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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 |  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                |



# ROCKFALL PROTECTION & SNOW BARRIERS



## MAC.RO™ SYSTEMS NATURAL HAZARD & ROCKFALL MITIGATION

Rockfall protection and natural hazard mitigation systems are key elements in the security and safety of roads, railways, mining operations and infrastructure networks. Even small rockfalls or debris flows can obstruct infrastructure and have far-reaching economic effects beyond the immediate disruption. This also applies to buildings or other installations at risk of damage from rockfalls, debris flows or avalanches\*.

\*Please note that deep-seated slope instability is covered in other Maccaferri literature.

With over 60 years' experience in rockfall protection systems and natural hazard mitigation, Maccaferri offers a wide range of systems to stabilise rock faces, soil slopes and snow masses, reducing risks to people, buildings and infrastructure.

Maccaferri's philosophy is to offer a logical, graded range of engineered systems working together with each other, to reduce overdesign and unnecessary cost.

Certified and tested by leading institutes and in accordance with the latest standards, Maccaferri solutions are designed using state-of-the-art modelling software and techniques.

Developed in conjunction with contractors, Maccaferri Mac.RO™ Systems are simple to install, durable and effective. Components have been selected to reduce contractor workload; a global network of factories offers local product availability.

Maccaferri Mac.RO™ Systems are installed daily, worldwide, in demanding applications, reassuring clients with safe, cost effective and reliable natural hazard protection.

Covered in this brochure:

### **M** Mesh Systems:

Rockfall Netting

PoliMac® Coating

Steelgrid® HR

MacArmour®

HEA Panels

Ring Nets

Testing & Design

### **M** Dynamic Rockfall Barriers

### **M** Debris Flow and Shallow Landslide Barriers

### **M** Rockfall Embankments and Consolidation

### **M** Snow Fences and Avalanche Protection

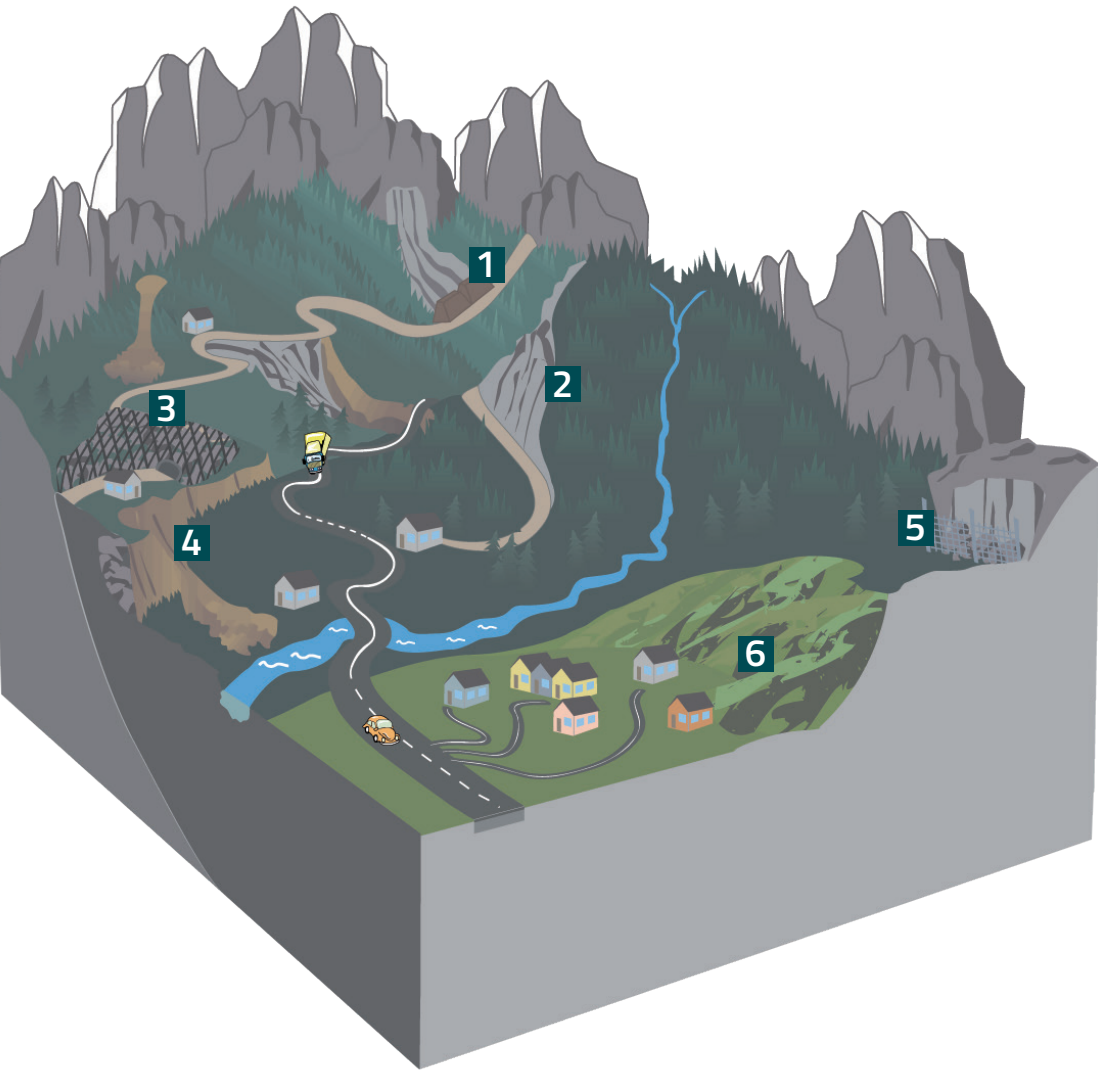
### **M** Soil Nailing and Surface Protection

