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maccaferri.com/rs

## 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 subsidiaries and 20 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



SOIL STABILISATION  
& PAVEMENTS



DRAINAGE OF STRUCTURES



FENCING & WIRE



HYDRAULIC WORKS



BASAL REINFORCEMENT



TUNNELLING\*



AQUACULTURE NETS/CAGES



ROCKFALL PROTECTION  
& SNOW BARRIERS



COASTAL PROTECTION,  
MARINE STRUCTURES & PIPELINE  
PROTECTION



LANDSCAPE & ARCHITECTURE



CONCRETE FLOORING,  
PRECAST & OTHER USES\*



EROSION CONTROL



ENVIRONMENT, DEWATERING  
& LANDFILLS



SAFETY & NOISE BARRIERS



INDUSTRIAL  
MANUFACTURING

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# MACCAFERRI

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## RENOMAC PLUS: SCOUR PROTECTION FOR UNDERWATER CHALLENGES

## UNDERWATER CHALLENGES

In today's rapidly changing world, the demand for technological development and innovative solutions has become more pressing than ever before.

With extreme weather events on the rise, the necessity for hydraulic works and erosion control applications is steadily increasing. This comes with a unique set of challenges, particularly when it comes to underwater installations.

Conventional hydraulic solutions often require complex underwater installations, posing difficulties for workers and putting a strain on the environment due to resource-intensive processes. To address these challenges, our primary objective was to devise environmentally friendly solutions that not only streamline the installation process but also significantly diminish material waste, saving valuable time and resources in the process.



Among the most challenging underwater applications are the implementation of longitudinal and grade control structures in watercourses, safeguarding bridge abutments and piles from scouring, ensuring anti-scour protection of berthing structures in harbor basins and protecting offshore structures and cables, like wind farms.

## WHAT DO WE EXPECT FROM OUR SOLUTIONS TO SUCCESSFULLY TACKLE THE CHALLENGES OF UNDERWATER APPLICATIONS?

### PROVEN EFFICACY

Excellent performance, proven through rigorous testing campaigns

### COST-EFFECTIVE DESIGN

Saving costs and space without compromising efficacy

### DURABILITY

Extending the solution's lifecycle and minimizing maintenance



### SPEED

Simplifying the installation operations to save time



### ACCURACY

Avoiding waste of materials and ensuring efficient installation



### SUSTAINABILITY

Saving materials and enhancing integration into the natural environment

## INNOVATION THROUGH COLLABORATION AND TESTING

At our core, we have always been committed to pushing the boundaries of technology and continuously improving our solutions to cater to the ever-growing needs of the market.

By blending **innovation** and **sustainability**, our ultimate goal is to develop cutting-edge solutions that not only meet the current demands but also contribute positively to safeguarding the environment for the benefit of future generations.

A key aspect of accomplishing this mission lies in our close **cooperation** with esteemed research institutes, where our solutions are rigorously studied and thoroughly tested by a diverse and skilled team of experts. This partnership and this multidisciplinary approach encourage us to "think out of the box", leading to groundbreaking advancements.



MACCAFERRI



with  
**COLORADO STATE UNIVERSITY**

The University of Colorado is a leading public research institution with multiple campuses across the state.

Known for its academic excellence and innovation, the university fosters a strong commitment to research, sustainability, and community engagement, making it a hub for cutting-edge advancements.

1960

Invention of Reno Mattress

1984

Test campaign at Colorado State University

1990

Development of double diaphragm Reno Mattress

2019

Test campaign at Colorado State University on double diaphragm Reno Mattress

2020

Development of Reno Mattress Plus



**HYDRAULIC BANK PROTECTION**  
OPTIMISED WITH TEST RESULTS

**OVER 70%**  
OF STONE SAVINGS  
VS RIP-RAP

**OVER 50%**  
OF STONE SAVINGS  
VS STANDARD MATTRESS\*



**Reno Mattress Plus**  
with X-Ties

In 2019, extensive research at Colorado State University demonstrated that **Reno Mattress Plus** offers exceptional resistance to shear stresses, thanks to valuable insights from prior testing. This improved design ensures not only superior performance and competitiveness against traditional systems but also substantial material savings, making it an environmentally friendly solution for erosion protection.



**HYDRAULIC BANK PROTECTION**  
RIP RAP

Traditional **loose boulder** riverbank protection (rip rap) requires thicker material layers due to imprecise placement, leading to increased stone usage and environmental impact.



**HYDRAULIC BANK PROTECTION**  
STANDARD MATTRESSES

**Standard mattresses** offer effective confinement for riverbank protection but tend to be overdesigned relative to the actual load they bear.

