

# DESIGN THE CHANGE

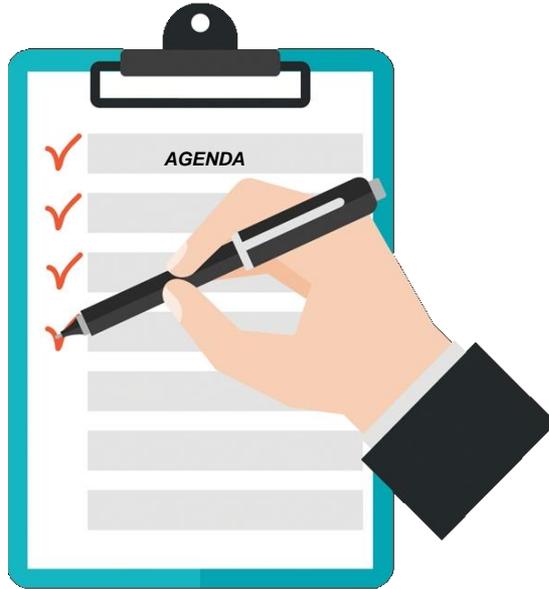


Speakers:

**ANTOINE GAGLIARDI**

**PAOLO DI PIETRO**

# Webinar Agenda?



## 5' Introduction

ANTOINE GAGLIARDI – Manager DT Business Unit

## 45' Design The Change – Serviceability in Retaining Walls

PAOLO DI PIETRO – Senior Specialist DT Business Unit

## Live Q&A Session

**Optimised design of walls can lead not only to economical but also to environmental benefits**





# A green thought has driven our engineering mindset.



For over 140 years, we have developed solutions that enhance river ecosystem resilience including the social ability to recover quickly from catastrophic events (flood, natural disasters)



*An approach to the  
**design of gabion structures**  
to provide an economically  
and environmentally more  
effective solution*

# VIDEO TEASER



**SERVICEABILITY IN RETAINING WALLS**



Civil engineering structures are exposed to increasingly **aggressive conditions**



The **over-use** of natural materials is becoming an environmental issue

A close-up photograph of several bright yellow flowers with five petals each, growing in front of a silver wire mesh fence. The background is blurred, showing more of the fence and some dry vegetation. The lighting is natural, highlighting the texture of the petals and the metallic sheen of the fence.

“Engineers are required to “meet the needs of the **present** without compromising the ability for **future** generations to meet theirs” [International Institute for Sustainable Development (IISD)]

# A LONG LASTING COMMITMENT IN IMPROVING MATERIALS AND SOLUTIONS FOR CIVIL ENGINEERING



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



			
			
UNICAMP	IIT Roorkee	University of Trento	Istituto Sperimentale Modelli Geotecnici



## THE R&D

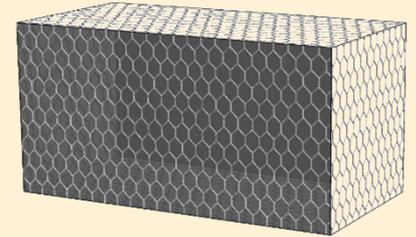
*Long term performance  
of walls*

## Design The Change

represents an innovative development in the engineering features of **Gabion** structures, which was possible through a thorough investigative testing campaign aimed at quantifying their performance limits when used as mass gravity retaining walls.

Main scope of the research was to monitor the performance of Gabions under the most severe conditions. This raised 2 questions:

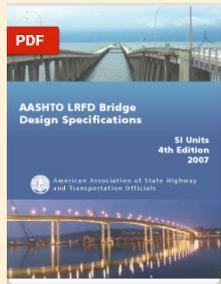
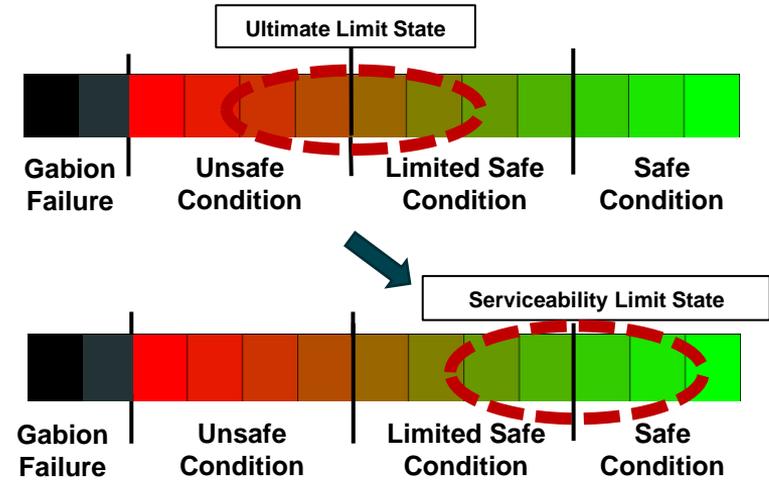
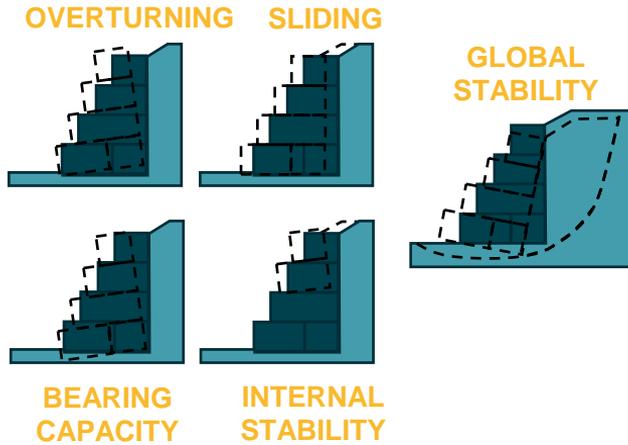
- M** How can we define a long-term performance for a Gabion Structure?
- M** How can we make a Gabion Structure more cost-effective?



INNOVATION CENTER  
MACCAFERRI



The research was carried out in various Engineering Centers, under the coordination of the **Maccaferri Innovation Center**



Effects of chemical **CORROSION**

Effects of **TIME & ENVIRONMENT**

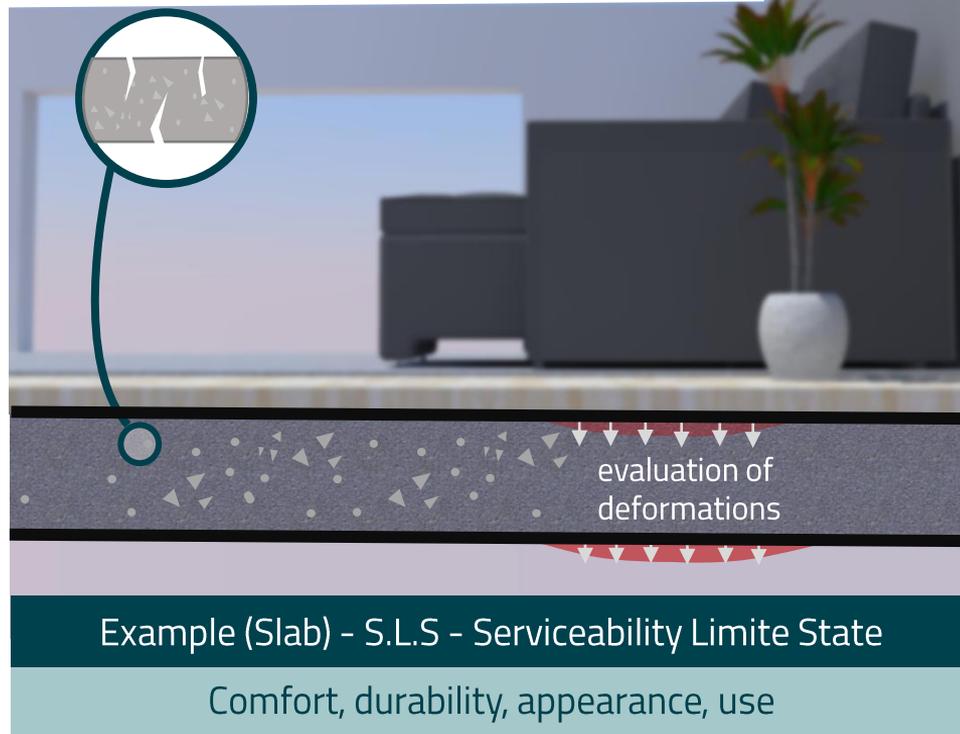
Sensitivity of structures to **DEFORMATION**

Avoid **BRITTLE FAILURES**

Avoid excessive **DISPLACEMENTS**

**Serviceability limite state (SLS)** is related to user comfort and **durability, appearance** e **good use** of the structures, whether in relation to users, or in relation to the machines and equipment supported by the structures.

