape of the drainage layer, various protection systems can be used (example for fine gravel).

Assuming a well compacted subgrade, a CCL or a Bentofix® GCL, a 2 mm thick HDPE geomembrane and a 30 - 50 cm thick leachate collection layer with 8 mm to 32 mm gravel, the following guide can be used to determine the mass per unit area for the Secutex® protection layer:

Height of waste	Mass per unit area of Secutex®
15 m	800 g/m ²
25 m	1,200 g/m ²
35 m	2,000 g/m ²
50 m	3,000 g/m ²

Prior to the utilisation of a nonwoven for puncture protection, puncture tests similar to the cylinder test (DIN EN 13719) are recommended with site-specific materials and the test protocol as specified by the design engineer.

Figure 3
Carbofol® and Bentofix® composite liner in a municipal landfill (landfill Argalarío, Spain).



Reinforcement

Long-term slope stability can be obtained with Secugrid® geogrids, when used either alone or in conjunction with other



Figure 4
Secutex® protection layer over the HDPE geomembrane (landfill in Germany).

geosynthetic materials. When used with a geomembrane, Secugrid® reinforcement products can support the down slope forces while protecting the Carbofol® geomembrane from potentially harmful stresses.

The low initial elongation and the interlocking nature of the Secugrid® with mineral drainage layers ensures immediate stress transfer and avoids installation deformation. The relatively thick, flat, monolithic elements of the Secugrid® provide structural security with all normal installation loads.

Conclusion:

The repair or remediation of a base liner is technically difficult and expensive. It is for this reason that high quality products, which can ensure long-term performance, need to be selected during the design phase of a project.

With complete geosynthetic solutions from Naue Fasertechnik, your next lining system will have the latest in geosynthetic innovations and the quality you need to ensure long-term performance.

Naue Fasertechnik can provide the ideal combination of geosynthetics for any project. A wide selection of geosynthetic products and styles allows efficient, project specific solutions, even for the most challenging applications. ■

Design Cross sections Details

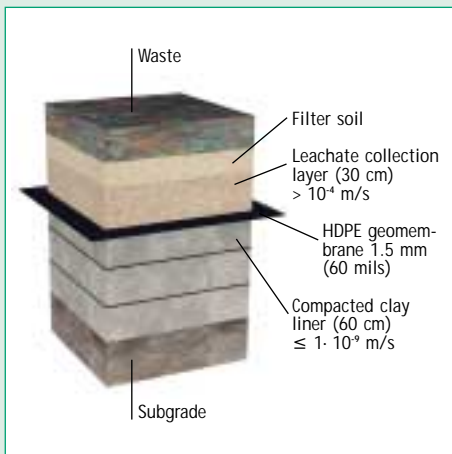


Figure 8: US-EPA directive, for base seals (non hazardous)

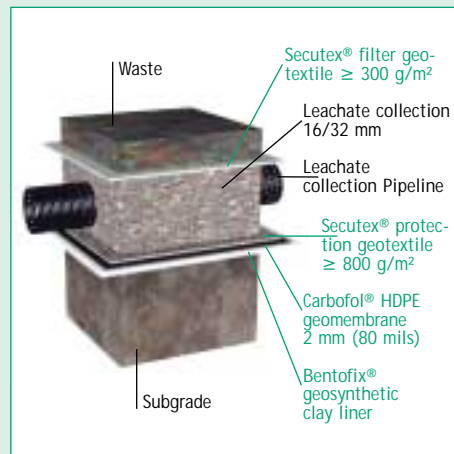


Figure 9: Naue base seal complete solution

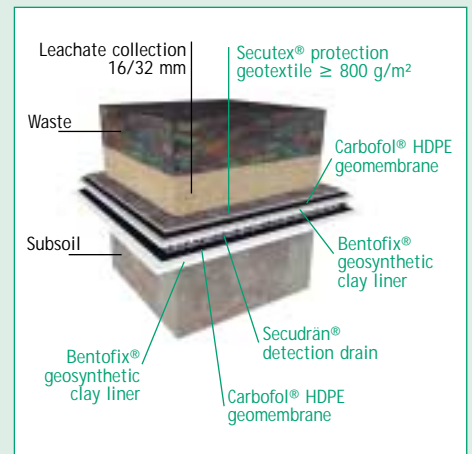


Figure 10: Naue double composite base seal

Landfill Capping

Figure 11
Installation of the
Secutex® protection
layer (landfill Nurem-
berg, Germany).



