



COASTAL & WATERWAY INFRASTRUCTURE

Solutions overview



Index

Introduction	3
Project approach	4
Our solutions for your coastal and waterway infrastructure needs	6
Applications	
1. Coastal protection	8
2. Beach protection	10
3. Scour and erosion protection	12
4. Green erosion protection	14
5. Quay walls	16
6. Dykes	18
7. Soil consolidation and land reclamation	20
8. Dewatering of sludge	22
9. Sediment control	24
10. Salt barrier	26
References	
Dike protection against erosion and scour due to flooding	30
Dewatering of sludge	32
Geobags to protect coastline from erosion and scour	34
Enka Solutions product overview	36
Our areas of expertise	37
Enka Solutions values	39

Introduction



One of the most profound effects of climate change is the increase in sea levels. Over the last 100 years, sea levels have risen globally by 0.25-0.50 m. However, refined projections for the next 100 years indicate the acceleration of tidal rise with estimates of an increase of 1.3 m in the North Sea increasing to 2.0-4.0 m by 2200.

Even small increases in sea level can have devastating effects on coastal habitats with flooding and coastal erosion being the most obvious and dramatic examples. Higher sea levels will also have a drastic effect on farming with low-lying farm land potentially being rendered unusable by salt water. Salt water will also affect the flora and fauna in coastal nature reserves and can even contaminate aquifers, threatening drinking water supplies further inland.

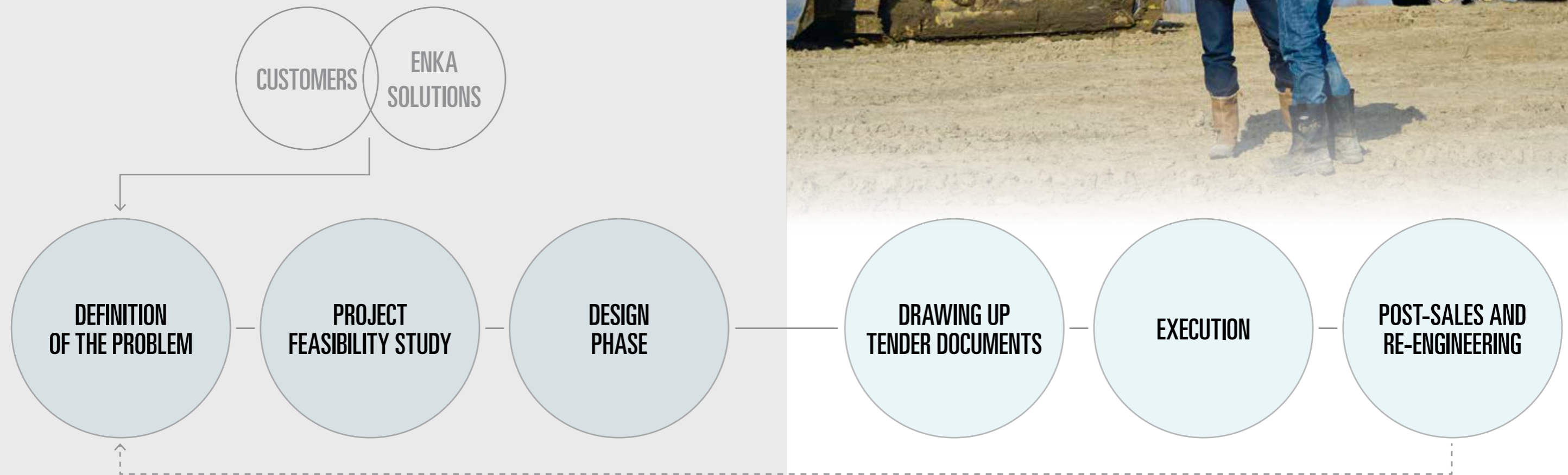
In addition to the rising sea levels, the effects of climate change are also felt in the increasing incidence of severe weather events with more severe storm damage, increased levels of rainfall in some areas and drought in others. All of these can contribute to further problems on inland rivers, waterways and reservoirs and increase the threat posed by the rising tide levels to existing coastal defences and coastal infrastructure.

Coastal economies will be affected as beaches and tourist areas are lost, whilst erosion and deposition caused by tidal flux around river mouths can alter the viable shipping channels and affect the operation and even viability of ports and quays further inland. This potentially threatens whole economies reliant on trade or fishing. Further inland, we are already seeing the effects of severe and repeated flooding events – with increasing frequency – in areas where flooding was previously unknown.

“At Low & Bonar, we are proud that our geosynthetics have a long history of erosion control, land reclamation, river and coastal works. They help to protect our infrastructure and economy from the worst ravages of the sea and weather. Geosynthetic solutions have long proven their cost effectiveness and environmental sustainability and remain one of the key tools to protect our waterside environment.”

ENKA SOLUTIONS PROJECT APPROACH

We monitor and supervise your project from the initial definition of the problem all the way through to the post-sales phase. Our specialist engineers will provide the appropriate type of support required for each individual step of your project.



From our many years of **international experience**, our specialists have accumulated the necessary expertise **to provide all the support you need** with regard to defining a problem and to gathering the necessary data that will lead to the creation of the appropriate framework.

We provide **advice and contribute possible solutions** for specific problems or applications. If desired, we can also provide training on specific topics associated with the use of geosynthetics in civil engineering.

In this phase we work out the best possible solution in conjunction with the customer. We provide **tailored advice** by means of calculations for the **all-round solution** and delivering drawings, sketches and models. An optimal mix of products is sought for the specific situation, including the relevant cost calculations.

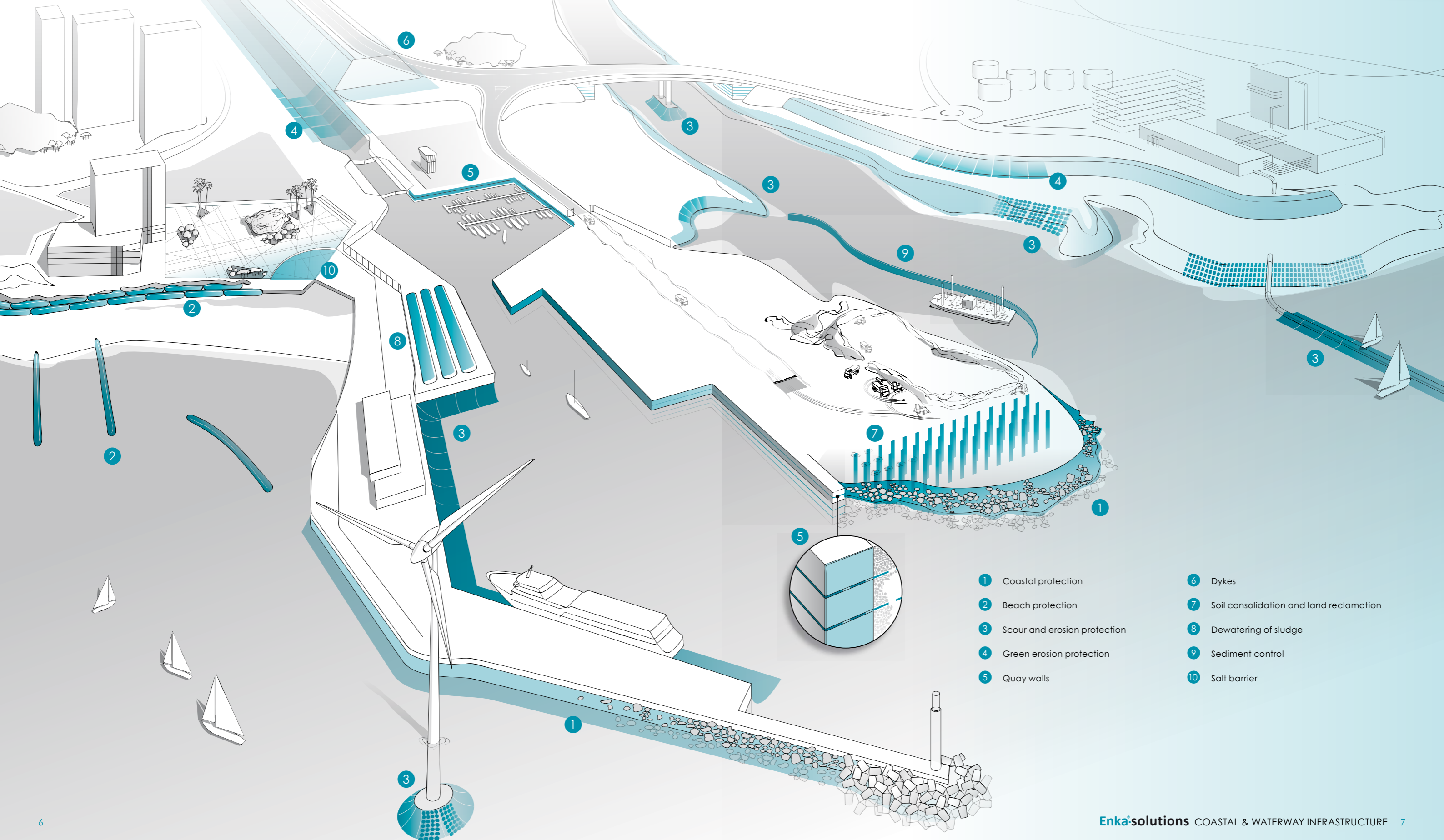
We can either deliver **standardised specification documents and drawings**, or draw up a set of **project-specific installation instructions**.

