GEOSYNTHETICS

Coastal and Marine Engineering

TenCate GEOSYNTHETICS

TenCate geotextile solutions

TenCate has geotextile solutions for many coastal and marine engineering applications. For these applications, the geotextile acts as a permeable protection layer - a filter - enableing relatively free water movement while protecting the adjacent soil from erosion. TenCate's geotextile filters are used where it is necessary to prevent the erosion of soil through stone and rock layers whiel at the same time allowing the relatively free movement of water. Geotextile solutions are very cost effective as they substitute for single or multiple gravel layers. These solutions, utilizing TenCate's Mirafi® and Polyfelt® geotextiles, can be employed above, at and below water level.

TenCate geotextiles solutions can be applied to the following coastal and marine structures.

Revetments:

Revetments provide surface erosion protection for soils. The outer revetment layer(s) are designed to resist the external water forces while the inner layer(s) are designed to prevent soil erosion. Polyfelt® and Mirafi® geotextiles are used as filters beneath rock revetments to prevent the protected soil from eroding out through the revetment.

Breakwaters and bed protection:

Breakwaters are offshore structures that dissipate wave forces, while bed protection is horizontal revetments that protect the beds of rivers, harbours and ocean outlets from scour. Mirafi® woven geotextiles are used as horizontal filters beneath breakwaters and bed protection to prevent erosion of the foundation soil which can cause instability of the structure.

Dykes and groynes:

Dykes are embankments that retain water and soils, while groynes are small embankment-like structures that control the littoral movement of beach sand. Mirafi® and Polyfelt® geotextiles are used as filters to prevent loss of the retained soil through the stone and rock in dykes and groynes.

Polyfelt® F filtration geotextile beneath rock revetment

Mirafi® FM geotextile beneath rock bed protection

Mirafi® FM geotextile behind rock containment dyke

TenCate Geotube® solutions

Geobag® revetment construction

Geotube® containment dyke construction

Geocontainer® offshore breakwater construction

TenCate has geocontainment solutions for many coastal and marine engineering applications. Here, the geocontainment solutions contain local sand-fill to provide permeable, mass-gravity structures that are resistant to erosion. These geocontainment solutions allow the movement of water while at the same time prevent loss of the sand-fill from the containers. These solutions, utilizing TenCate's Geotube®, Geocontainer® and Geobag® units, can be employed above, at and below water level.

TenCate geocontainment solutions utilize the contained local sand-fill to substitute for imported rock-fill and thus create greater value and better environmental practice. TenCate's geocontainment solutions have lower carbon footprints than conventional, wholly rock-fill solutions.

TenCate's geocontainment solutions can be applied to the following coastal and marine structures.

Revetments:

Geotube® and Geobag® units are used to protect exposed soil slopes from erosion. Here, the locally sand-filled containers replace imported stone and rock to create a stable slope protection layer. For permanent structures, special protection techniques may be required.

Breakwaters and bed protection:

Geotube® and Geocontainer® units may be used for the cores of breakwaters. Here, the locally sand-filled containers replace imported rock-fill to create mass-gravity structures that are stable and erosion resistant. For permanent structures, an outer layer of rock armour and a rock underlayer may be required.

Dykes and groynes:

Geotube®, Geocontainer® and Geobag® units may be used for dykes and groynes. Here, the locally sand-filed containers replace imported rock-fill to create mass-gravity structures that are stable and erosion resistant. For permanent structures, special protection may be required.

Case Study:

Rock revetment, Port Klang, Malaysia

Port Klang is the largest and busiest port of Malaysia. A major expansion of the Westport area of Port Klang involved the development of an integrated complex of container terminals, cement terminal, LPG cargo terminal, ocean going cruise liner terminal, port management support buildings and warehouses.

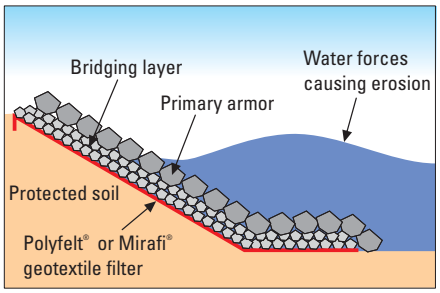
To construct the platform for this complex extensive land reclamation works were carried out. Rock revetments were designed to provide coastal erosion protection for the new reclamation. A Polyfelt TS nonwoven geotextile was used as the filter layer between the armour rocks and the sand fill of the reclamation. The revetmetns were graded to a slope of 1V:3H while the armour rock sizes used were up to 1 m in diameter.