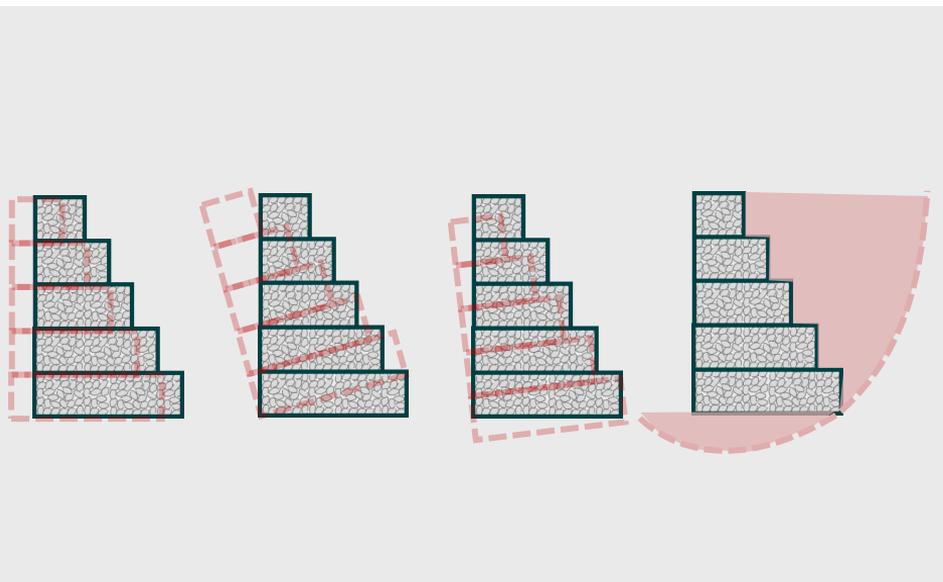
Checking for cracks



# ULTIMATE LIMITE STATE

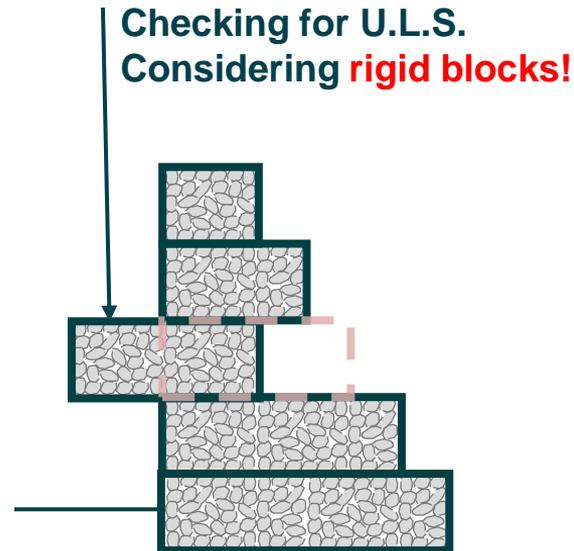
Security check against collapse

MACCAFERRI



The use of ULS for external stability analysis considers the gabion as a rigid block.

External stability  
(Ultimate Limite State)



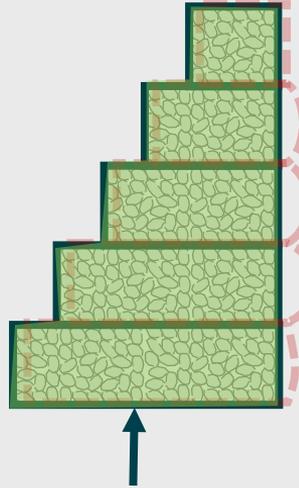
The analysis of internal stability through the ELU, **does not represent** the aspects of durability, appearance and use of the structure.

Internal stability  
(Ultimate Limite State)

# SERVICEABILITY LIMITE STATE (SLS)

Analysis of comfort, durability, appearance and use

Even considering the ULS analysis, gabion structures can present deformations, which affect their performance and are identified in the SLS analysis..



**SLS – OK!**

(Internal stability considering mesh influence)



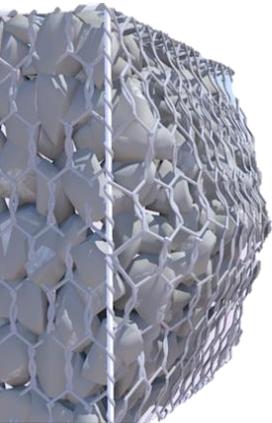
**ULS – It is not acceptable!**

Some works may have deformations, which the E.L.U analyzes were not able to identify.

# SERVICEABILITY LIMIT STATE CHECK

How to ensure that the gabion meets the conditions of serviceability?

- M** Serviceability analysis through the GSC
- M** Correct installation of gabions
- M** Use of mesh with correct performance on the face (StrongFace)
- M** Use of POLIMAC coating



**S.L.S.**  
**satisfied!**

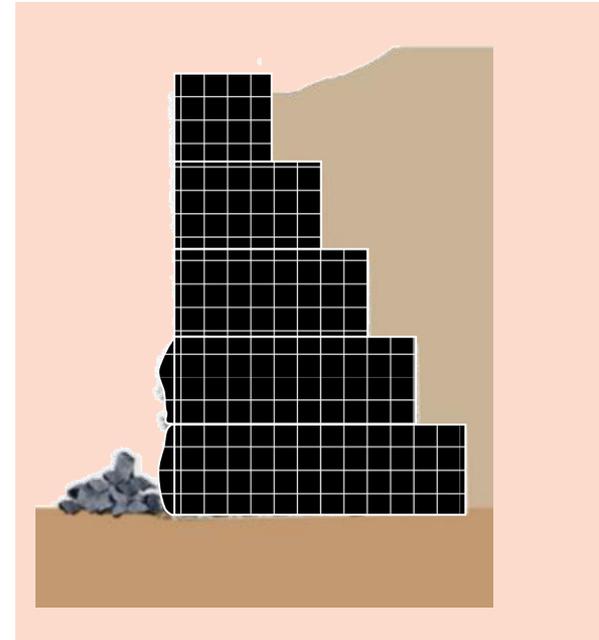
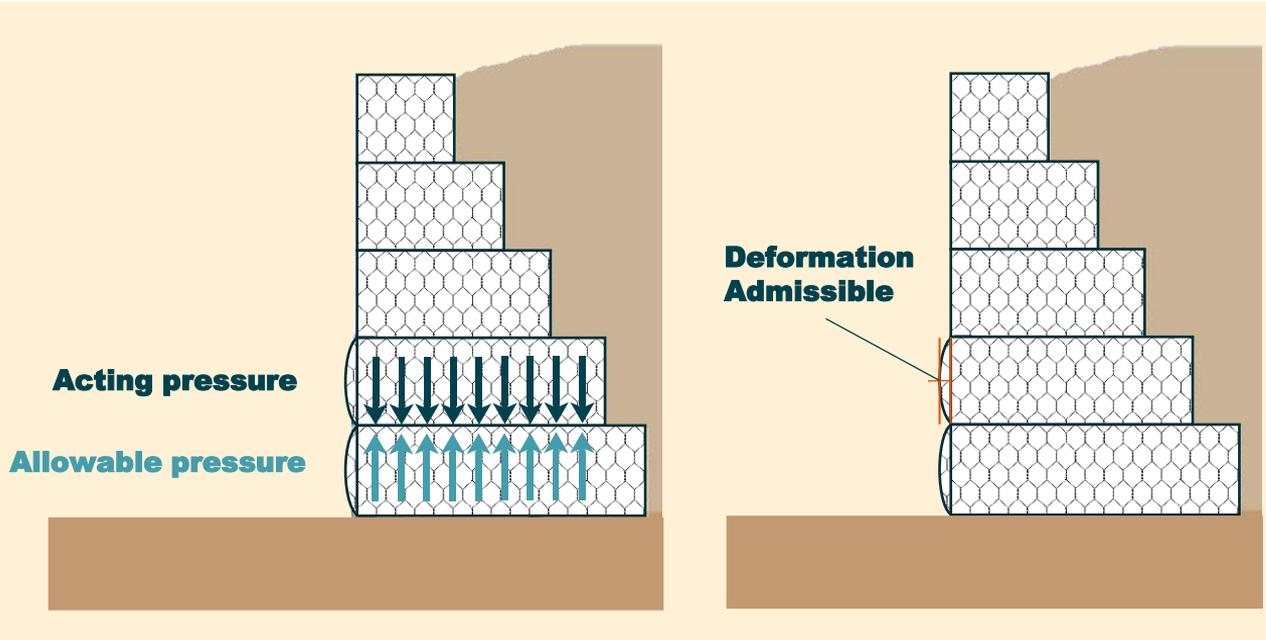