### **M** HELLOMAC Alert System





GENERAL CONCEPTS  
OF NATURAL HAZARDS



1 Rockfall and Landslide Embankments



4 Debris Flow & Shallow Landslides



2 Mesh Systems - Simple Drapery



5 Dynamic Rockfall Barriers



3 Mesh Systems - Secured Drapery / Surface Stabilisation

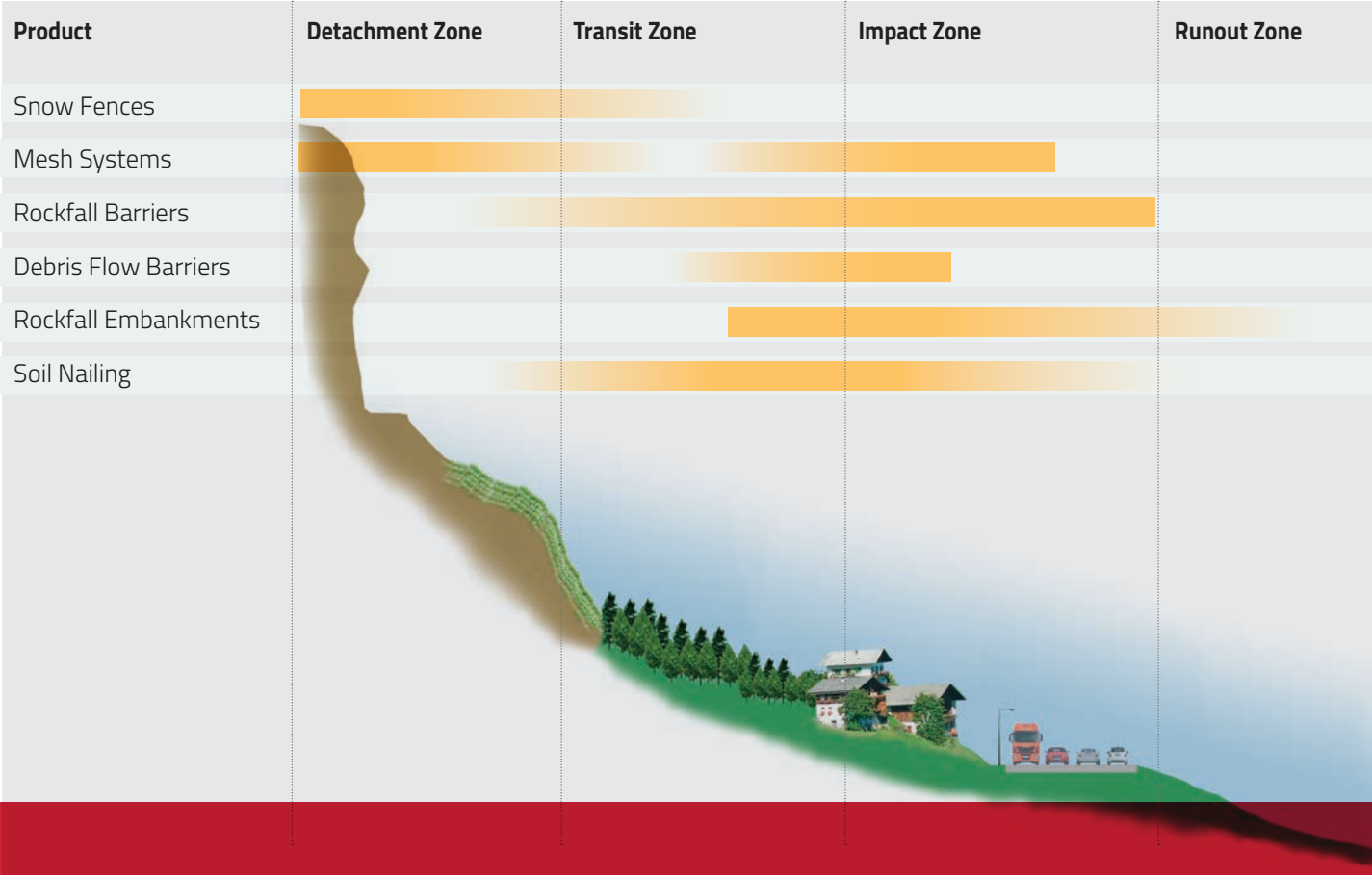


6 Soil Nailing and Surface Protection

GENERAL CONCEPTS  
SOLUTION SUITABILITY  
& LOCATION

There are many factors to consider when selecting appropriate interventions to mitigate natural hazards. Understanding the suitability and effectiveness of the systems and where they offer optimal performance is important.

Combinations of systems often provide the most cost-effective solutions, where a balance is found between technical performance, risk, client value and ease/safety of installation; one product cannot solve all natural hazard problems.





MESH SYSTEMS  
INTRODUCTION

Maccaferri offers a complete range of mesh systems for rockfall protection. Selection of the optimum solution is based upon the analysis of the project site conditions (geology, topography, environment, static and dynamic loading conditions) and client requirements (design life, maintenance).

Maccaferri technical software MACRO 1, MACRO 2 and MAC S-DESIGN, enable designers to select the appropriate system and product type.

Often the Serviceability Limit State sets the design criteria, in this case deformations and not failure loads are to be considered, so stiffness is the key design parameter. Another important parameter is punching resistance, which defines the resistance of the system to the pressure of a punching body.

Maccaferri’s wide variety of systems offer a range of values for both stiffness and punching resistance, allowing designers to select the optimum solution.

Corrosion resistance of Maccaferri mesh systems is provided by heavily galvanised steel with optional polymer coatings. For aggressive environments, the polymer coated mesh, Steelgrid® HR, MacArmour®

and HEA panels are available. The performance of these are often necessary, especially in coastal applications.

| Solutions             |                                                                                                                                                                                                                             |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Drapery               | Mesh is hung down the slope face from a secure top rope. Rock debris falling from the slope is contained safely behind the mesh and collects at the toe of the slope. Periodic removal of collected debris is needed.       |
| Secured Drapery       | Like drapery, but the mesh system is enhanced by anchors (with or without face ropes) securing the mesh back to the slope. Loads in the system are transferred back to these anchors, enhancing the stability of the slope. |
| Surface Stabilisation |                                                                                                                                                                                                                             |
| Pinned Drapery        |                                                                                                                                                                                                                             |

| System        | Stiffness | Strength  |
|---------------|-----------|-----------|
| DT Mesh       | Moderate  | Moderate  |
| Steelgrid® HR | Very High | High      |
| MacArmour®    | Very High | Very High |
| HEA Panels    | Extreme   | Very High |
| Ring Nets     | Low       | Extreme   |



MESH SYSTEMS  
ROCKFALL NETTING

Double Twist (‘DT’) steel wire mesh is a highly efficient mesh combining ease and flexibility of use with unsurpassed cost-effectiveness. Used around the world for over 60 years, Maccaferri DT mesh is proven to offer robust, long lasting and cost-effective rockfall protection.

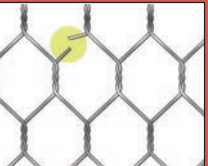
Commonly used as ‘drapery’, DT mesh provides a protective curtain on the slope; any rocks and debris detaching from the slope are contained behind the mesh.

Maccaferri DT mesh is available in a variety of puncture (punch) resistances and corrosion protection coatings to suit the project design and exposure conditions. It can be supplied with a range of installation accessories including C-rings, DT-Links and installation tools to increase site productivity.



Double Twist vs Single Twist Mesh

Unlike Single Twist (chain-link) style mesh, the construction of Double Twist (‘DT’) mesh inhibits the propagation of tears in the mesh. Research shows that damage to a DT mesh remains local and the mesh does not unravel/unzip, due to the Double Twist ‘locked yet flexible’ connection between adjacent wires.



| Feature                                     | Benefit                                                                                           |
|---------------------------------------------|---------------------------------------------------------------------------------------------------|
| Double Twist mesh construction              | Does not unravel in the event of wire breakage                                                    |
| Flexible in 3 dimensions                    | Excellent containment of debris<br>Easy to install on site                                        |
| Light-weight                                | Ease of installation                                                                              |
| Variety of coatings                         | Balance commercial and performance requirements                                                   |
| C-Rings, DT-Links and tools                 | No overlapping mesh on lateral connections = fast installation and minimal material wastage       |
| Variety of lengths and widths of mesh rolls | Different lengths and widths are available to suit site conditions, saving install time and waste |





## MESH SYSTEMS POLIMAC®

PoliMac® is the new long-lasting and sustainable coating to respond to more aggressive environmental exposure and more demanding operating conditions.

Maccaferri has developed **PoliMac®**; a new polymer coating for hexagonal double twist steel wire mesh products. It has been developed to:

- Meet environmental project requirements.
- Achieve the technical performance demands of Rockfall, hydraulic, geotechnical, erosion control and environmental protection projects.
- Maximise longevity and structural efficiency through increased abrasion and chemical resistance.

The new **PoliMac®** coating is an inert polymeric compound which exhibits high abrasion resistance. It is capable of withstanding the most severe application conditions including highly aggressive mechanical and chemical impact, long-term ultraviolet radiation and low temperature effects.

The polymer recipe is exclusive to Maccaferri and has been selected for use within the rockfall, construction, mining and environmental industries.

In order to meet durability requirements, the design of civil engineering structures should consider the environmental condition expected over structure's working life.

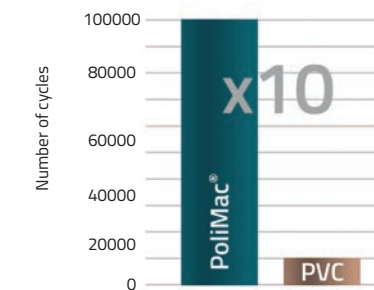


### Abrasion resistance tests

PoliMac® showed excellent performance by withstanding 100,000 cycles of abrasion in accordance with test method described in EN 60229-8.

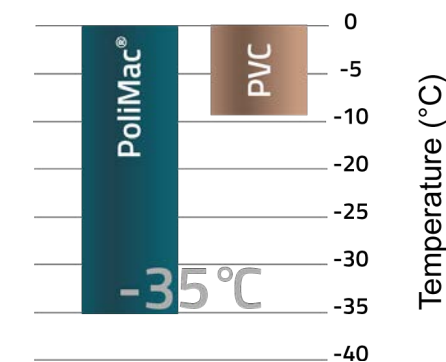


### BETTER RESISTANCE THAN TRADITIONAL POLYMERIC COATINGS



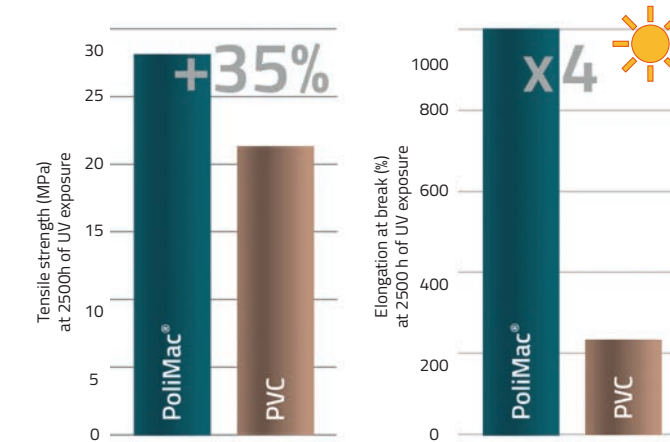
### Low temperature brittleness

PoliMac® maintains its properties right down to -35°C according to the ASTM D 746 test method.