Revetments

Revetments are used in coastal and marine environments to protect the toes of coastal cliffs, bluffs and dunes, and to protect exposed land areas. They may also serve other purposes such as reducing wave energy, limiting wave overtopping or wave reflection. TenCate provides a wide range of geotextile, Geotube® and Geobag® solutions depending on the type of revetment being constructed.

Rock revetments

A revetment is a surface protection layer that is applied to the sloping surface of soils to prevent their erosion by wave action, tides and currents. Rock revetments consist of an outer armour layer designed to resist the hydrodynamic energy; a Polyfelt of Mirafi geotextile filter under-layer designed to prevent erosion of the base soil; and bridging granular layer is commonly constructed using rock but may also be constructed from pattern-placed concrete units, etc. The revetment structure is designed with a freeboard to extend the protection beyond the water run-up expected. If this is impractical due to site conditions the top of the revetment structure may include a capping structure to deflect the run-up.

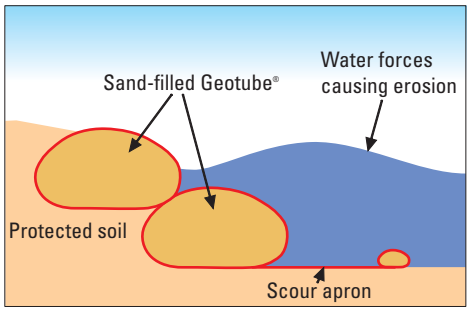


Rock revetment with geotextile filter

Revetments may be constantly exposed to the water forces or they may be submerged. Submerged revetments are normally associated with beach and sand dune protection where the revetment is burried beneath the sand and hence out of sight. When storms occur, the sand may be eroded away from the face of the revetment, but its presence then prevents any further sand erosion. After the storm activity the sand cover is replenished (by natural or artificial means) and the revetment is submerged again.

Geotube® revetments

Geotube® units are also used for revetments. Here, they are hydraulically filled insitu with local sand to provide a mass-gravity structure that is erosion-resistant. Depending on the required height of the revetment multiple Geotube® units may be stacked to a required slope angle. To prevent scour at the toe of the Geotube® revetment, and consequent undermining, a scour apron can be installed prior to filling of the Geotube® units.

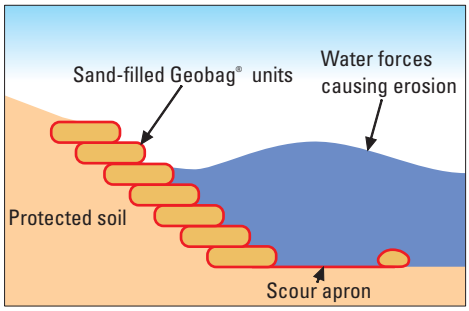


Geotube® revetment

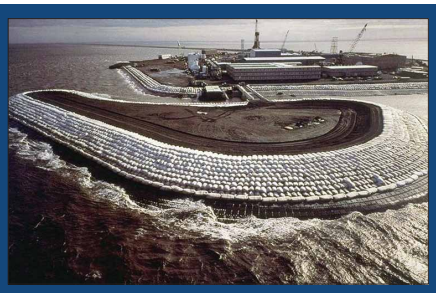
Geotube® revetments are particularly suited for beach protection works because they do not utilize rock and concrete. Here, the Geotube® revetments can be submerged beneath a sand covering, and when exposed during storm activity, can protect the rear of beach fronts from erosion. Following the storm, the beach can be replenished by either natural or artificial means, and the Geotube® revetment coverted again.

Geobag® revetments

Geobag® units are also used for revetments. They are sand-filled to maximum density on site and then pattern-placed to provide maximum revetment stability. Geobag® revetments may be exposed or may be submerged. When constantly exposed they may have a limited lifetime.