Using the STRONG FACE gabion

Face with higher strength mesh

- M** Serviceability condition – OK!
- M** Good appearance – OK!
- M** High durability
- M** Long-term high performance

**GABION  
STRONG  
FACE**

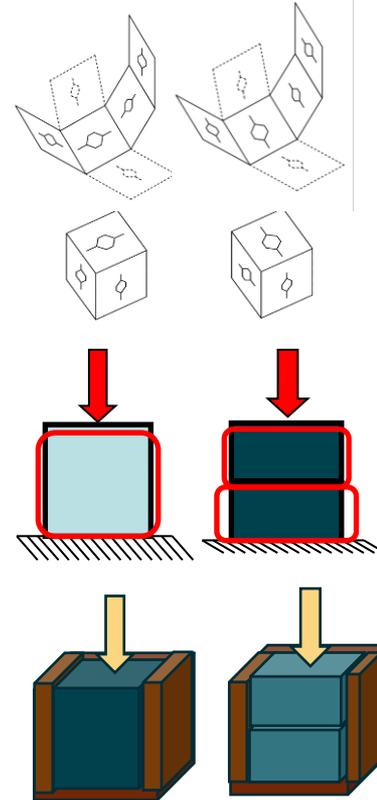


# THE RESEARCH

Mesh Type	Wire [mm]	H <sub>gabion</sub> [mm]
6x8	2.7	1000
8x10	2.7	500, 1000
	3.0	1000
	3.4	1000
10x12	2.7	1000
	3.0	1000



Grand total : approx 70 tests



## MESH ORIENTATION

- vertical
- horizontal

## STONEFILL

- limestone
- granite
- rounded

## UNCONFINED

lateral expansion

## CONFINED

lateral expansion

DESIGN  
THE  
CHANGE

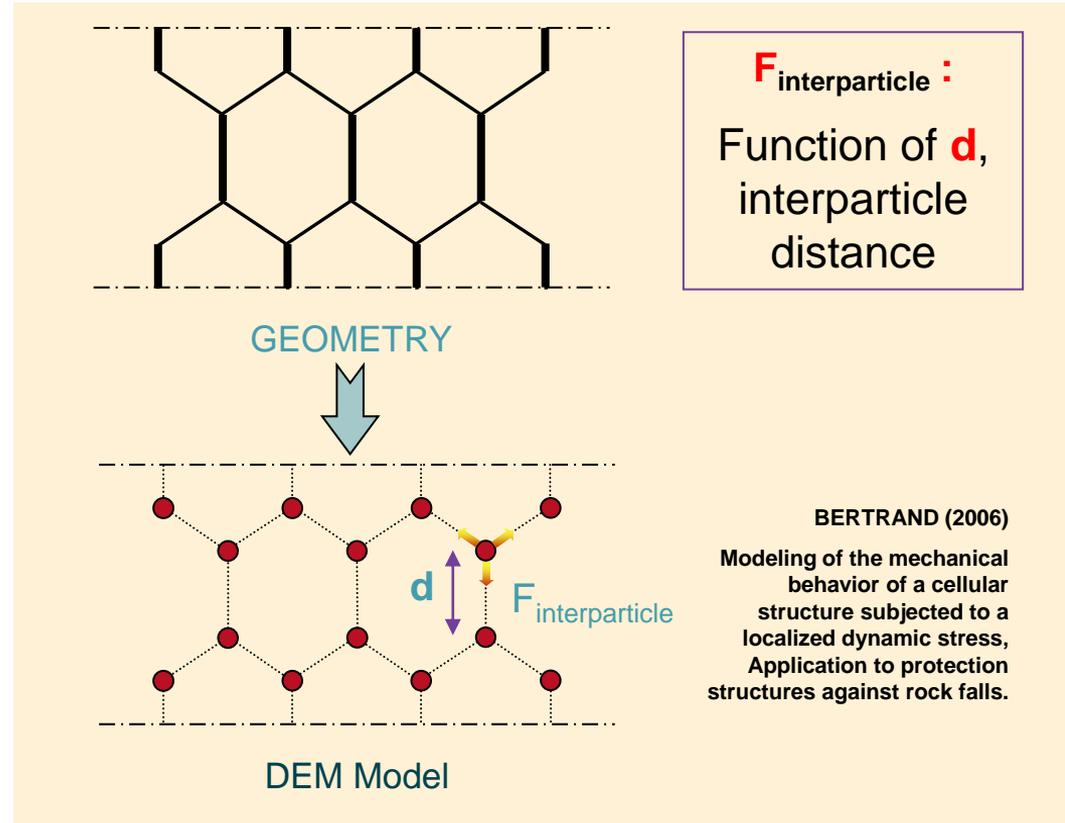


# THE NUMERICAL MODEL - CALIBRATION

Discrete Element Method (DEM)



Compression Test  
UNICAMP - IIT - ISMGEO

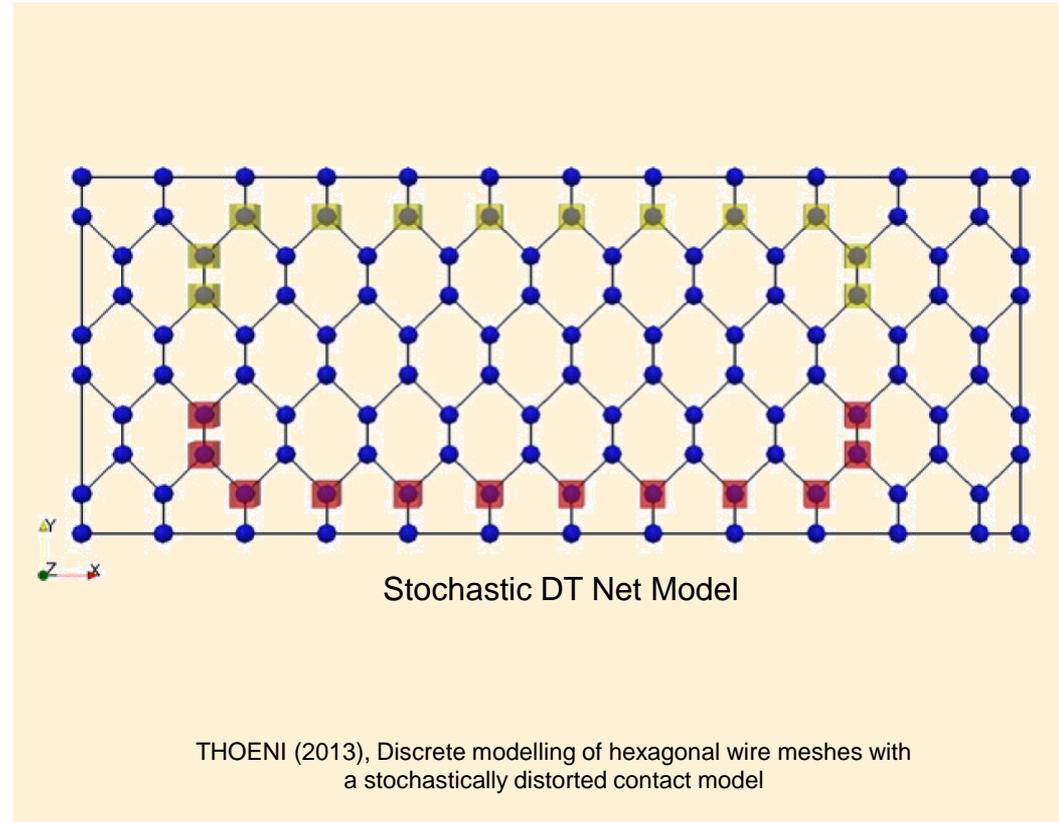


# THE NUMERICAL MODEL - CALIBRATION

Discrete Element Method (DEM)

