VERTICAL WALL INNOVATIONS: MSE STRUCTURES AND ABUTMENTS IN URBAN DEVELOPMENT

Date 26 September 2023

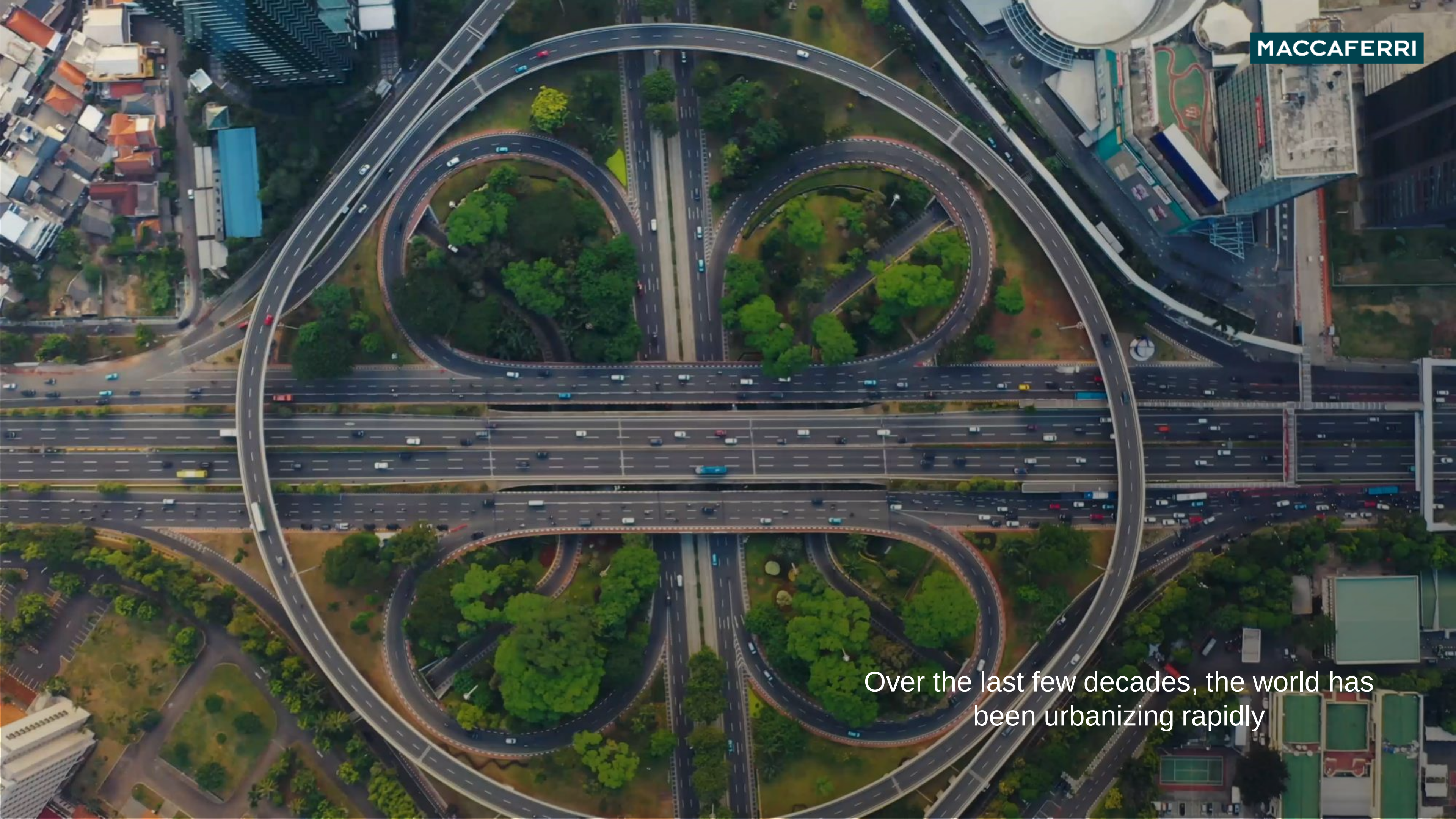
WEBINAR AGENDA

5’	*Introduction*
10’	*MacRes System: solution features and typical applications*
15’	*True abutments - design method and available standards*
5’	*Conclusions*

Live Q&A Session

Speaker

G. Lugli – Group Business Development GSY Unit



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Over the last few decades, the world has been urbanizing rapidly

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New infrastructure is continuously built
around the globe to keep up
with the need of economic development
and population growth


MACCAFERRI
In the urban environment, space is a key resource
that is becoming more and more limited

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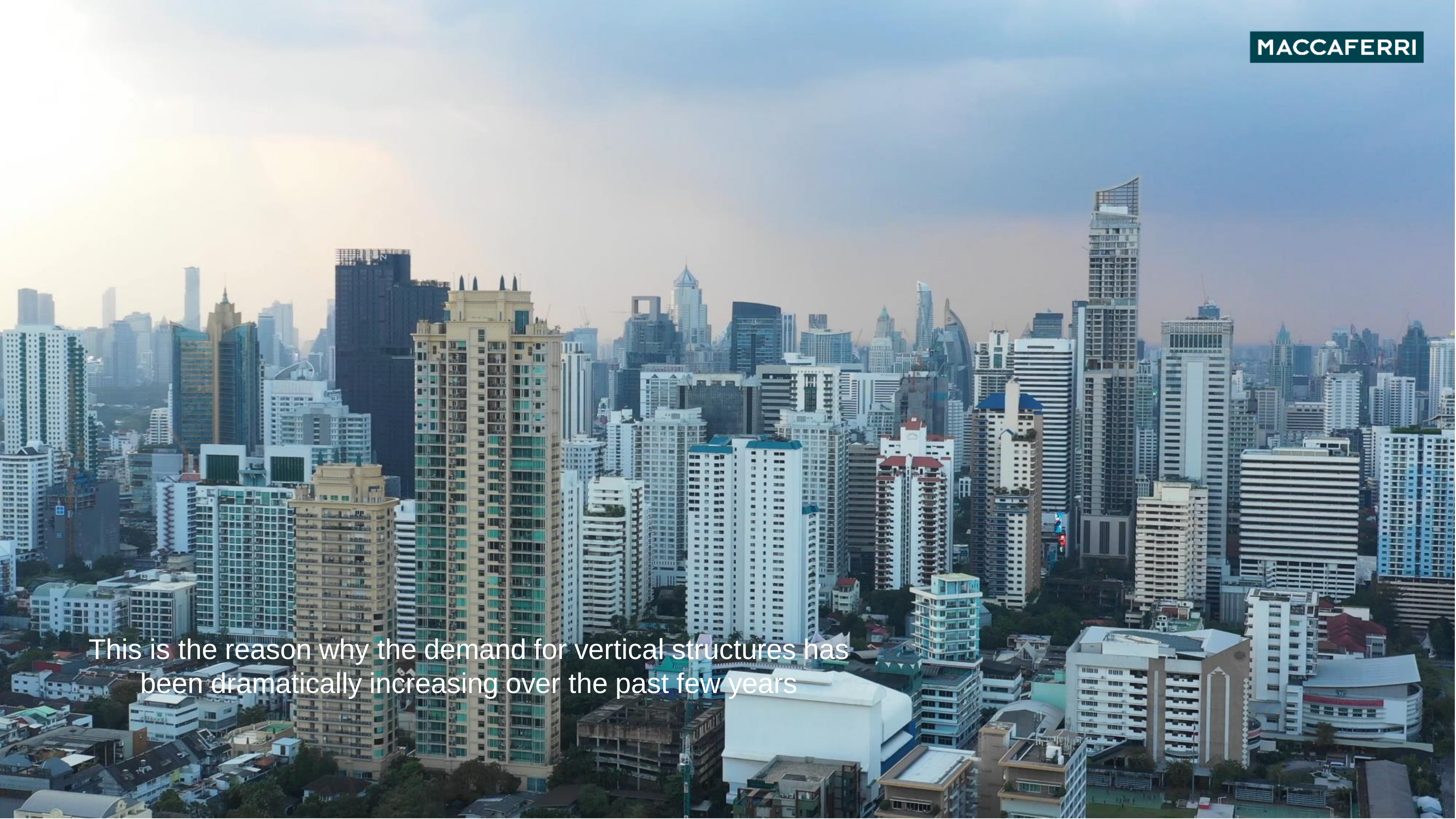

This is the reason why the demand for vertical structures has been dramatically increasing over the past few years