## THE INNOVATIVE PREFILLED MATTRESS: RENOMAC PLUS

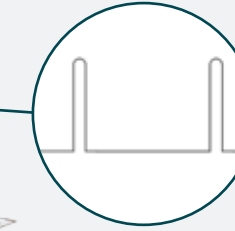
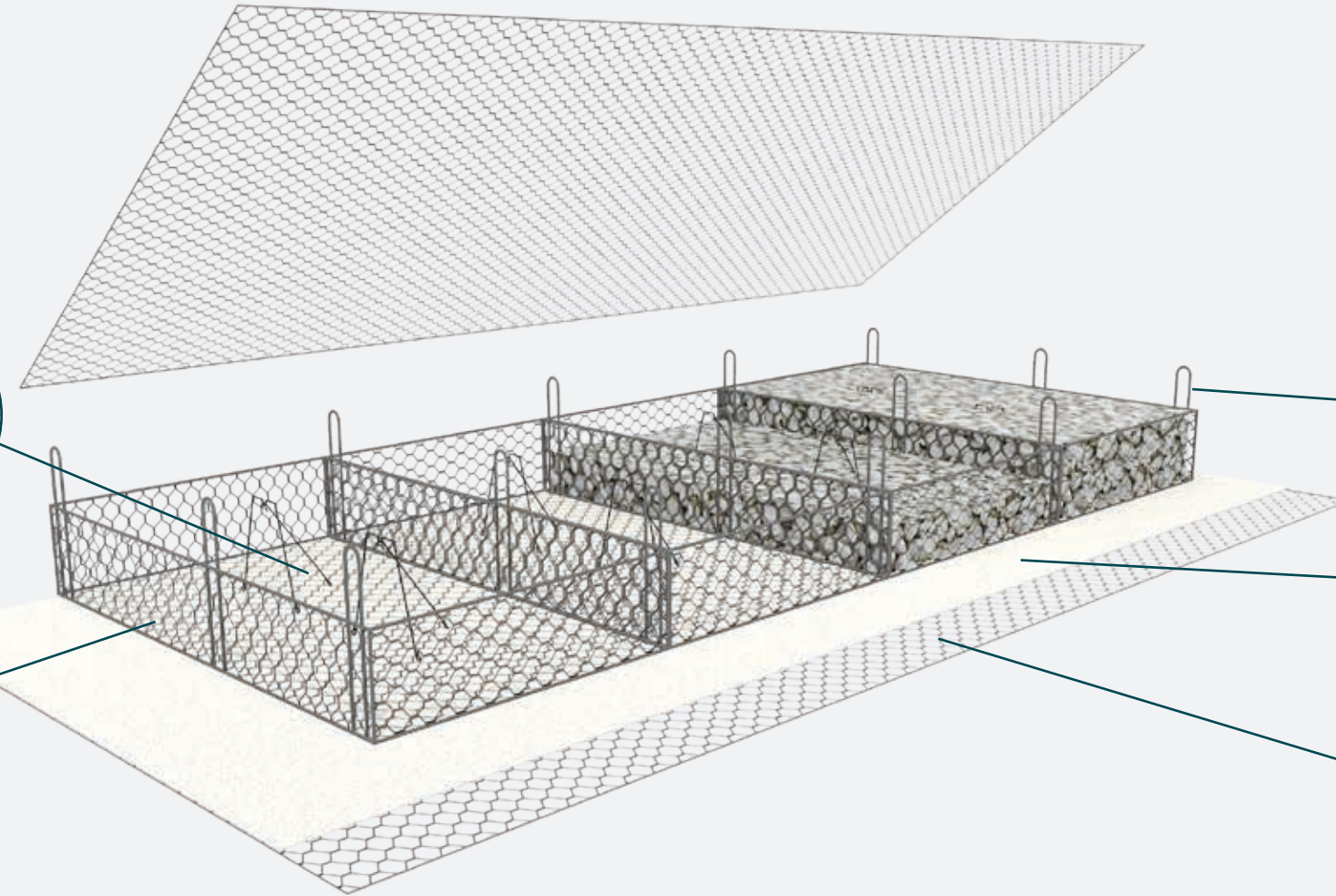
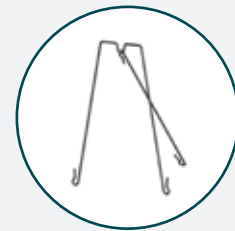
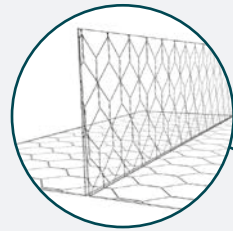
Building upon the knowledge acquired through our rigorous testing campaigns in Colorado, we embarked on a progressive journey to develop a cutting-edge solution that would streamline the installation process in underwater environments, all the while maintaining the exceptional performance achieved by our renowned Reno Mattress Plus.

The result of our endeavor is **the innovative RenoMac Plus**, meticulously designed to offer unparalleled efficacy even in the most resource-intensive conditions. Unlike traditional methods, RenoMac Plus eliminates the need for on-site filling, allowing for easy transportation to the construction site, fully prepared for installation. This prefilled approach ensures greater accuracy during the laying process, minimizing unnecessary waste of time and resources, while enhancing the overall sustainability of the installation process.



