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Engineering a Better Solution

Maccaferri's motto is **'Engineering a Better Solution'**; We do not merely supply products, but work in partnership with our clients, offering technical expertise to deliver versatile, cost effective and environmentally sound solutions. We aim to build mutually beneficial relationships with clients through the quality of our service and solutions.

GLOBAL ENGINEERS

In the second half of the 19th century, we invented Gabions and dramatically changed the civil engineering landscape. We are still changing today. We work every day to find better solutions for our clients at every degree of latitude and longitude. Our worldwide network grows through innovation and diversification of sectors of activity and through an increasing range of high quality and environmentally friendly products and applications.

OFFICINE MACCAFERRI GROUP PROFILE

Founded in 1879, our Group soon became a worldwide reference in the design and development of advanced solutions, with offices in over 70 countries and 30 factories worldwide.

Our mission is to pursue excellence through continuous improvement, while delivering to customers engineered solutions that are innovative, advanced and environmentally friendly. We are committed to outstanding safety, quality and sustainability, to create value for all stakeholders as well as our communities.

MACCAFERRI APPLICATIONS

- RETAINING WALLS & SOIL REINFORCEMENT
- HYDRAULIC WORKS
- ROCKFALL PROTECTION & SNOW BARRIERS
- EROSION CONTROL
- SOIL STABILISATION & PAVEMENTS
- BASAL REINFORCEMENT
- COASTAL PROTECTION, MARINE STRUCTURES & PIPELINE PROTECTION
- DRAINAGE OF STRUCTURES
- SAFETY & NOISE BARRIERS
- LANDSCAPE & ARCHITECTURE
- FENCING & WIRE
- AQUACULTURE NETS/CAGES
- ENVIRONMENT, DEWATERING & LANDFILLS

MACCAFERRI

MACCAFERRI

COASTAL & MARINE PROTECTION

INTRODUCTION: COASTAL & MARINE PROTECTION

Mankind has always had a reliance on the sea whether for food, transportation or trade. As a consequence, a high proportion of the world's population lives in coastal cities, resulting in the emergence of large ocean ports, harbours and major transport infrastructure to support commercial development and population mobility. Additionally tourism is increasingly developed along our coasts, boosting economic activity.

In parallel with this coastal development is the global environmental change we are now experiencing, bringing with it storms, typhoons and hurricanes. The predicted effects of this climate change will be increased coastal flooding and erosion; the Intergovernmental Panel on Climate Change (IPCC) has predicted an estimated sea level rise of 28-42cm for the period 2000-2100, which thus far has proved to be correct.

As it is not possible to relocate our society away from the coasts, a conflict arises which requires new and more effective strategies for building, upgrading or maintaining our coastal defences to protect human life, property and infrastructure.

Maccaferri has over a century's experience in hydraulic works: the protection of coasts and the training of rivers and streams. Our engineers provide advice and tailored solutions to coastal protection problems, to international consultants, major construction companies and policy makers.

New solutions for coastal and marine works should take into consideration:

- Meteo-marine parameters
- Geological/geotechnical parameters
- Availability of "in situ" materials
- Aggressiveness of the local environment (fresh/salt waters, presence of hydrocarbons or other agents)
- Landscape requirements
- Availability of construction site area and works program.

The appropriate design of coastal protection works has proven important for several years now, especially in the light of recent catastrophic events including hurricanes, tsunamis and typhoons that have caused widespread damage and destruction.

Maccaferri offers a range of engineered solutions to minimise the erosion of the coastline caused by waves and currents and hence reduce inland flooding.

- Dune Reconstruction and Preservation
- Breakwaters and Groynes
- Ballasted Mattress Technology
- Seawalls and Shoreline Structures
- Port Structures, Quays and Open Pile Jetties
- Pipeline and Cable Protection
- Seagrass Meadows
- Polluted Sediment Capping & Remediating.