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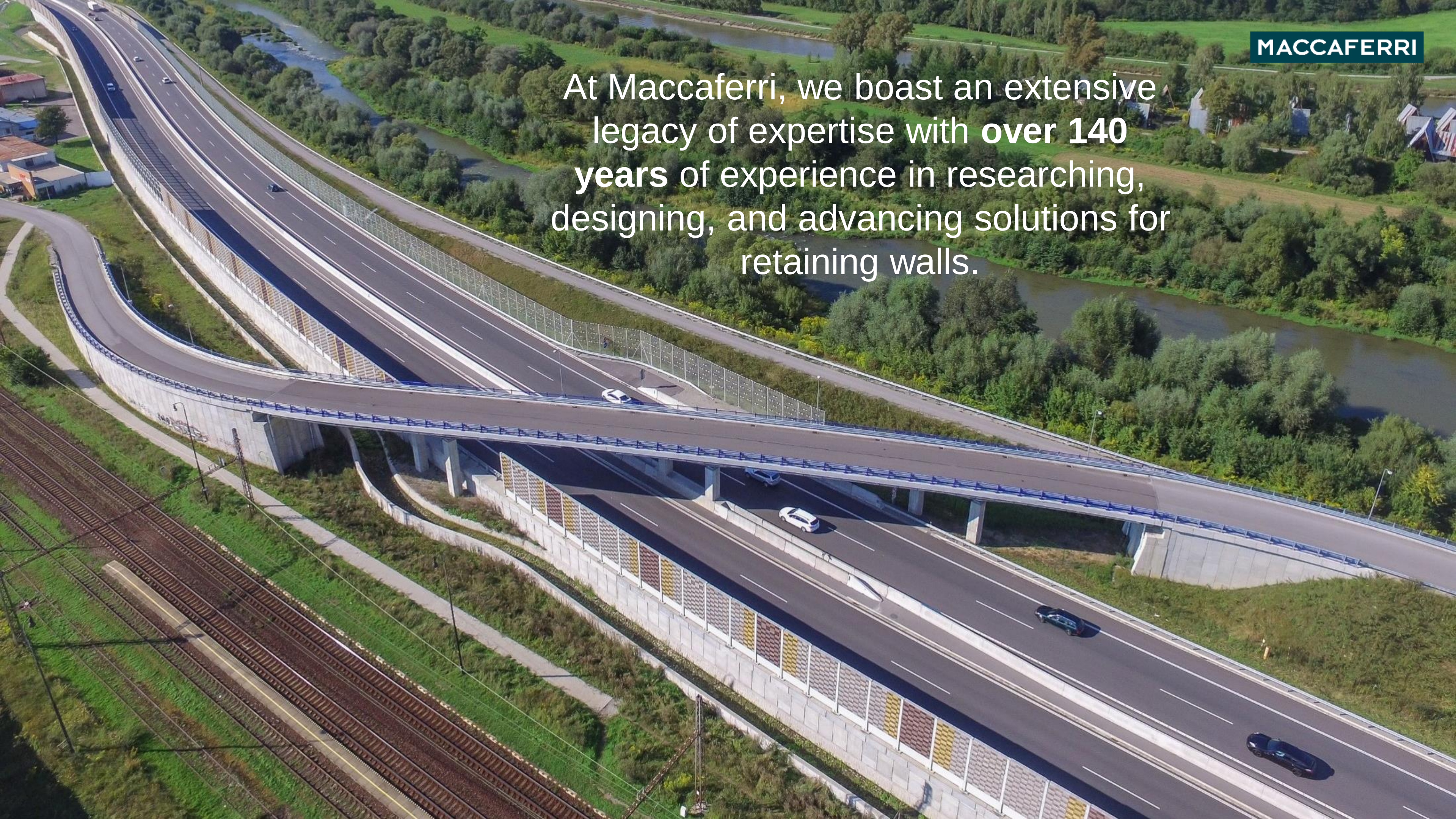
Civil engineering works with reduced ground footprint
can contribute
to space saving and life quality enhancement



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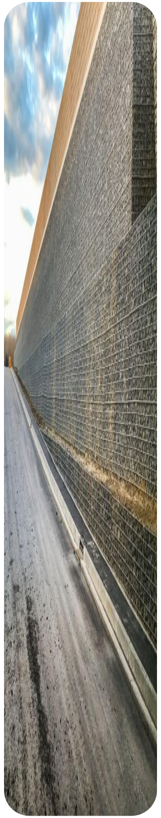
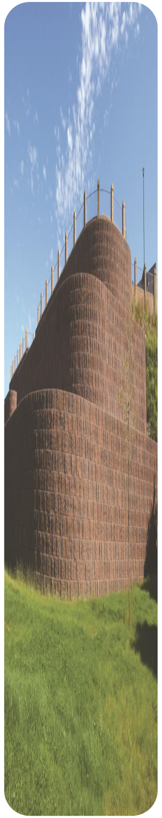
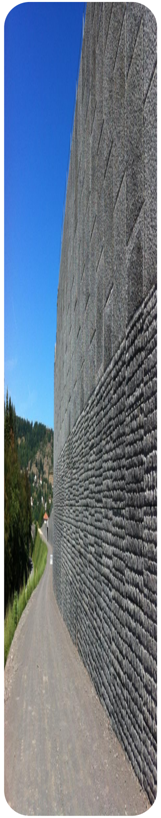
At Maccaferri, we boast an extensive legacy of expertise with **over 140 years** of experience in researching, designing, and advancing solutions for retaining walls.

MACCAFERRI

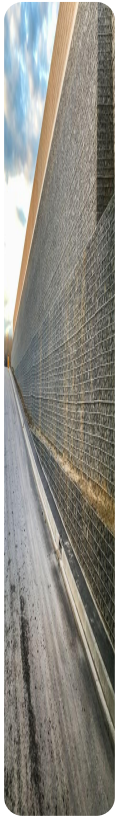
Our **long-standing experience** allows us to offer a **wide-ranging portfolio** of solutions for vertical walls.

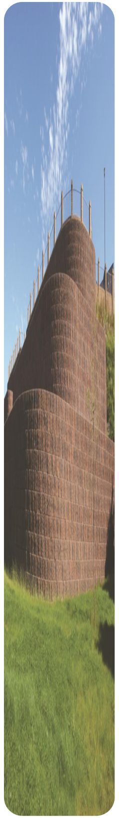


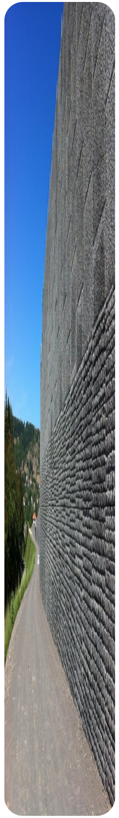




MASS GRAVITY WALL







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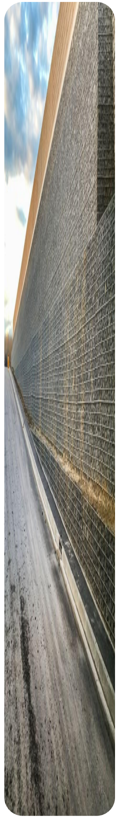
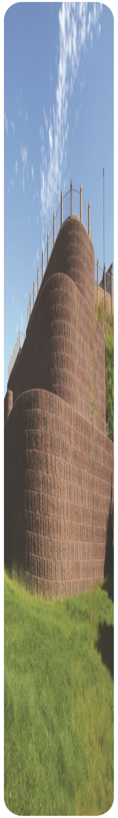
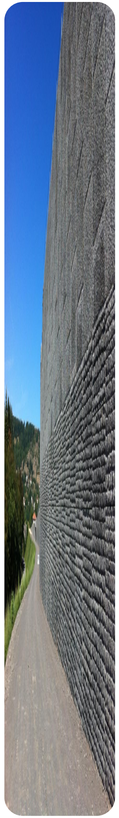
REINFORCED FILL STRUCTURES

