SIMSG ISSMGE

TC-218 Special Session
Reinforced Fill Structures

SIMSG ISSMGE
TC218 REINFORCED FILL STRUCTURES

...in collaboration with:

igs Reinforcement

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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AGENDA **(Page)**

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

AGENDA

Updates from ISSMGE TC-218 and IGS TC-R, *Shahriar Mirmirani & Ivan P. Damians*

Presentations by the Marginal / Alternative Fills Subcommittee, *Shahriar Mirmirani*

- **Aníbal Moncada Ramírez / Ivan P. Damians**: Pullout Response of Polyester Strap Reinforcements and Reclaimed Asphalt Pavement (RAP): Influence of Confinement and Environmental Conditions
- **Castorina Vieira**: Use of Recycled Construction and Demolition Wastes as Backfill in Geosynthetic-Reinforced Soil Structures
- **Lizeth Ardila/ Oliver Detert**: Geosynthetics Mechanically Stabilized Earth Walls: Numerical Modeling and Case Studies in South America
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Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

- **Updates from ISSMGE/TC-218, *Shahriar Mirmirani***

✓ **Secretary of the ISSMGE/TC-218 (Reinforced Fill Structures)**
✓ Vice President – Engineering, at Geoquest Group, Canada
✓ shahriar.mirmirani@geoquest-group.ca

- **Updates from the IGS/TC-R, *Ivan Puig Damians***

✓ **Chair of the IGS/TC-R (soil reinforcement)**
✓ Associate Research Professor at CIMNE / UPC-BarcelonaTech
✓ VSoL® R&D Manager at VSL International (Bouygues Constr. Group)
✓ ivan.puig@upc.edu

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TC218 Reinforced Fill Structures

How TC218 Started:

- MSE walls and reinforced soil structures were part of TC211 (Ground Stabilization) until 2017
- Rapid growth in the field highlighted the need for a dedicated committee
- John Sankey initiated the formation of TC218

TC Chair: Giulia Lugli
Vice Chair: Oliver Detert
Secretary: Shahriar Mirmirani

TC 218 – Main Objective

- Established to promote and disseminate knowledge on reinforced soil structures globally
- Improve understanding and application of reinforced fill technologies
- Support the design and implementation in geotechnical engineering
- Cover geosynthetic and metallic reinforcement systems

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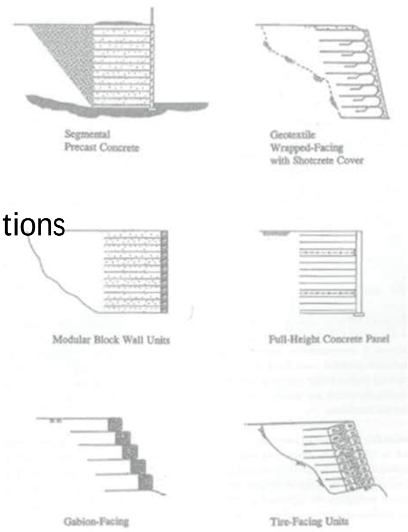
TC218 Reinforced Fill Structures

Importance for the Geotechnical Community

- Reinforced soil systems are widely used worldwide
- Support safer and more cost-effective infrastructure solutions
- Promote more sustainable geotechnical practices
- Connect academic research with industry experience
- Consolidate international expertise



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TC218 Reinforced Fill Structures

Activities and Events

- **Sessions and workshops** at major ISSMGE conferences
- Regular **online seminars** for members
- **Working groups** on selected technical topics
- **Presentations** on projects, innovations, and research results
- **Collaboration** with organizations such as IGS
- Periodic updates via LinkedIn
- Quarterly Meetings

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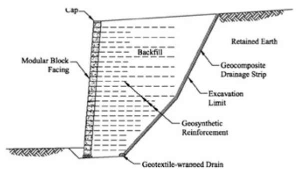
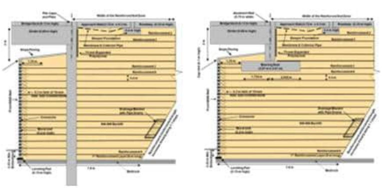
TC218 Reinforced Fill Structures

Jan. 22nd, 2026

Key Technical Topics

- Mechanically Stabilized Earth Structures
- Reinforced Soil Bridge Abutments
- Use of Marginal Soils as Construction Materials
- Information Sharing on Current Technical Topics
- Updates on Upcoming Events and Activities





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TC218 Reinforced Fill Structures

Access to TC Information

- Reports available on the ISSMGE website
- Webinar recordings and newsletters published online
- Regular updates on LinkedIn
- Additional documents shared via GeoWorld (with **1878** members)
- Working group results made available to members

GeoWorld

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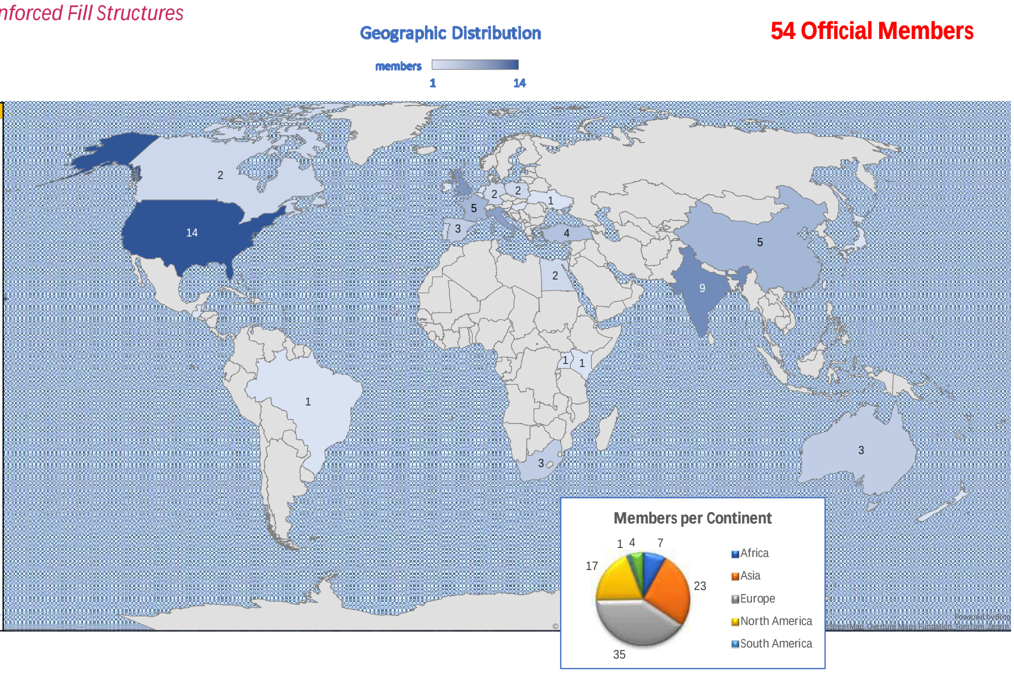
TC218 Reinforced Fill Structures

54 Official Members

Country	Count
Australia	3
Belgium	1
Brazil	1
Canada	2
China	5
Egypt	2
France	5
Germany	2
Guatemala	1
Hong Kong	1
Hungary	1
India	9
Ireland	1
Italy	7
Japan	1
Kenya	1
Lebanon	1
Luxembourg	1
Netherlands	1
New Zealand	1
Poland	2
Portugal	2
Slovenia	1
South Africa	3
Spain	3
Taiwan	1
Turkey	4
Uganda	1
Ukraine	1
United Kingdom	8
United States	14
Grand Total	**87**



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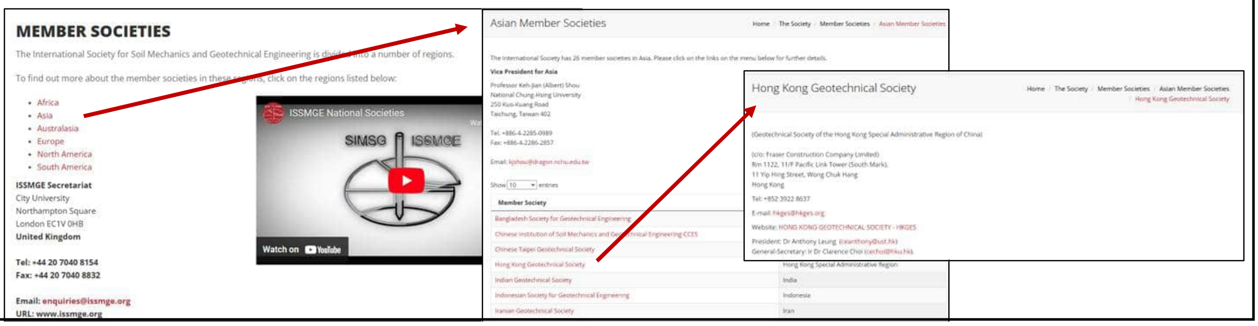
TC218 Reinforced Fill Structures

TC218 membership - How does it works

- **To be a member of TC 218, submit your request to your Member Society**
- Official Members must be members of the ISSMGE
- Each Member Society may nominate up to two (2) members to serve on each TC.
- Other individuals may be added as Corresponding Members but with no voting right. This should be requested through your Member Society as well.



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INTERNATIONAL GEOSYNTHETICS SOCIETY

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International Geosynthetics Society (IGS): https://www.geosyntheticssociety.org/

- What we are: The International Geosynthetics Society (IGS) is a learned society dedicated to the scientific and engineering development of geotextiles, geomembranes, related products, and associated technologies.
- Who we are: IGS is a global community of 4,000 members including corporate, individual and student members, with a shared passion for what geosynthetics can achieve. With 45 chapters worldwide → easy to connect with us locally!
- What we do: We provide greater understanding of geosynthetic technology and promote its appropriate use throughout the world.

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TC Soil Reinforcement (TC-R)

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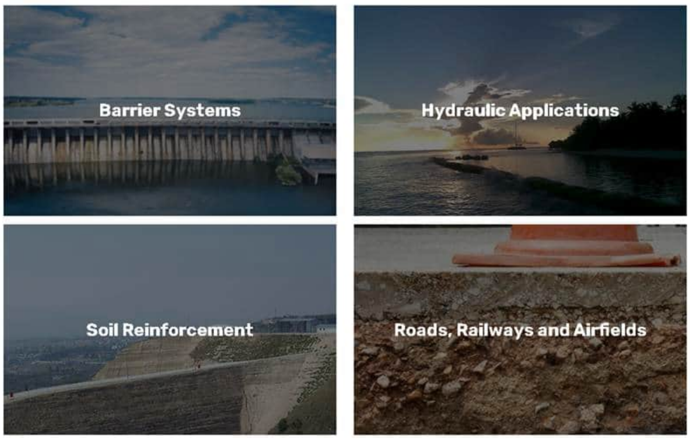
The IGS's TCs: https://www.geosyntheticssociety.org/council-committees/technical-committees/



\+ **IGS Sustainability Committee**

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TC Soil Reinforcement (TC-R)

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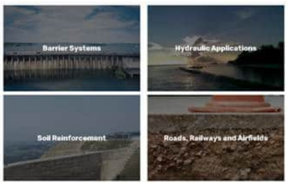
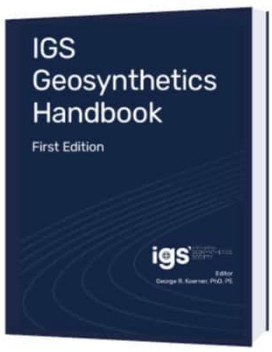


Edited by George R. Koerner. Chapters:

1. Introduction to Geosynthetics
2. Geosynthetics in Roads and Pavements
3. Geosynthetics in Subsurface Drainage
4. Geosynthetics in Erosion and Sediment Control
5. Geosynthetics in Reinforced Soil Systems
6. Geosynthetic Barriers in Seepage Control Systems
7. Geosynthetics in Environmental Protection
8. Geosynthetic Support Systems



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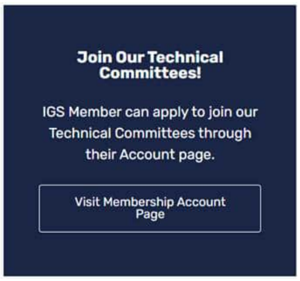
TC Soil Reinforcement (TC-R)

The IGS/TC-R:

https://www.geosyntheticssociety.org/council-committees/technical-committees/soil-reinforcement/

- Chair: Ivan P. Damians, co-chairs: Fernanda Ferreira and Pietro Rimoldi; Secretary: Yewey Zheng; Advisor: Yoshihisa Miyata.
- We are currently **99 members** from 27 different countries, well representing both Academia and professional engineering companies in the field.

https://www.linkedin.com/showcase/igs-technical-committee-soil-reinforcement



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TC Soil Reinforcement (TC-R)

The IGS/TC-R – Activities:

https://www.geosyntheticssociety.org/council-committees/technical-committees/soil-reinforcement/

- Organization and participation in Special Sessions in the field. Recent examples:
  - ✓ 6th EGRWSE (June 2025, Vigo)
  - ✓ EuroGeo8 (September 2025, Lille)
  - ✓ GeoAsia8 (June 2025, Brisbane)
  - ✓ 17th IACMAG (December 2025, Hong Kong)
  - ✓ 13ICG (September 2026, Montréal)
  - ✓ ...
- *The Richard* ***Bathurst Lecture***

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TC Soil Reinforcement (TC-R)

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TC-R Workshops:

https://www.geosyntheticssociety.org/council-committees/technical-committees/soil-reinforcement/

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TC Soil Reinforcement (TC-R)

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TC-R Workshops:

https://www.geosyntheticssociety.org/council-committees/technical-committees/soil-reinforcement/

Proceedings available (free!)

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TC Soil Reinforcement (TC-R)

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Next TC-R Workshop: https://www.geosyntheticssociety.org/events/5th-workshop-of-igs-tc-reinforcement-issmge-tc-218/

5th Workshop of the IGS/TC-R & ISSMGE/TC-218

Mediterranea University
Via dell'Universita, 25 - 89124 Reggio Calabria, Italy

Università degli Studi Mediterranea di Reggio Calabria

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TC Soil Reinforcement (TC-R)

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Next TC-R Workshop: 5th Workshop of the IGS/TC-R & ISSMGE/TC-218

DAY 1 - TUESDAY 7 JULY

PRESENTATION	SPEAKER
MORNING SESSION: SEISMIC	
Mechanical and Dynamic Behaviour of Fiber-Reinforced Soils at Very Small Strains	Ioannis N. Markou
Modal analyses methods for the seismic response of reinforced soil walls	Pietro Rimoldi
The Influence of Soil and Reinforcement Stiffness on the Seismic Response of MSE Walls: A Time-History Dynamic Analysis	Oltion Korini
Geofoam seismic buffers for unreinforced retaining walls and geosynthetic MSE walls	Richard J. Bathurst
LUNCH BREAK	
AFTERNOON SESSION: CASE HISTORIES	
Geosynthetic Reinforcement Concepts for Temporary Construction Roads in Linear Infrastructure Projects	Oliver Detert
The use of geosynthetics in the construction of the Eco-Park of Durres: a symbol of sustainability, resilience and recycling strategy	Lidia Sarah Calvarano
Use of Precast RC Arch (Replacement of conventional RC culvert) in combination with MSE wall	Karim Mohsen
Reinforcement of a Huge Landslide in Northern Italy through a Geogrid Reinforced Steep Slope 60.0 m high	Daniele Cazzuffi
EVENING: BEACHSIDE COCKTAIL HOUR	

DAY 2 - WEDNESDAY 8 JULY

PRESENTATION	SPEAKER
MORNING SESSION: DESIGN / NUMERICAL	
Displacement Method for the horizontal deformation of reinforced soil walls from Limit Equilibrium calculations	Pietro Rimoldi
Design and Durability of Polymeric-Coated Steel Woven Wire Mesh Reinforcements under the New Eurocode 7-3 (2025) Framework	Marianna Ferrara
3D numerical modelling of geogrids isolated and confined in soil	Margarida Pinho-Lopes
Design and Performance of Geosynthetic Reinforced Soil Systems with Vertical Facings	July Ellen Jaramillo Castro
Design Method of veneer cover soils under static and seismic loading conditions	Fabrizia Trovato
Numerical Assessment of Geosynthetic for Mitigating Seasonal Temperature Change-induced Problems for Integral Bridge Abutments	Yuqiu Ye
LUNCH BREAK	
AFTERNOON SESSION: TESTING / MATERIAL FEATURES	
Pull-out and direct shear behavior of geogrid-recycled aggregate interfaces	Maximilien Van Breusegem
Evaluation of the accuracy of analytical models for pullout resistance using polymeric straps reinforcements	Anibal Moncada
GSY/GSY Interface Characterization by means of Inclined Plane and Direct Shear Tests	Paolo Carrubba
Tensile Behaviour of Geosynthetics Made from Recycled Polymers after Mechanical Damage under Repeated Loading	Fernanda Bessa Ferreira
EVENING: WORKSHOP DINNER	

DAY 3 - THURSDAY 9 JULY

PRESENTATION	SPEAKER
MORNING SESSION 1: MARGINAL FILLS / SUSTAINABILITY	
Sustainability evaluation of different backfill materials used in geosynthetic reinforced soil walls	Ivan P. Damians
Development of an LCA-Based Tool for Comparing MSE walls and Conventional Earth Retaining Structures.	Edoardo Forte
The use of CLSM (Controlled Low-Strength Material) material as reinforced backfill material in MSE wall	Raynoos Ahmed
COFFEE BREAK	
MORNING SESSION 2: BASAL REINFORCEMENT	
Enhancing Railway Ballast Performance through Reclaimed Materials and Innovative Geosynthetic Confinement	Stanislav Lenart
Basal reinforcement design for piled embankments: a parametric comparison between analytical approaches and numerical modelling	Oltion Korini
33 Years of Instrumentation Experience with Geotextile Basal Reinforcement	Oliver Detert
CLOSING REMARKS & FAREWELL	

Mediterranea University
Via dell'Universita, 25 - 89124 Reggio Calabria, Italy

Università degli Studi Mediterranea di Reggio Calabria

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TC218 Reinforced Fill Structures

Subcommittee: Use of Marginal Fill in Reinforced Fill Structures

SC Chair: Ratnakar Mahajan

Main Goals of the Subcommittee

- **Collection of relevant standards, documents, literature, and Case Histories**
- **Preparing a Booklet**
- **Develop a Webinar**

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CIMNE

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

igs

Pullout response of polyester strap reinforcements and Reclaimed Asphalt Pavement (RAP)

Anibal Moncada[1)], Ivan P. Damians[2)], Shuxiong Xao[3)], Sebastià Olivella[1)], Richard J. Bathurst[4)]

[1)] Universitat Politècnica de Catalunya·BarcelonaTech (UPC), International Centre for Numerical Methods in Engineering (CIMNE), Spain.

[2)] Universitat Politècnica de Catalunya·BarcelonaTech (UPC), International Centre for Numerical Methods in Engineering (CIMNE), and VSL Construction Systems, Spain; International Geosynthetics Society (IGS), Austin, Texas, USA.

[3)] Department of Civil and Environmental Engineering (DECA), Universitat Politècnica de Catalunya – BarcelonaTech (UPC), 08034 Barcelona, Spain.

[4)] GeoEngineering Centre at Queen's-RMC, Civil Engineering Department, Royal Military College of Canada, Canada.

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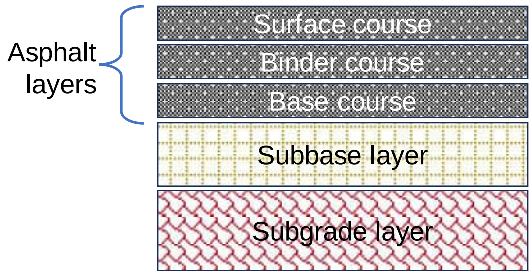
Background

(European Asphalt Pavement Association EAPA, 2024)

- Recycled (or reclaimed) asphalt pavement (RAP).
  - Sourced from maintenance, replacement, and/or demolition of existing paved roads.
  - 2.75 Mt of site-won asphalt generated in 2024 (Spain) (EAPA, 2024), around **50 Mt** of material available Europe-wide.
  - ~ 65-75% used in new asphalt mixes; ~25%-30% can be use as granular material for engineering applications (**~12.5 to 15 Mt**); and ~ 5% to landfill.



Country	Total amount of site-won asphalt generated in 2024 [tonnes]
Austria	2.200.000
Czech Rep.	2.900.000
Denmark	1.374.000
France	9.529.600
Germany	14.100.000
Norway	1.642.000
Spain	2.750.000
Switzerland	1.650.000
Turkiye	2.214.400
…	…

Background

- Viability of RAP as backfill material in reinforced soil walls (RSWs)?
- Properties must be evaluated for short- and long-term conditions:
  - Direct shear tests
  - **Pullout tests**
  - Hydraulic conductivity
  - Creep?
  - Chemical composition
  - …

(AASHTO, 2024)

$$P_r = f'\,(C\,w\,L_e\,s_v)$$

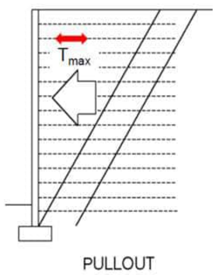
$$f' = \alpha\,F^* = \alpha R_i \tan(\phi_{soil})$$

$$P_r = \boxed{\alpha\,R_i \tan(\phi_{soil})}\,(C\,w\,L_e\,s_v)$$

$$\mathbf{C_i \tan(\phi_{soil}) = \tan(\delta)}$$

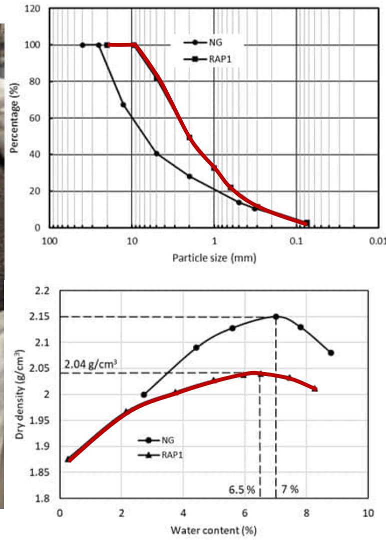
$$\left.\begin{array}{l}\alpha = 0.8\\ R_i = 0.67\end{array}\right\}\ C_i = 0.54$$

(default AASHTO values for geosynthetics)



Materials

- Well graded RAP.
- $\gamma_{dry} = 2.04$ t/m^3
- $w_{opt} = 6.5\%$ (tests carried out with values of w = 5-6%)



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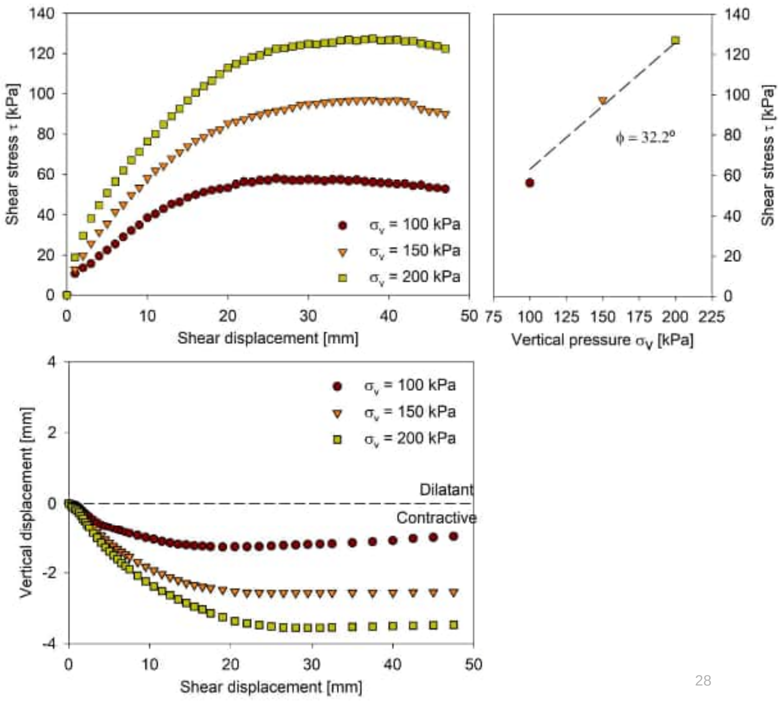
Materials

- Well graded RAP.
- $\gamma_{dry} = 2.04$ t/m^3
- $w_{opt} = 6.5\%$ (tests carried out with values of w = 5-6%)
- $\phi_{peak} = 32^o$ (with w_{opt})
- Null cohesion.
- Contractive response.



