



**HAL**  
open science

## Application of cement modified soils in retaining walls

Mario Castaneda-Lopez, Thomas Lenoir, Luc Thorel, Jean-Pierre Sanfratello

► **To cite this version:**

Mario Castaneda-Lopez, Thomas Lenoir, Luc Thorel, Jean-Pierre Sanfratello. Application of cement modified soils in retaining walls. Journées techniques routes, Jan 2023, Nantes, France. hal-04425220

**HAL Id: hal-04425220**

**<https://univ-eiffel.hal.science/hal-04425220>**

Submitted on 29 Jan 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



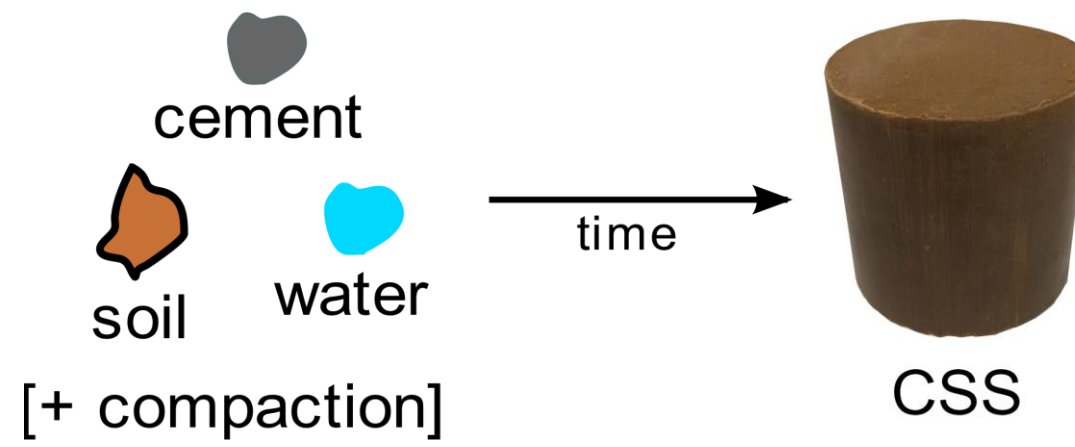
## CONTEXT

### Cemented-stabilized soils (CSS)<sup>[1]</sup>

in situ soil + hydraulic binder

- Reduction of environmental impact
- low-cost technique

Applications: embankments, foundations, pavement construction, retaining wall (RW)<sup>[2]</sup>



$$\text{Factor of Safety (FOS)} = \frac{\text{shear strength } \uparrow (?)}{\text{applied stress } \downarrow}$$

Failure criteria<sup>[2,3]</sup>  
Commonly not determined (empirical)  
Performance: tensile + compressive properties

### CSS-RW analysis methods<sup>[2,4]</sup>

Conventional vs Finite Element Modelling  
External vs internal stability

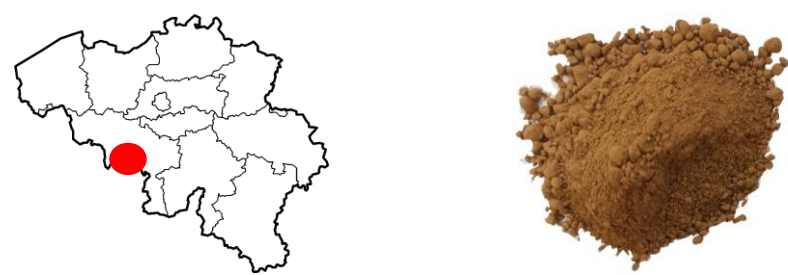
Empirical oversized design

**Objective:** Understand and verify consistency between mechanical characteristics of CSS and the stress states when employed as RW

## MATERIALS AND METHODS

### 1 Materials and treatment

"BC soil"



Soignies (Belgium)  
Covering soil - aggregate quarry

USCS %	LL = 30 %, IP = 13 %
Gravel 1	A = 0.29 (↓)
Sand 5	
Silt 70	
Clay 24	

[CL]

Standard proctor [3% cement content, CC]  
Optimum Moisture Content (OMC)  
Maximum Dry Density (MDD)