The vertical standing **double diaphragm**, obtained by pleating the base panel, confines the stones making filling and lifting operations easier

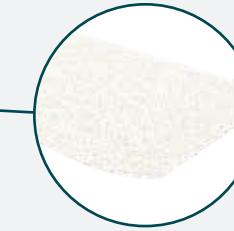
**X-Tie** is the experimentally developed and patented connection to maximize the structural resistance of the mattress, further increasing the stone confinement during handling



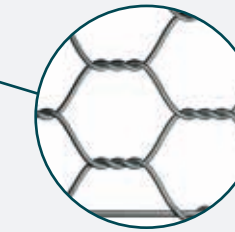
The **lifting bars** are shaped specifically to facilitate the lifting by crane for handling. They are assembled as part of the system, and provide uniform distribution of the stresses during lifting operations.



Our lifting frame, when manufactured according to our guidelines, is **CE certified** and sized to fit both the unit and the lifting equipment for optimal handling.



**MacTex™** is the high quality non-woven geotextile used for separation and fine sediments protection.



An additional double twisted wire mesh base panel guarantees continuity of protection between adjacent units.

1960

Invention of Reno Mattress

1984

Test campaign at Colorado State University

1990

Development of double diaphragm Reno Mattress

2019

Test campaign at Colorado State University on double diaphragm Reno Mattress

2020

Development of Reno Mattress Plus

2022

Development of RenoMac Plus



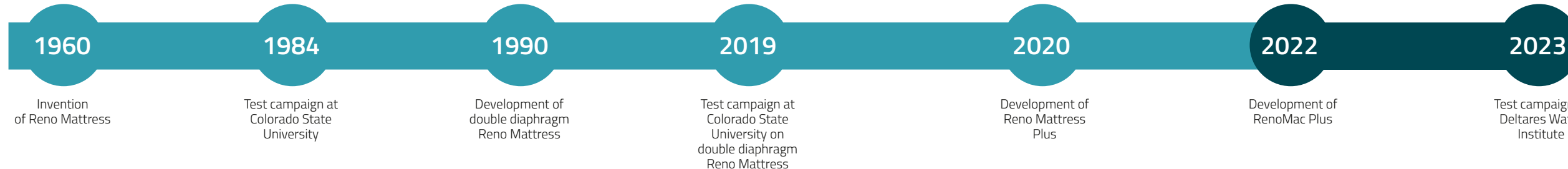
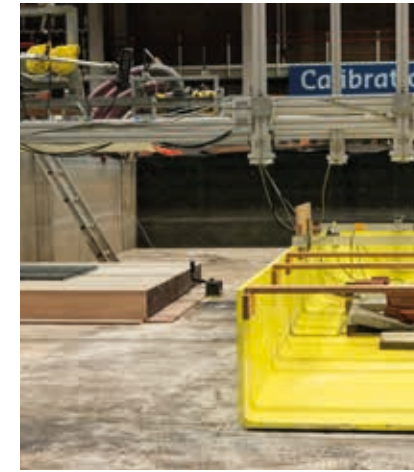
COATED WITH  
**PoliMac®**  
WIRE PROTECTION FOR A CHANGING WORLD

## EVOLVING KNOWLEDGE IN UNDERWATER CHALLENGES

With a new collaboration alongside Deltares Water Institute, we launched an advanced research project to rigorously test and validate our innovative solution: RenoMac Plus.

At Deltares Water Institute, our research has applied a scientific approach to a unique field of underwater operations that faces significant uncertainties. The research validated the effectiveness of RenoMac Plus as an erosion protection solution, showcasing its significant benefits.

“Through a collaborative approach and drawing upon our experiences, we pioneered sustainable and cutting-edge solutions.”

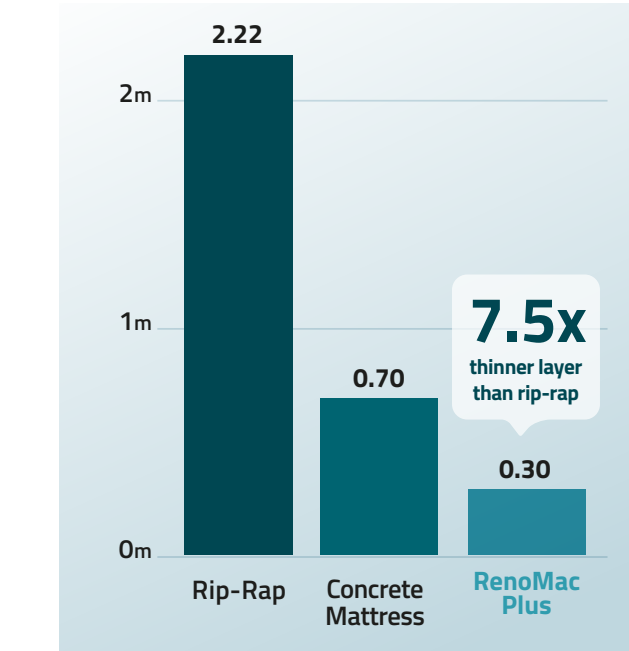


## MACCAFERRI with Deltares

Deltares is a renowned, independent research institute focused on water management, infrastructure, and environmental sustainability. Based in the Netherlands, it focuses on flood risk management, coastal resilience, and sustainable water resources. Collaborating with governments, industries, and academic institutions, Deltares develops innovative, science-based solutions to global water challenges for a more resilient and sustainable future.

