



USE OF HIGH PERFORMANCE GEOSYNTHETICS IN RAILWAY PROJECTS

Date September 30, 2021

MACCAFERRI

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Webinar Agenda



10' Introduction

30' Engineering Challenges, Solutions and Case Histories

5' Conclusions

Live Q&A Session

Speaker: Pietro Pezzano

Technical Expertise Center of Excellence for the GSY & MacRes Business Unit

MACCAFERRI AT A GLANCE

MACCAFERRI

Founded in 1879, Officine Maccaferri is based upon long-held values of innovation, integrity, excellent service and **respect for the environment**.

We are a leading international provider of **advanced solutions** to the civil, geotechnical and environmental construction markets.

We deliver solutions from **retaining walls** to hydraulic works and from rockfall mitigation systems to **soil reinforcement**.

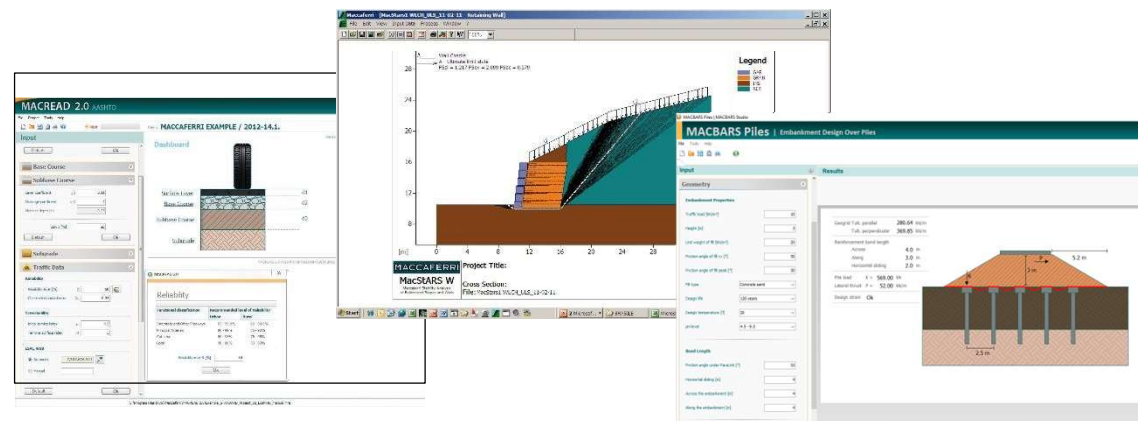


A PARTNER FOR RAILWAY PROJECTS

MACCAFERRI

As **manufacturer** as well as **designer**, we can combine products, creating tailor-made solutions

- M** 140 years of technical experience
- M** Global presence and local mindset
- M** Internal **R&D** center, experimental labs and testing facilities
- M** World's widest portfolio of products and **solutions**
- M** Proprietary **software** developed with leading universities



MACCAFERRI AROUND THE GLOBE

MACCAFERRI



Sales in **100+** countries



Revenues ~ **500 M€**



2,500+ employees



25+ factories



60+ subsidiaries



OUR CENTRE OF KNOWLEDGE

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Maccaferri has a centre of excellence entirely dedicated to **research and development**, concentrating in a single place the capital of **knowledge** and **know-how**: in Bolzano (Italy) the Maccaferri Innovation Center (M.I.C.) is constantly working to innovate our products and solutions



MIC in NoiPark research centre



Quality Control Tests



Testing Facility

MACCAFERRI FOR RAILWAY INDUSTRY

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We cover a number of applications within the railway sector, assisting our clients through all the different project stages. Our solutions start from the design of the project, with the simple aim of solving a problem. Then, we proceed through all the stages of development, in close synergy with our clients; **manufacturing**, **designing** and **installing** solutions throughout the world.



Basal
Reinforcement



Retaining Walls &
Soil Reinforcement



Drainage of
Structures



Erosion Control



Rockfall Protection
& Snow Barriers



Hydraulic Works



Safety & Noise
Barriers



Tunnelling



Soil Stabilisation
& Pavements



Fencing & Wire

MACCAFERRI FOR RAILWAY INDUSTRY

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Focus on Geosynthetics



**Hydraulic
Engineering**



**Geotechnical
Engineering**



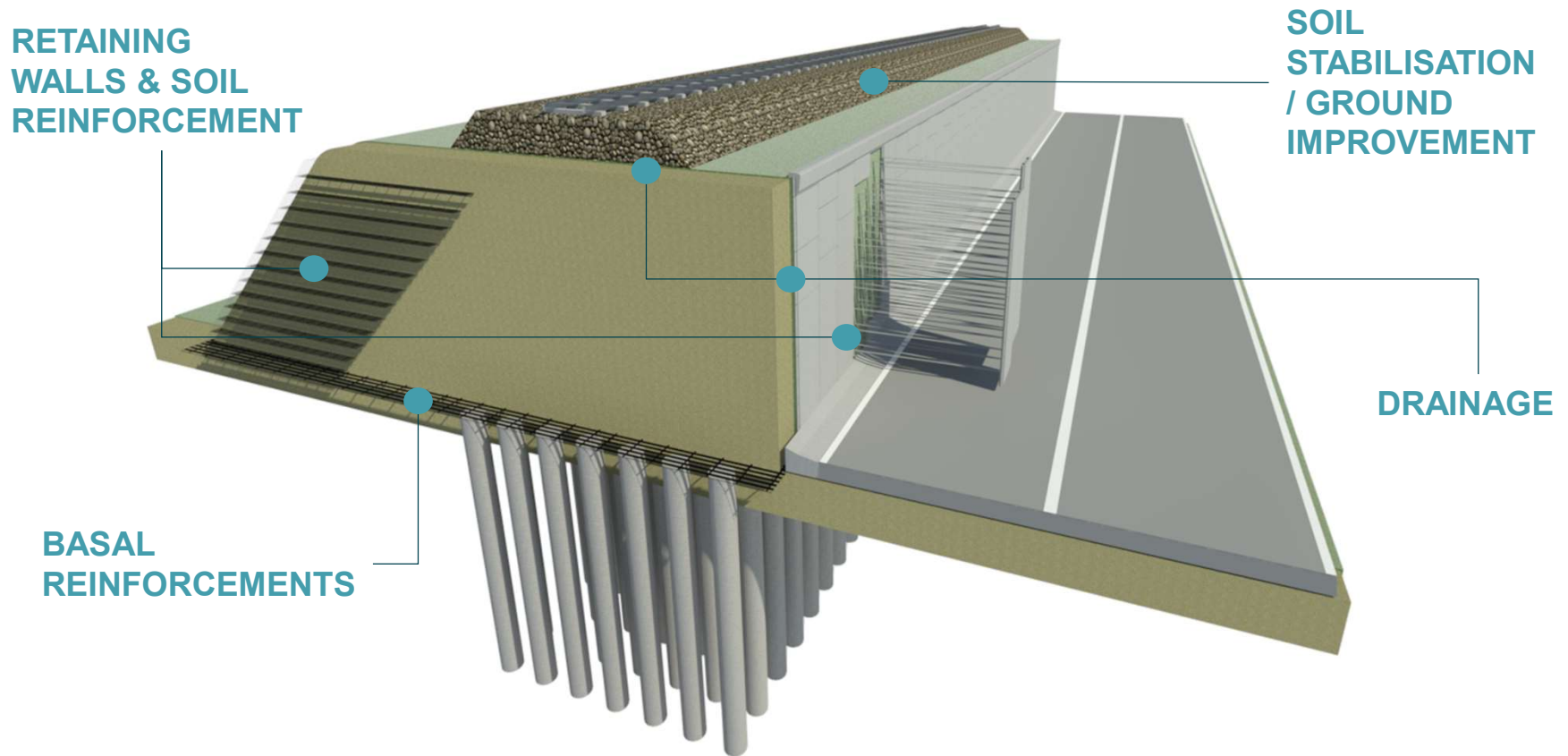
**Erosion
Control**



RAILWAY INFRASTRUCTURE

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Typical Applications for Railway Embankments