Binder [FR]  
Cement CEM II/A  
LL 42.5R CE CP 2

Mixture  
3% CC,  
96%MDD, OMC

### 2 Experiments

- (A) Indirect Tensile Strength, ITS (NF EN 13286-42)
- (B) Unconfined Compression Strength, UCS (NF EN 13286-41)
- (C) Direct Shear, DS (NF EN ISO 17892-10)

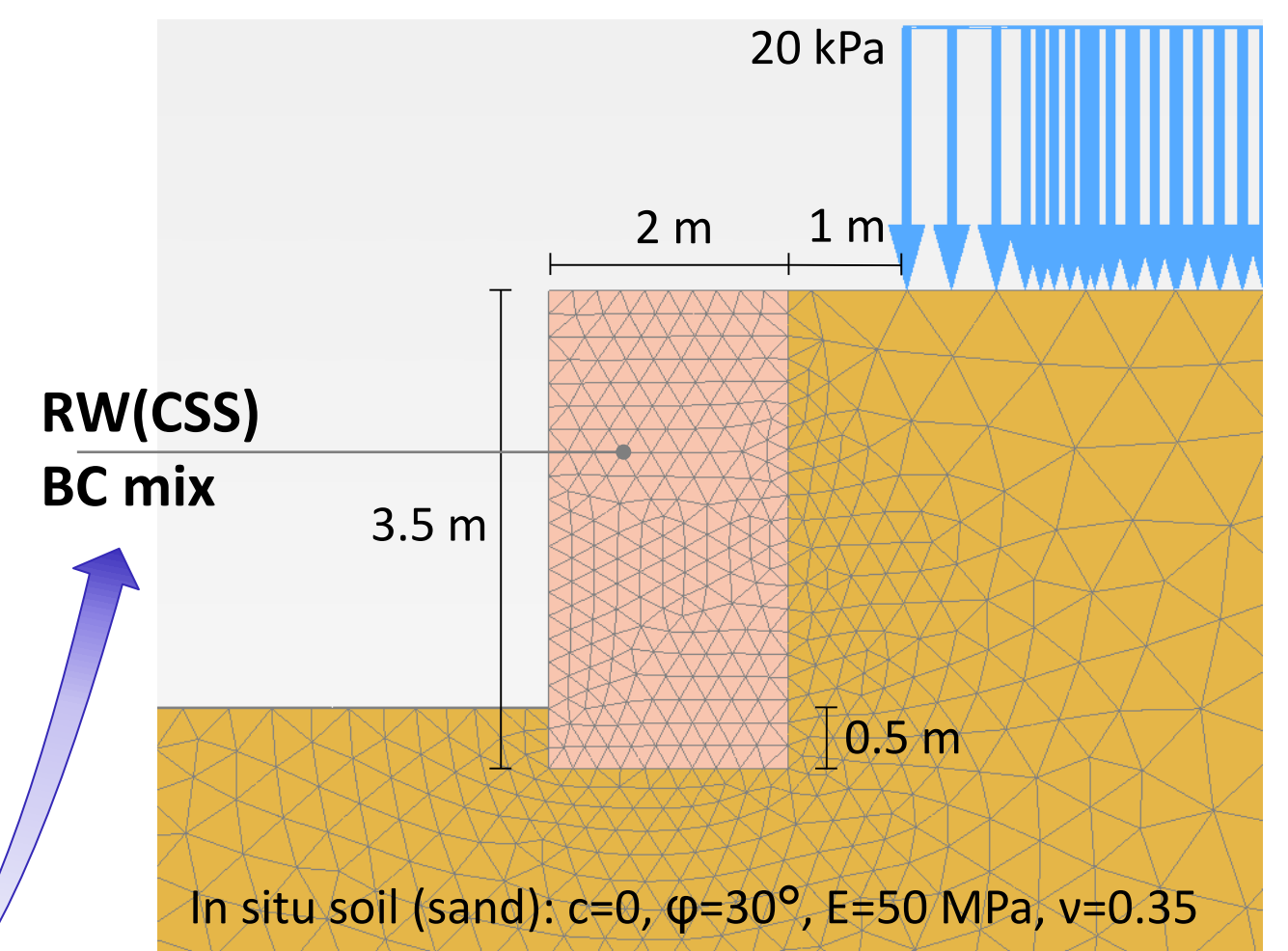


(D) Curing time (CT):  
7, 28, 90, 180, 360 days

ITS+UCS → Construction of failure criteria ← DS  
UCS → elastic parameters: elastic modulus (E), Poisson ratio (ν)

