



GUARDIANS OF THE EARTH:

Geosynthetics In Erosion Control And Stabilisation

Date 26 April 2024
Author Tshepang Mokoena

MACCAFERRI



Introduction

Understanding Erosion and Its Impact

Erosion Control in Construction

Permanent Erosion Control Structures

Geosynthetics for Erosion Control

Environmental Sustainability

Case Studies



INTRODUCTION

Who we are:



Who we are:



“Meeting the needs of the present without compromising the ability of future generations to meet their own needs” UNESCO



VISION

Trusted global partner, **nurturing** the world of tomorrow, harmonizing life and nature through innovative solutions.

Nurturing for Maccaferri means to care, to protect, to be responsible for. Our vision is not just about ‘what’ we want to be but even more importantly it is also about ‘how’ we want to be as an organisation.

Responsible, respectful, caring, and sensitive not only to the **environment** but also very much to our **people**, our stakeholders and to the world at large.



MISSION

Pursue excellence through **continuous improvement** while delivering to our 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.



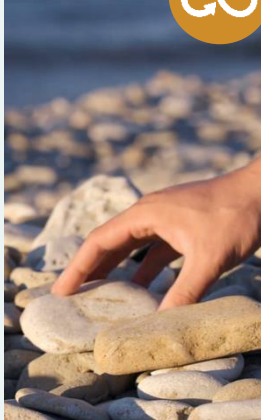
INTRODUCTION

Who we are:



Foster innovation

Continuous improvement through engineering test campaigns and product performance evaluation



Responsible design and production

Sustainable material management, with re-use and recycling of materials.
Our solutions cause no harm to the environment



Promote clean energy adoption

Working to maximize the share of green energy in the global energy mix



Integration into the natural environment

Enhancing biodiversity
Respecting the wildlife
Boosting vegetation growth



Safety of people and assets

Preserving our cultural heritage, improving public safety and preventing disaster risks



Involvement of local communities

Promoting an inclusive growth and restoring livelihood and economies after natural disasters



Soil erosion refers to the wearing away of the field's **topsoil**, in which the high organic matter is contained. Wind and stormwater runoff are two common causes of soil erosion.



Soil is a precious **source of biodiversity**, fundamental in **storing and releasing carbon** and maintaining the balance of gasses in the air we breathe.





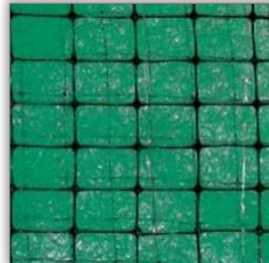
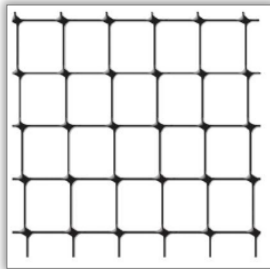
We are all becoming more concerned about the loss of soil and, as engineers, we are called to **control the erosive force of wind and rainwater** to prevent the detachment of the topsoil, hence **promoting vegetation growth**.

Geosynthetics used for erosion control applications can be classified based on:

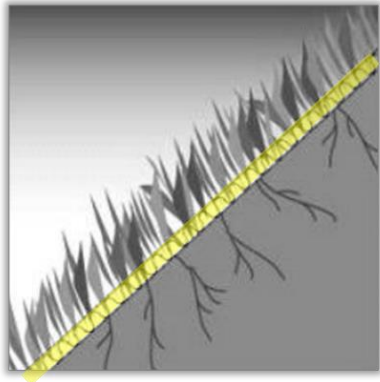
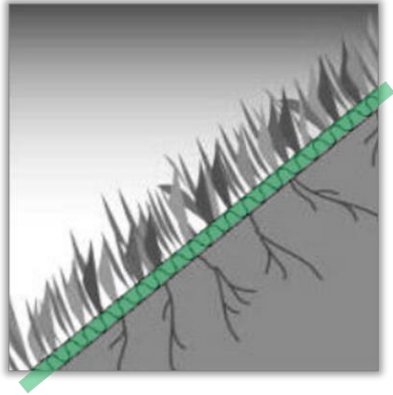
- **Product configuration** (mat, sheet, grid or web)
- **Origin/Raw material** (natural fibers, such as jute or coir, or artificial fibers, such as polyethylene, nylon or polypropylene)
- **Protection duration** (temporary or permanent protection)

Erosion control geosynthetics can be then classified based on the protection duration in:

- **PERMs** (**P**ermanent **E**rosion **R**evegetation **M**aterials)
- **TERMs** (**T**emporary **E**rosion **R**evegetation **M**aterials)



Permanent erosion and revegetation materials (PERMs)



PERMs (Permanent Erosion and Revegetation Materials) provide:

- permanent protection against erosion
- aid in vegetative growth
- reinforcement to the root system if entangled with the vegetation.

As long as the material is shielded from sunlight, it should not degrade.

PERMs, can be used in two main ways:

TRM (Turf Reinforcement Mat)

- topsoil and seeds are infilled inside the TRM and roots grow through the TRM and get improved resistance to shear stresses;

ECRM (Erosion Control Rolled Materials)

- the ECRM is laid on the slope without being infilled; it protects the slope against raindrops splash and runoff, but it doesn't improve root resistance, it may increase the shear resistance of stems.



Temporary erosion and revegetation materials (TERMs)



TERMs (Temporary erosion and revegetation materials) consist of **geosynthetics** that **are wholly or partly degradable**.

TERMs provide temporary erosion control and are either degradable after a given period or they function only long enough to facilitate vegetative growth. After the growth is established, the TERM becomes sacrificial.

TERMs are requested to deliver a temporary protection to the soil promoting favorable conditions to the development of the vegetation which consist itself in the effective durable protection against erosion.

Grade Control Structures

GRADE CONTROL STRUCTURES

GROYNES



PERMANENT EROSION CONTROL STRUCTURES

MACCAFERRI

Function of grade control structures

WEIRS FUNCTION

in mountains

reduces landslide's occurrence

in floodplains

reduces sedimentation & siltation of canals



Types of Gabion Weirs

**SINGLE VERTICAL
DROP**



STEPPED WEIR



SLOPED WEIR



Groynes

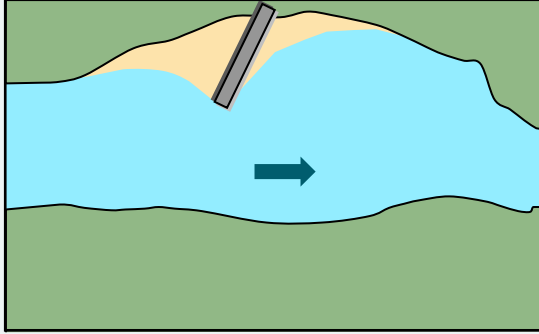
GRADE CONTROL STRUCTURES

GROYNES



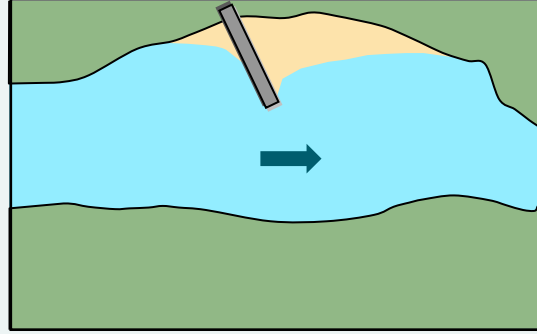
Types of Groynes

GROYNE POINTING UPSTREAM



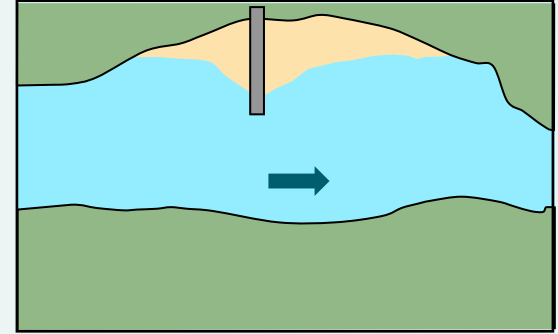
- Attracts silt upstream and downstream of the structure
- Pushes the main current away from the bank
- Has great potential for scour hole at the head

GROYNE POINTING DOWNSTREAM



- Attracts only silt downstream of the structure
- Does not form much eddy current and pulls the main current to the bank
- Has a relatively low potential for scour at head
- Not recommended for concave bend

