HYDRAULIC ENGINEERING
with Geosynthetics

NAUE




HYDRAULIC ENGINEERING

CONTENT

INTRODUCTION

Geosynthetics are used in every major sector of civil engineering. One that has grown substantially in importance is hydraulic engineering. Flooding, coastal erosion, more frequent and intense storms, tsunami triggered flash-floods, expected sea-level rise, natural disaster prevention and other infrastructure concerns have prompted a call for solutions that are extremely durable, minimize a construction's carbon footprint, require less land disturbance, and are easier to implement. The sheer scale of needs in hydraulic infrastructure also puts an emphasis on finding economical solutions without sacrificing safety and long-term performance.

The performance, adaptable design options, and economics of geosynthetics have brought them into hydraulic engineering projects more each year.

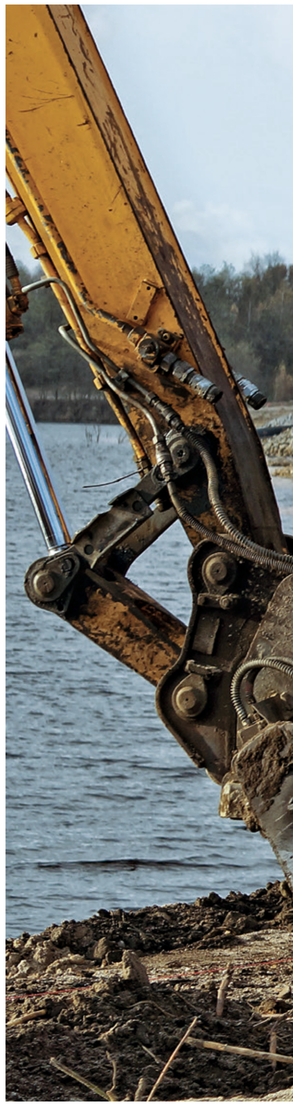
Geosynthetics provide filtration, sealing, protection, containment, separation, reinforcement, and erosion control solutions for canals, beaches, sea walls, waterside retaining structures, ports, levees, dams, offshore wind turbines, and much more. They replace, improve, or minimize the need for more costly, older engineering solutions.

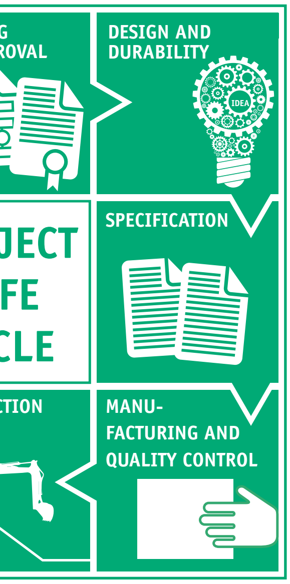
The full range of geosynthetics are utilized: geotextiles, geomembranes, geogrids, geosynthetic clay liners, drainage materials, and others.

NAUE manufactures and supports design with all of these materials in hydraulic applications.

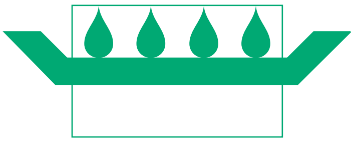
Sand-filled nonwoven geotextile containers and tubes provide scour protection and stabilize beaches. Weighted materials such as sand ballasting mats and geosynthetic clay liners may be installed underwater. Geomembranes and geosynthetic clay liners protect water resources against pollution and seepage loss. Geogrids, geocomposites, and turf reinforcement mats strengthen levees.

The range of work is broad and the beneficial impact of geosynthetics in these projects is substantial.



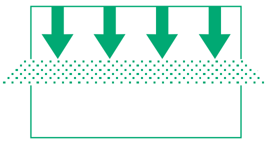

DESIGN AND
DURABILITY
IDEA
SPECIFICATION
MANU-
FACTURING AND
QUALITY CONTROL

FUNCTIONS



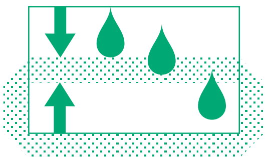
Sealing

Acting as liquid and gas barriers, geomembranes have become a fundamental component in landfill engineering as well as 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 thicknesses of more than 1.5mm, 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 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. 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.

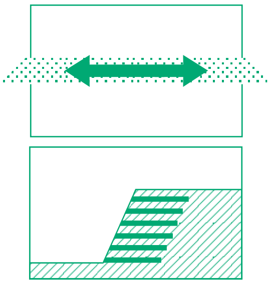


Containment (Packing)

Geosynthetic containment (packing) applications are those in which a geotextile in the form of a tube, bag or container, is used to encapsulate a construction material, such as soil or sand. They perform project-specific functions such as protection, filtration and separation. Nonwoven geotextiles as well as geocomposite products are the primary products for these applications due to their high elongation capacity.

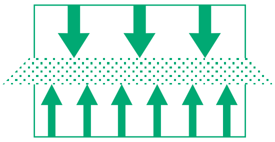
Drainage

Drainage materials are required for the surface collection of precipitation, the subsurface collection and diversion of groundwater and 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 preformed composite drainage elements. Composite drainage elements consist of at least one filter layer and one drainage collection layer. The drainage collection layer is required for the flow and discharge of fluids at a collection point, without the build-up of hydraulic pressure. Single and multiple component geosynthetic drainage systems made from high density polyethylene as well as polypropylene will often replace the conventional thick mineral drainage layer.



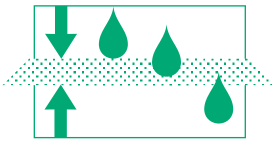
Reinforcement

Geosynthetics are installed beneath or between soil layers to improve the mechanical properties of soil layers by assuming the tensile forces and minimizing 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 minimizes expensive constructive measures, can reduce soil intermixing and eliminates the need for additional soil layers.



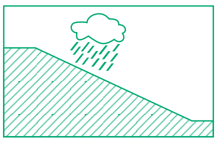
Separation

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 engineering, landfill engineering and sport fields.