The US Environmental Protection Agency (EPA) Federal Regulations and the European Council Directive on the Landfill of Waste describe prescriptive cross sections for hazardous and non-hazardous waste landfill cover systems. These systems are designed to prevent the intrusion of precipitation into the waste or the release of landfill gas from the waste. Technically equivalent cost-efficient alternatives can be obtained with complete geosynthetic solutions from Naue Fasertechnik.

Sealing

Multidirectional shear strength transmitting Bentofix® needle-punched GCLs can replace difficult to build compacted clay liners (CCLs) in non-hazardous as well as in hazardous landfill cover systems. Due to their excellent multi-axial strain behaviour, Bentofix® needle-punched GCLs retain their sealing capability under high elongation, differential settlement conditions of landfill capping systems. Steep slope applications up to 2.5h:1v are possible with needle-punched nonwovens as the carrier and cover components of Bentofix®.

The physical requirements and chemical resistance of geomembranes for landfills are comparable to those needed in

Figure 12
Composite liner with
Bentofix® in a land-
fill cap (landfill
Bamberg, Germany).



landfill basal linings. Carbofol® HDPE geomembranes have been successfully tested for their resistance to many chemical environments and are considered suitable for landfill sealing systems in covers and caps.

Structured or textured Carbofol® geomembranes are used to increase shear force transmission between the adjacent components under more challenging conditions to ensure long-term stability.

Protection

Geomembranes must be protected from mechanical damage from the cover material or any underlying source.

When using a mineral drainage layer the mechanically bonded Secutex® PP nonwovens are often installed rather than a sand protection layer. To avoid significant geomembrane deformation during installation and to ensure long-term protection, Secutex® nonwoven geotextile with a minimum mass per unit area of 800 g/m² is recommended.

When used in combination with Carbofol® geomembrane, Secudrän® geosynthetic drainage systems not only fulfil the filter and drainage function, but also act as a protection layer for the geomembrane. The Secudrän® protection and drainage system also prevents deformation in the Carbofol® geomembrane.

Drainage

In landfill caps, Secudrän® drainage systems can effectively transmit and direct the percolated rainwater to a collection or drainage point. Proper drainage minimises the standing water build-up on the sealing element, increases liner efficiency and improves the capping system stability.

Secudrän® geosynthetic drainage systems consist of three individual layers made of the following components:

1. filter nonwoven - protects the drainage layer from clogging,
2. drainage layer - transmits the water in the filter level,

Design Cross sections Details



Figure 15: EU directive for landfill caps (non hazardous)

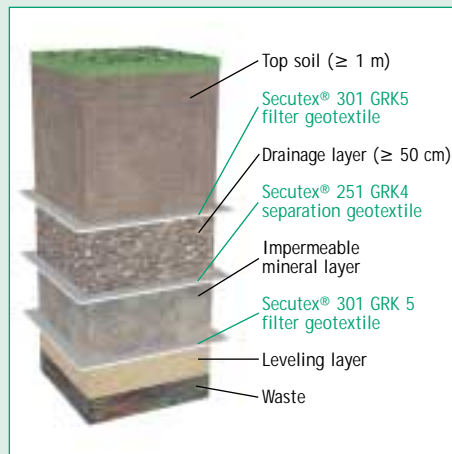


Figure 16: EU directive, state-of-practice for landfill caps (non hazardous)

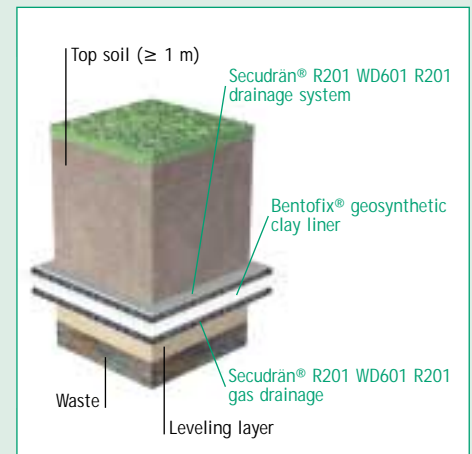


Figure 17: Naue capping complete solution

- filter/protection nonwoven - serves as filter or separation layer to the mineral component or the protection layer for the geomembrane.