RAILWAY INFRASTRUCTURE

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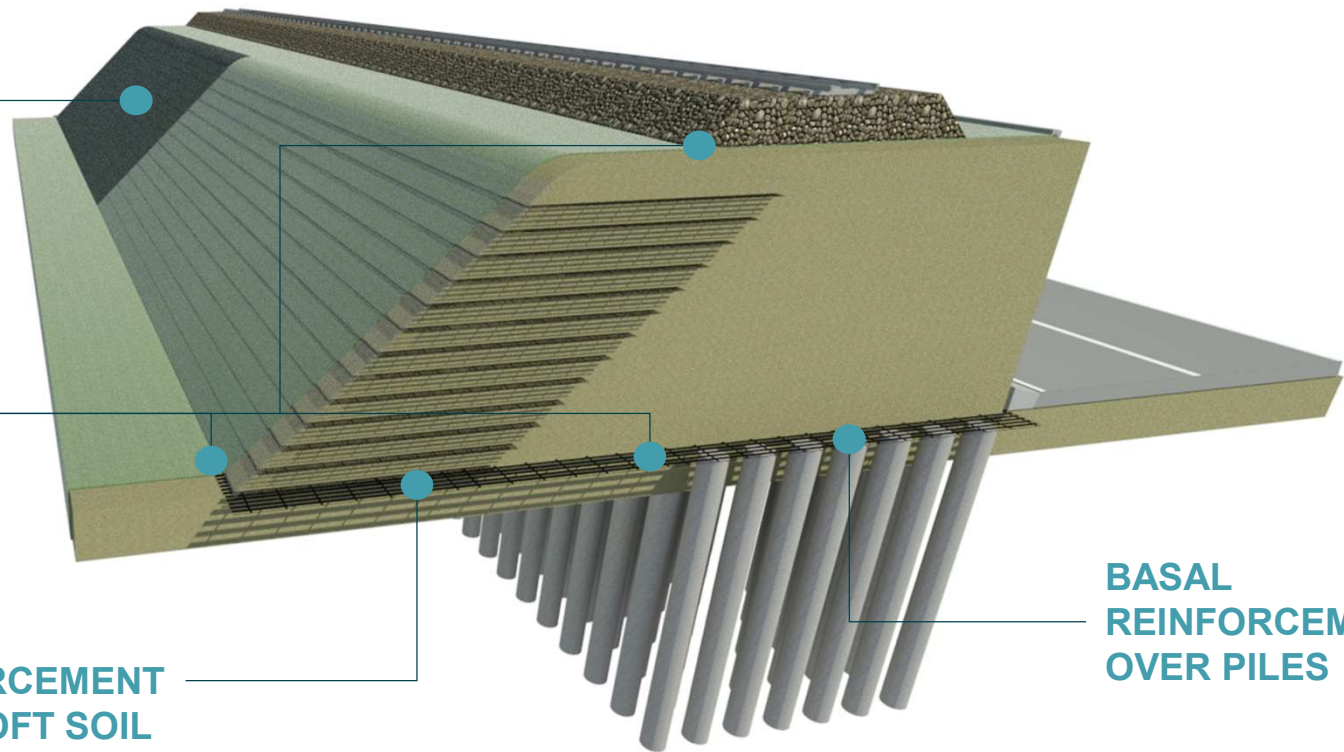
Typical Applications for Railway Embankments

EROSION
CONTROL

DRAINAGE

BASAL
REINFORCEMENT
OVER SOFT SOIL

BASAL
REINFORCEMENT
OVER PILES



A photograph of a construction site for a road or railway embankment. In the foreground, a grid of black, wavy basal reinforcement strips is being laid out on a gravel base. Several large rolls of these strips are stacked on the right side. A worker in an orange safety vest and blue hard hat stands in the middle ground. In the background, a yellow roller is compacting the gravel, and a red excavator is visible on the right. The site is bordered by a steep, rocky hillside.

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BASAL REINFORCEMENT

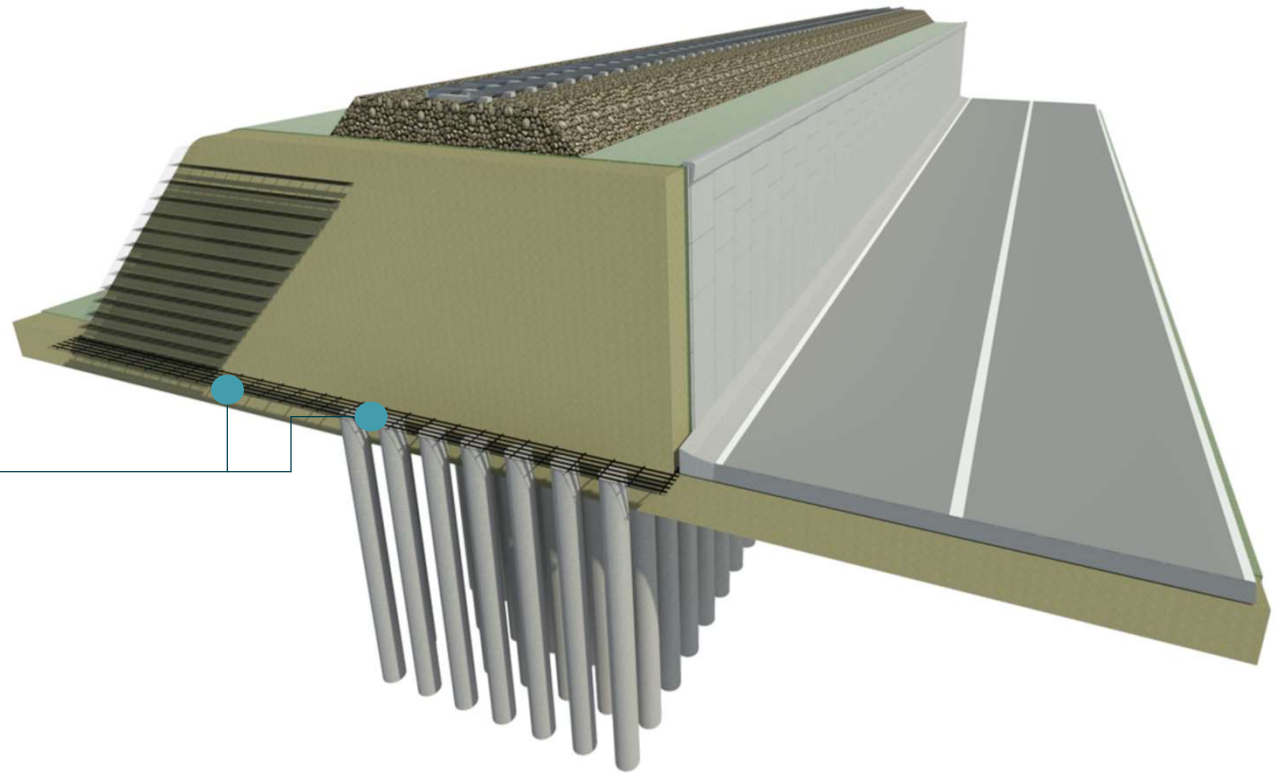
RAILWAY INFRASTRUCTURE

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Typical Applications for Railway Embankments

BASAL REINFORCEMENTS

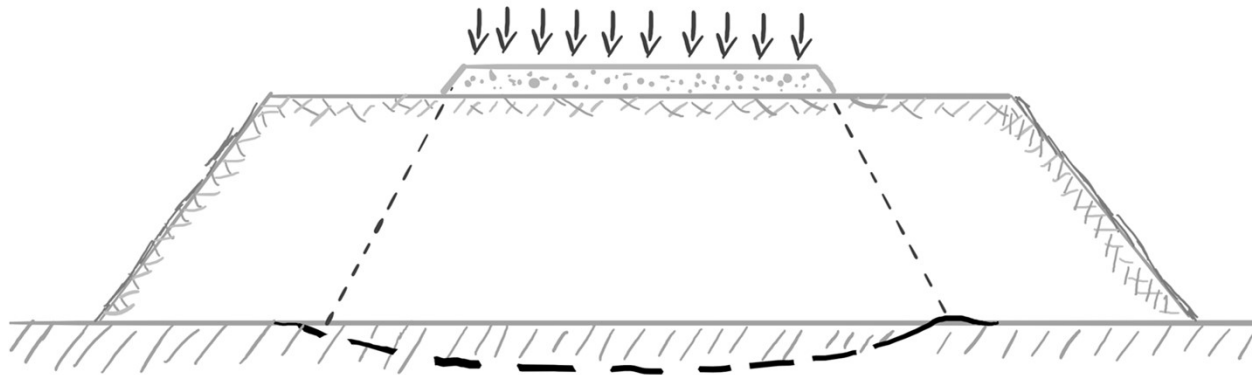
Avoiding potential differential settlements and increasing durability of structures built upon soft soils.



DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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The base of the embankment



COMMON PROBELMS

- Differential settlements
- Construction of a second railway track next to the existing one
- Delayed consolidation



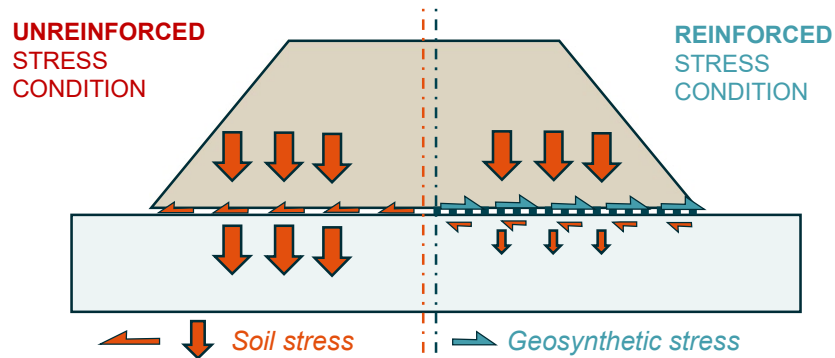
SOLUTIONS

- **Optimization** of the load transfer from the embankment to the foundation
- Enhancement of the consolidation process

GEOSYNTHETICS FOR BASAL REINFORCEMENT

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Bearing Capacity: Basal Reinforcement



Geosynthetic reinforcement, such as, **ParaLink** and **ParaGrid**, guarantee :