The primary objective of this research was to validate the numerical models used in designing erosion protection systems for berthing structures exposed to the forces generated by jet propellers. By ensuring that these models accurately represent the real-world conditions experienced at ports, the study aimed to confirm the reliability and effectiveness of these protection systems in mitigating erosion.

The outcomes of the study, conducted at the Deltares Water Institute, not only confirmed the robustness of the design criteria but also introduced significant improvements. These included reductions in material usage and simplified installation procedures. These advancements contribute to greater sustainability by minimizing both environmental impact and the resources required for implementation.



## DISCOVER MORE ABOUT THE RESEARCH!

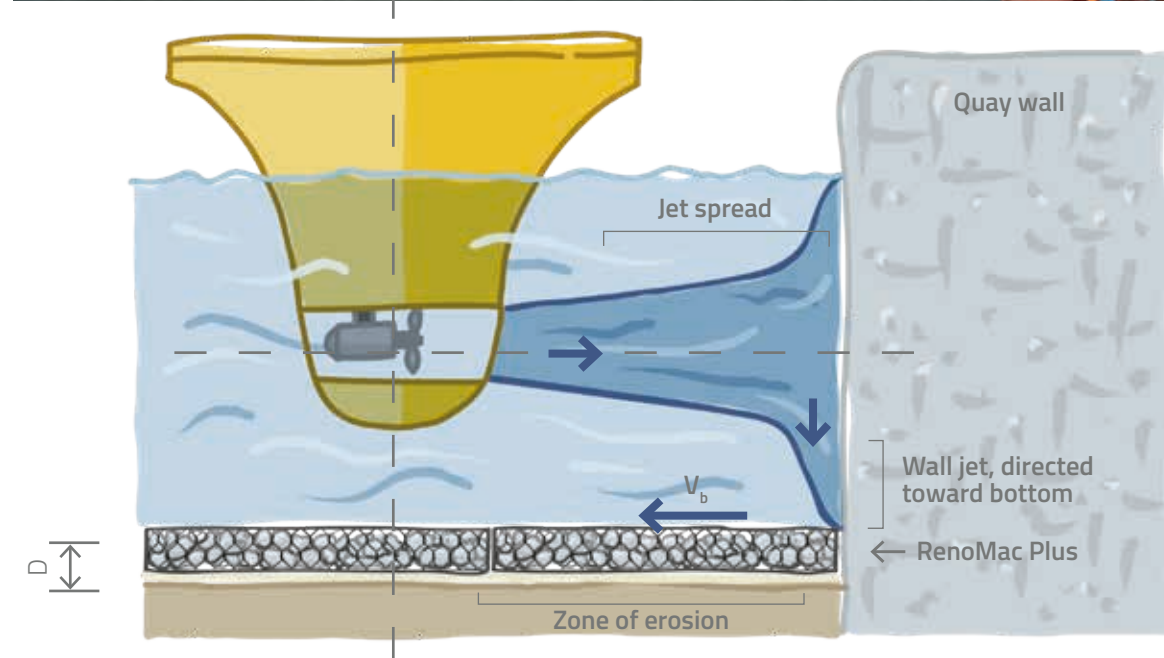
Scan the QR code to access our website, where you can listen to the full webinar on the topic or watch the exclusive video interview with Deltares experts discussing their insights.



## PORT PROTECTION AGAINST JET PROPELLER FLOW

In response to global market demands, ships for marine transport have grown larger and deeper. The intensified velocities generated by these large propellers can result in greater bottom erosion and potential failure of quay walls. Consequently, to withstand these extreme velocities, effective harbor bottom protection has become essential.

Our prefilled mattress, RenoMac Plus, has been specifically designed to tackle such challenges and underwent extensive testing at Deltares Water Institute to establish new design criteria with heightened resistance parameters against turbulent actions. RenoMac Plus stands as the sole solution tested exclusively for deformation.



RenoMac Plus layout for port bottom protection against forces generated by jet propeller

When designing erosion protection for berthing structures affected by jet propellers, both the guidelines from PIANC Report No. WG180 and the Dutch approach are taken into account, with the latter recommending the utilization of the Pilarczyk formula.

### THE PILARCZYK FORMULA

$$D = f \left( \frac{V_b^2}{\psi_{cr}} \right)$$

With this formula, the **minimum thickness required** for the protection (**D**) is determined.

**UP TO 7.5X** Reduction of thickness protection compared to rip-rap solutions

**MORE THAN 2X** Reduction of thickness protection compared to concrete mattresses

**Bed velocity (V<sub>b</sub>).** The maximum bottom velocity is the primary driving force in the design and is calculated, based on different scenarios and types of quays, starting from the propulsor exit velocity.