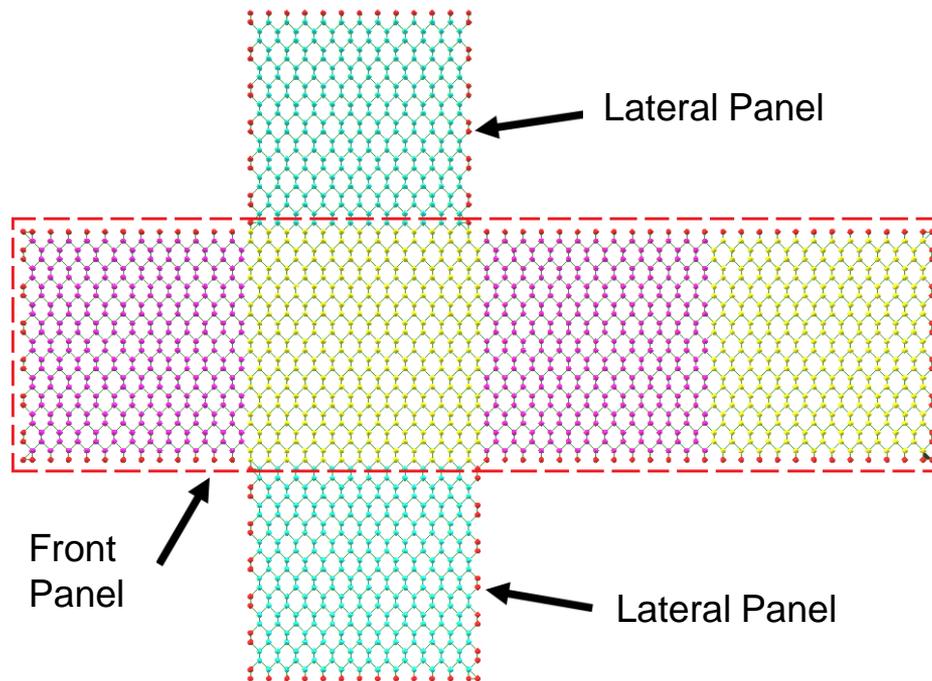
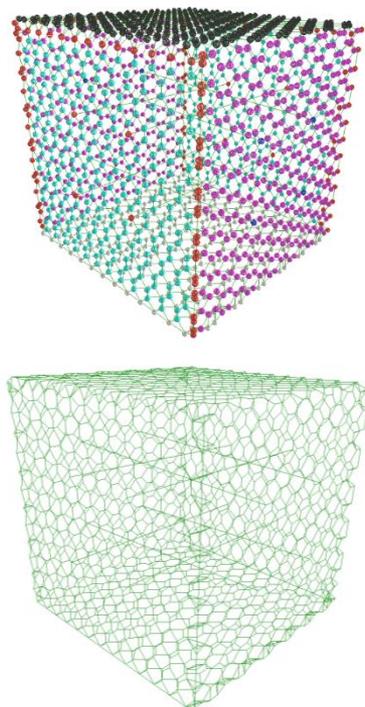


Compression Test  
UNICAMP - IIT - ISMGEO



# THE NUMERICAL MODEL - CALIBRATION

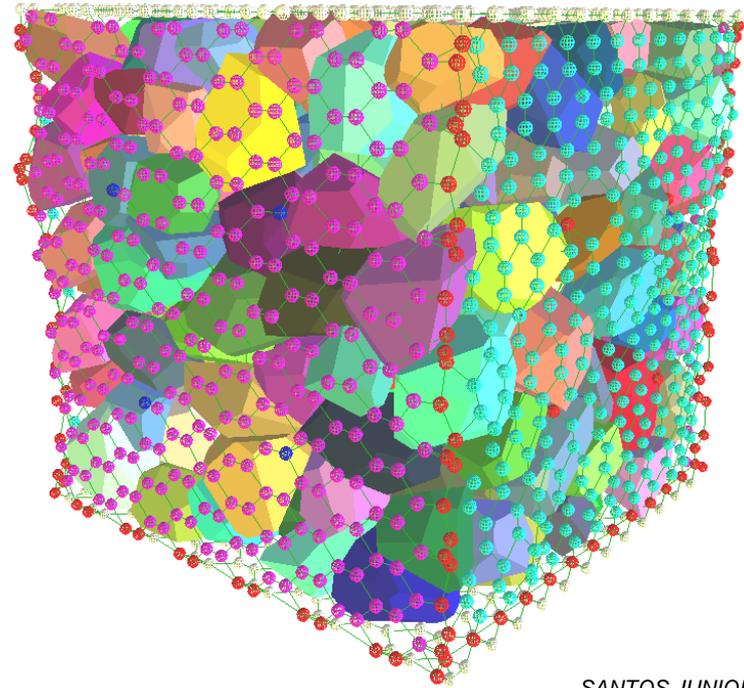
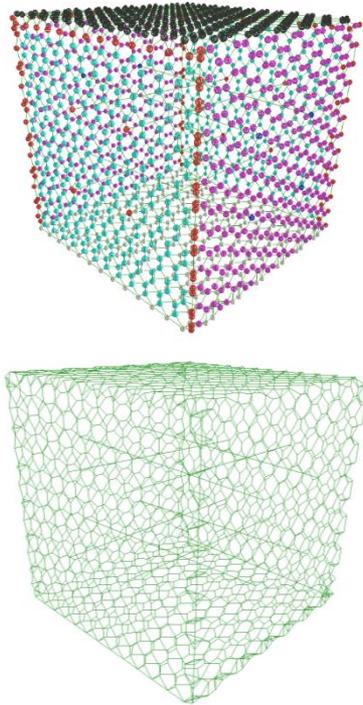
Discrete Element Method (DEM)



SANTOS JUNIOR, 2018

# THE NUMERICAL MODEL - CALIBRATION

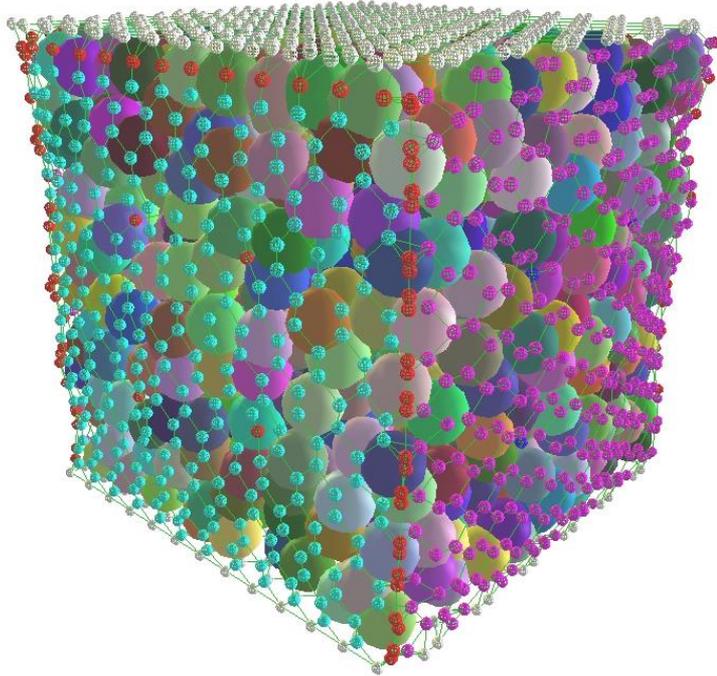
Discrete Element Method (DEM)



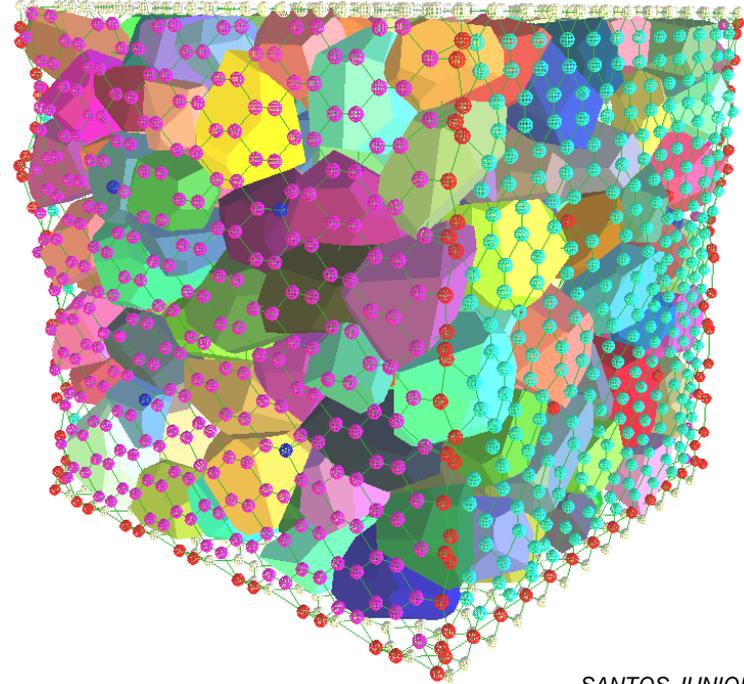
SANTOS JUNIOR, 2018

Discrete Element Method (DEM)