Filtration

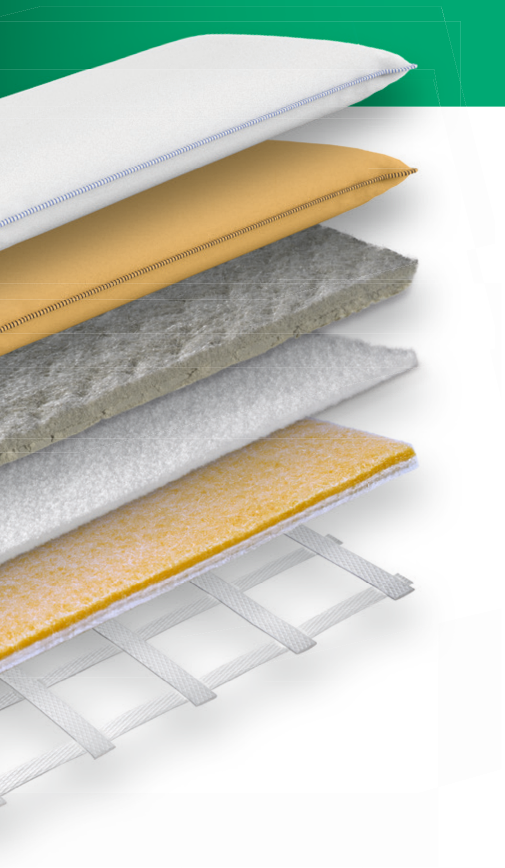
In filtration applications and drainage systems, nonwoven geotextiles are employed to retain soil particles while allowing the vertical passage of liquids through the filter media. There are two aspects to filtration that should be evaluated when designing. The mechanical filter efficiency (does the fabric have sufficient soil retention capacity) and the hydraulic filter efficiency (does the water discharge without building up hydraulic pressure). As with mineral filter layers, the geotextile thickness directly benefits the long-term mechanical and hydraulic efficiency of the filter.



Erosion control

Geotextiles or three-dimensional open structured geosynthetics can be used to minimize the movement of soil particles due to flow of water. By preventing soil particles from being washed off slopes or channels, rapid vegetation is ensured when erosion control mats are employed.

COASTAL PROTECTION



The hydraulic engineering sector was actually one of the earliest adopters of geosynthetics. One of the earliest and often quoted projects designed with geosynthetics is the Valcros Dam in France (1970). More than a decade before that, practitioners in the US and Europe used geotextiles for coastal protection works.

A common application in coastal works is to use a geotextile, such as NAUE Secutex® H, as a separation, filtration and erosion control layer. Geotextile underlay, topped with either sand/soil or stone, prevents wash out of the sediments below. This ensures that even if a hard storm affects the layer above, the geotextile prevents further erosion.

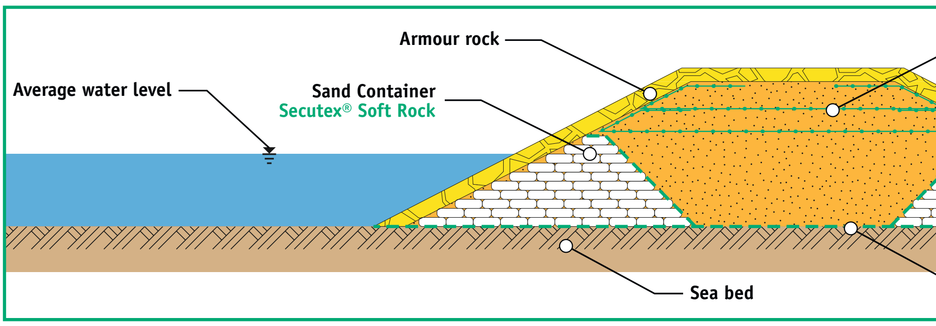
Sand-filled nonwoven geotextile bags, containers or tubes (e.g., Secutex® Soft Rock) provide scour protection for wave-exposed structures. They protect port walls. They create artificial reefs and stabilize beaches. Of note, these highly durable bags, containers and tubes can be filled with site soils, making them efficient and cost-effective.

In dykes, geogrids and geotextiles strengthen flood defenses. They enable taller, more efficient construction and long-term strength against daily wave forces and surges. Geosynthetics are also used to prevent erosion of the core of a dyke, which can occur in unprotected systems when water overtops and begins to carve out the dyke's "dry" side.

Whatever the application, nearly every coastal protection application must have a robustness. Seaside environments are challenging. Loads are frequent and fluctuating. There is considerable moisture to soften soils. Swift changes in weather and wave forces can occur and stress different points of a construction.

NAUE's decades of manufacturing experience and design, supply, and installation of geosynthetics give a detailed understanding of the challenges in hydraulic applications. Our materials are designed to survive the difficult environments and provide long-term protection of coastal infrastructures.

Figure 1
Cross-section of a safe groyne with NAUE geosynthetics

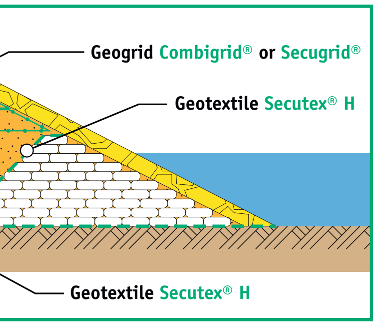


UNDERWATER INSTALLATION

In some cases, underwater installation of a geosynthetic solution is possible. For coastal defense works, NAUE Secutex® HB 751 sand ballast mats can be used. This uniquely engineered product features a sand layer encapsulated by two durable geotextiles. The increased density allows it to sink in water for simplified, more efficient installation and material control during hydraulic engineering applications.

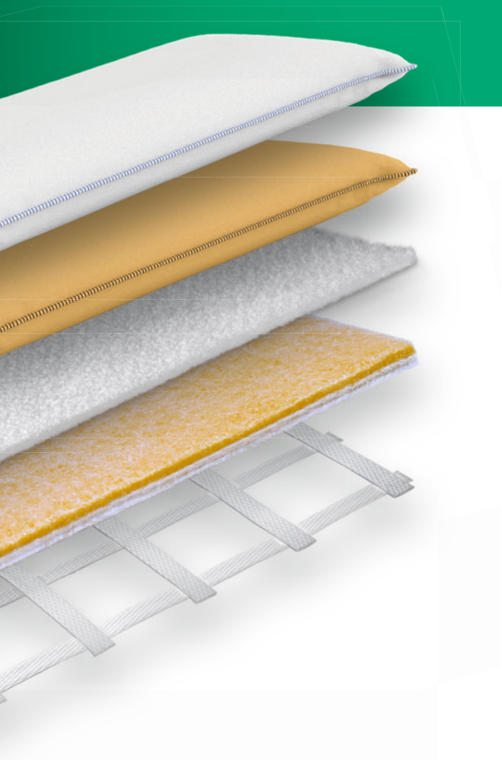
SAND-FILLED GEOTEXTILE CONTAINERS

Secutex® Soft Rock is a geotextile-based system for sand-filled bags, containers, and tubes. The needle-punched Secutex® filter nonwoven geotextile provides a highly durable solution for the efficient construction of coastal structures, dune security systems, and scour protection designs.



Secutex® Soft Rock provides an alternative to conventional rock materials such as riprap, gravel filters, and other hard armour and aggregate solutions. The availability of different sizes, weights, and fill capacities makes it a highly flexible design solution. The decades of performance in applications such as scour protection and the ability to use local sands and soils makes it a very sustainable solution in coastal protection.

OFFSHORE



The Amrumbank West offshore wind farm is located 35km north of Helgoland, Germany and 37km west of the North Frisian Island of Amrum. It extends over 34km² and has 80 Siemens 3.6MW class wind turbines and a generating capacity of 288 megawatts. How can offshore installations like this protect their turbine footings from ocean scour? Nonwoven geotextile containers replace the typically several meter thick bedding layer of expensive large stones or rocks.