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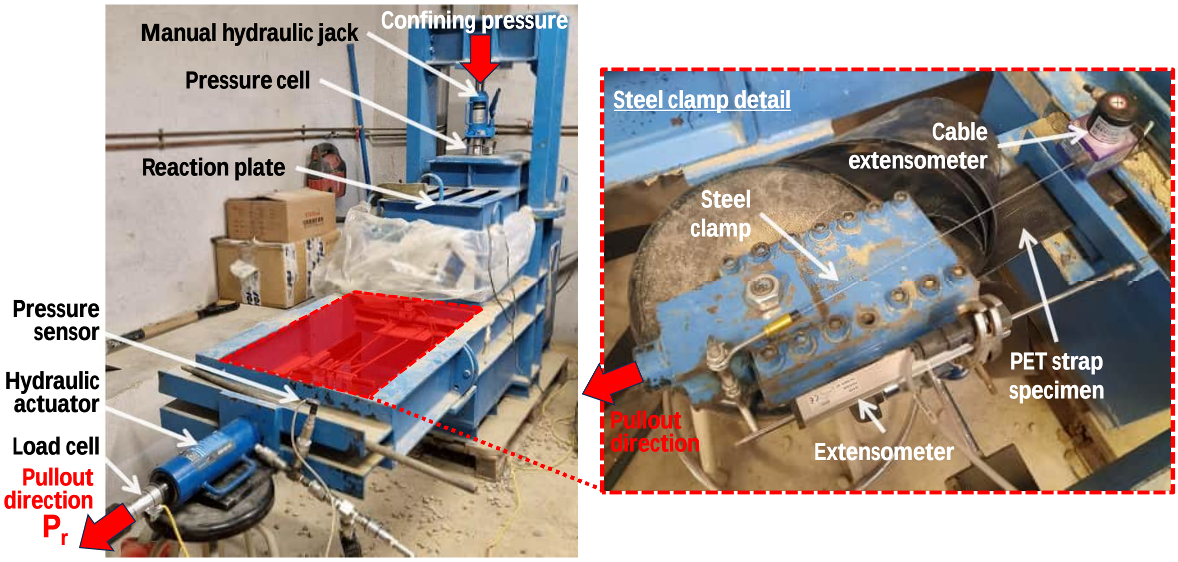
Methodology



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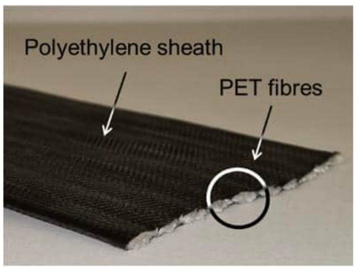
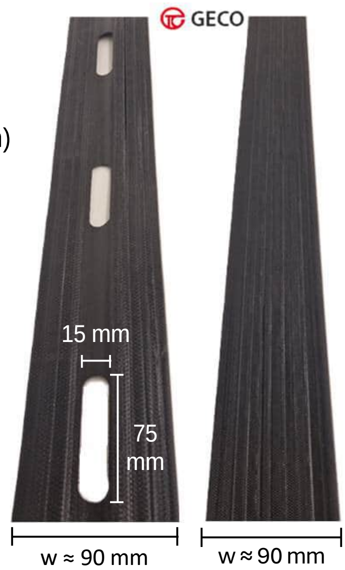
Methodology

- Grade 30 strap reinforcements.
- Continuous and punctures sheaths.
- Vertical pressures of 30 to 140 kPa (Simulated depths of 1.5 to 7 m)
- Constant rate of strain: **1 mm/min**
- In-soil temperature of 20±1ºC





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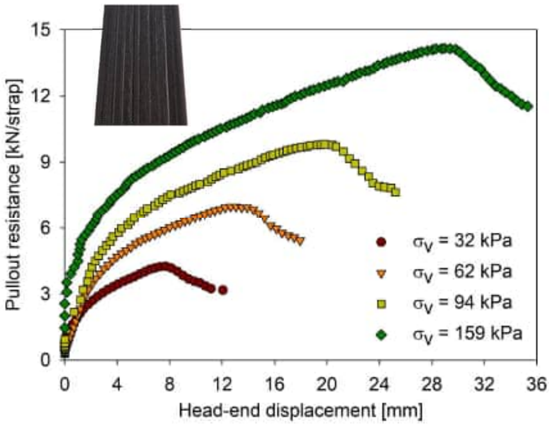
Results

- Results with continuous sheaths.
- Constant rate of strain: **1 mm/min**
- In-soil temperature of 20±1ºC



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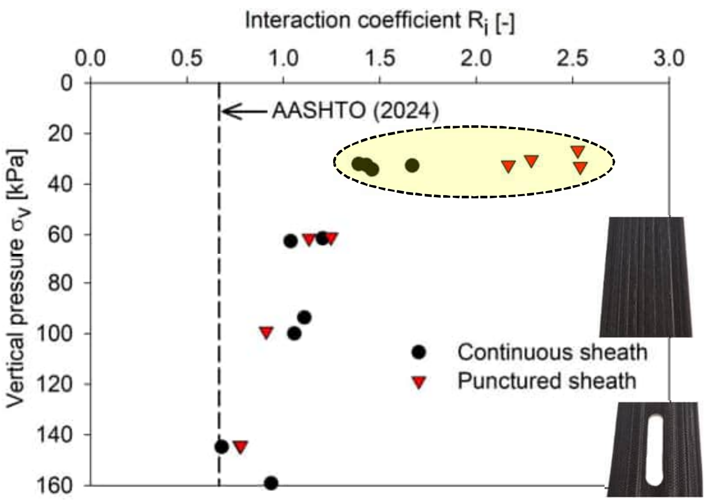
Results

$P_r = \alpha R_i \tan(\phi_{soil})\ (C\ w\ L_e\ s_v)$

$\alpha = 0.8$

$R_i = 0.67$ (AASHTO, 2024)

- Constant rate of strain: **1 mm/min**
- In-soil temperature of 20±1ºC
- Measured interaction coefficient can be over twice the suggested value, particularly for low vertical pressure scenarios **Suitable material !**
- Noticeable difference in performance between geometries for low vertical pressure scenarios



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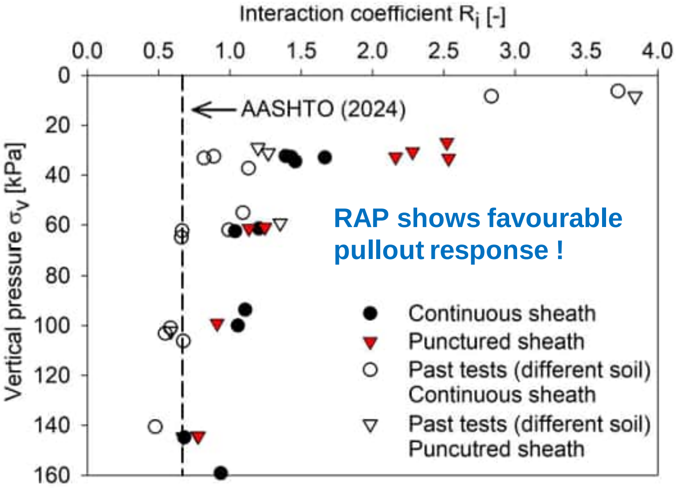
Results



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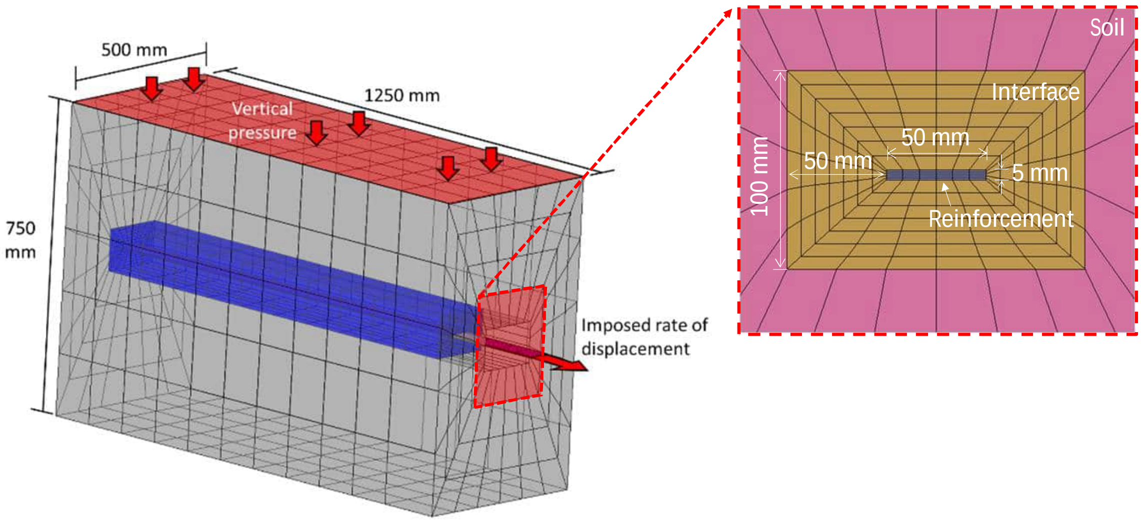
Numerical model - CODE_BRIGHT



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Numerical model - CODE_BRIGHT

- Soil + interface materials
  - Elasticity: linear
  - Plasticity: Drucker-Prager based on Mohr-coulomb parameters
- Reinforcement
  - Elasticity: linear, porosity dependent

Properties	Soil	Interface	Reinforcement
Unit weight (kN/m3)	20	20	70
Elastic modulus (MPa)	30	30	$E = E_0 + (\phi-\phi_0)*dE/d\phi \geq E_{min}$
			E_{min} = 1282 (J@3%)
			E_0 = 1989 (J@1%)
Poisson's ratio (-)	0.3	0.45	0.3
Cohesion (kPa)	0	0	-
Friction angle (º)	32	**Variable**	-
Dilatancy angle (º)	0	0	-
Initial porosity ϕ_0(-)	0.20	0.20	0.005

35

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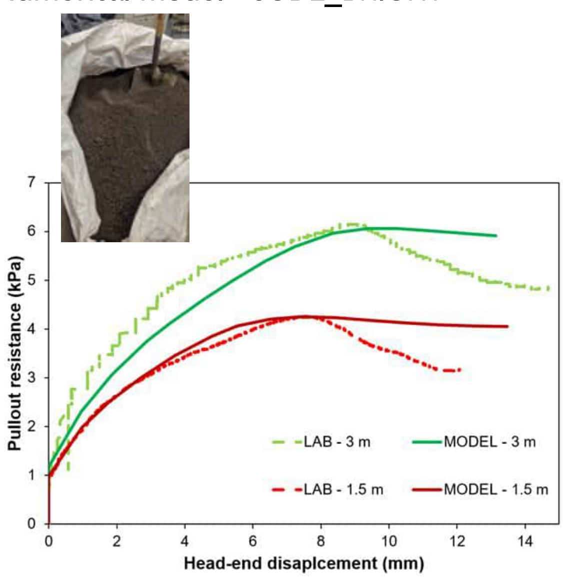
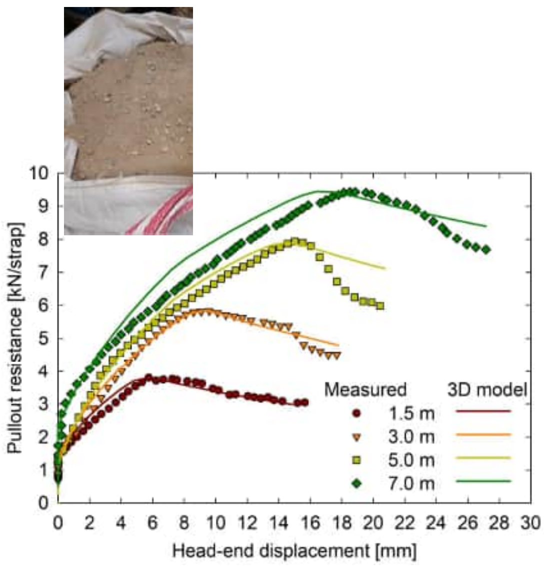
Numerical model - CODE_BRIGHT





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Closing remarks

- Tested RAP material has an adequate pullout response. The use of recycled materials can result in considerable environmental benefits.
- Measured interaction factors (R_i) showed a non-linear response with vertical pressure.
- Numerical simulations were carried out with CB. The force-displacement pullout response was properly reproduced, specially for shallow depths (i.e., low vertical pressure scenarios). The system's response is particularly sensible to reinforcement stiffness and soil strength parameters
- On-going temperature tests to evaluate the material sensitivity as well as the long-term response.

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Pullout response of polyester strap reinforcements and Reclaimed Asphalt Pavement (RAP)

Thank you for your attention !

Anibal Moncada[1)], Ivan P. Damians[2)], Shuxiong Xao[3)], Sebastià Olivella[1)], Richard J. Bathurst[4)]

[1)] Universitat Politècnica de Catalunya·BarcelonaTech (UPC), International Centre for Numerical Methods in Engineering (CIMNE), Spain.

[2)] Universitat Politècnica de Catalunya·BarcelonaTech (UPC), International Centre for Numerical Methods in Engineering (CIMNE), and VSL Construction Systems, Spain; International Geosynthetics Society (IGS), Austin, Texas, USA.

[3)] Department of Civil and Environmental Engineering (DECA), Universitat Politècnica de Catalunya – BarcelonaTech (UPC), 08034 Barcelona, Spain.

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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AGENDA

Updates from ISSMGE TC-218 and IGS TC-R, *Shahriar Mirmirani & Ivan P. Damians*

Presentations by the Marginal / Alternative Fills Subcommittee, ***Shahriar Mirmirani***

- **Aníbal Moncada Ramírez / Ivan P. Damians**: Pullout Response of Polyester Strap Reinforcements and Reclaimed Asphalt Pavement (RAP): Influence of Confinement and Environmental Conditions
- **Castorina Vieira**: Use of Recycled Construction and Demolition Wastes as Backfill in Geosynthetic-Reinforced Soil Structures
- **Lizeth Ardila/ Oliver Detert**: Geosynthetics Mechanically Stabilized Earth Walls: Numerical Modeling and Case Studies in South America
- **Erol Guler**: Centrifuge and shaking table test results analysing MSE walls using clay backfill

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- **Mitul Dalwadi**: Load-Carrying Reinforced Soil Bridge Abutments – Integral and Semi-Integral Bridges: Design and Construction with UK Experience (Including Carbon Assessment)

Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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2026 AUSTRIA VIENNA WHERE IT ALL BEGAN 21st ICSMGE

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USE OF RECYCLED CONSTRUCTION AND DEMOLITION WASTES AS BACKFILL IN GEOSYNTHETIC-REINFORCED SOIL STRUCTURES

CASTORINA SILVA VIEIRA

U.PORTO FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

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OUTLINE

1. Background
2. Recycled Construction and Demolition Wastes
3. Characterisation of recycled C&D waste and its interaction with geosynthetics
4. Pilot installation
5. Main Conclusions

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BACKGROUND

❖ Construction sector accounts for ≈50% of all extracted materials

❖ Construction and demolition (C&D) waste: largest waste stream in the EU (>35% of total waste generation); identified as a priority waste stream

EUROPEAN COMMISSION

A new Circular Economy Action Plan
For a cleaner and more competitive Europe

Research

❖ Demonstrate the satisfactory performance of geosynthetic-reinforced structures built with recycled C&D waste throughout their design working life

❖ Promote the use of recycled C&D waste as a sustainable replacement for traditional backfill materials, thus contributing towards the implementation of circular economy in the construction sector and a resource-efficient world

12 RESPONSIBLE CONSUMPTION AND PRODUCTION
SUSTAINABLE DEVELOPMENT GOALS

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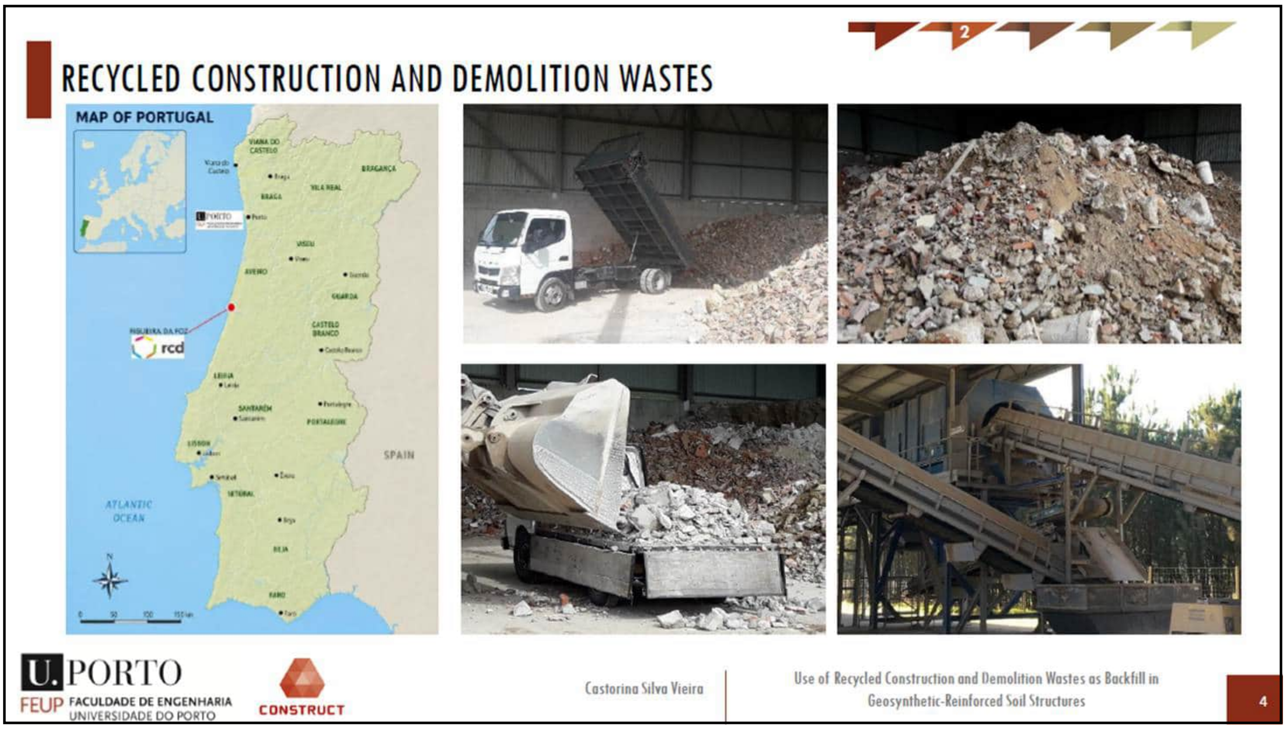

2
RECYCLED CONSTRUCTION AND DEMOLITION WASTES
MAP OF PORTUGAL
rcd
SPAIN
ATLANTIC OCEAN
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2
RECYCLED CONSTRUCTION AND DEMOLITION WASTES
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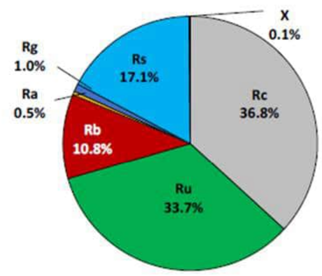
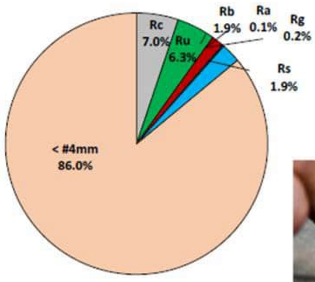
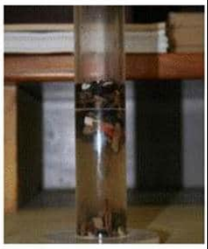
CHARACTERISATION OF RECYCLED C&D WASTE AND ITS INTERACTION WITH GEOSYNTHETICS

Classification test for the constituents (EN 933-11)







Floating particles

Rc: Concrete, concrete products, mortar, concrete masonry units. **Ru**: Unbound aggregate, natural stone, hydraulic bound aggregate. **Rb** :Clay masonry units, calcium silicate masonry units; **Ra**: Bituminous materials, **Rg**: Glass; **Rs**: Soils X: Other materials; **FL**: Floating particles (cm^3/kg).

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CHARACTERISATION OF RECYCLED C&D WASTE AND ITS INTERACTION WITH GEOSYNTHETICS

Assessment of the contamination risk

Leaching test

Parameter (mg/kg of dry matter)	Batch 1	Batch 2	Batch 3	Acceptance criteria for leached concentrations – Inert landfill
Arsenic, As	0.020	0.021	0.024	0.5
Lead, Pb	< 0.01	< 0.01	< 0.01	0.5
Cadmium, Cd	< 0.003	< 0.003	< 0.003	0.04
Chromium, Cr	0.015	0.012	< 0.01	0.5
Copper, Cu	0.12	0.10	0.039	2
Nickel, Ni	< 0.01	0.011	< 0.01	0.4
Mercury, Hg	< 0.002	< 0.002	< 0.002	0.01
Zinc, Zn	< 0.1	<0 .1	< 0.1	4
Barium, Ba	0.12	0.11	0.098	20
Molybdenum, Mo	0.027	0.018	0.026	0.5
Antimony, Sb	< 0.01	< 0.01	< 0.01	0.06
Selenium, Se	< 0.01	< 0.02	< 0.02	0.1
Chloride, Cl	130	300	150	800
Fluoride, F	2.7	6.1	3.3	10
Sulphate, SO_4	**1900**	**3200**	**2300**	1000
Phenol index	< 0.05	< 0.05	< 0.05	1
Dissolved Organic Carbon, DOC	47	220	31	500
Total Dissolved Solids, TDS	2630	**6580**	**4530**	4000*
pH	7.8	8.2	8.3	-

Leaching test in accordance with EN 12457-4

"(o) If the waste does not meet this limit, it may still be considered to comply with the acceptance criteria provided that leaching does not exceed 6000 mg/kg at a solid-to-liquid ratio of 10 l/kg..."

*The evaluation of TDS is not compulsory to the classification as inert material

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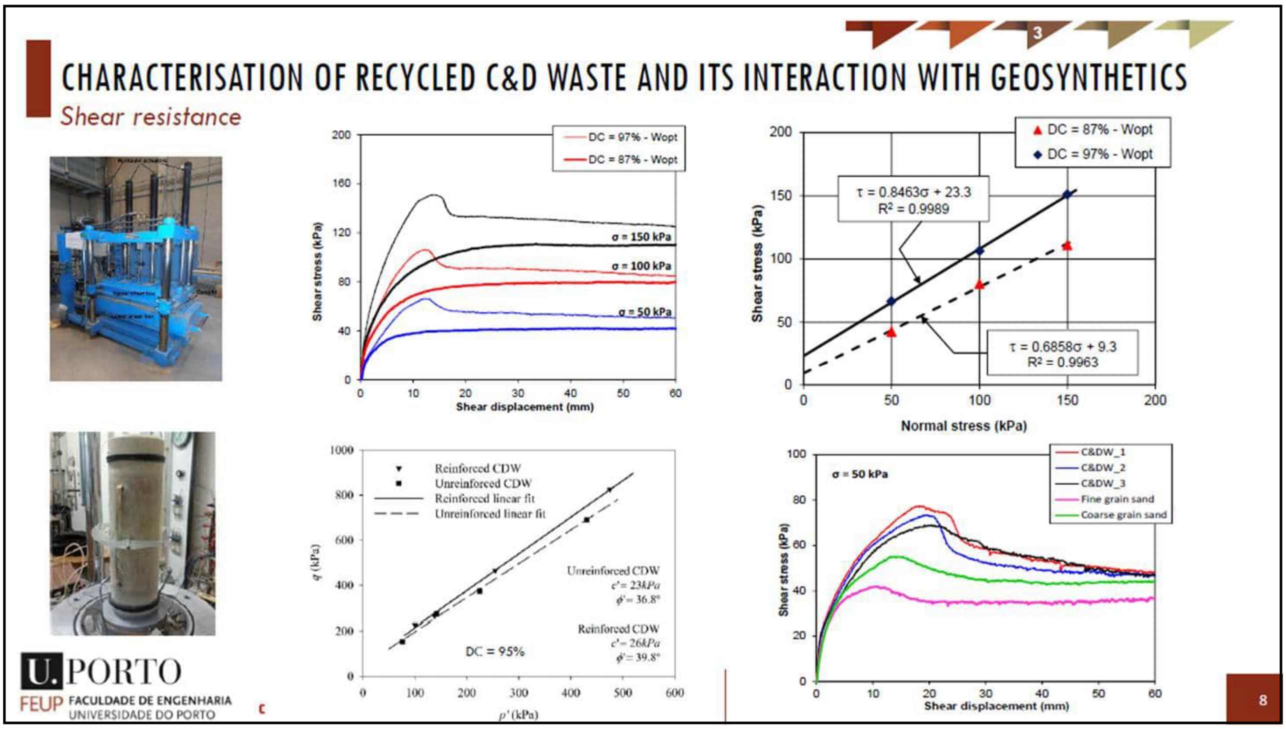
3
CHARACTERISATION OF RECYCLED C&D WASTE AND ITS INTERACTION WITH GEOSYNTHETICS
Shear resistance
DC = 97% - Wopt
DC = 87% - Wopt
σ = 150 kPa
σ = 100 kPa
σ = 50 kPa
Shear stress (kPa)
Shear displacement (mm)
DC = 87% - Wopt
DC = 97% - Wopt
τ = 0.8463σ + 23.3
R² = 0.9989
τ = 0.6858σ + 9.3
R² = 0.9963
Shear stress (kPa)
Normal stress (kPa)
Reinforced CDW
Unreinforced CDW
Reinforced linear fit
Unreinforced linear fit
Unreinforced CDW
c' = 23kPa
φ' = 36.8°
Reinforced CDW
c' = 26kPa
φ' = 39.8°
DC = 95%
q (kPa)
p' (kPa)
σ = 50 kPa
C&DW_1
C&DW_2
C&DW_3
Fine grain sand
Coarse grain sand
Shear stress (kPa)
Shear displacement (mm)
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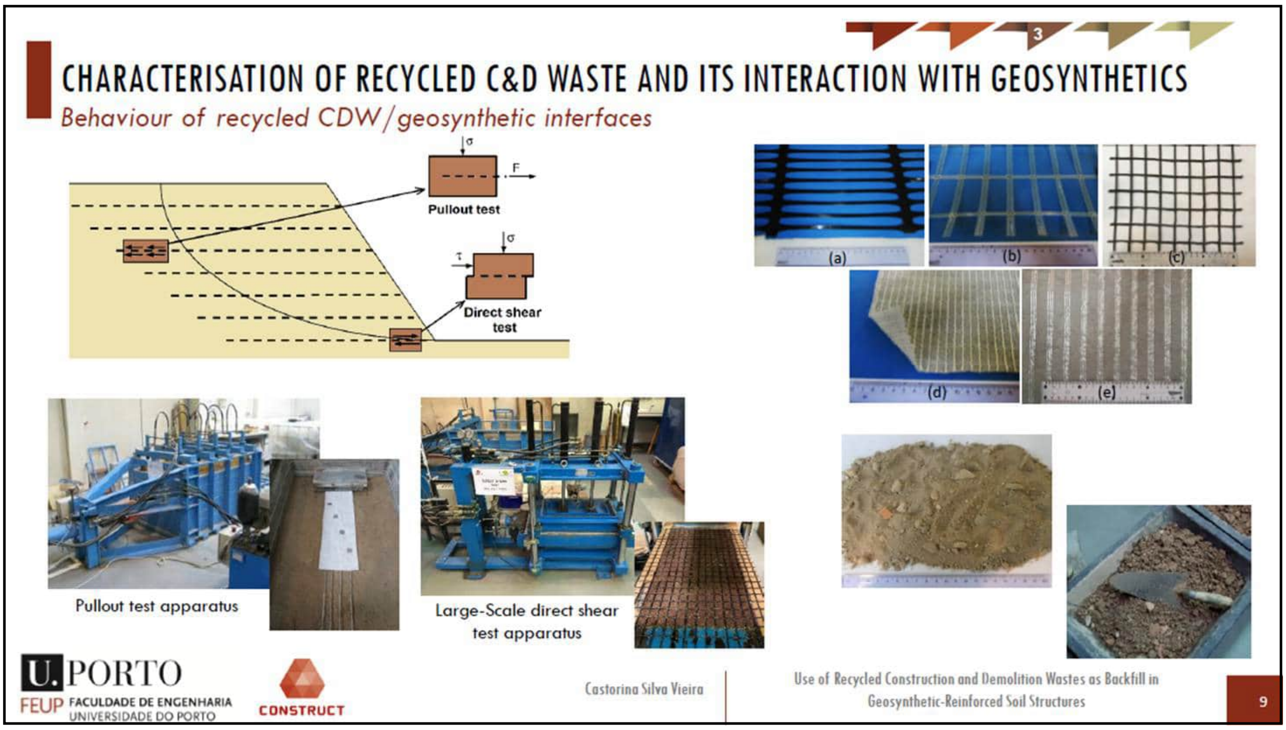
3
CHARACTERISATION OF RECYCLED C&D WASTE AND ITS INTERACTION WITH GEOSYNTHETICS
Behaviour of recycled CDW/geosynthetic interfaces
σ
F
Pullout test
τ
σ
Direct shear test
(a)
(b)
(c)
(d)
(e)
Pullout test apparatus
Large-Scale direct shear test apparatus
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CHARACTERISATION OF RECYCLED C&D WASTE AND ITS INTERACTION WITH GEOSYNTHETICS