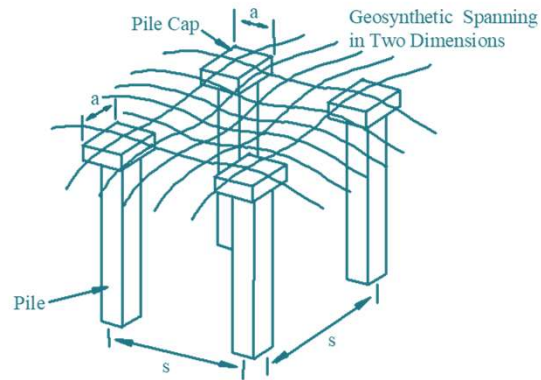
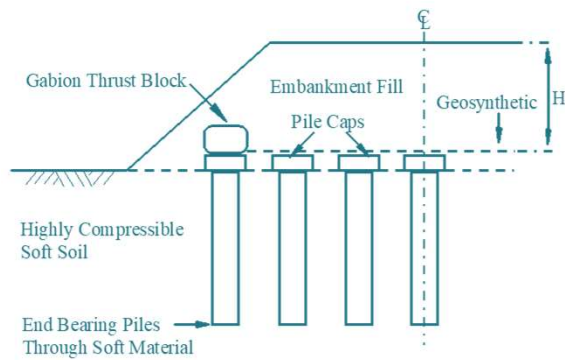
- Improved stability and bearing capacity SF
- Project cost and time reduction
- Effective load transfer to foundation piles (*in presence of piled embankments*)



GEOSYNTHETIC FOR BASAL REINFORCEMENT

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Basal reinforcement: Piled Embankment



Piled embankment	When?	Why Geosynthetic?
	Mandatory in presence of highly compressible foundation soft soil	ParaLink combined with soil act as a Load Transfer Platform (LTP) to ensure effective load distribution to each pile cap

PROBLEM DESCRIPTION & SOLUTION

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Basal Reinforcement: High Speed Railway, RFI, Italy



- M** Improvement of the stability of the railway embankments
- M** Limiting the differential settlements.



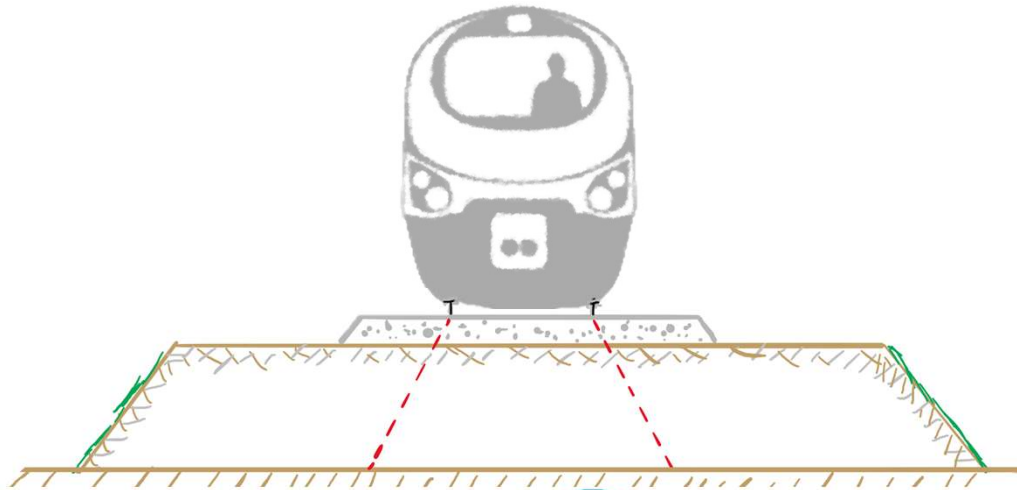
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SOIL STABILISATION / GROUND IMPROVEMENT

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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The base of the embankment



COMMON PROBLEMS

- High dynamic loads
- Infrastructure permanent damages



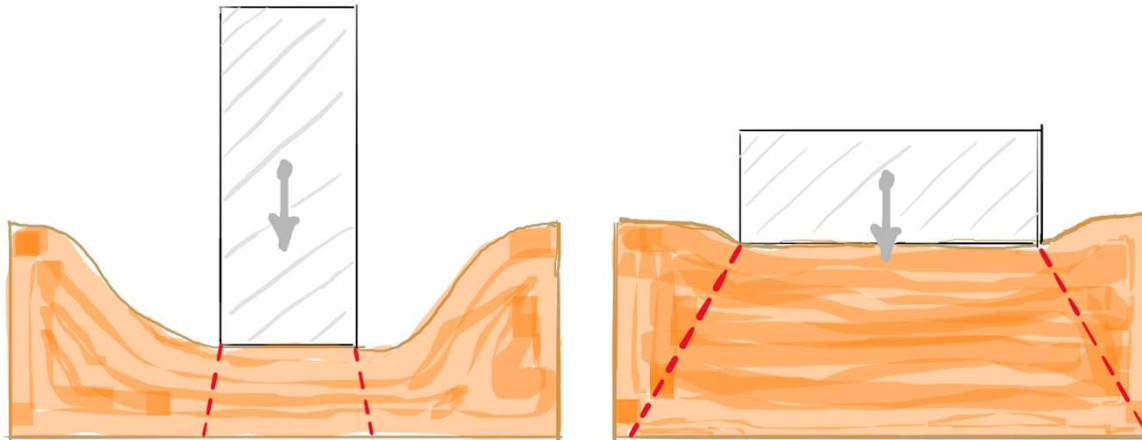
SOLUTIONS

- **Optimization** of the dynamic load transfer
- Long term permanent strength gains

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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Bearing Capacity



“Effective load distribution over the widest area possible is the key principle to limit settlement also on poor quality soils...”

..but due to technical constraints embankment footprint is often limited”