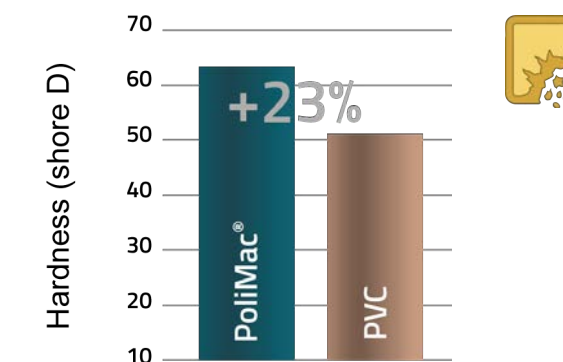
### UV resistance tests

As a result of severe accelerated aging tests, PoliMac® achieved conformance with ISO 4892-3, EN 10223-3, showing better tensile strength retention and elongation than other traditional polymeric coatings after 2,500 h of exposure to UV.



### Hardness Test (ASTM D 2240)

PoliMac® is 23% harder than traditional polymeric coatings providing better resistance to impact and installation damage.

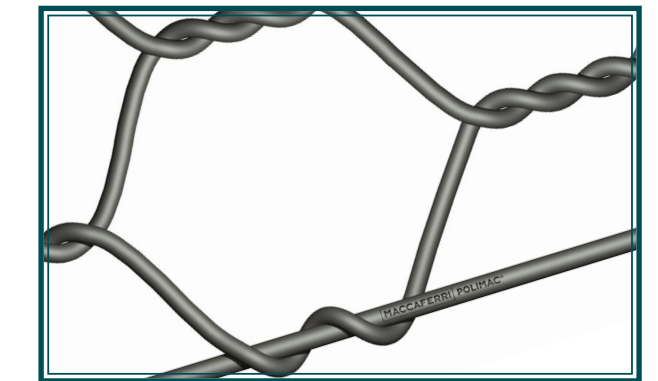


The new **PoliMac®** polymer coating is more resistant to chemical attack, both in alkaline and acidic pH conditions, versus traditional polymeric coatings for steel wire.

Extensive testing has been carried out to maximise the performance of **PoliMac®** coated steel wire, double twist mesh structures.

**PoliMac®** polymer coating is applied to all Maccaferri Drapery System to enable the development of solutions that meet the durability, performance and cost-efficiency demands of today's civil engineering projects.

To identify the coating, the Maccaferri double twist mesh solutions will have a selvage wire with **POLIMAC®** printed on it.





# MESH SYSTEMS STEELGRID® HR

Steelgrid® HR is a composite mesh offering high stiffness; high tensile strength at low strain and high punch resistance with low deformation.

This patented mesh is an engineered combination of Double Twist steel wire mesh and high tensile (1770N/mm2) wire ropes in a single, easy to install product. The presence of the steel cables, woven within the mesh during manufacture, enables better stress distribution in the upper longitudinal cables and reduced strain in the drapery system.

- Steelgrid® HR combines the flexibility and simplicity of installation of Double Twist mesh with the high tensile strength, low extension and durability of steel wire rope.
- Steelgrid® HR is used as a drapery or as a high stiffness (low extension) bolted facing when working loads exceed the capability of traditional DT Mesh.
- Steelgrid® HR is available in a variety of strengths (up to 180kN/m tensile resistance and up to 155 kN for punch resistance), enabling designers to optimise solutions both technically and commercially.

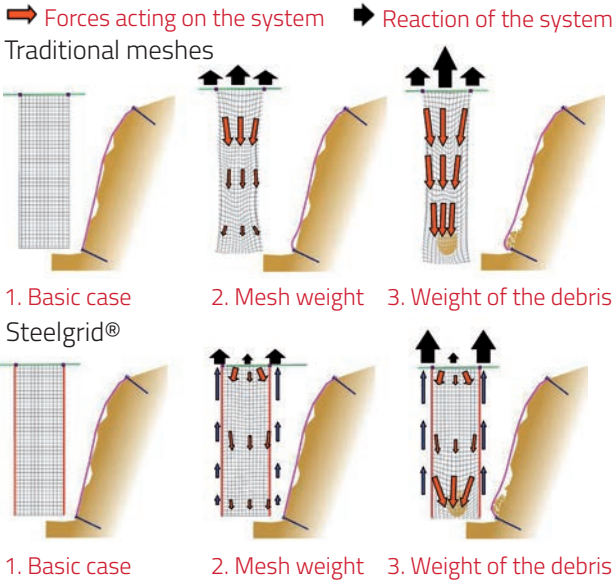


The product is available in two levels of corrosion resistance:

- Steelgrid® HR:** Mesh wires and ropes galvanised with GalMac® (Zn/Al) alloy Class A
- Steelgrid® HR-PoliMac®:** As Steelgrid® HR, but with an additional continuous polymer coating on mesh and ropes.

When site conditions are more aggressive (e.g. infrastructure, urban or coastal), or the project demands a longer design life than that offered by the Class A GalMac® (Zn/Al) coating, polymer coated Steelgrid® HR has a unique ability to provide reliable long-term performance.

Installation of Steelgrid® HR is straightforward; the adjacent lateral rolls of mesh do not need to be overlapped, reducing product wastage and saving installation cost and time compared to other meshes.



| Feature                  | Benefit                                                                                    |
|--------------------------|--------------------------------------------------------------------------------------------|
| Integral steel ropes     | Low strain, high strength composite mesh                                                   |
| Integral steel ropes     | "2 products in 1" reduces installation time and cost                                       |
| Integral steel ropes     | No overlap required between adjacent rolls of mesh on the slope = reduced material wastage |
| Flexible in 3 dimensions | Excellent containment of debris and easy to install on site                                |
| Variety of coatings      | Balance commercial and performance requirements                                            |



## High Strength Drapery

Steelgrid® HR is ideal for use on high rock faces and slopes with a long drop, or where large volumes of debris are expected; the integral longitudinal steel ropes allow the efficient transmission of loads to the top ropes and anchors, with minimal mesh deformation.

Certain types of un-reinforced drapery (especially some types of single twist or 'chain link' type meshes) can exhibit considerable heterogeneous deformation during loading from the accumulation of fallen material between the mesh and the slope and due to other factors such as self-weight and ice accumulation.



## Bolted facing and surface stabilisation

Available with tensile strengths up to 180 kN/m and up to 155 kN for punch resistance, Steelgrid® HR is also designed to work in conjunction with anchors to increase the stability of the unstable superficial layer of a rock or soil slope.

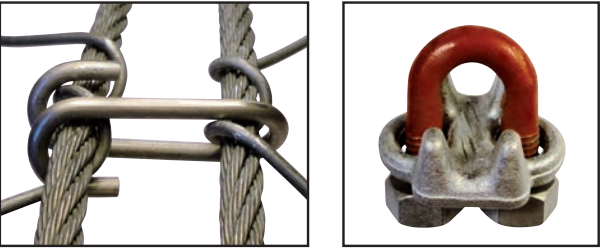
Due to its structure, Steelgrid® HR is flexible in terms of anchor positioning, thereby saving time and cost on site.

The HR Anchor Plate transfers loads from the mesh into the anchors. The four spikes on the corners of the HR Anchor Plate engage with the Steelgrid® HR and effectively restrain the steel cables.

Steelgrid® HR is also available with an integral erosion protection mat providing two products in one; MacMat® HS.

It features a 3D matrix of polymer monofilaments extruded onto the reinforced mesh during manufacture. The polymer matrix provides immediate erosion protection from rainfall runoff, supports revegetation of the soil slope and provides root reinforcement.