Behaviour of recycled CDW/geosynthetic interfaces – Direct shear

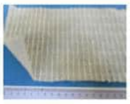
Interaction coefficient:

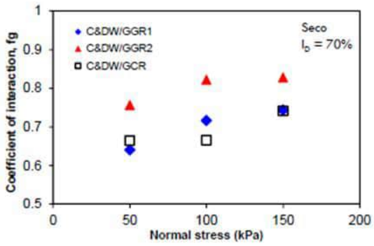
$$f_g = \frac{\tau^{max}_{C\&DW/geo}(\sigma)}{\tau^{max}_{C\&DW}(\sigma)}$$

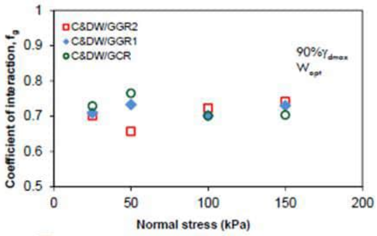
GGR1

GGR2

GCR







Authors	Type of geosynthetic	Material properties	Interaction coefficient
Abu-Farsakh et al (2007)	Uniaxial polyester geogrid	Areia; γ_{dmax} = 15.9 kN/m³; w_{opt} = 4.8%	0.95
		Clay; g_{dmax} = 16.9 kN/m³; w_{opt} = 16.5%	0.79 - 0.86
	Woven polypropylene geotextile	Areia; γ_{dmax} = 15.9 kN/m³; w_{opt} = 4.8%	0.74
		Clay; g_{dmax} = 16.9 kN/m³; w_{opt} = 16.5%	0.67 - 0.76
Liu et al. (2009b)	Uniaxial polyester geogrid	Sand; dry; I_D = 80%	0.90 - 0.94
	Woven polyester geotextile		0.71 - 0.78
Vieira et al. (2013)	High-strength geotextile (polypropylene and polyester)	Sand; dry; I_D = 70%	0.82 - 0.95
		Sand; dry; I_D = 90%	0.76 - 0.94
Ferreira et al. (2013)	High-strength geotextile (polypropylene and polyester)	Granite residual soil; I_D = 90%	0.65 - 0.74
	Biaxial polyester geogrid	Granite residual soil; I_D = 80%	0.79 - 0.95
Arulrajah et al. (2014)	Geogrelha biaxial de polipropileno	Recycled concrete aggregate; γ_d = 98%γ_{dmax}; w_{opt} = 12.5%	0.61 - 0.69*
		Crushed bricks; γ_d = 98%γ_{dmax}; w_{opt} = 12.7%	0.64 - 0.70*

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CHARACTERISATION OF RECYCLED C&D WASTE AND ITS INTERACTION WITH GEOSYNTHETICS

Behaviour of recycled CDW/geosynthetic interfaces – Direct shear

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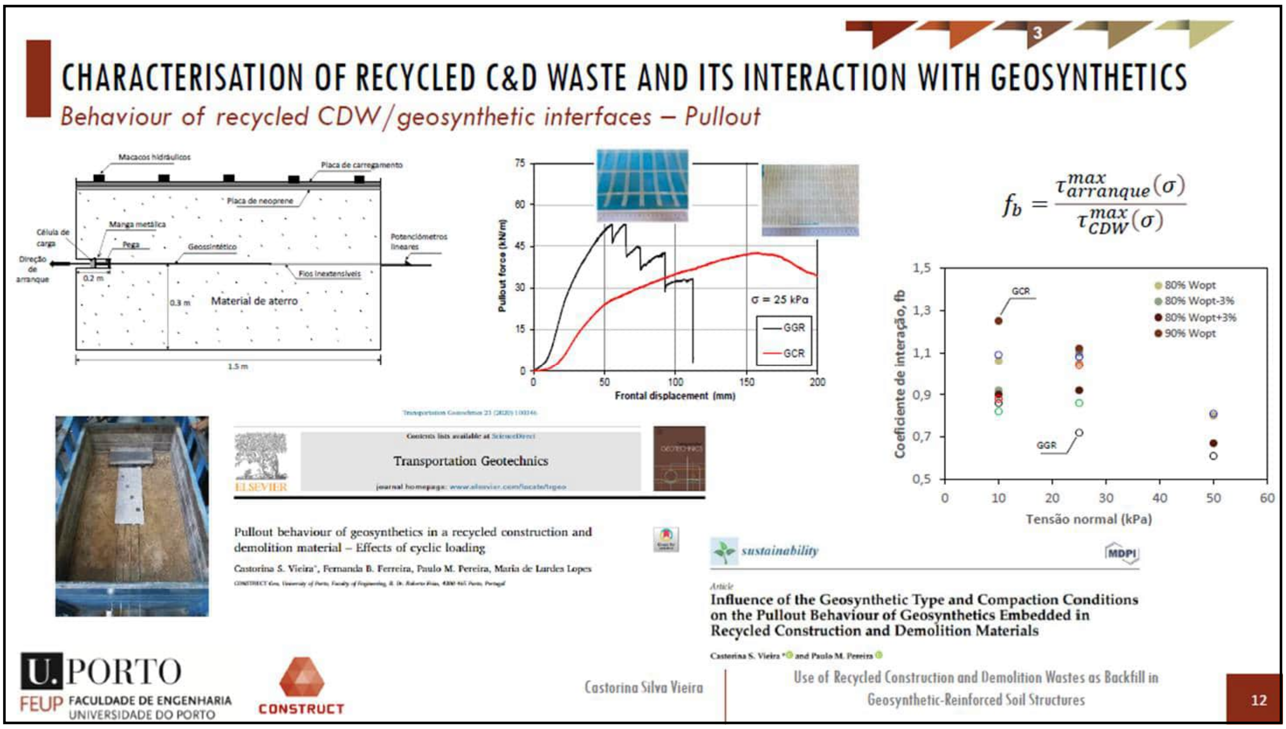
3
CHARACTERISATION OF RECYCLED C&D WASTE AND ITS INTERACTION WITH GEOSYNTHETICS
Behaviour of recycled CDW/geosynthetic interfaces – Pullout
Macacos hidráulicos
Placa de carregamento
Placa de neoprene
Manga metálica
Pega
Geossintético
Potenciómetros lineares
Fios inextensíveis
Material de aterro
1.5 m
σ = 25 kPa
GGR
GCR
Pullout force (kN/m)
Frontal displacement (mm)
$f_b = \frac{\tau_{arranque}^{max}(\sigma)}{\tau_{CDW}^{max}(\sigma)}$
80% Wopt
80% Wopt-3%
80% Wopt+3%
90% Wopt
Coeficiente de interação, fb
Tensão normal (kPa)
Transportation Geotechnics
Pullout behaviour of geosynthetics in a recycled construction and demolition material – Effects of cyclic loading
Castorina S. Vieira, Fernanda B. Ferreira, Paulo M. Pereira, Maria de Lurdes Lopes
sustainability
MDPI
Article
Influence of the Geosynthetic Type and Compaction Conditions on the Pullout Behaviour of Geosynthetics Embedded in Recycled Construction and Demolition Materials
Castorina S. Vieira and Paulo M. Pereira
U.PORTO
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Use of Recycled Construction and Demolition Wastes as Backfill in Geosynthetic-Reinforced Soil Structures
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PILOT INSTALLATION
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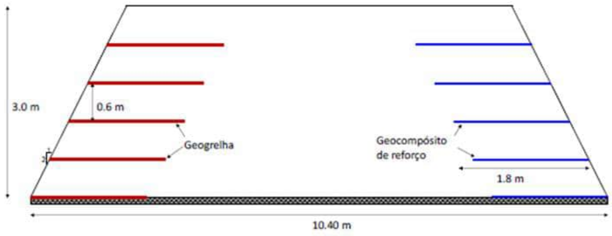
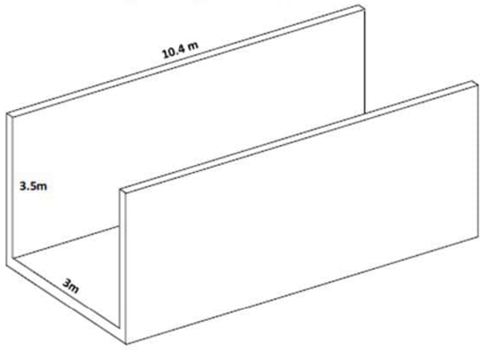
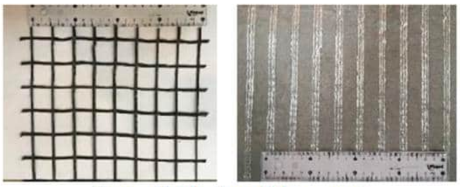
PILOT INSTALLATION
Overview







Geosynthetics for reinforcement

Backfill material

Drainage layer

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PILOT INSTALLATION

End of construction

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MAIN CONCLUSIONS

- It is important to remove contaminants (wood, metal, rubber, plaster, etc.) during demolition and recycling operations to ensure that the material meets the requirements set out in the standards/specifications.
- When properly compacted, C&D wastes exhibit shear strength similar to that of natural fill materials commonly used in the construction of geosynthetic-reinforced structures
- Leaching tests have shown that, in general, the use of these recycled C&D wastes do not pose environmental concerns.
- The pullout and shear strength of recycled C&D waste/geosynthetic interfaces proved to be adequate and within the expected range when soils are used as backfill material.
- The effects caused by the exposure of geosynthetics to CDW are similar to those caused by exposure to conventional backfill materials (tensile strength and creep failure)
- The performance of both reinforced slopes at the pilot installation has proven to be adequate.

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ACKNOWLEDGEMENTS

- To all colleagues and researchers involved in the research projects

fct Fundação para a Ciência e a Tecnologia

rcd resíduos de construção e demolição sa

GEOSIN GEOSYNTHETICS Representative SOLMAX

BBF Tecnologias do Ambiente

SOTECNISOL ENGENHARIA E AMBIENTE

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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AGENDA

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Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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GMSE Walls:
Numerical Modeling &
Case Studies in South America

Lizeth Ardila[1)], Oliver Detert[2)]

HUESKER
Ideen. Ingenieure. Innovationen.

[1)] HUESKER GROUP, BRAZIL

[2)] HUESKER GROUP, GERMANY

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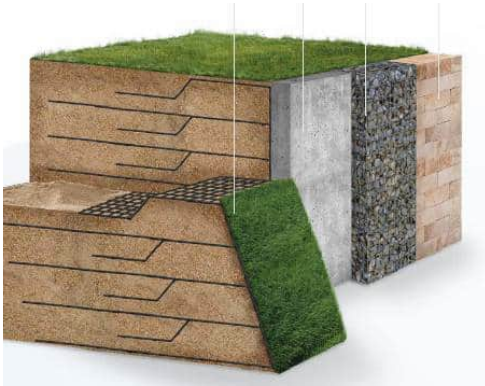
AGENDA

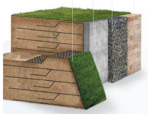
- BASIC MODELLING ASSUMPTIONS
- 2D AND 3D ANALYSIS
- SEISMIC PERFORMANCE
- INFLUENCE OF CONSTITUTIVE MODELS
- BACKFILL SOILS: SOUTH AMERICAN PERSPECTIVE
- CASE STUDY – BRAZIL
- CASE STUDY – ARGENTINA
- CASE STUDY – URUGUAY



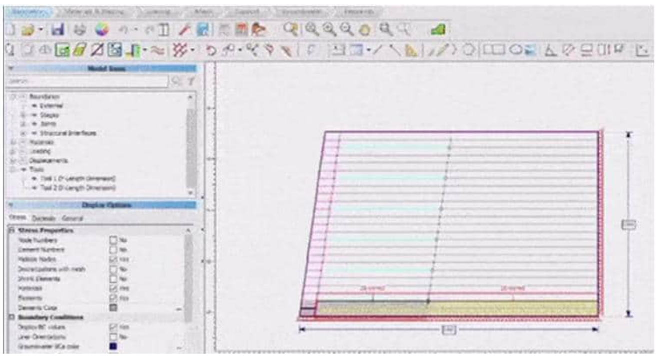
BASIC MODELLING ASSUMPTIONS

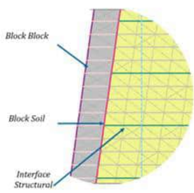
Results are highly dependent on modelling assumptions.

- Geometry.
- Reinforcement layers.
- Facing representation.
- Components interfaces.
- Boundary conditions.
- Construction staging.



Ardila Montilla, Schmidt, Silva, Rodriguez (2023, November). Applications and Modeling of Geosynthetics in Highway Infrastructure





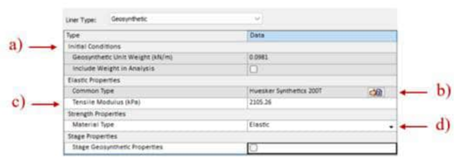
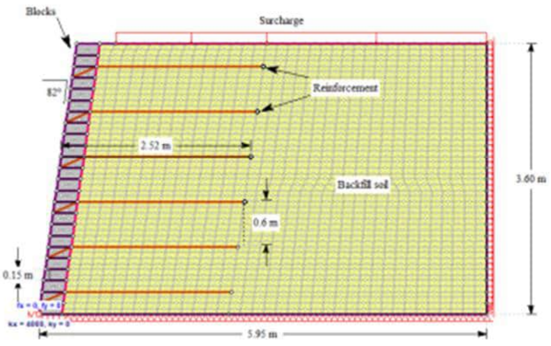
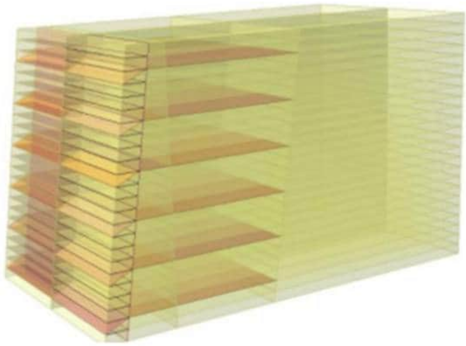


Fig. 8. Liner proprieties in RS2 and RS3- Rocscience

2D AND 3D ANALYSIS

- Which type of analysis???

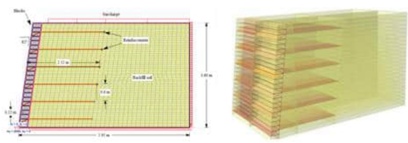




Ardila Montilla, Esquivel, Portelinha & Javankhoshdel (2021). 2D and 3D numerical study of geosynthetic mechanically stabilized earth GMSE walls

2D AND 3D ANALYSIS

- The elaboration and analysis of 3D models is much more complex, requires much more time, require higher data processing resources.



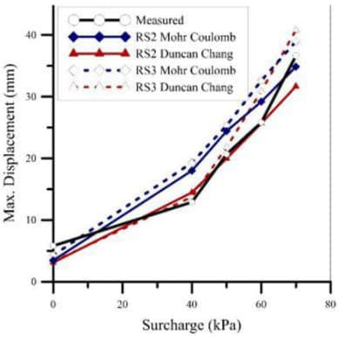


Figure 2. Maximum face displacement in surcharge load stages.

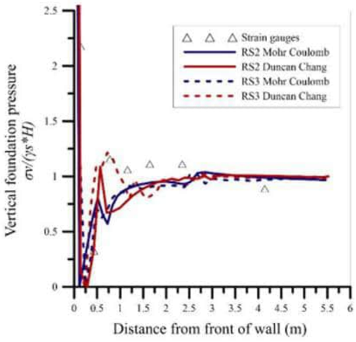
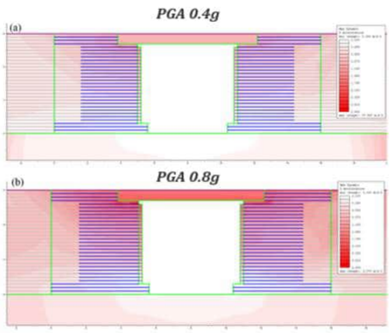


Figure 3. Vertical foundation pressure at end of construction.

Ardila Montilla, Esquivel, Portelinha & Javankhoshdel (2021). 2D and 3D numerical study of geosynthetic mechanically stabilized earth GMSE walls

SEISMIC PERFORMANCE

- Is the seismic condition the most critic factor?



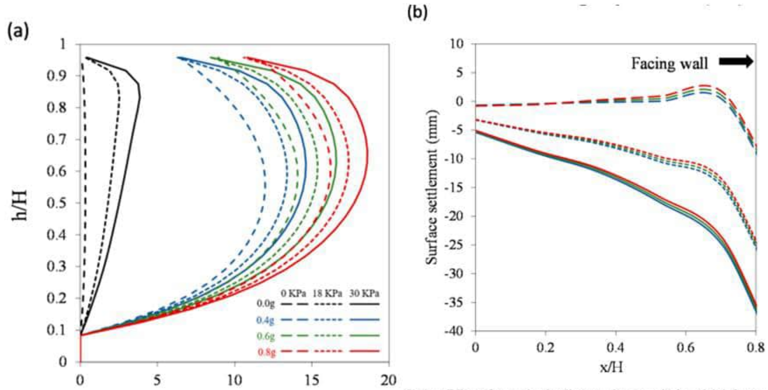


Fig. 10 Effect of operation loadings on the numerical model deformation **(a)** lateral facing displacement **(b)** surface settlement

Ardila Montilla., Portelinha & Esquivel (2024). Numerical Study of the Influence of Foundation Compressibility and Operational Loadings on the Seismic Behavior of Geosynthetic Reinforced Soil Bridge Abutments.

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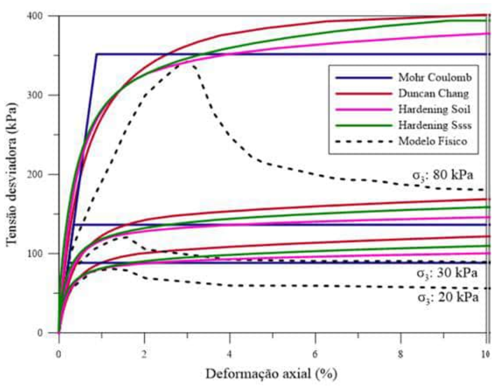
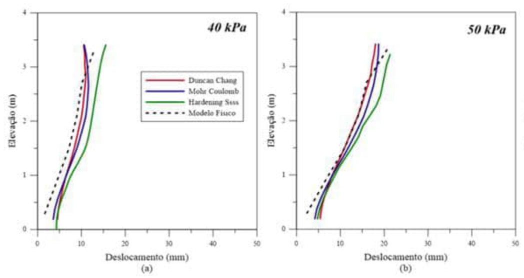
INFLUENCE OF CONSTITUTIVE MODELS

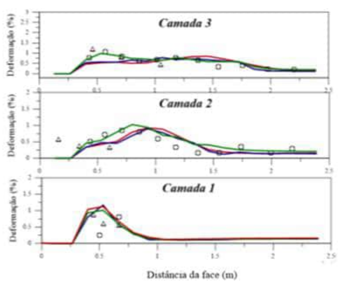
- Effect of the constitutive models of Soil



- Face



- Reinfocement



Ardila Montilla (2023). Estudo do desempenho de estruturas portantes de solo reforçado com geossintéticos GRS-IBS sob a ação de sismos

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BACKFILL SOILS: SOUTH AMERICAN PERSPECTIVE

- Many Different Soils

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BACKFILL SOILS: SOUTH AMERICAN PERSPECTIVE

- BRAZIL - **ABNT NBR 16920-1:2021**

Tabela 3 – Critérios de compactação de aterros para solos reforçados

Característica	Solos laterizados e outros	Solos arenosos
Grau de compactação mínimo (Proctor Normal)	≥ 98 %	≥ 95 %
Teor de umidade (w) em relação à umidade ótima (w_{ot})	$0{,}9\, w_{ot} \leq w \leq 1{,}05\, w_{ot}$	$0{,}8\, w_{ot} \leq w \leq 1{,}1\, w_{ot}$
Espessura máxima da camada acabada (compactada)	≤ 20 cm	≤ 25 cm

Os critérios nesta Tabela podem ser alterados, desde que justificados pelo projeto. A espessura máxima da camada lançada (não compactada) deve ser ajustada e controlada no decorrer da obra para atender aos critérios desta Tabela.

NOTA 1 Alternativamente, para areias, quando não for possível definir a curva de compactação, o controle de compactação é feito pelo ensaio de compacidade relativa. A compacidade relativa mínima é de 70 %.

NOTA 2 Para efeitos desta Tabela, a classificação dos solos arenosos, laterizados ou outros é baseada no Anexo A.

Tabela A.1 – Materiais de aterro recomendados para maciços de solo reforçado em função do tipo de aplicação, do tipo de reforço e do tipo de paramento (continua)

Materiais de aterro recomendados	Tipos de aterro		
Características geomecânicas	Arenosos	Solos laterizados [f h]	Outros [f h]
% com diâmetro inferior a 0,075 mm	< 35 %	≥ 35 %	–
IA – Índice de Atividade de Skempton [f]	< 0,75		–
Aplicação [a b c]			
Maciços com partes sujeitas a inundação e/ou rebaixamento rápido de nível d'água	B	B	C
Maciços do tipo encontro portante e/ou com limitações de deformação	B	B	C
Muros com inclinação > 70° e de altura > 12 m	B	B	C
Taludes reforçados com inclinação ≤ 70° e com altura > 12 m	A	A	C
Muros verticais e taludes reforçados, com altura ≤ 12 m, sem restrições a deformação	A	A	C
Tipo de reforço			
Tiras metálicas lisas ou geotiras lisas	A	C [d]	C [f]
Tiras metálicas nervuradas ou grelhas metálicas	A	A	C [f]
Geogrelhas, geotêxteis, malhas tecidas metálicas ou poliméricas	A	A	C [f]

Características geomecânicas	Arenosos	Solos laterizados [f h]	Outros [f h]
Paramento			
Rígido: painéis inteiriços, paramentos em concreto projetado	B	B	C
Semiflexível: placas pré-moldadas, blocos estruturais de concreto com junta seca	A	A	C
Flexível: paramento em gabiões, envelopameno com geossintético, telas metálicas e outros	A	A	C [e]

Legenda

A aplicável

B aplicável a critério do projetista

C aplicação depende de ensaios e estudos específicos adequados à finalidade, a critério do projetista

NOTA 1 As combinações típicas desta Tabela são dadas como recomendação geral, sem pretender ser uma especificação.

NOTA 2 As breves descrições desta Tabela para os tipos de aterro se referem apenas a algumas de suas principais característica e não necessariamente descrevem a totalidade de suas propriedades.

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CASE STUDY - BRAZIL

- Logistic Center, São Paulo
- Height 34 m and face ~3.500 m²

Brugger,Schpun, Ardila & Schmidt (2024). Design, construction and monitoring of a high mechanically stabilized earth wall with PVA geogrids.

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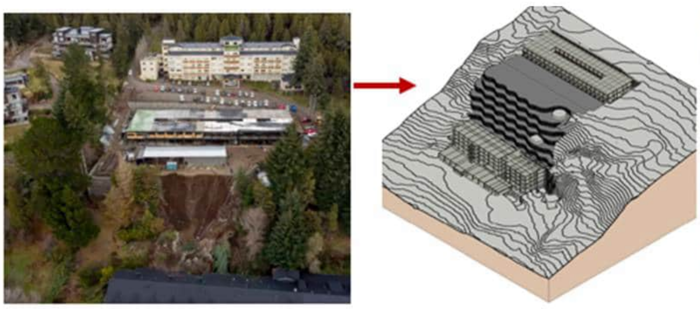
CASE STUDY - ARGENTINA

- hotel infrastructure, Bariloche
- Height 25 m and face ~2000 m²



Mendiz, De Loyola, Dal Farra & Ardila Montilla (2024). Mechanically Stabilized Earth (MSE) retaining wall at Hotel in Bariloche City. .

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CASE STUDY - BRAZIL

- Double deck Bridge, Caraguatatuba
- Height ~12 m and face ~5.000 m²


Schmidt, Brugger, Ardila, Cleto & Silva (2026). Geosynthetic Mechanically Stabilized Earth Wall as Lower Platform in a Double-deck Bridge: A Case Study.

69

69

CASE STUDY - URUGUAY

- Roadway Bridge, Parque del plata
- Height ~6 m

Ardila, Brugger, Burger, Curiel, Rechac (2025). Viaducto de Parque del Plata, Ruta IB. Caso de aplicación de suelo reforzado en muros de terraplenes y estribos.

