APPLICATION OF CEMENT MODIFIED SOILS IN RETAINING WALLS

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Université Gustave Eiffel

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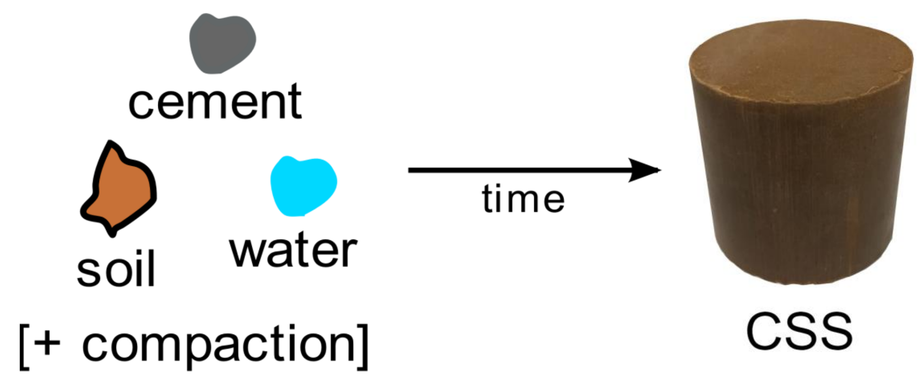
CONTEXT

Cemented-stabilized soils (CSS)[1]
in situ soil **+** hydraulic binder

Reduction of environmental impact
low-cost technique

Applications: embankments, foundations, pavement construction, retaining wall (RW) [2]



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

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

CSS-RW analysis methods [2,4]
Conventional vs Finite Element Modelling
External vs internal stability

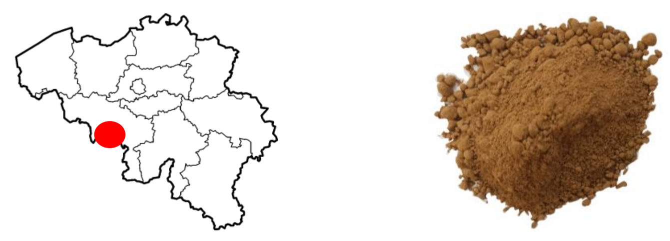
Empirical oversized design

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

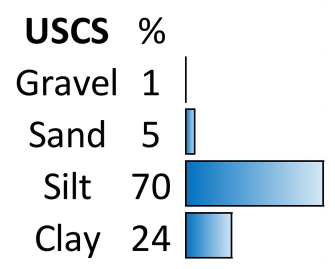
MATERIALS AND METHODS

1 Materials and treatment

"BC soil"



Soignies (Belgium)
Covering soil - aggregate quarry



LL = 30 %, IP = 13 %
A = 0.29 (↓)

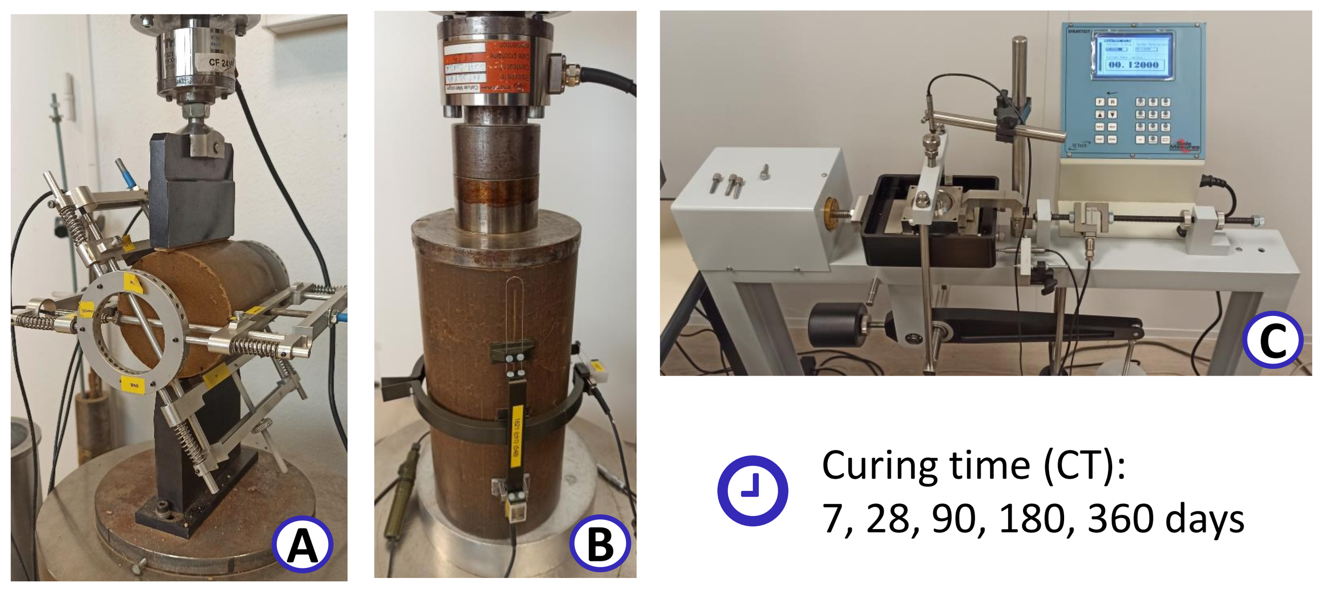
[CL]