### 3 Finite Element Modelling, FEM

Elastic analysis, 2D



PLAXIS (v.2013)  
10-noded, 14633 elements, 23696 nodes  
(Aver. elem. size 20,05 cm)

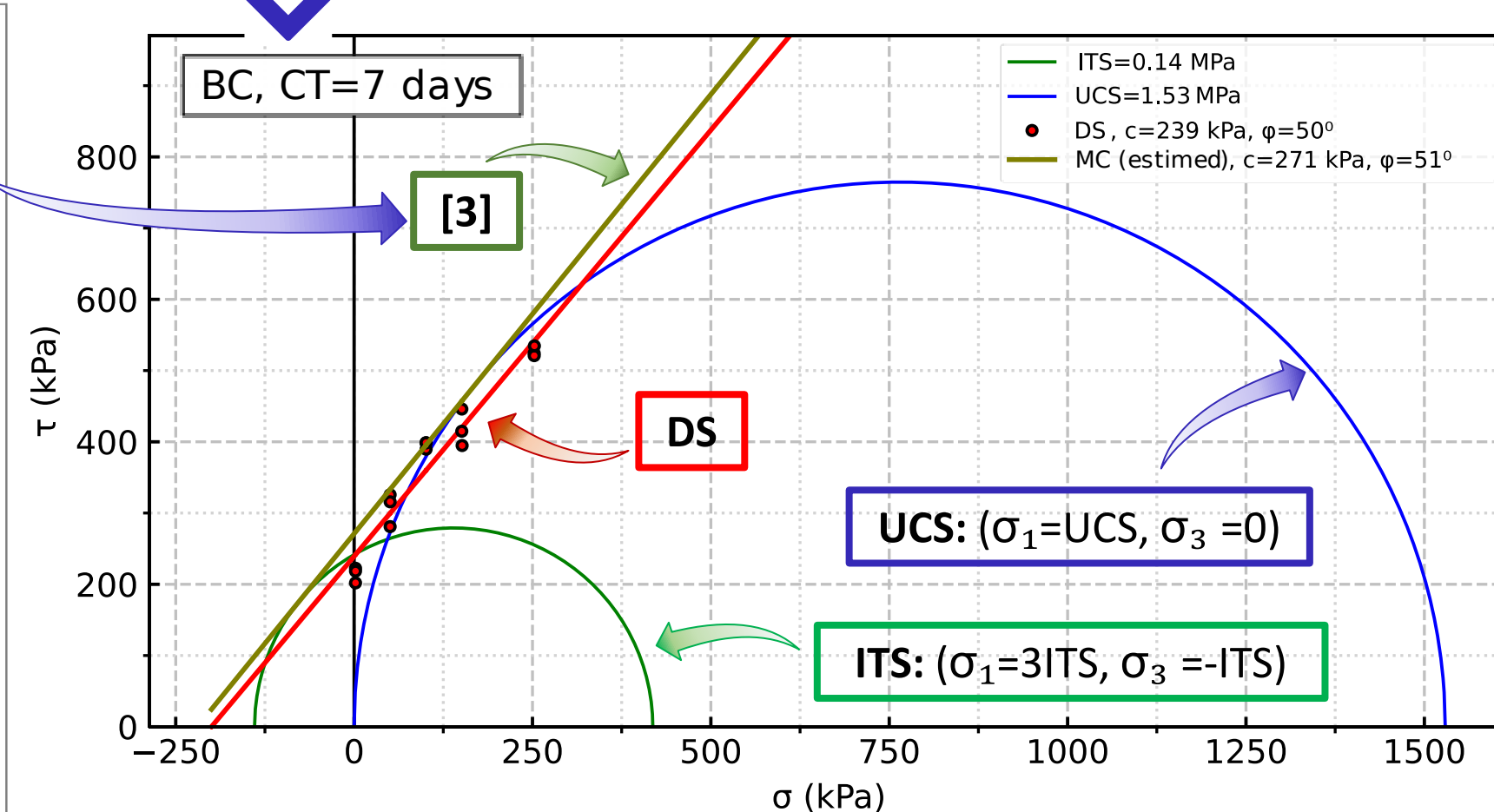
## RESULTS

### 1 Experimental results + assessment of MC failure envelope

CT (days)	7	28	90	180	360
ITS (MPa)	0.14	0.15	0.18	0.23	0.22
USC UCS/E (MPa)	1.53 / 1459	1.65 / 1281	2.41 / 1672	1.77 / 969	2.11 / 1271
DS c (MPa)	0.24 / 0.27	0.31 / 0.29	0.37 / 0.37	0.38 / 0.40	0.34 / 0.41
Experiment/[3] φ' (°)	50.1 / 51.0	49.2 / 50.8	55.9 / 56.0	35.2 / 41.0	61.9 / 48.0