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ACKNOWLEDGMENTS

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THANKS FOR YOUR ATTENTION

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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Centrifuge And Shaking Table Tests On Geosynthetic Reinforced Cohesive Soil Retaining Structures

Prof. Dr. Erol Guler

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CENTRIFUGE TESTS

Guler and Goodings (1992) "Centrifuge Models of Clay-Lime reinforced Soil Walls"
A.S.C.E. Geotechnical Special Publication No. 30

75

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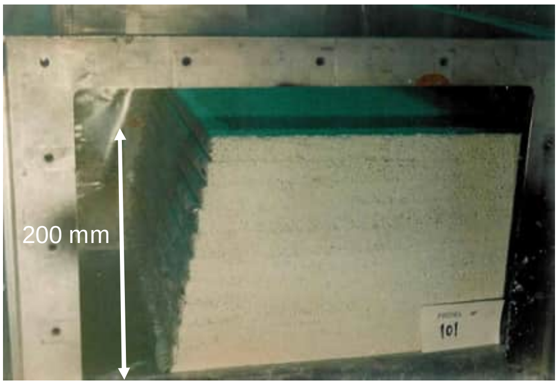
Centrifuge Models



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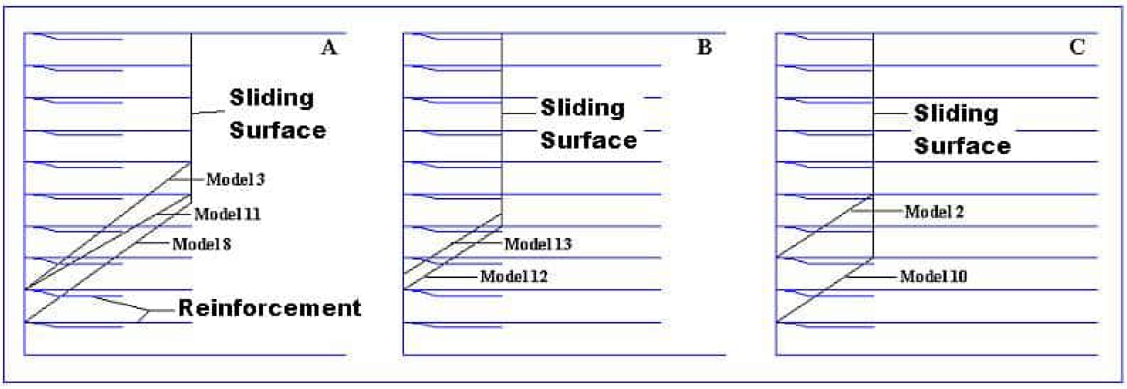
Failure surfaces



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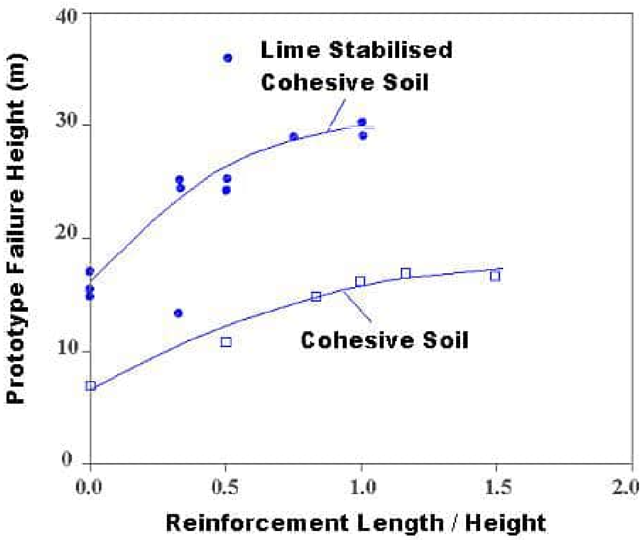
Effect of reinforcement



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AN EXPERIMENTAL 1:1 SCALE GEOSYNTHETIC REINFORCED COHESIVE SOIL

Guler and Ocbe (2003) "Centrifuge and full-scale models of geotextile reinforced walls and several case studies" Emirates Journal for Engineering Research

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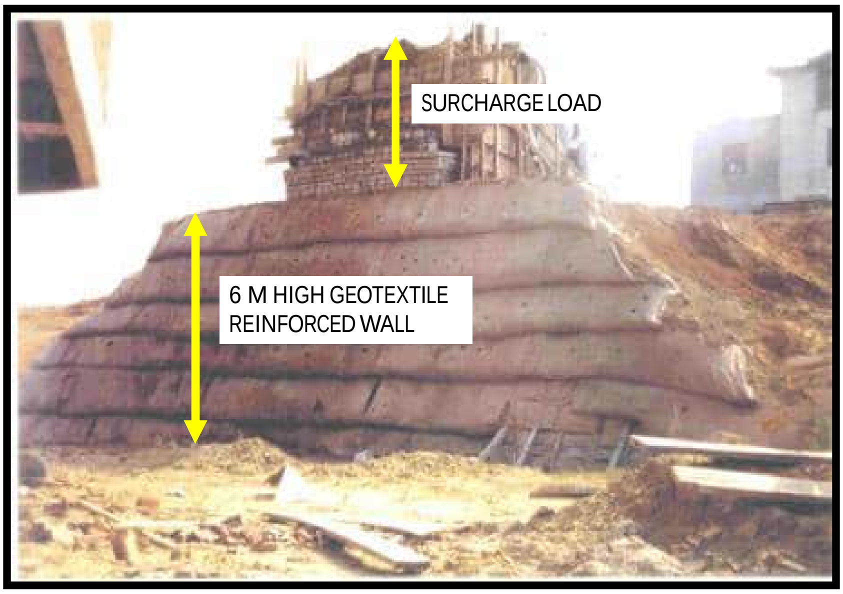

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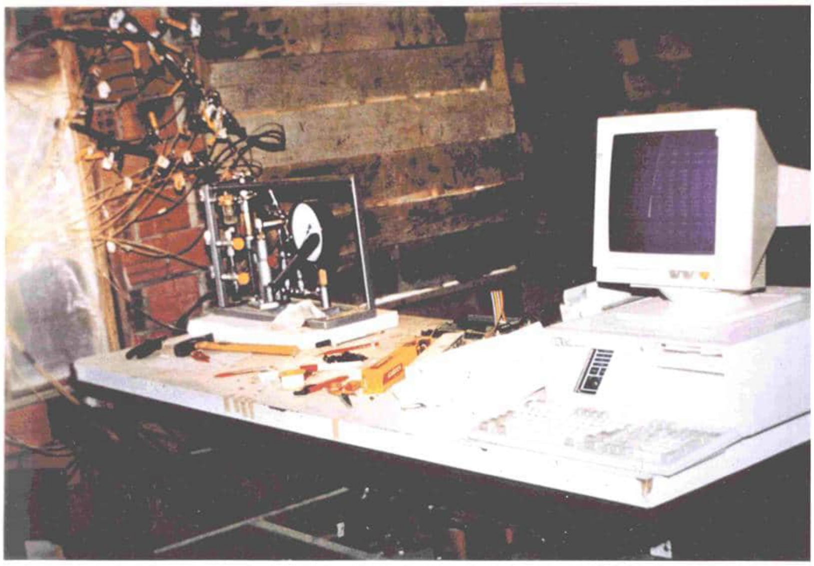
Instrumentation room



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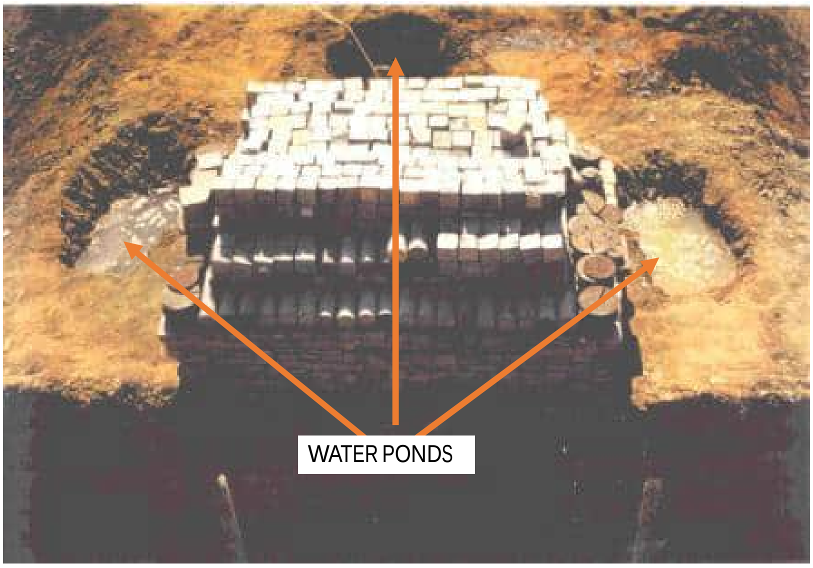

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SHAKING TABLE TESTS

Kilic et al (2021) "Seismic behavior of geosynthetic-reinforced retaining walls backfilled with cohesive soil" Geotextiles and Geomembranes

83

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Model Box

Model Dimensions:
1,9 m height
3,0 m length
0,7 m width

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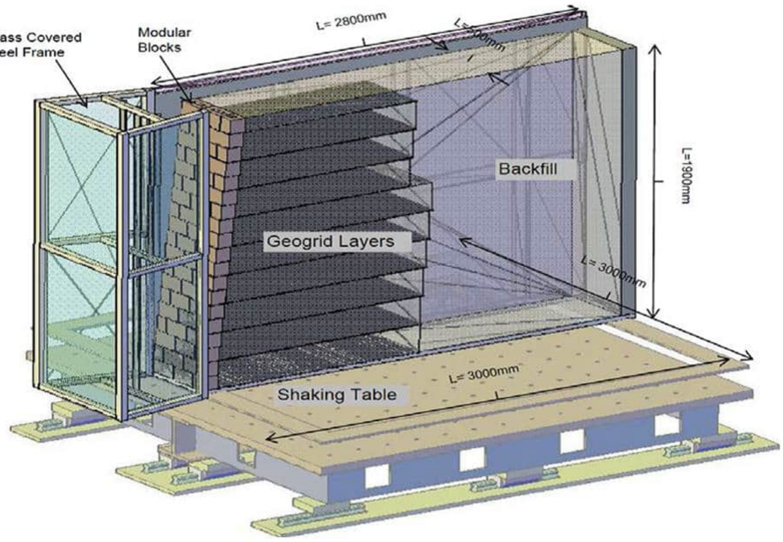
Typical Schematic of Test Setup



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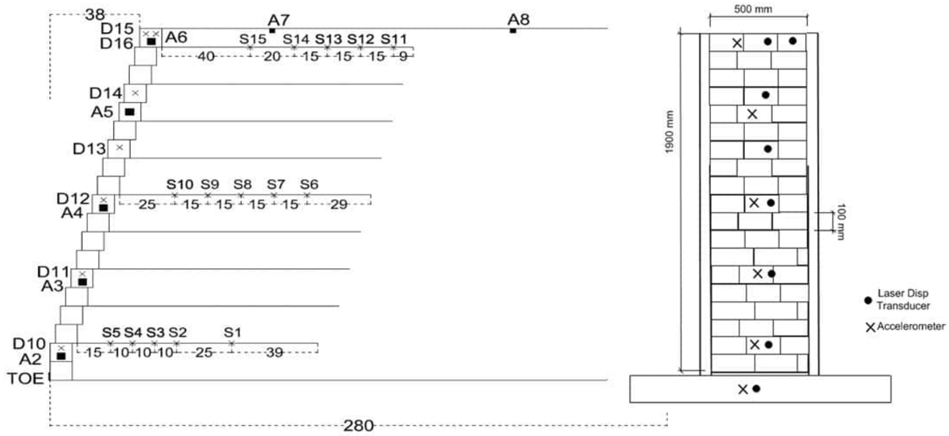
Instrumentation

- **Accelerometers:** 1 on the shaking table, 5 on the modular blocks and 2 on top of the backfill (Total 8 accelerometers)
- **Laser displacement transducers:** 1 on the shaking table, 7 on facing elements (Total 8 Laser transducers)
- **Strain Gauges on Reinforcement:** Bottom, top, and mid geogrids: 5 strain gages for each layer (Total of 15 gages)



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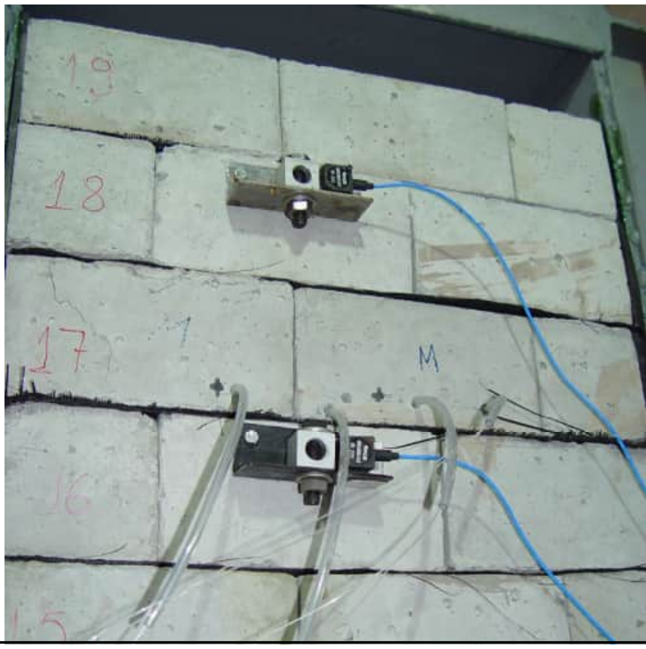
Accelerometers



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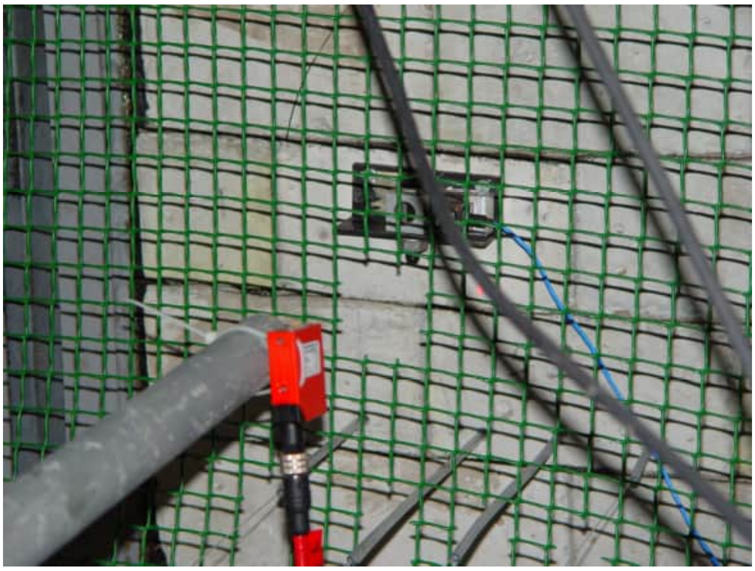
Laser Displacement Sensors



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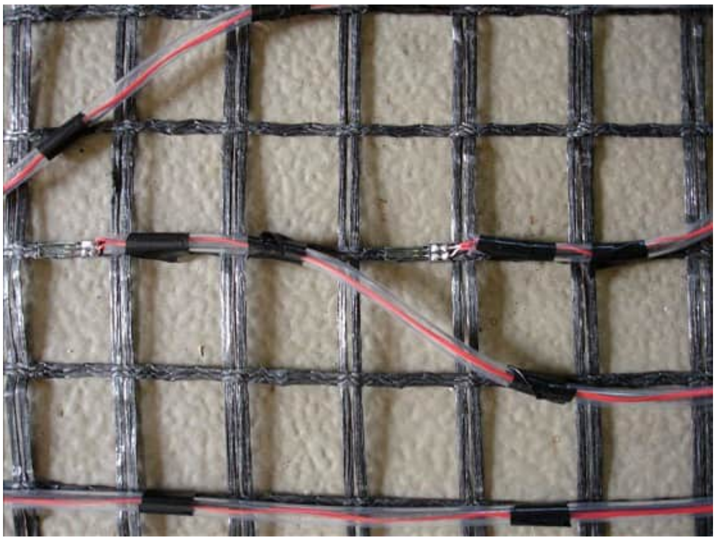
Strain Gauges on Geogrids



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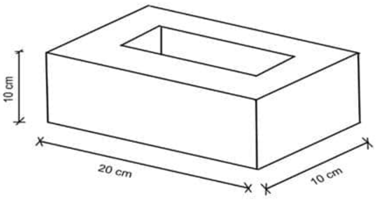
Methodology

- ½ scaled model, so prototype height is 3.8 m

- **Facing:**
  – hollow modular blocks 10x10x20 cm
  – 12.5° battered facing



- **Reinforcement:**
  – Polyester woven geogrid with T_{ULT} = 41 kN/m
  – Reinforcement length-to-wall height ratio (L/H): 0.8
  – Vertical reinforcement spacing (s_V): 20 cm

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An Important Element of GRS: Backfill Soil

- Design guidelines recommend as backfill:
  - fines content (0-15%)
  - plasticity index (PI<6)

- In practice often materials obtained from excavations are preferred to reduce the cost and environmental impact
- **The backfill soil used in this research:**
  - 30% kaolinite and 70% sand by weight
  - Soil prepared at slightly dry of optimum (w = 9%)
  - Cohesion and internal friction angle c=26 kPa and ϕ=27°

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Physical Model

- Soil compacted by vibration
- Reduced friction on sides by greased rubber sheets on the side walls
- Reflection of the seismic waves minimized by EPS board on the back

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Seismic excitation

- Model was ½ scaled, therefore the periods of the recorded seismic data were decreased by 1/√2
- **El Centro earthquake**: 23 seconds; peak ground accelerations 0.51g inwards and -0.41g outwards
- **Kobe earthquake:** 34 seconds; peak ground accelerations 0.94g inwards and -0.9g otwards. Kobe earthquake was induced at different PGA amplitudes

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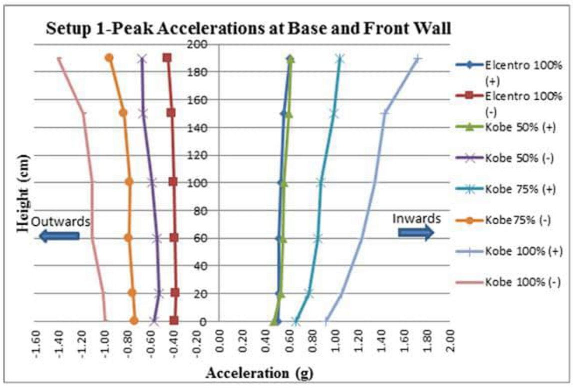
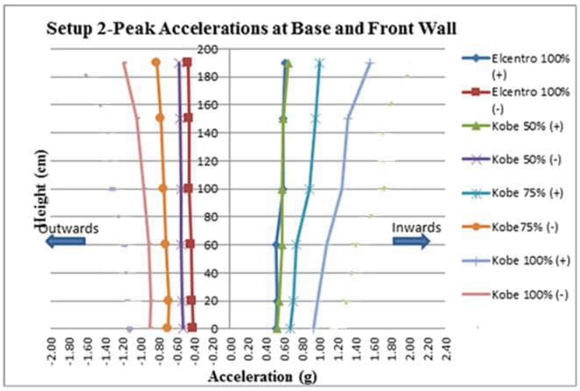
Peak accelerations of facing

- Max. amplification factors: 1.7 inward and 1.3 outward directions
- Unreinforced zone had lower amplification values. Possible reason: better damping characteristic of the less stiff unreinforced soil mass



Sand



Cohesive soil

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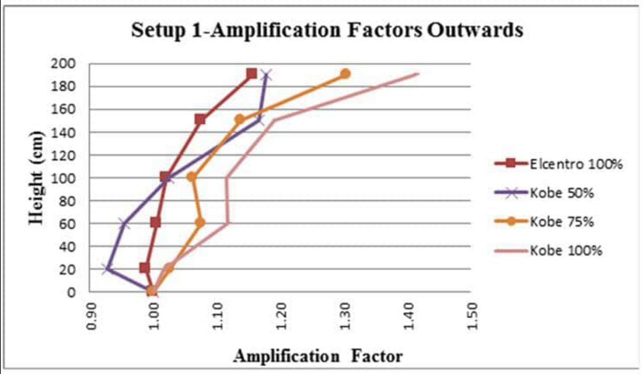
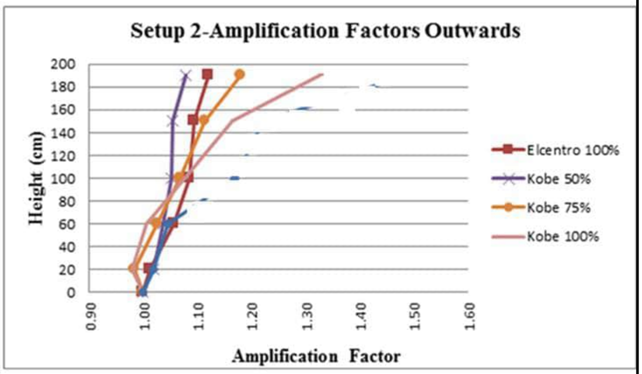
Amplification factors of facing

The amplification for cohesive soils are slightly less compared to sand



Sand



Cohesive soil

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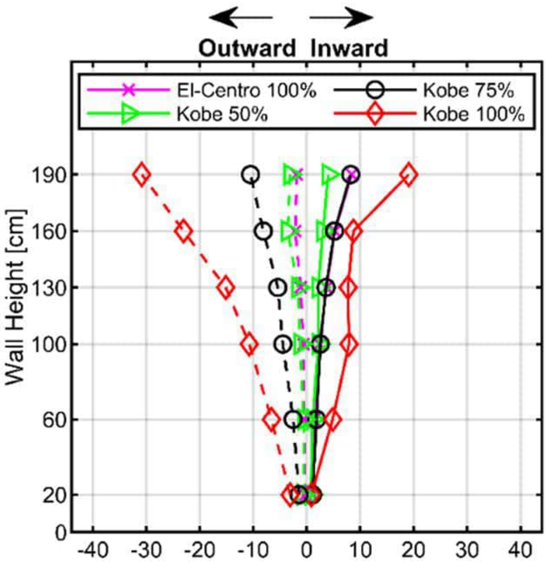
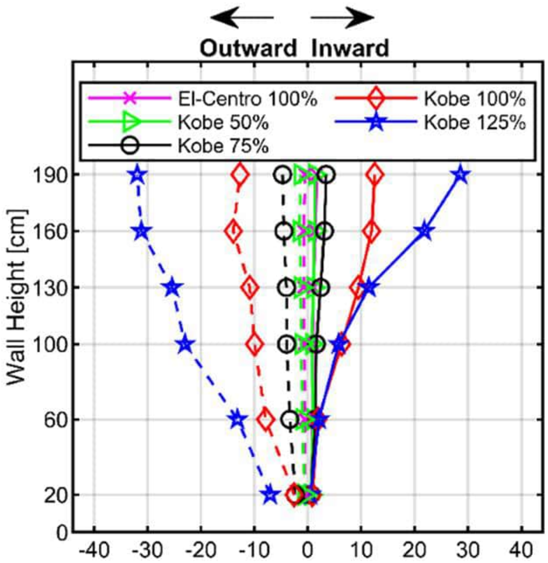
Displacement results



Sand



Cohesive soil

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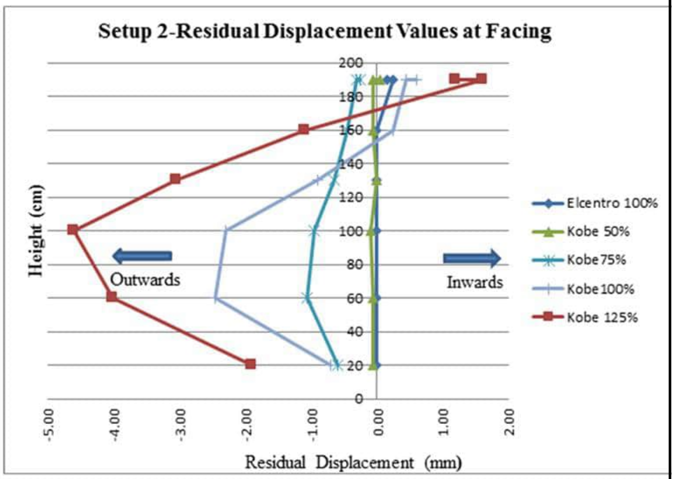
Residual displacements

- For Kobe 100% EQ, residual displacement of cohesive backfill was less than for sand backfill
- Even for Kobe 125% EQ, residual displacements for cohesive backfill was:
  - o 4.5 mm outwardat the mid-height of the facing
  - o 2 mm inwards at the top of the wall



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Stresses in the reinforcement

- The strains mentioned below are additional strains that occurred above the strains caused during construction
- The maximum recorded strain value in tension at 100% Kobe EQ was:
  - for granular backfill 0.52%
  - for cohesive backfill 0.35%.
- Maximum tension strain values even during Kobe 125% earthquake were 0.65% for cohesive backfill
- As a result, the maximum additional tensile load due to earthquake loading is only 4 kN/m even for 125% Kobe earthquake (the ultimate tensile strength of the reinforcement was 41 kN/m).

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CONCLUSIONS

- No failure or excessive deformation was observed on the model wall with cohesive backfill even under extreme seismic accelerations of over 1g
- Residual deformations observed at the facing were of acceptable magnitude
- Four tension cracks with acceptable dimensions were observed in the unreinforced backfill zone only when 125% Kobe base excitation was applied
- Reasonable (3 to 4 mm) surface settlement values were measured at the unreinforced backfill
- No separation was observed behind the modular blocks
- Model wall performed well under seismic loads when compared with the limit values reported in the literature
- As a result, of the test, it was found that the geogrid reinforced wall with cohesive backfill performed successfully

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ENVIRONMENTAL BENEFIT
DEMONSTRATED ON A CASE STUDY

Deger and Guler, E. (2024) “A Case Study of a 42-m High GRS Retaining Structure and CO2 Footprint Reduction due to the use of Marginal Backfill Available on site” International Journal of Geosynthetics and Ground Engineering

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Panoramic view of the geosynthetic reinforced wall and two tunnels

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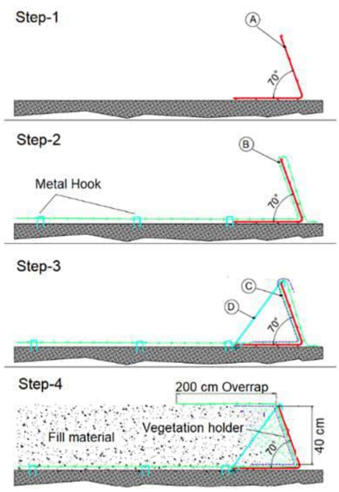
Construction method of the wall



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CO_2 emission comparison

- 605,000 m^3 of fill material was used for the construction of the reinforced fill
- If the reinforced fill material had to be imported from a query
  - The closest quarry was at 20 km distance
  - The excavated material from the tunnel had to be transported to a dump site
  - So, the total amount of CO_2 emission would be ≈ **7,600 ton**
- The fill material excavated from the tunnels has been transported from only 2 km
  - The amount of CO_2 emission was only ≈ **340 ton**
- The saving of CO_2 emission is equivalent to what a forest of 340,000 trees could absorb in a year

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THANK YOU FOR YOUR ATTENTION

Prof. Dr. Erol Guler

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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TC218 Reinforced Fill Structures

Subcommittee: Reinforced Fill Structures as Bridge Abutments

SC Chair: Mitul Dalwadi

Main Goal of the Subcommittee

- Promote Design, Construction, and understanding of Load-Carrying Mechanically Stabilised Earth (MSE) bridge abutments

Subcommittee Activities

- Periodic meetings with active members – Discussion on various topic
- Webinar – 1st Webinar – Year 2024 , Two time zone, (**http://virtualuniversity.issmge.org/courses/course-v1:ISSMGE+TC218-02+2024/about**) ~86 video play
- Need to do more to promote the application , ongoing work for the 2nd Webinar – Please contact (mitul.dalwadi@cmc.com or shahriar.mirmirani@geoquest-group.ca or g.lugli@maccaferri.com) if you would like to contribute for the webinar, article or any activity related to SC Bridge Abutment or if you would like to become a member of the SC
- 5 Presentations on Load bearing bridge abutment applications