We prepare for the **execution of the project** by providing clear installation instructions. If desired, we can also organise **project-specific installation training sessions**. Our customers can also rely on on-site support.

Once the project has been completed, we will be happy to assist our customers with any future challenges. We make use of the expertise gained during the execution of specific projects to further streamline our solutions and develop new products.



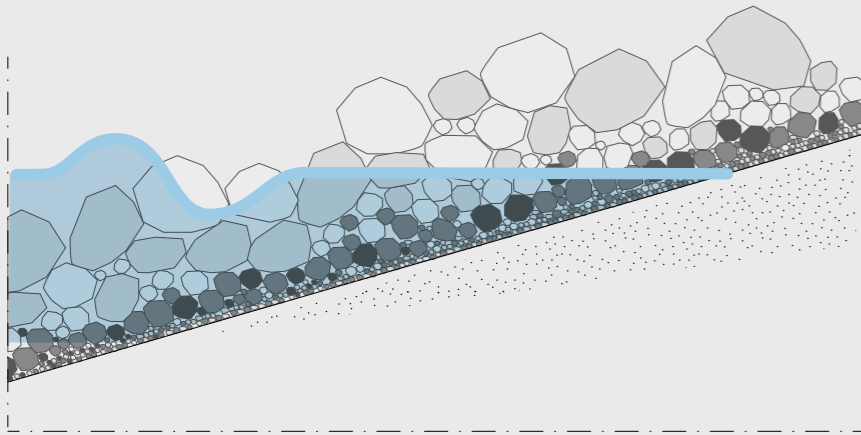
Our solutions for your coastal and waterway infrastructure needs



- 1 Coastal protection
- 2 Beach protection
- 3 Scour and erosion protection
- 4 Green erosion protection
- 5 Quay walls
- 6 Dykes
- 7 Soil consolidation and land reclamation
- 8 Dewatering of sludge
- 9 Sediment control
- 10 Salt barrier

1. Coastal protection

Waves and wind generated in marine conditions have the **most severe eroding effect on coastlines and structures** built by humans. Rock revetment is the most traditional way of protecting coastlines against erosion.



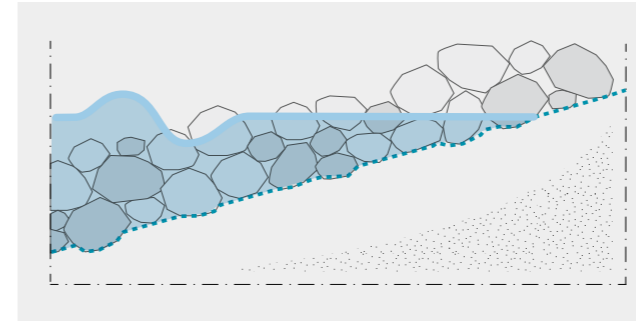
Constant wave attack and high velocity currents may result in the collapse of these thick filters and instability of the revetment.

Traditionally, rock revetments are made up of a granular filter progressing from fine granules to coarse granules that build up a natural filter. This filter prevents sand from being washed away from behind the rock revetment and assures the stability of the structure. **Geotextiles are able to replace up to 1 m of this granular filter** which makes it a very economical and

ecological alternative to granular filters. We have a broad range of geotextiles to answer to individual project needs. From geotextiles that are able to **absorb enough energy from falling rocks**, to fabrics with a water permeability that is in line with the permeability of the soil at the site. Also the opening size is taken into account to **prevent washing out, clogging, etc.**

FUNCTIONS:

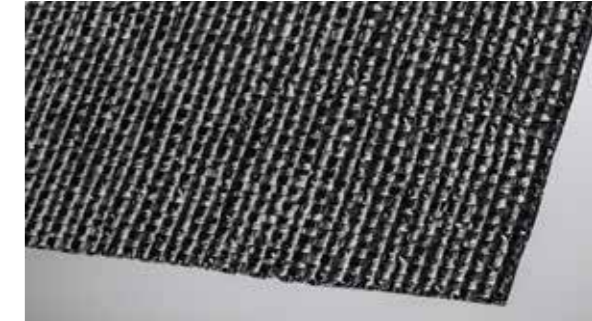
- Separation
- Filtration



Heavy nonwoven and woven Enka-Tex fabrics can be used as filter layers with proven performance in preventing instability of rock revetments.



Enka®-Tex nonwoven



Enka®-Tex woven

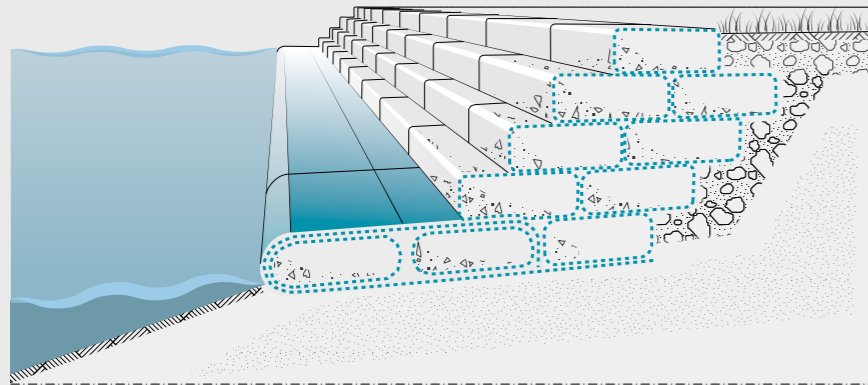
Relevant products:

- Enka®-Tex nonwovens
- Enka®-Tex wovens



2. Beach protection

More than 70% of the earth's shorelines are retreating due to rising sea levels. As shorelines move further inland, **structures located on or near the coast may be destroyed**. The appearance of a beach and its potential for recreational use may suffer. Importing sand to refill the beach levels is required every few years to keep beaches from retreating, and this typically comes at a very high cost each time.



Nonwoven flexible Enka-G-Bag forms a solid seashore area and riverbank protection. Enka-Tex high tensile woven fabrics, wrapped around the bottom layers and securely anchored back into the structure minimize local deformation and loss of stability.

Beach ecosystems may be negatively impacted by the importation of sand. Rock armour is a possible solution, but cannot always be used in highly populated areas or tourist resorts due to its hard structure. In these situations, Enka Solutions products can offer alternatives.

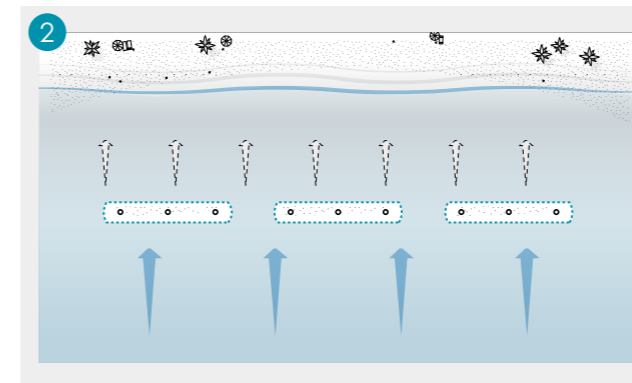
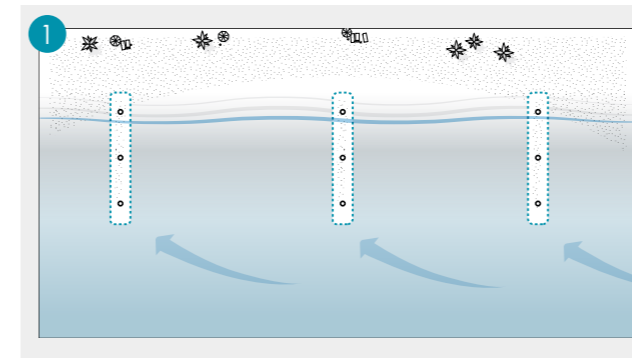
Enka-G-Bag is a direct solution to protect the beach from erosion. These are extremely robust nonwoven bags designed to be filled with local sand, which can be used as a building element. Enka-G-Bag has proven a **successful solution for beach wall protection, revetments, breakwaters and riverbank protection**.

The beach can also be protected indirectly by adapting the current along the beach or the wave action on the beach which is responsible for the erosion. Enka-G-Tube is installed perpendicular to the beach in **order to block the current**, which diminishes the strength of the current and causes the sand to settle rather than being washed away.

To influence the wave energy on the beach, Enka-G-Tube can be installed underwater parallel to the beach. This makes **the waves break earlier so that some of their energy will be lost before they reach the beach**. Consequently, the wave has less impact on the beach, which reduces erosion.

FUNCTIONS:

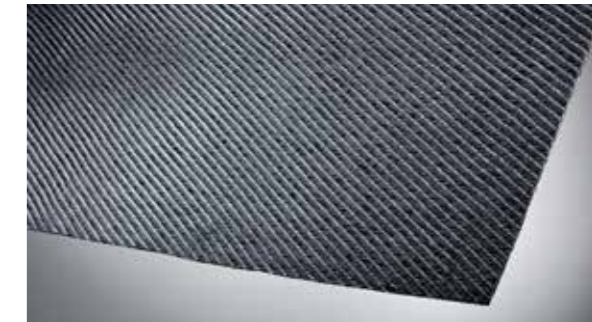
- Energy absorption
- Erosion control



Enka-G-Tube, perpendicular to ① or parallel to ② the coastline has proven to serve well in stimulating accretion in intertidal areas and offers protection against tidal currents by acting as groyne or breakwater.