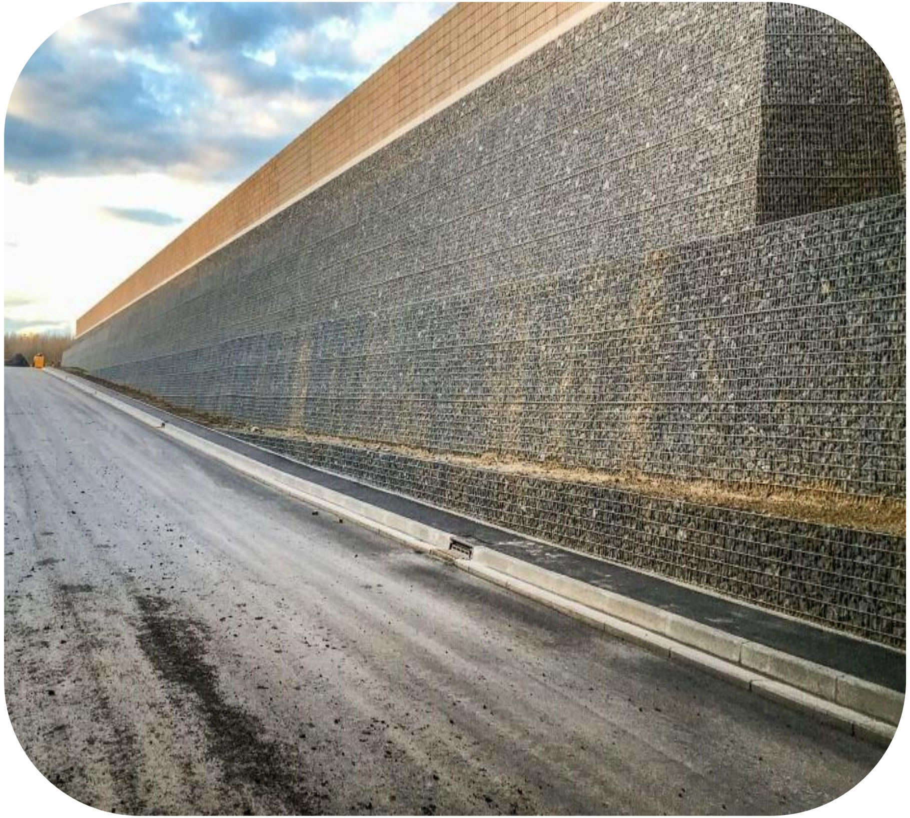
Vertical rock faced



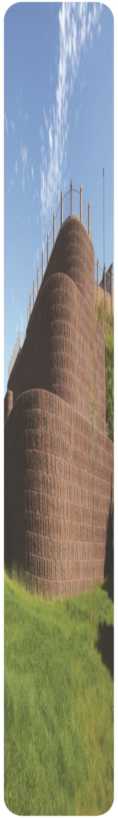


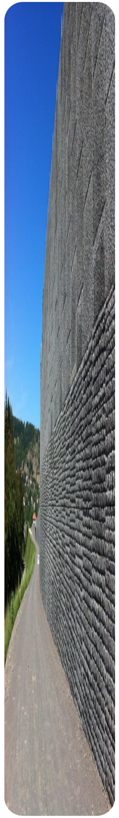


REINFORCED FILL STRUCTURES



Inclined rock faced





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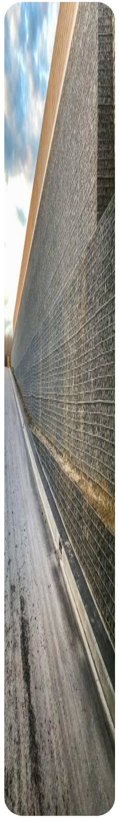
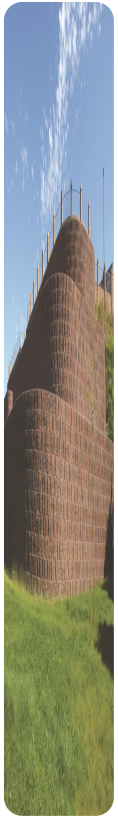
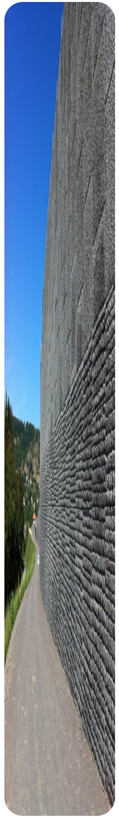
REINFORCED FILL STRUCTURES





Vegetated Faced

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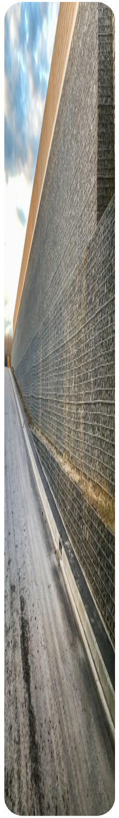
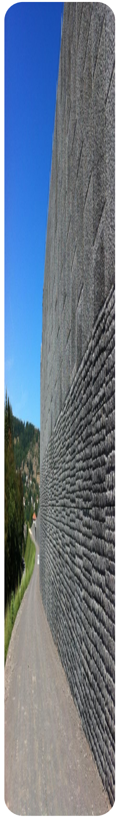
REINFORCED FILL STRUCTURES