The composite bonding of the three layers into one ensures the uniform shear force transmission within the drainage system. Due to the uniform bonding, Secudrän® is also suitable for the use in steep slopes.

The stable structure of the core layer provides the long-term drainage performance of Secudrän®.

Secudrän® can also be used as the gas venting and protection layer beneath the liner in capping systems.

Figure 13
Secugrid® reinforcement above Carbofol® geomembrane and Secutex® protection layer (landfill Ällässlo, Finland).



Filtration and separation

Needle-punched bonded Secutex® nonwoven filter geotextiles prevent the passage of soil particles from the vegetation layer into the drainage layer.

The requirements on the filtration and separation layer are dependant upon the recommendations of the geotechnics of landfills and contaminated sites working group (GDA).

Above all, the long-term permittivity of the geotextile filtration layer must be ensured to prevent the pressure build-up above the drainage layer that could compromise the liner system stability.

With hydraulic and mechanical filter properties defined by the Guideline of the Research Association for Roads and Traffic (FGSV) and by using a geotextile of at least robustness class 3, the long-term efficiency of the geotextile filter is ensured.

Reinforcement

Secugrid® is a geogrid made of flat extruded monolithic bars welded at their junctions. It can withstand high installation loads or support large forces when low deformation is required. On steep or long slopes, Secugrid® geogrids can be used to improve the stability of soil veneers or entire lining systems. Secugrid® geogrids also allow steeper walls and slopes to be constructed.

Covering during operation

Temporary covers, which are installed during landfill operations, can minimise precipitation infiltration and reduce gas emissions, when applied prior to the final or temporary seal. 1.5 mm thick Carbofol® HDPE geomembranes are ideal for this application.

They show excellent chemical as well as UV resistance and can withstand the robust weathering conditions of these areas.

Conclusion:

Complete geosynthetic solutions from Naue Fasertechnik can be employed to address the site-specific requirements of your project. The geosynthetic products of Naue are produced to the highest quality standards. Products certified by government regulators are available for single-layered and combination composite liner systems.



Figure 14
Secudrän® placement over a Bentofix® GCL (landfill Halle, Germany).

Carbofol® geomembranes and Bentofix® geosynthetic clay liners in combination with Secudrän® drainage systems, Secugrid® geogrids as well as Secutex® protection layers, permit high quality and cost-efficient solutions to the most demanding applications. ■

Design Cross sections Details

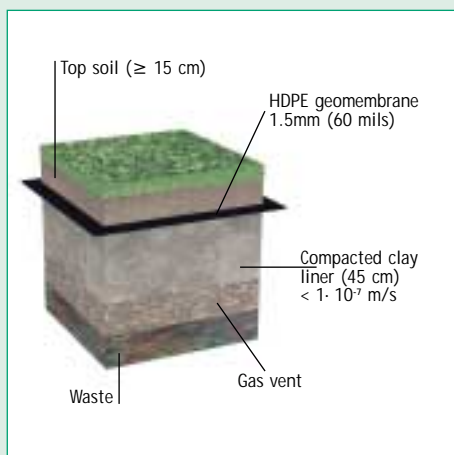


Figure 18: US-EPA directive for landfill caps (non hazardous)

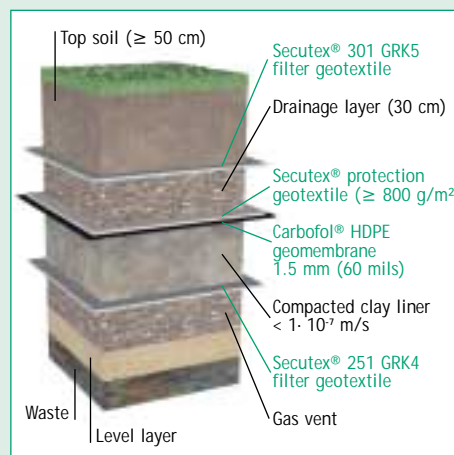


Figure 19: US-EPA directive, state-of-practice for landfill caps (non hazardous)