**The Steelgrid® HR mesh kit** is a complete system containing all of the components needed to install the mesh onto the anchors on a project site. The kit contains: the HR or HR-PoliMac® mesh, HR Anchor Plate (where required), HR-Grips, HR-Link mesh connectors and HR-Cap rope protectors.





## MESH SYSTEMS MACARMOUR®

MacArmour® is a 2 in 1 system which combines the stiffness of bi-oriented high tensile wire ropes with the flexibility of double twist steel wire mesh in a new, more robust and safer solution able to address any operational condition.

MacArmour® was developed with an eye towards reducing the exposure to risks for workers.

The new connection system minimises the activities for the connections of the rolls.

- M** MacArmour® is a 2 in 1 product which combines a homogeneous structure of steel wire rope with double twist wire mesh.
- M** MacArmour® has outstanding performance in both longitudinal and transverse directions.
- M** MacArmour® has an outstanding out-of-plane stiffness (punch resistance)

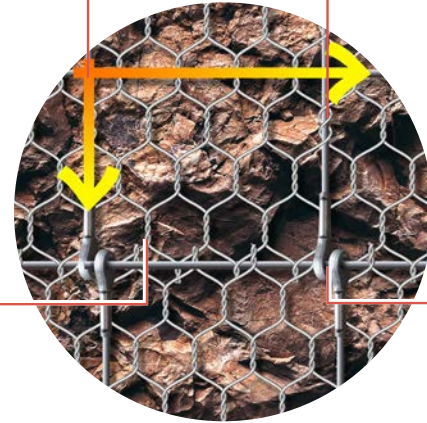
This maximises the serviceability of the protected infrastructure. The higher the stiffness, the lower the risk of hampering running infrastructure after a rockfall event.

### Higher performance

Conceived with longitudinal and transverse ropes to minimise the deformation.

### Long lasting protection

Engineered to withstand the most severe application conditions.



### Perfect Homogeneity

Created to ensure the maximum resistance in both longitudinal and transverse directions.

### New easy-to-install connections

Designed to minimize the time of installation and the relative associated costs.

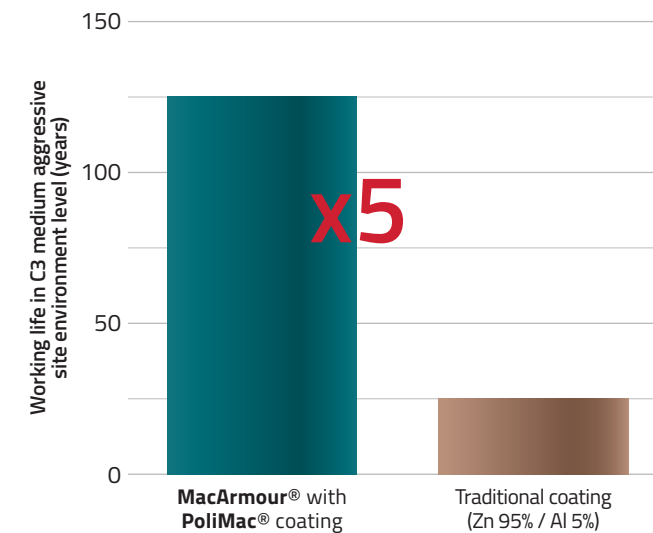


**NEW  
2 in 1  
DRAPERY  
SYSTEM**

### Durability

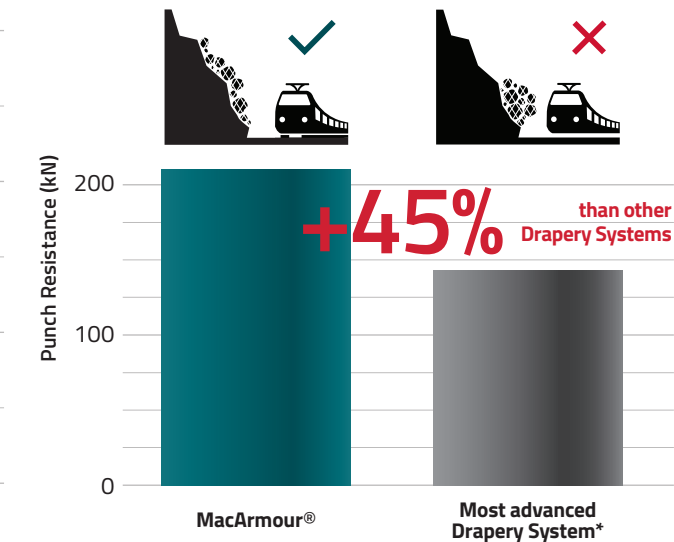
According to EN 10223-3, polymeric coatings last longer than metallic wire protection. The latter shall not be used in very aggressive environment, including coastal areas and polluted zones.

MacArmour® can be coated with **PoliMac®**, the revolutionary coating engineered to face the most aggressive environmental conditions. In addition, **PoliMac®** is 23% harder than other traditional polymeric coatings, thus reducing installation damage during unrolling.



### Serviceability

Draper system along infrastructure are designed to trap falling rocks, preventing any damage to the protected structure. Deformation under loading is measured by Punch Test, a standardized test (ISO 17745/6-2016) which replicates the load applied by a falling block on a mesh system. **MacArmour®** offers the **lowest deformation** under load in the industry.

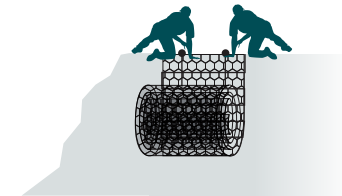


\*Value shown in the graph refers to SteelGrid® punch test.

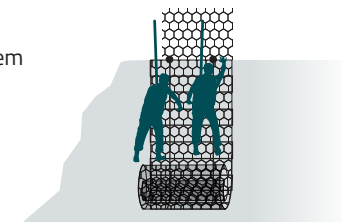
### Installation Time

MacArmour® is a 2 in 1 system which enables a reduction of up to 50% in the installation time compared to any other system currently in use. This additionally reduces the exposure to risk for workers.

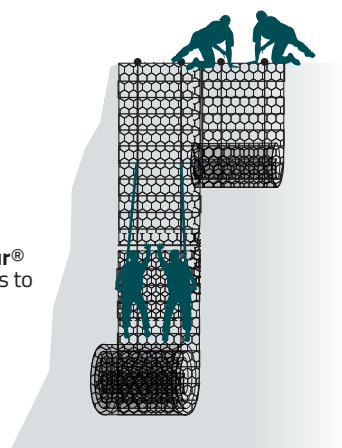
**1** Fix the first roll



**2** Unroll the MacArmour® system down the cliff face



**3** Unroll subsequent MacArmour® rolls



**4** Connect MacArmour® roll with ease thanks to new connections

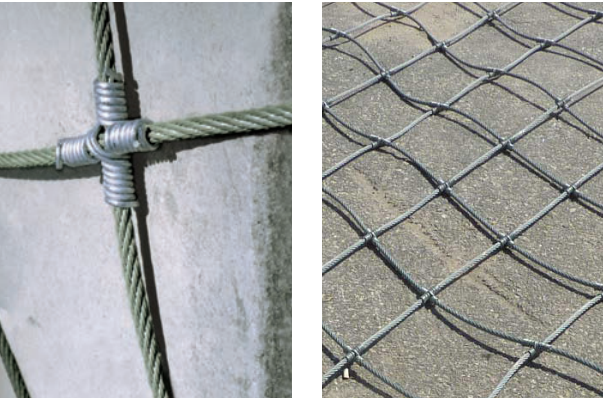




MESH SYSTEMS  
HEA PANELS

HEA Panels are the stiffest products within the Maccaferri Mac.RO™ Systems mesh range, offering extreme strength at low strain. The panels are woven from a single continuous length of high tensile strength steel wire rope, joined at each crossing point with the patented HEA ‘double knot’ connection. Unlike single twist spiral rope nets, the construction of HEA Panels provides exceptional stress/strain performance with the lowest possible deformation.

HEA Panels are used in secured drapery applications where a low deflection and high strength system is required. Due to the multi-axial performance of the panel, loads are transferred effectively to the anchors on the slope face regardless of the anchor layout.



Customisable Product

Maccaferri offers standard HEA Panels, however HEA Panels can be made for specific needs; they can be connected together in the factory to suit project dimensions, and even secondary small aperture meshes applied.