For monopole offshore installations, Secutex® Soft Rock sand containers have been used, including GPS support for precise seabed placement. The containers are fabricated from a Secutex® highly robust, staple fibre, needle-punched nonwoven geotextile. Containers are sewn together and closed after sand filling with a high-performance durable yarn. After sand filling, the container remains flexible and can adapt to variable seabeds. Secutex® Soft Rock offers outstanding long-term stability, a high contact angle of friction, high permeability, and high abrasion resistance.

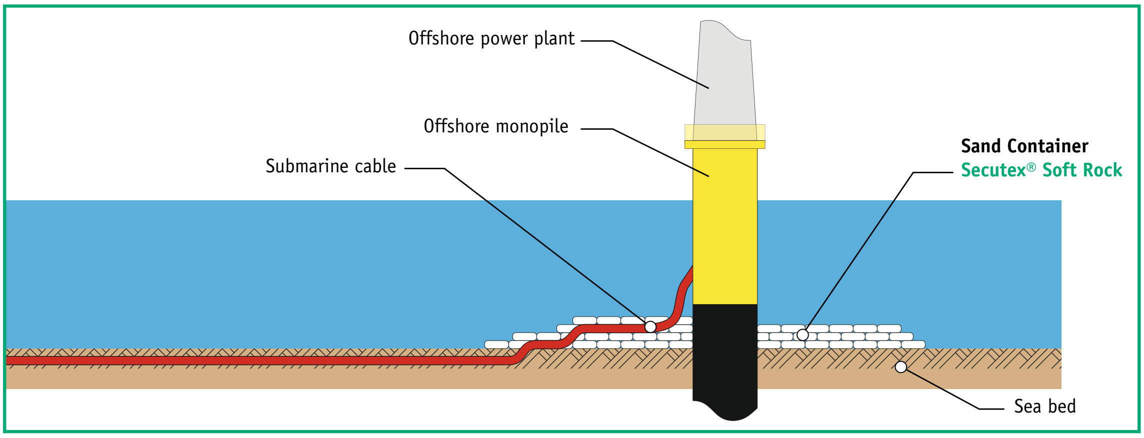
This geosynthetic solution enables the use of on-site fill, which provides considerable savings on material acquisition and transportation. It also shortens the construction window. Additionally, the nonwoven geotextile sand containers allow a decoupled construction process, because they can be installed before ramming of the monopile and unlike the rock bed they do not damage the coating of the monopiles when driven through the protection layer deep into the seabed.

This construction solution protects the turbine footings and other offshore structures against seabed washout and erosion around the structure.

Groyne Construction

Secutex® H filter mats are used in the construction of groynes. They have even been combined with traditional willow bundles (fascines) in large mats. For a North Sea project at the mouth of the Elbe River, fascines were affixed to 30m x 70m geotextile mats. Tugboats pulled the mats into position in the waters and the mats were weighted with small stone to sink. The process established the base of the groyne system. The full installation was completed with the addition of large stone.

Figure 2
Typical cross-section for a sand-filled Secutex® Soft Rock geotextile container protected offshore monopile

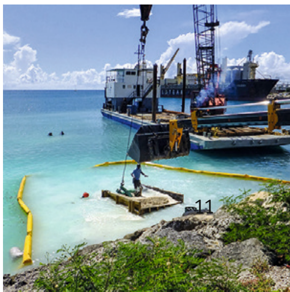


OFFSHORE ADVANTAGES WITH NAUE

Offshore installations such as port walls, monopiles for wind turbines, and groynes can be subjected to significant and erosive wave forces. Geotextile-based systems can provide the filter stability and abrasion resistance for true scour protection of these installations. This ensures that offshore structures provide the service lives for which they are designed.

NAUE Secutex® H provides exceptional durability for long-term scour protection. Filter stability is provided by the durability-enhancing strength of the needle-punch manufacturing process for NAUE's nonwoven geotextiles.

The selection of Secutex® H geotextiles for offshore installations also provides significant ecological advantages by way of greater reuse of site soils, decreased transportation costs for material delivery to site, and simpler, faster, more affordable constructions that last longer.



CANALS

Commercial, agricultural, and recreational canals continue to be important economic drivers in many countries. A wide range of geosynthetic products, such as geotextiles, geomembranes, and geosynthetic clay liners (GCL), help create more efficient waterways. These geosynthetics improve the long-term performance of canal systems by preventing bed and slope erosion and by decreasing significantly the risk of problematic sedimentation. The oldest canal installation carried out with a NAUE nonwoven geotextile is a testament to the long-term durability and success of geosynthetics in erosion control applications. The Mittelland Canal in Germany incorporated NAUE geotextiles in 1967. In 2017, the project marks its 50th anniversary.

Water quality is preserved, water flows more dependably, and canals continue to operate as intended. When installed below permeable revetments (e.g., riprap) as a filter layer, needle-punched nonwoven geotextiles (e.g., Secutex® H) prevent erosion and soil displacement, even under high hydrodynamic loads. The high elongation capacity and robustness of the nonwoven geotextiles allow them to easily accommodate to irregular and soft subgrades.

Geotextiles are also used in protection applications with canals, such as to separate a barrier material (e.g., geomembrane) from a cover aggregate. When geotextiles like Secutex® H are used this way, the canal lining system takes full advantage of the durability properties of the nonwoven geotextiles. The lining system is protected against damage during installation, which is crucial to ensuring its proper performance in service.

Barrier geosynthetics such as Bentofix® GCLs and Carbofol® geomembranes are used to improve canal performance in numerous applications.

For irrigation canals, geosynthetic lining systems prevent seepage loss into soils. This improves the economics and sustainability of the irrigation system. The geosynthetic barrier also optimizes water flow in the canal network. Irrigation is conveyed more quickly and efficiently. For hydroelectric canal systems, water is delivered to the power generating stations more dependably and cleanly.

Commercial and recreational canals also benefit from the installation of geosynthetic lining systems. Carbofol® geomembranes and Bentofix® GCL barriers can prevent sedimentation of waterways from high flow or from propellers stirring up the water along the bed. Where water levels are at an elevation higher than the natural groundwater level, the seal guards against seepage loss, thus keeping the canals open to safe navigation.