PROBLEM UNDERSTANDING

For over a century, Maccaferri has worked with its clients to provide solutions to limit erosion and protect coasts, estuaries, rivers and pipelines.

The forces and exposure conditions associated with coastal interventions requires the careful selection of solutions and clear advice on the expected performance. This extends to product choice, installation techniques and integration into the local environment, all geared to provide value for money for our clients.

Our global presence enables us to draw upon a wide experience of different site conditions and project requirements, which can be translated to a local level on individual projects. Furthermore, being a manufacturer as well as solution provider, we are able to develop specific products, tailor-made to overcome particular local conditions and requirements. This optimises the intervention both technically and commercially.

Wherever feasible, we select solutions which reinstate, as much as possible, the natural conditions; providing interventions which enhance and strengthen the natural environment.

With increasing technology and sophistication of coastal modelling, Man's understanding has improved, leading to a 'coastal management' approach. Coastal management includes both protection of the coast and allowing erosion to claim land in a managed approach. Coastal zones are areas of increasing human activity and use, and solutions must address this whilst recognising the global problem of rising sea-levels.

SOLUTION PORTFOLIO

From a starting point of discovering and understanding the engineering problems facing our clients, we draw upon our experience of similar projects and technical knowledge to select the most appropriate solutions from our portfolio. Often a number of products are combined to optimise the coastal protection intervention.

Our experience in coastal protection and hydraulic structures enable our team of engineers to provide a range of solutions based upon the analysis of the project site conditions and client requirements:

- Needs of the landscape
- Meteo-marine parameters: tide, waves, coastal current
- Availability of 'site won' materials: crushed stone, sand, gravel, silt, clay
- Conditions: fresh water, salt water, presence of hydrocarbons, presence of aggressive agents.

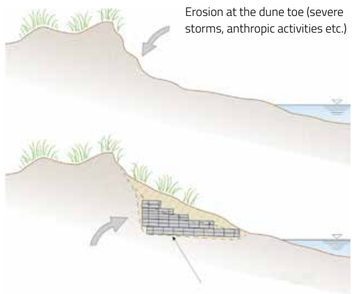
Problem	Gabions	Reno Mattress®	MacTube®/ MacBag®	BFM/BSM RFM/RSM	MacMat® Range	Marine Mattress	ACBM/ Sarmac®
Dune reconstruction	✓	✓	✓		✓	✓	
Breakwaters & groynes	✓	✓	✓	✓		✓	
Seawalls & shoreline structures	✓	✓	✓		✓	✓	
Quays	✓	✓				✓	
Open pile jetties	✓	✓				✓	
Pipeline/cable protection		✓	✓	✓		✓	✓
Seagrass meadows		✓			✓	✓	
Polluted sediment capping		✓		✓		✓	✓

We manufacture and supply high quality durable materials which:

- Enhance the service life of the works
- Reduce environmental impact
- Provide client reassurance

DUNES & INTERTIDAL ZONES
RECONSTRUCTION & PRESERVATION

The vital role that dunes play in the equilibrium of the coastal environment is widely recognised. Many countries have undertaken projects to reconstruct and preserve existing dunes.



Dune core reconstruction from Gabions, Reno Mattresses®, MacTubes®, MacBags®, MacGrids® as appropriate

The dune profile changes naturally throughout the seasons but disruptions to this, through exceptional storms or man-made events, can affect the long-term stability of the dune. Any breach in the protective dune alignment can be exploited, leading to accelerated erosion and should be filled.

Solutions can include:

- A complete rebuilding of the dune by providing a structural core
- Short-term surface protection to enable re-establishment of protective vegetation
- Reducing the causes of the erosion.

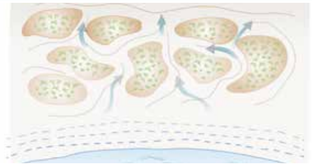
Our engineers are able to offer cost effective solutions based upon the project site conditions:

- Environmental conditions (waves, wind, currents)
- Material availability (sand, stones)
- Installation conditions.