This reduces installation time on the rock face, and minimises material wastage.

| Type of junction      | Resistance to tear (kN) | Resistance to pull apart (kN) |
|-----------------------|-------------------------|-------------------------------|
| HEA Panel             | 24.4                    | 11.9                          |
| High resistance clips | 13.5                    | 8.0                           |
| Low resistance clips  | 4.6                     | 1.3                           |



| Feature                                                 | Benefit                                                                             |
|---------------------------------------------------------|-------------------------------------------------------------------------------------|
| Double knot connections                                 | Creates high strength mesh and when overloaded, fail progressively, not explosively |
| Steel wire rope construction                            | Mechanical durability and resistance to abrasion                                    |
| Multi-axial configuration                               | Multi-directional stress / strain performance                                       |
| Single rope architecture in main panel                  | Low number of connections provides robust product                                   |
| Flexible in 3 dimensions                                | Excellent containment of debris and easy to install on site                         |
| High tensile steel wire cable construction              | Market leading, lowest possible deflection under load                               |
| Heavily galvanised cables with optional polymer coating | Long design life to suit project requirements                                       |

MESH SYSTEMS  
RING NETS

Maccaferri Ring Nets have the highest strengths of any mesh in the Mac.RO™ Systems range. With high strain performance, Ring Nets are ideal for situations where there is a high risk of dynamic impacts. The nets are also used to face rock slopes featuring large rock masses prone to failure; Maccaferri Ring Nets can sustain high local stresses without any damage.

The technical performance of the ring nets has been optimised to provide a balance of strength, weight and flexibility. The performance of the nets is dependent upon wire strand diameters, bundle configurations and the number of connection points to adjacent rings within the panel.



| Feature                                     | Benefit                                                                                       |
|---------------------------------------------|-----------------------------------------------------------------------------------------------|
| Ring based construction                     | High mechanical durability                                                                    |
| Multi-axial configuration                   | Multi-directional strength / strain performance                                               |
| High strength / High strain panel           | Excellent dynamic impact resistance                                                           |
| Specialist termination of individual rings  | High durability and safety during maintenance operations                                      |
| Variety of coatings                         | Balance commercial and performance requirements                                               |
| Connection elements                         | No overlapping mesh on lateral connections = fast installation and minimal waste              |
| Variety of lengths and widths of mesh rolls | Lengths and widths are available to suit site conditions reducing installation time and waste |

4 POINT RING





# MESH SYSTEMS TESTING & DESIGN

Maccaferri meshes have been extensively tested by recognised technical institutions and on project sites throughout the world. Quality Management processes continuously improve the systems.

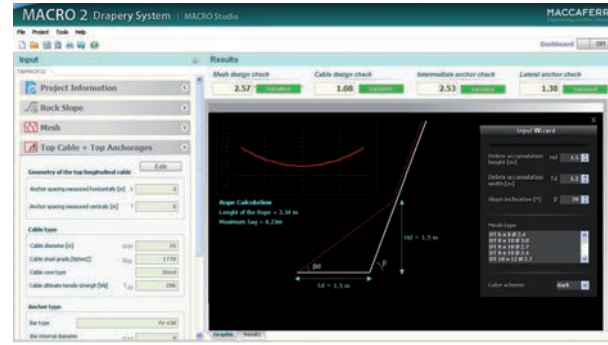
Wherever possible, full-scale testing of samples is carried out to model real-world situations and load conditions as accurately as possible.

The strain performance (stiffness) of the mesh is highly important in real-world applications as this determines the expected displacement of the mesh under load; a product with high tensile strength is of limited use if it requires significant displacement in order to mobilise that resistance as this could cause serviceability failure.

The combination of the performance data determined from these tests has been included within Maccaferri's state-of-the-art design software, MACRO Studio:

- MACRO 1** Secured Drapery design
- MACRO 2** Simple Drapery design
- MAC S-DESIGN** Soil Nail Facing design

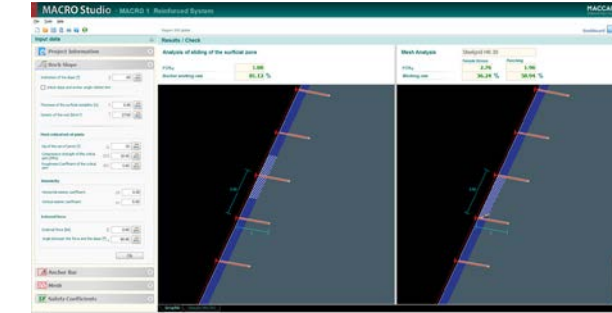
- 1 Tearing, pull-apart and local puncture tests represent rock penetration forces upon the mesh.  
This models the resistance of the mesh to unravelling under extreme puncture loads.



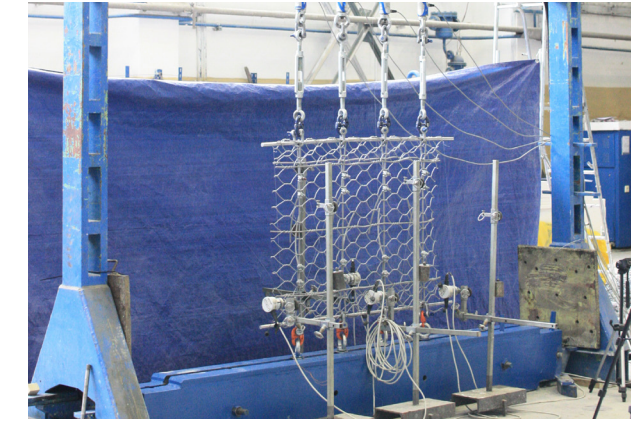
MACRO 2 Studio: Simple Drapery design



- 2 Testing of Maccaferri meshes has been carried out in accordance with UNI 11437:2012; EN 10223-3:2013 ; ISO 17745:2016 and ISO 17746:2016  
The use of full-scale samples enables the test results using this methodology to be included in the MACRO Studio Design Software.



MACRO 1 Studio: Secured Drapery design



- 3 Soil box compression and tensile testing are carried out to simulate the action of anchor plates bearing upon the mesh and soil beneath.



MACRO 1 Studio: Secured Drapery design





## DYNAMIC ROCKFALL BARRIERS

When commercial, safety, access or other conditions prohibit the implementation of a solution within the Detachment Zone, barriers within the Transit or Impact zones can be very effective at protecting infrastructure.

Maccaferri offers a range of barriers to suit most project problems;

**M** Debris Flow barriers

**M** Dynamic Rockfall barriers

Maccaferri dynamic rockfall barriers are available with energy absorption capacity starting from 100kJ.

Maccaferri's barriers have been developed in conjunction with specialist contractors. Therefore, the barriers include features to make the installation faster and safer, reducing time on site.

Selection of the appropriate barrier is based upon design and commercial analysis considering the type and volume of material to impact the barrier, the geological characterisation of the slope above and the infrastructure to be protected.

This procedure enables the type, location, height and capacity of the barrier to be determined.

### Limited slope space?

Maccaferri can deliver dynamic rockfall barriers without uphill anchors, saving costs and time on site.



## ETA APPROVAL & CE MARKED BARRIERS

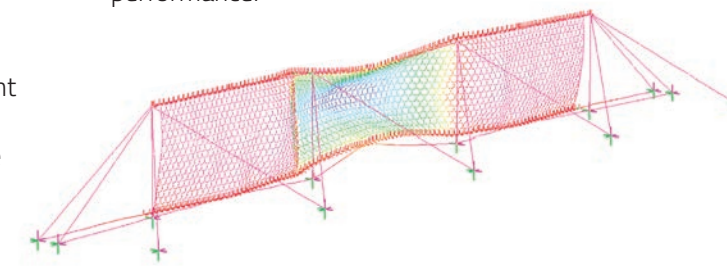
Maccaferri's dynamic rockfall barriers are tested and certified in accordance with the European Assessment Document (EAD 340059-00-0106) of the European Organisation for Technical Approvals (EOTA).

Maccaferri has been awarded European Technical Approval (ETA) for its range of barriers starting from 100kJ energy absorption capacity. Subsequent detailed verification of manufacturing, supply and assembly systems has permitted the award of the CE mark for the barrier systems.

During an impact a barrier deforms plastically. The residual height of a barrier, after the maximum energy level impact, is an important parameter to consider, as a second (and a third...) rock could impact the barrier before maintenance; this is a direct indication of the residual capacity of the barrier to withstand subsequent impacts. All Maccaferri rockfall barriers have been awarded the Class A classification regarding residual height in accordance with EAD 340059-00-0106.