Spherical elements



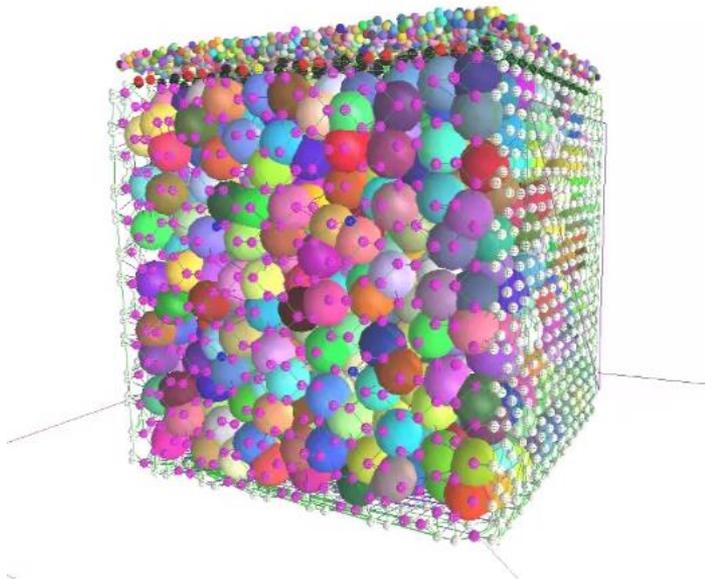
Polyhedral elements



SANTOS JUNIOR, 2018

# THE NUMERICAL MODEL - CALIBRATION

Discrete Element Method (DEM)



DEM | Discrete Element Method

SANTOS JUNIOR (2018)

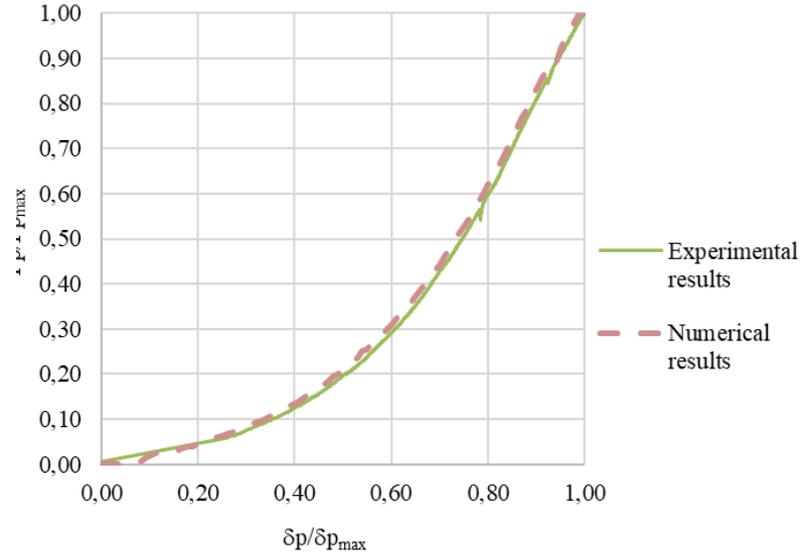
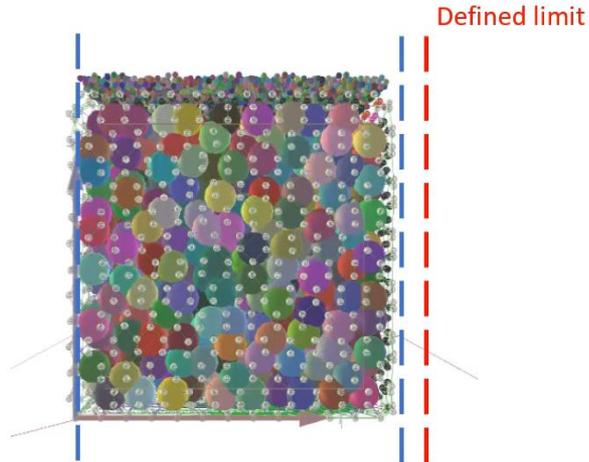


Restricted compression Test  
ISMGEO

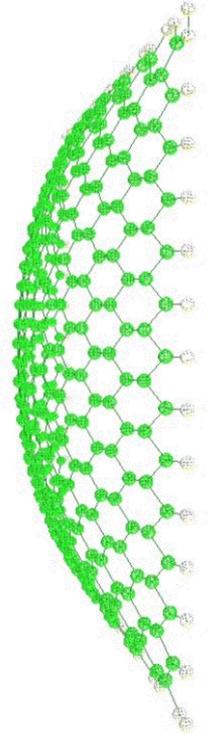
GET IN CONTACT WITH US TO RECEIVE MORE INFORMATION ON OUR R&D CAMPAIGNS. TYPE **“TRAINING”** IN THE CHATBOX

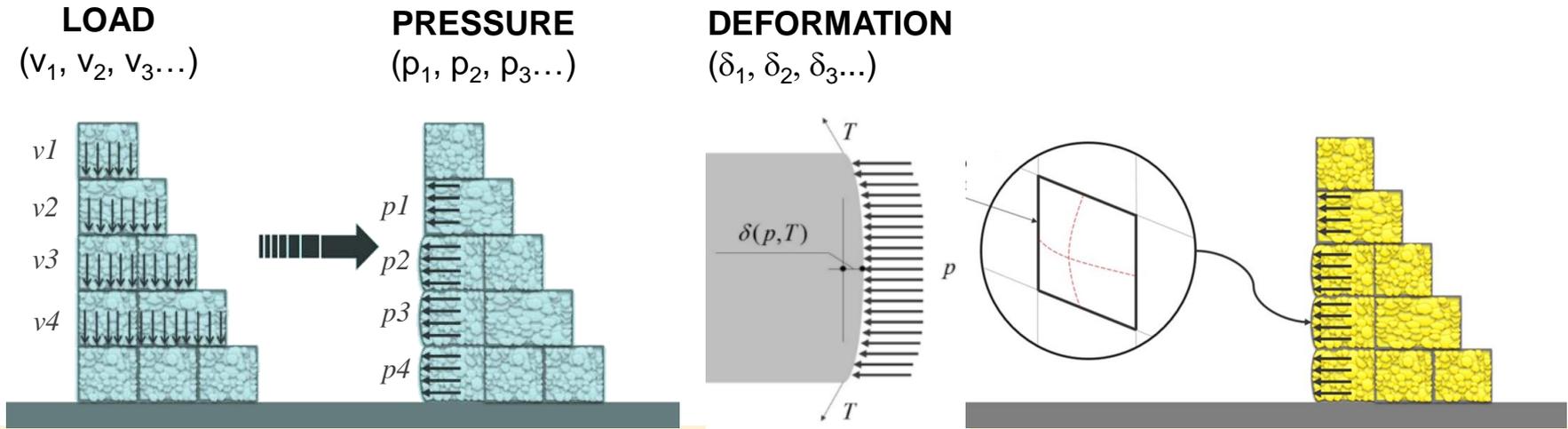


The maximum deflection in face of the wall can be determined numerically



Good agreement between the numerical model and experimental data!