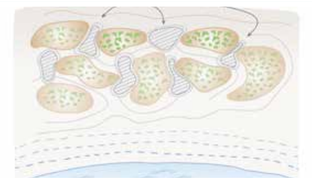
“ **MacTubes®** or gabions can be ideal to reconstruct dunes, by providing a robust core.”

Clovelly Beach, Cape Town, South Africa

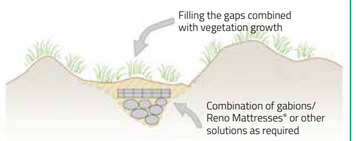
PROBLEM Erosion paths generated by a combination of people movement and wind erosion



SOLUTION Filling the gaps with dune vegetation restoration



DETAIL



COASTAL PROTECTION
BREAKWATERS & GROYNES

Breakwaters and Groynes are designed to reduce the effects of waves and currents approaching the coast. They can be submerged or emerged and in the case of breakwaters can be either attached to the shore, or positioned offshore.

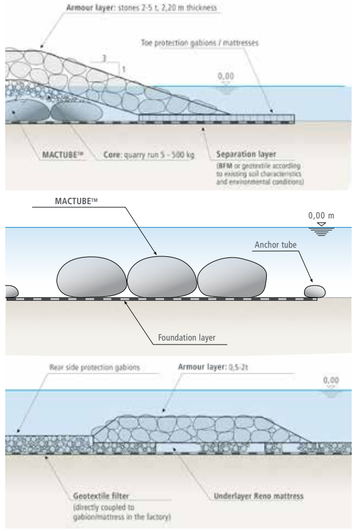
Breakwaters are used to protect shorelines or shore based infrastructure such as ports and harbours. They reduce the impact of waves on the shore and on the operation of the port.

In estuarial zones where the sediment transport regimes are very dynamic, groynes are often used to stabilise the banks and channels.

Solutions can include a combination of products:

- Foundation: **Ballasted Filtering Mattress** (**BFM**) is a unique geocomposite that combines a filtration and separation function in one product and can be used as a foundation beneath the breakwater.
- Core of structure: Tubes (**MacTube®**) and bags (**MacBag®**) constructed from high strength, durable geotextile and/or geocomposites, can be used to form the core of groynes/breakwaters. The **MacTube®** is filled in situ with a sand/water slurry and is the preferred solution where sand is available in great quantity.
- Armour layer/underlayer: **Reno Mattresses®** and gabions can be used as the outer armour layer when significant wave heights are lower, otherwise they can be used as the underlayers.
- Toe protection: **Reno Mattresses®** and gabion structures provide erosion protection to the base of the breakwater and are offered as the preferred solution when larger 'rip-rap' is not available on site.

Typical cross-section



As groynes reduce the littoral longitudinal transport they are normally implemented with a beach nourishment scheme, with the overall objective of reducing shoreline erosion. Groyne works can also be combined with submerged offshore breakwaters.

In the armour layers, rocks contained within our gabions or mattresses offers numerous advantages:

- Use smaller stones – Rocks contained in mesh perform better than loose rocks of the same diameter
- Reduction of armour layer thickness
- Reduced quantity of materials required with less quarrying, haulage and vehicle pollution
- Units can be pre-filled onshore and then lifted into place offshore saving time and cost.

When the sea-bed cannot offer sufficient bearing capacity, either for simple **MacTube®** structures or more complex structures involving rocks or tetrapods, **ParaLink®** geogrids can offer basal reinforcement and foundation support.

Polymeric Marine Mattress (PMM) constructed from 'sand' coloured **MacGrid® WG** to minimise visual impact of intervention.

Reclamation works: Simplified breakwater structures can also be used during reclamation works by forming the perimeter to the new area to be reclaimed. Dredged material (or other) is then pumped into this cell area where it is contained by the breakwater/barrier.