Geobag® revetment



Case Study:

Geobag® revetment, Endicott Island, Alaska, USA

Endicott Island is a 0.2 km2 artificial island located 4 km offshore of the Sagavanirktok River Delta in the Alaskan Beaufort Sea. It is 1900 km from the North Pole and 400 km North of the Artic Circle. The island was constructed in 1987 for the purpose of extracting and processing oil reserves of the Endicott oil field and is still in use today. It consists of an offshore oil production facility, a desalination plant, and a wastewater treatment plant. This was the first continously producing offshore oil field in the Arctic, producing around 20,000 barrels of oil per day. Processed oil is sent from Endicott Island through a 38 km pipeline to the Trans-Alaska Pipelne, and then to Valdez, Alaska.

The islanf was created using locally dredged gravel. The gravel was also used to fill the Geobag® units to form the outer revetment layer protecting the shoreline of the island. These Geobag units have had to survive freezing conditions for the most part of the year as well as resist wave attact during summer storms.

Breakwaters and bed protection

Case Study:

Offshore breakwater, Kerteh, Malaysia

The Peninsular Malaysia oil and gas production on-shore base camp is situated within Kerteh Bay. This development was exposed to direct wave attack which can be particularly severe during the annual north-east monsoon season.

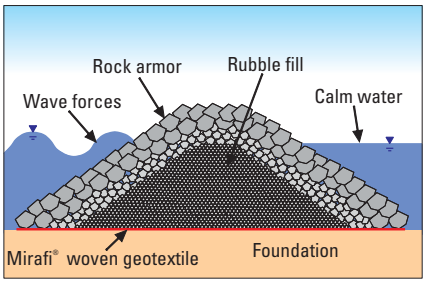
Offshore breakwaters were constructed to protect the on-shore base camp development. The offshore breakwaters options was adopted over other alternatives because, although requiring a higher initial cost, it was the most cost effective over time due to low cost of maintenance. From a technical point of view the offshore breakwater option had the least environmental impact on the coastline.

A Mirafi woven polypropylene geotextile was used to fabricate large fascine mattresses that were floated out the sea and sunk on the seafloor. The Mirafi woven geotextile acted as a basal filter layer for the rubble breakwater and associated toe scour protection . Once the Mirafi geotextile had been installed the stone and rock for the breakwater was placed on top.

TenCate's Mirafi® woven geotextiles are used as filters beneath rock-fill breakwaters and bed protection works to prevent the erosion of the foundation soil. TenCate's Geotube® and Geocontainer® geocontainment materials are used for the cores of breakwaters providing mass-gravity, stable structures.

Breakwaters

Breakwaters are marine structures that have the primary function of dissipating wave energy. They reduce the wave energy by partial reflection as well as by breaking on the structure. Consequently, the water conditions on the protected side of the breakwater remain relatively calm. Breakwaters may be attached to, or detached from, the shoreline. Detached breakwaters are sometimes designed to be permanently submerged and may be designed to retain a perched or artificial beach behind.

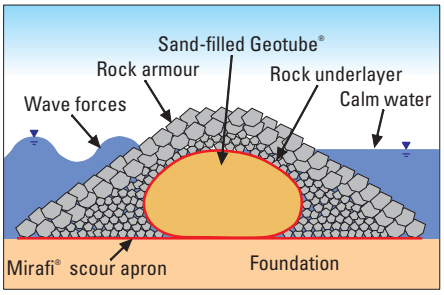


Mirafi® woven geotextile filter placed beneath the rubble breakwater

In dissipating wave energy considerable turbulence can occur at the toe and across the base of (rock) breakwaters. If the breakwater is founded on sand, this can result in severe sand erosion and consequent breakwater instability. To prevent this, a Mirafi® woven polypropylene geotextile is installed across the top of the sand foundation prior to the construction of the breakwater. The Mirafi® geotextile acts as a filter preventing the erosion of the sand foundation through the breakwater.

More recently, Mirafi® woven polyester geotextiles have been used to reinforce the base of breakwaters constructed over soft clay foundations. In this instance the geotextile reinforcement provides stability to the breakwater until such time as the clay foundation has consolidated and can support the weight of the breakwater by itself.