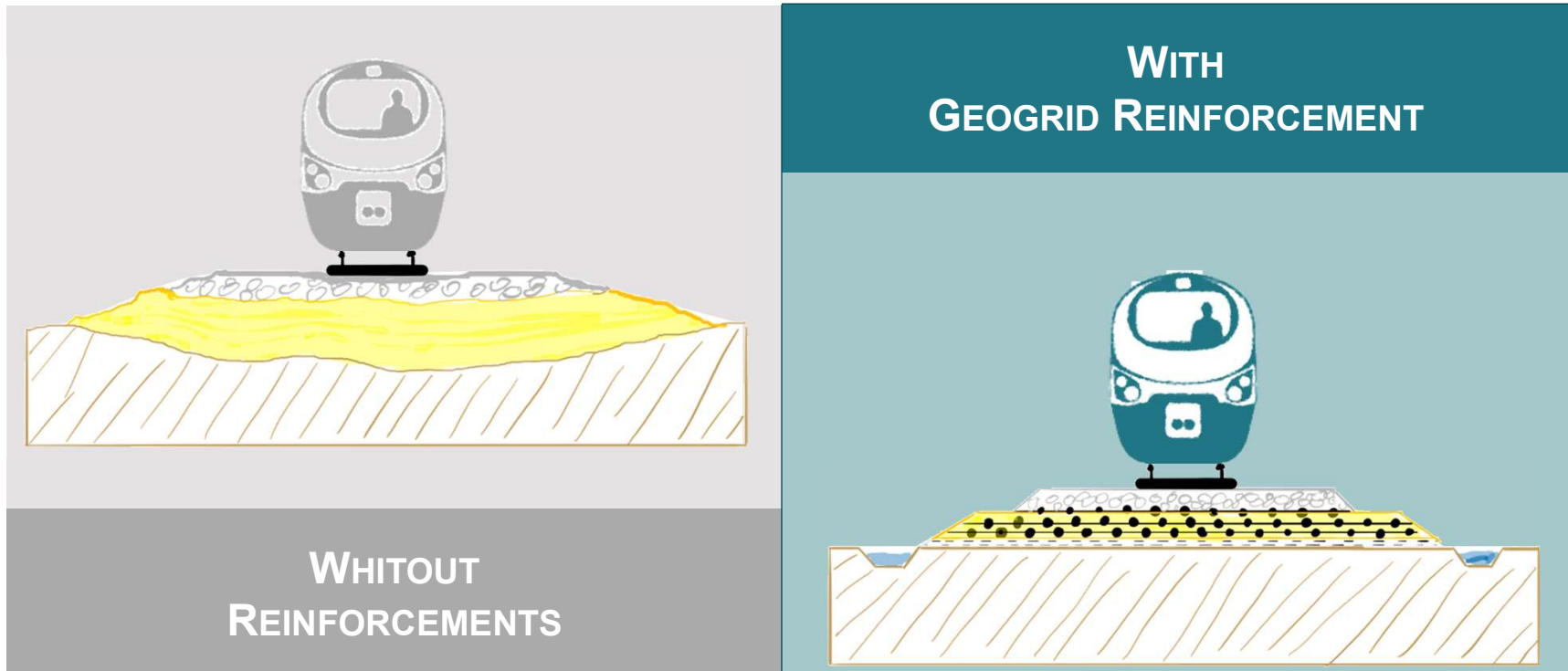
TECHNICAL CONSTRAINTS

- M** Limited Space / Existing Infrastructure
- M** Ground Geomorphology



BENEFIT OF USING GEOGRIDS

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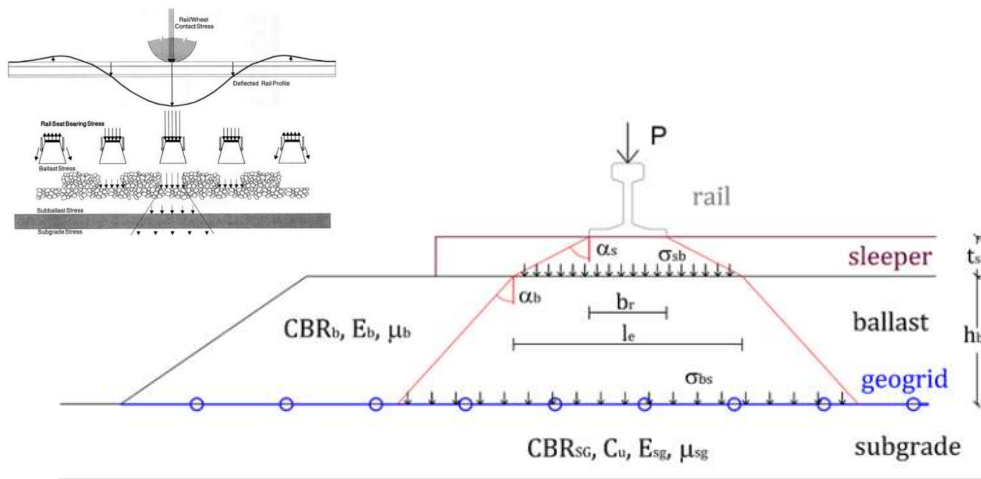


STABILISATION OF RAILWAY BALLAST AND SUB-BALLAST

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Design method for the use of geogrids

Based on our design experience in the design of railway applications, we have developed a design tool for the optimization of railway ballast and sub-ballast.



INPUT DATA	SYMBOL	CARGO TRAIN		PASSENGERS TRAIN	
		VALUE	UNIT	VALUE	UNIT
Design axle load	W	250	kN	170	kN
Train speed	C	100,00	km/h	300,00	km/h
Wheel diameter	D_w	0,90	m	0,92	m
Rail width	b_r	0,15	m	0,15	m
sleeper thickness	t_s	0,16	m	0,16	m
sleeper width	b_s	0,26	m	0,26	m
Load spreading angle in sleepers	α_s	60,00	deg	60,00	deg
Number of trains/day	N_t	5	kN	15	kN
Number of cars/train	N_w	20	-	8	-
Number of axis/car	N_p	4	-	4	-
design life	T	20	years	20	years
Thickness of soft subgrade	H_s	5	m		
CBR of ballast	CBR_b	100,0	-		
CBR of subballast	CBR_{sb}	30,0	-		
CBR of subgrade	CBR_{sg}	1,50	-		
Poisson ratio of ballast	μ_b	0,35	-		
Poisson ratio of subballast	μ_{sb}	0,42	-		
Poisson ratio of subgrade	μ_{sg}	0,30	-		
Ballast type (1 = Basalt, 2 = Granite, 3 = Dolomite)		2	-		
Subgrade soil type (1 = Fat clay; 2 = Lean clay; 3 = Elastic silt; 4 = Silt)		1	-		
Tensile strength of geogrid reinforcement at 2	$T_{2\%}$	10,50	kN/m		

Figure 11. Input data for the design example.

DESIGN SUMMARY	SYMBOL	UNSTABILISED		STABILISED	
		VALUE	UNIT	VALUE	UNIT
Ballast thickness without subballast	h_u	2,30	m	h_s	0,86 m
Ballast vertical deformation without subballast	d_{vu}	0,104	m	d_{vs}	0,039 m
Rut depth at the ballast - subgrade interface	r_u	0,012	m	r_s	0,003 m
Ballast thickness with subballast below	h_b with sb, u	0,97	m	h_b with sb, s	0,36 m
Subballast thickness	h_{sbu}	1,57	m	h_{sb}	0,59 m
Ballast vertical deformation with subballast below	d_v with sb, u	0,044	m	d_v with sb, s	0,014 m

OUR EXPERIENCE

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Railway line Plovdiv-Burgas, Bulgaria



- M** Construction over soft soil without differential settlement
- M** Important reduction of ballast height
- M** Project cost and time reduction



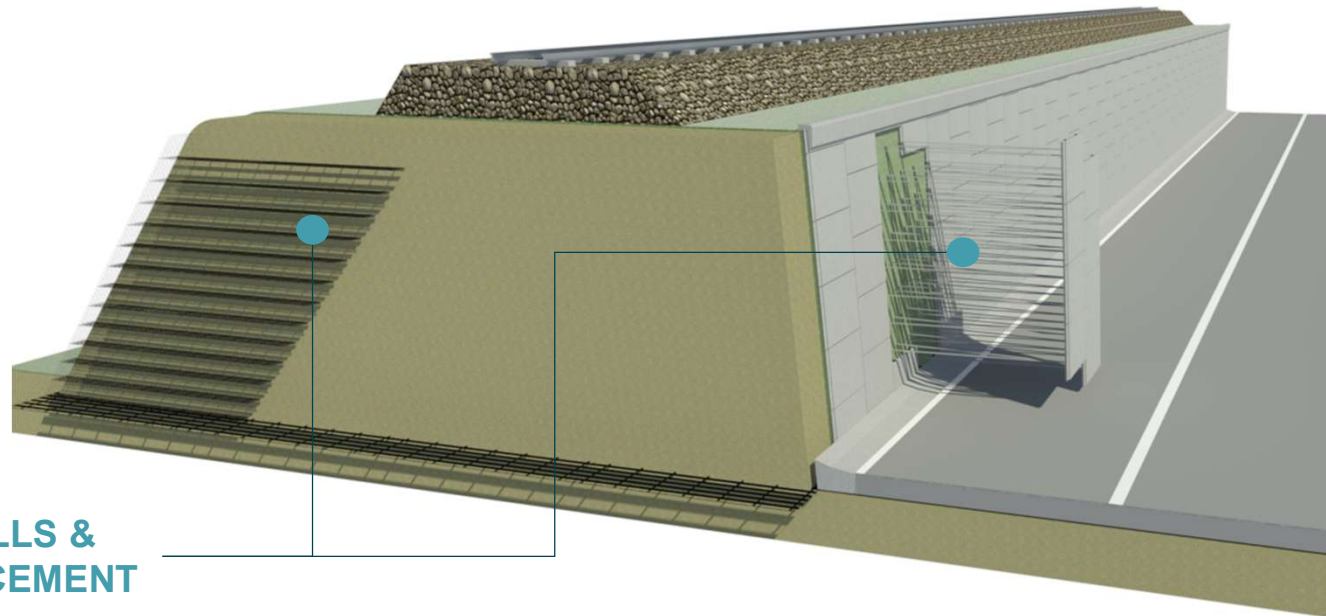
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RETAINING WALLS & SOIL REINFORCEMENT

RAILWAY INFRASTRUCTURE

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Typical Applications for Railway Embankments



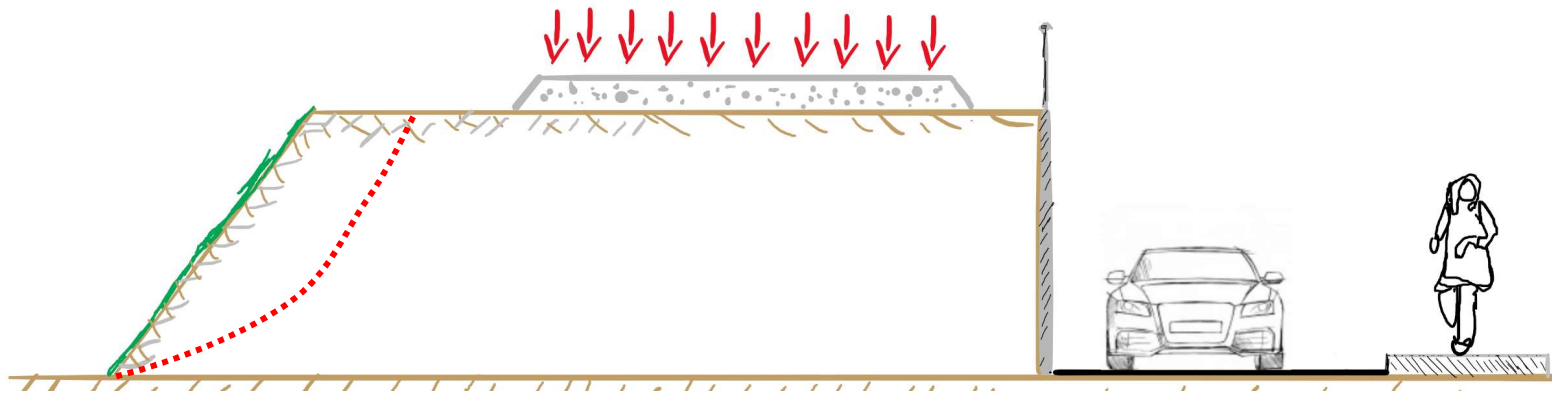
RETAINING WALLS & SOIL REINFORCEMENT

Soil mechanical proprieties improvement thanks to geogrids which allow to design and build a safer embankment reducing its footprint.