Enka®-Tex nonwoven for Enka®-G-Bag



Enka®-Tex woven for Enka®-G-Tube

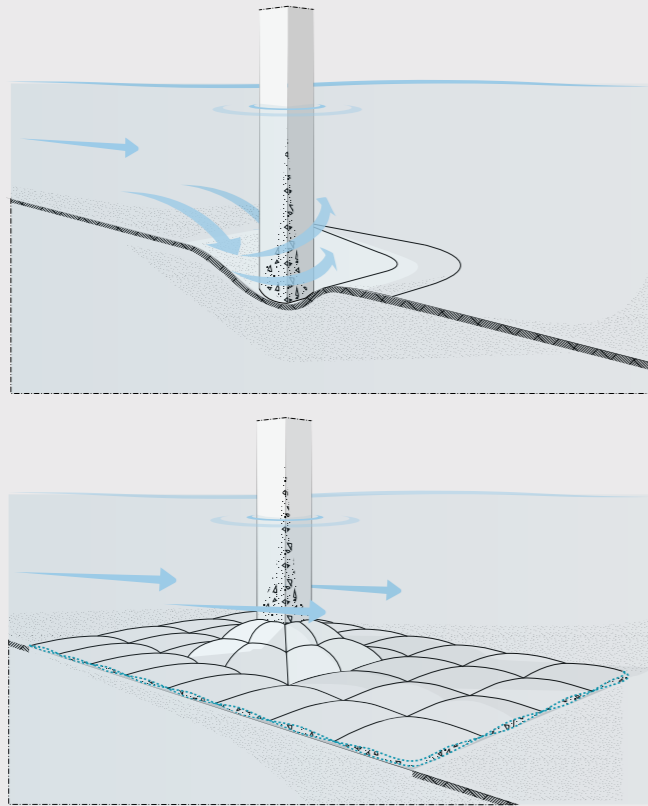
Relevant products:

- Enka®-Tex wovens
- Enka®-G-Bag
- Enka®-G-Tube



3. Scour and erosion protection

Built-up areas have an increased need for protection against the erosion and scour which go along with rising water levels. Scour means **a localised loss of soil often situated around underwater foundation elements** such as piles, quay walls, bridge abutments, etc.



Scour is the result of bottom shear stress induced by water velocity. Once this becomes higher than the critical shear stress, soil will be transported away from the foundation element posing stability risks to the superstructure.

Typically, Enka Solutions products for this application **combine ballast with filtration to withstand the stronger shear forces** that are involved in these situations.

The sand tightness is assured by the Enka-Tex filtration function. This is **the crucial key to the stability of the entire structure**.

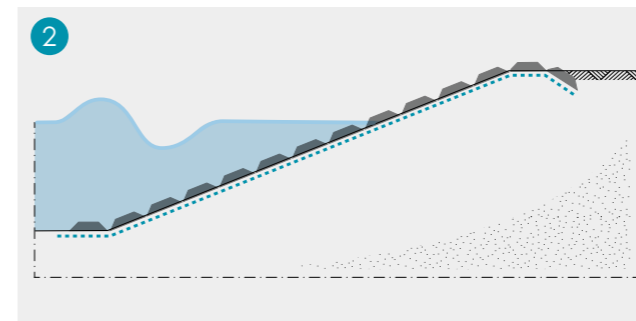
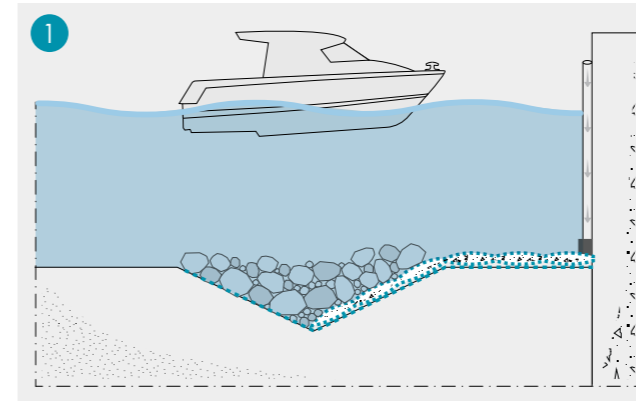
Enka-Mattress is a lost shuttering concrete mattress which **follows the soil surface perfectly** so that no gaps are subjected to erosion. It becomes a robust, rigid and long-lasting protection layer.

Enka-Mattress can be tailor made so it can be zipped around or layed down over pipelines prior to filling. Once filled it will protect the durable coating of pipelines from damage induced by falling anchors, rock or abrasion forces.

Enka-Fix is a three-dimensional woven fabric onto which concrete blocks are cast, thus combining ballast and filtration. The woven fabric offers a flexible connection between the concrete blocks. This flexibility **offers a self-healing erosion control system**, which is able to adapt to new scour-sensitive spots.

FUNCTIONS:

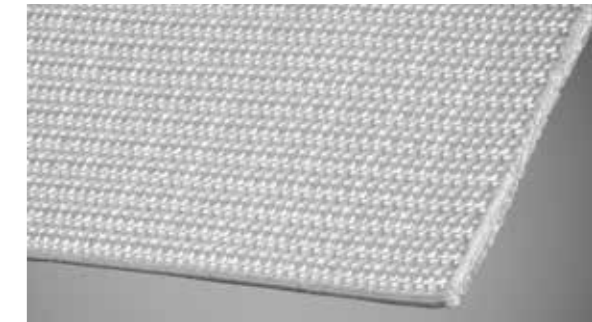
- Surface stabilisation
- Ballasting
- Filtration
- Protection



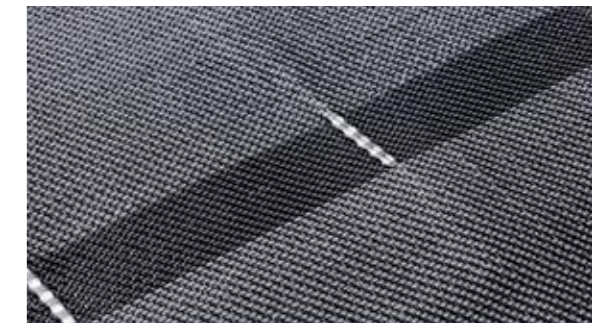
The foreshores of quaywalls **1** are subject to erosion due to turbulent ship propeller forces and vortices. Enka-Mattresses can be used as a bottom protection to secure the lifetime of the structure. Critical riverbank sections and attacked seashore areas **2** can be defended by Enka-Fix with precast concrete blocks.



Enka®-Fix



Enka®-Force



Enka®-Mattress (unfilled)

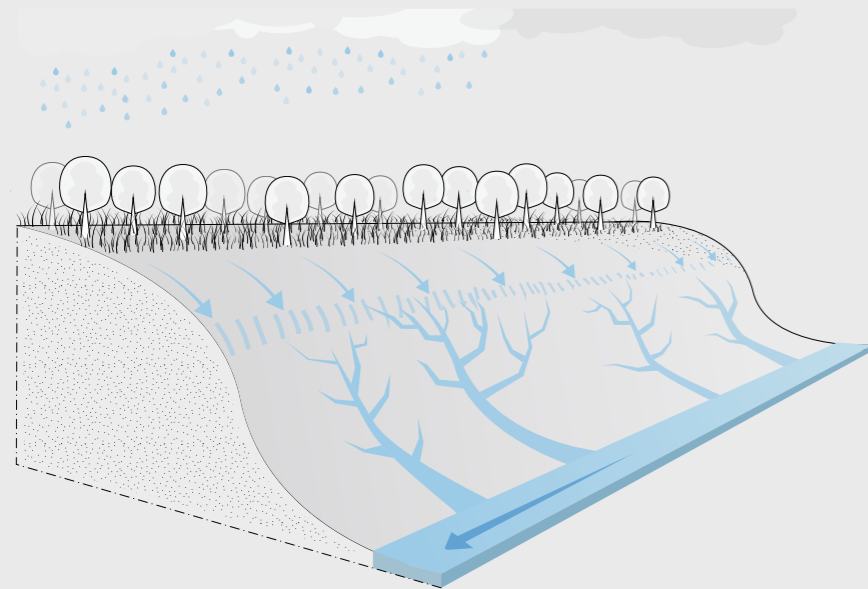
Relevant products:

- Enka®-Tex wovens and nonwovens
- Enka®-Force
- Enka®-Fix
- Enka®-Mattress
- Enka®-G-Tube
- Enka®-G-Bag



4. Green erosion protection

Erosion is the action of surface processes such as water and wind **displacing soil aggregates from one location to another**. There are various types of erosion, including splash, sheet, rill, gully and stream channel erosion.



Understanding the type of soil and how prone it is to erosion can help avoid problems on waterways and infrastructure. Soil erosion removes valuable top soil which is an important part of the profile for infrastructure purposes.

Nature itself provides an excellent product to protect soil against erosion in the form of vegetation. Sometimes however **nature needs a helping hand**, for instance if the erosive forces are too strong or when vegetation needs to grow under difficult conditions.