Barrier performance data, collected during the full scale impact tests required for EAD 340059-00-0106, are used by engineers during the design process.

A dynamic rockfall barrier system which has been tested in accordance with EAD 340059-00-0106 provides confidence to clients and designers that the rockfall protection kit has been independently tested and assessed, in accordance with a rigorous set of guidelines to ensure standards of quality and performance.



### Energy dissipating devices

Maccaferri Dynamic Barriers can be equipped with two types of brakes. The patented STEEL Omega-Type Brake enhance the control of the loads on the rockfall barrier and reduce the load on the foundations. Alternatively, lightweight compression brakes can be installed. Those are lightweight, corrosion resistant, easy to replace and very simple to inspect visually for evidence of impacts, however minor.





## DEBRIS FLOW & SHALLOW LANDSLIDE BARRIERS

Debris flows are highly mobile flows of mixed material and are triggered by the rapid build-up of water within the slope, saturating the ground. Debris flows can travel at high speeds and contain huge volumes of material and consequently pose a high risk to people, property and infrastructure.

It is predicted by meteorologists that global climate change will increase rainfall in many areas and is likely to influence the incidence of debris flow and shallow landslide events.

Maccaferri DF Barriers are positioned within the anticipated path of the debris flow or shallow landslide, often in natural gullies, channels or chutes on the slope.

The DF Barriers are customised to suit the dimensions of the project, the anticipated debris material and the expected volume of flow.

During a debris flow impact, the barrier deforms, dissipating the hydraulic pressure allowing the water to pass through it whilst retaining the solid part of the debris flow. The main parameter of the process is the pressure (dynamic and static) exerted upon the barrier by the impacting debris flow. Maccaferri offers different barriers, able to withstand varying levels of pressure, maintaining the structural integrity and securing the downstream infrastructure.

### After-impact maintenance

Once the Maccaferri DF barrier has deployed and arrested the debris flow, the debris is emptied and disposed of.

Compression brakes are replaced whilst support ropes and containment mesh are checked for serviceability before reuse or replacement.

The cost of replacing components is a minor consideration compared to emptying the debris from the barrier, or cleaning up after a debris flow event which has not been intercepted by a barrier.





## ROCKFALL EMBANKMENTS & CONSOLIDATION

When the capacity of dynamic rockfall barriers is not sufficient, earth embankments and bunds are commonly used as protection from natural hazards; landslides, rockfalls, avalanches and more.

Until recently, the dimensions of the footprint of these embankments have been limited by the geotechnical parameters of the material used to construct the embankment. With over 30 years of geogrid and geosynthetic knowledge, Maccaferri has significant expertise in the use of soil reinforcement. Using Maccaferri's soil reinforcement solutions to construct rockfall embankments has numerous advantages:

- M** Footprint of embankment is dramatically reduced
- M** Slope face angles can be steeper
- M** Embankment is more stable and robust
- M** Site won materials can often be reinforced and re-used, embracing sustainability
- M** Maccaferri manufactures a wide variety of soil reinforcement geogrids and textiles to suit most sites and conditions
- M** Revegetating embankment face provides environmental benefits

FEM analysis has been used to design Maccaferri reinforced soil embankments offering a capacity of 20,000kJ.

Given enough space, almost unlimited energy absorption capacities are achievable.

### Maccaferri soil reinforcement systems

- M** Terramesh®
- M** Green Terramesh®
- M** Paragrid® & Paradrain®
- M** MacGrid® WG
- M** Duna® System

### Embankment benefits

In situations where extensive natural hazards are expected, embankments can offer;

- M** Cost effective solution (\$/kJ capacity)
- M** Almost unlimited capacity (>20,000kJ)
- M** Withstand multiple impacts without repair
- M** Can contain vast quantities of debris
- M** Very low maintenance
- M** Can divert flows away from infrastructure



## ERDOX® TERRA

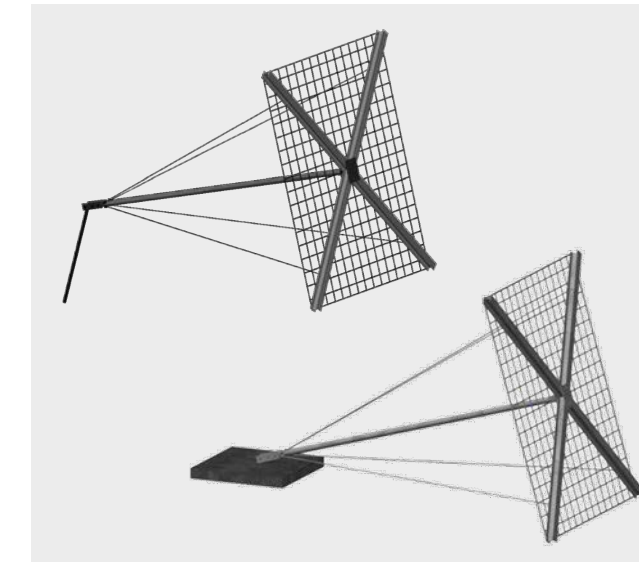
Erdox® are pre-assembled structures particularly suitable for rapid and safe remediation.

Erdox® Terra structures are multifunction devices designed to provide soil stabilisation on slopes. Being foldable, Erdox can be easily transported.

Erdox® units have a single anchorage that simplifies the installation and are ideal for emergency works. Erdox® can be backfilled re-using in-situ materials

### Main benefits:

- M** Pre-assembled and ready to deploy
- M** Lightweight and simple to install
- M** Easy to transport



Erdox® is the most efficient solution for rapid and secure remediation in areas affected by landslides that are not easily accessible.



## SNOW FENCES & AVALANCHE PROTECTION

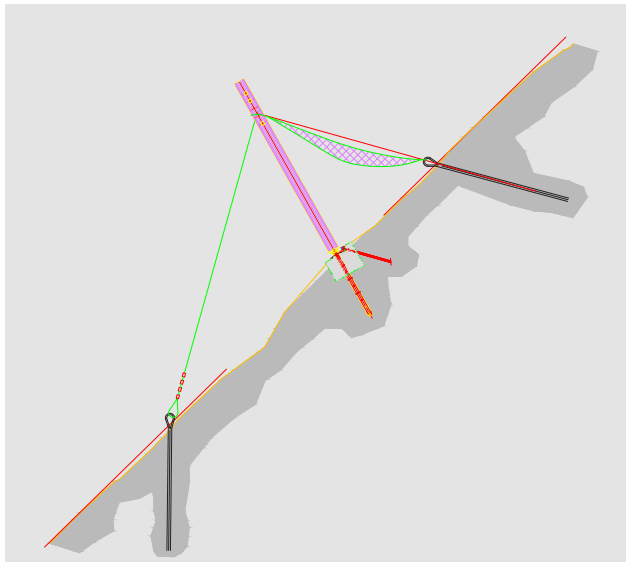
Maccaferri's snow nets significantly reduce the threat of avalanches to infrastructure and winter sports resorts.

The snow nets are designed to stabilise the layers of snow at the potential avalanche detachment zone, preventing the triggering of the avalanche. The snow exerts a pressure which must be absorbed by the nets and transmitted to the ground by means of a system of snow fence posts and anchors.

It is common to install rows of snow nets on the upslope and downslope of a potential avalanche initiation point, limiting the propagation of shear failures in the snow pack.

### Maccaferri snow net benefits:

- M** Adaptable to irregular surfaces
- M** Lightweight and simple to install
- M** Suit a wide range of snow depths
- M** Low visual impact



Our snow fences up to 4.0m high have been approved by the Swiss Federal Institute for Snow and Avalanche Research in Davos – SFISAR “Swiss Guidelines for avalanche control structures in the starting zone”, 2006.

## ERDOX® SNOW

The Erdox® Snow structures are protection measures that are placed in the zones of avalanche initiation and stabilise the snowpack. This limits the volumes of snow that can be mobilized, reducing the overall avalanche hazard risk.

The Erdox® Snow supporting structure is a pre-assembled unit with a single anchorage element. It features a cruciform facing panel structure made with steel beams. One of the two beams is divided into two parts connected together in order to simplify the transportation of “folded units”.