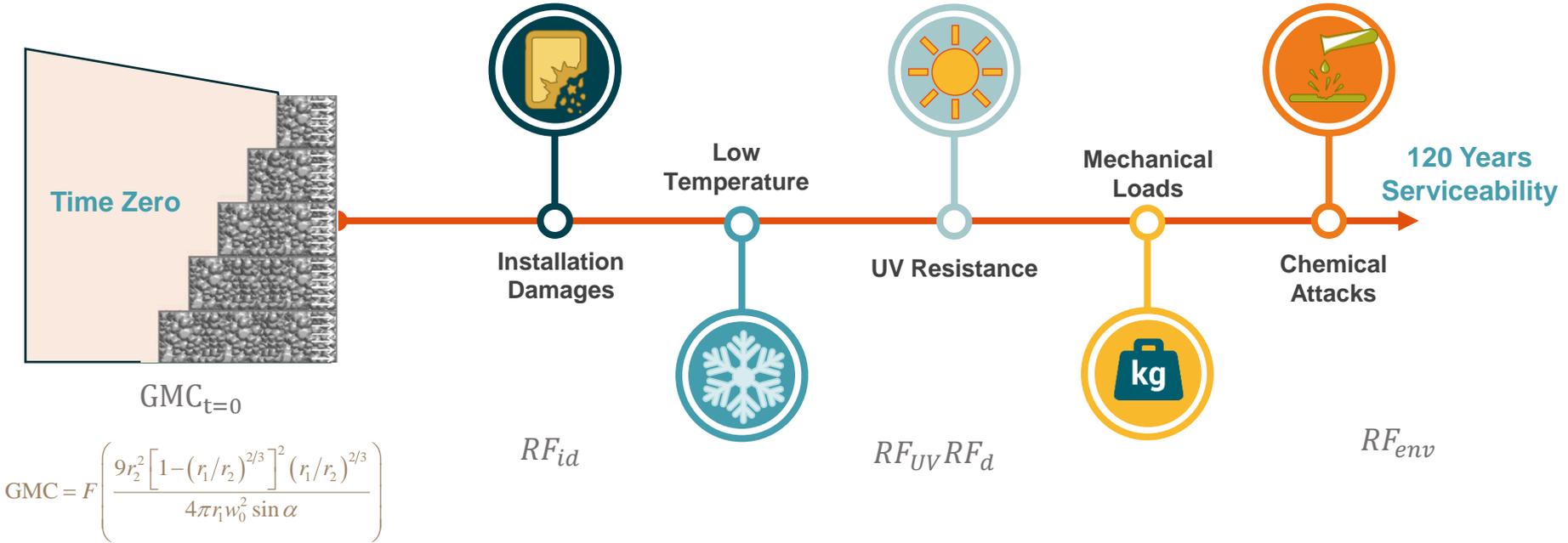




## ASSUMPTIONS

- M** MESH => ELASTIC MEMBRANE
- M** 2D MATHEMATICAL MODEL POISSON
- M** MAX DISPLACEMENT IN DIRECTION OF PRESSURE APPLIED  $\delta(p, T)$
- M** PRESSURE IS A FUNCTION OF VERTICAL STRESS AT EACH LAYER

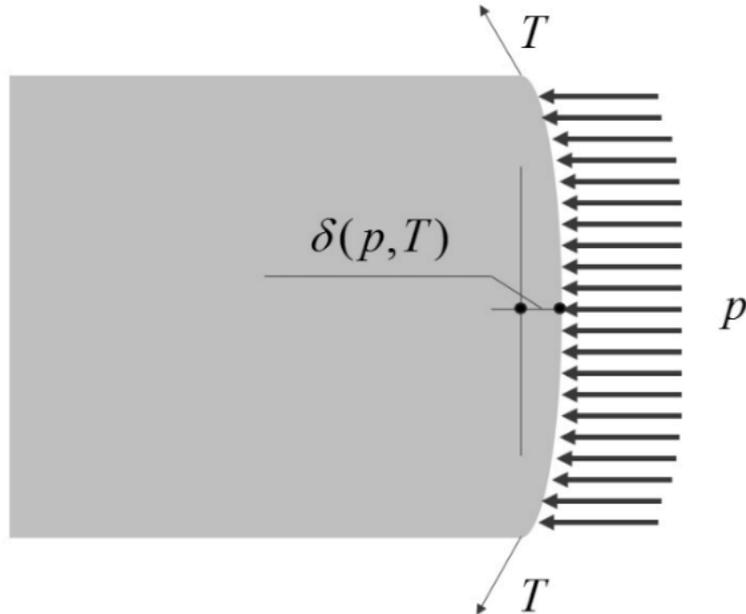




$$GSC_{120yrs} = \frac{GMC_{t=0}}{RF_{id}RF_{UV}RF_dRF_{env}}$$

## GABION SERVICEABILITY COEFFICIENT

An **experimental coefficient** that evaluates the gabion **performance over time**, considering mechanical and environmental stresses



- M** Experimentally tested and numerically **verified** method
- M** Increased **cost-effectiveness** of the design
- M** Significant **environmental benefits**

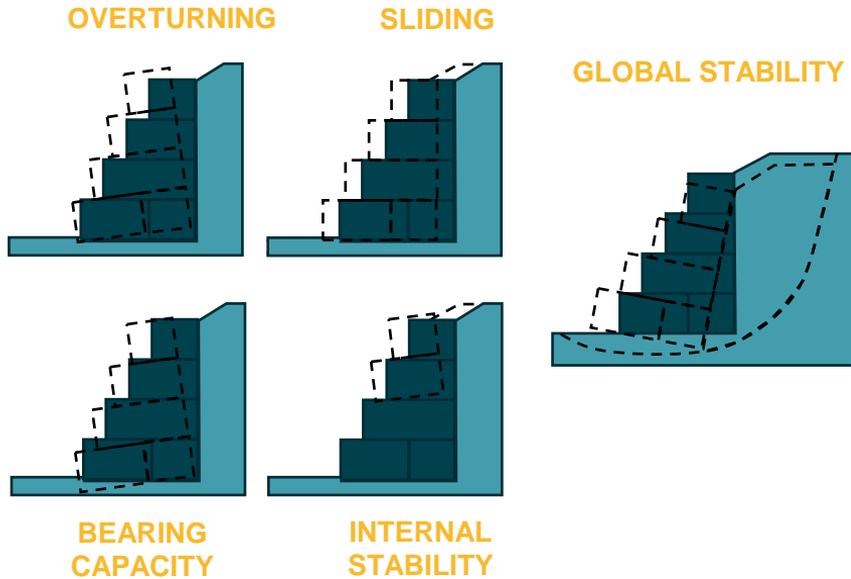
MESH TYPE	WIRE (mm)	POLIMAC	PVC	GALMAC 4R (Zn90Al10)	GALMAC 95 (Zn95Al5)	ZINC
8x10	3.9	NA	NA	504	252	84
8x10	3.4	678	NA	387	194	65
8x10	3.0	623	NA	356	178	59
8x10	2.7	489	342	279	140	47
8x10	2.4	410	287	234	117	39
6x8	2.7	638	NA	365	182	61
6x8	2.4	528	370	302	151	50
10x12	3.4	NA	NA	315	157	NA
10x12	3.0	481	337	275	137	46
10x12	2.7	418	293	239	119	40
10x12	2.4	378	265	216	108	36

 mesh/wire/coating combination under validation

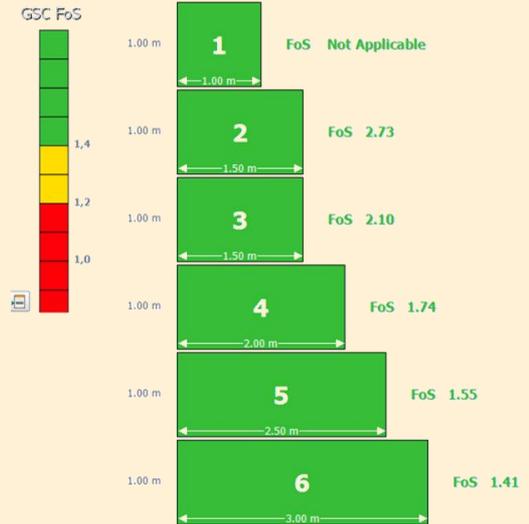
## Classic Design Calculation



## Design based on Gabion PERFORMANCE



### SLS Serviceability Limit State Gabion Serviceability Coefficient





**DESIGN WITH  
SERVICEABILITY**

*GAWAC 3.0 & GABION  
STRONG FACE*



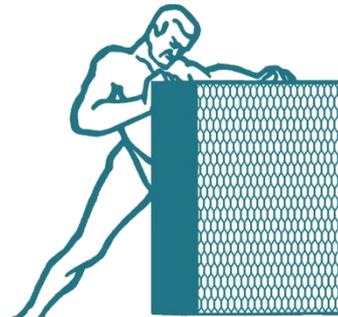
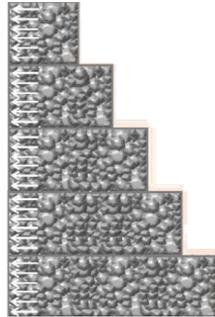
## NEW DESIGN APPROACH