SOLUTION FOCUS
BALLASTED MATTRESS TECHNOLOGY

> " Even the simplest breakwater using large rip-rap stones or tetrapods, requires a filter layer between it and the seabed, to avoid differential settlement and reduced performance. "

PROBLEM

When designing marine structures, engineers traditionally focus on the performance of the structure itself and especially the armour layer:

- How large does the structure (e.g. breakwater) need to be?
- What forces must it accommodate?
- Can I use a **MacTube®** for the core of the structure?
- What size armour stones are required? Are "tetrapods" needed?
- Do I use **Reno Mattresses®** at the toe?

However, equal importance must also be placed on the interface between any new structure and the existing sea or estuary bed. Without a reliable and correctly designed filter layer, the structure above will not perform as designed; it could settle into the seabed due to the gradual erosion and displacement of the bed materials.

On dry land, a quality geotextile selected to offer the correct filtration characteristics and puncture resistance, would be straightforward to install. However, transfer this solution to the sea and its buoyancy causes significant problems during placement.

INNOVATION

For over 10 years, we have established expertise in the use of the **Ballasted Filtering Mattresses (BFM)**.

Maccaferri **BFMs** are designed to provide the required filter performance, be simple to deploy in water and also remain in contact with the seabed in order to limit erosion and consequent instability beneath the structure.

The **BFM** is a unique geocomposite. It combines filtration and separation functions in one product. However, in contrast to other geotextiles, the **BFM** is heavier than water and so it can be installed underwater. It can be used beneath rip-rap, breakwaters and other marine structures.

TECHNOLOGY

Drawing upon our extensive geosynthetic portfolio and manufacturing expertise, we use our geotextiles and reinforcement materials in specific combinations to deliver the performance characteristics required on the project.

Recently Maccaferri has extended this technology to offer solutions for remediating polluted sediment areas and even sealing these areas.

The loads imposed upon the product during installation can be significant (self-weight, wave and current forces, impacts during rip-rap placement) and have to be considered in the design of the product.

The Maccaferri mattresses consist of a number of customisable components:

	Lower geotextile	Core	Fill material	Upper geotextile	Use
BFM Ballasted Filtering Mattress	Filtering geotextile	Reinforced geomat	Gravel ballast	Separation geotextile	Filtration & separation
RFM Remedial Filtering Mattress	Filtering geotextile	Reinforced geomat	Organoclay/active carbon-gravel mix	Separation geotextile	Polluted sediment remediation
BSM Ballasted Sealing Mattress	Impermeable MacLine® GCL	Reinforced geomat	Gravel ballast	Separation geotextile	Underwater waterproofing
RSM Remedial Sealing Mattress	Impermeable MacLine® GCL	Reinforced geomat	Organoclay/active carbon gravel mix	Separation geotextile	Underwater waterproofing & remediation

Depending on the size of the project, the **BFM** can be in large rolls or smaller panels.

- Maccaferri ballast and remedial mattresses are scalable solutions; our manufacturing know-how has made rolls of **BFM** 10m wide and 200m long
- An integrated system of packaging, transport and launching of the rolls is also necessary to ensure safe deployment into the works

INSTALLATION

Deploying large rolls requires a launching pontoon with a suitable mechanism to unroll the **BFM** onto the seabed. Movement of these pontoons is normally by GPS controlled winches, with cables fixed to moveable anchors on the seabed.

Smaller panels can be installed using suitable lifting frames.

PROJECT FOCUS

MOSE PROJECT, VENICE, ITALY

Regular high-waters frequently inundate Venice. Since 2003, **The Consorzio Venezia Nuova** has developed a system of gates within each of the inlets to the Venice lagoon. At times of high tides, these **MOSE (Modulo Sperimentale Elettromeccanico)** gates are raised, isolating the lagoon and protecting this World Heritage Site.