In many instances the installation of the geotextile can be difficult. One technique commonly used is for the Mirafi® woven geotextile to be prefabricated onshore into



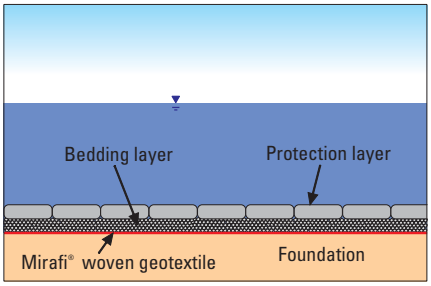
Sand-filled Geotube® used as the core of a breakwater

a large panel (or fascine mattress) that can be floated out to sea and then sunk into place. This fascine mattress can then be ballasted into position on the seabed by dropping rock onto the floating fascine mattress as it sinks.

Alternatively, sand-filled Geotube® and Geocontainer® units may be used to replace the rock-fill core of breakwaters. This becomes an attractive proposition where rock is expensive and difficult to obtain and where the water forces are not extreme.

Bed protection

Bed protection works are similar to revetments in design except they are constructed in an essentially horizontal manner. They are used to prevent the beds of rivers, harbours and ocean outlets from scour, which can occur in the vicinity of (other) hydraulic and marine structures. The upper protection layer may consist of rock armour, but because of the necessity to protect shipping from damage, in many cases, it is more common to use prefabricated concrete elements that may be joined together by connecting cables.



Mirafi® woven geotextile filter placed beneath bed protection layers

A Mirafi® woven polypropylene geotextile is first placed on the water bed before the placement of a granular bedding layer which is then followed by the primary protection. The Mirafi® geotextile acts as a filter to prevent the erosion of the bed material through the horizontal protection above.

Case Study:

Geotube® offshore breakwaters, El Dorado Royale, Mexico

El Dorado Royale is a Four Diamond Resort. Settled on 450 acres of tropical jungle it is located in the heart of the Riviera Maya, about 25 minutes south of Cancun International Airport. Facing the beautiful Mexican Caribbean, the resort has a coastline of 1.6 km of unspoiled Punta Brava Beach.

This stretch of pristine beach was constantly under threat of erosion during the hurricane season. Over time, the beach was losing sand on a permanent basis and the owners decided to solve the problem by constructing an offshore breakwater system. Geotube® units were stacked in layers to construct a series of offshore breakwaters to protect the beach fronting the resort. The Geotube® breakwaters not only promoted the natural accretion of sand that widened the beach front over time, but also provided a sheltered recreational area for swimming and other aqua-sport activities.

Dykes and groynes

TenCate's Polyfelt® and Mirafi® geotextiles are used as filters for rock-fill dykes and groynes to prevent the erosion of adjacent soil. TenCate's Geotube® and Geocontainer® geocontainment units are used for the cores of dykes and groynes providing mass-gravity, stable structures.

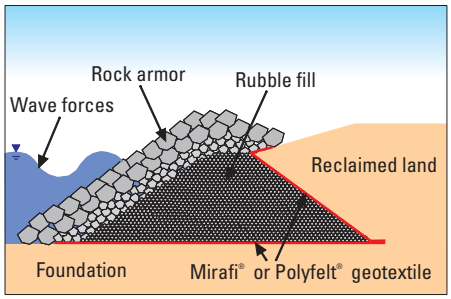
Protection dykes

Protection dykes (levees) are used to control the movement of water in confined areas to prevent flooding and other water damage. Where protection dykes are used to continually control and constrict the flow of water they are designed in a similar way to embankment dams where the raised water level is prevented from seeping through the protection dyke and causing inundation of the surrounding land. For this application the dyke consists of at least one zone of fine-grained soil to act as a hydraulic barrier to the seepage water. To prevent erosion of the water-exposed face of the protection dyke, a revetment is normally used.

Protection dykes also may be used to protect low-lying land from infrequent flooding due to storms, high tides, etc. In this application the time over which the high water level occurs is relatively short and thus the dyke-fill does not have to be too impermeable. Here, Geotube® units can be used as the core of protection dykes. The Geotube® dyke core is covered with a sand or soil mound that blends in with the local scenery. During periods of high water levels and heavy storms, the water-side surface of the dyke may be eroded exposing the Geotube® units, but the dyke cannot be breached. Following the storms, the sand mound over the Geotube® core can be regenerated either naturally or artificially.