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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Soil Mechanical Properties Enhancement



COMMON PROBELMS

- Embankment slope failure
- Differential settlements
- Interaction with urban environment



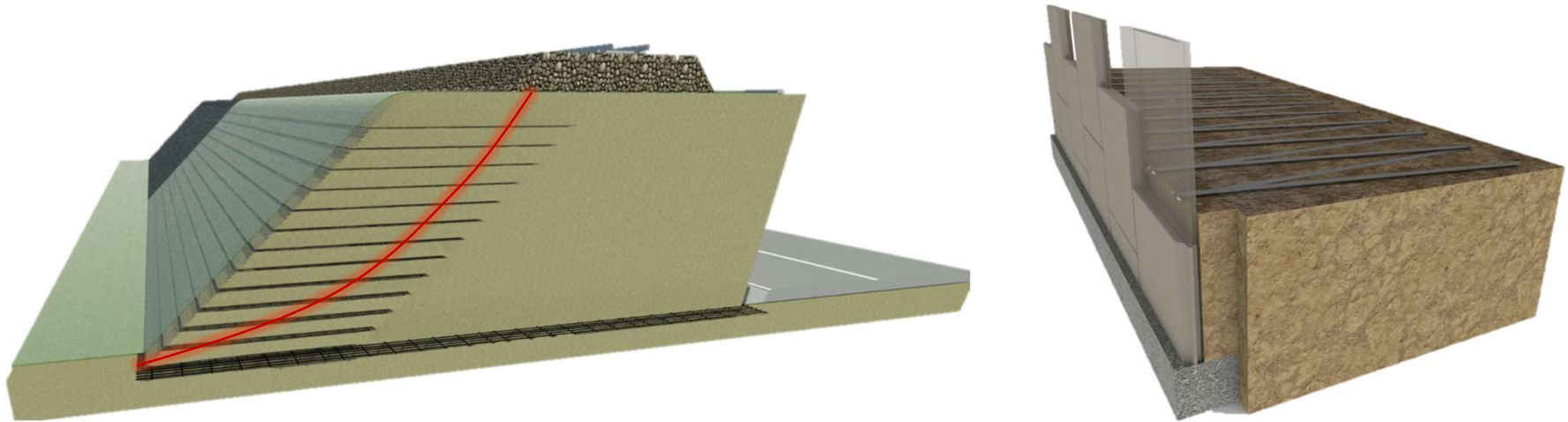
SOLUTIONS

- Geosynthetics embankment slope reinforcement
- Vertical concrete faced soil reinforcement

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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Soil Mechanical Properties Enhancement



**Tensile strength
enhancement**

**Lateral confinement
increase**

**Load distribution
angle increase**

**Superior behavior
under seismic loads**

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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Benefit for the railway industry

TECHNICAL

- M Smaller embankment print
- M Shorter ballast height
- M Higher SF static and dynamic condition



ENVIRONMENTAL

- M Re-use in situ soil as structural backfill
- M Lower CO2 emission
- M Low environmental impact
- M EPD certified products



ECONOMICAL

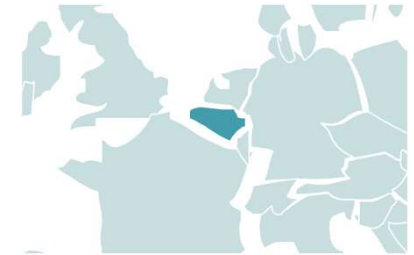
- M Cost effective
- M Fast installation
- M Low maintenance



OUR EXPERIENCE

MACCAFERRI

MacRes Vertical Retaining Wall – Antwerp, Belgium



- M** Construction in a highly urbanized environment
- M** Time and cost reduction
- M** Environment friendly, no concrete needs for embankment body

A photograph of a construction site for a drainage system. In the foreground, two large rolls of grey, textured geotextile fabric are visible, resting on blue wooden pallets. The fabric is being laid out along a series of parallel metal tracks or rails that run into the distance. Several workers wearing high-visibility yellow vests and hard hats are standing near the tracks. In the background, a white concrete mixer truck is parked, and other construction equipment and materials are visible. The sky is blue with some clouds.

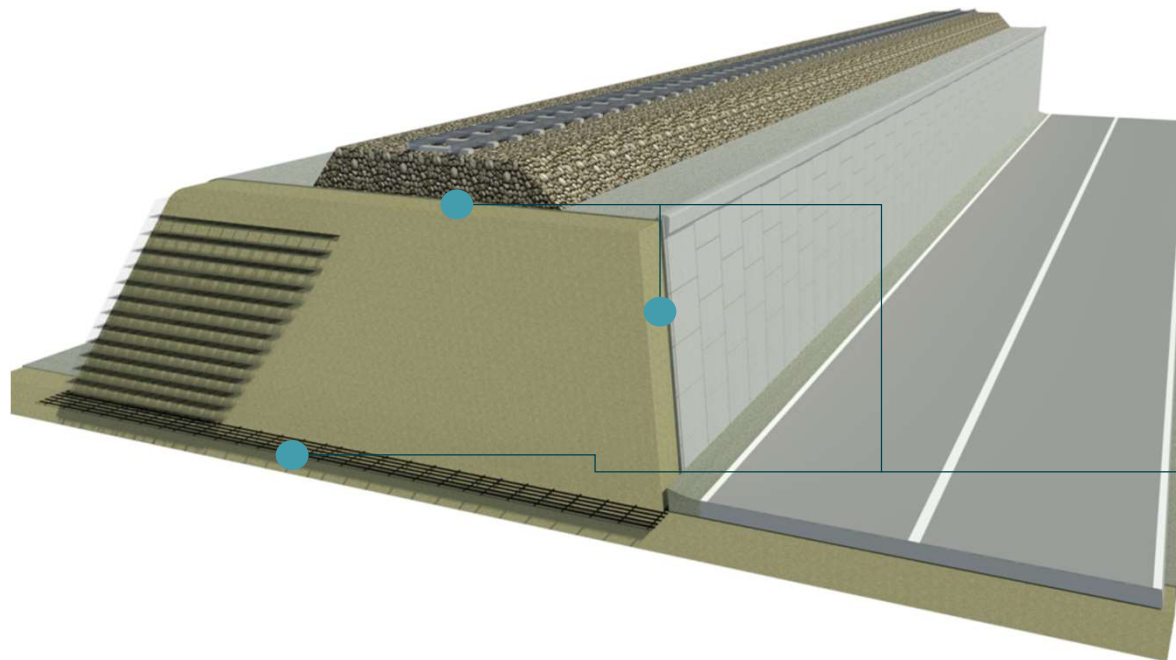
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DRAINAGE SOLUTIONS

RAILWAY INFRASTRUCTURE

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Typical Applications for Railway Embankments



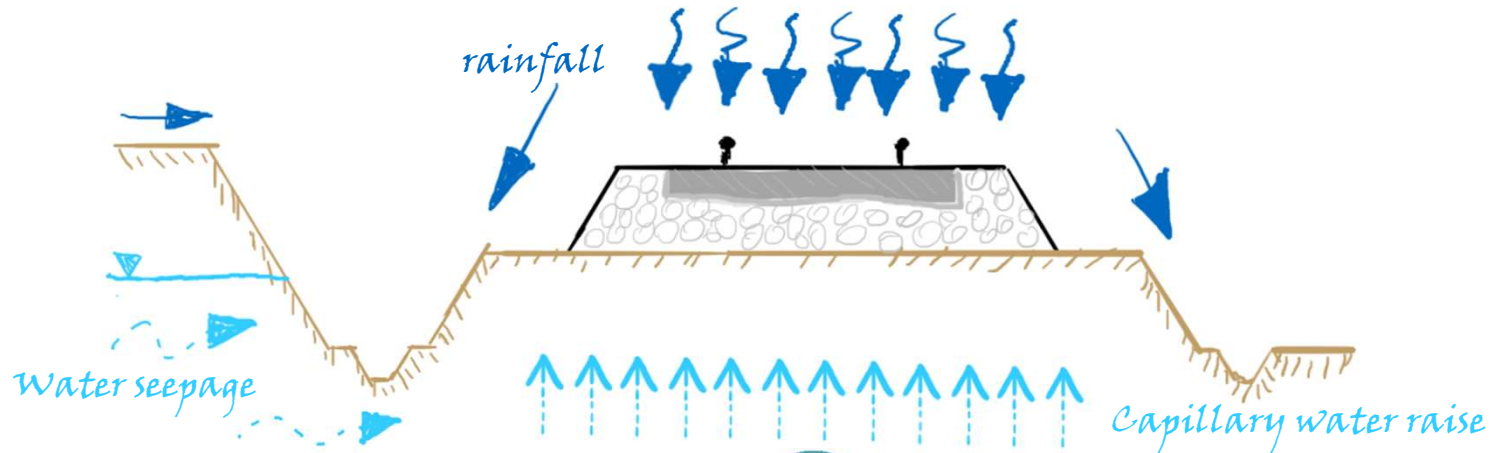
DRAINAGE

Geosynthetic solutions for draining out water from embankment, avoiding soil /retaining wall failure due to water table raise.