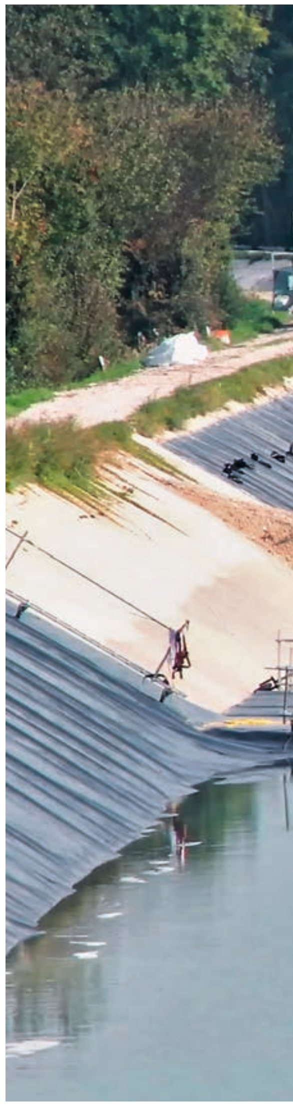
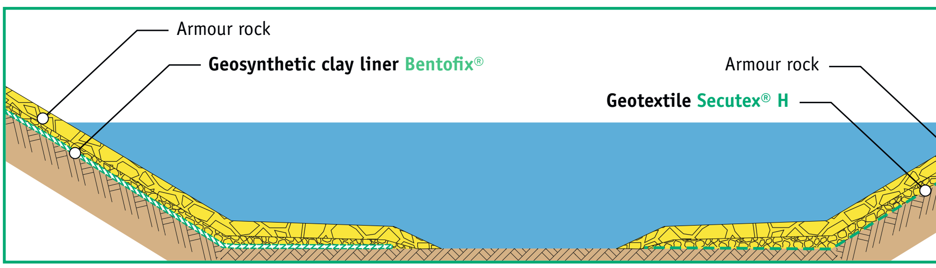


Figure 3
Cross-section of Bentofix® GCL lined slopes of a waterway canal



UNDERWATER INSTALLATION

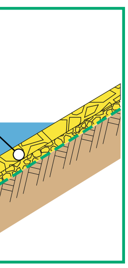
Bentofix® geosynthetic clay liners can be installed underwater during active canal operations. One type of Bentofix® (BZ 13-B) uses a composite construction with a sand ballast mat. For canals undergoing rehabilitation, this GCL-sandmat composite can give an aging network new life without taking the system out of service.

GEOMEMBRANE OPTIONS

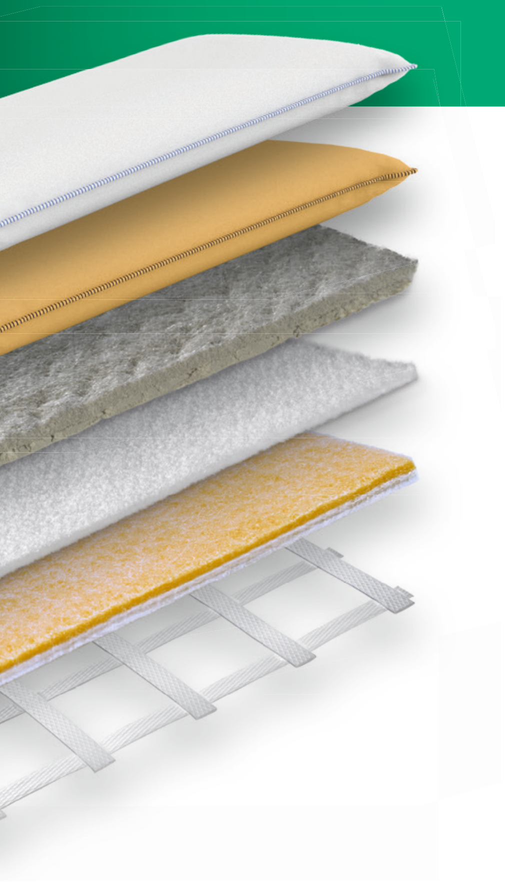
Carbofol® geomembranes are available in smooth and textured varieties to optimize designs for better flow, more effective transfer of shear forces, and more secure slope lining. These barriers may be used in water-covered, partially exposed, and fully covered (by soil or concrete) designs.

ROBUST PROTECTION

Nonwoven geotextiles, such as NAUE Secutex® H, perform many critical functions for canal systems. They cushion and protect containment geosynthetics. They prevent erosion and separate disparate soils. They filter out sedimentation and guard against washout. Ultimately, their robustness and versatility help ensure long-term, successful performance for canals.



SCOUR PROTECTION



Flowing water presents significant challenges. Currents erode banks and stir up sediments. They scour out soils at the base of bridge piers. Beachfronts get washed out and infrastructure is weakened. For canals, channels, rivers, and waterfronts, numerous geosynthetics are used to mitigate the impact of moving water.

Sand-filled geotextile bags (e.g., Secutex® Soft Rock) are used to provide scour protection for offshore wind turbine footings, port walls, bridge pilings, and other structures. Their filter stability and long-term durability resist the prolonged impact of wave forces and flowing water erosion. They are also an extremely efficient and economical solution, through enabling a greater re-use of local soils for filling the scour protection geocontainers, sand bags, and tubes.

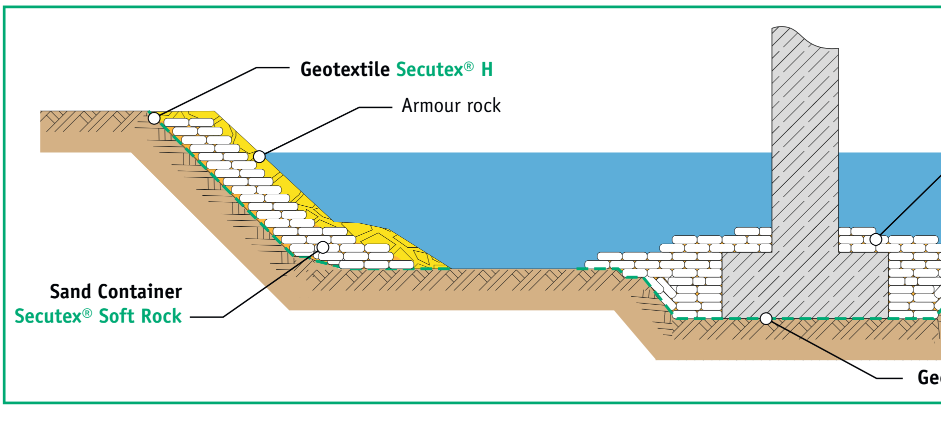
Where cavities have already occurred in a waterway due to scour, sand-filled containers can be installed to fill the space. The robust, needle-punched nonwoven geotextile material (e.g., Secutex® H) is durable against rough site conditions and prevents further scouring.

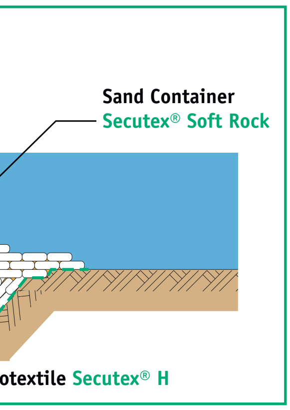
Barrier geosynthetics are also used to prevent the wash out of soils in flowing waterways. In irrigation, commercial, and hydroelectric canals, geomembranes and geosynthetic clay liners improve water flow and prevent currents from eroding canal beds and slopes.

Sites that benefit from lining system protection against scour include dams, dykes, canals, mining applications, and many others.