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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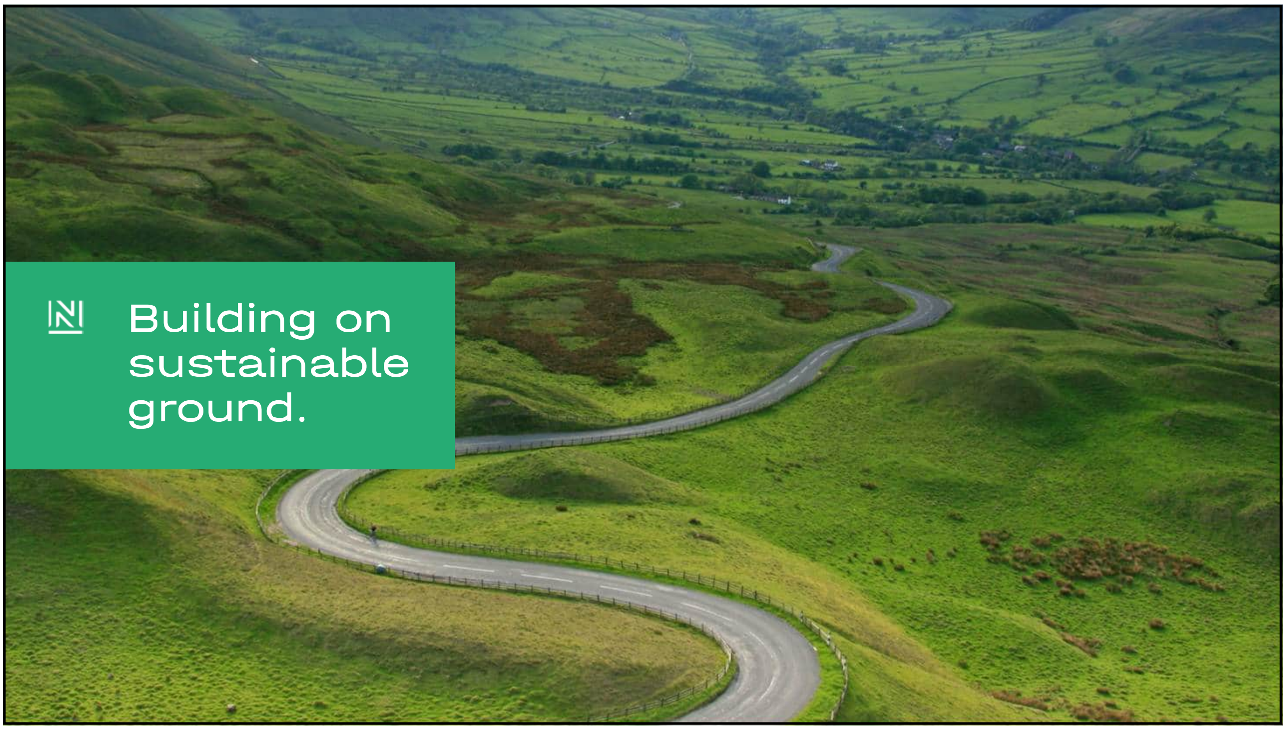

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Large Scale Trials and European Experience with Geosynthetic-Reinforced Bridge Abutments (GRS-BA)

QA and Construction Requirements

Naue GmbH & Co. KG	with courtesy
Dr.-Ing. Lars Vollmert	IBH – Herold & Partner mbB
Dipl.-Ing. Waldemar Pauls	Dipl.-Ing. Andreas Herold

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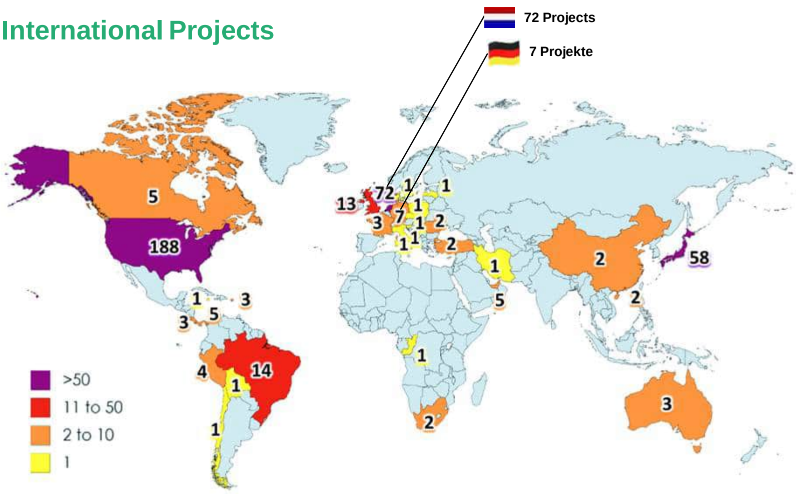
Geosynthetic reinforced bridge abutments in Europe

International Projects



72 Projects

No.	Structure	Country
1	Ecoduct Naadestraat	Netherlands
2	A1 Ecoduct Laaren	Netherlands
3	N417 National Road Ecoduct Zwaluwenberg	Netherlands
4	Ecoduct Utrecht-Hilversum Railway	Netherlands
5	Ecoduct A27 Motorway	Netherlands
6	Boele Staal	Netherlands
7	Damwald, Centrale As Noord, Dontawel	Netherlands
8	N33 und TT circuit Assen A28 Zuidbrug	Netherlands
9	Werk Opafrit TT Assen Reef Infra	Netherlands
10	N381 Drachten - Nanningaweg	Netherlands
11	Tcent Someren A67	Netherlands
12	Brug Heerenweg Heerlen	Netherlands
13	Ecoduct Dwingelerveld	Netherlands
14	Ecoduct Muggenbeet N333	Netherlands
15	Ecoduct Woeste en Buddelbergen	Netherlands
16	Four Ecoducten in Noord Brabant - A2 Groote	Netherlands
17	Four Ecoducten in Noord Brabant - A50 Herpe	Netherlands
18	Four Ecoducten in Noord Brabant - N324 Maas	Netherlands
19	Four Ecoducten in Noord Brabant - N398 Loo	Netherlands
20	N421 Bunnik	Netherlands
21	A Lanes A15 Vrijenburg Viaduct	Netherlands
22	N261 Tilburg Waalwijk Ecoduct K8	Netherlands
23	N261 Tilburg Waalwijk Fietsbrug K2	Netherlands
24	N261 Tilburg Waalwijk Viaduct K9	Netherlands
25	N261 Tilburg Waalwijk Europalaan K6	Netherlands
26	N261 Tilburg Waalwijk Fietstunnel Duinlaan	Netherlands
27	N62 Sloeweg	Netherlands
28	N381 Drachten Drentse grens wanden KW16	Netherlands
29	Westfrisiaweg N23, Hoorn	Netherlands
30	Zuidelijke Randweg Borne, kunstwerk Delden	Netherlands
31	N34 Aansluiting Exloo	Netherlands
32	Viaduct over de A1 bij Beekbergen	Netherlands
33	A6 - Almere Havendreef - Almere Buiten-Oost	Netherlands

…

Prof. Jorge Zornberg, University of Texas, Austin (USA), 2020

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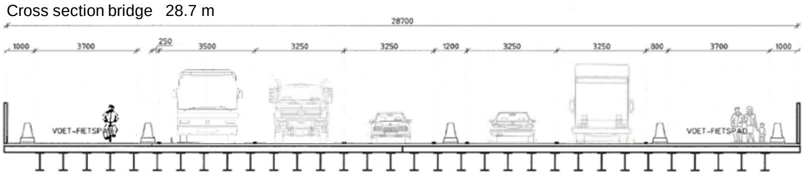
Geosynthetic reinforced bridge abutments

Types and structural design

Cross section bridge 28.7 m



Longitudinal section 17.65 m

GRS-BA for temporary application (i-Lent, Nijmegen, The Netherlands, 2013)

Bridge abutment vs. Reinforced wall:

$\sigma_q / \sigma_g > 1{,}0$

Example:

Typical reinforced wall:
σ_q / σ_g = 50 kPa / (5 m * 20 kN/m³)

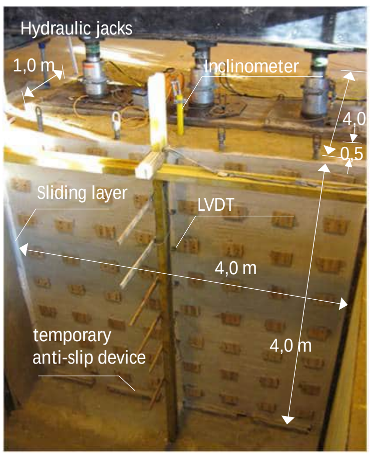
= 0.5 ≤ 1.0

Bridge abutment:
σ_q / σ_g = 250 kPa / (5 m * 20 kN/m³)

= 2.5 > 1.0

Large-scale laboratory test

Settlement und high impact loading



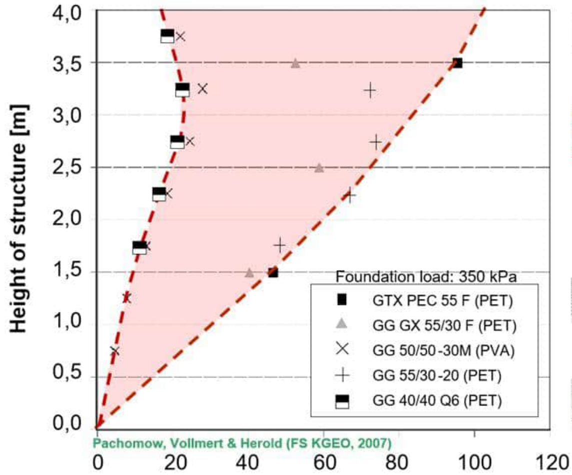
Pachomow et al. (2007)

Brandenburgische Technische Universität Cottbus - Senftenberg

Untersuchung	Bauwerkshöhe / -tiefe / -breite [m]	Breite des Fundament-balkens [m]	Füllboden	Reibungs-winkel [3] [°]	Dehnsteifigkeit J der Bewehrung (Sekantenmodul @ Bezugsdehnung, Art der Bewehrung) [kN/m]	Vertikaler Lagenabstand [m]	Flächenpressung bei 10 mm Setzung [kPa]
Krieger & Thamm [4] [BASt]	1,8 / 2,0 / 2,0	0,45	Sand (SE) D_{Pr} = 98%	39	$J_{@6\%}$ = 1115 Gewebe, PET $J_{@6\%, 0,5m}$ [1] = 929	0,60	~ **370**
Gartung & Zanzinger [18] [2] [LGA]	4,1 / 4,0 / 2,7	1,00	Sand (SE) I_D = 0,84 dichte Lagerung	41	$J_{@6\%}$ = 404 gewebtes Geogitter, PET	0,51	~ **190**
Pachomow et al. [19], vgl. auch [20] [BTU]	4,0 3,0 4,0	1,00	Sand (SE) e = 0,5 dichte Lagerung	44	$J_{@6\%}$ = 640 gelegtes Geogitter, PET [4]	0,50	**> 350**

[1] $J_{@6\%, 0,5m}$: installed tensile stiffnesss related to vertical spacing of 0.5m
[2] Foundation with a width of 0.1m was installed with a depth of 0.4m to prevent local bearing failure
[3] from shear box testing related to plain strain conditions.
[4] different types of products have been used. The given results are related to the type of geogrid named here, using welded junctions and structured/embossed surface of tensile bars.

Large-scale laboratory test
Influence of tensile stiffness of geogrid reinforcement



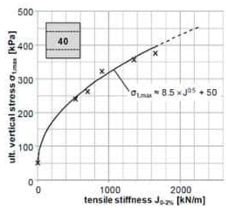
Brandenburgische Technische Universität Cottbus - Senftenberg

Range according to type and stiffness of geogrid reinforcement (Gabion & Steel mesh facing)

GTX PEC 55 F (PET): $J_{2\%}$ = 450 KN/m

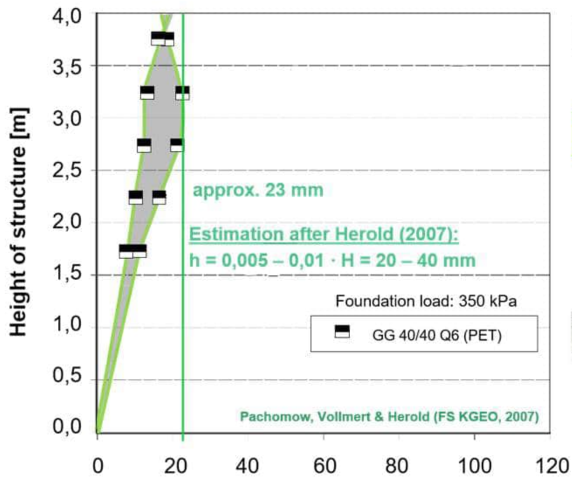
GG 40/40 Q6 (PET): $J_{2\%}$ = 925 KN/m

Influence of tensile stiffness $J_{2\%}$ of used samples on the ultimate load using biaxial testingsetup (Jacobs et al., 2012)



  Vollmert et al. | European Experience with GRS Bridge Abutments – QA and Requirements | Workshop ISSMGE TC218 & IGS TC-R | 2026-06-15

Large-scale laboratory test
Influence of facing system



Brandenburgische Technische Universität Cottbus - Senftenberg

Range according to stiffness of facing system:

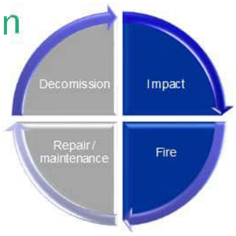
- partially deformable facing system (gabions) and
- non-deformable facing system (concrete panels)

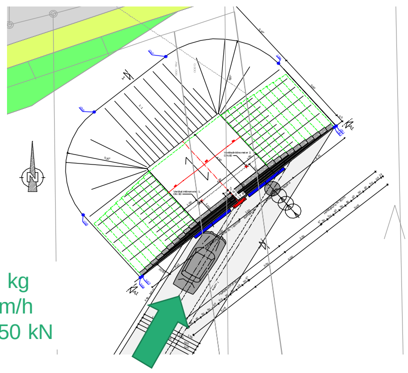
GG 40/40 Q6 (PET): $J_{2\%}$ = 925 KN/m

  Vollmert et al. | European Experience with GRS Bridge Abutments – QA and Requirements | Workshop ISSMGE TC218 & IGS TC-R | 2026-06-15

Large scale testing of GRS

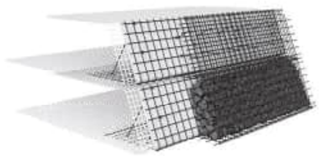
Dynamic impact by car crash and fire - large scale testing B6n

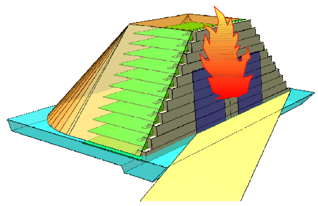




m = 800 kg
v = 80 km/h
F_{Res} = 350 kN

Facing: Naue DW





GRS:
H = 5,5m
Facing: ca. 85°
Vertical layer distance : 5.5m
Reinforcement lenght: 4,5m

Herold & Vollmert (2013)

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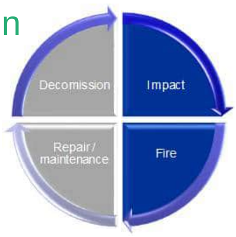
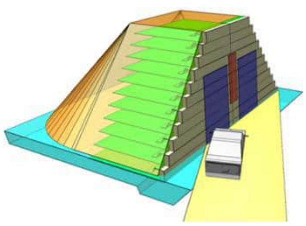
Large scale testing of GRS

Dynamic impact by car crash and fire - large scale testing B6n





Herold & Vollmert (2013)

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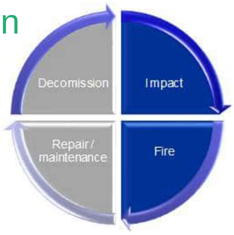
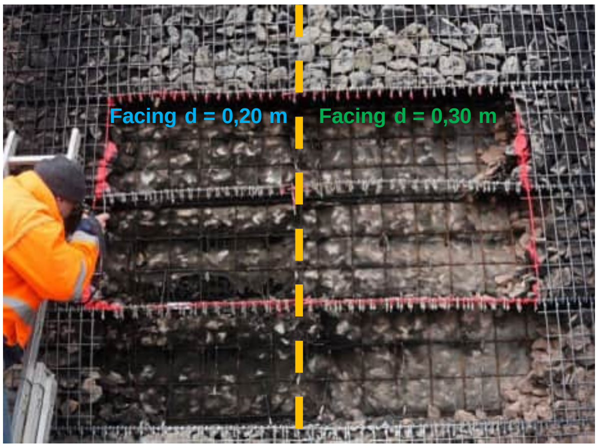
Large scale testing GRS

Dynamic impact by car crash and fire - large scale testing B6n





Herold & Vollmert (2013)

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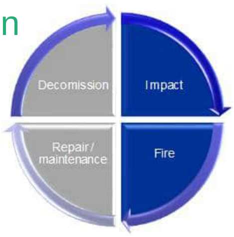
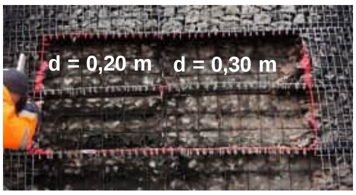
Large scale testing GRS

Dynamic impact by car crash and fire - large scale testing B6n

a. Prepared for repair

b. Finalised repair





c. Impact T ≈ 1.100°C, t = 10 min

Thickness d [m] of facing	0,2 m	0,3 m
Remaining tensile strength [%]	76,6	85,7
Reduction [%]	23,4	14,3

d. Remaining tensile strength after fire impact

Herold & Vollmert (2013)

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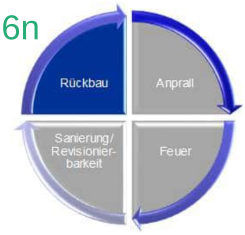
Large scale testing GRS

Dynamic impact by car crash and fire - large scale testing B6n





- Geogrid
- Non-woven fabric
- Stone filling
- Secondary formwork
- Front elements
- Fill

100% homogeneous separation with conventional earthmoving technology

Proper decomissioning is the result of a design process

⇒ Decomissioning guidelines

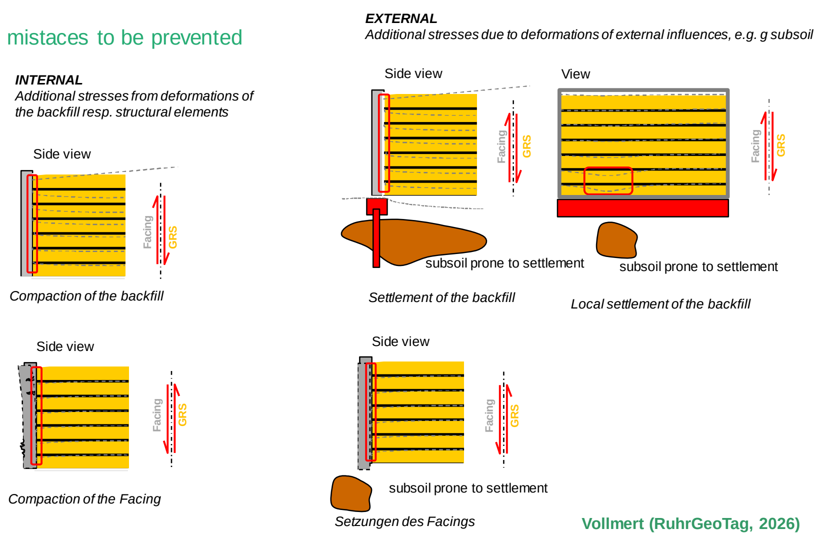
Herold & Vollmert (2013)

GRS – QA and requirements

Ductility meets stiffness – mistaces to be prevented

Stresses on the structures due to deformations:

The more evenly the deformations are applied, the lower the risk of stress concentration between facing and backfill.



Vollmert (RuhrGeoTag, 2026)

with courtesy
IBH – Herold & Partner mbB
A. Herold

Design recommendations for GRS abutments

Layer spacing :
$d_{Primär}$ = 0,50 m
$d_{Sekundär}$ = 0,5 * $d_{Primär}$

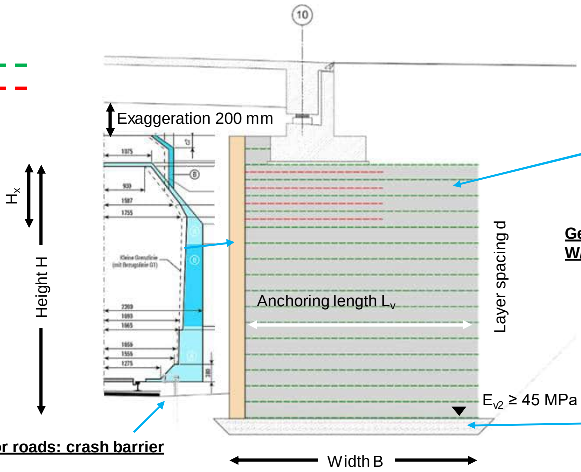
Anchoring length :
L_v = const.

Secondary reinforcement :
H_x = mind. 4 Lagen bzw. 0,25*H

Facing :
β = 45 .. 90 °
- Single-shell
- Double-skinned

Spacing A :
A ≥ 0,50 m

Primary reinforcement
Secondary reinforcement



Fill
per EBGEO section 2.1.2
with D_{Pr} ≥ 100 %
Minimum requirements:
$E_{s,k}$ ≥ 80 MPa
φ'_k ≥ 35,0 °
c'k ≥ 0..5 kN/m²
γ_k ≤ 20..21 kN/m³
pH = 8-9

Geometry:
W/H = 0.8-1.0

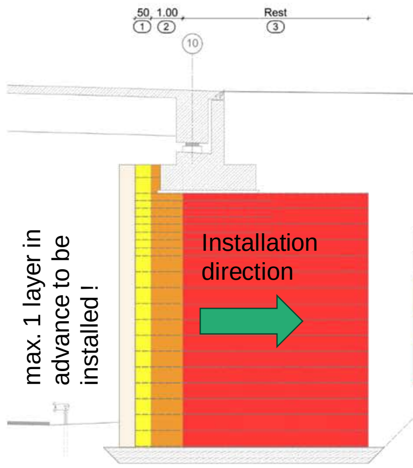
Soil replacement
as required d_{min} = 0,50 m mit D_{Pr} ≥ 100 %

Herold (FS KGEO / DGGT, 2025)

with courtesy
IBH – Herold & Partner mbB
A. Herold

Design recommendations for GRS abutments

Permissible equipment load for compaction / installation recommendations



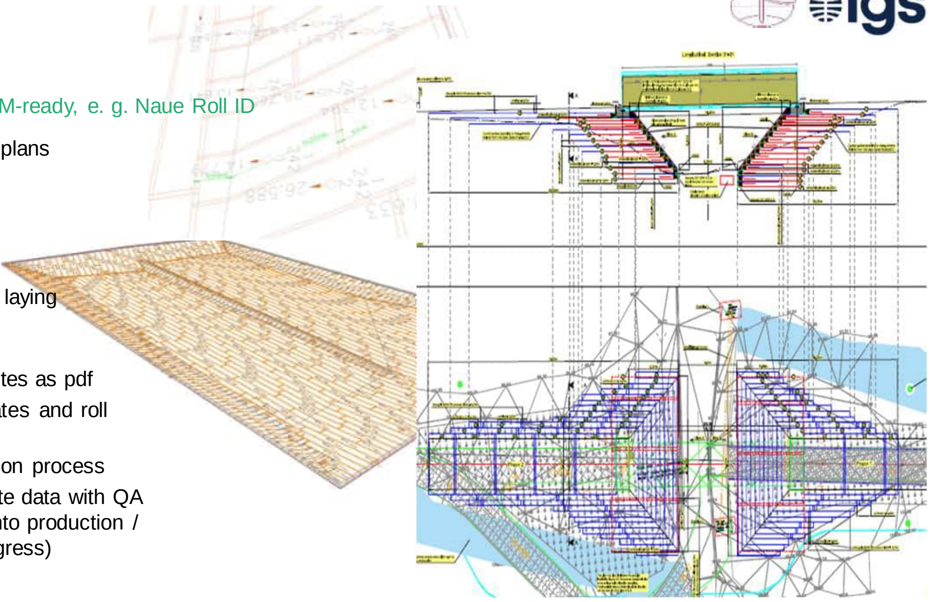
Verdichtung

Bereich	Beschreibung	zulässige Lasten	Breite	Lagenhöhe	Arbeitsweise
1	Front nur mit Rüttelplatte	G ≤ 0,1 t	b = 0,5 m	d = 0,10...0,15 m	dynamisch
2	Zwischenbereich nur mit Rüttelplatte	G ≤ 0,5 t	b ≥ 1,0 m	d = 0,25 m	dynamisch
3	Hinterfüllbereich Walze, dynamische / statische Betriebsart	G ≤ 12,5 t	ab Bandagen-breite b ≥ 2,0 m	d ≤ 0,50 m	statisch / dynamisch

Herold (FS KGEO / DGGT, 2025)

Shop-drawings - BIM-ready, e. g. Naue Roll ID

- Installation and execution plans
- Direction of unrolling
- Overlaps md/cmd
- Use of offcuts
- Calculation of strains from geometric constraints and laying inaccuracies
- 3D visualization, suitable for construction sites as pdf
- Mat list with GPS coordinates and roll numbers
- Modelling of the construction process
- Merging of construction site data with QA data and reflection back into production / logistics (construction progress)



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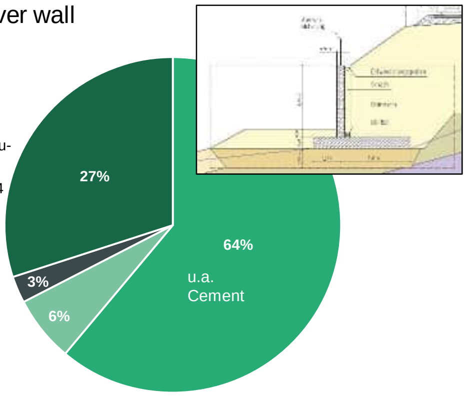
Geosynthetic-reinforced earth permanent construction as part of a railway embankment

Concrete cantilever wall

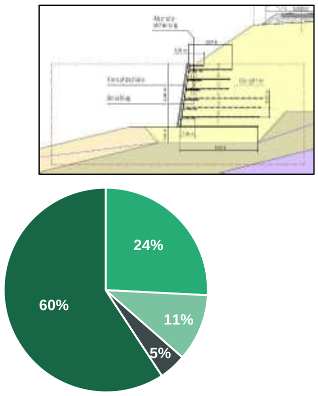
- Herstellungsphase A1-3
- Errichtungsphase A4 (Transport)
- Errichtungsphase A5 (Bau-/Einbauprozesse)
- Entsorgungsphase C1-C4



GRS

- Herstellungsphase A1-3
- Errichtungsphase A4 (Transport)
- Errichtungsphase A5 (Bau-/Einbauprozesse)
- Entsorgungsphase C1-C4

- 68%



Greenhouse gas potential and primary energy demand in comparison via environmental impact points (UBP)
Method of ecological scarcity. DIN EN 15804, DIN EN ISO 14040 and 14044

Wittl, Klügel, Vollmert & Ehrenberg. BGT 2024, DGGT

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Monetization of environmental impact

Comparison of construction and environmental costs

	GRS	2,5 CCL	Savings
Construction costs (2023)	343.902 €	770.419 €	426.517 €
Environmental CO_2 (2023)	85.684 €	319.869 €	234.185 €
Environmental costs tkm	47.709 €	85.663 €	37.953 €
Summe	**477.295 €**	**1.175.950 €**	**698.655 €**
Difference total (CCL = 100%)	41%	100%	59%
Difference environmental (CCL = 100%)	33%	100%	67%
Percentage environmental costs to construction costs	39%	53%	64%
Percentage environmental costs (CO2 only) to construction costs	25%	42%	55%

Wittl, Klügel, Vollmert & Ehrenberg. BGT 2024, DGGT

Aansluiting TT-Circuit op A28, NL (2014)

Temporary bridge crossing Prüm river, Minden, Germany (2023)

Thank You.