**Critical Shields parameter** depends on the type of material considered and it represents the material's resistance to the flow.

|                    |        |
|--------------------|--------|
| Rip-rap:           | 0.0035 |
| Concrete mattress: | 0.07   |
| RenoMac Plus:      | 0.19   |

With increased resistance, the protection layer can be reduced, requiring less material and creating additional space.

### WHY CHOOSE RENOMAC PLUS?



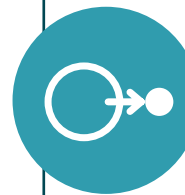
#### SPEED AND ACCURACY

RenoMac Plus is an all-in-one solution for both filtration and scour protection, simplifying installation operations and ensuring accuracy.



#### PROVEN EFFICACY

RenoMac Plus is the only solution on the market that has been specifically tested for this application, achieving excellent performance.



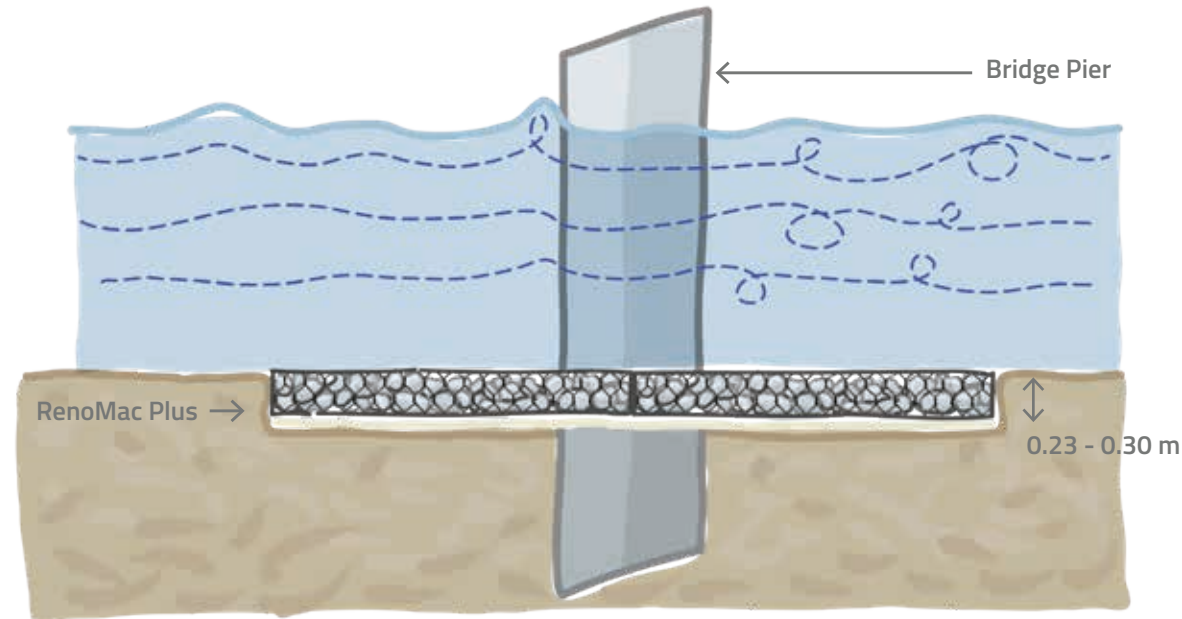
#### COST-EFFECTIVE DESIGN

RenoMac Plus prevents scouring while providing space for large vessels, thanks to its thin layer design, and reducing dredging needs.

## SAFEGUARDING BRIDGE ABUTMENTS AND PILES FROM SCOURING

Scour in watercourses causes significant damage to engineering infrastructures. To minimize long-term costs, protective measures are essential. Total scour at bridge piers comprises three components: degradation of the riverbed, contraction scour at the bridge, and local scour at the piers. Understanding and addressing these factors are crucial for safeguarding the structures.

For this type of application, a solution is needed that can adapt to the riverbed and bridge pier configuration, ensuring continuous protection. Therefore, it requires a precise yet rapid installation process to overcome potential challenges posed by tides and fast currents.



RenoMac Plus layout for bridge pier protection against scour

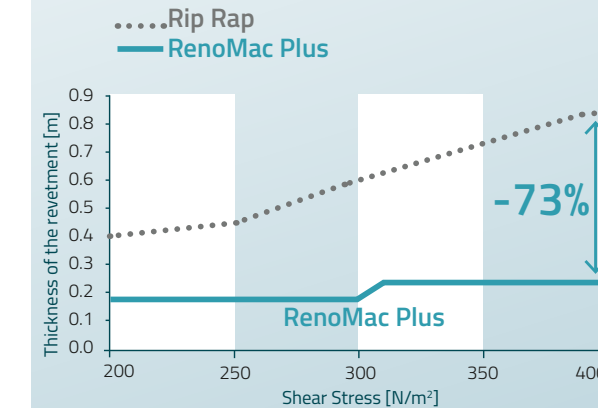
The **design shear stress** has to be compared to the **admissible shear stress** in order to determine the protection thickness. The hydraulic conditions near a bridge pier are more demanding compared to the upstream approach conditions.