Bentofix® geosynthetic clay liners and Carbofol® geomembranes provide this sealing support. Depending on the force of water flow and site conditions, additional geosynthetic support such as a protection geotextile may be used.

Figure 4
Scour protection with NAUE geotextiles and sand filled geotextile containers in a river application





ECOLOGICAL AND COST BENEFITS

NAUE's geosynthetics offer long-term performance for infrastructure in and around moving waterways while reducing the carbon footprint both of the construction and the lifetime operations. In constructing with geosynthetics like Carbofol® geomembranes, Bentofix® GCLs, and Secutex® H nonwoven geotextiles, water quality is improved when scour is prevented. Removing the threat of scour also improves the service life and maintenance requirements for the site, which ultimately reduces site soil disturbance.

The durability and filter stability of Secutex® Soft Rock geocontainers reduce or eliminate the need for special fill in installations, and the lightweight, efficient character of these geosynthetics in delivery to site (versus conventional aggregate) means significantly fewer trucks are needed in transport.

Some Bentofix® products can even be installed in very wet conditions or underwater, which can enable a waterway to remain in operation during rehabilitation or for construction works to proceed safely despite difficult weather conditions. The design of NAUE geosynthetics into these sections of infrastructure at risk of scour can eliminate the scour risk while making construction more efficient, improving water quality and dependability of water delivery, minimizing long-term costs, and extending service lives.

HYDRO-
ELECTRIC
POWER

Hydropower generates roughly 17% of the world's electricity and 70% of global renewable energy. Canals, dams, pumped storage stations, and other engineered structures are all part of the vast hydroelectric infrastructure. Geosynthetics play a strong role in the sector, particularly in rehabilitation of aging hydroelectric facilities and in decreasing the construction costs and long-term maintenance needs of new facilities.

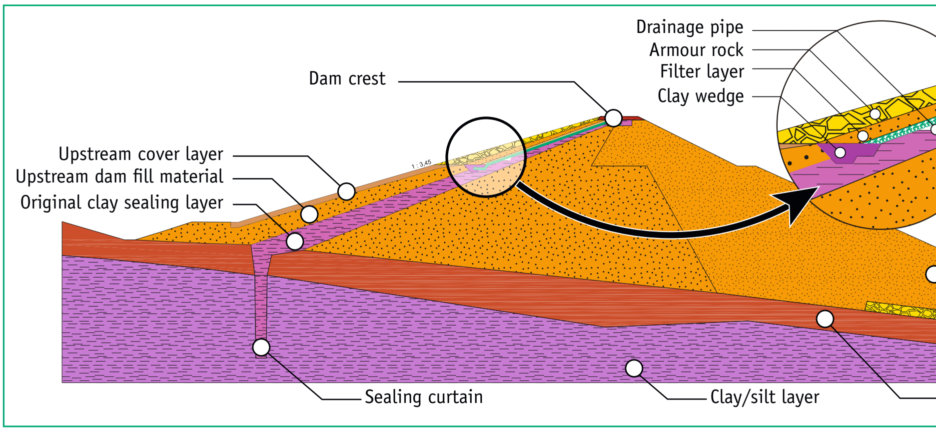
For hydroelectric canal systems, which provide operational waters to generation stations or navigation ways around generation points, a variety of geosynthetics are used. Geomembranes can provide cleaner, swifter flow of hydroelectric water supplies, just as geosynthetic clay liners can.

Pumped storage systems are highly efficient means for balancing electrical grids. Water can be stored during non-peak times and released at peak into the hydroelectric generation system. In this way, strain on the system and the cost of responding to fluctuating electrical demands decreases. Geosynthetic barriers, such as Carbofol® geomembranes and Bentofix® GCLs, are used to provide storage security in these facilities to increase operational efficiency.

With dams and power stations, geosynthetic reinforcement can be used to replace more conventional and significantly more expensive concrete retaining walls. For example, the use of a NAUE m³ system for the wing walls of a hydropower station in Turkey saved 40% on the originally proposed concrete wall design. The use of Secugrid® geogrids and nonwoven geotextiles in the MSE system also replaced what would have required 700 trucks of special concrete pour.

Whether construction is new or a site is being rehabilitated, geosynthetics make hydroelectric power applications more economical and efficient. Waterways can be deepened, retaining walls can be built with significantly smaller carbon footprints, erosion can be removed from the system, stored water supplies can be more sustainable, and much more.

Figure 5
Cross-section of a huge water pump storage station sealed with a Bentofix® GCL



RENEWED LIFE

While hydroelectric energy continues to develop steadily, a good amount of the existing infrastructure is quite old and requires rehabilitation to continue operations. The Hohenwarte pumped storage facility in Germany is a strong example. After 50 years of operation, the 320 MW-facility renewed its safety and relevance by updating the storage area with Bentofix® GCLs and Secudrain® geocomposites.

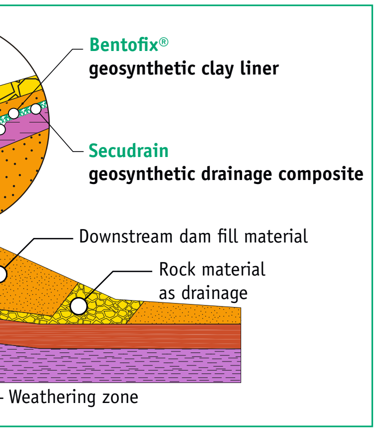
DRAINAGE MANAGEMENT

Geosynthetic drainage systems provide capacity and control. For hydroelectric systems, this is often related to the slopes of storage facilities. The use of a geocomposite drainage solution such as Secudrain® provides capacity for removing water and controlling sedimentation. This combination keeps the overall system cleaner and reduces the impact of rising water on an engineered slope. The Secudrain® line includes multiple constructions to accommodate a site's unique capacity and flow rate requirements.

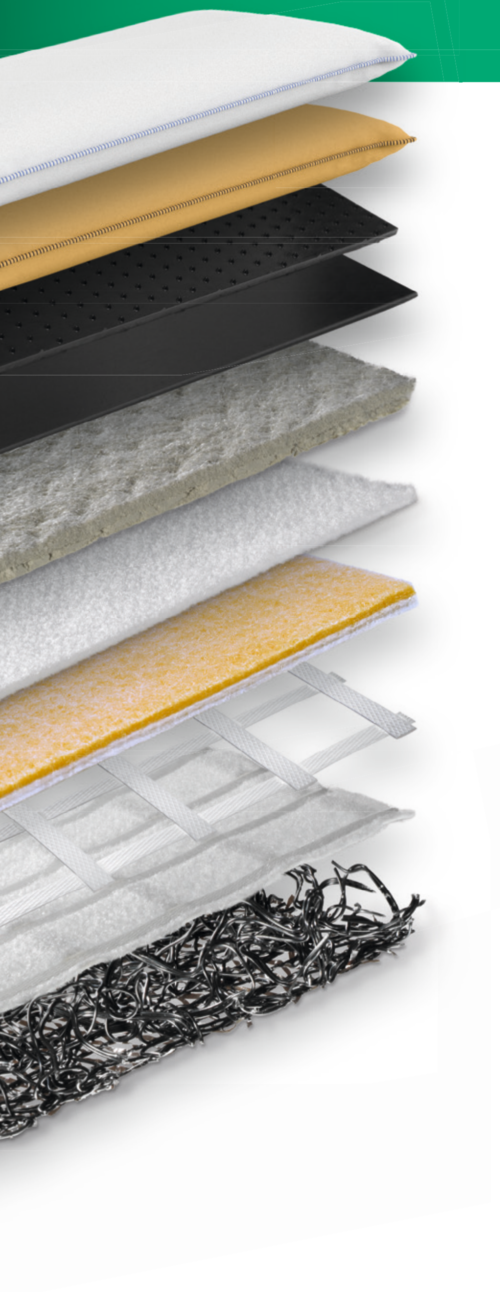
SAFETY WITH GEOSYNTHETICS

Geosynthetics provide hydraulic engineering with what they need:

- Excellent filtration properties
- Robustness and long-term performance
- Good interface friction and shear resistance
- Excellent chemical resistance
- Protection of barrier systems with Secutex® nonwovens



FLOOD PROTECTION



Geosynthetics provide easy-to-implement solutions for flood defenses, with project records extending back 40 years or more.

When waters rise in a levee system, the integrity of the levee itself may be at risk if the water overtops. The "dry" side of the embankment often lacks the engineering found at the expected interface of water and soil/structure. But, if water reaches the other side of the levee, that embankment – often earthen – may develop rills. Erosive water might seep into the core of the levee, weakening it, and precipitate failure.

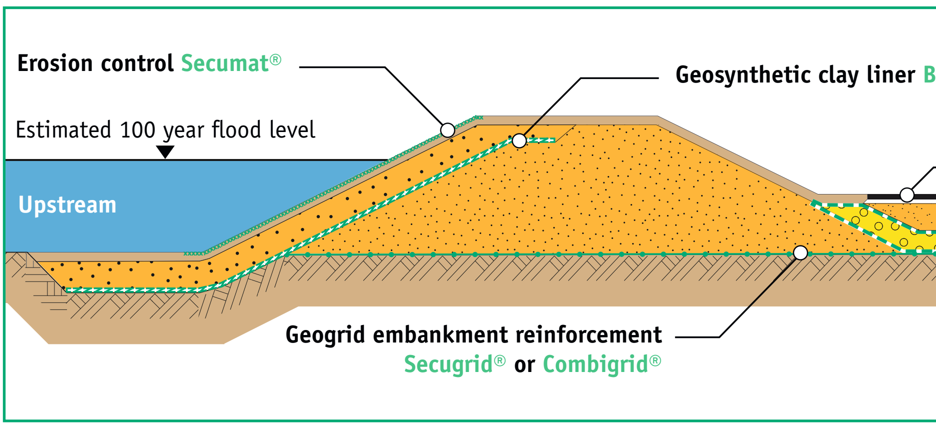
Geosynthetics resolve threats like this, often in ways that can be adapted easily to the local conditions. This flexibility in options is one of the great advantages in incorporating geosynthetics.

For flood protection designs, Secutex® geotextiles provide filter stability, drainage performance, and soil separation. They prevent clogging and guard against piping to maintain the integrity of a flood defense structure.

Carbofol® geomembranes and Bentofix® geosynthetic clay liners provide long-term containment protection. Bentofix® X coated GCL can provide a durable and uniform polyethylene coating on the material's woven side, creating an additional low permeability barrier for exceptional waterproofing.

For earthen embankments and flood plains, Secumat® erosion control materials give roots security and help retain soil in heavy precipitation. The labyrinth-like, three-dimensional matrix of the erosion control matting prevents the sliding and washing out of the soil and cover layer while facilitating rapid vegetation growth. The reinforcing character of the matting prevents erosion under heavy rains and water flows.

Reinforcement geosynthetics are used too. In poor soil conditions or on steeper slopes, Secugrid® geogrids can be used to further ensure slope stability. Combigrid® geogrids are also an option. The unique construction of the product embed a nonwoven geotextile within the high-strength bar of the geogrid, thus providing separation, drainage, and filtration along with the expected reinforcement.



NAUE SOLUTIONS

Overflow protection for dykes can increase the cost of design, and for this reason many dyke systems have historically not had overflow defenses designed into them. Geosynthetics provide cost-savings through various design, construction, and performance means to reduce costs while enhancing safety.

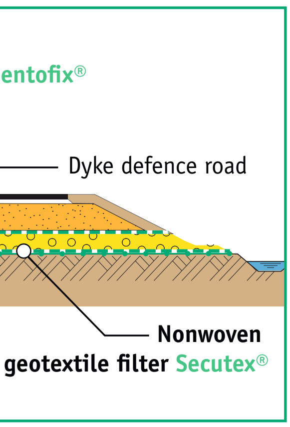
Carbofol® geomembranes and Bentofix® GCLs prevent seepage into the core of an embankment. The special coating on Bentofix® X GCLs enhances root penetration protection into a dyke system.

Bentofix® GCLs provide efficient, long-term lining performance and strong protection in barrier applications. The polymeric coating on the Bentofix® X series provides additional protection against desiccation and root encroachment as well as enhanced hydraulic barrier characteristics.

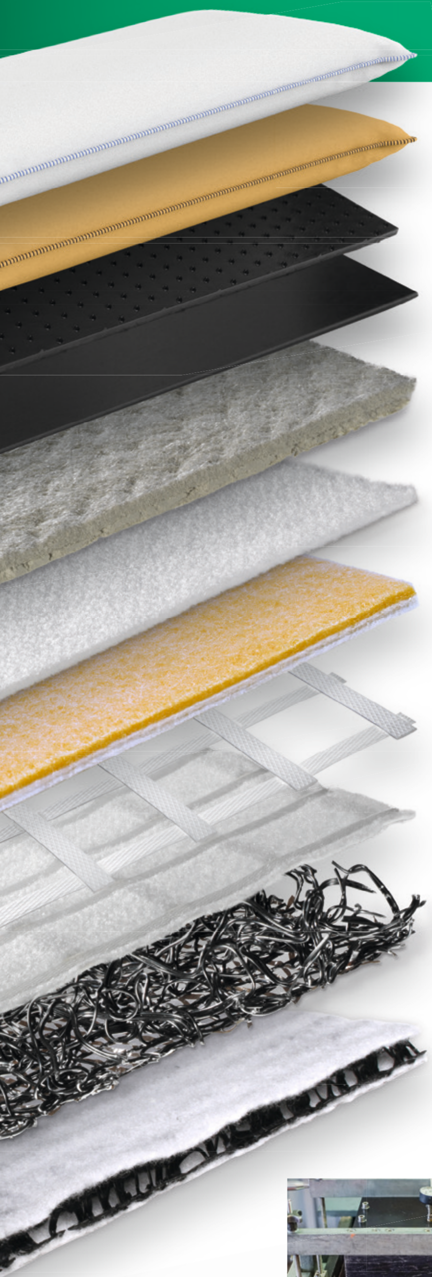
SAVING ON SPACE AND TIME

The thin profile of Bentofix® geosynthetic clay liners takes up considerably less space than conventional compacted clay. In a flood protection design, this can provide substantial savings, as far less soil may need to be removed to install the geosynthetic solution versus compacted clay. The GCL, being a rolled good, can be installed on site much more quickly than compacted clay, which requires timely placement and preparation. Bentofix® GCLs can also be delivered to site in far fewer truckloads than clay, with a single truckload of GCL rolls.