Simplified method for MC assessment<sup>[3]</sup>

If  
 $ITS = \lambda \times UCS$   
Then,  
 $\phi = f(\lambda)$   
and  
 $c = \begin{cases} f(\lambda, ITS) \\ \text{or} \\ f(\lambda, UCS) \end{cases}$



### 2 FEM (CT=7 days): c – φ reduction

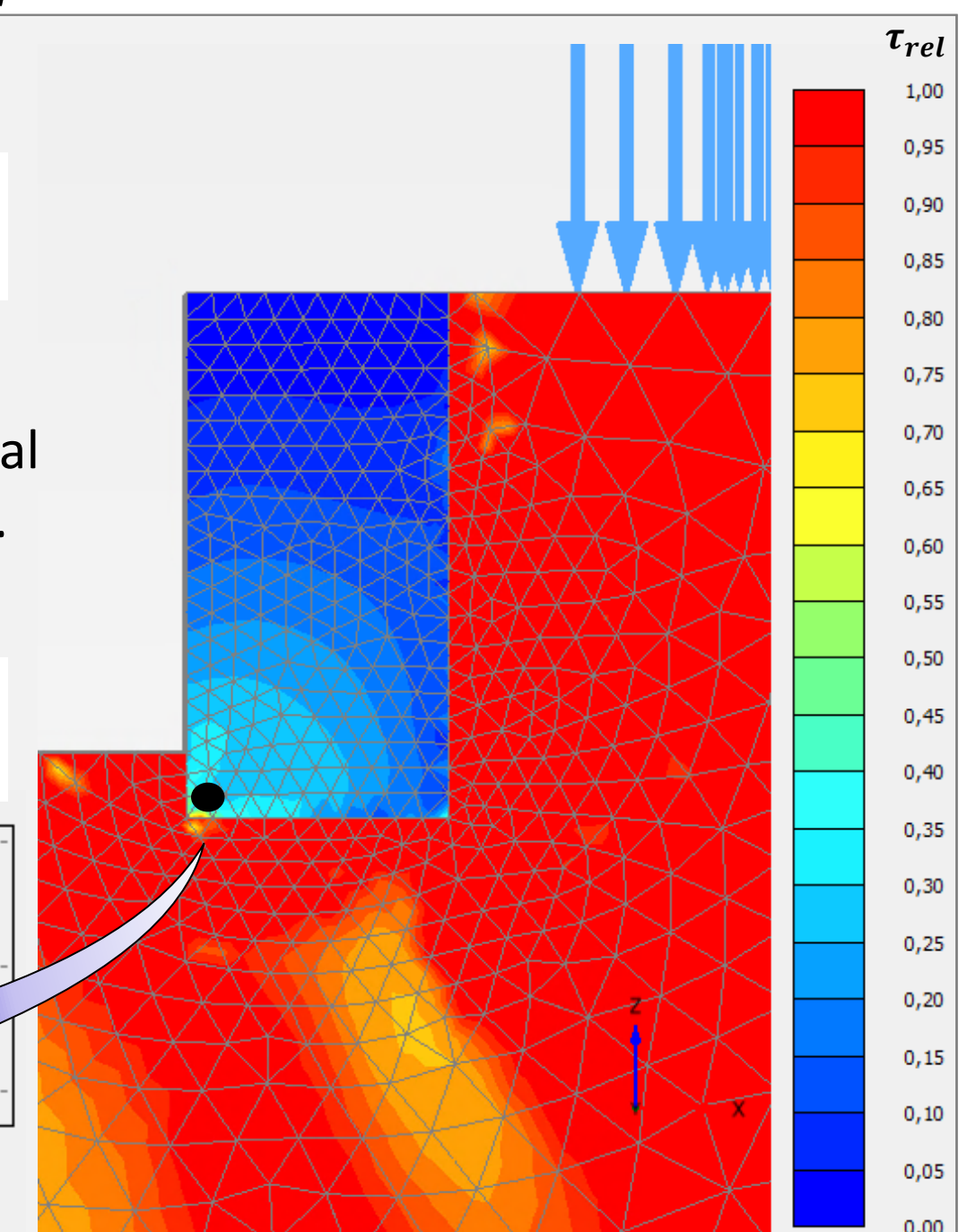
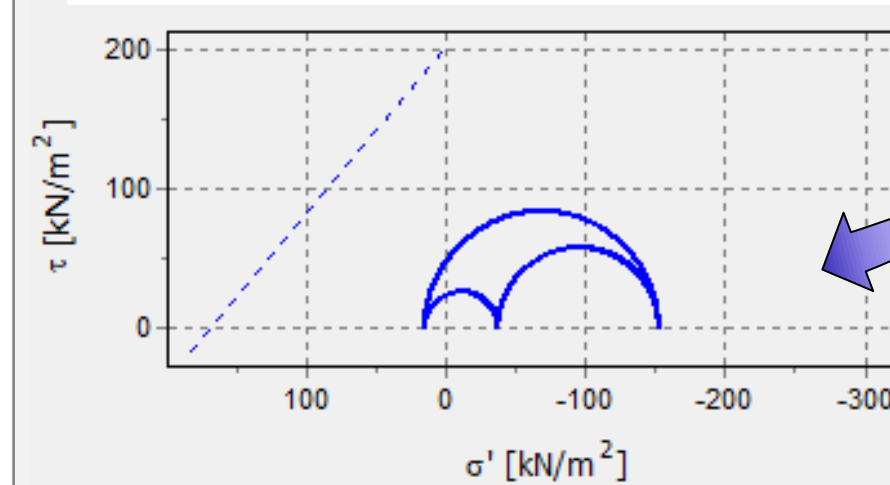
Relative shear stress,  $\tau_{rel}$