Containment dykes

Containment dykes are used to retain water borne sediments, hydraulic fills and other fills. To reclaim land from the sea, or to provide a storage facility for spoil or other soil materials, it is common practice to first construct a containment dyke around the extremity of the area to be filled. The function of the containment dyke is to prevent loss of the fill into the surrounding water.



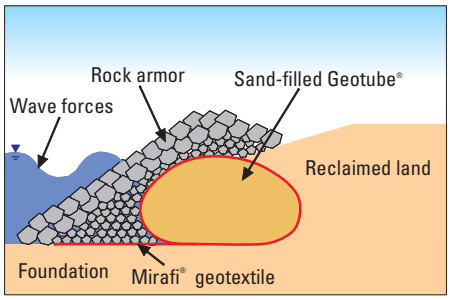
Rubble containment dyke with geotextile filter

Case Study:

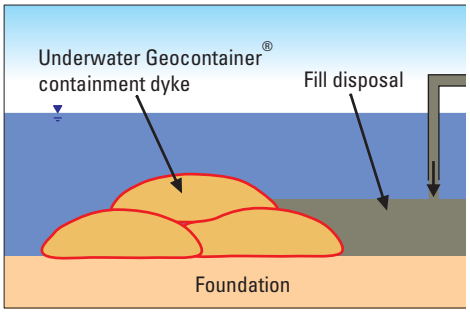
Rock containment dyke, Calcasieu River, Louisiana, USA

The Port of Lake Charles is the 12th largest seaport in the USA and is situated 18 km from the Gulf of Mexico along the Calcasieu River. To maintain water depths the Calcasieu River has been continually dredged since the early 1800's to enable ship and barge traffic to pass between the Port and the Gulf. When current disposal sites for dredged material were near exhaustion, the US Army Corps of Engineers decided to construct a new 8 km long rock containment dyke about 160 m from the existing east shoreline of the Calcasieu River. This containment dyke will retain the dredged spoil from the shipping channel for the next 20 years.

The dyke core was constructed into a mound using granular fill. A high permeability Mirafi® woven geotextile filter was placed on the inside of the dyke to prevent the loss of the dredged spoil through the dyke and into the Calcasieu River. Finally, rip-rap was placed over the outside as the primary armour.



Geotube® containment dyke



Underwater Geocontainer® containment dyke

Commonly, the dyke consists of dumped rubble with a layer of Mirafi® or Polyfelt® geotextile filter placed behind, and across the bottom of, the rock-fill bund to prevent the retained fill and the foundation from washing out through the dyke.

Alternatively, Geotube® units may be used to construct the dyke using locally available sand as the dyke fill.

In some instances, underwater containment dykes are constructed to retain spoil and other fills in an environmentally acceptable manner. Here, Geocontainer® units can be used to construct the dyke walls.

Groynes

Groynes are structures that run normal to the coastline and intercept the littoral transport of sediment within the surf zone. As well as preventing beach erosion, groynes facilitate sand accretion by slowing down water velocities.

Conventionally, groynes consist of rock mounds or timber or steel sheet piles. For rock mound groynes it is common practice to place a layer of Mirafi® or Polyfelt® geotextile across the base of the groyne prior to placement of the rock. The geotextile filter prevents the erosion of the soil foundation and the consequent undermining of the rock mound groyne. More recently, conventional groynes composed of rock or sheet piles have lost favour because of their unsightly appearance and public safety issues especially where they are located close to popular beaches.

An alternative groyne structure that does not require the use of rock or sheet piles utilises Geotube® units. The Geotube® groyne is installed insitu using locally available sand-fill. To prevent erosion around the sides of the Geotube® groyne a scour apron can be installed prior to the installation of the Geotube® groyne. For safety, the surface of the Geotube® groyne is smooth and cannot cause injury to the public.