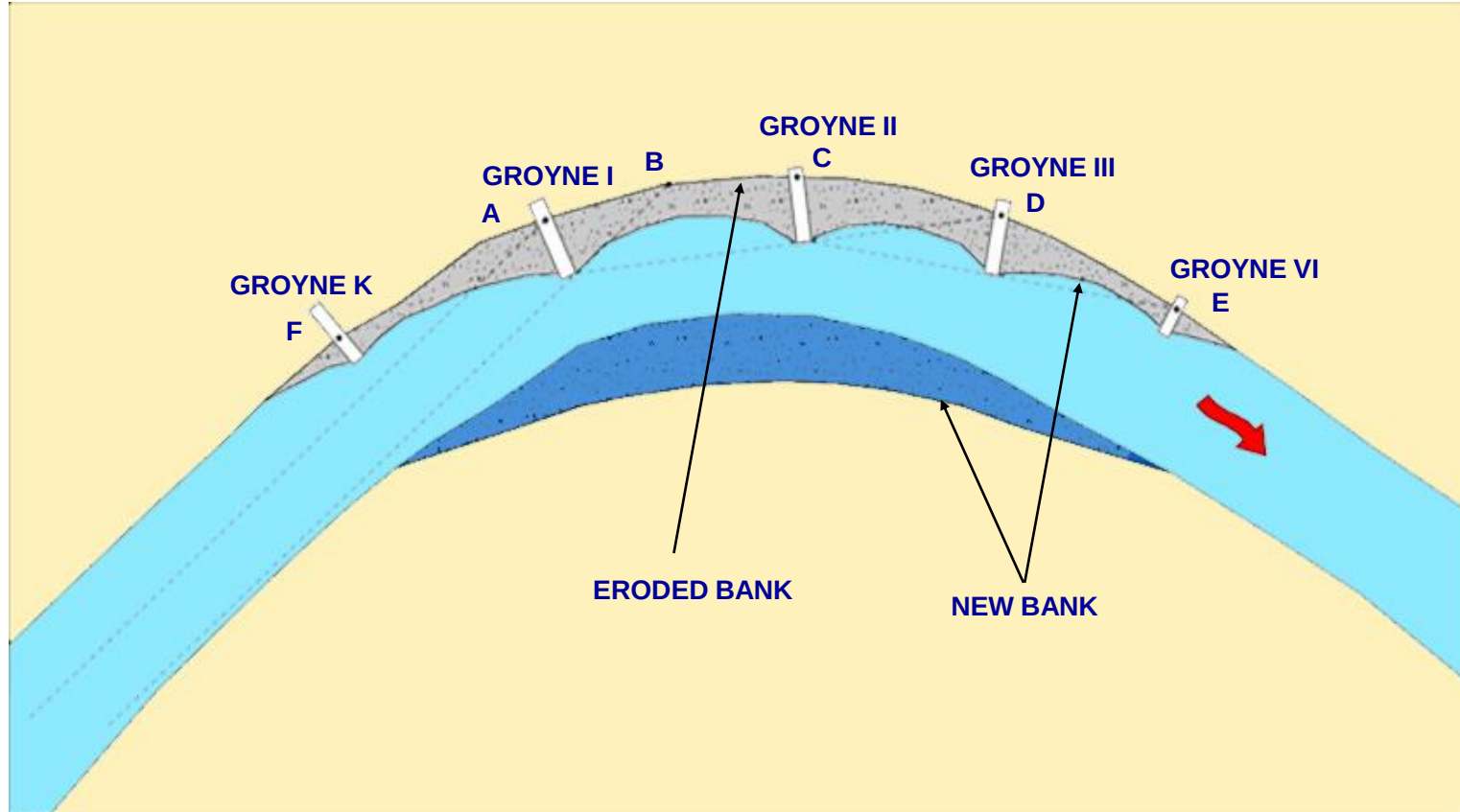
GROYNE PERPENDICULAR TO FLOW



- Groyne attracts a moderate amount of sediment upstream and downstream
- Keeps current more or less parallel to the bank
- Has medium potential for scour at the head

PERMANENT EROSION CONTROL STRUCTURES

Advantages of Groynes

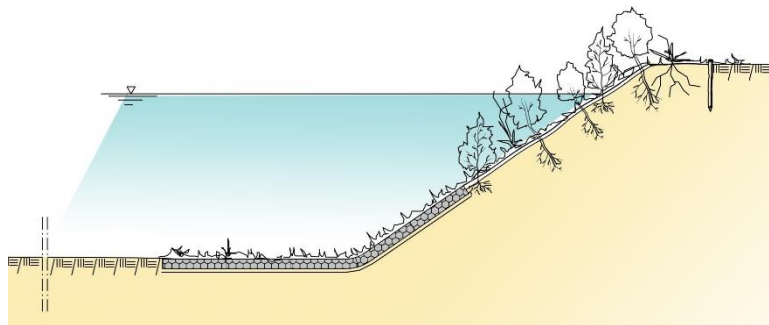


PERMANENT EROSION CONTROL STRUCTURES

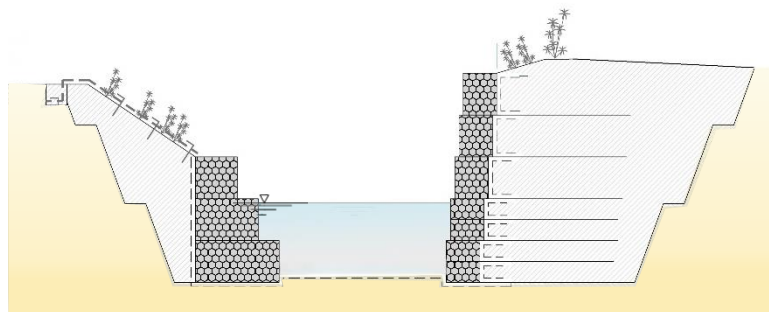
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Longitudinal protection and Earth retaining systems

LININGS
&
SOIL NAILING



EARTH
RETAINING
SYSTEMS



PERMANENT EROSION CONTROL STRUCTURES

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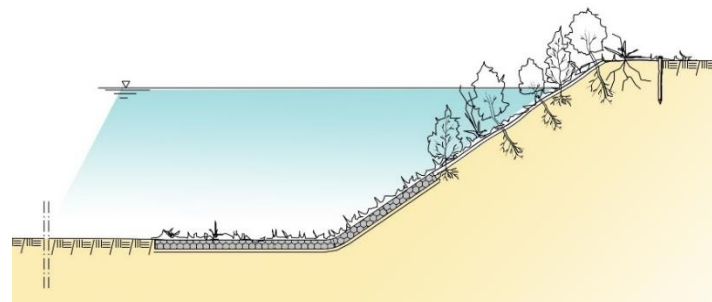
Longitudinal protection and Earth retaining systems