### Erdox® Snow benefits

- M** Suitable to steep slope
- M** Lightweight and easy to install
- M** Easy to transport



Erdox® Snow performance are approved by the Italian Superior Council of Public Works (CVT)



## SOIL NAILING & SURFACE PROTECTION

Soil nailing is a technique that can be used both on natural and excavated slopes, where the slope is reinforced by the insertion of tendons.

These nails address the global slope stability and are connected to a facing system which provides surficial stability. The facing system can be rigid, flexible or even a structural revegetating system such as MacMat® R.

The facing system restrains the superficial portion of the slope which can mobilise between the anchors, potentially destabilising the overall slope.

Where high performance and revegetation are required, the innovative MacMat® HS, combines the reinforcing benefits of Steelgrid® HR and a 3-dimensional geomat in one product; installation time is reduced and simplified.

To design such facing systems, Maccaferri has developed MAC S-DESIGN, a new online software to assist in the selection of flexible and soft facings. To check the overall (global) stability of the soil nail reinforced slope, suitable geotechnical design software is used, e.g. Maccaferri MacSTARS.

Maccaferri's numerous rockfall mitigation and erosion protection systems provide solutions (either stand-alone or in combination) for the local surface stability including;

- Reinforcing flexible facings: DT mesh, HEA Panels, SteelGrid® HR, MacMat® R, MacMat® HS.

Geotechnical investigation and design determine the suitability of soil nailing to reinforce an unstable slope. Maccaferri offers numerous other solutions, including retaining structures and soil reinforcement, in the event that soil nailing is not suitable.

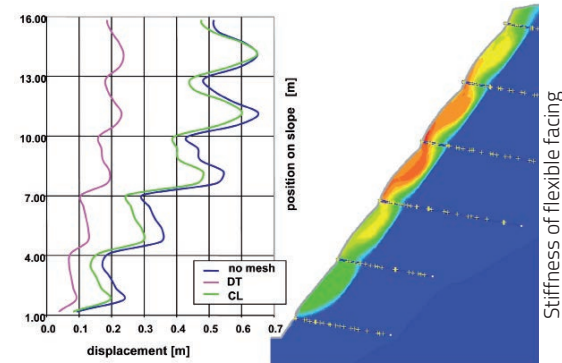
### Functions of the facing system;

- Protects the exposed surface from erosion
- Provides stability while vegetation grows
- Connects the unstable surficial layers with the stabilised deep slope

### Functions of the soil nailing system;

- Enhance the deep-seated stability of the slope
- Provide long-term reinforcement of the slope
- Be connected to the suitable facing system

### Slope with nails and mesh



MACCAFERRI Mac S-design POLITECNICO DI TORINO

Home Projects Case 1

Input pre-Analysis Design Analysis Results

Mac S-design

Geometrical Slope Parameters

| Description                   | Symbol   | Value | Unit |
|-------------------------------|----------|-------|------|
| Slope Angle                   | $\alpha$ | 25.0  | deg  |
| Unstable Soil Thickness       | $h$      | 1.0   | m    |
| Nail Inclination (horizontal) | $\beta$  | 25.0  | deg  |
| Nail Inclination (vertical)   | $\gamma$ | 65.0  | deg  |

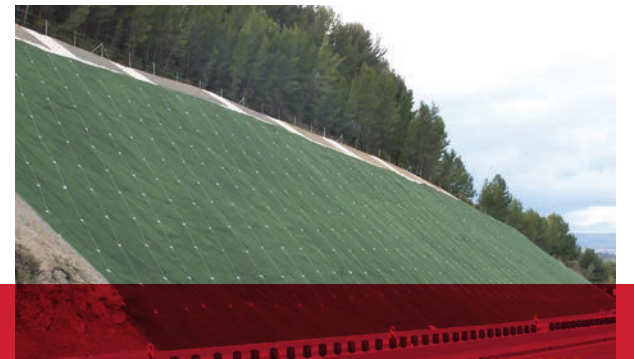
Anchor Bar Mechanical Parameters

| Description         | Symbol | Value | Unit |
|---------------------|--------|-------|------|
| Anchor Bar Length   | $L$    | 1.0   | m    |
| Anchor Bar Diameter | $\phi$ | 16.0  | mm   |
| Anchor Bar Spacing  | $s$    | 1.0   | m    |

Longitudinal Cross Section of an Anchor Bar

MAC S-DESIGN Soil Nailing Design

Online software to design pinned drapery solutions





## ALERT SYSTEM HELLOMAC

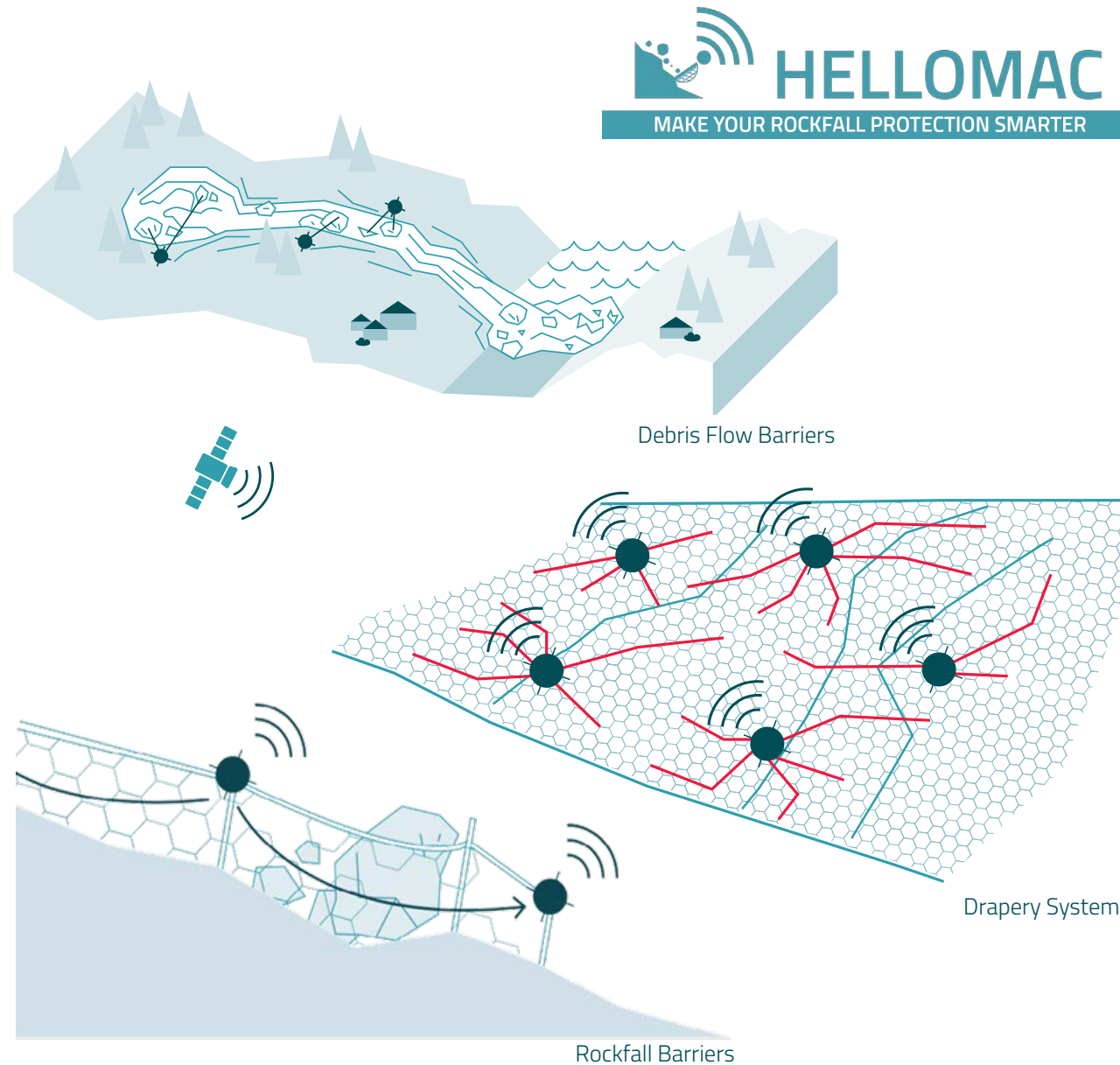
HELLOMAC is an alert system developed to monitor our rockfall protections, especially in remote areas. Get an alert when a rockfall event occurs!