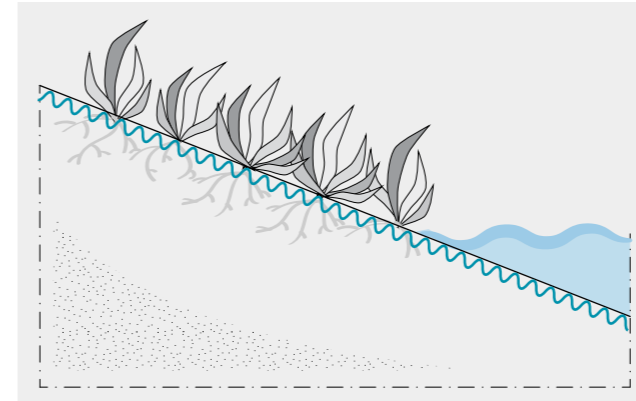
Biodegradable materials such as jute, coir, flax, wood wool and straw mats will typically retain their structural integrity for one or two years in a moist soil environment. They are intended to provide temporary protection until the vegetation can take over.

An open, three-dimensional synthetic mat such as Enkamat provides this temporary protection for the bare soil to encourage the development of vegetation. **Enkamat will also permanently reinforce the topsoil** in the root zone should the vegetation fail.

Enkamat fills the gap between protection with ordinary vegetation and more radical protection with materials such as rock and concrete. This solution is **ideal for the environmentally friendly protection** of dry slopes with an incline of up to 60 degrees and is perfectly suited for the erosion protection of ditches, canals, lakes and rivers.

FUNCTIONS:

- Surface stabilization
- Erosion protection
- Vegetation reinforcement



The three dimensional Enkamat erosion prevention mats provide immediate protection, allow for fast growth of vegetation and offer a long-term strong foothold for vegetation root systems.



Enkamat®



Enkamat® A20

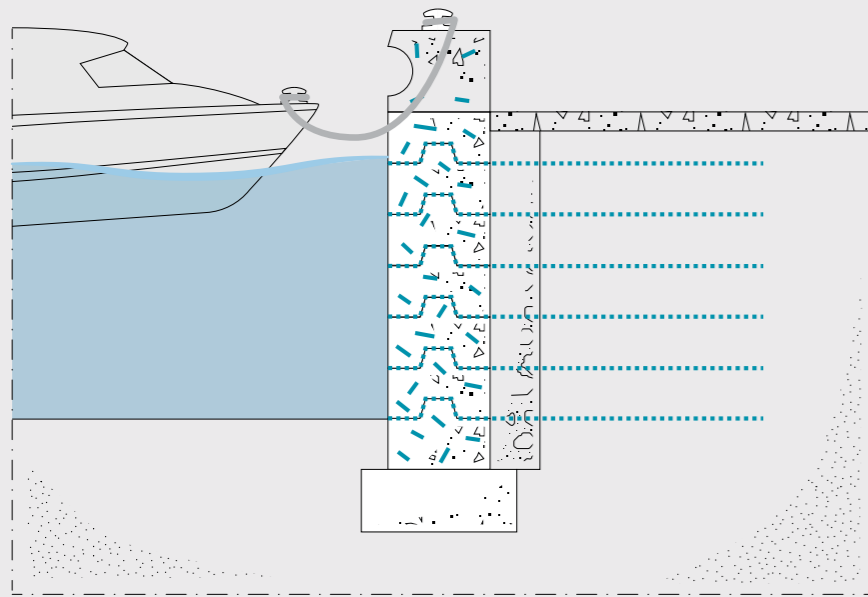
Relevant products:

- Enkamat®
- Enkamat® A20
- Enkamat® J
- Armater®
- Enka®-Net



5. Quay walls

Horizontal soil pressure on quay walls can lead to serious failure modes and requires attention during the design phase. Concrete element block walls are often used to create quay walls, but they may be **subject to deterioration when the blocks are reinforced with steel bars.**



Reinforced soil solutions offer increased flexibility in the design and construction of quay walls and the types of fill material that may be used behind them. Concrete facings, either segmental or cast in situ are proven to have improved durability, micro crack resistance and reduced maintenance when appropriate mixes of synthetic fibres are included within the concrete.

For quay walls, reinforced soil layers combined with steel gabion facing, modular concrete blocks or thin concrete panels are used to build a vertical facing. A facing designed in this way can **accommodate high surcharges**, including mobile cranes.

Conventional solutions such as steel sheet piling, gabions, mass concrete gravity walls, concrete L-shape cantilever or piled walls all work by passively resisting the weight of the soil itself.

The distinct advantage of reinforced soil solutions is that **they are stabilised internally.** This is achieved by the installation of horizontal layers of woven fabric or geogrids in the soil adjacent to the quay wall. The

tensile strength of the reinforcement is mobilised by the weight of the soil and surcharge loads.

Concrete used in marine applications is subjected to a harsh environment. Salt penetrates the concrete and **causes the steel to rust over time.** This makes it expand, which may crack the concrete surface leading to spalling of the concrete, while sand and shells cause severe abrasion.

To improve the durability of the concrete in the quay wall, Micro fibres are added to the concrete, creating a fibre network that decreases the permeability of the concrete by controlling micro-cracking during the curing process. This **increases the impact and abrasion resistance.**

Macro fibres can be added to provide a residual flexural strength after cracking. In this way, **macro fibres reduce the amount of steel** used inside quay walls and help to maintain the integrity of the concrete mass even when it has been cracked by preventing spalling.

FUNCTIONS:

Geogrid:

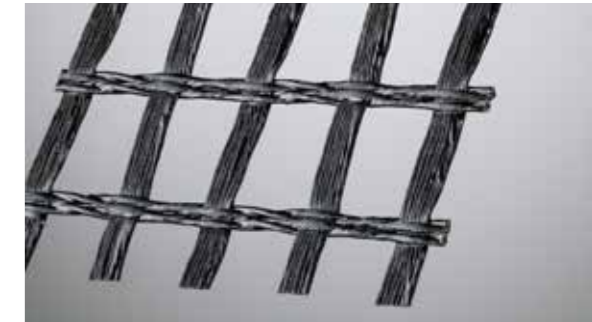
- Reinforcement of wall structures

Fibres:

- Reducing plastic shrinkage
- Enhancing residual flexural strength
- Improving freeze-thaw resistance
- Increasing impact and abrasion resistance
- Improving chemical resistance
- Reducing the need for maintenance and replacements
- Minimizing steel reinforcement



Enkagrid® PRO



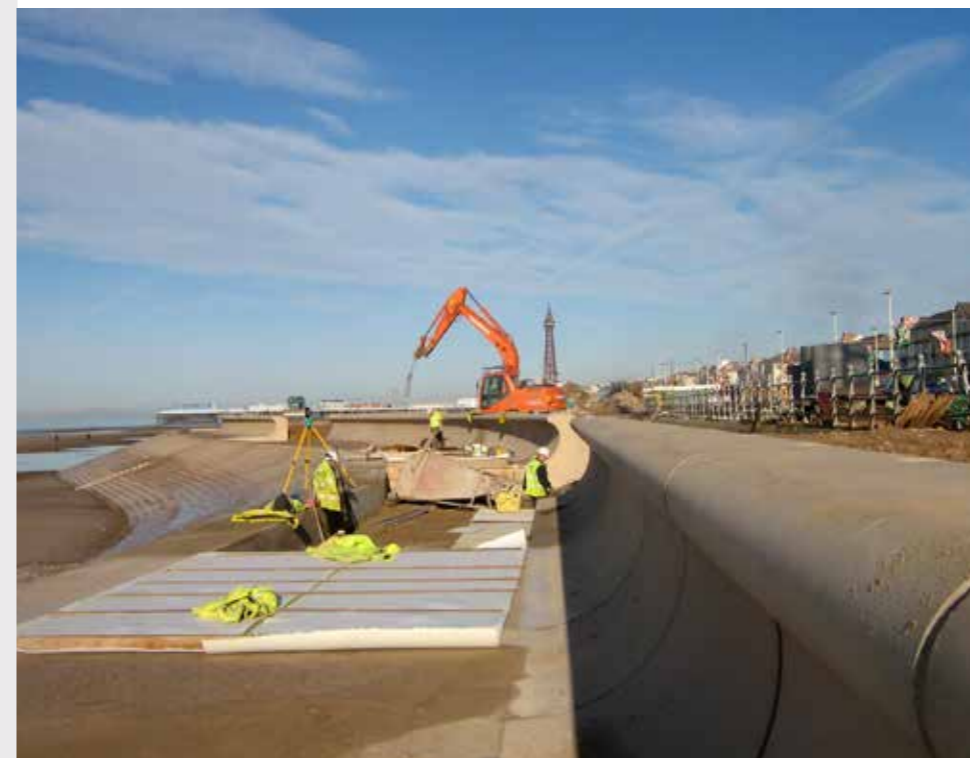
Enkagrid® G



Adfil Durus® Macro fibre

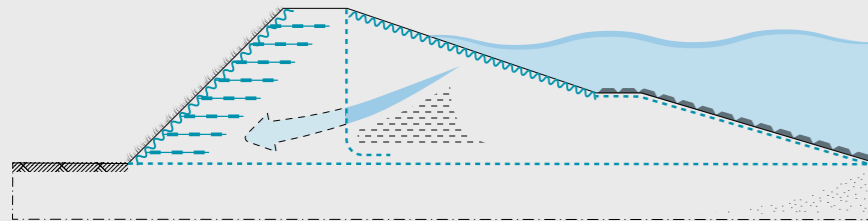
Relevant products:

- Enkagrid® PRO
- Enkagrid® G & M
- Enka®-Force
- Adfil Micro fibres
- Adfil Durus® Macro fibres



6. Dykes

Dykes are essential structures to protect us from floodings. By definition they are **built on weak soils which will cause differential settlements**. Erosion becomes a risk when water levels are high and dykes are under heavy attack from waves for a period of time. Another risk is the **so-called piping phenomenon** that may cause serious damage during high water.