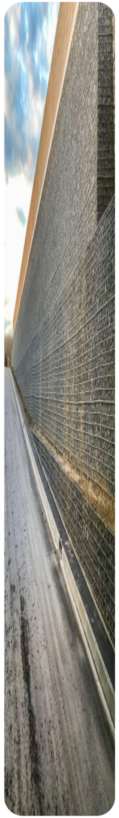


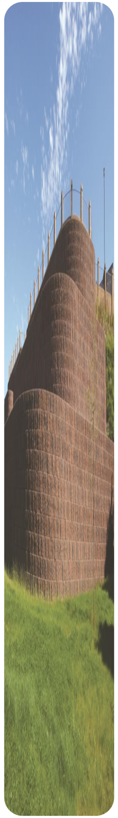


Vertical Concrete Facing
with blocks for segmental walls

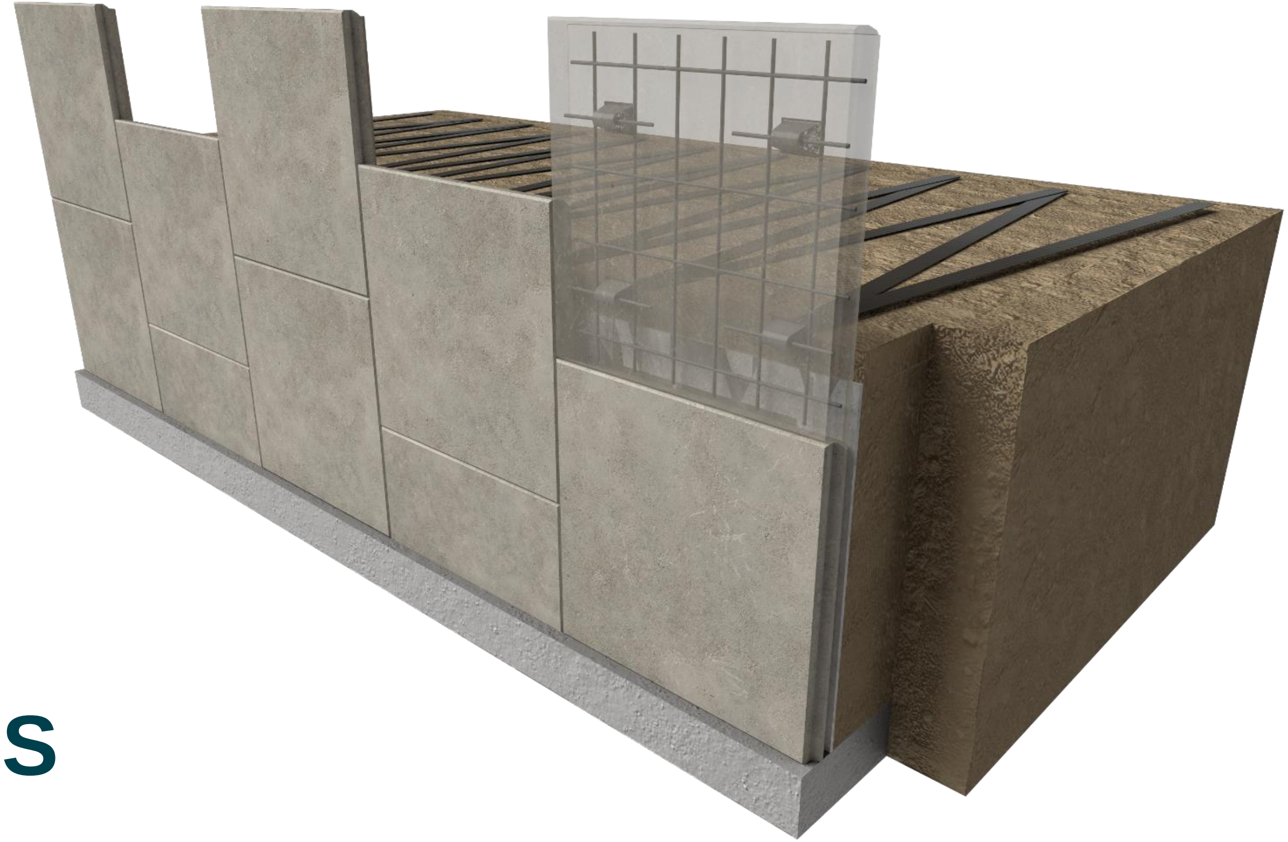
REINFORCED FILL STRUCTURES







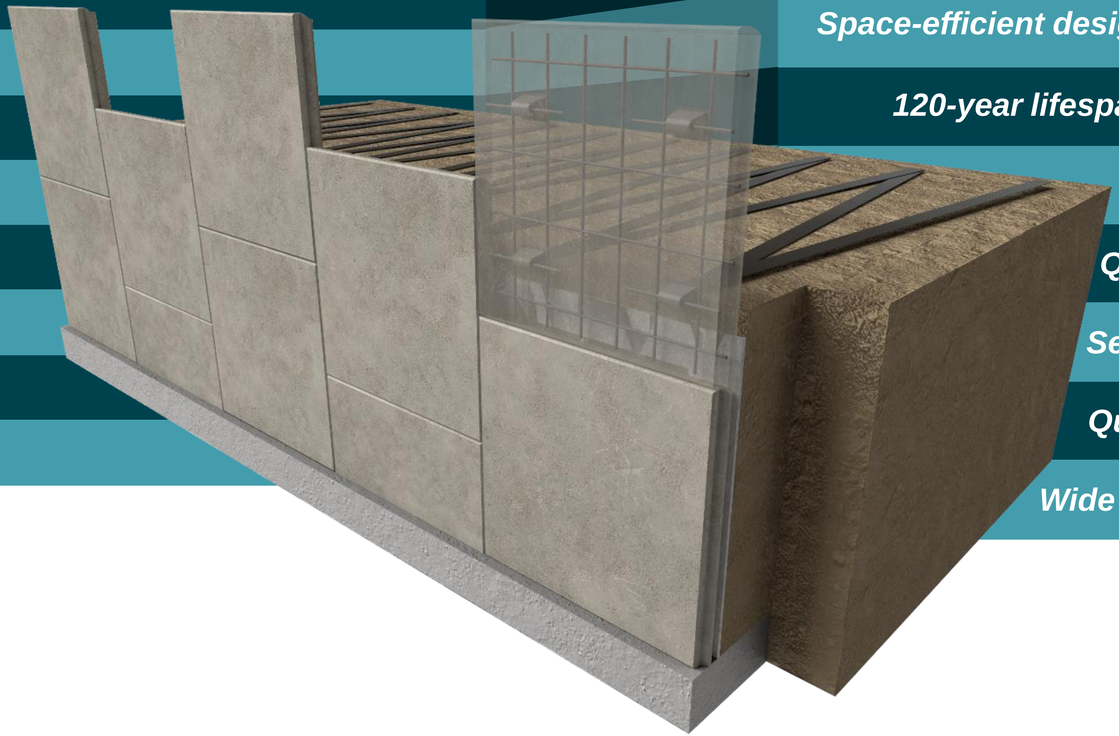

Vertical Concrete Facing
with Panels



MACRES

MACRES SYSTEM

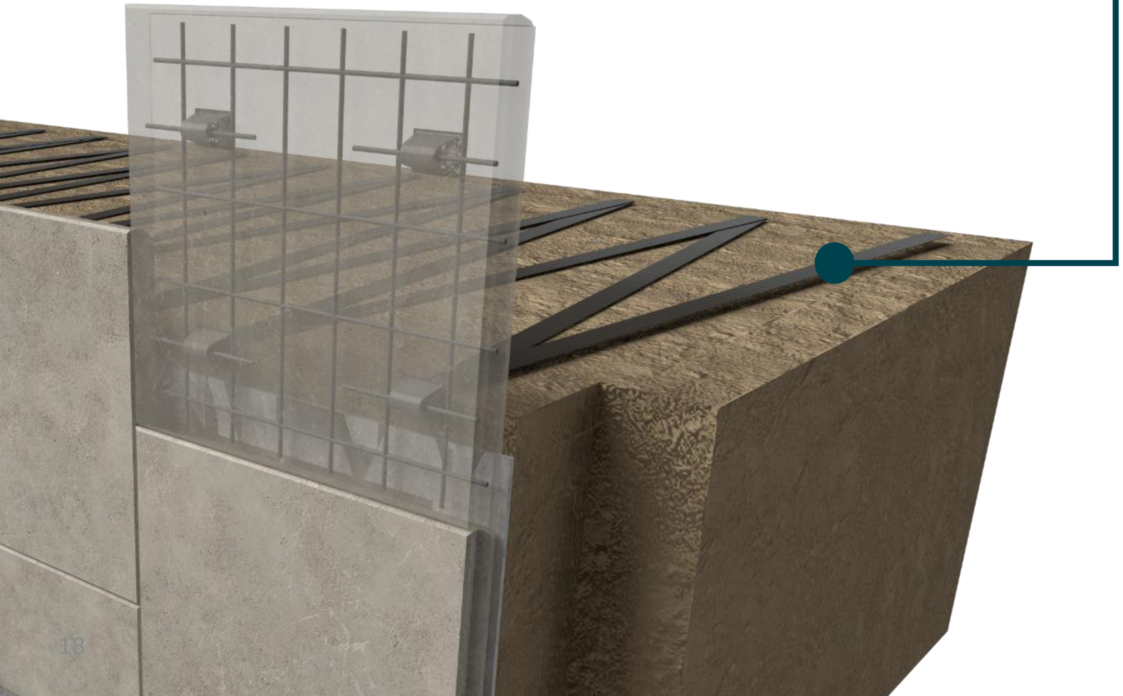
Behind the wall - Paraweb



- High resistance against seismic events
- Space-efficient design
- 120-year lifespan engineering
- High alkaline environment durability
- Quick and easy installation capability
- Service disruption minimization
- Quality of life enhancement
- Wide range of customization options available

MACRES SYSTEM

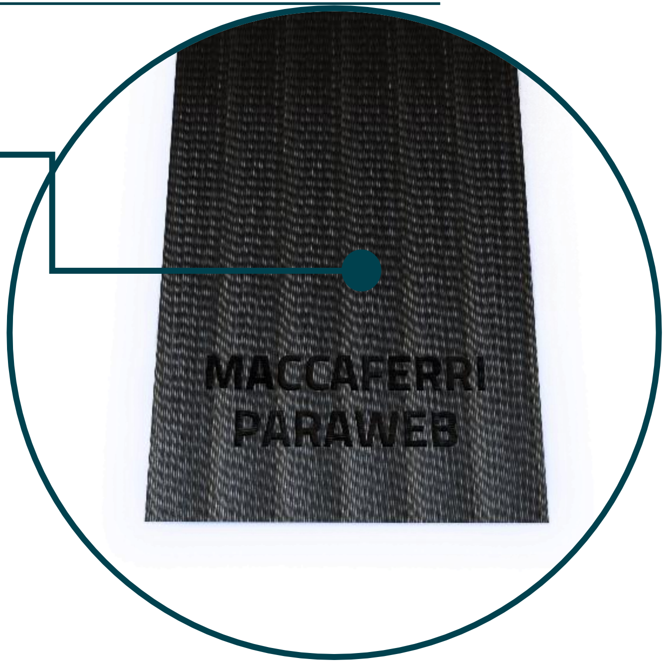
Behind the wall - Paraweb



MACRES SYSTEM

Behind the wall - Paraweb

PARAWEB POLYMERIC STRIPS



Paraweb PET strips with LLDPE coating

Several strip types available to optimize the design – Paraweb M & 2

What is the difference?
Same materials but different thickness and width.

Why wider strips are needed?
Because the pullout is the critical failure mode for the first top layers of the MSE structure, while at the bottom, the tensile strength is the driven force.

MACRES SYSTEM

Behind the wall - Paraweb

Paraweb™ PET strips with LLDPE coating

International Certifications and Worldwide Experience

Resistant to corrosion

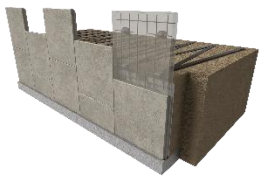
Several strip types available to optimize the design

Rough surface which develops excellent friction

Durability tested up to 120 years

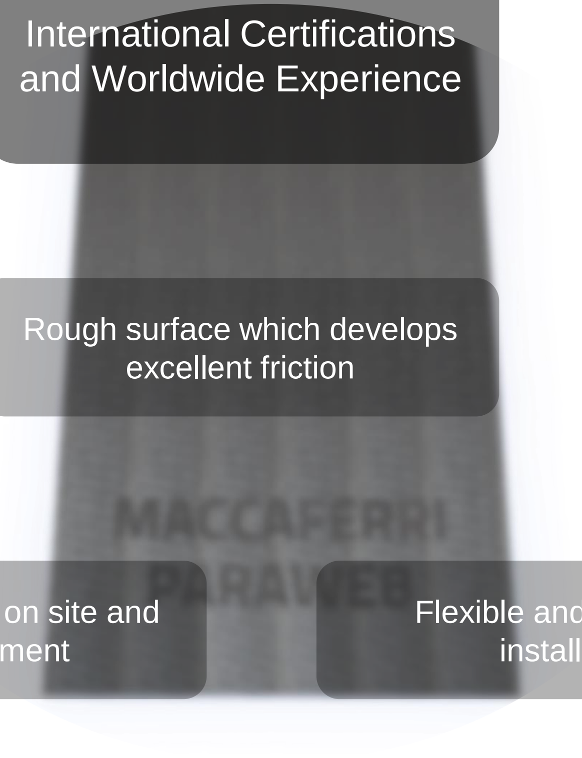
Easy to be treated on site and ease of shipment

Flexible and adaptable installation



MACRES SYSTEM

Behind the wall - Paraweb



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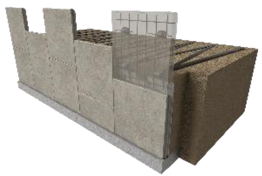
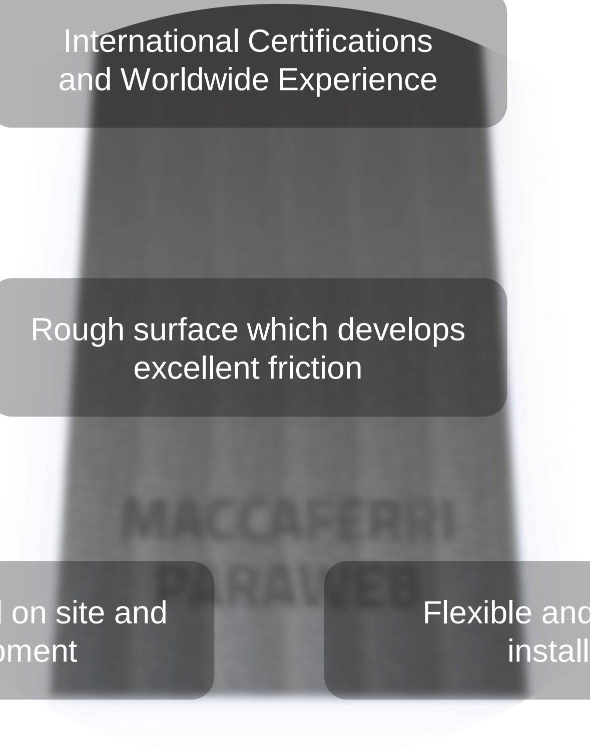