Easy-to-install alert system that fits **Drapery Systems**, **Rockfall** and **Debris Flow Barriers**.  
HELLOMAC is suitable also for natural event monitoring.

- M** Super reliable and accurate
- M** Easily deployable by a rockfall worker
- M** Does not require on-slope wiring activities
- M** Does not need an external power supply
- M** Does not require maintenance

Developed to also work in remote areas, where cell coverage is not available.

Unlike traditional systems, HELLOMAC signals events on every single portion of the barrier, allowing the detecting system to be restored in a simpler and more economical way.



### HELLOMAC Device

HELLOMAC is the alert system for safeguarding lives, infrastructures and buildings protected by any kind of barrier.

It can be carried to remote places due to small dimensions and lightness

It can be easily fixed to the barrier post by unskilled workers.

HELLOMAC has 8 batteries with an estimated working life of 5 years making annual maintenance visits unnecessary. Each device communicates its status and battery level daily.

Daily transmission of location and rockfall protection status. Simplicity avoids data transmission issues.

Tested against impacts (resists up to 16g acceleration)

It works between  $-40^{\circ}\text{C}$  and  $+60^{\circ}\text{C}$

It was specifically tested on Maccaferri rockfall barriers by Politecnico di Milano

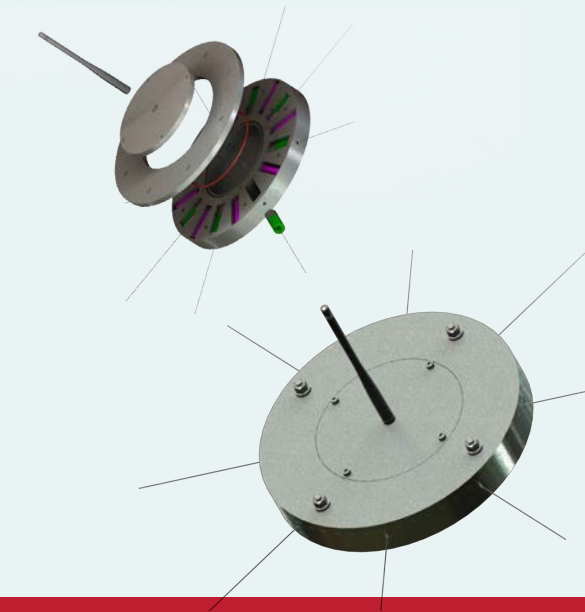
Suitable for retrofitting on existing rockfall protections.  
HELLOMAC is suitable also for natural events monitoring.

### How it's made

HELLOMAC is a compact and robust device, made with a special metal alloy, chosen to withstand considerable forces.

HELLOMAC weight is approx. 8 kg.

It's able to detect events (boulders, stresses, sagging, etc.) from up to 8 directions in each rockfall protection module.



### What it does

In line with the recommendation of UNI 11211-5 (May 2019) and the UNI 11211-2 (June 2007) norms, HELLOMAC alerts people in time.

Whatever barrier is monitored, an alarm is sent via app, email or SMS to computers and smartphones and is also able to activate local sirens and warning lights.

Get notified when a rockfall event occurs via **mobile app**, **SMS** and **email**.





## SYSTEM ACCESSORIES

Maccaferri also offers a variety of accessories, specifically selected for their compatibility with the range of rockfall mitigation solutions. Clients can select whether they require a package solution, or individual components to suit the project and local relationships.

### High Capacity Self-drilling bars

Available with a variety of diameters, steel strengths and corrosion protection treatments including electrolytic, hot-dipped galvanised or epoxy-coated. Drill bits, couplers, plates and bolts are available to suit the project requirements and ground conditions.



**STEP 1**  
Bar strength, steel type  
& corrosion protection



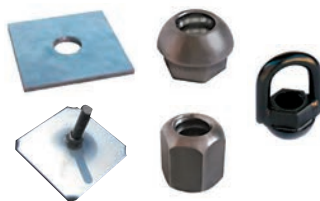
**STEP 2**  
Various drill bits  
to suit ground  
conditions



**STEP 3**  
Coupler



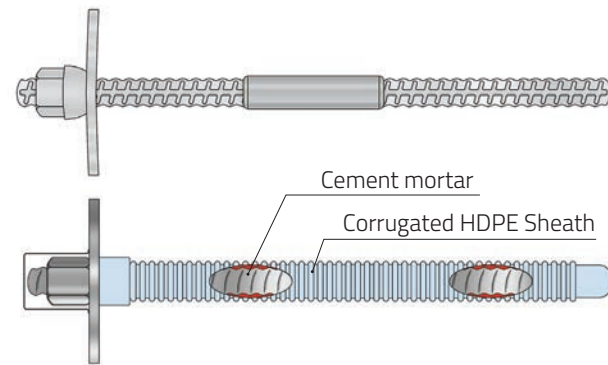
**STEP 4**  
Plates & Nuts



### Continuous Threaded Bars

Available in a variety of diameters, steel strengths and corrosion protection treatments including electrolytic or hot dipped galvanised, epoxy coated or with double corrosion protection. Couplers, perforated drill liners and plates are available to suit the project requirements.

Mac.RO™ Double Corrosion Protection bars (in accordance with EN 1537) feature high resistance continuous threaded bars protected with a cement mortar layer encapsulated within a 1.2 mm thick corrugated HDPE sheath.



**STEP 1**  
Bar strength, steel type  
& corrosion protection



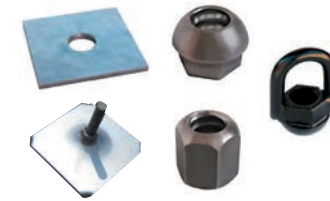
**STEP 2**  
Coupler



**STEP 3**  
Liner / Centralisers

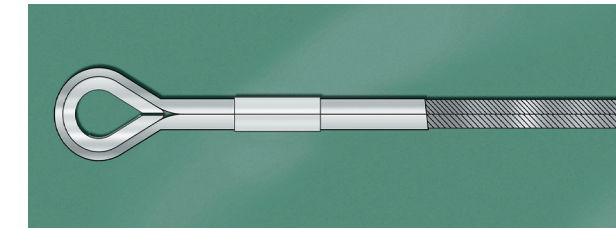


**STEP 4**  
Plates & Nuts



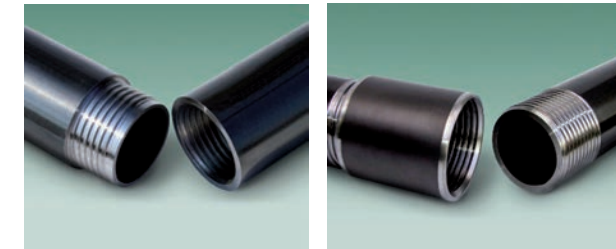
### Flexible Rope anchor

Used when the direction of the pullout forces is variable or inclined to the axis of the anchor. Uses include; as a top anchor on drapery systems and the ground anchors for the support cables of rockfall and debris flow fences and snow supporting structures. Available in a variety of strengths and lengths, all the steel components are heavily galvanised for durability.



### Micro-piles

Used to restrain foundations for rockfall, debris flow and dynamic barriers. Can be supplied as a single length, with either a direct screw connection, or couplers depending on diameter and specification.



### Steelgrid® HR Mesh Kit - System Accessories

This range of accessories are used within the high strength Steelgrid® HR system;

**HR Links** connect laterally adjacent panels of Steelgrid® HR mesh and require no tools. These links clip around the steel cables, connecting them intimately. Available in two finishes, GalMac® galvanised (Class A) and stainless steel (for use with **PoliMac®** coated Steelgrid® HR).



**HR Grips** are technically superior to traditional rope grips and are used to connect the interwoven cables within Steelgrid® HR over the crest and toe ropes on the rock or slope face. Produced from forged carbon steel and hot-dip zinc coated, HR Grips offer optimum performance, reliability and design life.



**HR Plates** are engineered to offer optimal performance with Steelgrid® HR by enhancing system stiffness. They can remove the sensitivity of anchor placement within secured drapery and 'profile-bolted' installations.



**HR Caps** are a recommended accessory for projects involving Steelgrid® HR-**PoliMac®** and are used to enhance design life in highly aggressive environments.



Not all accessories are available in all Maccaferri companies worldwide. Please consult your local Maccaferri office for more information.