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

Binder [FR]	**Mixture**
Cement CEM II/A LL 42.5R CE CP 2	3% CC, 96%MDD, OMC

2 Experiments

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

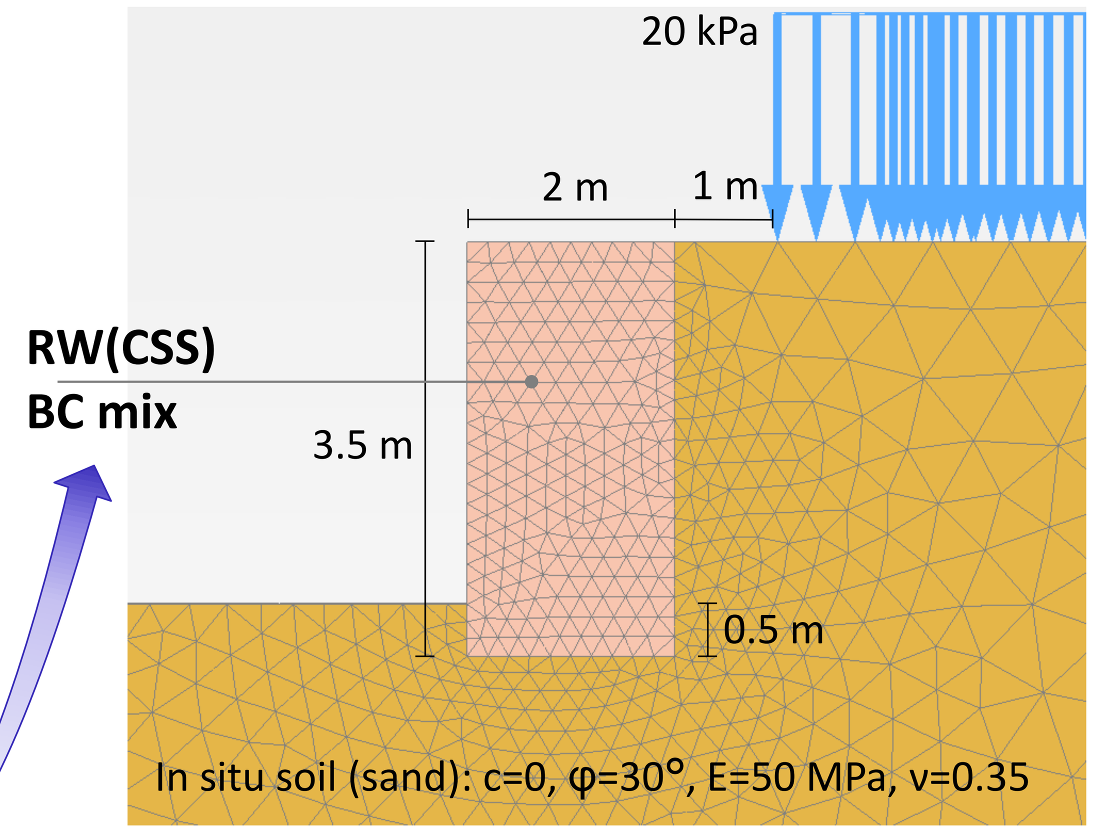


Curing time (CT):
7, 28, 90, 180, 360 days

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)