A large variety of uses for geosynthetics contributes to the stability of embankments during construction and during their lifetime.

Building dykes on weak soils with heavy duty woven reinforcing fabrics is a technology that has existed for 40 years since it was first used along the Mississippi in the USA. In general **three failure modes can be identified:**

- 1 loss of overall stability;
- 2 loss of foundation stability;
- 3 bearing capacity failure, as illustrated on the next page. Design advice is available on request.

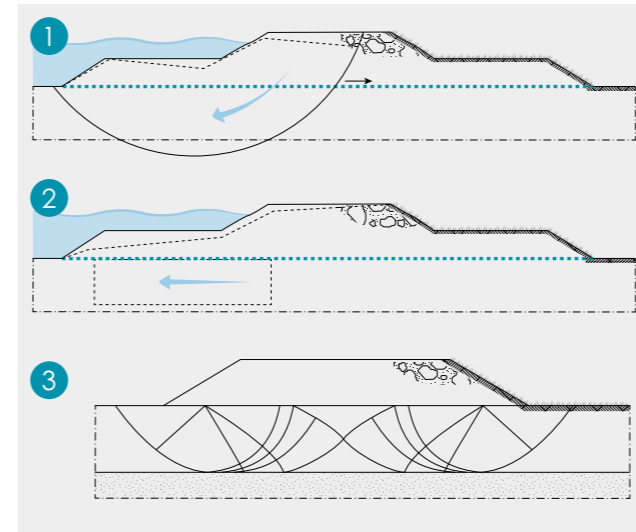
When water levels are high, the resulting pressure can force water to seep through the base of a dyke. This water may **take grains of sand with it, creating tubular openings (pipes) under the dyke** that get bigger and bigger, jeopardising the stability of the structure. This can weaken the

dyke and, in the worst case, cause it to collapse. Vertical screens of Enka-Tex geotextiles are used as filtering layers to avoid piping. The principle of the vertical screen is based on **allowing water, but not sand, to pass through the base of the dyke**.

Where **environmentally friendly engineering** is a priority, Enkamat is used for dyke slope sections above the main water level. This allows for erosion protected embankments to grow naturally vegetated facings. Below that level, flexible Enka-Fix with precast concrete blocks or Enka-Mattress have proven to withstand heavy wave attacks.

FUNCTIONS:

- Reinforcement
- Piping prevention
- Separation
- Filtration
- Erosion protection



Horizontal base layers prevent extremely soft silt layers from being squeezed out and contribute to global stability against sliding and skip circles. By using this method the bearing stability is better controlled during installation.



Enka®-Force



Enkamat®

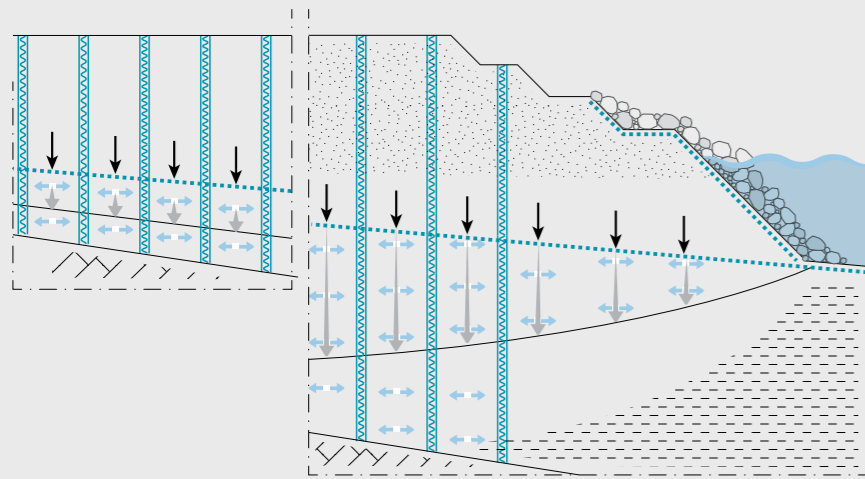
Relevant products:

- Enka®-Force
- Enkagrid®
- Enkamat®
- Enka®-Tex nonwovens
- Enka®-Fix
- Enka®-Mattress



7. Soil consolidation and land reclamation

On coastal reclamation works, a thick layer of granular reclamation material is applied to form the new land profile. Typically, the foreshore and seabed overlaid with this material is of a low quality alluvial material which may be poorly compacted and have low permeability. Variations in the depth of the weak soil and the differing depths of the reclamation mean that **the finished reclamation profile may not settle evenly**, and the presence of low permeability marine clays and silts will pose consolidation risks.



Woven Enka-Force fabrics at the intersection of marine clay and hydraulic sand fill contribute to the stability of steep side slopes and avoid differential settlements.

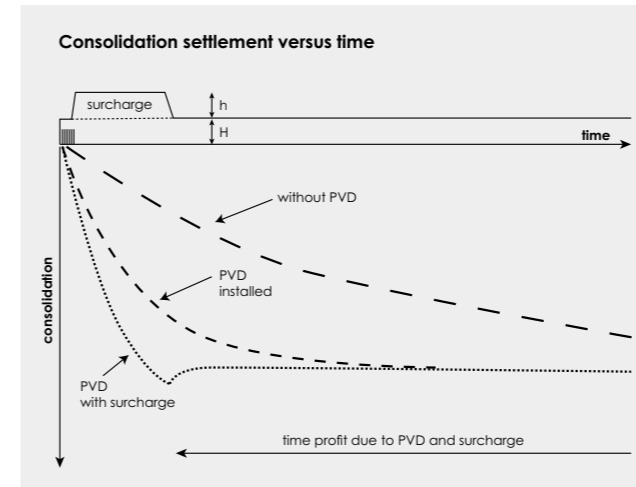
Allowing for consolidation can be a long process, lasting more than 25 years in weak saturated soils under surcharge loading. The solution lies in **releasing the groundwater and reducing the pore water pressure** as quickly as possible. To facilitate this drainage and accelerate consolidation, regularly spaced prefabricated vertical drains (PVDs) are installed to **create shorter drainage pathways** for the groundwater. This enables consolidation settlement to be completed while reclamation works and infrastructure installation are underway.

For shallow water reclamation or sea bed consolidation, the PVDs can be **installed from a barge and cut off at sea bed level**. The pore pressure is then released into the freely draining granular material placed in the reclamation works. For deeper reclamations, the drains are typically placed from the finished ground profile prior to placement of any additional surcharge fill.

Colbondrain CX1000 prefabricated vertical drain is a geocomposite that resists tearing under load during installation. This maintains its integrity and thus supports the drainage pathway. The **outer filter fabrics are bonded to the core structure over its entire surface** to form a homogeneous geocomposite product.

FUNCTIONS:

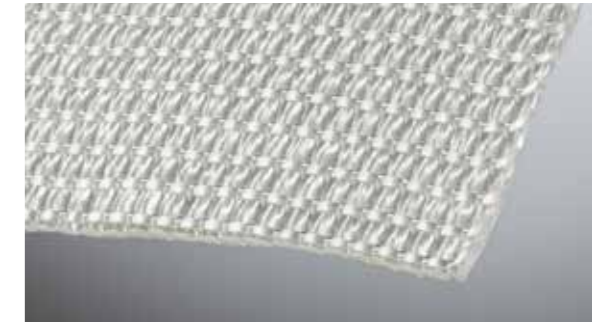
- Soil consolidation
- Stabilisation



Full consolidation of weak soils beneath the reclamation can be achieved in months rather than years when using Colbondrain prefabricated vertical drains (PVD).



Colbondrain®



Enka®-Force

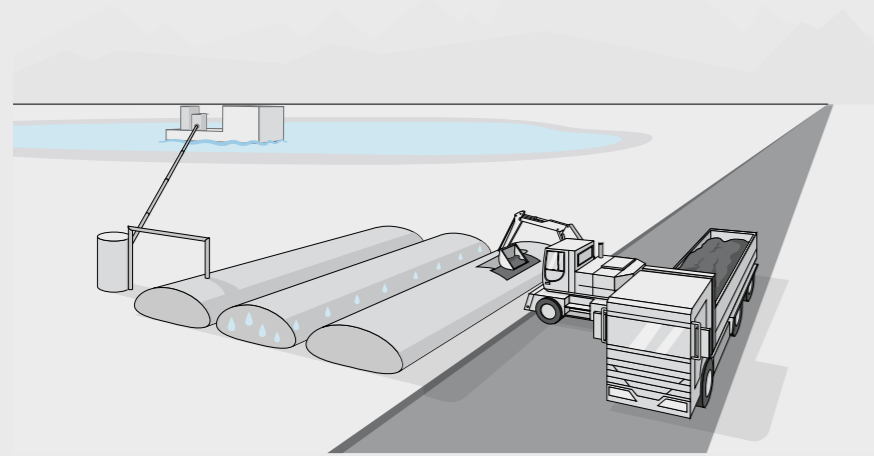
Relevant products:

- Colbondrain® CX1000
- Enka®-Force



8. Dewatering of sludge

Dewatering is a physical process by which water is removed from sludge. Sludge is dewatered to **reduce the cost of transportation**. Moreover, dewatered sludge is easier to handle.