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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Drainage of water away from railway infrastructure



COMMON PROBELMS

- Water level rise behind containment structures
- Capillary rise
- Slopes erosion due to heavy rainfall



SOLUTIONS

- Geosynthetic drain layers between the different elements (foundation soil, embankment, ballast)
- Draining geogrid inside the embankment

PROBLEM DESCRIPTION & SOLUTION

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Water: a major risk for infrastructure integrity



GEOSYNTHETICS FOR WATER DRAINAGE

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Ensuring drainage effectiveness with Maccaferri products

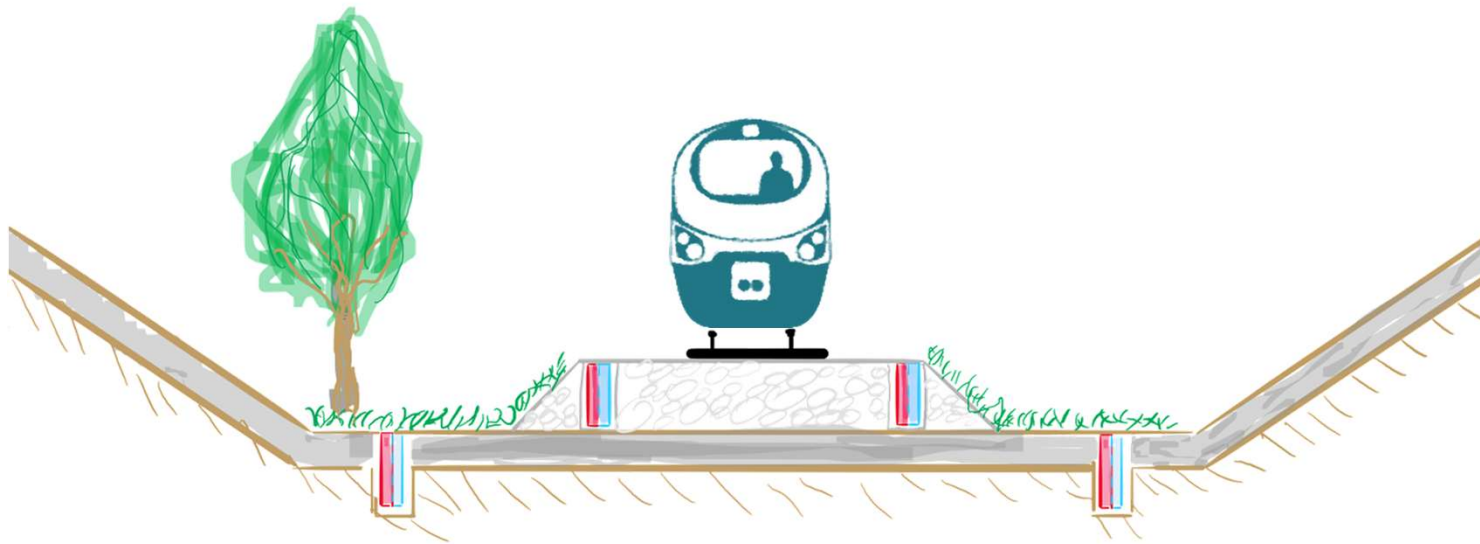
- M** Maccaferri offers tailor made solutions able to absolve drainage and reinforcement functions
- M** **ParaDrain** offer excellent drainage function in addition to reinforcement one
- M** Long-term drainage effectiveness guarantee by combination of geotextile layer, avoiding drain occlusion due to fine deposit.



GEOSYNTHETICS FOR WATER DRAINAGE

Ensuring drainage effectiveness with Maccaferri products

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DYNAMIC FLOW RATE TESTS ON MACDRAIN

Specific test for railway applications

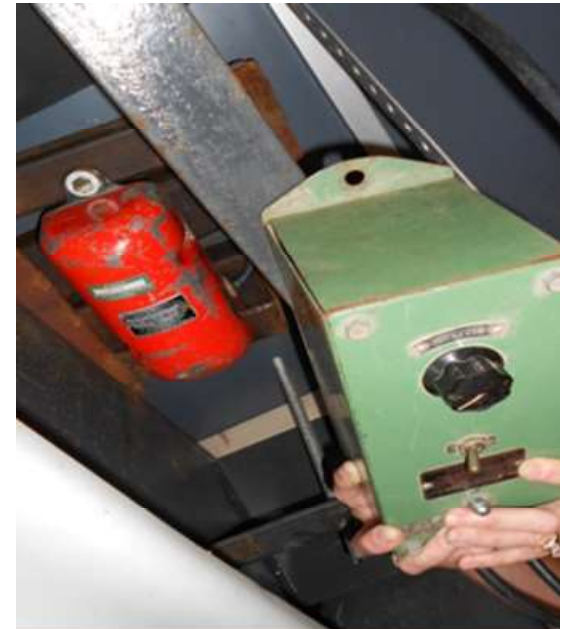
An **experimental research program** was carried out at the Geosynthetic Institute (GSI) for the application of geocomposites for drainage of fast railways.

The transmissivity apparatus conforms to **ASTM D4716**

A vibratory controller was used in the **dynamic tests**. This mechanism was applied to the loading plate on top of the GCD test specimen



Apparatus

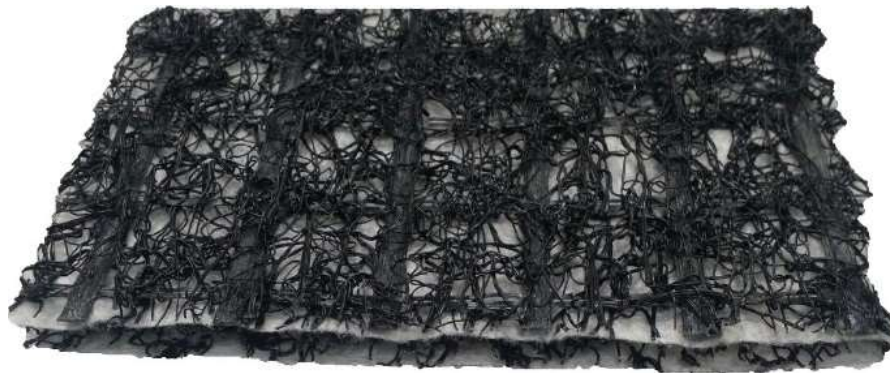


Vibratory controller

DRAINAGE TRICOMPOSITE

MACCAFERRI

Unique solution providing drainage, separation and anti-erosive function



OUR EXPERIENCE

MACCAFERRI

Proof of excellence certified by Italian High Speed Railway Company

ITALFERR, part of the RFI group, has installed our drainage products for new high-speed tracks.

- M** 150.000 m2 of **MacDrain** installed
- M** Installation started in 2000

High-speed track are **in service** since 2007 **without any problem** related to the use of MacDrain.



Direzione Tecnica
UO Corpo Stradale e Geotecnica
Il Responsabile

DIREZIONE TECNICA
PROGETTAZIONE AREA NORD-
INFRASTRUTTURE NORD
Data: 01.08.2016
Prot.: DT-AN-INF-0054344.16.U
Scenario: CRV 2016

Officine Maccaferri S.p.A.
c.a. Ing. Moreno Scotto
Corporate Manager -
Geosynthetics Business Unit

Via Kennedy, 10
40069 - Zola Predosa (BO) Italy

Oggetto: Use of Maccaferri MacDrain Drainage Composite in the construction of new embankments for the Italian Railways

Drainage composites have been widely used by the Italian Railway authorities during the construction of the High Speed tracks connecting Milano to Venice and Milano to Bologna (year 2000-2007) as also in the ordinary non high speed network as the track connecting in Sardinia Cagliari to Golfo Aranci and Padova to Mestre (years 2004-2007). Different grades of drainage composites have been successfully used either to replace the drainage capillarity natural layer and to drain retaining walls structures build on the railway track depending on the loads applied and the drainage properties requested as per the Italferr Specifications.

Maccaferri MacDrain Drainage Composite was among the selected and approved materials to be used and approx. 150.000 m2 has been successfully applied under several embankments of the mentioned jobsites as anticapillarity layer and/or behind the walls as drainage layer to reduce hydrostatic pressure on the retaining concrete structures.

The mentioned track are currently in service and no problem has been detected up to now related to the use of the drainage composite as replacement of the natural gravel layers in the sites where such replacement of a natural layer with a geosynthetic drainage layer took place.