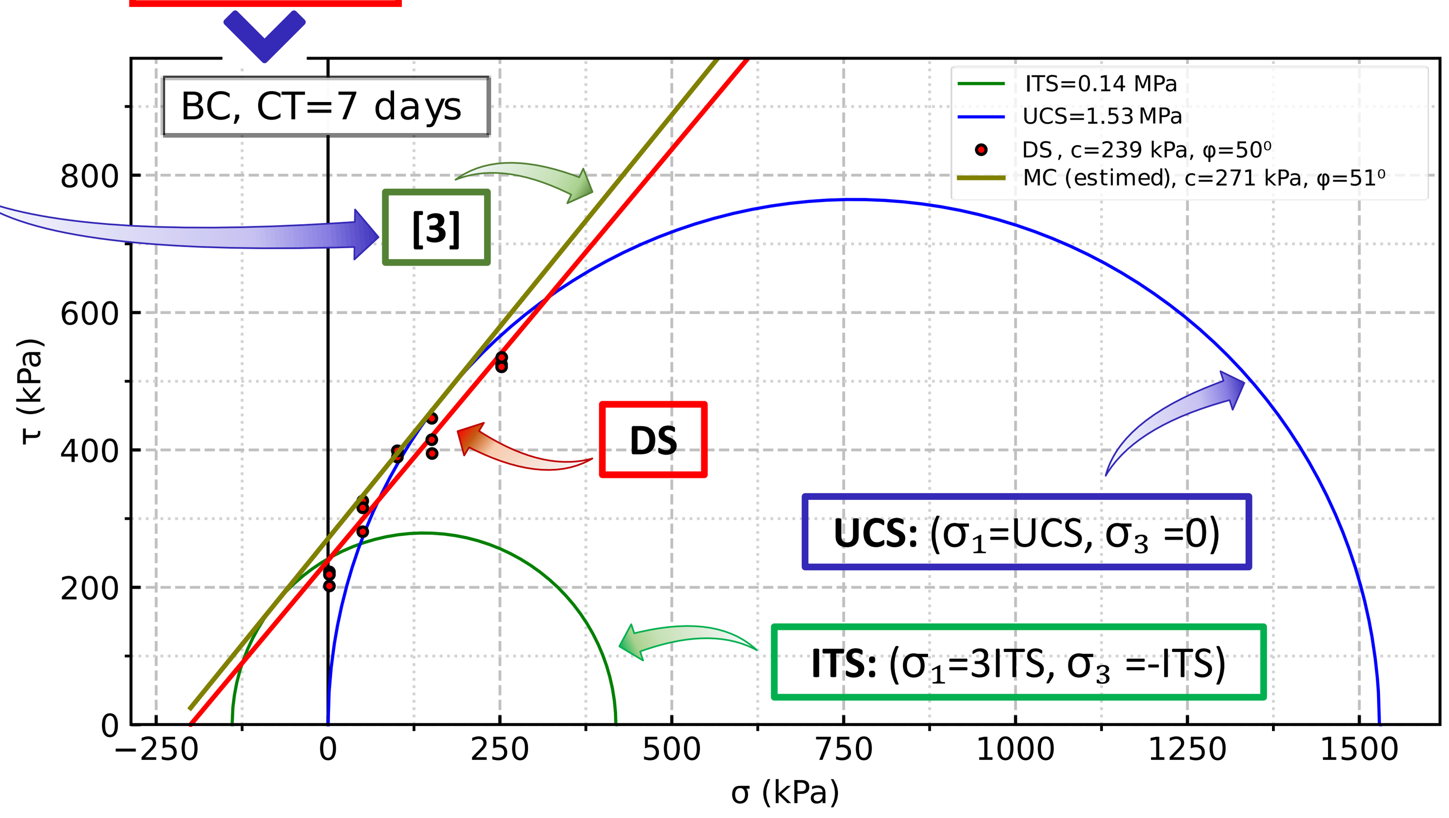
RESULTS

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[3]