Dewatering sludge to achieve a dry more easily transported material is important to be able to further process the sludge for agricultural or industrial use.

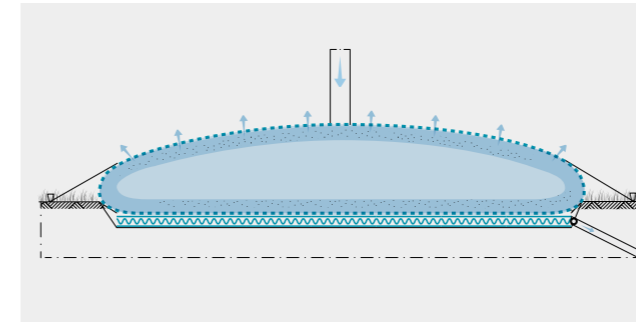
A simple and low-cost way to dewater sludge can be obtained by Enka-D-tube **resulting in volume reductions of up to 85%**. The sludge is pumped from the water into the tubes that are positioned at the lake side or on the sea shore. During the dewatering process **the sludge forms a cake against the inside of the special woven fabric** Enka-D-Tube is manufactured from. This cake acts as a natural filter and ensures clean water flows out of the tube. The water is collected on a membrane from which it is channeled back to the lake or the sea.

In order to use the whole circumference of the tube, Enkadrain can be rolled out under the tube to facilitate the run-off.

Flocculants can help to speed up this process by increasing the settlement speed of the sludge particles in the water, but also by increasing the water permeability of the natural filter (called the 'cake') in the tube. Typically these tubes are filled up in four or five stages. The maximum height must be respected at each stage.

FUNCTIONS:

- Filtration
- Containment
- Drainage



Flexible lightweight Enka-D-Tube can easily be transported as close as possible to the project location to function temporarily during the dewatering process after which the site can be restored to its original shape.



Enka®-Tex woven for Enka®-D-Tube



Enkadrain® Wide

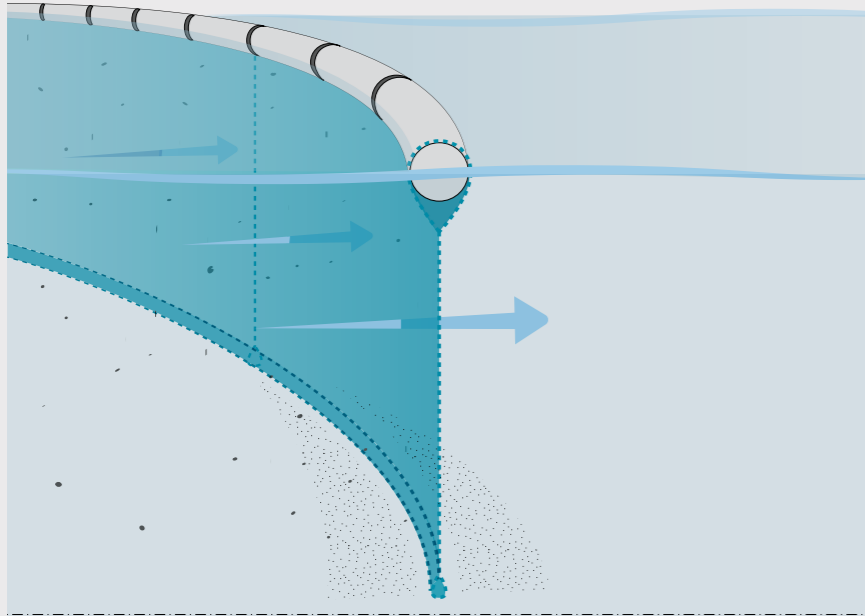
Relevant products:

- Enka®-D-Tube
- Enkadrain® Wide



9. Sediment control

During land reclamation and other works where silt plumes are generated, **the migration of dredged silt into open water can be harmful** to the existing vegetation and wildlife.



Enka-Tex silt screens can be used during land reclamation and other works in open water to prevent silt plumes from migrating.

Silt screens are placed as a **protective barrier** in the water around a site.

They allow for containment of water that holds the sediment in a restricted area. They also **protect contained water from turbulence**, allowing particles to fall out of suspension. This solution is typically used within a water body and along shorelines for the duration of the work causing the turbidity.

A silt screen consists of a woven fabric wrapped around a flotation tube.

The ballast at the bottom ensures that the screen is under light vertical tension to prevent it from floating to the surface.

The ballast can also provide an anchoring function to keep the silt screen in place when it is in contact with the sea or river bed.

FUNCTIONS:

- Filtration
- Separation
- Containment



Enka®-Tex woven for silt screens



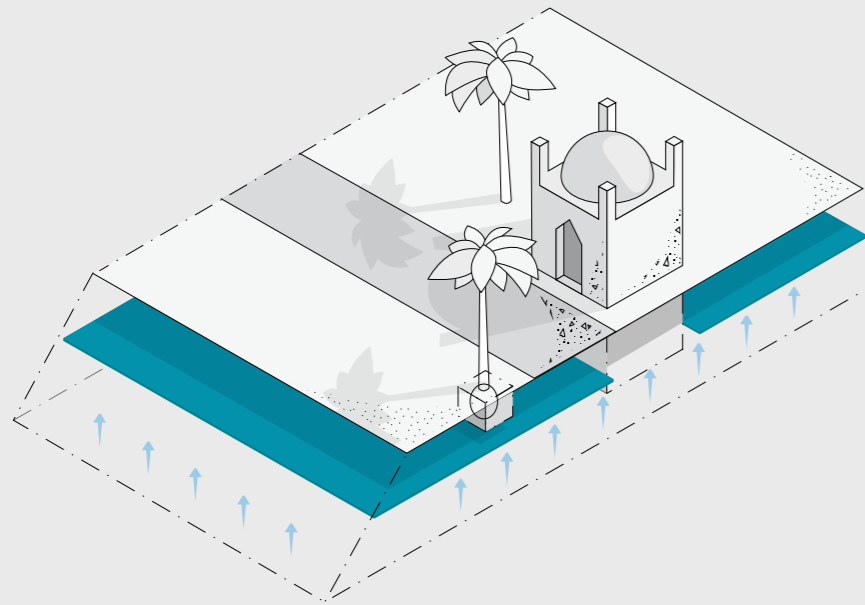
Relevant products:

Enka®-Tex Wovens



10. Salt barrier

In deserts and arid areas close to the sea it is quite common for groundwater to move upwards. This is known as a **'capillary rise process' and brings dissolved salt in water close to the surface**. Vegetation and marble pavements are seriously affected.



Salt barriers are typically used in heavily populated sandy (desert) areas close to the seashore where marble pedestrian pathways are present and trees struggle to survive in high saline content groundwater.

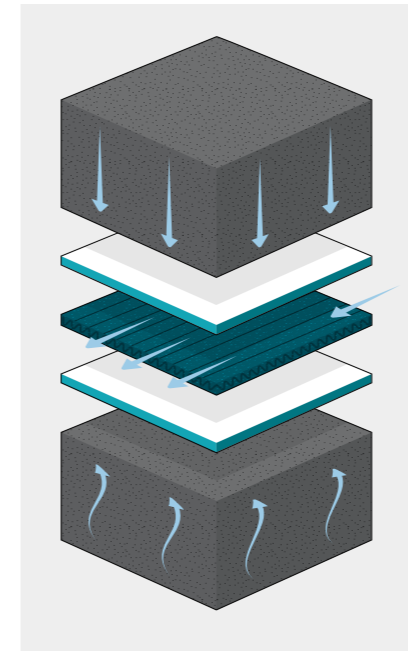
To avoid the risks of capillary rise a barrier can be installed as a **capillary break layer** between saline soil and clean soil.

The Enkadrain Wide composite with its 6 mm thick V-shaped filament core is particularly good at creating a void break. With 95% air space it **will allow water to flow in all directions** almost equally; thus acting as an efficient salt barrier.

A capillary break (salt barrier) must be **situated above the high water level** so that it does not become saturated by the contaminated, saline water. Even **saline levels of 4 or 5 g/l are generally too high for plants and trees** to survive. Enkadrain Wide has a sufficient flow capacity for both irrigation and groundwater flows percolating to the barrier to be drained away through the core without restriction.

FUNCTIONS:

- Capillary break
- Drainage
- Filtration
- Separation



Salt barriers both serve as a capillary layer to break the saline groundwater particles from moving to ground level and also serve as traditional drainage mats for excess sweet water.