Francesco Specchi

Via V. G. Galati, 71 - 00158 Roma
Italferr S.p.A. - Gruppo Ferrovie dello Stato Italiane
Società con unico socio: gruppo alla direzione e coordinamento
di Ferrovie dello Stato Italiane S.p.A.
Sede legale: Via V. G. Galati, 71 - 00158 Roma
Capitale Sociale Euro 11.100.000.000
Iscritta al Registro delle Imprese di Roma
Cod. Fisc. 067802058 - P. IVA 0602080967 - R.E.A. 59420

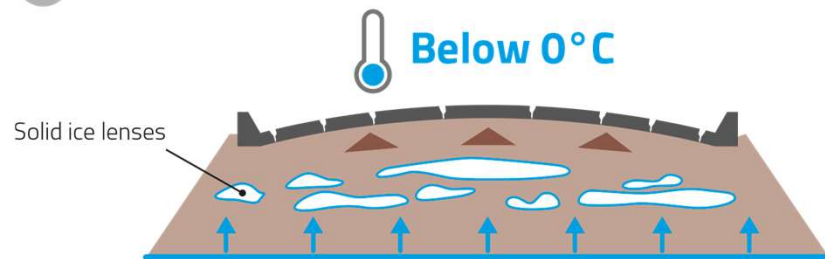


WHAT HAPPENS IN COLD CLIMATES

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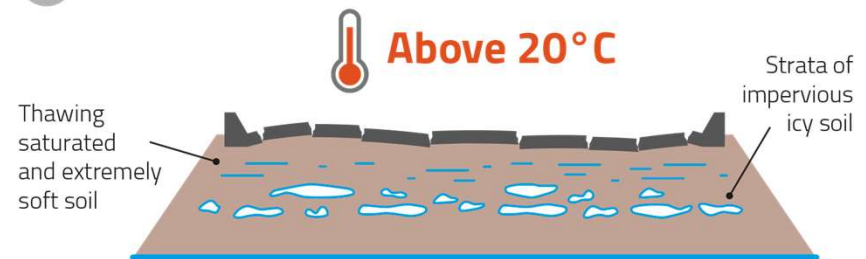
Uplift of the soil due to groundwater expansion on freezing

1 FROST HEAVE DEFORMATION AND CRACKING OF SURFACE ROAD LAYERS



In frost susceptible soils, **ground water** is drawn up into the soil above by capillary action. When the moisture in the capillary zone freezes, **water becomes solid ice**. Due to the frost heave phenomenon during low temperatures, initial cracking and damage of the road surface occur.

2 SURFACE ROAD DESTRUCTION DUE TO TRAFFIC AND THAWING

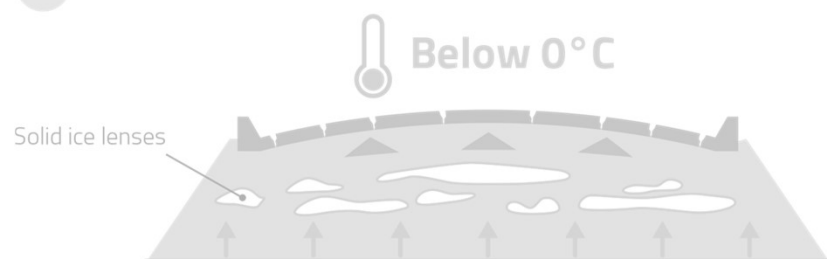


As the air temperature rises **above freezing**, the ground begins to thaw. **Ice melting** leads to the creation of voids in the road structure. The **extensive use** of the already cracked and weakened road surface results in further severe damage.

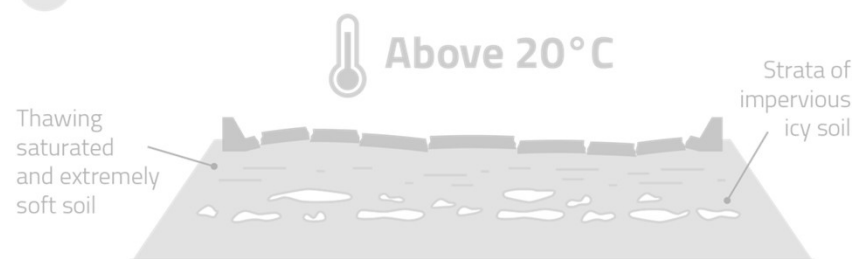
WHAT HAPPENS IN COLD CLIMATES

MacDrain Arctic Blanket

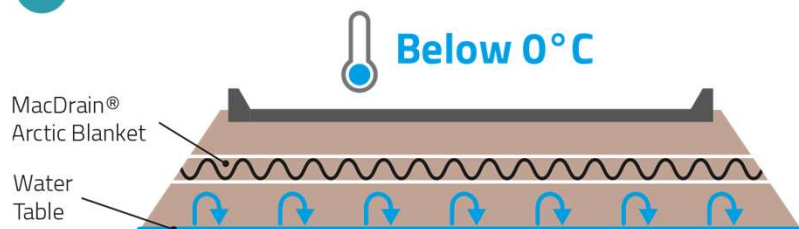
- 1 FROST HEAVE DEFORMATION AND CRACKING OF SURFACE ROAD LAYERS



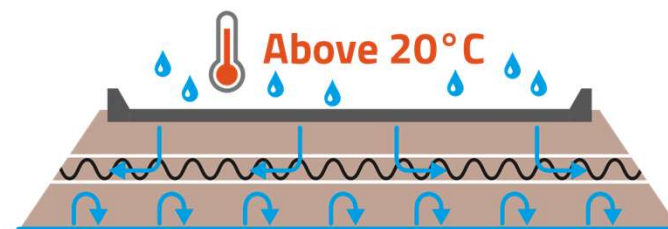
- 2 SURFACE ROAD DESTRUCTION DUE TO TRAFFIC AND THAWING



- 1 NO DEFORMATION AND CRACKING OF THE ROAD SURFACE



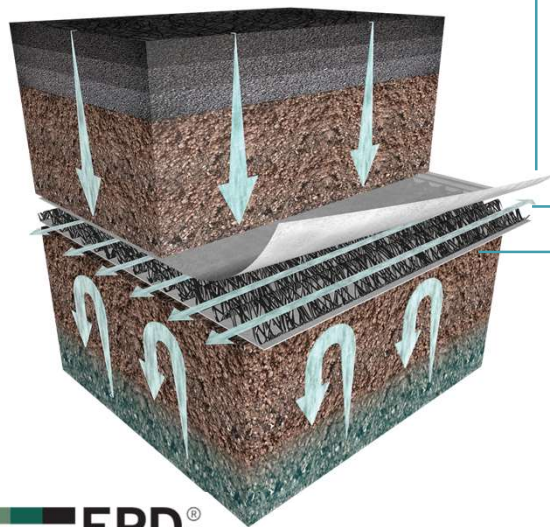
- 2 NO ACCUMULATION OF WATER IN THE ROAD SUB-BASE LAYER



MacDrain ARCTIC BLANKET

MACCAFERRI

MacDrain® ARCTIC BLANKET



Nonwoven geotextile

Selected to meet the highest standard of resistance during the loading and compaction phase in the overhead structure. The top layer acts as a filter allowing water from the overlying soil to enter the drainage core below, enhancing drainage along the plane of the geosynthetic and providing enhanced soil stabilization performance.

GeoMat with W-shaped

Developed to provide drainage characteristics with high resistance to compressive loads and high flow rate thus minimizing compressive creep.

Nonwoven geotextile with hydrophobic polymer enhancement

Designed to prevent the upward capillary rise of groundwater whilst remaining permeable to downward flow.

EPD®
CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION
S-P-01461 S-P-01464 S-P-01468 S-P-01471
S-P-01462 S-P-01465 S-P-01469
S-P-01463 S-P-01466 S-P-01470
www.environmentalproduct.com



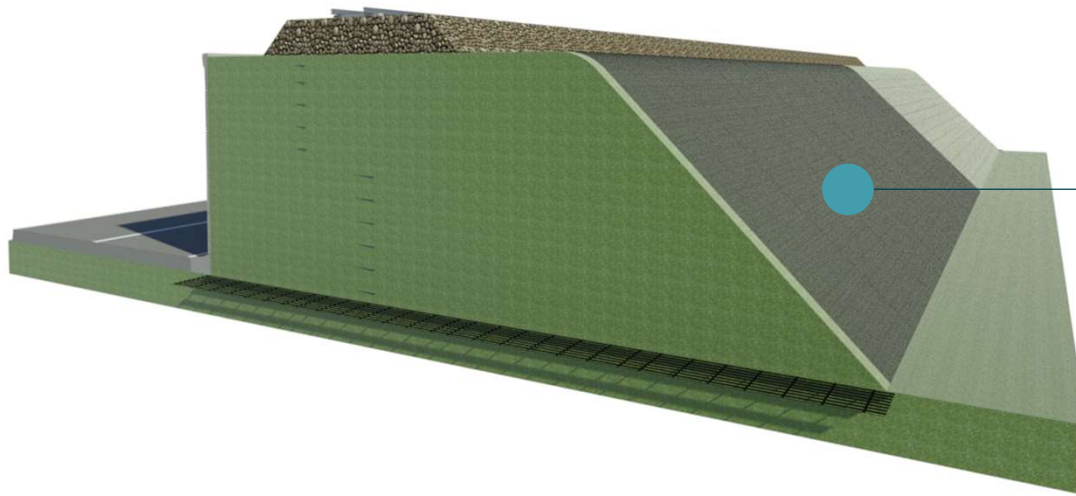
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EROSION CONTROL

EROSION CONTROL SOLUTIONS

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Typical Applications for Railway Embankments