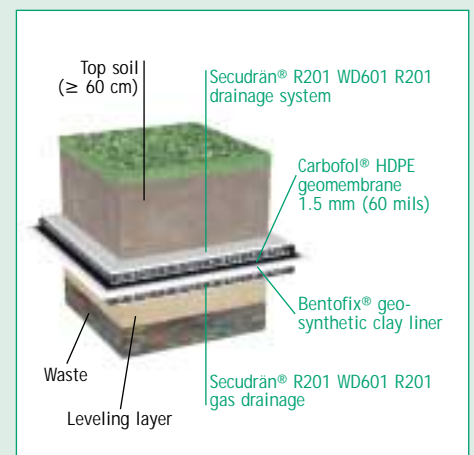


Figure 20: Naue capping complete solution

Reclamation and redevelopment of contaminated sites

Figure 21
Welding of Carbofol®
geomembranes over
Combigrig® (tar pond
"Neue Sorge",
Germany).



Old factory sites and abandoned areas are often redeveloped for new uses by the reclamation of the contaminated area. Geosynthetic systems are an effective solution to prevent the discharge or emission of contaminants into the environment.

Complete geosynthetic solutions from Naue Fasertechnik save natural building material resources while making expensive processing of rubble and decontamination measures unnecessary.

Encapsulation of Contaminants

The encapsulation of polluted areas is necessary to prevent the discharge of contaminants. To ensure long-term effectiveness of the liner system, high quality geosynthetic materials should be selected and rigorous construction practices should be followed. This is achieved with the installation of quality assured, 2.0 mm thick Carbofol® high density polyethylene (HDPE) geomembranes. Carbofol® HDPE geomembranes are produced to the highest quality standards and have the chemical resistance necessary to contain contaminated soils or liquids. Secutex® protection nonwovens as well as Secudrän® protection and drainage systems, guard the Carbofol® geomembranes from damage, Secugrid® geogrids are used to prevent settlement or deformation of the contaminated subsoil. These products protect the other liner components from damage during the installation process as well as over the operational life of the liner system under subsequent long-term loads.

When the geosynthetic liner system will be subjected to high normal loads, the efficiency of a protection or cushioning material is tested in a load plate bearing test (DIN EN 13719). The results of this test determine the minimum mass per unit area that should

be used for the protection component. Under lower confining stresses, a minimum mass per unit area for the protection component of no less than 800 g/m² is recommended.

Due to the location and topography of many remedial sites, construction on steeper slopes is often necessary. With structured or "textured" Carbofol® geomembranes, the frictional requirements of demanding steep slope applications can be accommodated. With the proper selection and product specification, the long-term performance and optimum transmission of shear forces is assured. As a replacement to compacted clay liners, Bentofix® is also well suited for the encapsulation of contaminated areas.

Upon selection of the lining product, the aggressiveness of the contaminants should be considered, as one style of product may be more appropriate due to its chemical resistance to the material in question. To increase the versatility of Bentofix® GCLs, they can be manufactured with either polypropylene (PP) or HDPE geotextiles.



Figure 22
Carbofol® geomembrane protected between Secutex® nonwovens (business park Lammerting, Germany).

Regardless of the style of geotextile used, the natural sodium bentonite sealing layer is safely encapsulated between the cover and carrier geotextiles, fully capable of long-term transference of shear forces through the fibre reinforcement. The robust cover and carrier geotextiles used in Bentofix® are designed to resist the physical stresses of the installation process and prevent damage to the seal.

Depending on the existing soil conditions and slope lengths, the mechanically bonded cover and carrier nonwoven geotextiles also make many applications possible, with slopes greater than 2.5h:1v.