Building on sustainable ground.

ISSMGE/TC-218 (& IGS/TC-R) Special Session

SIMSG ISSMGE

igs

AGENDA

Updates from ISSMGE TC-218 and IGS TC-R, *Shahriar Mirmirani & Ivan P. Damians*

Presentations by the Marginal / Alternative Fills Subcommittee, *Shahriar Mirmirani*

- **Aníbal Moncada Ramírez / Ivan P. Damians**: Pullout Response of Polyester Strap Reinforcements and Reclaimed Asphalt Pavement (RAP): Influence of Confinement and Environmental Conditions
- **Castorina Vieira**: Use of Recycled Construction and Demolition Wastes as Backfill in Geosynthetic-Reinforced Soil Structures
- **Lizeth Ardila/ Oliver Detert**: Geosynthetics Mechanically Stabilized Earth Walls: Numerical Modeling and Case Studies in South America
- **Erol Guler**: Centrifuge and shaking table test results analysing MSE walls using clay backfill

Presentations by the Bridge Abutments Subcommittee, *Mitul Dalwadi*

- **Lars Vollmert / Waldemar Pauls**: Large-Scale Trials and European Experience with Geosynthetic-Reinforced Bridge Abutments: QA and Construction Requirements
- **Nicolas Freitag**: Integral Bridges on Load-Carrying MSE Abutments: Theory and Practice
- **Richard Bathurst**: Design of Geosynthetic MSE Walls Supporting Bridge Abutment Footings Using the Stiffness Method
- **Yewei Zheng**: Seismic Response and Performance Evaluation of GRS Bridge Abutments
- **Mitul Dalwadi**: Load-Carrying Reinforced Soil Bridge Abutments – Integral and Semi-Integral Bridges: Design and Construction with UK Experience (Including Carbon Assessment)

Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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GEOQUEST

MSE Integral Bridge abutments

or

Integral bridges carried by reinforced fill abutments

Nicolas Freitag, Geoquest, Development Director

29/06/2026

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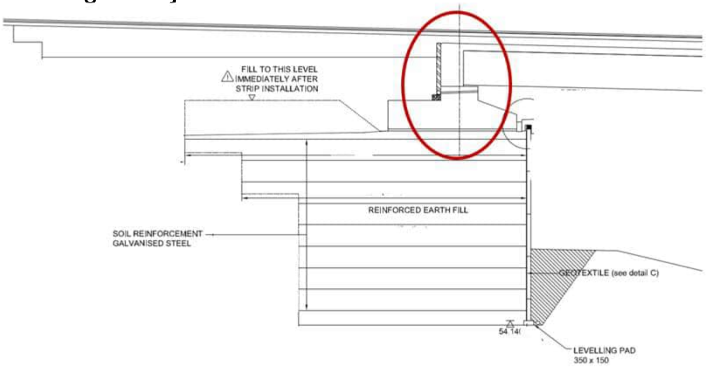
What is it ?

- A specific bridge system
  - Generally single span deck
  - Deck carried directly by MSE block
  - With no bearings nor joints -> the deck and the beamseats are embedded



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First RE abutment for an integral bridge

- UK
- 1997
- 36 m bridge span !

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Benefits

💰 fast and cost-effective construction

🌱 significantly reduced carbon emissions vs conventional methods

AECOM UK unpublished study :

-77% CO_{2eq} emissions compared with piles + frame solutions !

🚧 lower maintenance cost for the owners

no replacement of bearings and/or joints

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A common understanding is required

- Too often bridge engineers require to consider MSE abutments as rigid blocks:
  - erroneously **huge lateral forces** requested at the top of the MSE mass
  - long discussions to agree on the design principles
  - all actors, designers and contractors, must work together

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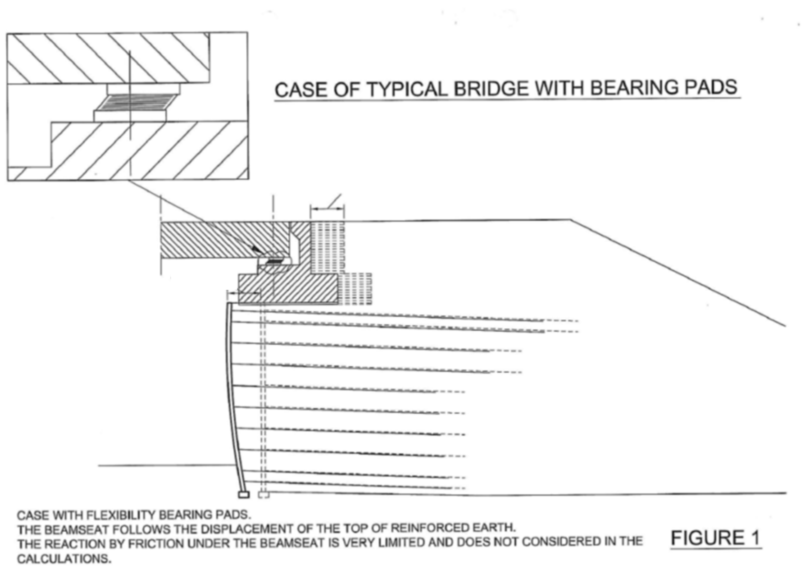
Simply supported versus integral



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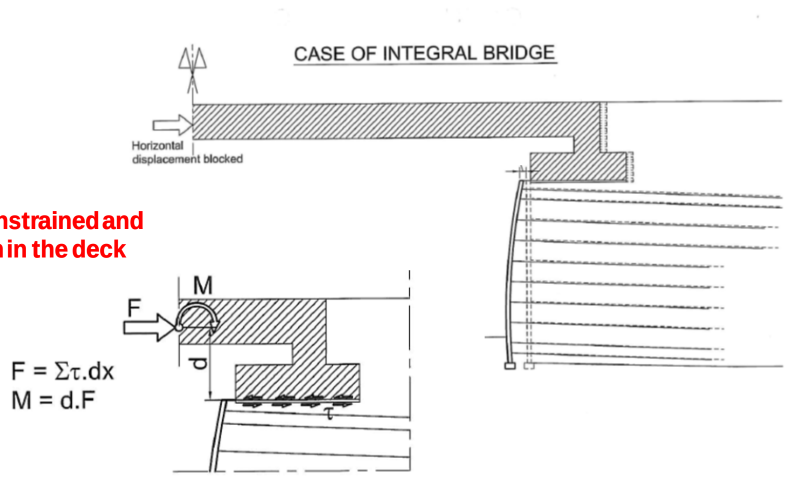
Simply supported versus integral

Lateral displacements are constrained and converted into compression in the deck



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Integral MSE abutment

- Thermal contraction and expansion can be calculated according to EN 1991-1-5 and the relevant national annex
  - The use is straightforward but there are many steps
  - Globally for a bridge around Paris, the total temperature variation to expect over the structure service period is 42°C for expansion and 44°C for contraction (from the placement of the deck)
- With a thermal expansion coefficient of 10.10^{-6} /°C, this gives design deformations :
  - Contraction : 0.044%
  - Expansion : 0.042%
- So for an 18m long deck :
  - **Contraction : 8 mm**
  - **Expansion : 8 mm**

- **These are small displacements compared to the flexibility of a reinforced fill structure**

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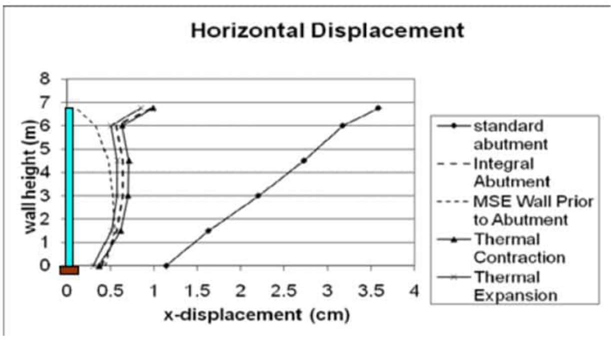
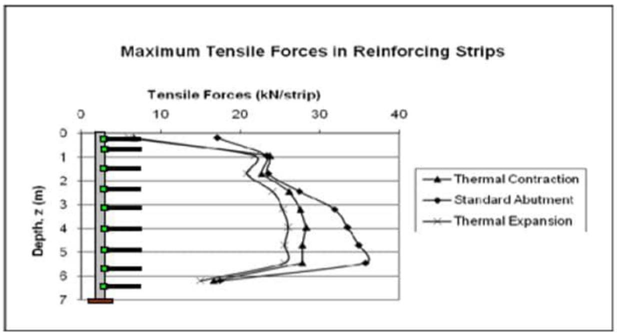
Integral MSE abutment



Study of Mechanically Stabilized Earth Structure Supporting Integral Bridge Abutment

M. J. Grien[1], K. Truong[2] and M. R. Tavakolian[3]

Earth Retention Conference 3, Bellevue, WA, USA, 2010



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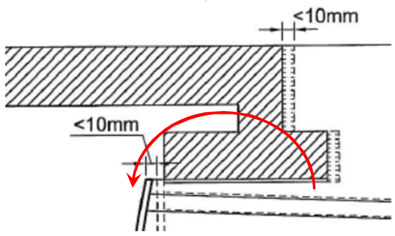
Integral abutment

- Rotations of the beamseats may be critical

- Sources of rotation :
  - Casting of the deck on T-beams, if the connection at the beamseats is already done
  - Creep of the concrete deck
    - rule of thumb : short term deformations x 3
    - So rotations are x 3+
  - A rapid calculation leads to approximately long-term 1% of rotation, i.e. 0.5°



Potentially high stresses

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Design methodology

- ➢ Complex geostructural problem
- ➢ Cannot be represented by simplified limit equilibrium methods / failure mechanisms
- ➢ For larger spans:
- ➢ numerical methods
- ➢ in addition to traditional methods (like coherent gravity)
- ➢ Note: future Eurocode 7 part 1 (2027) will provide a better framework for design verification assisted by numerical methods

Vélizy – September 16, 2008

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Conclusion

- Very interesting solution
  - Cost
  - Speed of construction
  - Environmental impacts
- Design complexity
  - Avoid foundation soils with long consolidation times
  - Beware of construction sequence
  - Use numerical models in addition to conventional methods

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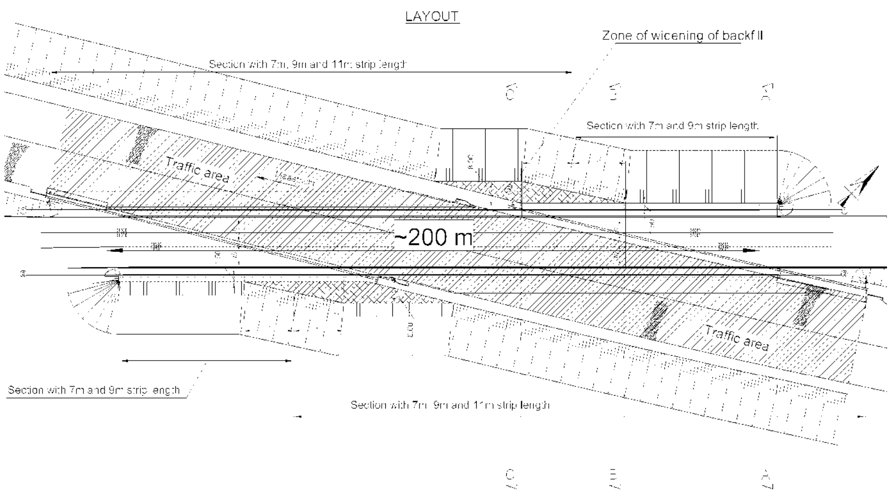
Netherlands: KW39-A73

2007



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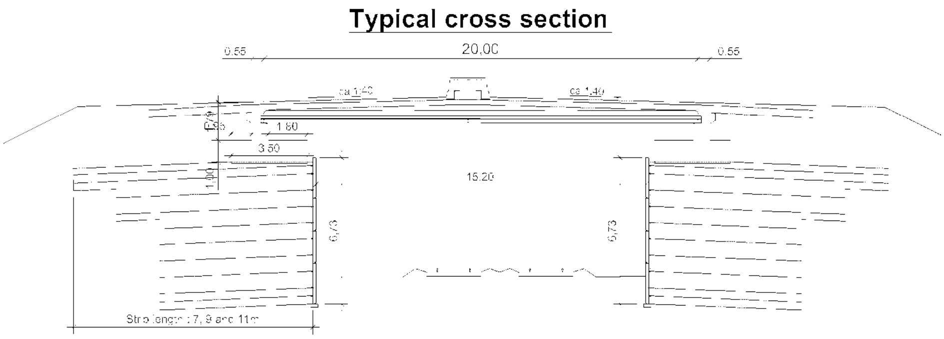
Netherlands: KW39-A73



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166 beams installed in 16 hours

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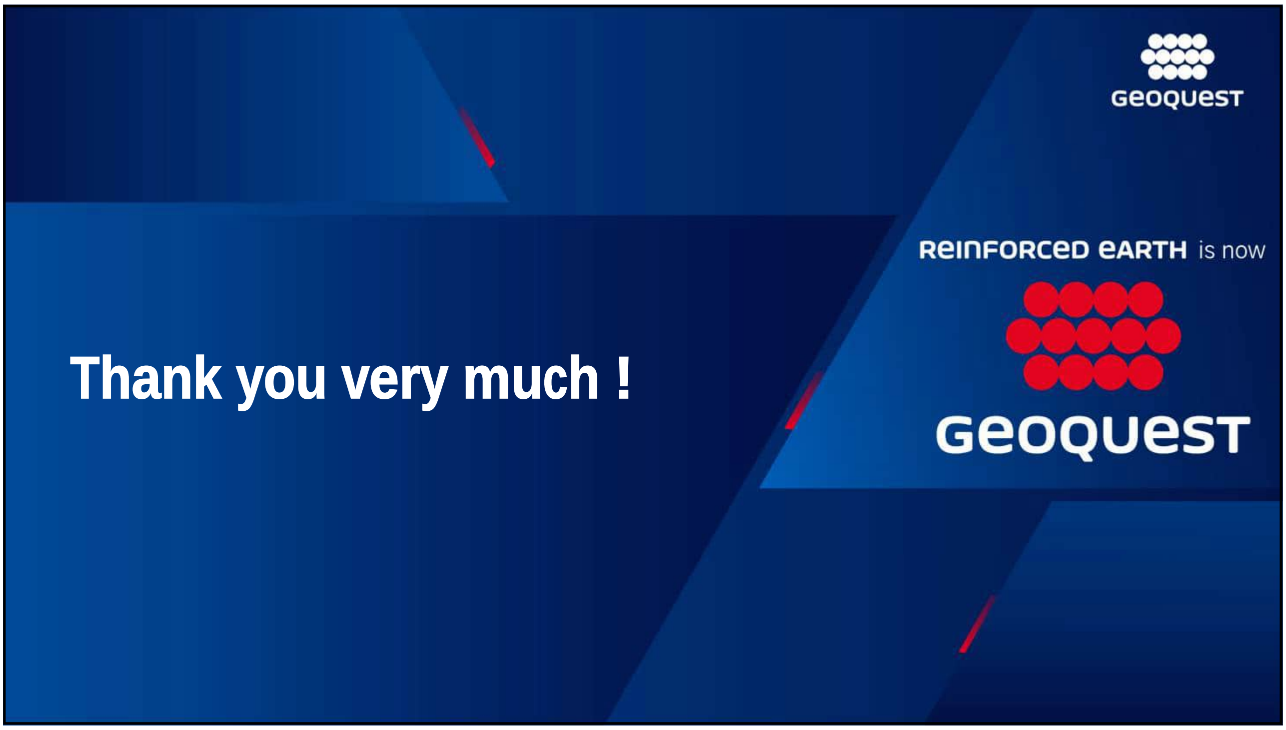

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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AGENDA

Updates from ISSMGE TC-218 and IGS TC-R, ***Shahriar Mirmirani & Ivan P. Damians***

Presentations by the Marginal / Alternative Fills Subcommittee, ***Shahriar Mirmirani***

- **Aníbal Moncada Ramírez / Ivan P. Damians**: Pullout Response of Polyester Strap Reinforcements and Reclaimed Asphalt Pavement (RAP): Influence of Confinement and Environmental Conditions
- **Castorina Vieira**: Use of Recycled Construction and Demolition Wastes as Backfill in Geosynthetic-Reinforced Soil Structures
- **Lizeth Ardila/ Oliver Detert**: Geosynthetics Mechanically Stabilized Earth Walls: Numerical Modeling and Case Studies in South America
- **Erol Guler**: Centrifuge and shaking table test results analysing MSE walls using clay backfill

Presentations by the Bridge Abutments Subcommittee, ***Mitul Dalwadi***

- **Lars Vollmert / Waldemar Pauls**: Large-Scale Trials and European Experience with Geosynthetic-Reinforced Bridge Abutments: QA and Construction Requirements
- **Nicolas Freitag**: Integral Bridges on Load-Carrying MSE Abutments: Theory and Practice
- **Richard Bathurst**: Design of Geosynthetic MSE Walls Supporting Bridge Abutment Footings Using the Stiffness Method
- **Yewei Zheng**: Seismic Response and Performance Evaluation of GRS Bridge Abutments
- **Mitul Dalwadi**: Load-Carrying Reinforced Soil Bridge Abutments – Integral and Semi-Integral Bridges: Design and Construction with UK Experience (Including Carbon Assessment)

Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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21st International Conference on Soil Mechanics and Geotechnical Engineering

2026 AUSTRIA VIENNA WHERE IT ALL BEGAN 21st ICSMGE

TC218 Workshop

Design of geosynthetic MSE walls supporting bridge abutment footings using the stiffness method

Richard J. Bathurst & Reza Jamshidi Chenari

Royal Military College of Canada

GeoEngineering Centre at Queen's-RMC, Kingston, Canada

Queen's UNIVERSITY

The Geo Engineering Centre

15 June 2026, Vienna

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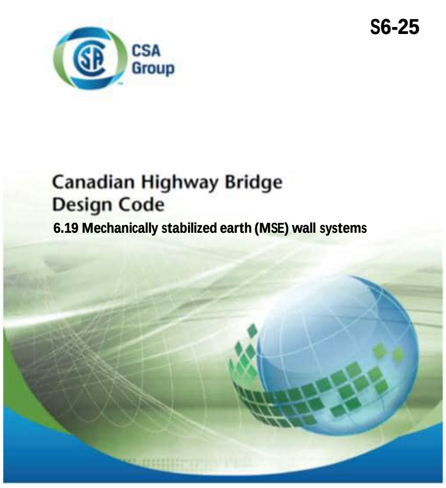
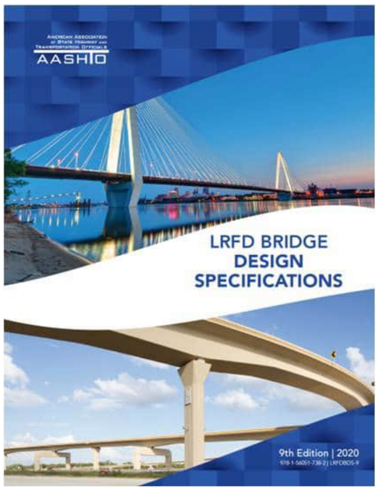
Design for internal limit states for MSE walls is carried out using a load and resistance factor design (LRFD) framework in Canada and the US





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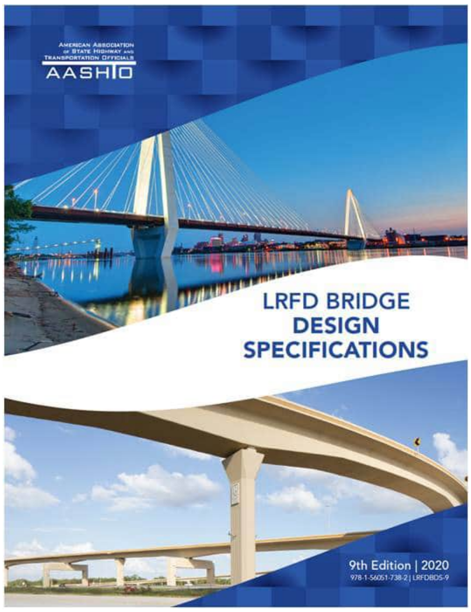
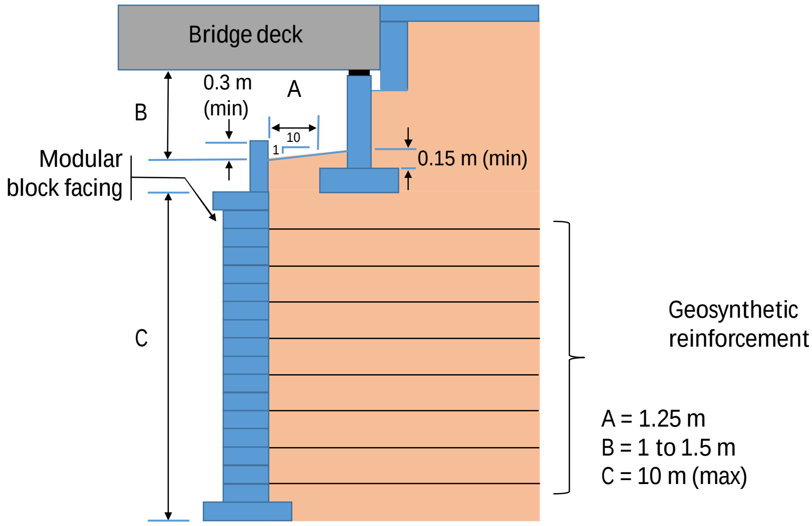
Stiffness Method is now specified for the internal stability design of geosynthetic mechanically stabilized earth (MSE) walls in AASHTO 2020

A signature feature of this approach is the use of the creep-reduced tensile stiffness of the reinforcement as a key parameter to compute the magnitude of reinforcement loads under operational conditions

This is a paradigm shift from the Simplified Method in previous editions of the AASHTO code which is based on the soil peak friction angle for geosynthetic MSE walls

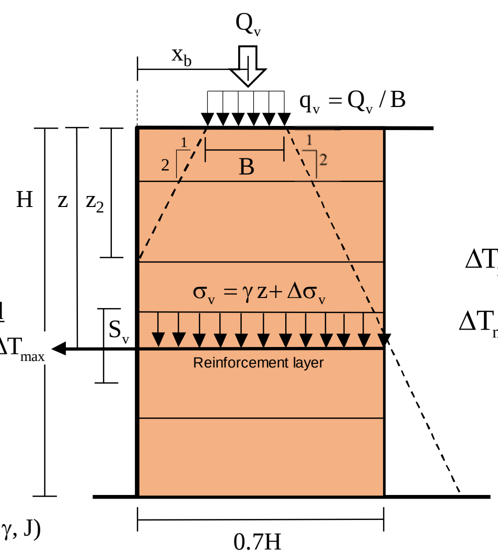
However, the Stiffness Method has not been calibrated for the case of a footing seated on the top of a MSE Wall





Problem geometry for bridge abutment spread footing seated on a geosynthetic MSE modular block wall (based on WSDot Geotechnical Design Manual 2019).