The comprehensive tests carried out at Colorado State University assessed both the mattress stability and its anti-scour properties, following ASTM D6460 guidelines. The results revealed that our mattresses can endure remarkable shear stresses while reducing material usage by over **70%** compared to conventional rip-rap solutions.

$$\tau_{\text{design}} < \tau_{\text{admissible}}$$

The **design equations** should incorporate the local velocity and shear stress at the pier. As suggested in NCHRP Report 593, the section average approach velocity should consider the pier's shape and its location in the channel.

The testing conducted at Colorado State University demonstrated that our mattresses can withstand exceptionally high shear stress while maintaining a minimal protection thickness. As a result, RenoMac Plus proves to be the ideal solution for challenging hydraulic conditions.



## WHY CHOOSE RENOMAC PLUS?

### COST-EFFECTIVE DESIGN

RenoMac Plus has a **flexible structure** that can follow the erosion's development while maintaining its function and protecting the bridge piers/abutment foundations.

### ACCURACY

The double-twisted wire mesh base panel and the geotextile extend beyond the mattress to create an overlap that ensures continuous protection.

### SPEED

As a ready-to-use prefilled solution, RenoMac Plus can be installed with great accuracy even at high depths. The installation process is fast, allowing its application even in challenging working conditions.

## WIDE RIVERS AND INLAND WATERWAYS

Rivers, along their banks, pose a constant threat of instability as they erode the toe and create potential failure surfaces. This instability is especially pronounced in wide river sections, typically found in alluvial plains, where meandering can be hazardous, potentially leading to progressive scouring near critical infrastructures.

Inland waterways typically experience moderate flow velocities, with hydrodynamic impacts on the banks primarily stemming from waves generated by passing vessels. Among these, primary waves, especially stern waves, pose the most severe threats to the stability of waterway banks.

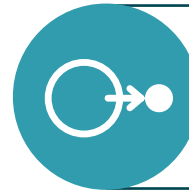
In scenarios where dry installation is not feasible, the ideal solution lies in the implementation of RenoMac Plus, safeguarding the stability and integrity of the surrounding infrastructure while facilitating a secure underwater installation.

The **wave height** ( $H_d$ ) is a crucial factor to determine the thickness and extension of the protection.

$$D \propto H_d$$

The **minimum thickness required** for the protection (**D**) is determined.

### WHY CHOOSE RENOMAC PLUS?



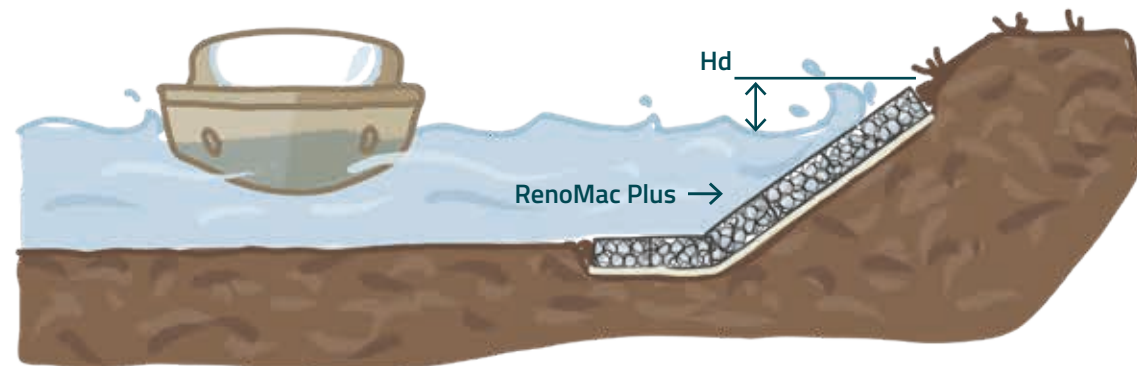
#### COST-EFFECTIVE DESIGN

RenoMac Plus allows effective protection only where necessary, saving costs.



#### SUSTAINABILITY

RenoMac Plus uses fewer materials, reduces emissions, and integrates with aquatic environments, preserving biodiversity.



RenoMac Plus layout for bank protection against waves generated by vessels.

## OFFSHORE SUPPORT STRUCTURES AND CABLE PROTECTION

Offshore structures often experience scour at the seabed interface, which can lower the seabed level and affect their stability.

Scour protection is used to prevent this, and cost savings can be achieved by selecting the right protection system and optimizing its design. Different types of scour include local scour around individual structures, global scour within the footprint of multilegged structures, edge scour outside the protection area, and general seabed level changes unrelated to structures.