The presence of these **MOSE** gates at the inlets would inevitably generate focused water movements and cause scour problems unless suitable erosion protection was installed. A layer of armour-stones (0.5-2t each) nearly 3m thick was designed to protect against scour. Project designer Technital, detailed a filtering mattress on the seabed, beneath the armour stone to preserve the performance and stability of the scour protection.

Maccaferri, working as part of a consortium, designed, developed and installed the innovative BFM that could be installed accurately underwater, provide the required filtering function beneath the 2000 kg armour stones and be efficient to deploy over large areas of the sea floor. The mattress also had to remain stable under current loads so that erosion beneath the armour stones could not occur.

COASTAL PROTECTION
SEAWALLS & SHORELINE STRUCTURES

Sea walls protect infrastructure (cities, transportation and industrial plants) from wave action and are typically rigid and parallel to the shoreline. They can increase the reflection of the incident waves and are affected by erosion phenomena at the foot of the structure and if this is not adequately addressed, the structure will be undermined.

Reducing the slope of the intervention (sea-side) lessens the reflection of the incident waves. A combination of **MacTube®**, **MacBag®**, **gabions** and **Reno Mattresses®** can be used depending on the characteristics of the seawall work protection and the availability of materials.

Turf reinforcement mats (with metallic or polymeric) reinforcement can be used in light-load conditions.

MacTube® and **MacBag®** solutions are favourable when a large amount of sand is available, whereas **gabions** and **Reno Mattresses®** may be offered when a suitable quantity of rock fill is available. These solutions are often retro-fitted to existing vertical walls to reduce the environmental impact.

Where it is not possible to reduce the slope in front of the sea wall, robust scour protection is required at the toe of the wall to avoid the wall foundations being exposed.

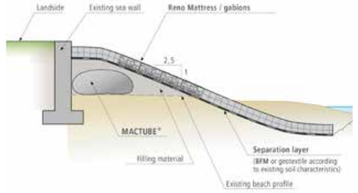
Shoreline structures are installed longitudinally and parallel to the shoreline and can be used alone or in combination with other interventions.

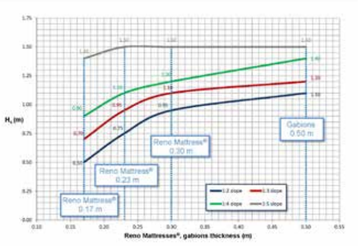
They are used for a variety of purposes including:

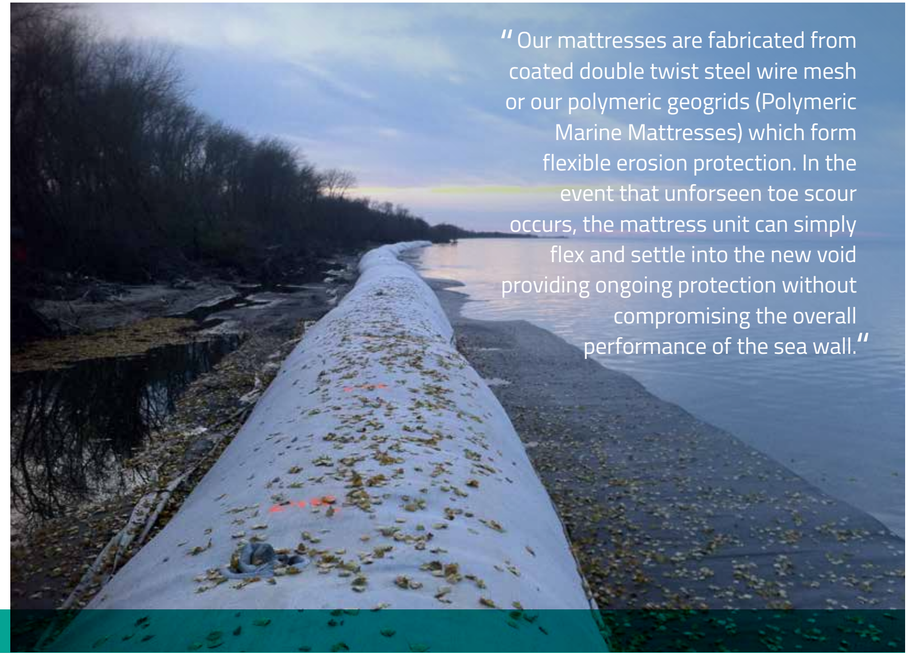
- Erosion control
- Landslide protection
- Beach stabilisation.