MACRES SYSTEM

Behind the wall - Paraweb



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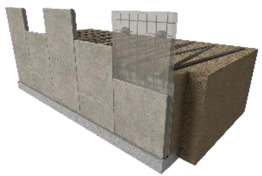

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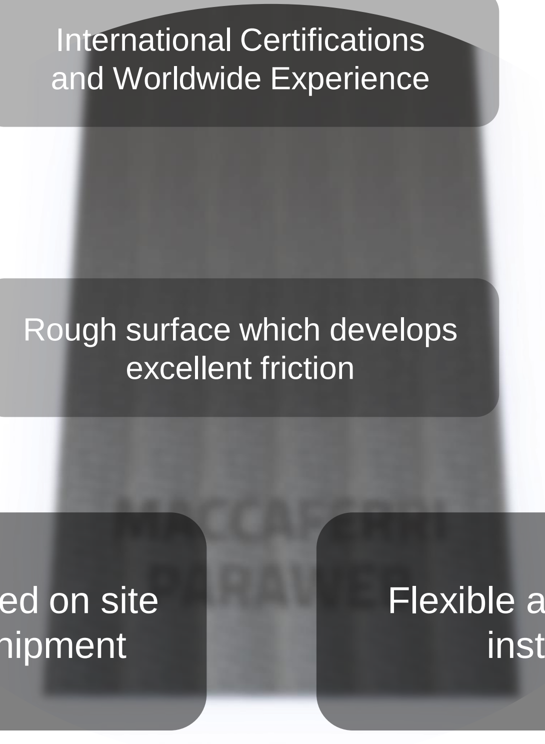

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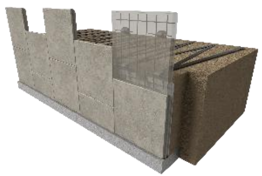

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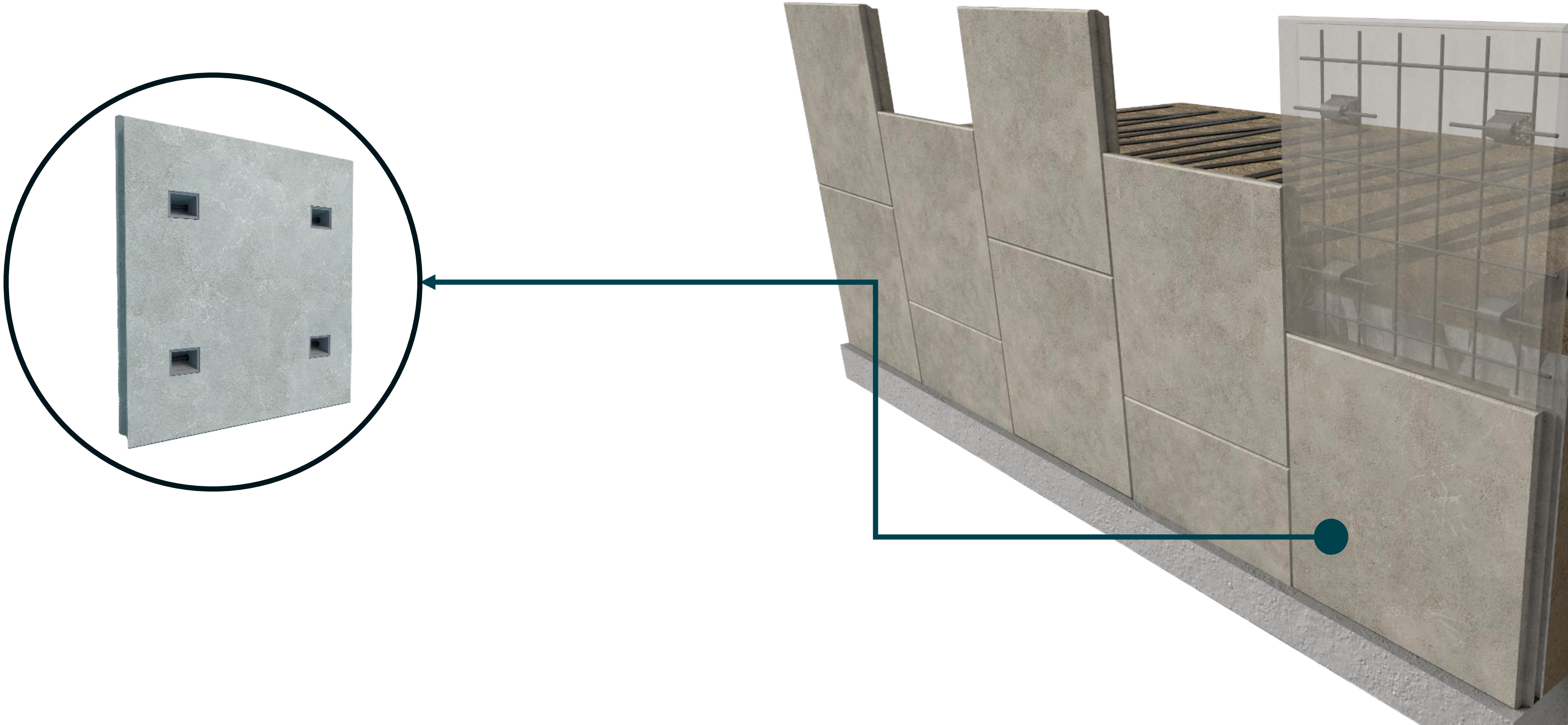


Behind the wall - Panels

CONCRETE PANEL

Concrete type depends on project specifications, but minimum requirements are:

- Class XF1 and XC4 (according to EN 206 or equivalent, resistant to rainwater and de-icing salts)
- Minimum compressive strength Rck at 28 days, >37 Mpa
- Geometric tolerances and finishing shall meet EN13369
- Minimum panel thickness is 14cm

MACRES SYSTEM

Behind the wall - Panels

CONCRETE PANEL (VARIANTS)

Several panels' geometries are available to meet finished elevation requirements.

Corner elements are needed when bend ray is less than the one allowable by panels

The top-course panel can be capped with a precast coping to expedite the installation.

Panels can be also customized according to clients needs and on-site obstructions.

MACRES SYSTEM

Behind the wall - Panels

Simplification

Several panel dimensions available to easily meet the wall geometry

Customization

Concrete surface finish can vary upon client request and project specifications

Support

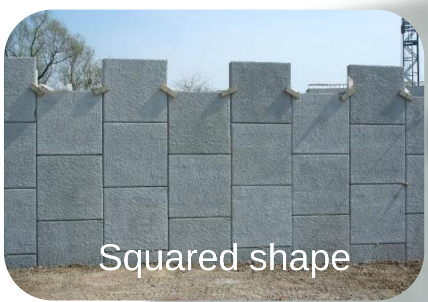
Maccaferri supports construction companies and precaster with technical manuals and site supervision.