$$0.0 < \tau_{rel} = \frac{\tau_{max}}{\tau_{mob}} < 1.0$$

- Critical cohesion value (Ccrit.)
- Displac./stress pattern: external
- $C = f(CC=3\%, CT=7\text{days}) > C_{crit.}$

FOS

$$FOS = 1.2 = \frac{c}{c_{red}} = \frac{\tan \phi}{(\tan \phi)_{red}}$$



## CONCLUDING REMARKS

- Simplified method for MC assessment ✓
- $\phi = f(\lambda) \rightarrow$  independent of CC
- ITS and UCS interdepend parameters  $\rightarrow \lambda$
- $C = f(UCS \text{ or } ITS) \rightarrow$  validation of dosage techniques
- $C = f(\text{degree of cementation, CT})$
- FEM – internal stability:  $\phi$ , cohesion  $\rightarrow C_{crit.}$
- CSS-RW: external failure for CT<7 days
- Failure pattern : overturning/bearing capacity (?)

## PERSPECTIVES

- Application of the simplified method on others CSS
- Sensibility study for durability evaluation
- Dosage optimization to obtain Ccrit.
- Conventional stability analysis for RW

## REFERENCES

- Xuan, D. X., Houben, L. J. M., Molenaar, A. A. A., & Shui, Z. H. (2012). Mechanical properties of cement-treated aggregate material – A review. *Materials & Design*, 33(1), 496–502. <https://doi.org/10.1016/j.matdes.2011.04.055>
- Morris, D. V. & Crockford, W. W. (1991). Design of cement stabilized soil retaining walls with concrete panel facing (Issue November).
- Piratheepan, J., Gnanendran, C. T., & Arulrajah, A. (2012). Determination of c and φ from IDT and Unconfined Compression Testing and Numerical Analysis. *Journal of Materials in Civil Engineering*, 24(9), 1153–1164. [https://doi.org/10.1061/\(asce\)mt.1943-5533.0000493](https://doi.org/10.1061/(asce)mt.1943-5533.0000493)
- Ismail, M. A. (2005). Performance of cement-stabilized retaining walls. *Canadian Geotechnical Journal*, 42(3), 876–891. <https://doi.org/10.1139/t05-021>