We have partnered with Deltares Water Institute in the JIP HaSPro Project to actively test and validate our solutions in these unique conditions. Our aim was to propose an eco-friendly erosion protection solution that integrates with the marine ecosystem while reducing project costs through simple installation, even in dynamic environments with frequent changes.

The project results are presented in the 'Handbook of Scour and Cable Protection Methods' (2023), which includes design considerations for using RenoMac Plus in offshore applications.

### WHY CHOOSE RENOMAC PLUS?



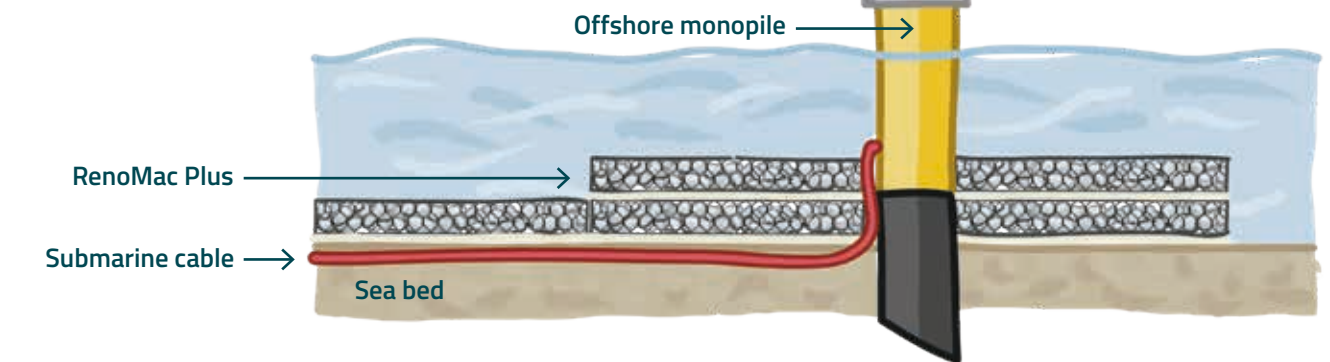
#### DURABILITY

RenoMac Plus is coated with PoliMac, extending its lifecycle even in harsh marine conditions and reducing maintenance.



#### SPEED AND ACCURACY

As a ready-to-use prefilled solution, RenoMac Plus can be installed with great accuracy even at high depths.



RenoMac Plus layout for protection of offshore monopile foundation and submarine cables

MACCAFERRI

with

**Deltares**

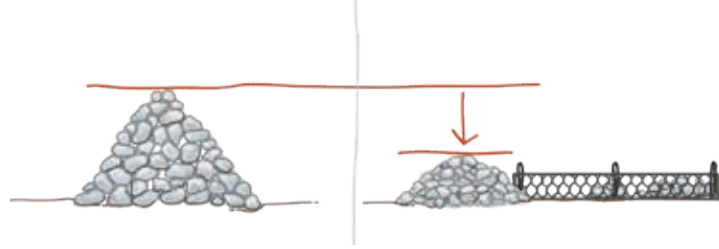
## DESIGNING FOR A SUSTAINABLE FUTURE

Sustainability is at the heart of our innovations. RenoMac Plus embodies this commitment by offering a solution that significantly reduces environmental impact across all phases.

RenoMac Plus not only preserves natural ecosystems but also contributes to reducing emissions, conserving biodiversity, and aligning with the highest sustainability standards.

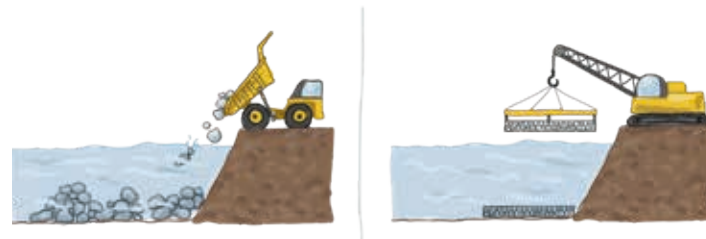
The confined stone structure allows for a significant reduction in the amount of material required, while its pre-filled design ensures precise installation, reducing excess and waste. Furthermore, the use of eco-friendly materials, such as natural stones and the PoliMac coating, guarantees safety in aquatic environments and promotes environmental responsibility.