Where a softer shoreline structure is required, **MacTubes®** or **MacBags®** are used and can be filled with locally available material to reduce the import of rocks or other armour.

If the sea-bed cannot offer sufficient bearing capacity, **ParaLink®** geogrids can provide reinforcement of the foundation.







"Our mattresses are fabricated from coated double twist steel wire mesh or our polymeric geogrids (Polymeric Marine Mattresses) which form flexible erosion protection. In the event that unforseen toe scour occurs, the mattress unit can simply flex and settle into the new void providing ongoing protection without compromising the overall performance of the sea wall."

PORT STRUCTURES
QUAYS & OPEN PILE JETTIES

Maccaferri offers cost-effective solutions for slope and bottom protection against scour generated by propellers of large vessels. Use of **gabions** or **mattresses** instead of large stones or rip-rap enables the reduction of the thickness of the protection by more than 50-70%.

Jetties, marinas and other structures can be constructed and protected from erosion using systems within the Maccaferri portfolio. **Gabions** are proven to integrate well into the environment and become colonised by marine life within a short time; the voids forming habitat to fish and crustaceans.

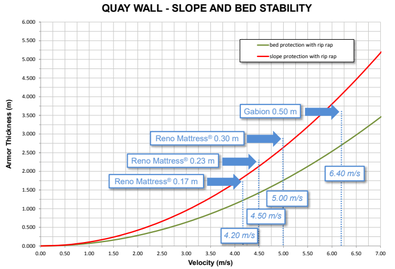
"We can select from a range of woven or non-woven geotextiles to suit the technical requirements; in the **Venice MOSE Project**, we even developed a specific **BFM** and deployment methodology to suit the project, combining engineering knowledge with manufacturing capability."

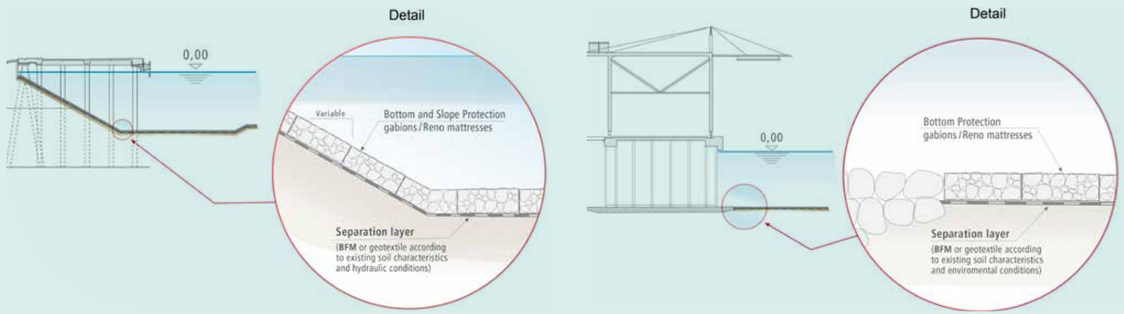
Gabions, **Reno Mattresses®** and **Marine Mattresses** can be also used to protect the seabed from the action of ship propellers during mooring/unmooring operations, or for the protection of embankments beneath quays or piled jetties.