Figure 6
Cross-section of a dam for flood protection with NAUE geosynthetics



QUALITY CONTROL



The performance characteristics of a geosynthetic are determined by components such as its polymer, additive package, fibres, and other raw materials. These components give products their chemical compatibility, UV resistance, durability in exposed or buried conditions, biological resistance, elongation, and other characteristics needed to provide the proper service life and strength in an application.

The quality of these raw materials, the manner in which they are handled and the technology used to manufacture the final product further influence material performance.

Here, the quality control (QC) program of a manufacturer is vitally important to ensuring that a geosynthetic enters service in the field in an optimal condition.

NAUE manufactures geosynthetics in ISO 9001-certified and audited facilities. All products are subject to a strict material analysis. Acceptance test certificates, submitted by base material suppliers, are reviewed and qualified in accordance with product-specific protocols.

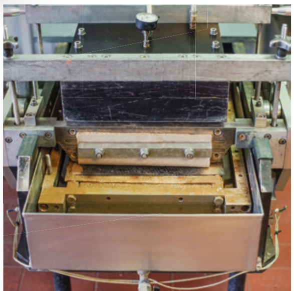
During production, additional quality assurance measures are performed by highly trained team members who are part of a special, autonomous division.

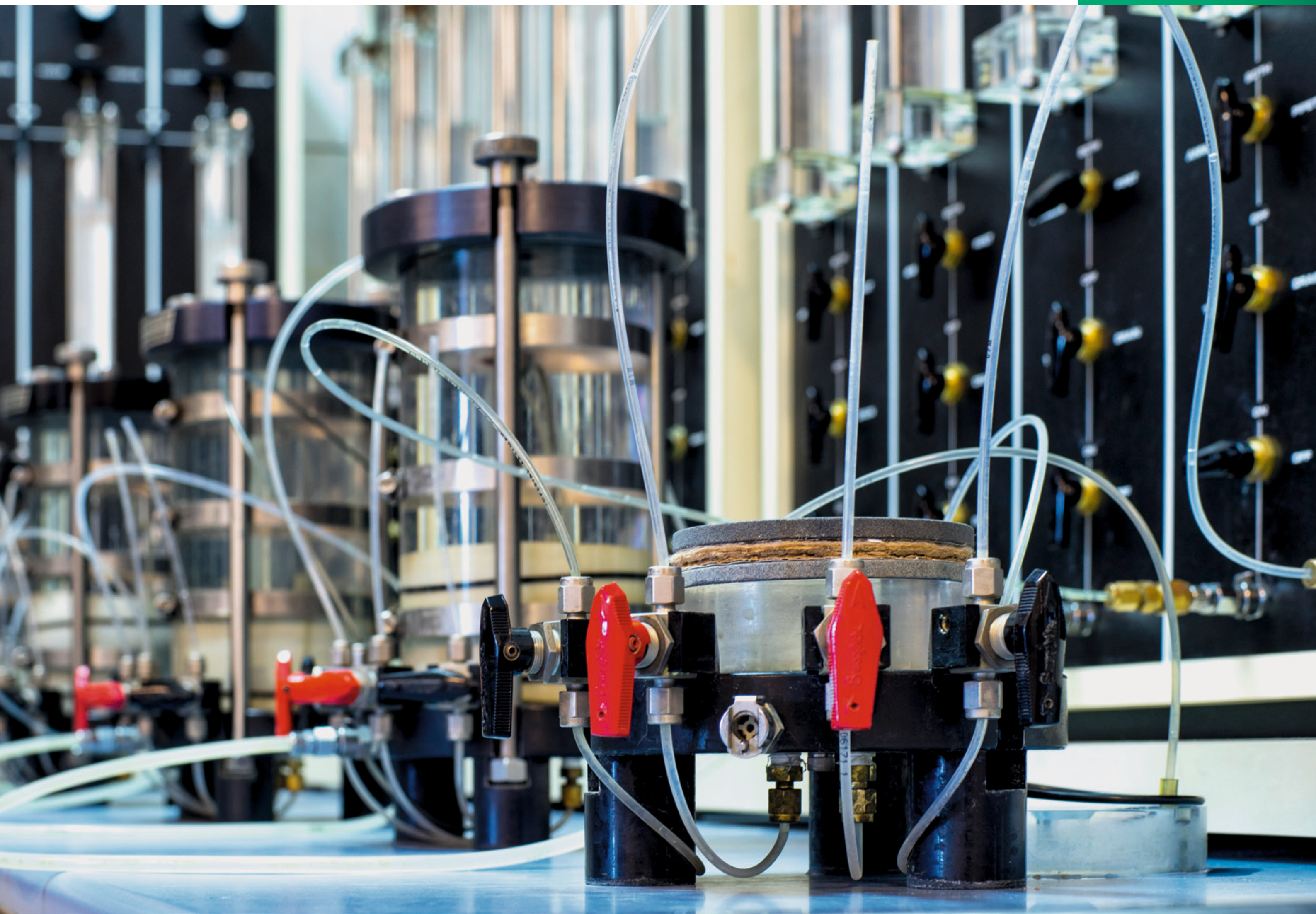
ISO 10204 certificates are available for the manufacturing quality control and assurance measures performed during the production of materials. Products are released only once they have passed all quality reviews and checks and when all supporting documentation is completed.

Continuous manufacturing quality control is at the center of NAUE's operations. From the acquisition of raw materials through production and delivery of the final product, components are thoroughly reviewed, the production process is closely monitored, documentation is constant and storage and handling follow strict rules for ensuring material integrity. These measures are the best guarantee of product performance.

NAUE utilizes independent, third-party review of quality processes, material data, and product inventories. In certain project-specific cases, independent experts are retained to test project-related geosynthetic properties as part of certifying test results.

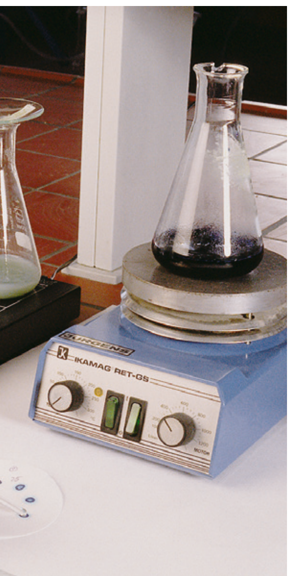
Furthermore, the company has made CE marking compulsory for their geosynthetics since 2002. It is another way in which NAUE establishes quality and trust at every step.