LININGS
&
SOIL NAILING

SOFT ARMOR LININGS

HARD ARMOR LININGS

EARTH
RETAINING
SYSTEMS



Soft Armor Linings

LININGS
&
SOIL NAINING

SOFT ARMOR LININGS

HARD ARMOR LININGS

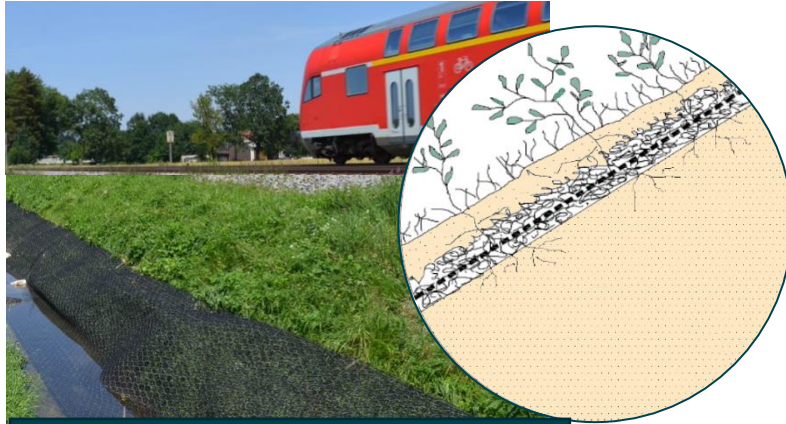
EARTH
RETAINING
SYSTEMS



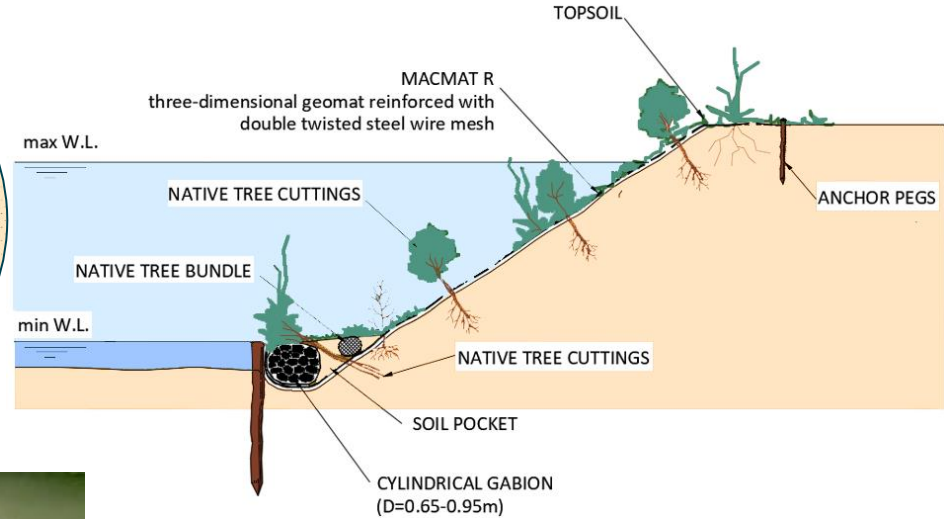
PERMANENT EROSION CONTROL STRUCTURES

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Soft Armor Linings



MacMat R



Advantages of MacMat R

- Rapid growth of vegetation (3-4 weeks)
- It works as a barrier against rodents (beavers, etc.)
- It can incorporate deep anchors
- There are no overlaps on longitudinal joints



Hard Armor Linings

LININGS
&
SOIL NAILING

SOFT ARMOR LININGS

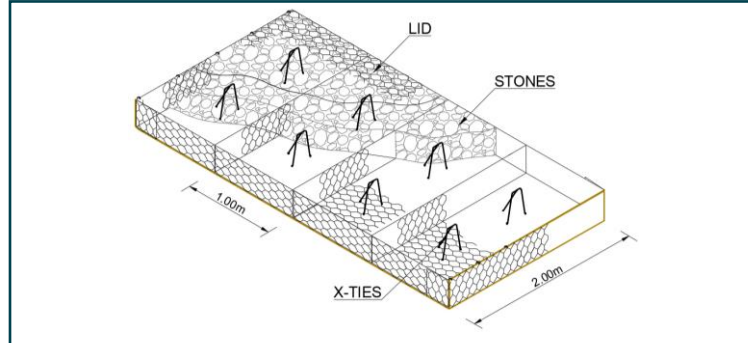
HARD ARMOR LININGS

EARTH
RETAINING
SYSTEMS



PERMANENT EROSION CONTROL STRUCTURES

Hard Armor Linings



Reno Mattress Plus



PERMANENT EROSION CONTROL STRUCTURES

MACCAFERRI

Earth retaining systems

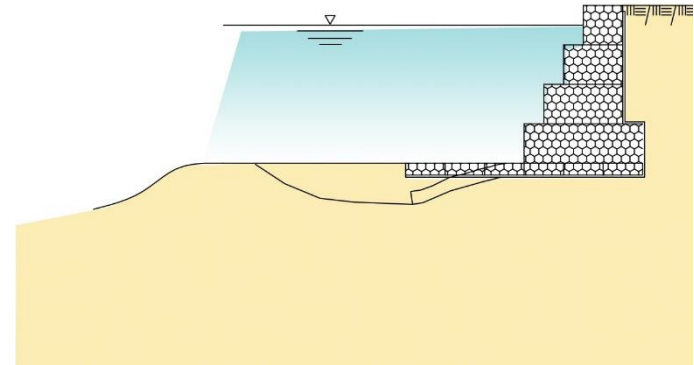
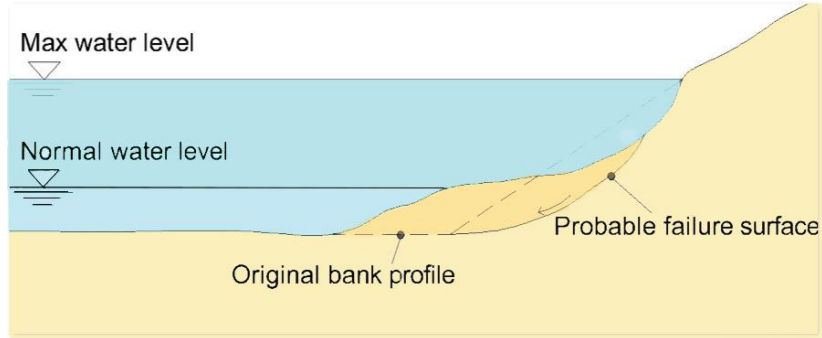
LININGS
&
SOIL NAILING

EARTH
RETAINING
SYSTEMS



PERMANENT EROSION CONTROL STRUCTURES

Earth retaining systems





Over the years Maccaferri has been working along with some of the most prominent universities at international level to develop **sustainable solutions** to **prevent the loss of soil** and to **enhance the re-vegetation**

MACCAFERRI



UNIVERSITÀ
DEGLI STUDI
DI MILANO

Utah State
UNIVERSITY



Colorado State University





**WE HELP
NATURE
GROW**

What influences the growth of vegetation on slopes?

The Study Carried out by Univerisity of Milan

We posed the question to **Prof. G. Bischetti**, Head of Department of Agricultural and Environmental Sciences at the **University of Milan**.

The study focuses on the relationship between erosion control solutions and vegetation growth.



UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI SCIENZE AGRARIE
E AMBIENTALI - PRODUZIONE,
TERRITORIO, AGROENERGIA

Relationships between Erosion Control
Products and vegetation growth

Prof. Gian Battista Bischetti

Report di ricerca – luglio 2021



How 7 Key Parameters Affect Revegetation and Erosion Control Maximization

Product related

- M** Light Penetration / opening size
- M** Thickness
- M** Color
- M** Water Absorption
- M** Weight
- M** Roughness and run-off
- M** Uniformity