MACRES SYSTEM

Behind the wall – Panels customization

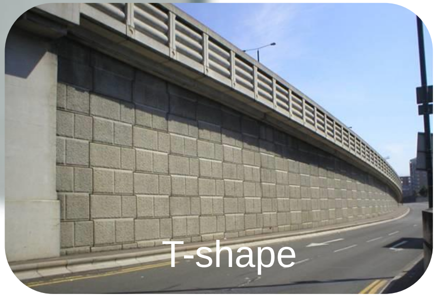
Customization

Concrete surface finish can vary upon client request and project specifications


Squared shape


Rectangular shape


T-shape

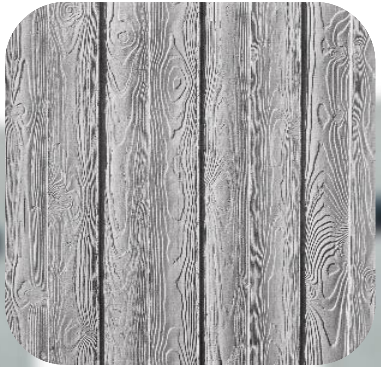

T-shape

MACRES SYSTEM

Behind the wall – Panels customization

Customization

Concrete surface finish can vary upon client request and project specifications



MACRES SYSTEM

Behind the wall – Panels customization

Customization

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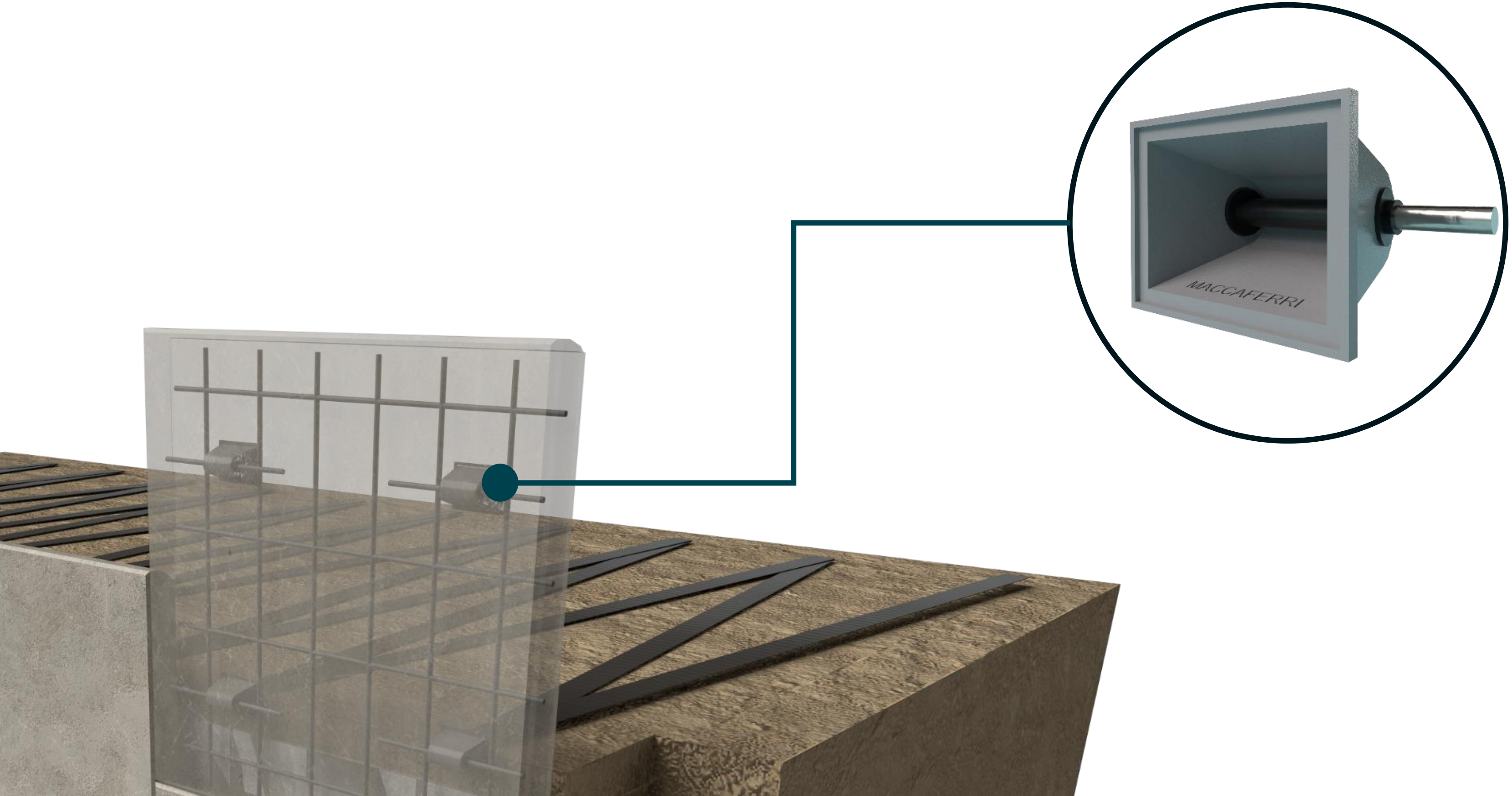
MACRES SYSTEM



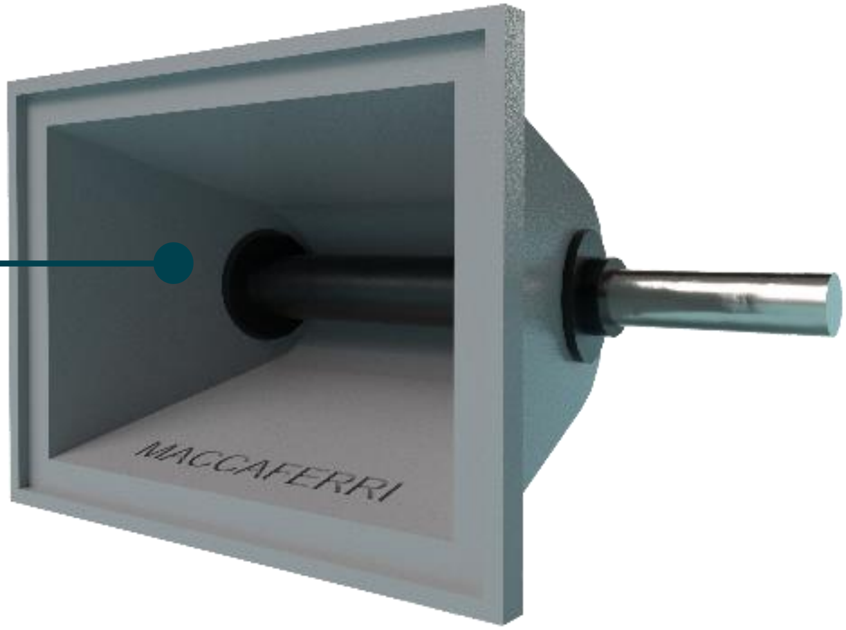
MACRES SYSTEM

Behind the wall - MacBox

MACBOX

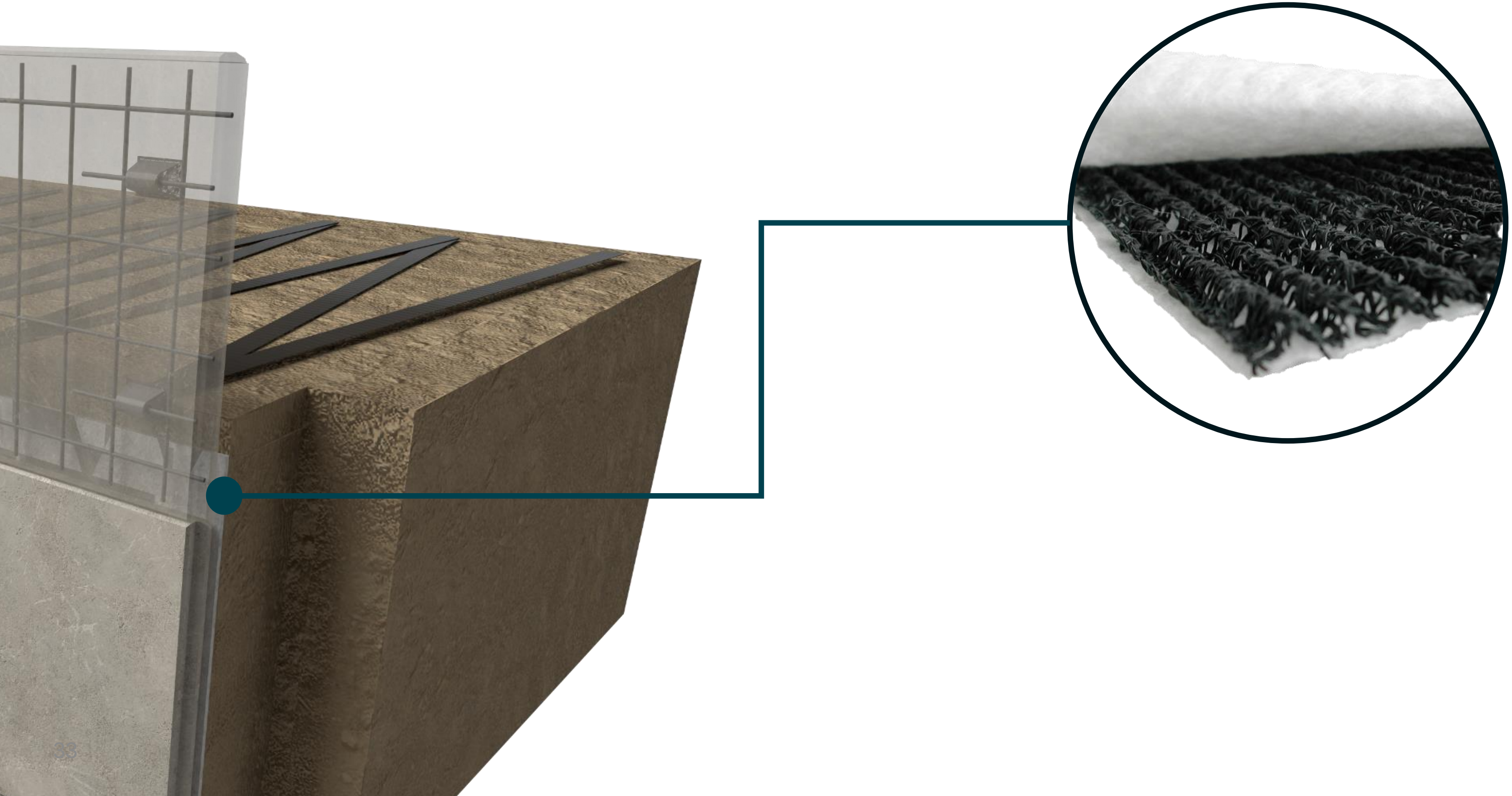
MacBox: the insert is secured by a steel rebar embedded in the panel and protected by a polymeric sleeve

The strength of both connections has been determined through independent connection/pullout testing program