Enkadrain® Wide

Relevant products:

Enkadrain® Wide





Dike protection against erosion and scour

The Roy Hill project, Pilbara region, Australia

The Roy Hill Project is a 55 million tonne per annum (Mtpa) iron ore mining, rail and port project being developed in West Australia's Pilbara region. Situated approximately 115 kilometres north of Newman, Roy Hill is a world-class, low phosphorus, Marra Mamba iron ore deposit.

Challenge

The dykes that protect a part the iron ore mining against flooding need to be protected against erosion and scour in case flooding occurs. The durability of the construction is important and therefore every component used in this project must have a design life of 85 years in marine conditions. The original design was a traditional rock revetment with a nonwoven filter. The remote project location and the elevated price of quality rock would lead to high transportation costs. New alternatives imposed themselves.

Solution

Low & Bonar delivered 94,000 m² of Enka-Fix to the Roy Hill Project. Flexible concrete mats are used as an erosion control system in case of flooding. Enka-Fix combines the weight of the ballast with a filter by means of a very durable woven/ looped fabric.

Concrete blocks were cast upon the fabric before installation. The loops on the fabric provide an extremely strong connection between concrete block and woven fabric. The finished panels were brought to the site by truck.

A durability of 85 years in marine conditions is required. The woven fabric plays a crucial roll to maintain the stability of the structure. Low & Bonar developed a special woven fabric by adding stabilisers to the extrusion process to increase the oxidation resistance. The woven geotextile was tested according to the new norm EN ISO 13438 which also defines the test procedure for a durability of 100 years.

Also the UV resistance is important. The product needs to withstand 200 kLy. By adding stabilisers and carbon black to the extrusion process Low & Bonar was able to reach the required durability.

Benefits of the solution

- Enka-Fix offers a unique combination of ballast and filtration in one product.
- Easy and fast installation (all-in-one go)
- Durability up to 100 years
- Cheaper solution than rock revetment (depending on availability of rock)
- Better alternative for articulating block mats, gabion mats,...

Result

A fast and cheap solution was offered with Enka Solutions to replace traditional rock revetment. The stability of the structure is assured by the loop pile fabric and its connection to the concrete.



Enka-Fix is strong enough to lift the concrete mats in the air



Transportation of the 2.6 m width flexible concrete mattresses



Installation of the product



The anchorage trench was filled with concrete

PRODUCT
• Enka®-Fix

FUNCTIONS
• Erosion control
• Scour protection

CONTRACTOR
• Marecon

VOLUME
• 94,000 m²

Dewatering of sludge Lake Balaton, Hungary

An average depth of 4 m and a maximum depth of 11 m make Lake Balaton a shallow lake. During storms or high wind event sediments are transported from the west to the east of the lake. The sediments contaminate the beaches of hotels located at Lake Balaton.

Challenge

The sediments settle down at the sides of the lake making it impossible to swim or sail. Therefore the sludge needed to be removed so customers of the hotels could enjoy the lake again.

Unfortunately normal dredging was impossible as the water is only 1 m deep. So a very small dredger was required. As there was no possibility to store the sludge on the boat, it needed to be transported landwards. The project included 1500 m³ (or 65 trucks) of dewatered sludge. This would result in a huge space needed to store and to dewater the sludge.

Solution

Low & Bonar offered a solution which saved a lot of space and transport by means of Enka-D-Tube dewatering tubes. Two tubes with a circumference of 30 m and 15 m length were delivered on site. Both tubes are able to contain 400 m³ of drained sludge. A larger tube with a

circumference of 30 m and a length of 30 m is placed on the top of the two smaller tubes saving even more space. In this way only a small area of the hotel garden was in use for the dewatering of the sludge.

Enka-D-Tubes are fabricated out of a special technical woven fabric, allowing the tubes to filter the solid particles out of the sludge coming from the lake into the tubes. The water of the slurry flows through the fabric back into the lake. In this way great volume reductions are possible (up to 85%). Underneath the tubes a containment is installed by means of a membrane which gathers all the water and leads it back towards the lake.

Strong seams for a reliable product

During pumping the height of the tubes will rise due to the pressure which is building up inside the tube. The maximum allowable height of the tubes (2.6 m) was calculated by Low & Bonar and monitored during the

whole process. The allowable height depends on the circumference, the density of the sludge, the pumping pressure, the strength of the fabric and its seams. Low & Bonar developed a unique strong seam for its dewatering fabrics which combines a very strong yarn with a multiple needled flat seam. The strength of the seams has been determined in a geotextile lab and reached up to 67% seam efficiency. This strength is implemented in the software used to calculate the maximum height and pressure possible for the Enka-D-Tubes. By using Enka-D-Tube, the contractor was able to offer an economical, efficient and ecological solution to improve the beaches at Lake Balaton.



Water coming out of the Enka-D-Tube is very clear.



The two smaller tubes were pumped to a height of 2.3 m. The biggest tube is placed on top of the two smaller tubes.

PROJECT OWNER
• Geosynthetic Kft.

PRODUCTS
• Enka®-D-Tube 30x15
• Enka®-D-Tube 30x30

FUNCTIONS
• Dewatering of sludge

Geobags to protect coastline from erosion and scour Jerudong Beach, Brunei

Many of the sandy beaches around the world are subjected to ongoing erosion, with the subsequent threat to the integrity of beach infrastructure. Enka-G-Bag is a proven solution for beach wall protection, revetments, breakwaters and as riverbank protection.

Challenge

Jerudong Beach suffered of intense erosion and scour along a big part of the coast line. Breakwaters were installed to reduce the wave impact on the beach but still this was not enough. The coastline kept moving landward and became a problem for houses, roads,... built near the coast.

Low & Bonar was asked to cooperate in creating an erosion control system to stop the coastline from moving landward. Traditional rock revetment would be too expensive as no rock was available on this remote island. The system had to be easy to install, stable, environmentally friendly and with the same effectiveness as a rock revetment. The hydraulic specifications pushed our engineers towards a geobag system which could resist wave heights of $H_{max} = 1m$.

Solution

- Enka-G-Bag was used as an erosion control system
- Different materials were used to optimise the design

Enka-G-Bag is filled with in situ sand. This avoids the transportation of rock or fill material which has a positive influence on the carbon footprint of the whole structure.

The toe of the structure is wrapped with a UV stabilised Enka-Tex woven fabric. The ends of the woven are retained by the weight of the structure. In this way the bags are able to move downward in case scour would transport sand away from underneath the lowest sand containers.

The geosynthetic bags are fabricated out of highly UV stabilised nonwoven. The robustness of the fabric makes the bags easy and fast to work with. They can be installed over granular fill without the risk of being damaged during installation.

Benefits of the solution

Enka-G-Bag offers a soft engineering solution which is a sustainable and cost effective alternative to rock revetments. Because of their size and weight engineers can use them as building elements to create stable, durable erosion control structures.

Mussels, algae and other underwater life attach to the nonwoven so that the geosynthetic bags integrate quickly and easily into the sensitive sea ecosystem.

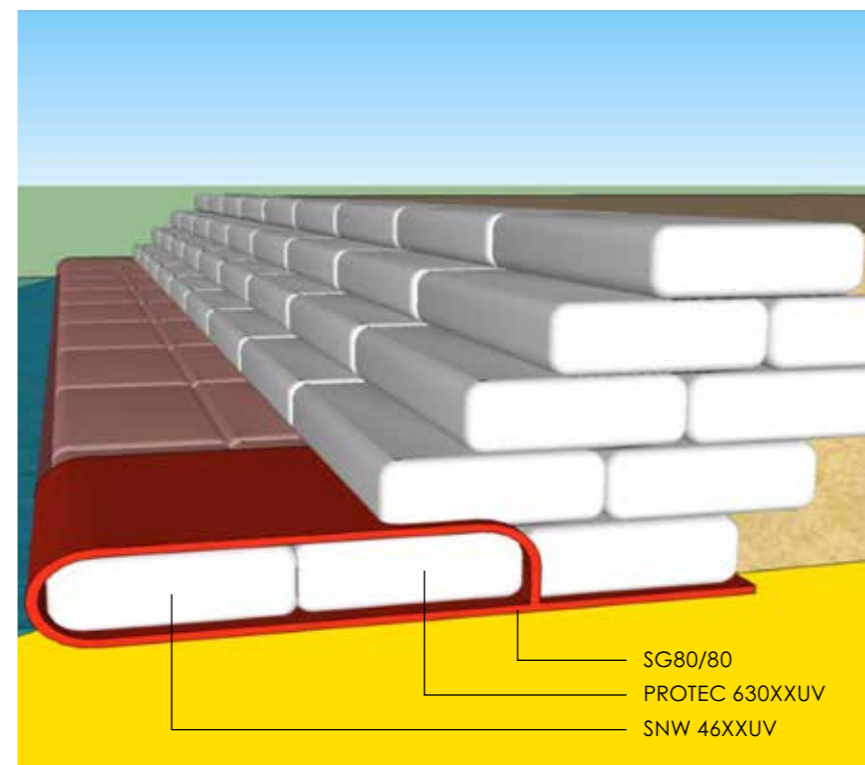
The high elongation of the fabric makes the erosion control structure self healing. Once a bag gets pulled out, the other bags will elongate and fill the gab.

Result

The bund of bags protects the coastline from eroding and moving landward.



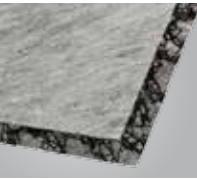
Enka-G-Bag is filled with in situ sand which avoids the transport of rock or fill material.