Certified energy management

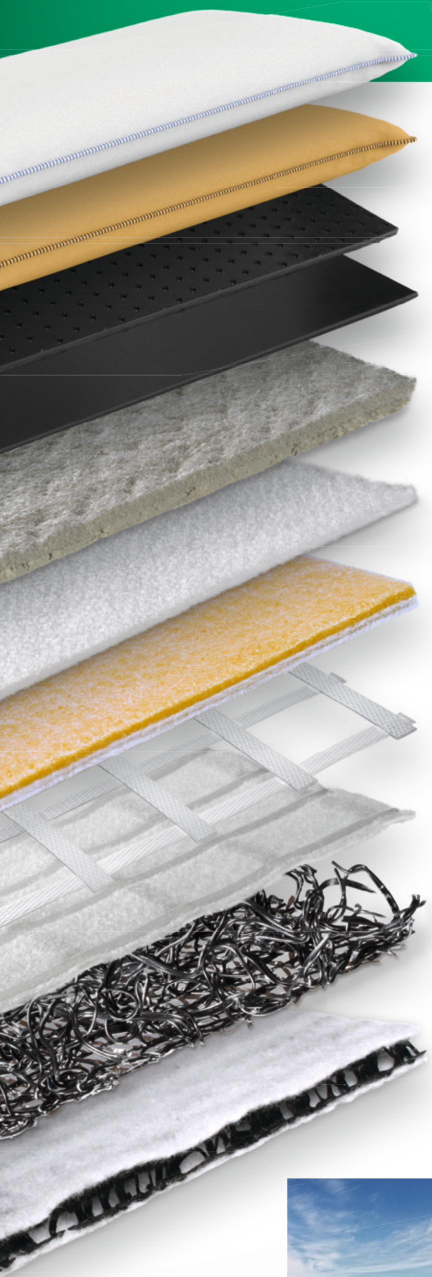
NAUE has dedicated itself to energy efficiency for years, an organizational effort that led to DIN EN ISO 50001 certification in 2016. The goal of our energy management system is to continuously optimize energy consumption and reduce associated CO_2 emissions, with respect to regulatory requirements and larger goals in resource conservation. The framework of NAUE's energy policy establishes energy targets on an annual basis, utilizing past consumption, production data, and profitability measures.



Environmental management

Building on quality and energy management, NAUE has launched an environmental management system and will achieve ISO 14001: 2004 certification in 2017. Essentially, the installation of geosynthetics often saves resources, reduces transport emissions, and increases the service life of construction projects. NAUE's environmental management programme is designed to minimize the environmental impact of our own business as far as possible and to achieve continuous improvements in environmental protection. In addition to the objectives of energy policy, this includes the optimization of processes with regard to natural resource consumption and control of environment-impacting emissions.

PRODUCTS



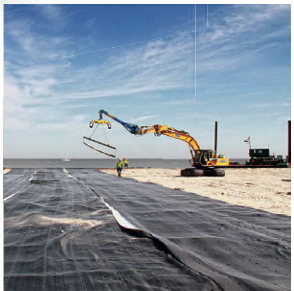
The company's comprehensive range of geosynthetic products serves the diverse geotechnical needs of the hydraulic engineering industry, providing solutions for coastal defense, offshore and coastal scour protection, canals, water supply for hydroelectric power, flood protection, dam constructions and much more.

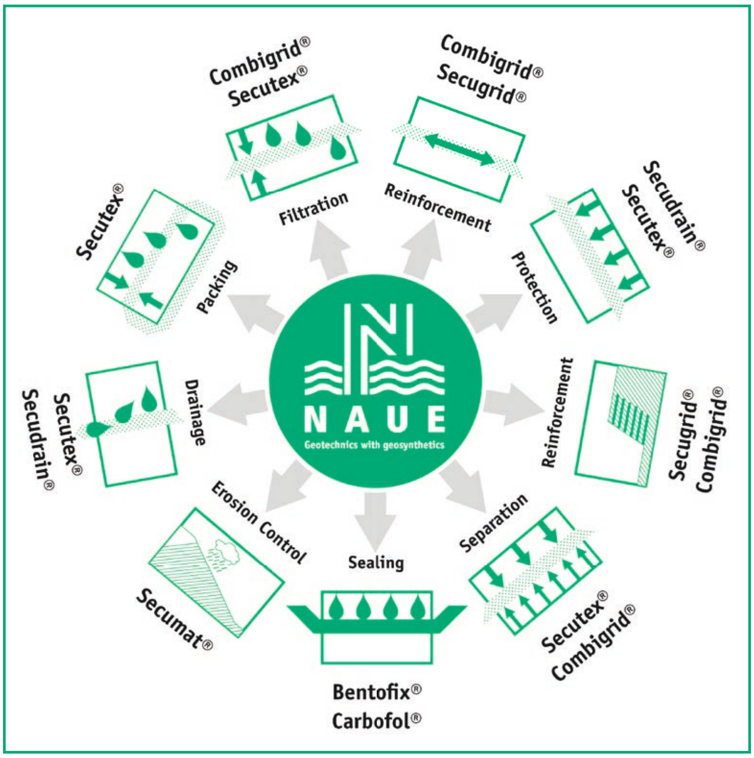
These materials are engineered for long-term performance, delivering economy and environmental effectiveness to landfill operations around the world.

Key products include:
- Bentofix® geosynthetic clay liners
- Bentofix® X polyethylene coated geosynthetic clay liners
- Carbofol® geomembranes (smooth and friction)
- Combigrid® geogrids (composite reinforcement, filtration and separation material)
- Secudrain® geosynthetic drainage/venting materials
- Secugrid® soil reinforcement geogrids (R - uniaxial, Q - biaxial and HS - high strength)
- Secumat® erosion control mats
- Secutex® H filtration, separation, and protection geotextiles
- Secutex® Soft Rock geotextile sand-filled containers, bags and tubes (RS with an additional protection surface)

NAUE geosynthetics are produced with a stringent quality control programme and supported by independent testing, ISO 9001 certification and auditing of processes, strong documentation, and an extensive project and data record.

The company's portfolio meets all the requirements of geosynthetic functions in civil engineering, such as filtration, separation, protection, drainage, erosion control, sealing, containment/packing and reinforcement. The performance of these products extends service lives, improves project economics, and enhances sustainability and environmental protection in engineering works.




Combigrid®
Secutex®
Filtration
Combigrid®
Secugrid®
Reinforcement
Secudrain®
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Packing
Secutex®
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Drainage
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Geotechnics with geosynthetics
Reinforcement
Secugrid®
Combigrid®
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Sealing
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Secutex®
Combigrid®

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Approvals for the NAUE Group

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Bentofix® X2 BFG 5300

Secugrid® Q6 and R6

Secugrid® HS R6