General Approach



Nominal load

$$Q_n = T_{max} + C \times \Delta T_{max}$$

$$T_{max} = f(H, D_{tmax}, \Phi_{fs}, S_v, z, \phi, c, \gamma, J)$$

Stiffness method

$$z_2 = 2(x_b - B/2)$$

$$\Delta T_{max} = S_v K_a Q_v/(B + z) \qquad z < z_2$$

$$\Delta T_{max} = S_v K_a \frac{Q_v}{0.5(B + z) + x_b} \qquad z > z_2$$

1H:2V footing load dispersion method

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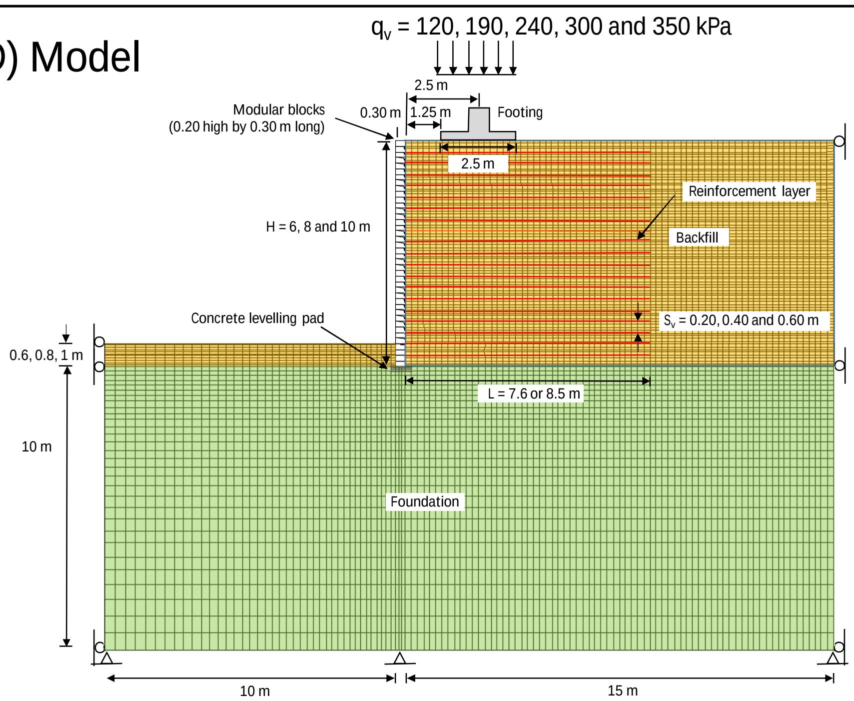
FLAC (2D) Model



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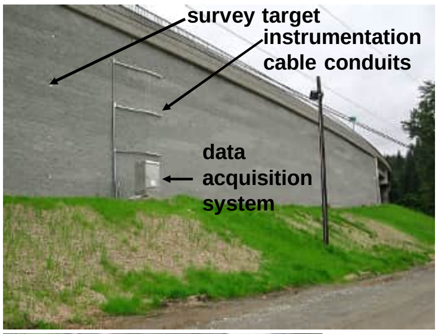
Part A: FLAC code checking

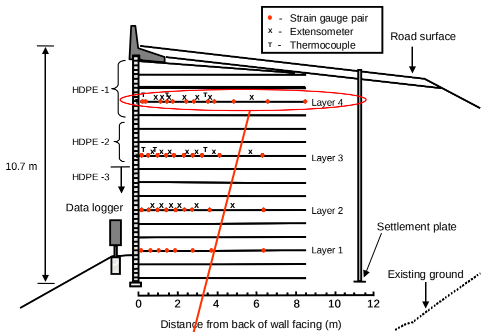
Cases:

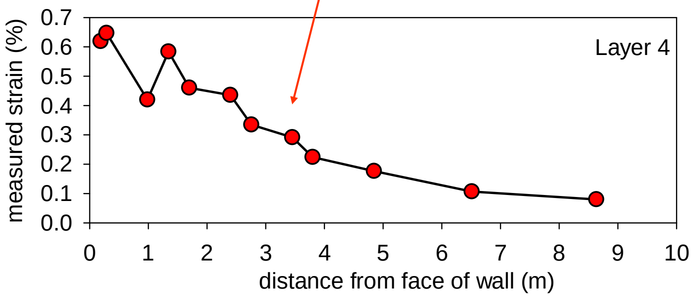
1. SR18 Walls D & C: End of construction

2. Ahmadi & Bezuijen (2018): Footing on MSE wall

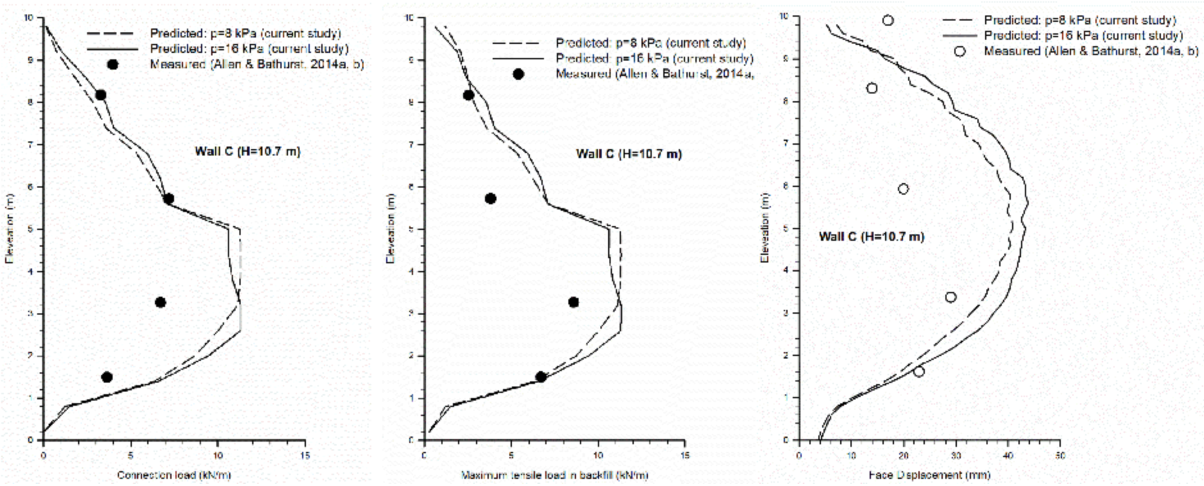
Wall C: Highway SR-18, Maple Valley, Washington, USA (Allen and Bathurst 2006)







SR18 Project (Allen and Bathurst 2014a, b)



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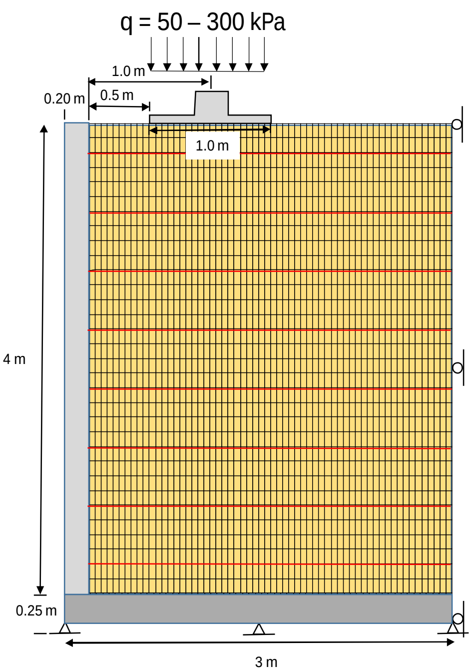
Ahmadi & Bezuijen (2018):
Footing on MSE wall with rigid facing and hinged toe



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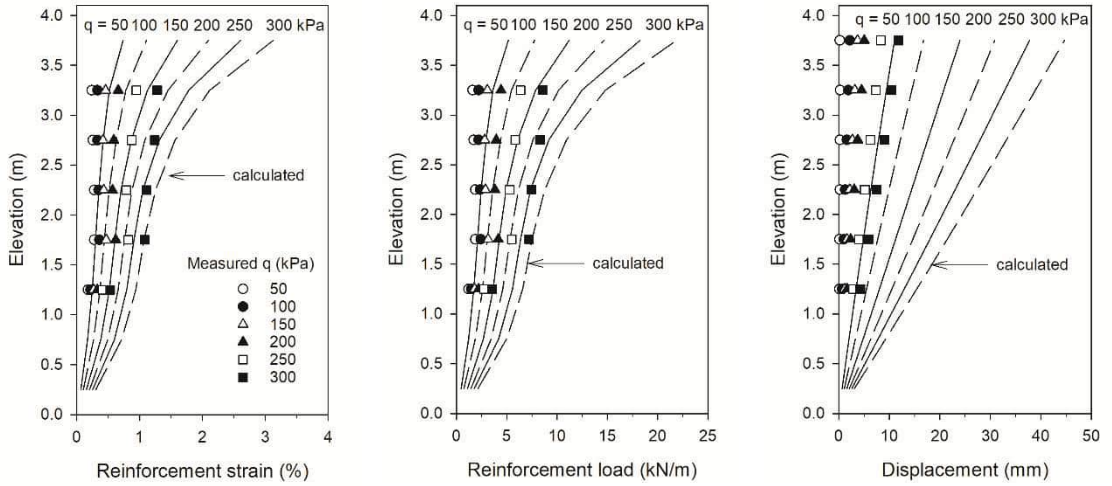
Ahamdi & Bezuijen (2018)_Rigid Wall Hinged Toe: E=35 GPa (Linear MC soil model)



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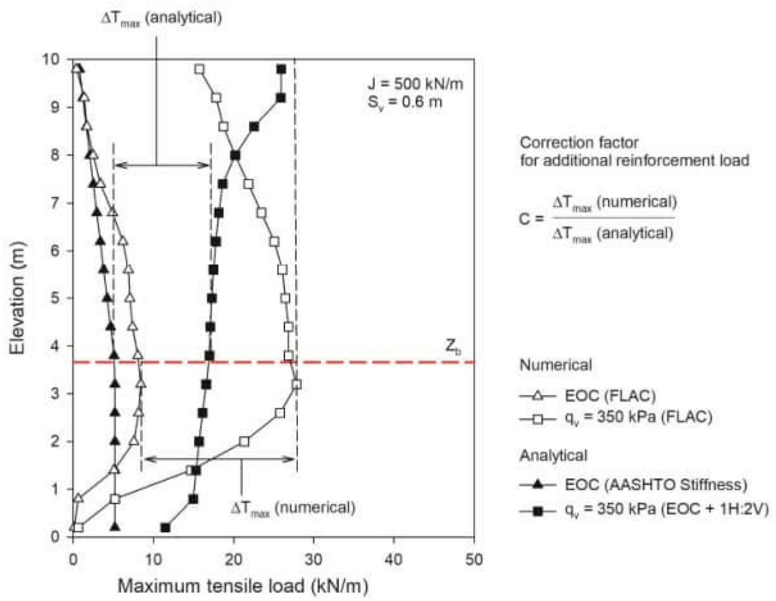

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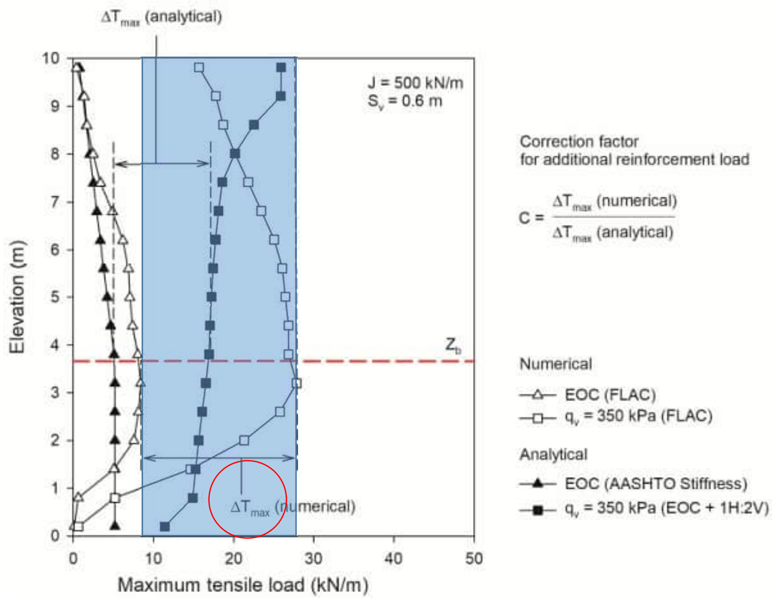

ΔT_{max} (analytical)
J = 500 kN/m
S_v = 0.6 m
Elevation (m)
Maximum tensile load (kN/m)
Z_b
ΔT_{max} (numerical)
Correction factor
for additional reinforcement load
C = ΔT_{max} (numerical) / ΔT_{max} (analytical)
Numerical
EOC (FLAC)
q_v = 350 kPa (FLAC)
Analytical
EOC (AASHTO Stiffness)
q_v = 350 kPa (EOC + 1H:2V)

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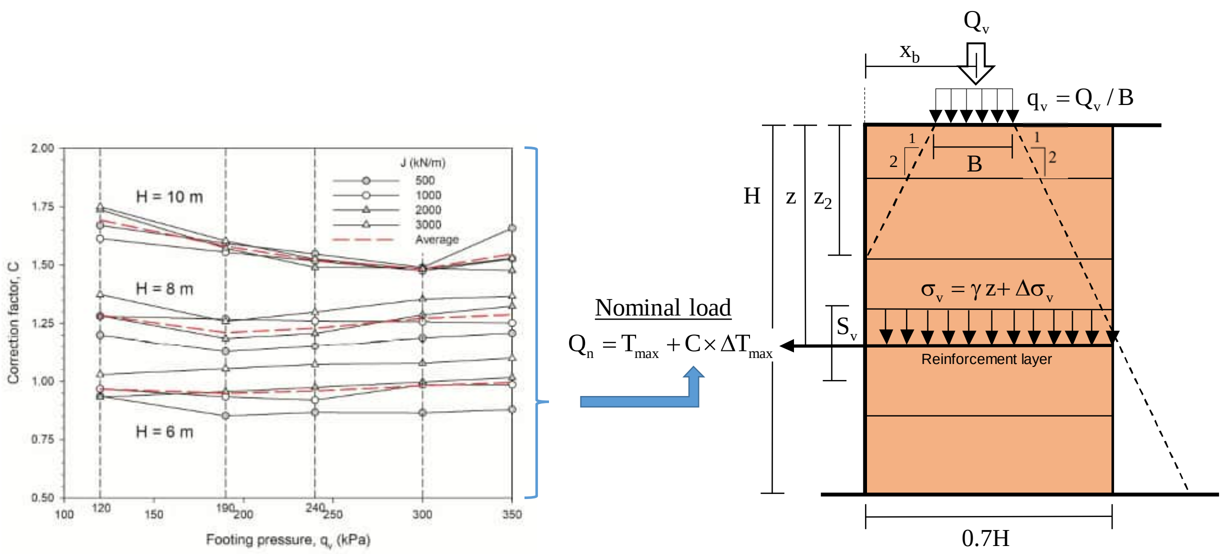

J (kN/m)
500
1000
2000
3000
Average
H = 10 m
H = 8 m
H = 6 m
Correction factor, C
Footing pressure, q_v (kPa)
Q_v
x_b
$q_v = Q_v / B$
B
H
z
z_2
$\sigma_v = \gamma z + \Delta\sigma_v$
S_v
Reinforcement layer
0.7H
Nominal load
$Q_n = T_{max} + C \times \Delta T_{max}$

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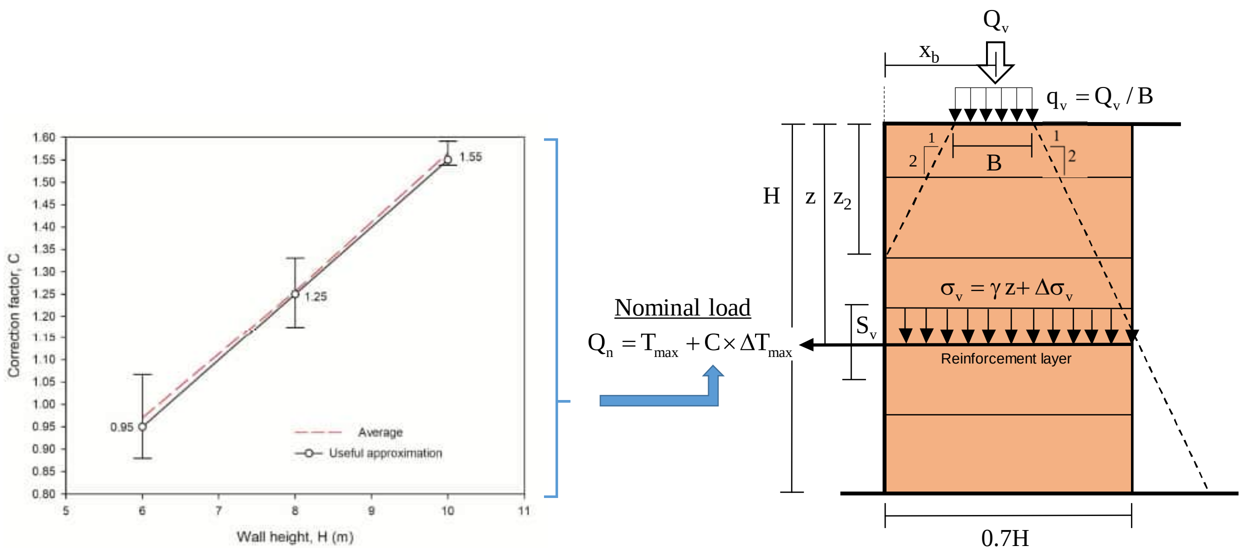

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Summary

- A method to include additional tensile loads in a geosyntethic reinforcement layer due to a surface footing on a MSE wall is proposed
- The additional loads (ΔT_{max}) are first calculated using the familiar 1H:2V method
- The additional load is corrected and added to the maximum load in the reinforcement for the EOC condition using the stiffness method
- A design chart that considers a wide range of wall heights, reinforcement spacing and reinforcement stiffness is available
- The method is conservative (safe)
- Can be adopted for future additions of the AASHTO code in the US and the Canadian Highway Bridge Code in Canada

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21st International Conference on Soil Mechanics and Geotechnical Engineering

2026 AUSTRIA VIENNA WHERE IT ALL BEGAN 21st ICSMGE

TC218 Workshop

Design of geosynthetic MSE walls supporting bridge abutment footings using the stiffness method

Richard J. Bathurst & Reza Jamshidi Chenari
Royal Military College of Canada
GeoEngineering Centre at Queen's-RMC, Kingston, Canada

15 June 2026, Vienna

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

AGENDA

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Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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Dynamic Response and Seismic Performance Evaluation of GRS Bridge Abutments

Yewei Zheng, Ph.D., Professor

School of Civil Engineering, Wuhan University

21st International Conference on Soil Mechanics and Geotechnical Engineering, June 15, 2026, Vienna, Austria

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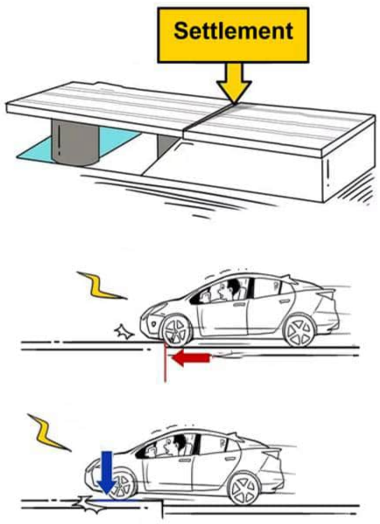
Geosynthetic Reinforced Soil Bridge Abutments

❐ Effective mitigation of bridge approach bump



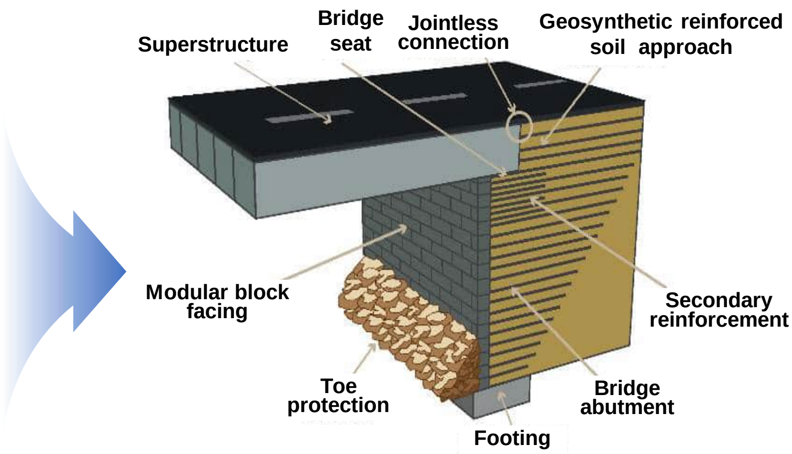


Illustration of GRS bridge abutment

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Seismic Performance of GRS Bridge Abutments

❒ Typical seismic damages from the 2010 Maule earthquake

➢ Further research on the **dynamic response** and **seismic performance** of GRS bridge abutments is needed.

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Outline

1 Background and Significance

2 Shaking Table Tests

3 Numerical Simulation

4 Seismic Fragility Analysis

5 Conclusions

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Outline

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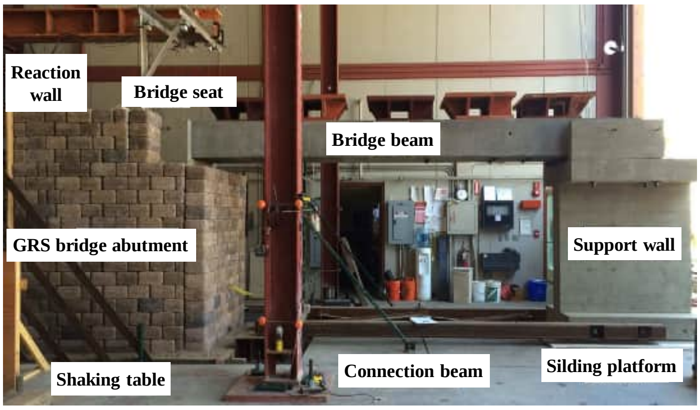
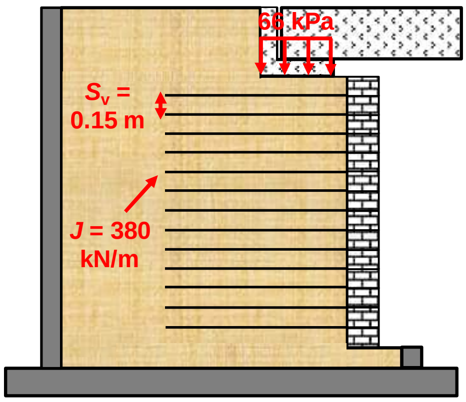
Shaking Table Test Program (I)

- Half-scale Model Tests





Model 1	Model 2	Model 3	Model 4
Baseline Case	Bridge Surcharge Stress	Reinforcement Vertical Spacing	Reinforcement Stiffness

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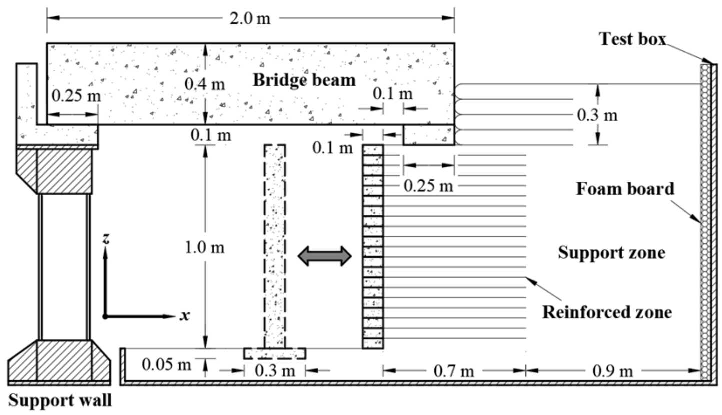
Shaking Table Test Program (II)

❑ ¼-Scale Model Tests



➢ Evaluate the influence of facing type on the dynamic response

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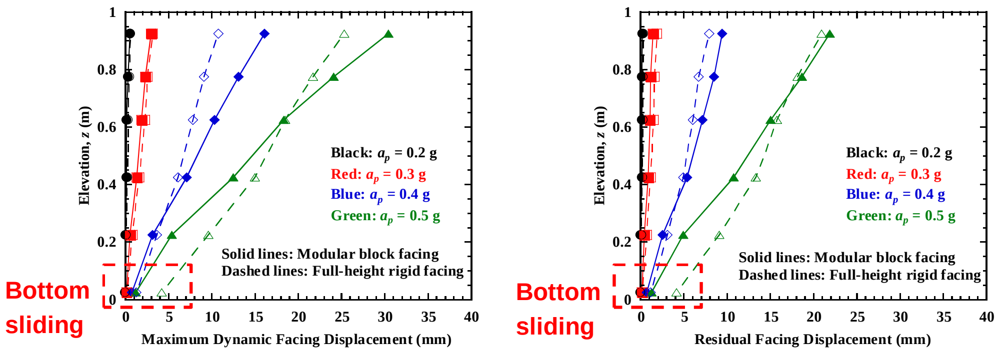
Test Results

❑ Facing displacements



Maximum facing displacement

Residual facing displacement

➢ The modular block facing GRS abutment generally exhibited larger displacements

➢ Once the full-height rigid facing GRS abutment reached 0.5g, its displacement increased rapidly and was accompanied by bottom sliding

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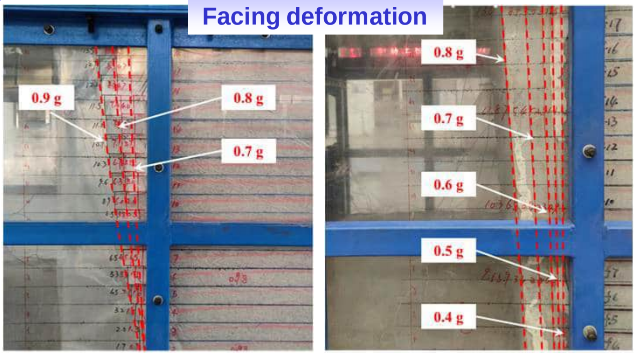
Test Results

❒ Failure condition

Facing deformation



Modular block facing | Full-height rigid facing

Failure surface and connection failure

Modular block facing

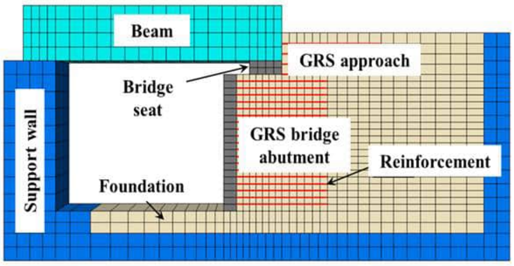
Full-height rigid facing

- The modular block facing GRS abutment mainly exhibited an outward tilting failure mode
- The full-height rigid facing GRS abutment developed a combined failure mode characterized by outward tilting and sliding at the bottom of the wall

Outline

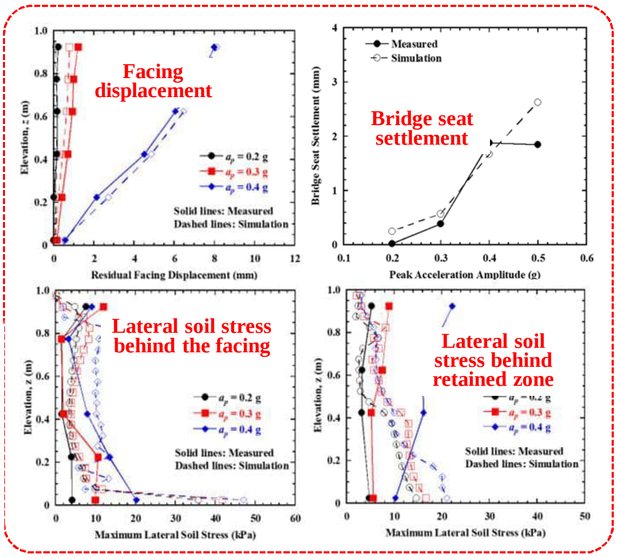
Numerical Simulation

❒ Numerical model and validation



Numerical model of shake table test

Validation Results



Reasonable agreements between the simulated and measured results

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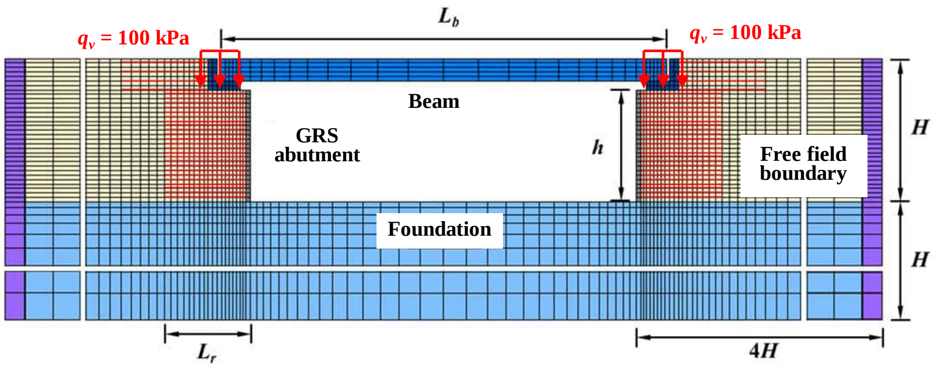
Numerical Simulation

❒ Baseline case model



- Total height $H = 7.4$ m, lower wall height $h = 5.0$ m
- Concrete beam length $L_b = 20$ m
- Bridge surcharge stress $q_v = 100$ kPa
- Reinforcement spacing $S_v = 0.2$ m
- Reinforcement length $L_r = 3.5$ m
- Input sinusoidal wave $PGA = 0.3$ g, $f = 2$ Hz, $t = 6$ s

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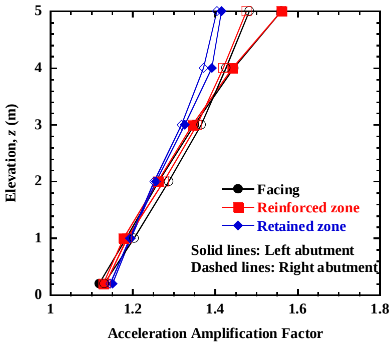
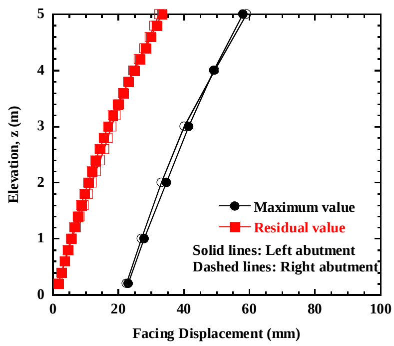
Numerical Simulation