MACRES SYSTEM

Behind the wall - MacDrain

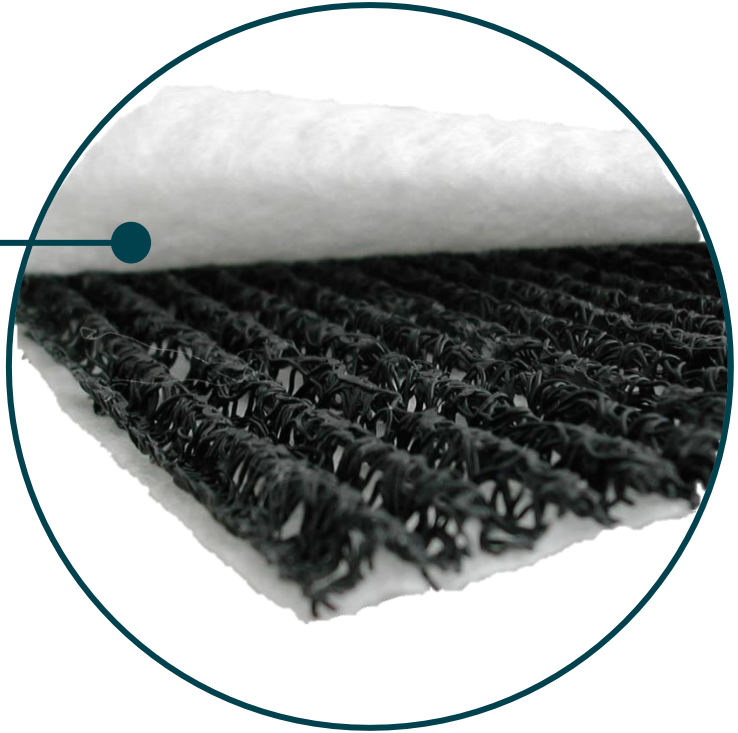


MACRES SYSTEM

Behind the wall

MACDRAIN

MacDrain™ is comprised of a flexible core and 1 or 2 non-woven geotextile filters. The channel pattern has very high void ratio and can be customized variable thickness based upon the required flow capacity. MacDrain™ has excellent performances in long term conditions.



MACRES

Main applications

MACRES

Retaining walls

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Railway structures

MACRES

Crusher walls

MACRES

Abutments

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A bridge abutment is a substructure that supports one terminus of the superstructure of a bridge and, at the same time, laterally supports the embankment which serves as an approach to the bridge


MACCAFERRI
As component of a bridge, the abutment provides vertical support to the superstructure at the bridge ends, connects the bridge with the approach roadway, and retains the roadway base materials from the bridge spans

MACCAFERRI

Abutments come in **various shapes and sizes** and can be designed to match the architectural style of the bridge and the surrounding environment.

Common types of abutments include wing walls, rubble masonry abutments, and reinforced concrete abutments.

MACCAFERRI

MSE walls as bridge abutment has become an attractive option to the traditional wall abutment. The use of an MSE wall abutment simplifies the design and construction, requires less site preparation, allows faster construction, and consequently leads to cost saving.

ABUTMENTS

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Abutments Definition

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ABUTMENTS

Abutments definition

Abutments Definition

False abutment

False abutment

True abutment

ABUTMENTS

Abutments definition – False abutments

Abutments Definition

False abutments refer to a construction technique used in bridge engineering. A false abutment, also known as **mixed MSE abutment** is a **pile-supported abutment** where the MSE structure, act as a simple retaining wall.

Piles can either be driven through the constructed MSE wall or installed before construction of the MSE wall.

ABUTMENTS

Abutments definition – Mixed abutments

Abutments Definition

Piles can be inside the structure or outside. In any case, the MSE wall only provides lateral support for the approach embankment, whereas the **piles support mainly the loads from the bridge.**

ABUTMENTS

Abutments definition – True abutments

Abutments Definition

When a bridge beam is **supported on a spread footing that bears directly on top of an MSE structure**, this configuration is known as **true MSE abutment**.

ABUTMENTS

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True abutments

Available standards

Design

ABUTMENTS

Available standards

Available standards

When dealing with reinforced soil bridge abutment only a limited number of standards provides details and guidance on these structures design. Below the list of most known:

- FHWA-NHI-10-024 - Vol I / AASHTO (USA)
- BS 8006 (England)
- NF P 94-270 (France)

ABUTMENTS

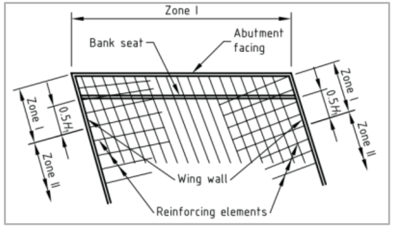
Available standards – BS 8006

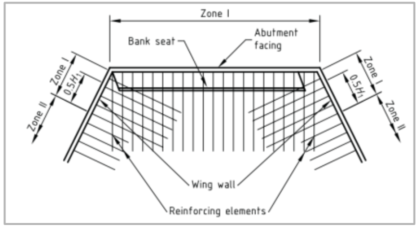
BS 8006 is the **British Standard** for designing and construction of reinforced soil structures. BS 8006 provides guidance on the design procedure for true abutments over MSE walls.

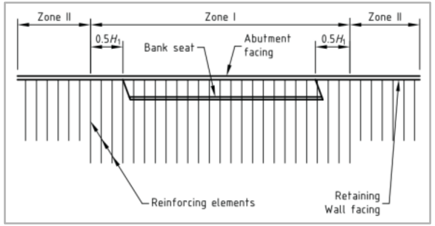
Available standards

One of the important considerations is that **the abutment design can be divided into two parts:**

- ✓ Zone I should be designed assuming loading includes that of the bank seat and its applied loads.
- ✓ Zone II should be designed as a retaining wall ignoring any loading derived from the bank seat.
- ✓ The load from the bank seat should be assumed to diffuse downwards at 2v:1h so that the width of Zone I increases linearly from bank seat level to be $0.5H_1$ greater in width at foundation level.







ABUTMENTS

Available standards – BS 8006

Available standards

According to BS 8006 the reinforced soil design must consider:

- Weight of the bankseat,
- Dead load from the deck,
- Live loads acting on the deck.
- Other load cases
- ***Earthquake loads NOT CONSIDERED IN BS 8006***

ABUTMENTS

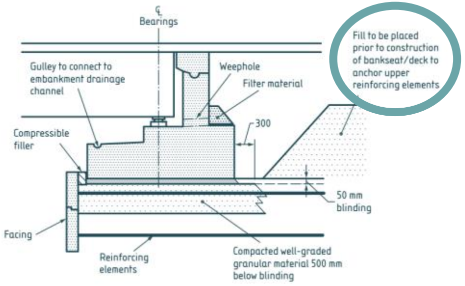
Available standards – BS 8006

Available standards

It is important to build a MSE bridge abutment in several stages:

1. Erection of the reinforced soil mass,
2. Construction of the bankseat,
3. Installation of the deck.

The design should **consider all the possible load cases** and state clearly on the working drawings the arrangement and **level of fill to be in place above the reinforced soil mass before construction of the bankseat and also before installation of the deck**.
For these construction load cases, the strength of the soil reinforcement may be taken as that appropriate for the **service life of temporary works**



ABUTMENTS

Available standards – FHWA-NHI-10-024 - Vol I / AASHTO

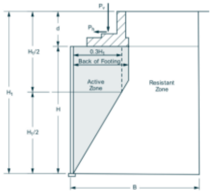
FHWA-NHI-10-024 by **the Federal Highway Administration** (FHWA) and **the National Highway Institute (NHI) in the United States**.

Along with FHWA, also AASHTO includes many details on the design procedure of abutments over MSE walls as per Paragraphs 11.6.2 to 11.6.6.

Available standards

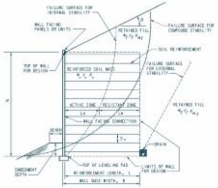
Sizing of the structure

Minimum length of the reinforcement based on the experience is 0.6 (H+d) + 2m



Minimum embedment

Slope of the ground at toe should be always zero.



Slope in Front of Structures		Minimum Embedment Depth
Horizontal	for walls	$H/20.0$
	for abutments	$H/10.0$
$3.0H{:}1.0V$	walls	$H/10.0$
$2.0H{:}1.0V$	walls	$H/7.0$
$1.5H{:}1.0V$	walls	$H/5.0$

ABUTMENTS

Available standards – FHWA-NHI-10-024 - Vol I / AASHTO

Available standards

According to FHWA-NHI-10-024 in case of a true MSE abutment, a designer shall always evaluate the following aspects:

- Service Limit State
- Strength Limit State
- Considerations on Frost Penetration
- Reinforcement Density across wing-wall
- Eccentricity of load at each level should be considered

ABUTMENTS

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True abutments

Available standards

Design

ABUTMENTS

Design method

Design

The design of an MSE wall for a bridge abutment shares most of the principles and steps as a standard MSE wall design.

The design of these MSE structures and its general behavior is very much depending on the interaction between soil and reinforcing elements and the interaction is a function of the properties of the materials.