A "Dutch toe" is created by wrapping the lowest two bag of the structure with Enka-Tex SG 80/80.

- PRODUCTS
- Enka®-G-Bag
 - Enka®-Tex SNW 46 XXUV
 - Enka®-Tex PROTEC 630 XXUV
 - Enka®-Tex SG 80/80
- FUNCTIONS
- Erosion control system

Enka Solutions product overview



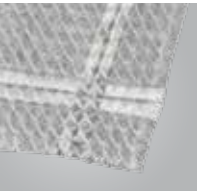
Enkadrain®

Consistent and excellent long-term performance is a key feature of the Enkadrain drainage mat. Each variant has a drainage core bonded to a synthetic nonwoven geotextile layer or is sandwiched between two such layers. Enkadrain provides solutions for groundwater issues for civil engineering and building projects, both during construction and in service. With an extensive portfolio of product types, Enkadrain is suitable for many different applications.



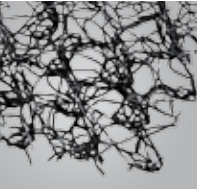
Enkagrid®

The Enkagrid product range comprises a large portfolio of rigid and flexible geogrids, their common values being the optimum soil-grid interaction delivered for each application in any soil type and their outstanding mechanical long-term durability. Enkagrid types are uni-axial or bi-axial, manufactured from either laser welded strips or woven coated yarns. When soil reinforcement or stabilization is required, our wide choice of readily available products will meet individual project needs.



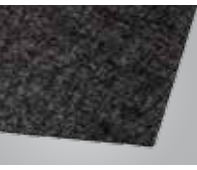
Enkagrid® PLUS

Enkagrid PLUS is a high performance knitted geocomposite for reinforcement of asphalt and soil. Manufactured from high tenacity yarns and a nonwoven geotextile, this geogrid increases the tensile strength of asphalt layers and reduces the formation of cracks. Enkagrid PLUS also provides an excellent solution for soil reinforcement, combining reinforcement, separation and filtration in one product. Both solutions contribute to a significantly longer service life of asphalt layers and road and railway foundations.



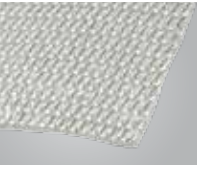
Enkammat®

Enkammat is a flexible three-dimensional mat for immediate, permanent erosion protection on many different slope types. Its unique structure creates an artificial root structure that prevents soil erosion from steep slopes, river banks, landfill containments and other vulnerable areas. Enkammat has excellent soil retention, providing the perfect conditions for vegetative root systems to develop. Embedded with soil, it forms an integrated and fully vegetated system to control erosion.



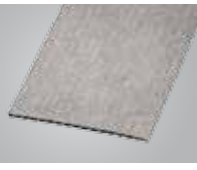
Enka®-Tex

Enka-Tex is Enka-Solutions' complete range of nonwoven and woven geotextiles. The nonwoven geotextiles are needle punched and can be thermally bonded. The Enka-Tex product range is extensive, each type having specific properties of tensile strength, weight or flow capacity. Enka-Tex is ideal for projects where erosion control, filtration, protection, drainage, stress relief, reinforcement or separation are called for.



Enka®-Force

The high modulus multifilament yarns used in the production of Enka-Force fabrics offer excellent creep characteristics, making them the perfect choice for use in soil reinforcement applications. The range has been specifically designed to exhibit high strength at low elongation. Typical areas of application include reinforced soil walls, embankments on weak soil and load transfer platforms.



Colbondrain®

When the sub-grade of a construction site is too weak to bear normal construction activity, Colbondrain will speed up consolidation considerably. Colbondrain is a tough and durable prefabricated vertical drain (PVD), designed to extract pore water from soils to achieve 90% consolidation within six months. Thanks to its high performance Colbondrain is often the chosen PVD for major, technically demanding projects.

Our areas of expertise

Our solutions offering provides answers for many different geotechnical challenges. They can be applied to what we consider our 'areas of expertise'.

AREAS OF EXPERTISE

TRANSPORTATION INFRASTRUCTURE

Our geosynthetic solutions support rails and roads throughout the world.

COASTAL & WATERWAY INFRASTRUCTURE

Geosynthetics are effective in protecting coasts and water embankments against the influence of hydraulic loadings.

ENVIRONMENTAL INFRASTRUCTURE

Our geosynthetic solutions help to create parks, playgrounds, ponds and canals to improve our residential, commercial or industrial areas.

LANDFILLS

Landfills are a common way of managing our disposal of regular waste. To ensure landfills will not cause any environmental harm, leachate and methane gas may not reach our environment.

GROUNDWORK CONSTRUCTION

When designing and constructing industrial, commercial or public buildings, special attention is required for foundation and drainage issues.

TUNNELING AND MINING

Enka Solutions' offer for concrete lining protection, railway support, rock wall covering, soil stabilization, tunnel wall drainage and protection and vibration control are amongst the best in the world.



Three fundamental values are at the core of Enka Solutions: expertise, reliability and responsibility



Expertise

We began creating our knowledge and expertise base on our products and the industry way back in the 1950's, which means that today we have a multitude of project references worldwide. Coupled with extensive research conducted internally and externally with renowned universities and specialist organisations, our Research, Development and Innovation Team is constantly working in conjunction with clients all over the world to develop new solutions to add to our range of products and applications. In addition to this, our team of experienced engineers, who provide support across all market segments, ensures that numerous innovative solutions come to fruition. We see expertise both as the foundation of our business and as an ongoing process.

Reliability

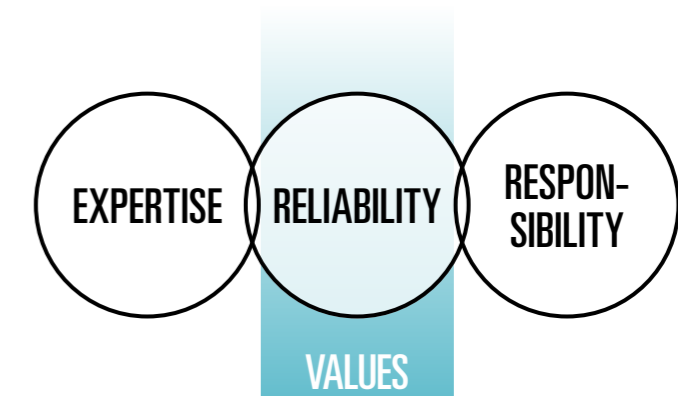
It's our daily mission to be a reliable partner for our customers in order for them to grow their business in a sustainable way. Reliability covers a range of different areas and ensures peace of mind for our partners. As well as our wide, high quality product range, we offer technical and marketing support for all market segments. All our processes are ISO 9001 certified and every single product is tested by our highly qualified laboratory staff. Furthermore, we hold specific product certifications in many different countries (e.g. Asqual, NorGeoSPec, Benor, HPQ, and BBA). Delivering what we promise is part of our nature.

Responsibility

We take our responsibilities seriously. This is why you can also rely on our solutions being sustainable. We not only examine the full product lifecycle and its impact on the environment to make continual improvements in terms of environment, nature and soil, but also ensure that we meet all legal requirements. We train and advise clients and stakeholders, and contribute to the establishment of new standards to help propel our entire industry forward into the future. It will therefore come as no surprise that safety is also a high priority for Enka Solutions. Safety is inherent to all our solutions and products, as part of our responsibility to care for both the people who use them on building sites, and our employees.

Enka®solutions
ENGINEERING NATURE

These values that are the core of Enka Solutions are reflected in our statement 'Engineering Nature', because not only is engineering in our nature, but we also see ourselves as **engineers delivering reliable solutions that respect nature.**





The Enka Solutions product range is manufactured by Low & Bonar who is a global leader in high performance materials selling in more than 60 countries worldwide and manufacturing in Europe, North America and China. Low & Bonar designs and manufactures components which add value to, and improve the performance of, its customers' products by engineering a wide range of polymers using in-house manufacturing technologies to

create yarn, fibres, geosynthetics, industrial and coated fabrics and composite materials. These materials contribute to a more sustainable world and higher quality of life. Low & Bonar is listed on the London Stock Exchange.

The quality systems of Low & Bonar facilities have been approved to the ISO 9001 Quality Management System Standard. Certificates are available on request.

CONTACT US FOR A FREE SAMPLE KIT OR TO DISCUSS YOUR SPECIFIC REQUIREMENTS

Belgium T +32 52 457 487
Czech Republic T +420 518 329 113
China T +86 21 6057 7287
France T +33 1 57 63 67 40
Germany T +49 6022 812020
Hungary T +36 49 886 200

Netherlands T +31 85 744 1300
Slovakia T +421 37 6556010
United Kingdom T +44 1482 863777
USA T +1 828 665 5050

Or contact your local distributor
www.enkasolutions.com / info@enkasolutions.com

Disclaimer

All information and product specifications provided in this document are accurate at the time of publication. As the Low & Bonar Group follows a policy of continuous development the provided information and product specifications may change at any time without notice and must not be relied upon unless expressly confirmed by a relevant member of the Low & Bonar Group upon request. No liability is undertaken for results obtained by usage of the products and information.

© 2016 Low & Bonar / SO-ENG-CW-08/2016