**GAWAC 3.0** is the new software developed for the design and optimisation of Gabion Walls.

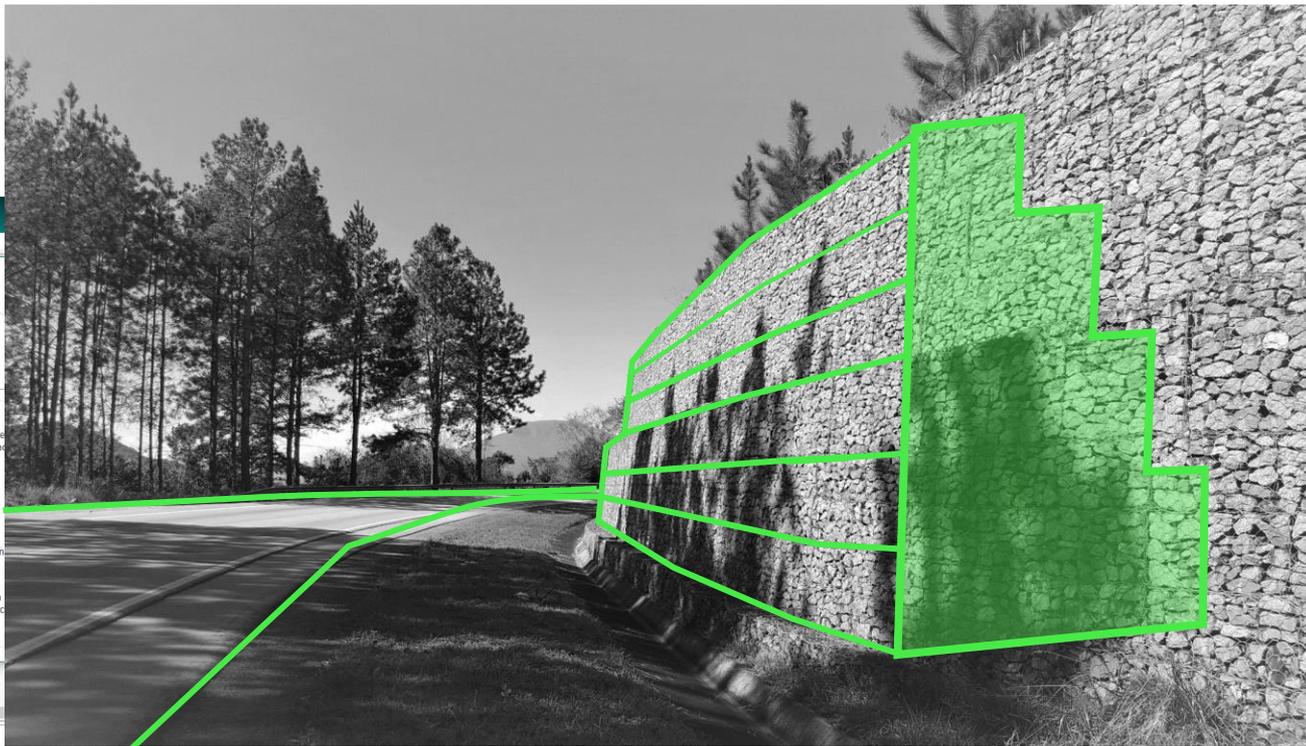
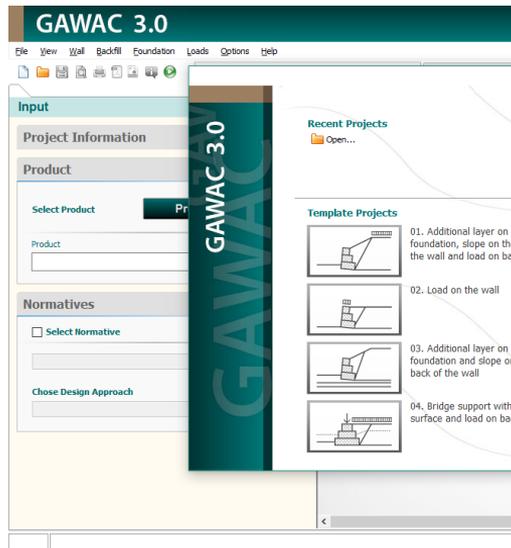


## INNOVATIVE SOLUTIONS

**Gabion Strong Face** with **PoliMac** is the innovative solution that minimizes structure long-term cost



# GABION STRONG FACE



TYPE "SOFTWARE" IN THE CHATBOX TO RECEIVE THE **NEW GAWAC 3.0 SOFTWARE**



A dark teal background with a faint, light-colored world map showing the outlines of continents and countries.

New worldwide  
tests

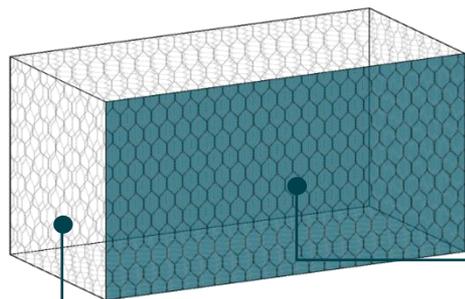
to develop

**A NEW WAY TO DESIGN  
GABIONS**



## Gabion Strong Face

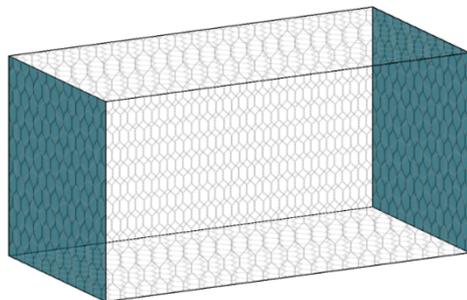
more resistance where required



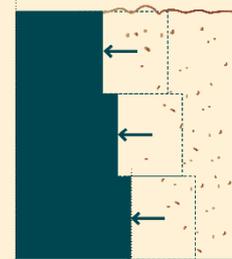
**2** different wire diameters

**Thick wire** diameter on the front exposed faces

**Light wire** diameter on the rear confined faces



Available in different configurations and wire diameters



Strong Face Gabions enable the **optimization of the wall cross section**



Less Gabions



Less Stones



Faster installation



Lower environmental impacts





**THE BENEFITS OF  
THE NEW  
APPROACH**

*Turn knowledge into value*

HOW MUCH  
DOES GABION  
WALL COST?



The purchase price is only part of what you actually end up spending when you purchase something it.

**Total Cost of Ownership** includes the purchase price as well as all the costs associated with the owning of the item.



## LESS MATERIALS

Less stone means savings! Thanks to the GSC concept, the amount of material needed to build a gabion wall is drastically reduced.



## QUICKER INSTALLATION

Material reduction means easier and faster installation. An optimised design increases the production rate.



## BETTER PERFORMANCE

PoliMac coating means outstanding performance in aggressive environments. It will preserve the structure serviceability reducing maintenance costs.



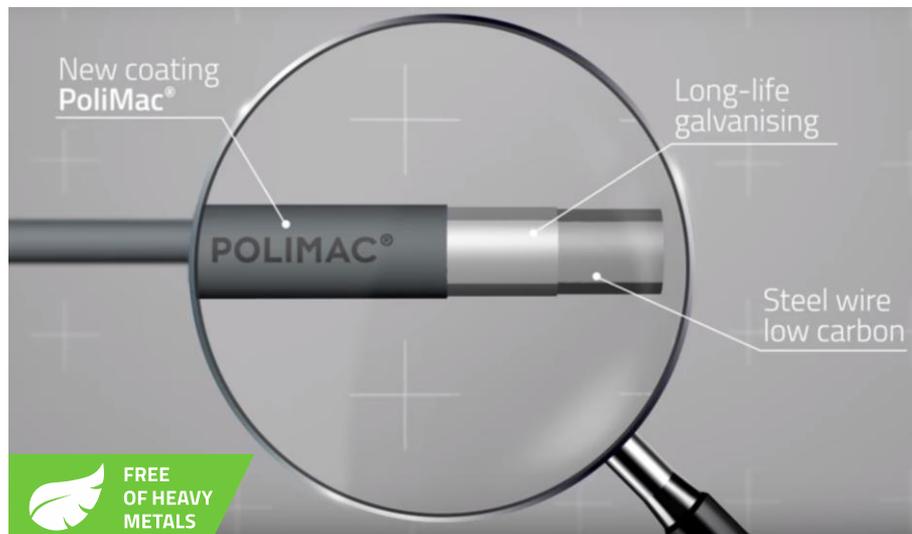
## LOWER ENVIRONMENTAL IMPACTS

Reduction of quarry stones means cutting the environmental burden. Take advantage of the new design approach for reducing the environmental impact of the structure.





Gabion Strong Face is coated with **PoliMac®**, the revolutionary coating that can withstand the most aggressive environmental conditions.