We offer a range of products to suit the exposure conditions of the intervention including wave action, UV exposure and intertidal zone. For the double twist steel wire **gabion** and mattress mesh products, the protection includes a heavy duty zinc/aluminium galvanising with an additional polymer coating. For more aggressive conditions, stainless steel mesh or mattresses made with polymeric geogrids can be used.

Geotextiles play an important role within coastal works to provide a separation and filtration function, especially within the foundation construction of interventions.

Ballasted Filtering Mattresses, or higher strength **ParaLink®** geogrids can offer foundation strengthening, if required.





PIPELINE & CABLE PROTECTION
TYPES OF MATTRESSES

Since the early 1980's, Maccaferri has offered solutions for the protection of submarine pipelines and cables. These pipes can be moved due to high current forces upon them as their immersed weight is insufficient to counteract these forces.

Flexible marine mattresses, placed over the pipes add ballast, increasing the mass of the pipe system and limiting movement. Depending on the expected current forces, the ballast can be continuous or at intervals along the pipe. These mattresses can additionally protect the seabed around the pipeline or cable, from scour erosion caused by currents.

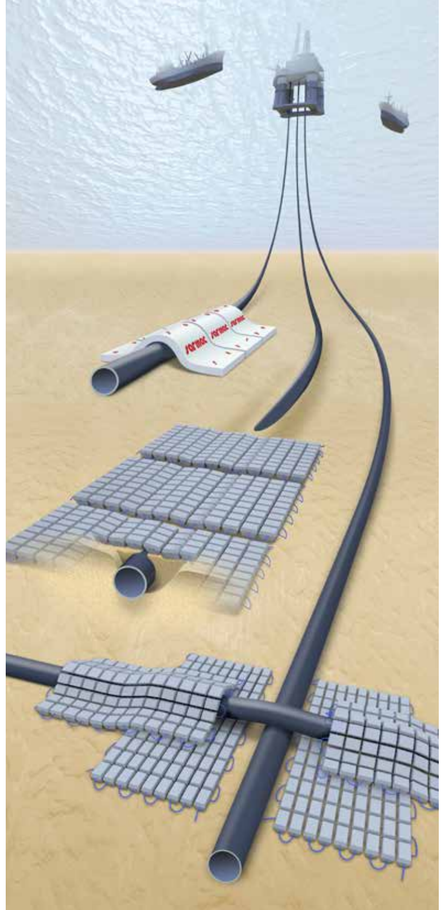
Our **Sarmac® Bituminous Mattress**, is a well-known and technically proven solution, used extensively in the Oil and Gas market. It consists of a double twist galvanised woven wire mesh mattress, lined with geotextile. It is filled with rock and a sand-asphalt mix, forming a malleable, dense and easy to deploy unit.

ADVANTAGES OF **SARMAC®** MATTRESS

- Flexible even in cold water conditions
- Softer, deformable surface limiting abrasion damage to pipe work
- Ideal as a separator between pipes at 'crossovers' or junctions
- Provides protection from vessel anchor damage
- Provides support over local uneven or soft ground areas

ADVANTAGES OF **ACBM** MATTRESS

- Flexible
- Provides ballast and protection of submerged pipelines
- Worldwide production capabilities



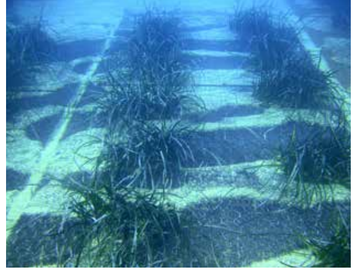
In response to market demand, we introduced **Articulated Concrete Block Mattresses (ACBMs)** to our range of solutions. It consists of a mattress of individual concrete blocks which are connected together with cables. The cables enable the unit to be simply lifted and deployed into position.

The **ACBMs** flexibility enables it to conform to the shape of the pipeline or seabed. The major innovation is the ability to produce Maccaferri **ACBMs** directly at the place of final delivery due to a patented mobile formwork. This results in a significant decrease in the time and cost of transport and which minimizes environmental impact.