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



2 FEM (CT=7 days): $c - \varphi$ reduction

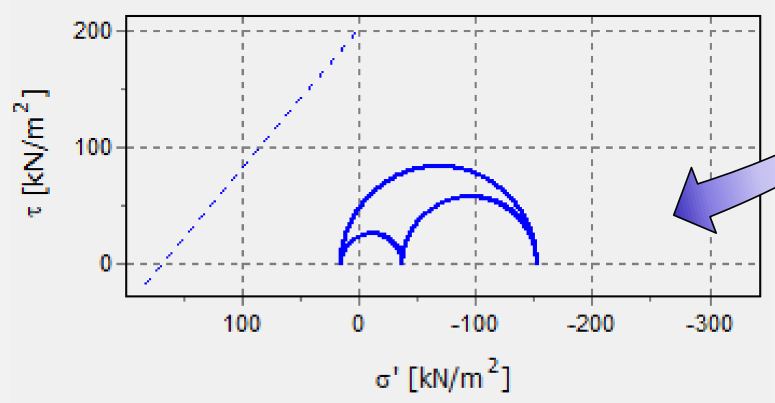
Relative shear stress, τ_{rel}

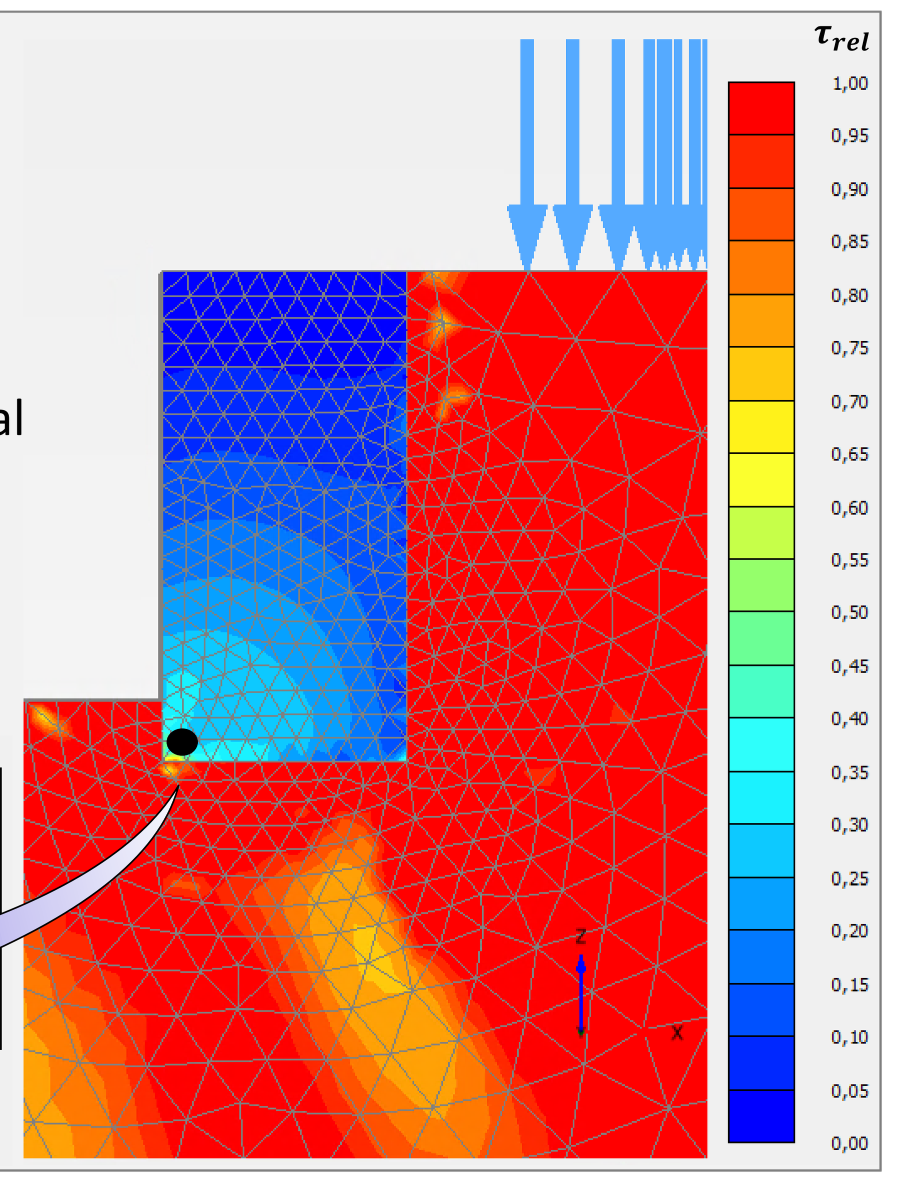
$$0.0 < \tau_{rel} = \frac{\tau_{max}}{\tau_{mob}} < 1.0$$

- Critical cohesion value (Ccrit.)
- Displac./stress pattern: external
- C = f(CC=3%,CT=7days) > Ccrit.

FOS

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





CONCLUDING REMARKS

1. Simplified method for MC assessment ✓
2. $\varphi = f(\lambda)$ → independent of CC
3. ITS and UCS interdepend parameters → λ
4. C = f(UCS or ITS) → validation of dosage techniques
5. C = f(degree of cementation, CT)
6. FEM – internal stability: ~~φ~~, cohesion → Ccrit.
7. CSS-RW: external failure for CT<7 days
8. 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

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