Design Cross sections Details

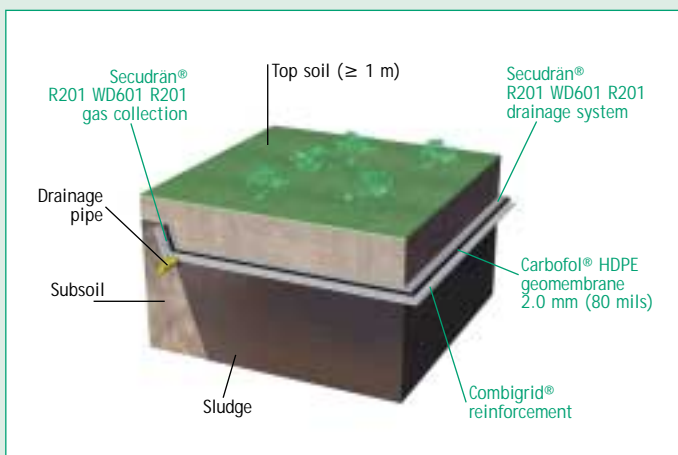


Figure 25: Naue solution for tar pond capping

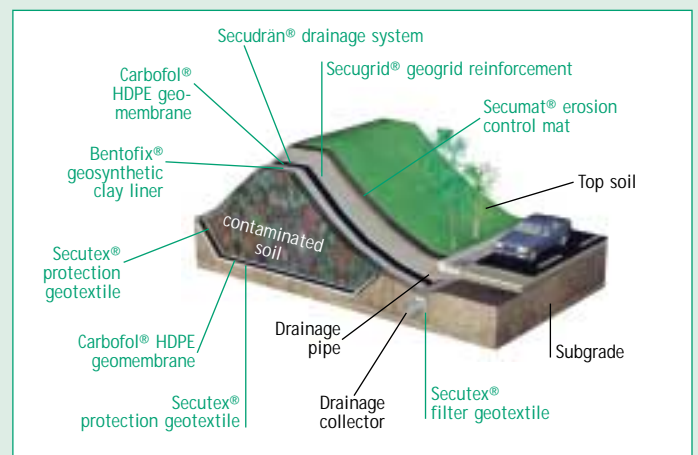


Figure 26: Encapsulation of contaminated soil

Earth Stabilisation

In select cases, a contaminated area has no bearing strength and conventional construction methods are not possible. In these instances the liner system must be capable of supporting itself as well as overlying soils.

In dredged lagoons for example, the area to be sealed cannot be trafficked nor walked upon due to the lack of bearing strength in the "subgrade". By first deploying Secugrid®, a monolithic extruded geogrid, it is possible to traffic over the surface immediately after installation or upon the placement of a mineral leveling layer.

Figure 23
Installation of
Secudrän®
vertical drains for
acceleration of
consolidation.



The extruded Secugrid® provides long-term stabilisation of soft subgrades by distributing the overlying loads and provides a firm foundation for subsequent layers of fill or other geosynthetics. However, when selecting products, the aggressiveness of the contaminants should once again be considered, to ensure compatibility or chemical resistance to the material in question.

As compacted clay liners are difficult to construct, and can form preferential flowpaths with only small amounts of deformation, Carbofol® geomembranes or Bentofix® geosynthetic clay liners are the materials of choice when lining over soft subgrades.

Decommissioned industrial and mine sites that possess abandoned shafts, underground voids and inhomogeneous areas with low bearing capacity, require an encapsulation system that ensures sufficient load distribution in the event of changing subsoil properties.

Secugrid® geogrids are especially well suited for these applications due to the ability of the grid mesh to interlock with the subsoil. The low initial elongation enables Secugrid® to immediately transfer or distribute stresses between the geogrid and subgrade or cover material.

With complete geosynthetic solutions from Naue, highly efficient, low profile sealing and drainage systems can be installed that do not require substantial excavation and recompaction or the placement of voluminous mineral layers.

Slope Stability

When remediating areas on steep slopes, Secugrid® geogrids can support the down slope forces in most situations while protecting the sealing elements from potentially harmful stresses as in land-fill applications. On steep or long slopes, Secugrid® geogrids can be used to improve the stability of soil veneers or entire lining systems.



Figure 24
Installed Carbofol®/
Bentofix®/Secudrän®
composite sealing
system on a contaminated
sand dam
(noise barrier
Hohenbudberg,
Germany).

Conclusions:

Complete geosynthetic solutions from Naue Fasertechnik are more economical than expensive in-situ treatment or excavation and removal techniques. If the available "airspace" or construction volume is limited, geosynthetic solutions from Naue offer high performance in a low profile system. Carbofol® geomembranes and Bentofix® geosynthetic clay liners are cost-effective sealing products that are more efficient as well as economical than conventional compacted clay liners. With Secudrän® drainage systems, additional "airspace" can be recouped by effectively replacing mineral drainage layers that are 15 to 30 times thicker!

The high tensile strength of Secugrid® geogrids enables the construction of space saving steep slopes. By using Secugrid® with its rigid junctions, even extremely soft subsoils can be built upon.