Site related



ALBEDO



WATER RUNOFF



PLANT
GROWTH



SOIL HUMIDITY



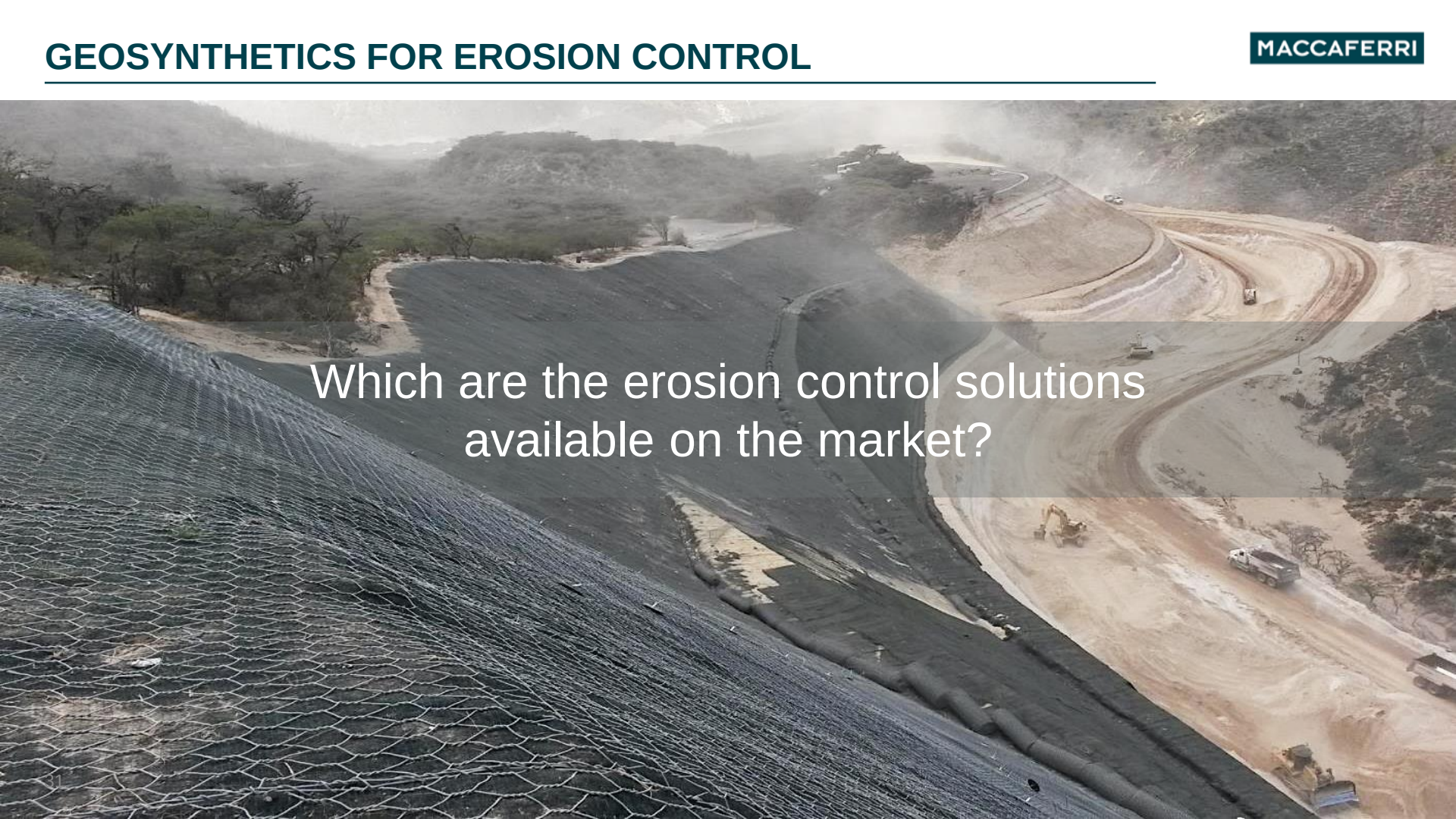
SOIL
TEMPERATURE



*“Relationships between Erosion Control
Products and vegetation growth”*

Prof. G.B. Bischetti et al, UniMi, 2021





Which are the erosion control solutions available on the market?

Geosynthetic Products for Erosion Control

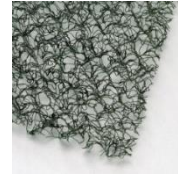
Biomat

2D shape fabric made of biodegradable natural fiber, such as jute, straw, coconut, cellulose fiber felt.



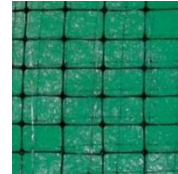
Geomat

3D shape mat made with polymeric filaments. The product could be reinforced with a geogrid.



Composite

Multi-layer 2D Geogrid coupled with a blanket in order to improve the soil coverage of the product.

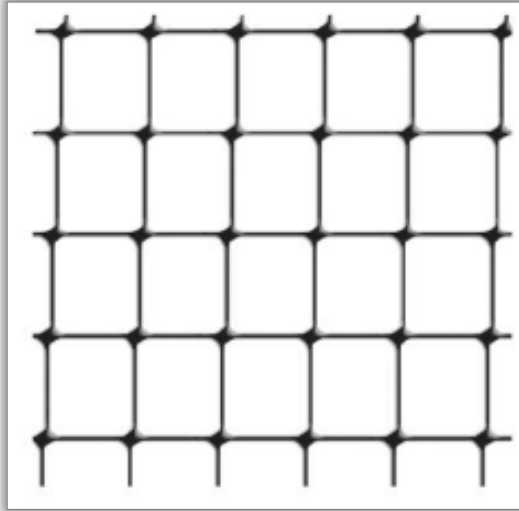


Geotextile

Woven planar geotextiles manufactured by weaving yarns in the warp and weft direction.



Geosynthetic Products for Erosion Control



Light geogrids consist in planar mono/biaxially oriented **light grades geonets** typically manufactured from **polypropylene (PP)** or **polyethylene (PE)** resins.

They vary in composition, strength, elongation, aperture size and shape. Colour and ultraviolet stability usually can be designed for specific site requirements and service life durations.

They can be placed on a slope to **assist vegetation in resisting erosion forces**.

Biaxially oriented light are often used to create more complex products and are even used alone to anchor loose fibers mulches such as straw, hay and wood chips.



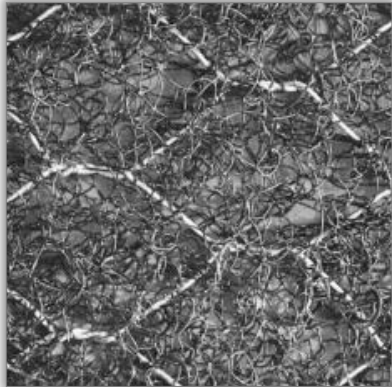


Geomats are generally made of synthetic monofilaments or nets tangled together to form a highly deformable mat 10 mm to 20 mm thick, featuring very high porosity (greater than 90 % on average).

They can be used on slopes and along the banks of canals and river courses for the following applications:

- **erosion protection on slopes** caused by the impact of rain drops and runoff. **Geomats can protect the soil against rainfall splash and runoff** by keeping in place soil particles. **Moreover, Geomats can increase the shear resistance of the roots system several times over if used as TRMs.**
- **lining of river/channel banks with low water velocities**

Geosynthetic Products for Erosion Control



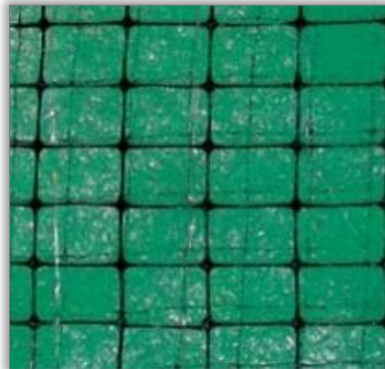
Reinforced geomats are **geocomposites** manufactured by joining a **geomat** and a **geogrid or metallic mesh**, having a tensile strength in the range 50 kN/m – 300 kN/m.

Reinforced geomats afford **all the characteristics of geomats**, **plus** they afford **high tensile strength**. Then can be used:

- **on long and steep slopes**
- **along the banks of canals and river courses with relatively high-water velocities**
- **where high tensile strength is required.**



Geosynthetic Products for Erosion Control



Geobblankets are made up of natural or synthetic fibres, in the form of a mat of fibres held together with natural or synthetic lightweight meshes.

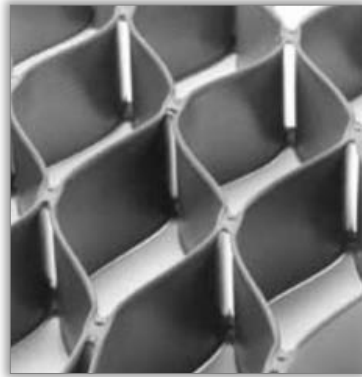
Typically manufactured based on natural fibers.

Geobblankets made of natural fibres can absorb high amounts of water. During their natural degradation, they can produce nutrients for the vegetation. Consequently, they are able to provide only temporary protection against erosion.

These materials can be used for temporary erosion control on slopes and along the banks of canals and river courses with low water velocities.



Geosynthetic Products for Erosion Control

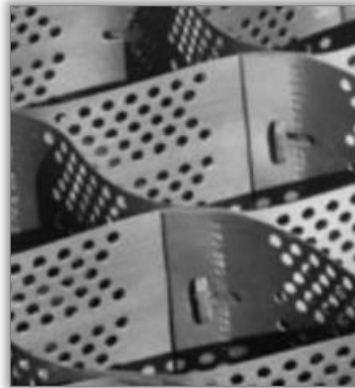


Geocells are honeycomb products manufactured by joining polymeric strips or geotextile strips through welding, gluing, or stitching.

The **only function afforded by geocells is lateral confinement**. The lateral movements of the soil infilled in the cells are prevented or limited by the cell walls and by the other surrounding cells. Hence, geocells by themselves **cannot prevent soil erosion, since the top surface is exposed to rain splash and runoff**.

Geocells can be used to **stabilize a soil thickness between 100 mm to 300 mm**, thus hindering it from sliding down the slope but then the **top surface shall be protected against erosion by some other erosion control material**.