❒ Baseline case results

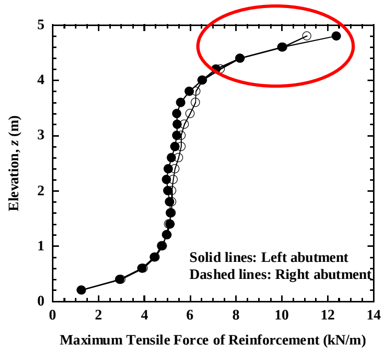
High tensile forces



Acceleration amplification factor



Facing displacement

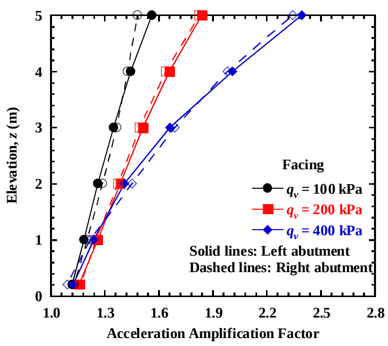


Maximum tensile force of reinforcement

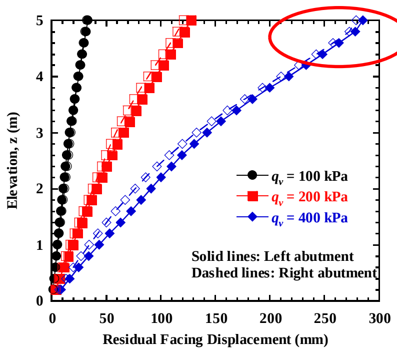
Numerical Simulation

❒ Influence of bridge surcharge stress

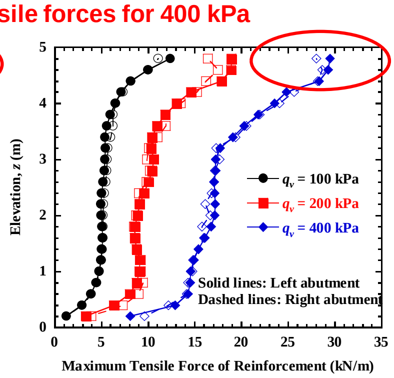
Significant displacements and tensile forces for 400 kPa



Acceleration amplification factor



Facing displacement



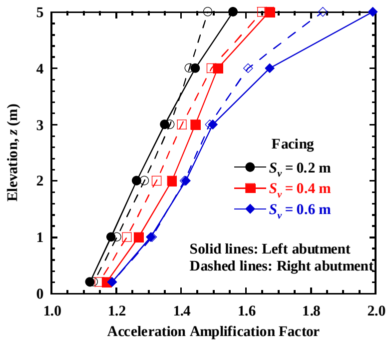
Maximum tensile force of reinforcement

- ➢ **Greater bridge surcharge stress leads to higher acceleration amplification, residual facing displacement, and maximum reinforcement tensile force.**

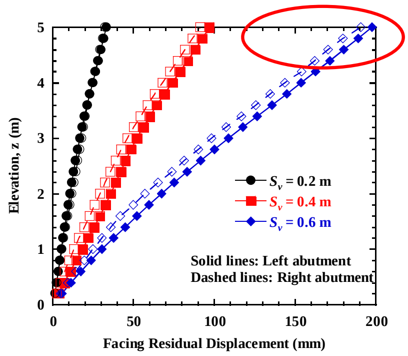
Numerical Simulation

❒ Influence of reinforcement spacing

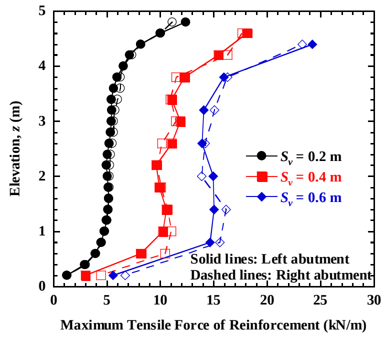
Large displacements



Acceleration amplification factor



Facing displacement



Maximum tensile force of reinforcement

➢ Larger vertical reinforcement spacing leads to higher acceleration amplification, residual facing displacement, and reinforcement tensile force.

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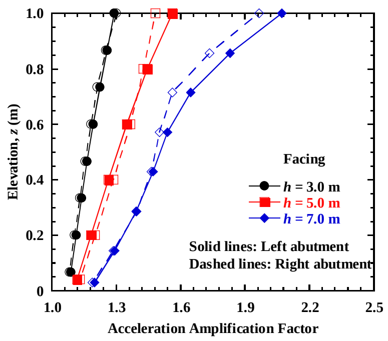
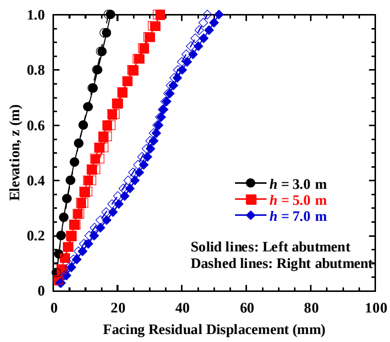
Numerical Simulation

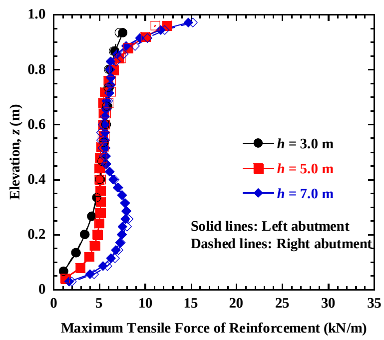
❒ Influence of abutment height



Acceleration amplification factor



Facing displacement



Maximum tensile force of reinforcement

➢ Greater abutment height leads to higher acceleration amplification, residual facing displacement, and reinforcement tensile force.

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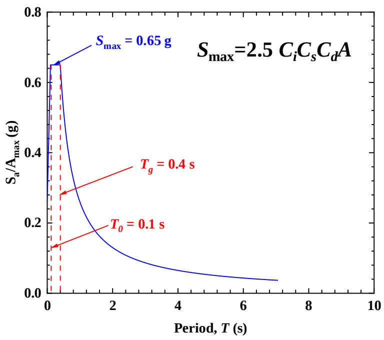
Outline

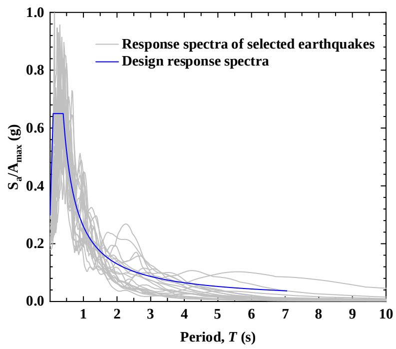
Seismic Fragility Analysis

❐ Input motions for IDA

- The design acceleration response spectrum was determined based on JTG/T 2231-01-2020 ($C_i = 1.3$, $C_s = 1.0$, $C_d = 1.0$, $A = 0.2$g)
- Twenty ground motions were selected from the PEER strong motion database



Design response spectra



Response spectra of selected motions

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Seismic Fragility Analysis

❒ Damage States

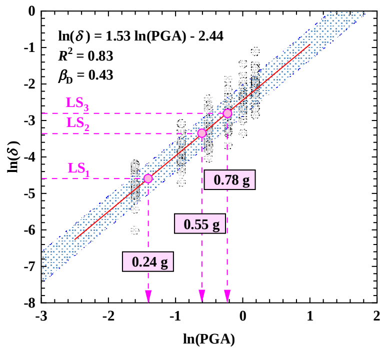
Definition of damage states for retaining structures (Zhang et al., 2009)

Damage state		Serviceability	Displacement Index *d* (%)
DS1	No/Slight Damage	Normal service	*d* ≤ 1.0%
DS2	Local damage	Short term recovery	1.0% < *d* ≤ 3.5%
DS3	Large deformation, no collapse	Speed restricted after repair	3.5% < *d* ≤ 6.0%

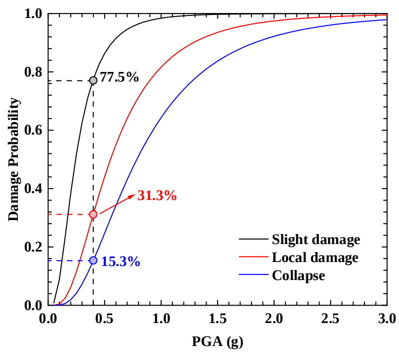
Zhang, J. J., Feng, J., Xiao, S. G., & Liu, C. Q. (2009). Discussions on two key technical problems for seismic design of retaining structures. Journal of Southwest Jiaotong University, 44(3), 321–326. (in Chinese)

Seismic Fragility Analysis

❒ Seismic Performance Evaluation



Probabilistic seismic demand model



Fragility curves

- At the design PGA of 0.4g, the probabilities of slight damage, local damage, and near collapse are 77.5%, 31.3%, and 15.3%, respectively, indicating favorable seismic performance of GRS bridge abutments.

Conclusions

- **Modular block facing and full-height rigid facing GRS bridge abutments exhibit different deformation modes**
- **Reinforcement spacing and bridge surcharge stress significantly affect the dynamic response of GRS bridge abutments**
- **Fragility analysis indicates that GRS bridge abutments have favorable seismic performance**

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Thank You!

Yewei Zheng

Email: yzheng@whu.edu.cn

21st International Conference on Soil Mechanics and Geotechnical Engineering, June 15, 2026, Vienna, Austria

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ISSMGE/TC-218 (& IGS/TC-R) Special Session

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AGENDA

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Closure: *5th Workshop on Soil Reinforcement (TC-R and TC-218), Reggio Calabria, 7-9 July 2026*.

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Tensar
A Division of CMC

Load-Carrying Reinforced Soil Bridge Abutments – Integral and Semi-Integral Bridges: Design and Construction with UK Experience

Mitul J Dalwadi-B.E. M.E. CEng MICE RoGEP
Application Technology Manager (EH)- Reinforced Soil Structures
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Load-Carrying Reinforced Soil Bridge Abutments – Integral and Semi-Integral Bridges

Proven Technology

Proven Savings

Proven Success

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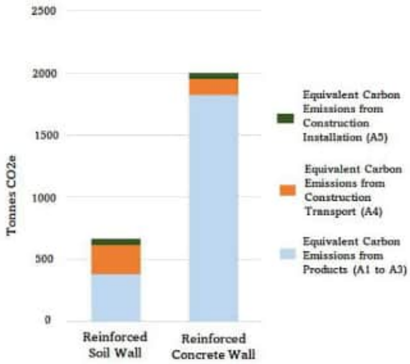
66%CO_2 savings!!



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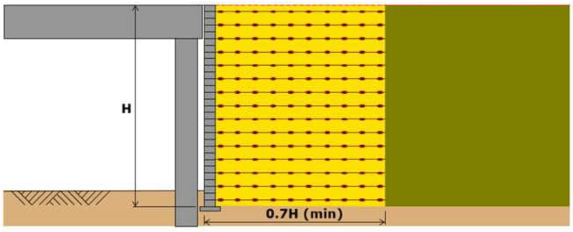
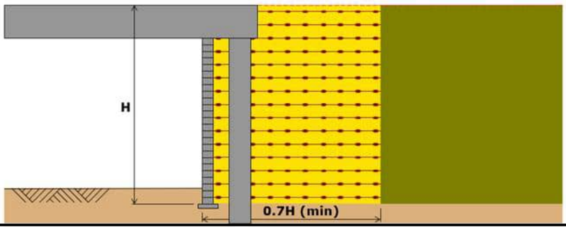
Types of Bridge Abutments: Non-Load Carrying Bridge Abutments

- Designed as a typical reinforced soil retaining structure
- Not part of today's discussion





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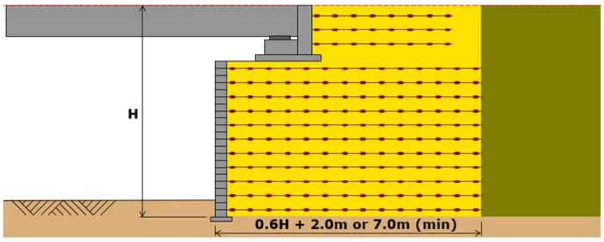
Types of Bridge Abutments: Load Carrying Reinforced Soil Bridge Abutments



via bearings and joints

Bankseat: Semi-Integral

Bankseat: Integral

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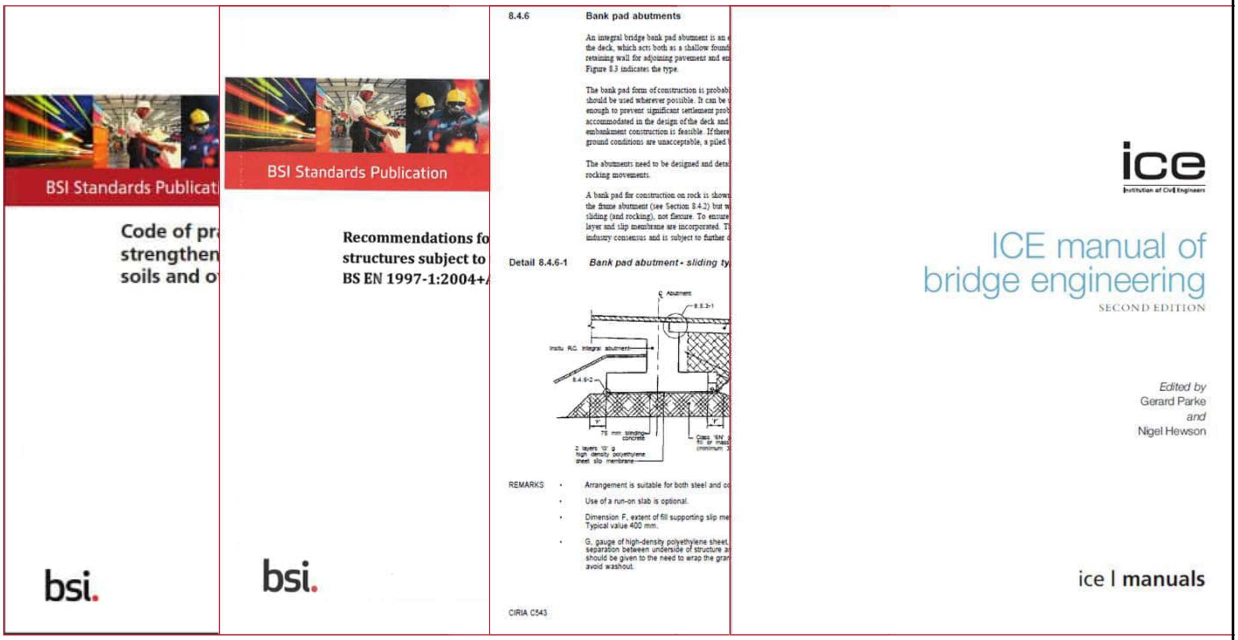
Standards and Guidelines - UK



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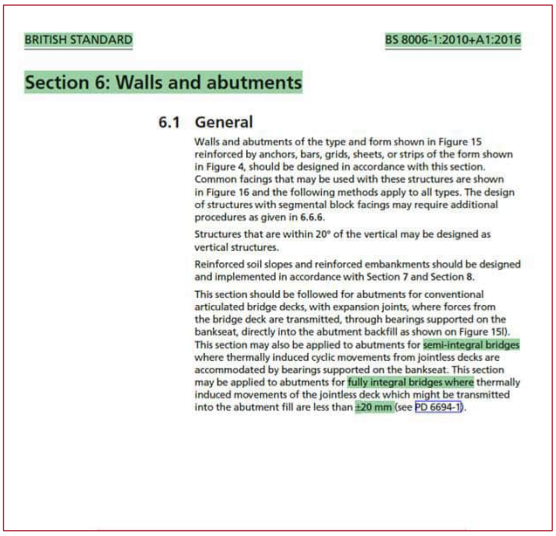
UK Standards- BS8006-1:2010 + A1:2016

- BS EN 14475:2006 Execution of special geotechnical works- Reinforced fill
- BS EN 1997-1 & NA to BS EN 1997-1
- BS EN 1997-1:2004 does not cover the design and execution of reinforced soil structures. The values of partial factors and load factors given in Eurocode have not been calibrated for reinforced soil structures
- Eurocode update*



BRITISH STANDARD BS 8006-1:2010+A1:2016

Section 6: Walls and abutments

6.1 General

Walls and abutments of the type and form shown in Figure 15 reinforced by anchors, bars, grids, sheets, or strips of the form shown in Figure 4, should be designed in accordance with this section. Common facings that may be used with these structures are shown in Figure 16 and the following methods apply to all types. The design of structures with segmental block facings may require additional procedures as given in 6.6.6.

Structures that are within 20° of the vertical may be designed as vertical structures.

Reinforced soil slopes and reinforced embankments should be designed and implemented in accordance with Section 7 and Section 8.

This section should be followed for abutments for conventional articulated bridge decks, with expansion joints, where forces from the bridge deck are transmitted, through bearings supported on the bankseat, directly into the abutment backfill as shown on Figure 15l). This section may also be applied to abutments for semi-integral bridges where thermally induced cyclic movements from jointless decks are accommodated by bearings supported on the bankseat. This section may be applied to abutments for fully integral bridges where thermally induced movements of the jointless deck which might be transmitted into the abutment fill are less than ±20 mm (see PD 6694-1).

The earlier British design manual for Roads and Bridges included design of load carrying reinforced soil bridge abutments but with a restriction on bridge span of 18 m for integral bridges.

*New Eurocode 7 part 3 includes Section 9 on reinforced fills

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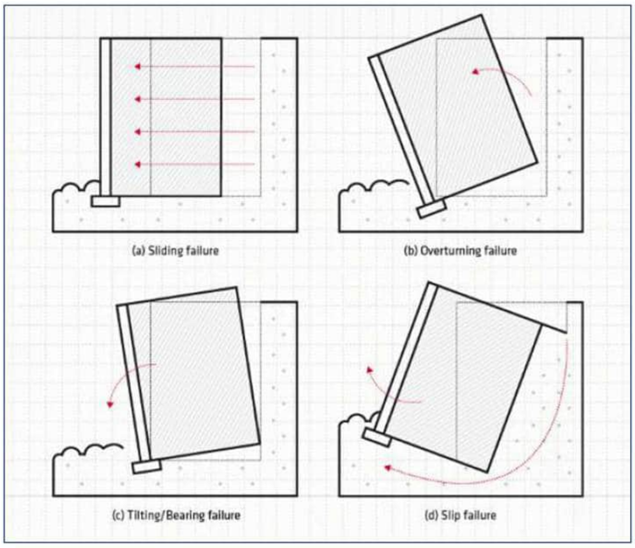
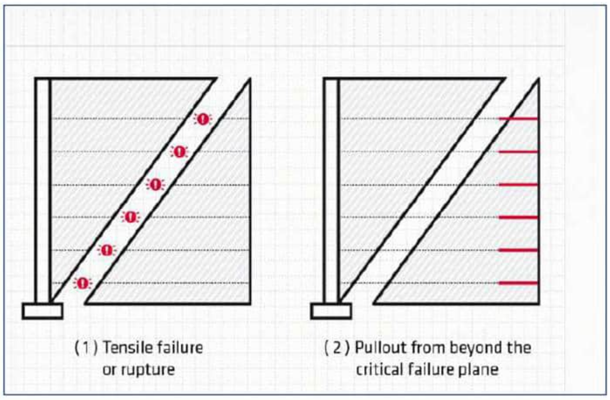
Assessment





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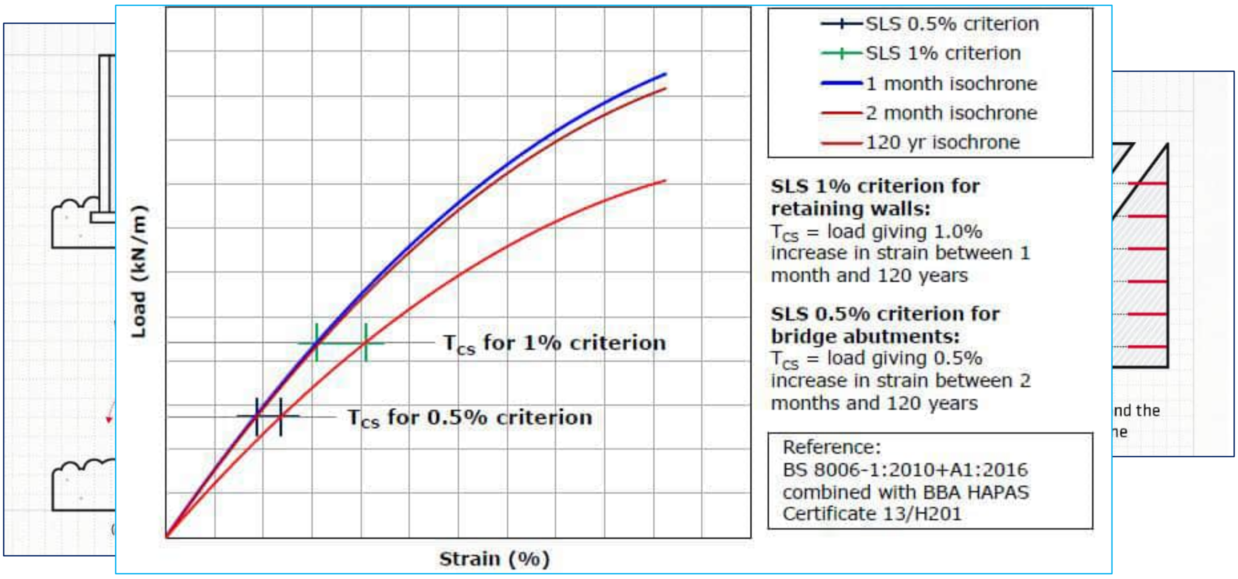
Assessment



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Load Combinations/Bridge Loading

Effects		Combinations A	B	C
		A	B	C
Mass of the reinforced soil body		$f_{fs} = 1.5$	$f_{fs} = 1.0$	$f_{fs} = 1.0$
Mass of backfill on top of the reinforced soil body		$f_{fs} = 1.5$	$f_{fs} = 1.0$	$f_{fs} = 1.0$
Dead load of bridge and bank seat		$f_f = 1.2$	$f_f = 1.0$	$f_f = 1.0$
Backfill pressure behind the bank seat		$f_{fs} = 1.5$	$f_{fs} = 1.5$	$f_{fs} = 1.0$
Backfill pressure behind the reinforced soil body		$f_{fs} = 1.5$	$f_{fs} = 1.5$	$f_{fs} = 1.0$
Horizontal loads due to creep and shrinkage		$f_f = 1.2$	$f_f = 1.2$	$f_f = 1.0$
Traffic Load: on reinforced soil body		$f_q = 1.5$	$f_q = 0.0$	
Behind reinforced soil body		$f_q = 1.5$	$f_q = 1.5$	
Bridge Vertical live load	Normal Vehicle traffic (LM1 and LM2)	$f_q = 1.5$	$f_q = 1.5$	
	Special vehicle -LM3	$f_q = 1.3$	$f_q = 1.3$	
Braking dynamic load	Normal Vehicle traffic (LM1 and LM2)	$f_q = 1.25$	$f_q = 1.25$	
	Special vehicle -LM3	$f_q = 1.1$	$f_q = 1.1$	
Temperature Effects		$f_q = 1.3$	$f_q = 1.3$	

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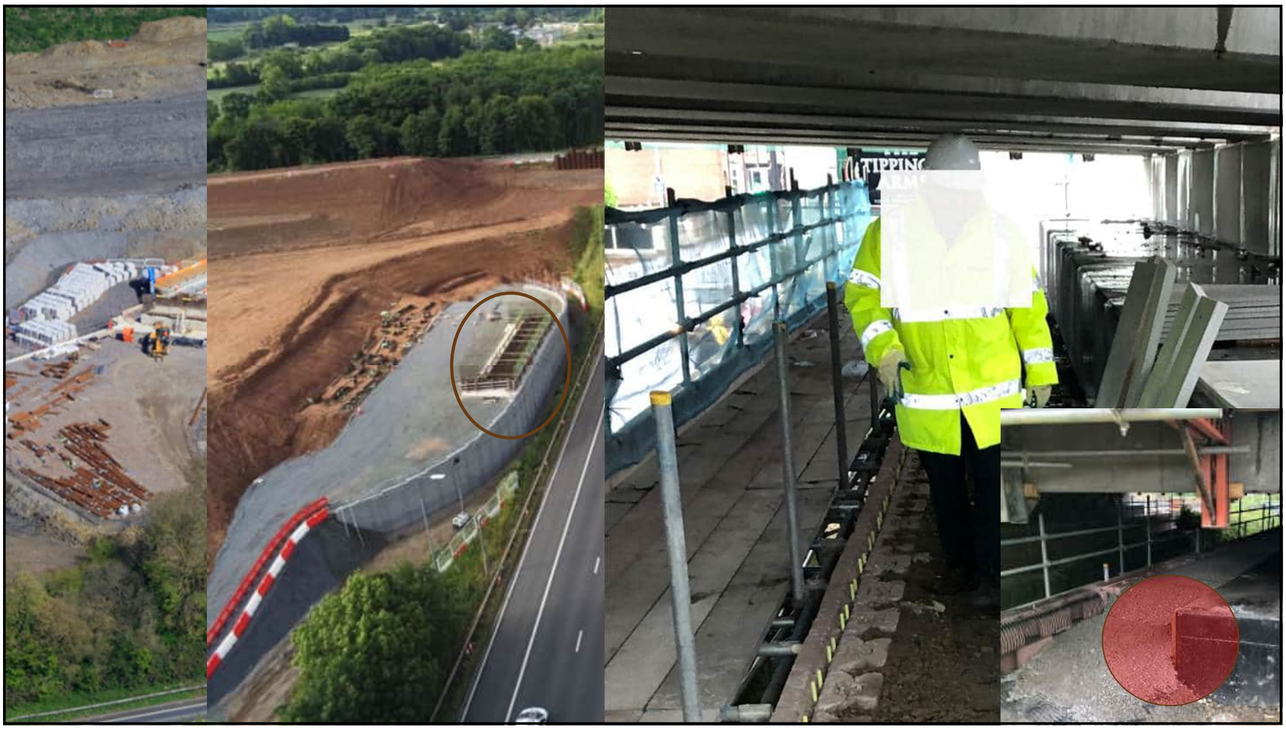

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Load Carrying MSE Bridge Abutment- Semi Integral/ Integral- UK Experience

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Some tips- Design + Construction

Reinforced Soil: >99%

Drainage –within and Infront

Loading and Construction phases

Long Term Design Strength of soil reinforcement

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Technical Paper on Carbon Assessment

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Réductions de carbone dans la conception et la construction du pont ferroviaire du réseau routier de la station HS2 avec culées de murs en sol renforcé par géogrille polymère et murs en aile sur des fondations peu profondes

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7 - 9 July 2026

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