Design Cross sections Details

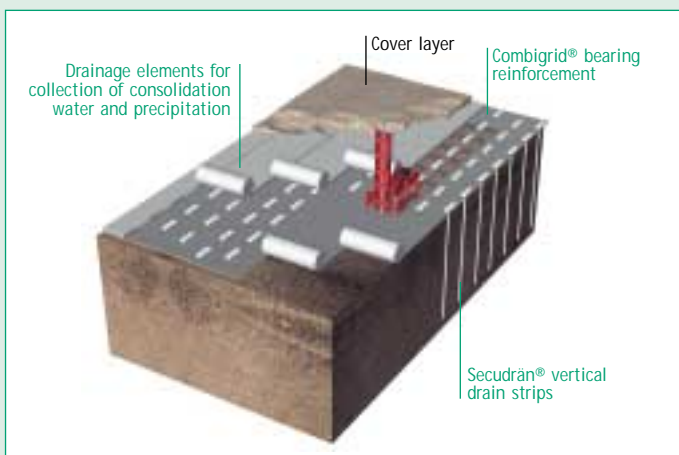


Figure 27: Bearing reinforcement and improvement of consolidation with geosynthetics

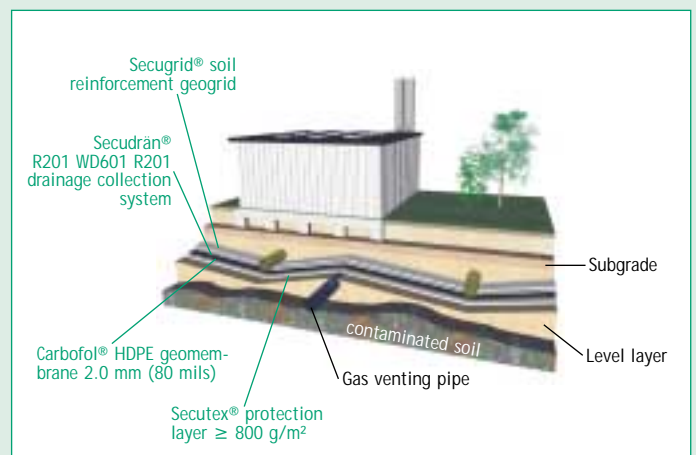


Figure 28: Naue solution for redevelopment of abandoned areas

Quality Assurance and Control

...the continuous monitoring of raw materials, components, production and products

All incoming raw materials, fibres or components, needed for the production of our geosynthetics, are subject to a strict material analysis. Acceptance test certificates, submitted by base material suppliers, are reviewed and qualified in accordance with our product specific protocols.

During production of all geosynthetics, additional quality assurance measures are performed. To ensure personnel effectiveness, the quality assurance staff is assigned to a separate and autonomous division from the production division.

After all quality assurance measures have been performed as defined in the quality assurance plan, an acceptance test certificate will be issued according to EN ISO 10204 when requested. Material will only be released once it has passed all quality reviews, checks and has all supporting documentation completed.

These quality assurance measures are conducted for all of our products, according to the current standards and guidelines in effect at that time. This continuous manufacturing quality control guarantees product performance characteristics, and enables complete documentation from the raw material to the final product.

Naue Fasertechnik geosynthetics also undergo third party quality process checks that are typically performed twice a year. Independent experts obtain test specimens from the different Naue production facilities as well as from the various product inventories. The properties of the geosynthetic products are tested and documented in detail, including the notation of production processes, the type and extent of the manufacturing quality control and any other relevant observations.

Project Specific Product Properties

In special cases, independent experts are retained to test project specific product properties and to certify the test results. This testing is in addition to and completes the manufacturing quality control carried out on the raw materials as well as the finished products.

Quality Management According to EN ISO 9001

Since December 1994, the geosynthetics development, production, sales and geotechnical engineering divisions of Naue Fasertechnik GmbH & Co. KG have been certified according to EN ISO 9001. This certification is regularly validated by scheduled audits.

With the aid of this integrated quality management system, the requirements of the customer and/or the projects are understood and fulfilled. While we continually strive to improve the quality level of our existing products and services, a high quality foundation is guaranteed by our EN ISO 9001 standards.