Geocells can be used on arid slopes when a thick topsoil layer is required to allow vegetation growth.

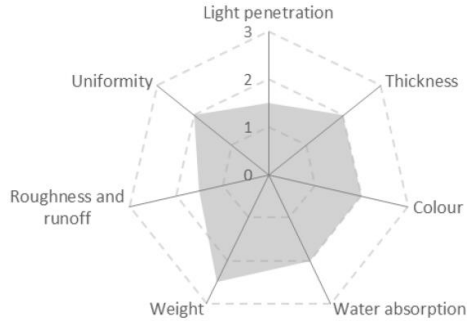


GEOSYNTHETICS FOR EROSION CONTROL

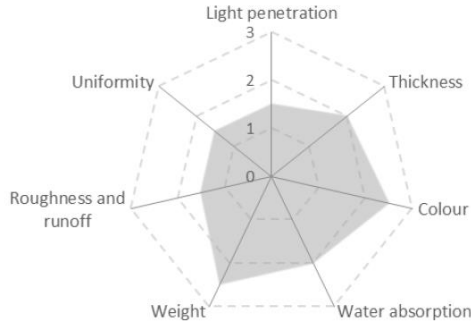
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Expected Performance of Erosion Control Solutions

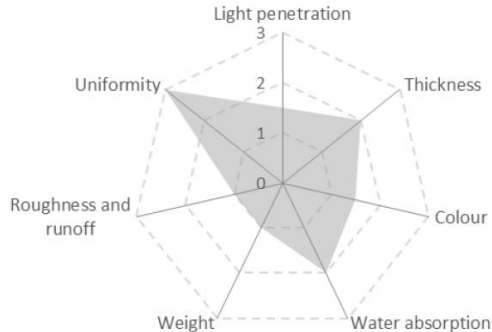
BIONETS



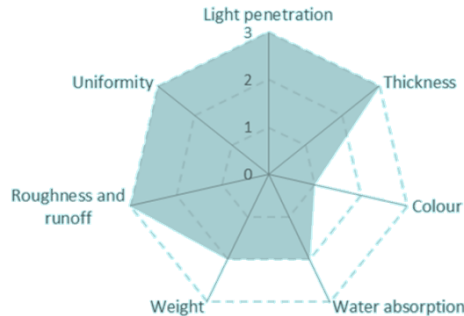
GEOBLANKETS



COMPOSITES



GEOMATS



Erosion Control solution **performance depends on complex processes** where different factors and features interact and those are not homogenous, quantitatively and qualitatively.

Considering all the interacting features, **Geomats globally show the best performance.**



"Relationships between Erosion Control Products and vegetation growth"
Prof. G.B. Bischetti et al, UniMi, 2021

GEOSYNTHETICS FOR EROSION CONTROL

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Macmat: The Sustainable Solution for Erosion Control

Geomat – MacMat® are made of synthetic material filaments, tangled together to form a highly deformable layer 10-20 mm thick, featuring a very high porosity (greater than 90% on average).

Perfectly suitable for slopes, along the banks of canals and river courses, or to convey liquids (drainage) in association with geotextiles and/or geomembranes.



Colorado State University Test Campaign

Tests on different products and different conditions have been carried out at the Colorado State University between 2019 and 2020



Tested products:

- M** MacMat 6822G0
- M** MacMat R1 05rs
- M** MacMat 6822G0+BTX
- M** **MacMat 6822G0 vegetated**

Relevant remarks:

- Based on ASTM D6460
- Failure criterion: average soil loss of 0.5 in
- Test duration (0.5 h in unvegetated condition, 1 h in vegetated condition)
- Vegetation period of 12 months



GEOSYNTHETICS FOR EROSION CONTROL

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Macmat: The Fastest Growth on the Market



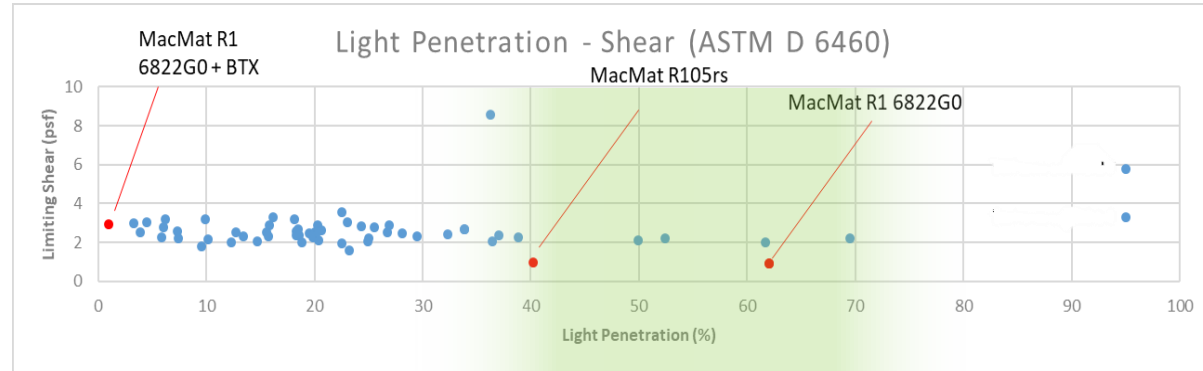
Test conducted by
Colorado State University
between 2019 and 2020
on MacMat-R

- Fully revegetation in only 6 week
- In 6 weeks, performances reach what traditional EC solution achieve in 1 year (*Limit shear strength* and *Limit Velocity*)
- 6th week performance achieve 60% of 1 year measured strength



The Importance of the Light

Lab tests and field experience evidence that a light penetration index between **40%** and **70%** is the optimum range for vegetation growth.

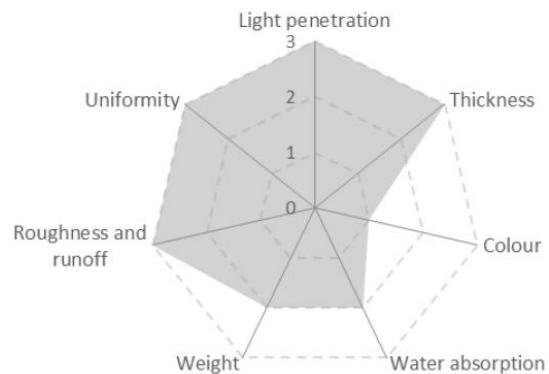


**Best light
penetration range for
vegetation growth**

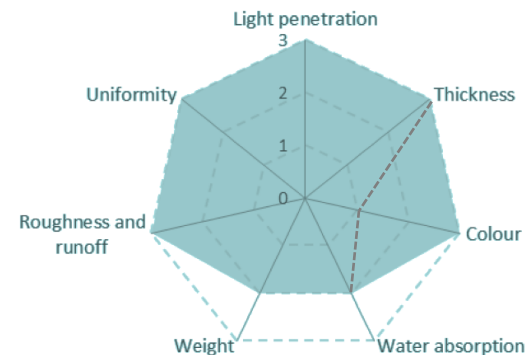
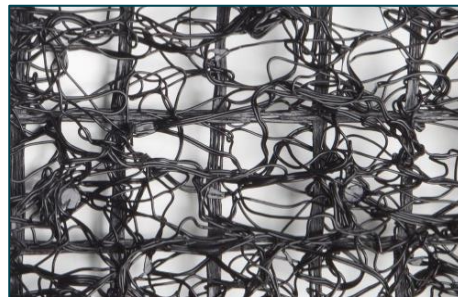


Performance Assessment on Maccaferri Macmat Geogrid & Macmat Steel

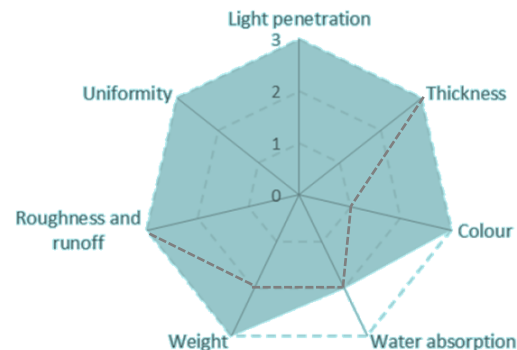
Erosion Control Geomats average performances