ABUTMENTS

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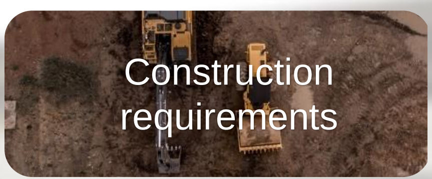
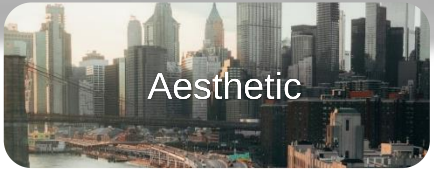
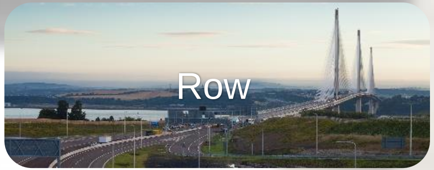
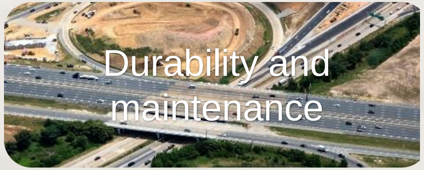
Design method

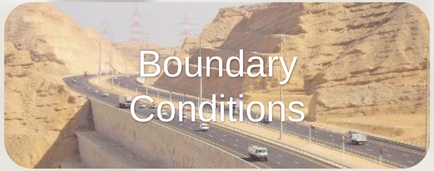
Design











ABUTMENTS

Design method

Design

The design load is sustained by the long-term design strength LTDS (Tal = Td) of the reinforcement, which is calculated considering the appropriate RFs for creep, installation damage and durability

$$T_{al} = T_{ult} \,/\, (RF_{cr} \times RF_{id} \times RF_{d})$$

ABUTMENTS

Design method - differences

Design

The design of a MSE wall bridge abutment shall take into consideration **additional loads**, generally not considered (not existent) in the design of a standard MSE wall.

- **Traffic loads**
- **Earthquakes loads**
- **Vertical distributed or concentrated loads**
- **Horizontal distributed or concentrated loads**

**The bridge reaction forces or pressures must be given by the designer.*
***Loads provided can be Characteristic (SLS) or Design loads (ULS).*

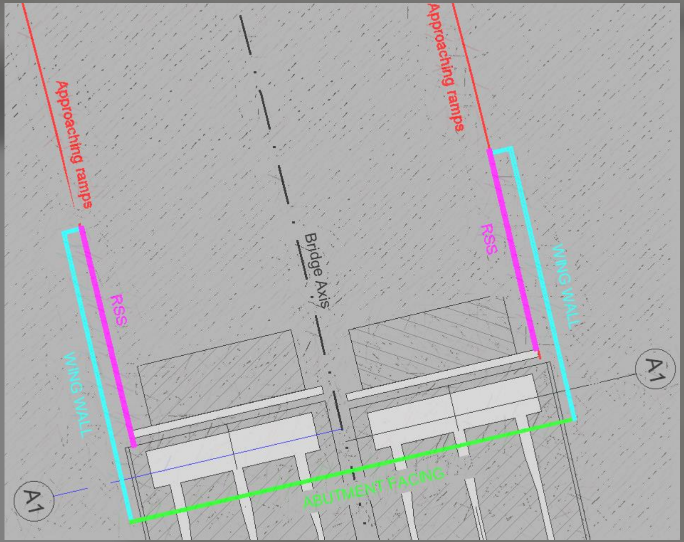
ABUTMENTS

Design method - differences

For the design approach to an abutment the abutments has to be divided into 3 Areas – as referred by the design approach of BS 8006

Design

- **Abutment facing**
- **Wing Wall**
- **Reinforced Soil Structure**



ABUTMENTS

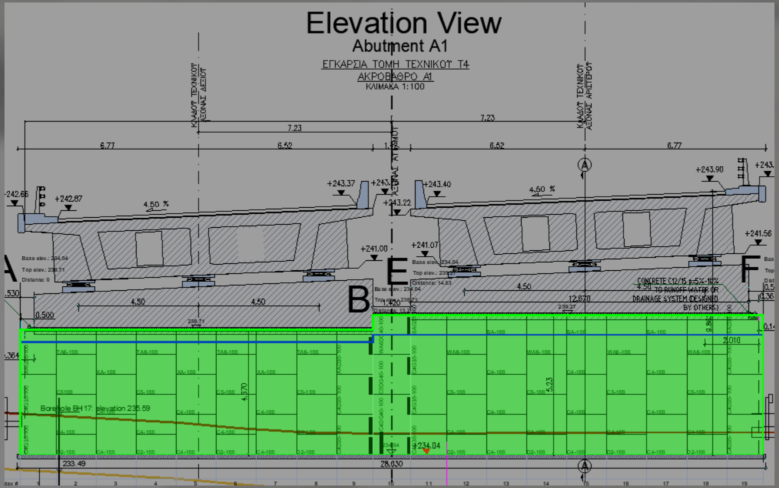
Design method - differences

MACCAFERRI

Design

MSE Abutment facing:

- Portion of wall below the abutment seat.
- Most loaded area as subjected to bank seat loads and braking forces.
- Typically, this area is perpendicular to the bridge axis, also trapezoidal layout are used.



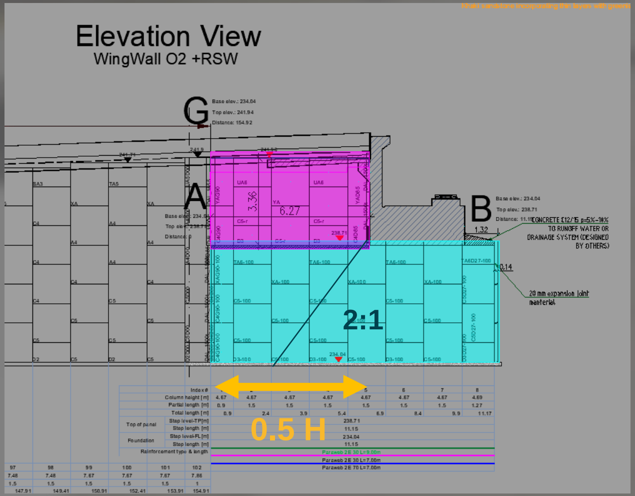
ABUTMENTS

Design method - differences

Design

Wing Wall:

- Portion of the wall designed as the abutment area; loads include bank seat and its applied surcharges.
- The width of this area is defined by assuming the load to diffuse downwards at 2v:1h from bank seat level. The area should be 0.5H greater in width at foundation level.



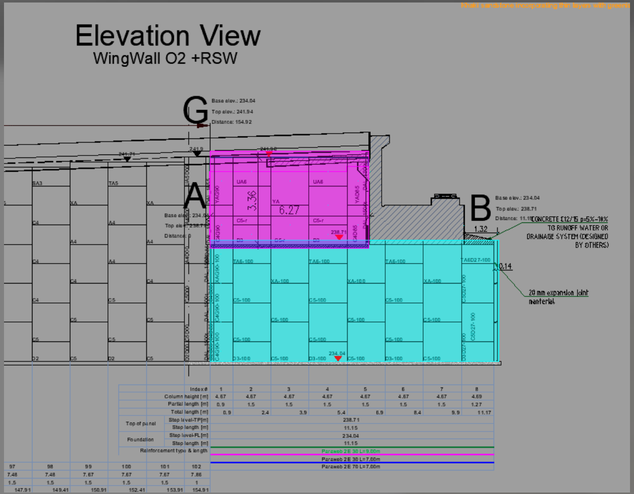
ABUTMENTS

Design method - differences

Design

Reinforced Soil Structure:

- Is the area above the wing wall and behind the bank seat designed as a retaining wall ignoring any loading from the bank seat



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Quality with nature

At Maccaferri, our primary commitment is to address environmental, economic, and social aspects with a holistic approach.

The MacRes® system aligns with the Company's vision and has earned certifications from accredited international laboratories, including BBA and NTPEP.

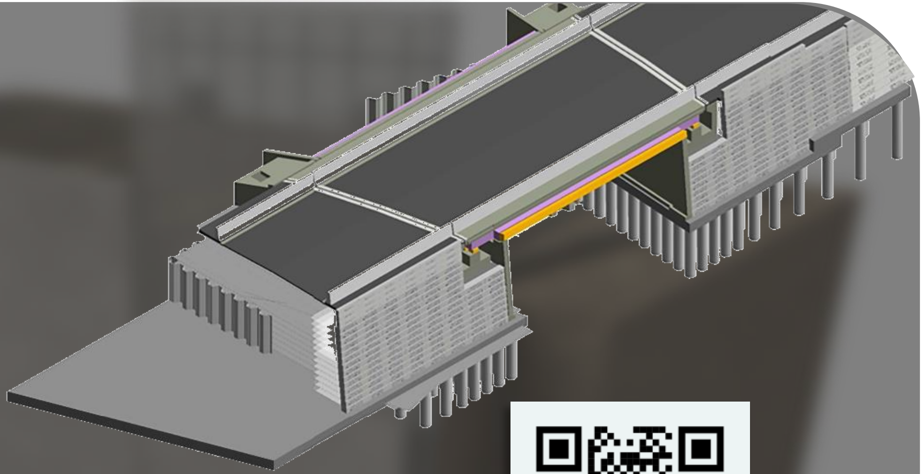
MacRes® system is approved for global use in various applications, from railways to highways, and lime-stabilized backfill to mining crusher walls.

Maccaferri prioritizes environmental sustainability by obtaining the EPD® certification for Paraweb™ products and offering project-specific MacRes® LCA analysis..

MACRES SYSTEM

BIM

Maccaferri values cooperation and actively collaborates with stakeholders, integrating BIM software to assist designers, construction firms, and clients in developing 3D visual plans while ensuring alignment with their product BBA Certificates through the "BIM Object Assurance" service.



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MACCAFERRI

LIVE Q&A