### EFFICIENT INSTALLATION, REDUCED IMPACT



**OVER 70%  
STONE SAVINGS  
VS RIP-RAP**

### MORE ACCURATE, LESS WASTE



**EFFICIENT  
USE OF SPACE**

### DESIGNED FOR DURABILITY AND HARMONY WITH NATURE

**DESIGN  
THE  
CHANGE**

#### ENVIRONMENTAL BENEFITS

Saving materials and avoiding waste to reduce polluting emissions

#### BIODIVERSITY

Providing a natural habitat for living species

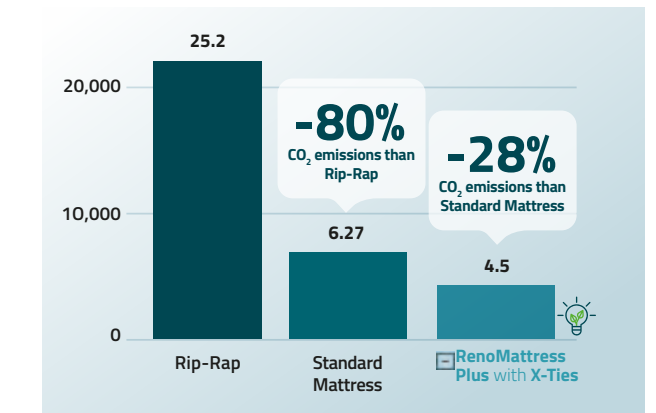
#### DURABILITY

Saving materials and avoiding waste to reduce polluting emissions

### CERTIFIED EXCELLENCE AND PROVEN RELIABILITY



### CUTTING EMISSIONS FOR GREATER SUSTAINABILITY



The CO<sub>2</sub> emission savings shown are based on testing campaigns conducted at Colorado State University.

## UNLOCK THE FUTURE OF HYDRAULIC PROTECTION

All our solutions are designed to enhance safety and efficiency in civil engineering. By integrating smart early warning systems, we can elevate these solutions to new levels of intelligence and effectiveness, contributing to empower communities and their well-being.

The HELLOMAC suite encompasses a wide range of IoT technologies designed to support smart engineering across multiple applications. Within this framework, HELLOMAC Hydro was specifically developed for hydraulic applications.

HELLOMAC Hydro provides versatile monitoring, tracking erosion for both assessment and protection, as well as monitoring water levels and water quality through key physical and chemical parameters. Designed with the latest IoT technology, HELLOMAC Hydro provides comprehensive, real-time data for more responsive and informed decision-making in hydraulic applications.



## DESIGNING HYDRAULIC PROTECTIONS WITH RENOMAC PLUS

MacQuay Design is our new online software, developed to simplify and enhance the design of scour protection systems for berthing structures.

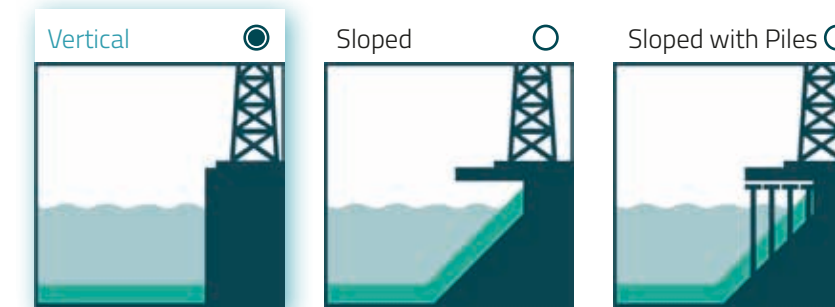
Drawing on insights from an extensive testing campaign with RenoMac Plus, this online software allows users to simulate multiple berthing scenarios and evaluate the stability of several solutions against the forces generated by ship propellers.

By adding MacQuay Design to our already comprehensive suite of engineering tools, we provide a simple yet precise way to design with our solutions, ensuring accuracy and reliability throughout the process. At Maccaferri, we are dedicated to offering innovative tools that make designing with our advanced solutions more accessible and efficient.

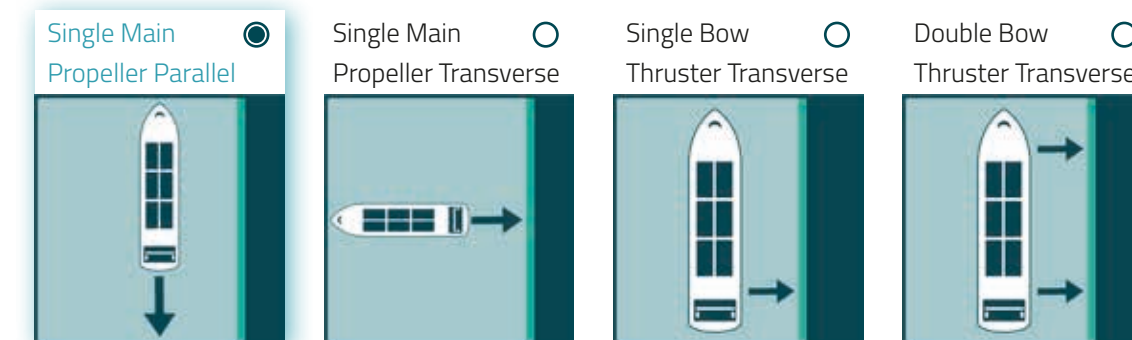
MacQuay Design is developed based on the latest guidelines and literature, incorporating our expertise and research findings on RenoMac Plus.



With MacQuay Design, you can choose the type of berthing structure for your project



And set up your simulation by selecting the ship type, propeller orientation, and number of propellers to tailor the design to real-world conditions.



Explore MacQuay Design and our full suite of software solutions