MacMat Geogrid



MacMat Steel



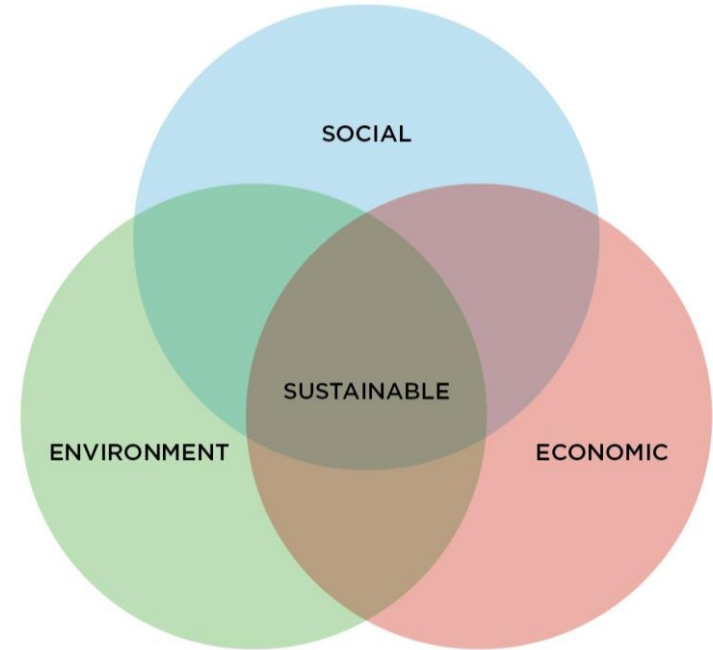
"Relationships between Erosion Control Products and vegetation growth"
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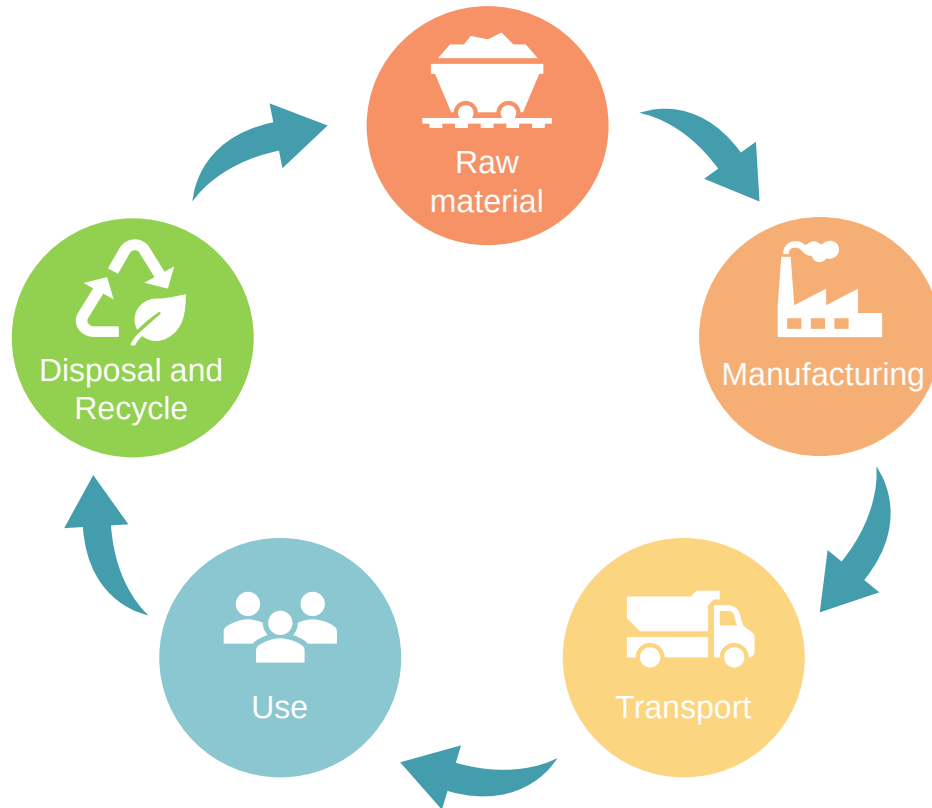


Any change in fragile ecosystems should be carefully considered, as **the value of biodiversity** extends far beyond the physical boundary of a project development.



- M** UN defines sustainable development as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.
- M** While traditional engineering design focuses mainly on function, cost & safety, sustainable engineering design additionally considers the impact of the design on society and the environment.
- M** For an engineering design to be sustainable, the competing requirements of the three pillars, namely environment, economy, and society need to be balanced.





Life Cycle Assessment

LCA involves an inventory of the **materials, energy & emissions** that are involved across the life cycle of a **product, process or service**, and thus calculates the cumulative potential impact on the **environment**

LCA provides a score for the **ENVIRONMENT** pillar only



Life Cycle Assessment

The **environmental performance** is assessed with reference to the below listed seven **midpoint impact category indicators**.



Global warming potential (GWP) is a measure of how much **heat a greenhouse gas traps in the atmosphere** up to a specific time horizon (KgCO_2eq).



Abiotic Depletion (ADP-M & ADP-F) is an indicator that is related to **the extraction of minerals and fossil fuels** for any activity (kgSbeq , MJ).



Acidification Potential (AP) provides a measure of the decrease in the **pH-value of rainwater and fog**, which has the effect of ecosystem damage (kgSO_4eq).



Eutrophication Potential (EP) provides a measure of **nutrient enrichment in aquatic or terrestrial environments**, which leads to ecosystem damage (kgPO_4eq).

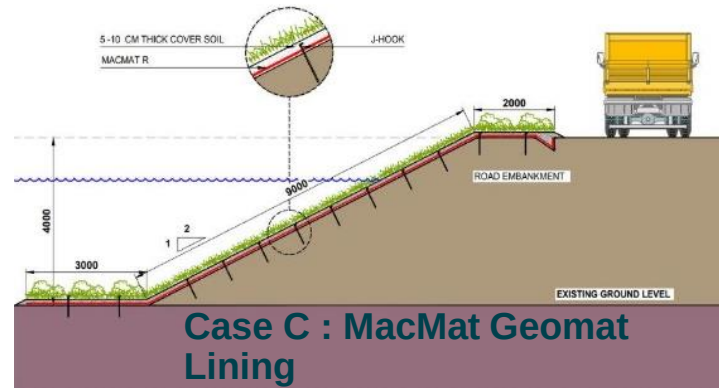
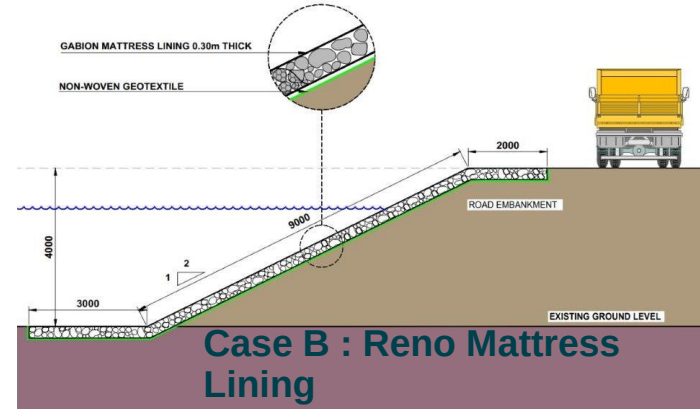
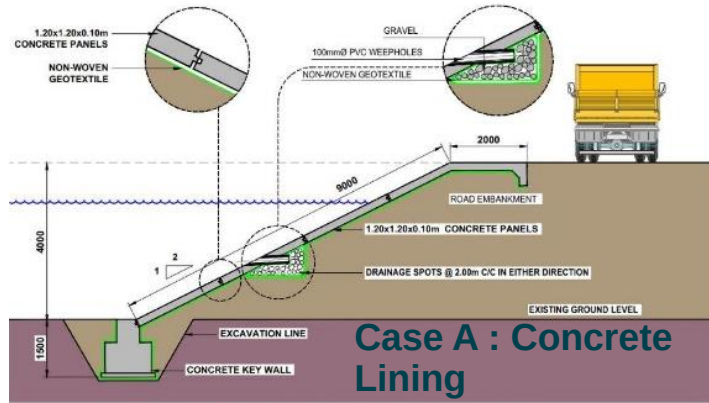


Photochemical Oxidation (PCO) is a chemical reaction that is a major contributor to the formation of **smog and air pollution** in urban areas ($\text{kgC}_2\text{H}_4\text{eq}$).