Tested against impact, Maccaferri **ACBMs** are proven to protect pipelines from damage from vessel anchors or other equipment accidentally falling from offshore rigs or other port infrastructure.

SEAGRASS MEADOWS & SALT-MARSHES

Seagrass meadows and salt-marshes are important features in the coastal environment as they reduce flow velocities, increasing sedimentation and limiting erosion. In addition, they form important marine habitats and sequester carbon. Whereas seagrass meadows are always underwater, salt-marshes are in the intertidal zone and are inundated daily.



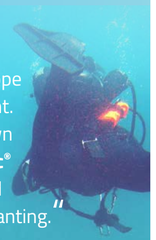
Our solutions can be used to stabilise these important structures, either through the reinforcement of channels on the approach to salt-marshes, or reducing current flows in the vicinity of seagrass meadows to assist in vegetation re-establishment.

In the Mediterranean sea, Posidonia Oceanica is a marine plant that has an important ecological role in the marine environment. It is protected under the Barcelona Convention.

Seagrass, and especially Posidonia, provides:

- Important daily production of O_2; from approx. 3 l/m²/day (December) to 14 l/m²/day (June)
- Environment protection for fish reproduction
- Seabed stabilisation, due to the consolidation action of the plant roots
- Natural protection system against waves and currents. Plant leaves reduce the action of hydrodynamic forces.

"Reinforced geomats such as **MacMat®** R have been used as root reinforcement for the fledgling seagrass plants, supporting them until they are substantial enough to cope with the natural environment. The plants can even be grown within a **MacMat®** or **BioMac®** substrate mat in a protected environment, before transplanting."



POLLUTED SEDIMENT
CAPPING & REMEDIATING

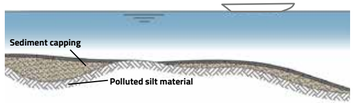
Many watercourses and estuaries are polluted due to the historic presence of heavy industries in the area. To prevent these polluted sediments moving and contaminating other areas, the material is dredged and disposed of. Not only is this expensive, but even disturbing these polluted sediments can lead to further watercourse contamination. Furthermore, the areas of contamination and dredging requirements can be enormous.

Now, new techniques are available to contain and remediate the pollutants in-situ.

Building upon the innovation of the **Ballasted Filtering Mattress**, Maccaferri has developed a new range of mattresses for use in these polluted areas.

Using the same technology within **BFMs**, **Sealing and Remediating mattresses** feature combinations of geosynthetics and various fill materials, according to the project requirements.

A Sealing mattress has an impermeable geomembrane on one face, typically a **MacLine®** GCL. These are designed to contain the polluted sediments in place, stopping them from cross-contaminating other areas.

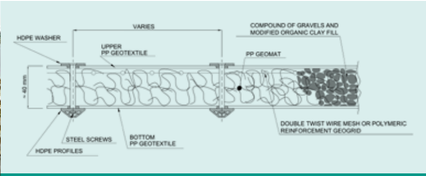


A Remedial mattress is filled with a combination of active ingredients to actually digest and remediate the pollutants. The fill material can include organoclays, super absorbent polymers, apatite minerals and activated carbon to target specific pollutants, including oils and heavy metals. The Remediating Mattresses are filled with a combination of materials to suit the contaminants expected in the works.

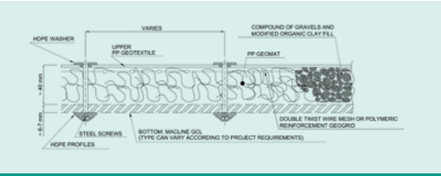
The selection of the appropriate solution involves many disciplines:

- Geotechnical
- Hydrodynamic
- Regulatory
- Sediment characterisation and uses of the watercourse.

Bentonite: a sedimentary deposit used as a foundation for the remediation product



Remedial Filtering Mattress (RFM)



Remedial Sealing Mattress (RSM)