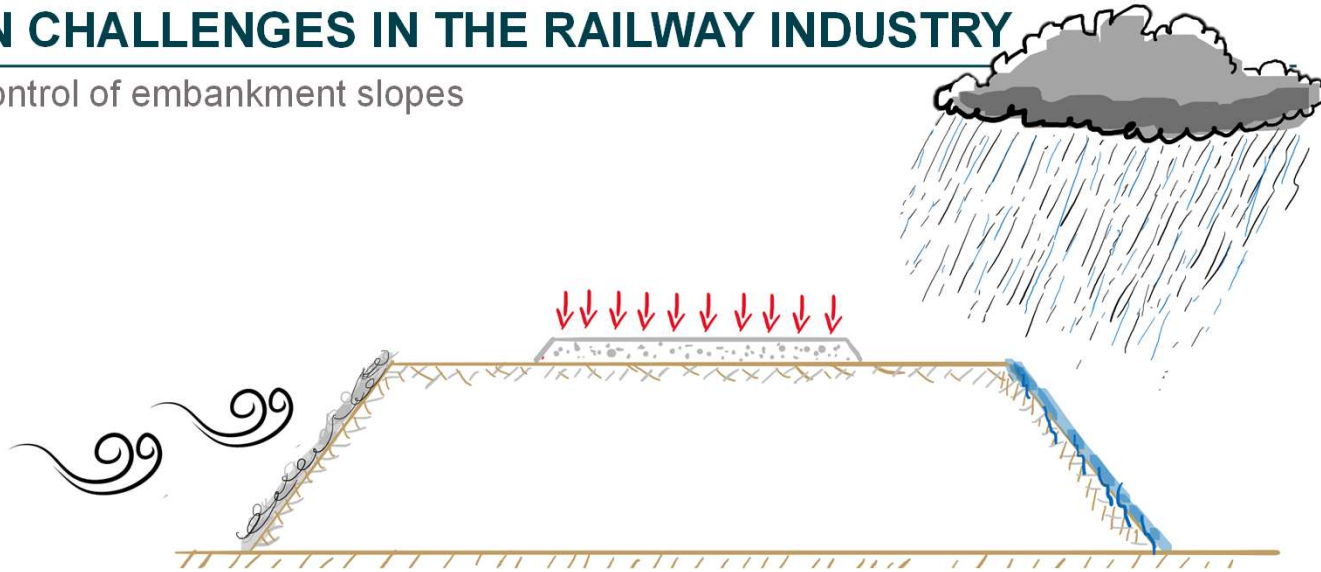
EROSION CONTROL

Protection of vulnerable soils slopes, reducing erosion through stabilization. Maccaferri geosynthetics solution prevent erosion phenomena due to wetting and drying, forces from wind, rain and gravity.

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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Erosion control of embankment slopes



COMMON PROBELMS

- Embankment slope failure
- Water seepage into embankment
- Superficial erosion due to weather elements



SOLUTIONS

- Reinforced geomat capable to avoid washout and top soil erosion

DESIGN CHALLENGES IN THE RAILWAY INDUSTRY

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Geosynthetics product for avoiding slope surface erosion

TECHNICAL



- M Superficial erosion protection from impact of rain drops and strong wind
- M Surface stabilization and liquid conveying

ENVIRONMENTAL



- M Natural revegetation process facilitated by the sunrays that pass through the geomat



WHAT ARE THE KEY REVEGETATION FACTORS?

MACCAFERRI



KEY INDICATORS

- M** Light Penetration
- M** Thickness
- M** Color
- M** Water absorption
- M** Weight
- M** Roughness and run-off
- M** Uniformity



GEOSYNTHETIC APPLICATION FOR SURFACE EROSION

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

They can be used on slopes, along the banks of canals and river courses, or to convey liquids (drainage) in association with geotextiles and/or geomembranes.



OUR EXPERIENCE

MACCAFERRI

Securing the way to Russia's key economic venture



- M** 640.000,00 m² of **MacMat-R** were used
- M** Slope erosion protection
- M** Frosting/defrosting cycle resistant material

SPECIAL SOLUTIONS FOR SPECIAL NEEDS

MACCAFERRI

ParaFence for Protection from Wind & Sand Drifting:

- It is Maccaferri's solution for Ultimate Windbreak Fencing Systems.
- ParaFence® effectively destroys or reduces wind velocities, it can also be used to control the drifting of sand.
- Its light weight, ease of installation, durability and the fact that it is rot proof and unaffected by Sunlight, rain or salt water, makes it the ideal choice for this type of application.





Not only **performance** certification but also to **environmental** and **digital** ones.



We provide reliable and comparable information on the environmental impacts of the product life cycle **reducing energy** and **material consumption**

visit maccaferri.com/EPD

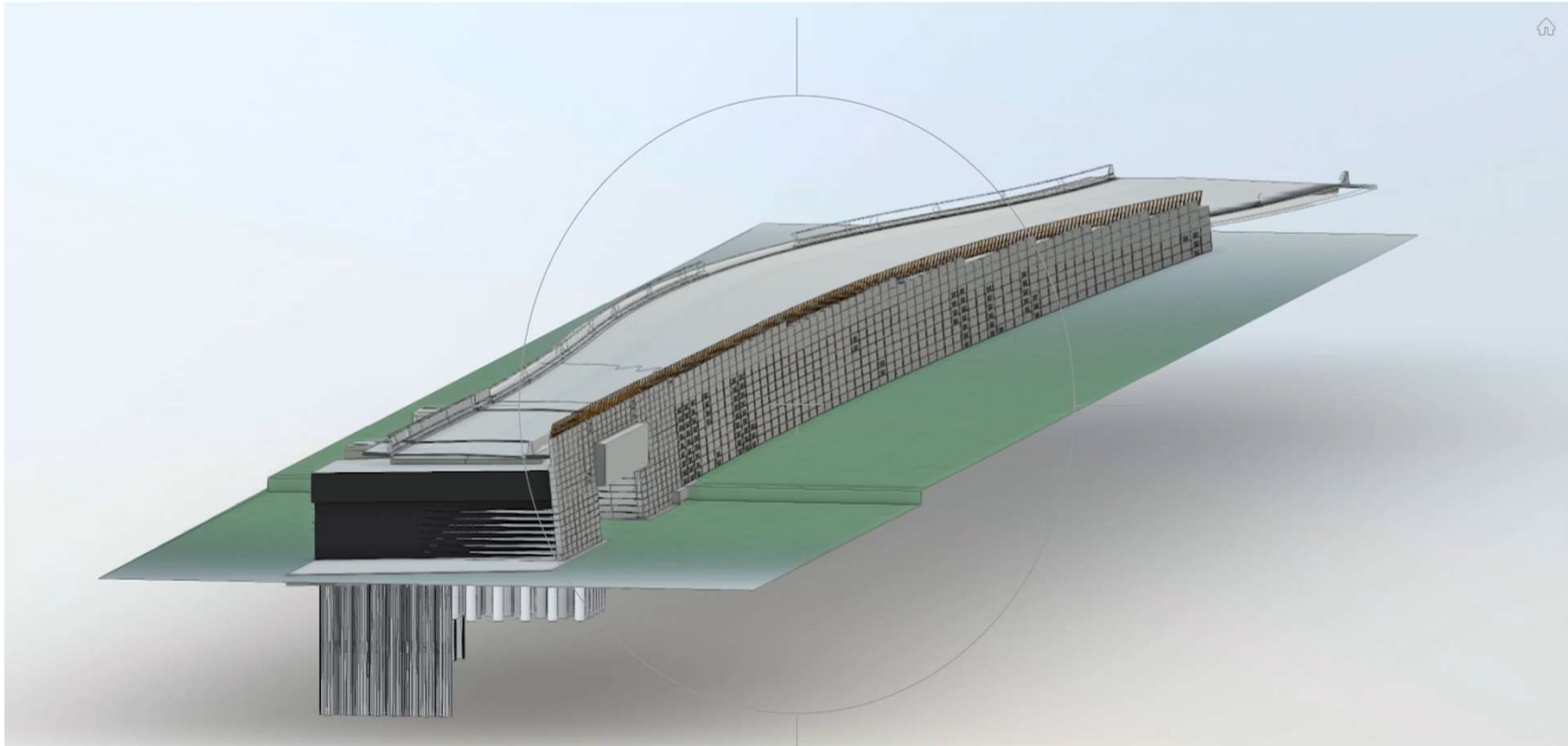


Our products are also available as BIM. Our BIM Object have been validated by the British Board Agreement (BBA) as being a true and fair representation of the physical product/system. BIM system **reduces design time and cost** and facilitates cooperation between project stakeholders

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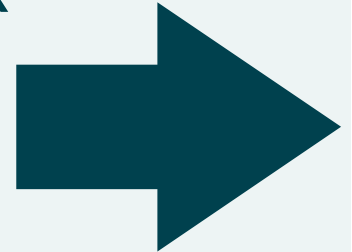


CONCLUSIONS

MACCAFERRI

- We can support you for the **design of your railways projects**
- Our Geosynthetics are among the **most tried and tested geogrids** in the world
- Thousands of reference cases available that prove the **cost effectiveness**

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