## PoliMac®

WIRE PROTECTION FOR A CHANGING WORLD

**10x** Better resistance to **abrasion**, including installation damages



**2x** More resistance to **chemical aggressions\***



**4x** More performance in **cold weather**



**4x** More resistance to **UV rays\*\***



\* In terms of resistance to sulphuric, nitric, formic, acetic acids

\*\* In terms of elongation after 2500 hrs of exposure





**A NEW ERA FOR  
RETAINING WALLS**  
*EXAMPLE*

**M** Consider the resistance to PUNCH and TENSILE for the mesh.

**M** In the stability analysis, Service Limit State (SLS) and Ultimate Limit State (ULS) are considered.

**M** Consider the long-term performance of the gabion based on the type of mesh and coating.

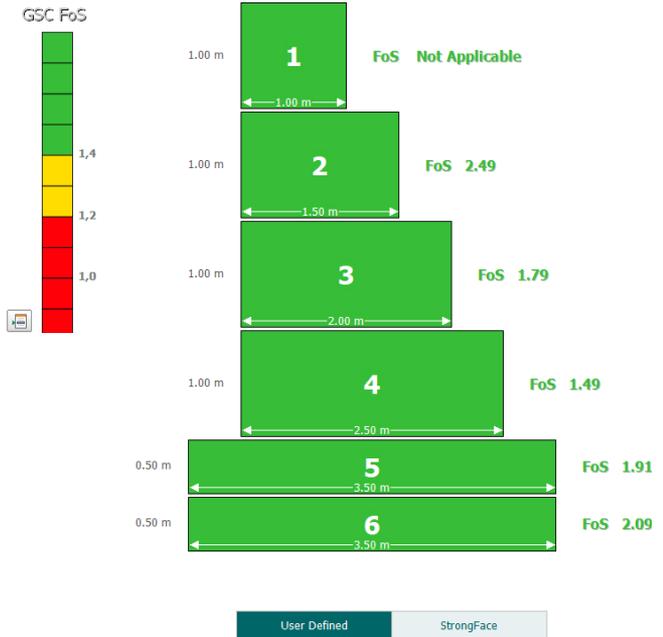
**M** It allows evaluating, by layer and by applied stress, the deformability conditions through the GSC.



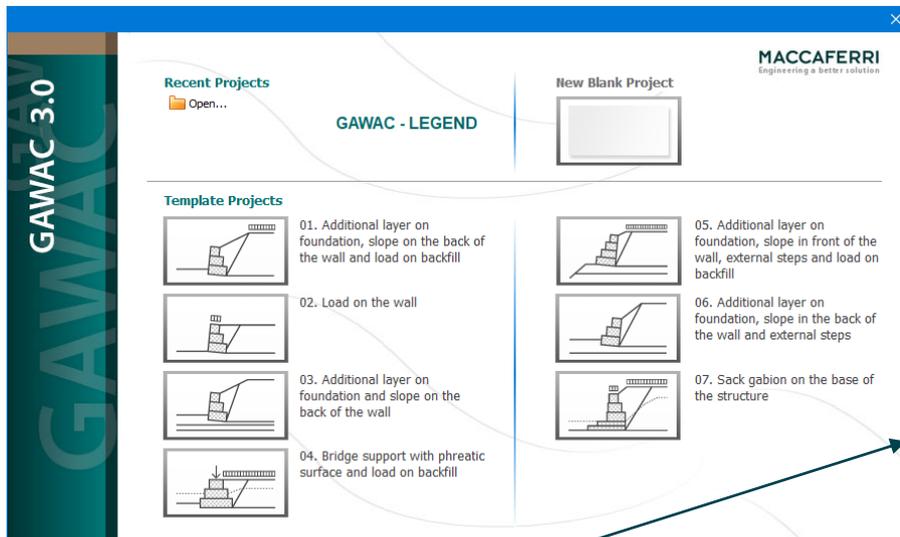
Numerical model using the discrete element method

Results | POLIMAC™ 80/489

SLS Serviceability Limit State  
Gabion Serviceability Coefficient



Serviceability Limit State Analysis  
**SATISFIED!**



**Low aggressive:** dry conditions in atmospheric environments with low pollution, rural areas (**ISO 9223 Cat. C2**)

**High aggressive:** dry and/or wet conditions in atmospheric environments with medium to high pollution or substantial effect of chlorides, polluted urban, coastal and marine areas (**ISO 9223 Cat. C3, C4, C5**)

## SF POLIMAC VS. PVC – High Aggressive Environment

### ULS Ultimate Limit State

#### External stability

Overturning check	Sliding check	Stress on foundation (Toe) Check	Stress on foundation (Heel) Check
FoS 1.99	FoS 1.73	FoS 2.67	FoS -

#### Global

Global Stability Check
FoS 1.76

### ULS Ultimate Limit State

#### External stability

Overturning check	Sliding check	Stress on foundation (Toe) Check	Stress on foundation (Heel) Check
FoS 2.67	FoS 1.82	FoS 4.52	FoS 37.57

#### Global

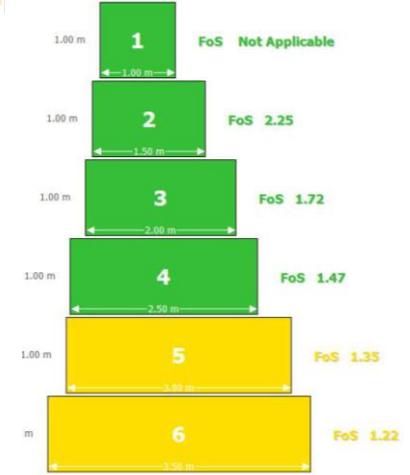
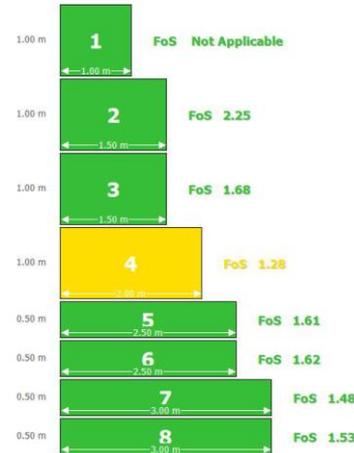
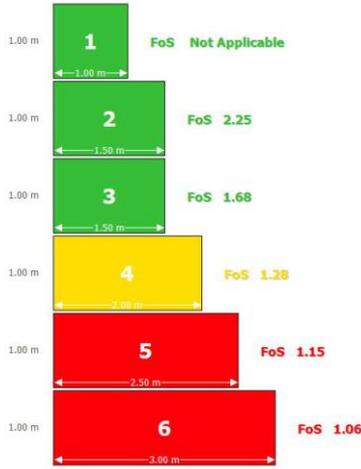
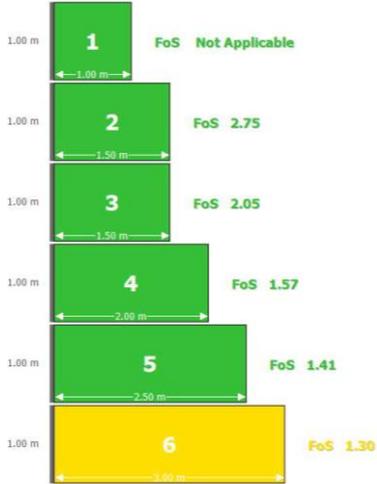
Global Stability Check
FoS 1.76

### POLIMAC SF 2.4/3.0 mm

### PVC 2.7 mm

### PVC 2.7 mm H=0.5

### PVC 2.7 mm Modified geometry



11.5 m<sup>3</sup>

13.5 m<sup>3</sup>

SERVICEABILITY OK

SERVICEABILITY NOK

SERVICEABILITY OK

SERVICEABILITY OK

# COMPARISON BETWEEN STRONG FACE AND STANDARD GABION



## GABION STRONG FACE

It has greater resistance in the face



## STANDARD GABION

Requires a larger volume of gabion.



A NEW ERA FOR  
**RETAINING**  
**GABION WALLS**



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



THE INTERNATIONAL EPD® SYSTEM

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

visit [maccaferri.com/EPD](https://maccaferri.com/EPD)



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

visit [maccaferri.com/BIM](https://maccaferri.com/BIM)



The UN set the SDG

We took on the challenge of achieving a better and more sustainable future for all.



- M** New calculation model that allows analyzing the gabion wall under **serviceability condition**
- M** Optimization of Gabion Walls in compliance with the main **international standards**
- M** Enhanced **long-term performance** and **reduction in environmental burden**

**GABION  
SERVICEABILITY  
COEFFICIENT**

**GAWAC 3.0**  
Gabion Wall Design  
2020



**PoliMac®**  
WIRE PROTECTION FOR A CHANGING WORLD



# DESIGN THE CHANGE



*United Arab Emirates,  
32-m high Retaining Wall*



# LIVE Q&A