Compulsory CE-marking

From 1st October 2002, CE-marking for most geosynthetics is compulsory (except for sealing systems and erosion control mats). The CE-marking certifies that a product corresponds to the product-specific European guidelines for specific applications and functions (separation, filtration, reinforcement, protection and drainage). By 1st October 2002, Naue Fasertechnik had taken all necessary steps to put into effect the compulsory CE-marking. ■





Static puncture test according to EN ISO 12236



Determination of the hydraulic properties of water permeable geosynthetics



Load plate-bearing test for the qualification of geotextile protection layers (EN 13719)



Determination of the strength and elongation properties of single fibres (DIN 53816)



Direct shear device for the determination of friction coefficients (EN ISO 12957 T1)



Raw material identification according to the DSC method



Determination of the bonded peel strength of Bentofix® geosynthetic clay liners ASTM D6496



Melt Index via ISO 1133



Determination of the montmorillonite content of bentonite via the methylene-blue-adsorption (titration) method

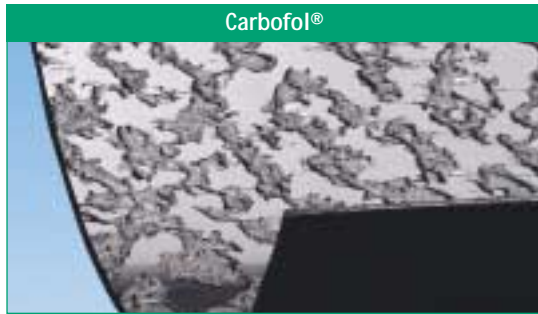


Tensile test on Carbofol® geomembranes (ISO 527)

Products

The innovations of Naue Fasertechnik are leading the geosynthetic industry into the future. We offer project

specific product development, geotechnical engineering support, and provide solutions to complicated challenges,



Carbofol® geomembranes are made with high density polyethylene (HDPE). They are available in different thickness' as well as with different surfaces for all of your sealing tasks.



Bentofix® is a needle-punched reinforced geosynthetic clay liner (GCL) that uses two geotextile layers to encapsulate a layer of natural sodium bentonite. The needle-punched fibres transmit shear forces through the bentonite core. It is used as a sealing barrier against liquids and gases in various civil and environmental applications.



Secutex® is a needle-punched staple fibre nonwoven geotextile used for separation, filtration, protection and drainage. Secutex® can be used in many civil engineering applications such as hydraulic engineering, landfill engineering, road construction as well as tunneling.



Secudrän® is a three-dimensional drainage system designed to discharge liquids and gases. It consists of a drainage core and one or more filter layers on the outer surfaces to protect the drainage core from clogging. All layers are uniformly bonded together to ensure high internal shear strength.

Data Facts Figures

Examples of interface shear values

between different geosynthetics and soil. The indicated approximate values result from over 15 years of project experience. The specific design values must be determined on a project by project basis and follow as close as possible on-site conditions.

■ Thermally fused nonwoven achieves the higher value

■ Is rarely designed

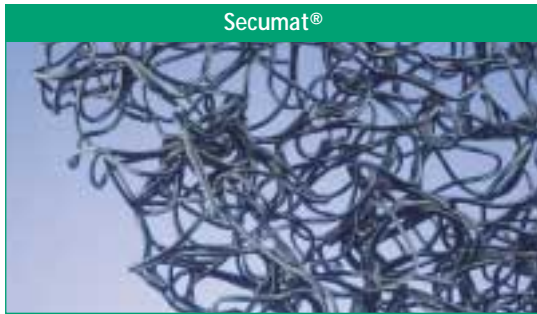
	Bentofix®	Secudrän®	Secutex® nonwoven	Carbofol® smooth	Carbofol® Friction	Sand 0/2 mm	Gravel 8/16 mm	Mixed grained top soil
Bentofix®	33°	19-25°		11°	30°	29°	32°	26°
Secudrän®	19-25°			11°	30°	29°	32°	26°
Secutex® nonwoven			18°	11°	30°	29°	32°	26°
Carbofol® smooth	11°	11°	11°			18°		
Carbofol® Friction	30°	30°	30°			25°		
Sand 0/2 mm	29°	29°	29°	18°	25°	32°	-	-
Gravel 8/16 mm	32°	32°	32°			-	36°	-
Mixed grained top soil	26°	26°	26°			-	-	28°