Case Study:

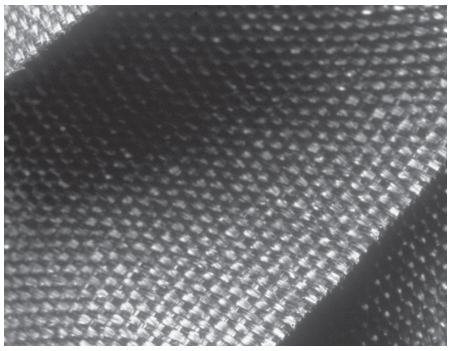
Geotube® containment dyke, Enkhuizen, The Netherlands

The Naviduct project in The Netherlands required significant dredging works for a new and deeper double-ship lock through the levee between Enkhuizen and Lelystad. This would allow large ocean going ships direct access into the harbour of Markermeer.

The dredged material, which consisted of a combination of sand and silt, had to be disposed of in an environmentally acceptable manner. It was decided to dispose of the dredged spoil by constructing a wetlands area in the adjacent lake. This wetlands area would also protect the Naviduct structure from ice flows during the winter.

A Geotube® containment dyke was constructed to contain the dredged material. The Geotube® containment units were also filled with the dredged material up to 2.4 m height to form the containment dyke. The entire 3.75 km of Geotube® dyke was constructed within a relatively short period of 20 weeks. For long term protection, the exposed sides of the Geotube® containment units were covered with rip-rap.

TenCate's geotextile materials



Mirafi® woven polypropylene geotextiles

Mirafi® woven polypropylene geotextiles consist of monofilament and/or fibrillated polypropylene tapes woven into a structured, stable pattern. These geotextiles have medium to high tensile strengths (40 kN/m to 200 kN/m). These robust tensile characteristics make these materials ideally suited for the separation and filtration of rock layers in marine and hydraulic environments, and also where high tensile loads are generated when installing geotextiles under water, such as in breakwaters, bed protection, etc. These geotextiles contain enhanced stabilisers in order to enhance durability following installation.

Polyfelt® nonwoven polypropylene geotextiles

Polyfelt® nonwoven geotextiles consist of continuous polypropylene fibres, needle-punched into a uniform, stable pattern. These geotextiles are very robust mechanically and combine the properties of small pore sizes with high water permeability. These geotextiles are ideal for the filtering soils to shallow water depths where installation is relatively easy. Because of their robust characteristics, large rocks can be placed immediately against these materials.

Mirafi® woven polyester geotextiles

Mirafi® woven polyester geotextiles consist of high strength polyester multifilament yarns woven into a structured, stable pattern. These geotextiles have high tensile strengths (100 kN/m to 1600 kN/m) at low peak extensions and have low creep characteristics. These characteristics make these geotextiles ideally suited for the basal reinforcement of marine structures such as breakwaters, dykes, etc. over soft clay foundations.

TenCate's geocontainment materials

Geotube® units

Geotube® geocontainment units are manufactured from high modulus polypropylene engineered fabrics combined with high capacity seams to produce tubular containers with ensured integrity during filling and during operational life. Normally, the sizes of the Geotube® units range from 1.5 m to 5 m theoretical diameter. These units have specially designed and spaced filling ports which enable the uniform hydraulic filling of sand, while water is drained through the permeable skin of the tubular units. This results in a compact sand-filled, mass-gravity, structure that is settlement free and erosion resistant.

Geocontainer® units

Geocontainer® geocontainment units are manufactured from woven polypropylene engineered fabrics combined with high capacity seams to produce mass-gravity containers with ensured integrity during installation and during operational life. Normally, the sizes of the Geocontainer® units range from 100 m^3 to 800 m^3 in volume. These units enable the containment of sand and other soils to be safely deployed in water using split-bottom barges. Geocontainer® geocontainment units are manufactured specifically to suit the dimensions of the split-bottom barges used for deployment. These units are site filled and closed. On opening of the split-bottom barge, the units fall through, and land in position on the seabed.

Geobag® units

Geobag® geocontainment units are manufactured from woven polypropylene engineered fabrics combined with high capacity seams to produce pillow, box or mattress shaped containers with ensured integrity during installation and during operational life. Normally, the sizes of the Geobag® units range from 0.5 m^3 to 5 m^3 in volume. These units enable the containment of sand and other soils and can be lifted and placed using standard construction equipment. Geobag® containment units are site-filled and closed. They are then lifted into position on land or dropped into position in the sea.

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