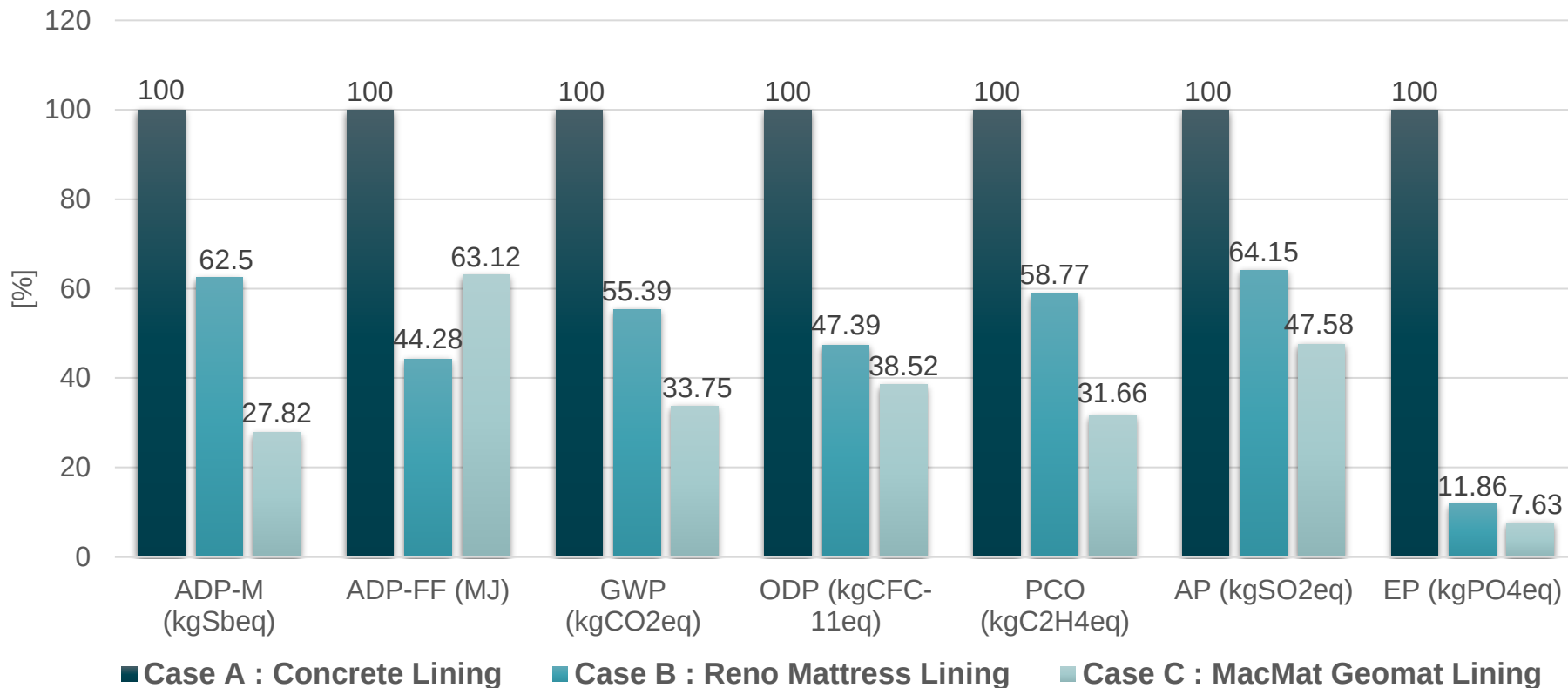


Ozone Layer Depletion Potential (ODP) provides a measure of the **depletion of stratospheric ozone layer** caused by different gases (kgCFC-11eq).

Comparative Lca Study : Channel / Erosion Control



Comparative Lca Study : Channel / Erosion Control



How do geosynthetics reduce the environmental burden?

- ease of installation
- increased speed of construction
- improved performance by increased longevity or reduction of maintenance

These advantages all translate into **life cycle** savings.

Also, the application of geosynthetics in construction improves **sustainability** in terms of **conserving natural environments** as compared to alternative designs.

Simon et al., EI-GEO Environmental Impact of Geosynthetics in aquatic systems, 2020



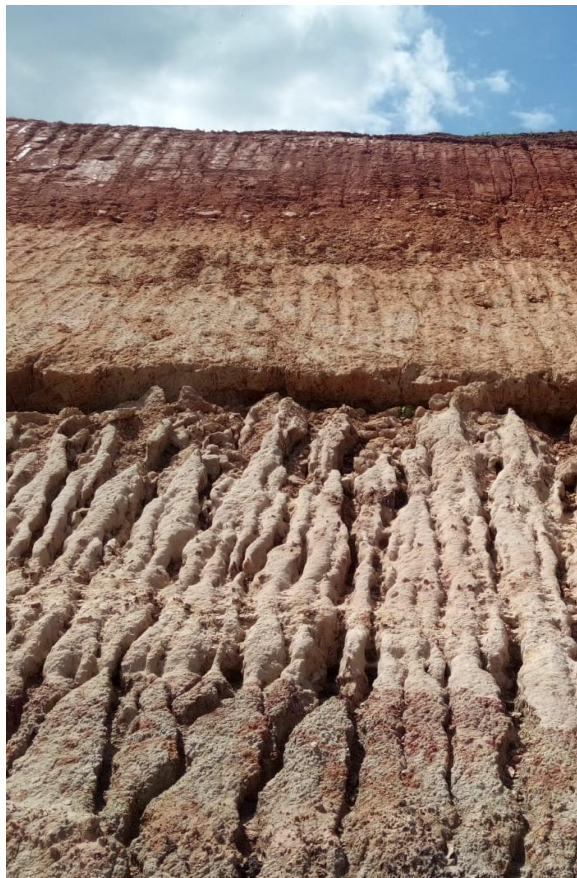
CASE STUDIES AND PROJECT SHOWCASE

Securing a Connection Between African Countries and the Access to the Indian Ocean

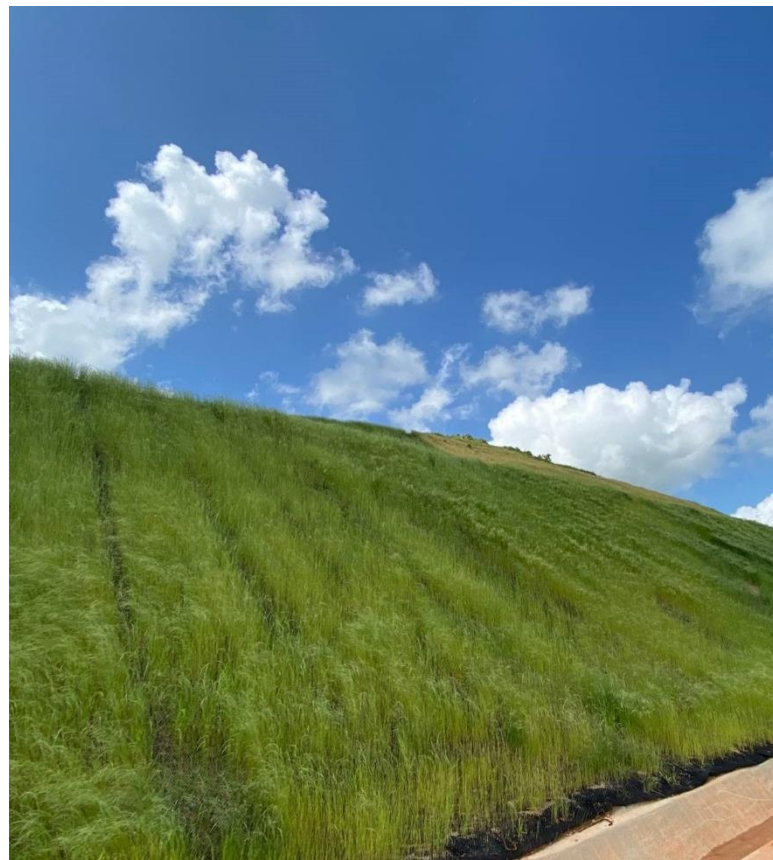


- 328.000 m² of **MacMat 12.1** and **MacMat R1** were used
- Successful revegetation









CASE STUDIES AND PROJECT SHOWCASE

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Chloorkop Eastern Canal: Midrand, Gauteng