Suggested geosynthetics as geomembrane protection layer, based on project experiences

confining stress			mass/unit area	product name
Waste	up to 15 m	mechanically bonded nonwoven	800 g/m ²	Secutex® R804
	up to 25 m	mechanically bonded nonwoven	1,200 g/m ²	Secutex® R1204
	up to 35 m	mechanically bonded nonwoven	2,000 g/m ²	Secutex® R2004
	up to 50 m	mechanically bonded nonwoven	3,000 g/m ²	Secutex® R3004
cover soil	up to 1 m	mechanically bonded nonwoven or geosynthetic composite drainage system	800 g/m ² / 1,000 g/m ²	Secutex® R804 or Secudrän® R201 WD601 R201
	up to 1 m	mechanically bonded nonwoven or geosynthetic composite drainage system	1,200 g/m ² / 1,000 g/m ²	Secutex® R1204 or Secudrän® R201 WD601 R201

simplifying your project. Naue Fasertechnik has decades of experience in the development and production of high

quality geosynthetics, offering complete geosynthetic solutions.



Secumat® is a three-dimensional erosion control mat consisting of a UV-stabilised labyrinth-like polymer core. Secumat® controls surface erosion by ensuring rapid vegetation growth on slopes while preventing soil erosion during heavy rains and water flows.



Combigrid® is a bonded composite of a high strength, low elongation Secugrid® and a needlepunched Secutex® nonwoven geotextile for soil stabilization and filtration applications.

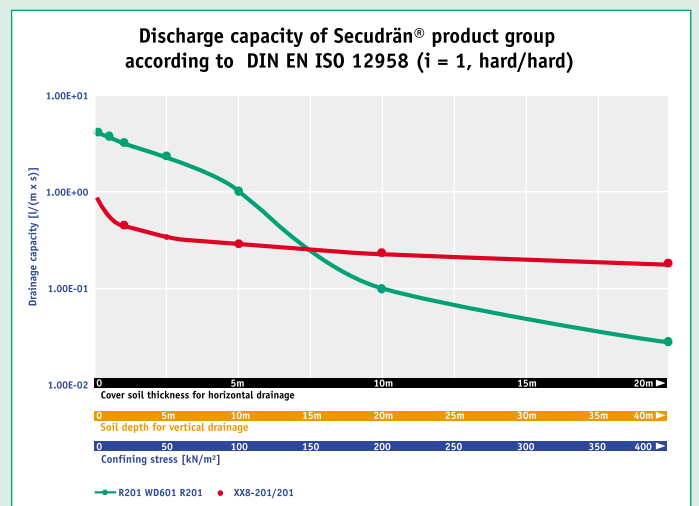
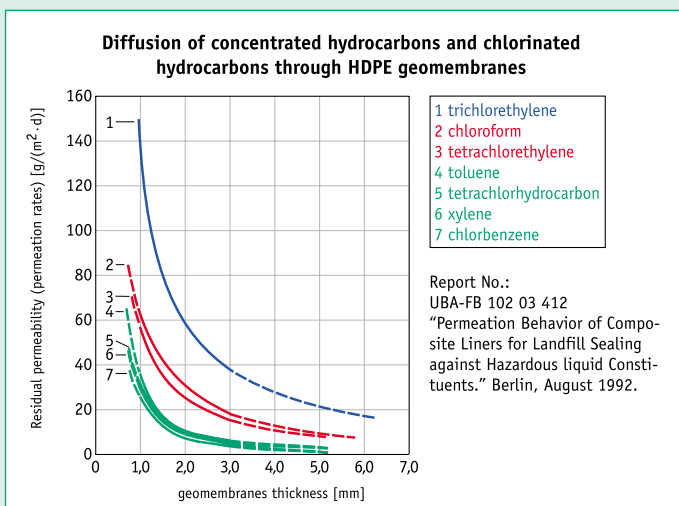


Secugrid® is a geogrid made of flat extruded monolithic bars with welded junctions. It is used for soil reinforcement in earth works, road construction, segmented wall construction, landfill engineering and hydraulic engineering.

Contact us -
we have the solutions!



Data Facts Figures



Further information on the subject **geosynthetics** are available through our website or from our:

- **corporate brochure**
- **application related brochures:**
 - Groundwater protection
 - Civil Engineering
 - Hydraulic Engineering
 - Waterproofing Manual
- **application related flyers and technical flyers with project specific solutions**



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