Client name:

SENTRACHEM

Main contractor name:

EWT CONSTRUCTION

Consultant:

ALAN ROBINSON CONSULTING ENGINEERS

Product used:

GABIONS, RENO MATTRESSES®

Construction info:

Construction date:	DECEMBER 2001
Completion date:	AUGUST 2003



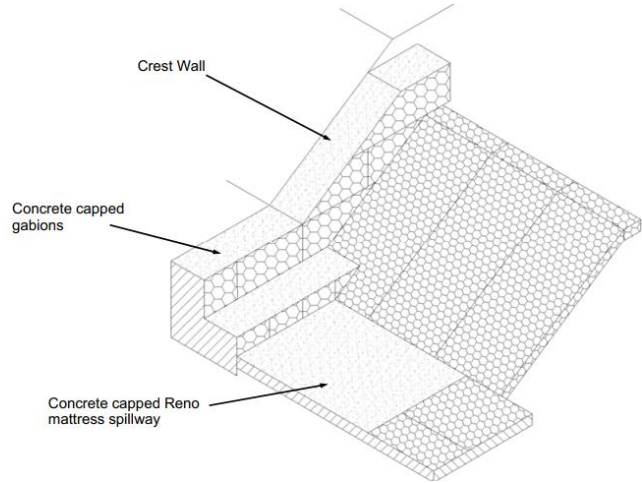
Gabion weirs to dissipate energy and protect the bed canal



CASE STUDIES AND PROJECT SHOWCASE

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Chloorkop Eastern Canal: Midrand, Gauteng



Tulear Flood Protection: Tulear, Madagascar

Client name:

MINISTRY OF THE PUBLIC WORKS/INFRASTRUCTURES

Main contractor name:

COLAS

Consultant:

BCEOM

Product used:

53 000m³ OF GABIONS AND RENO MATTRESSES®

Construction info:

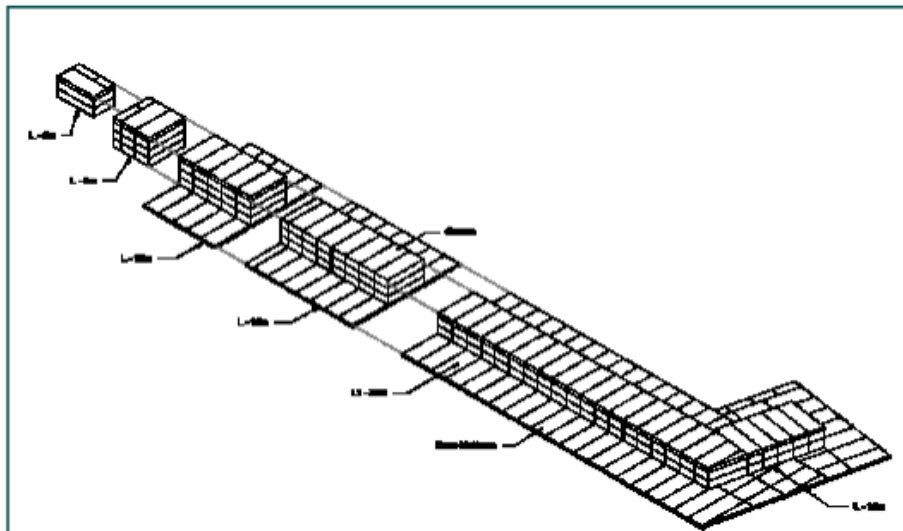
Construction date:	2001-2003 (NO CONSTR. IN 2002)
Completion date:	2003



Aerial view of protection works at Tulear

Date: Sept 2004

Tulear Flood Protection: Tulear, Madagascar



Isometric bayonet gabion groyne



Bayonet groyne

Date: Feb 2001

CASE STUDIES AND PROJECT SHOWCASE

MACCAFERRI

Tulear Flood Protection: Tulear, Madagascar



Straight gabion groyne

Date: Feb 2001





MACCAFERRI
GEOSYNTHETICS

FINAL REMARKS



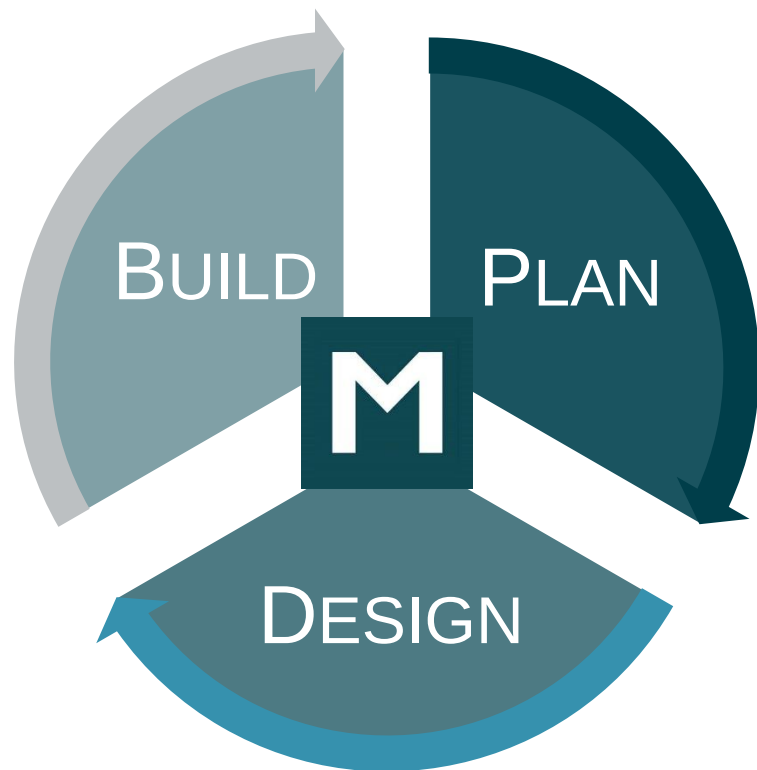
- M** We promote a **holistic approach** to the selection of the most suitable Erosion Control Solution
- M** Our geosynthetics are among the **most tried and tested** in the world
- M** Thousands of reference cases available that prove the **cost effectiveness**



360° SUPPORT FOR YOUR PROJECT

MACCAFERRI

Maccaferri is Always Side by Side with Engineers, Architects and Builders



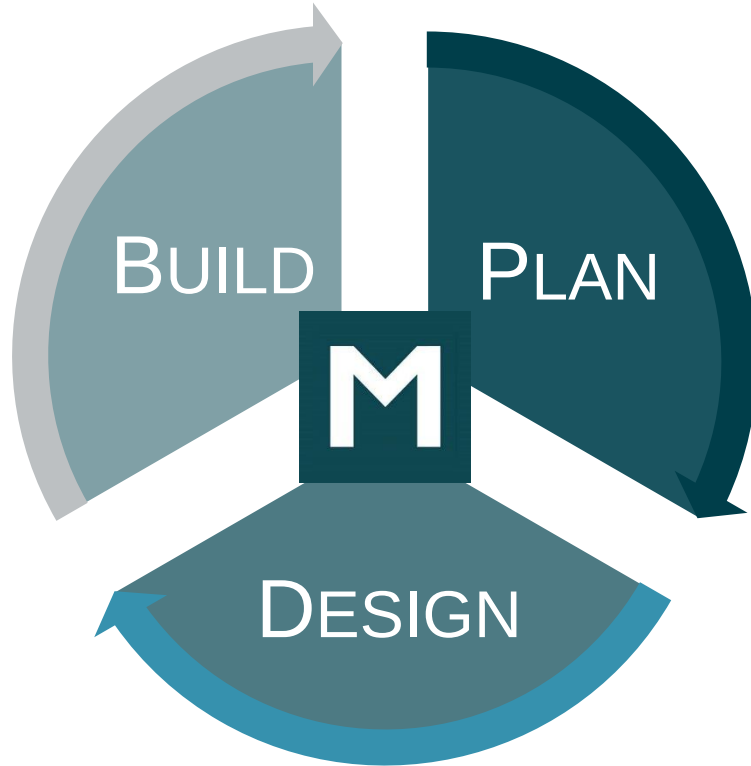
Our **experts** in **geotechnical, hydraulic & environmental engineering** can support trough all the project phases.



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LIVE Q&A



erosion CONTROL
sustainable durability

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