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Biaxial fatigue test for the utilization of stabilized soils in the subgrades of High Speed Rail infrastructures

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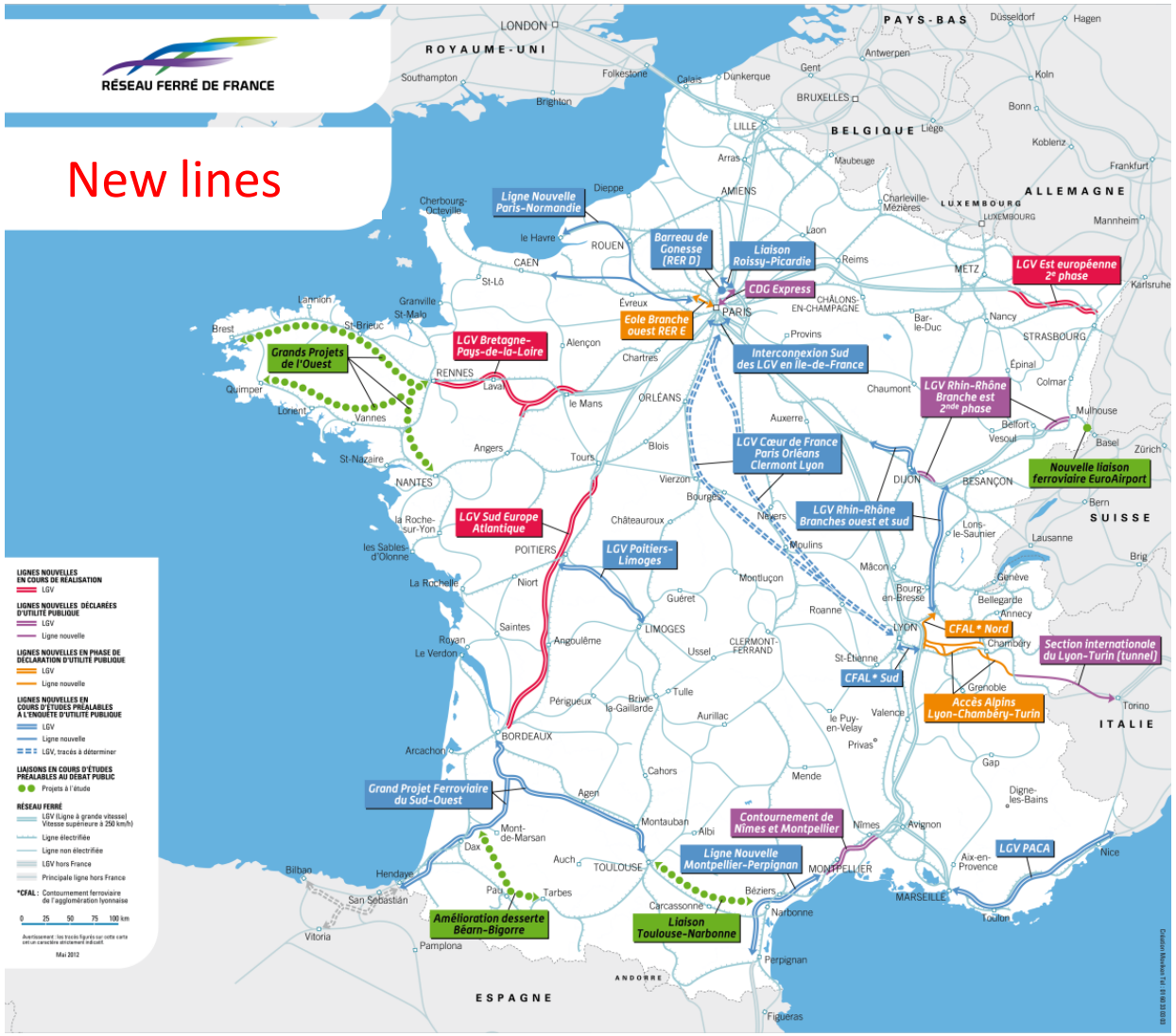
Context



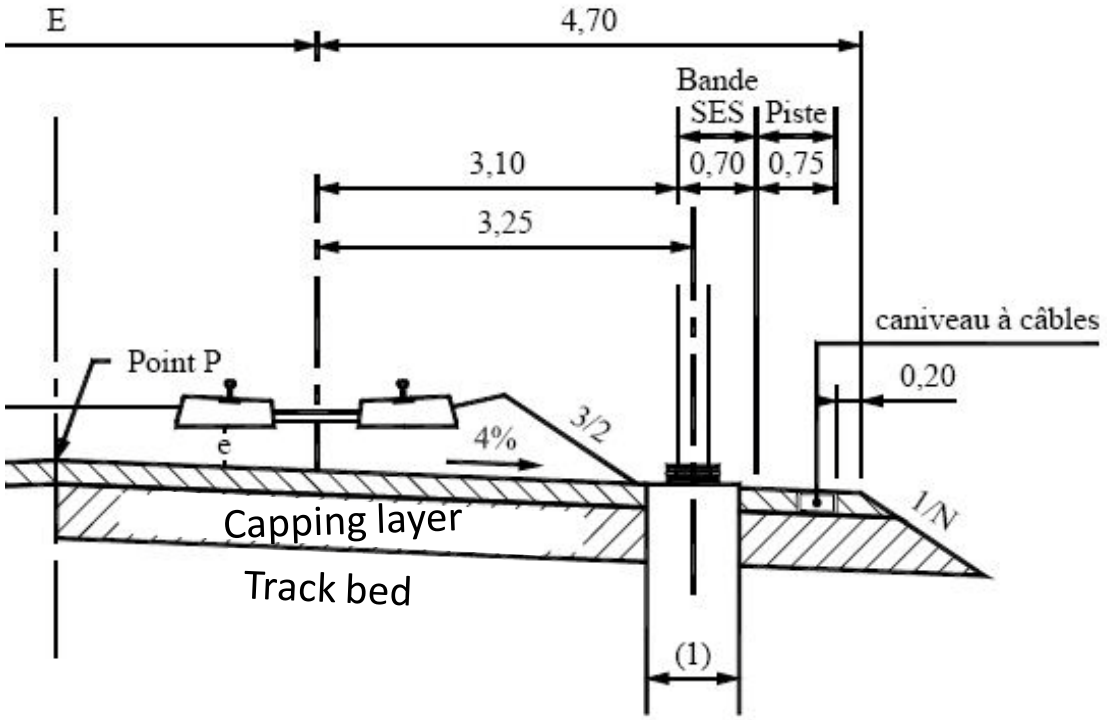
Keywords :
Second European network
30 000 km of lines with
2024 km of high speed lines
800 km of new high speed lines for 2017

Legend :
In red : Lines under construction
Others colours : Projects

Main objective:
Rationalization of the environmental and economical cost of new structures

HSR structures

Aim: Rationalization of the environmental and economical cost of new structures



HSR structure (IN 3278)

For the capping layer

Traditional solution:
Bring granular material from quarry
Advantage:
Design of such structure is well known
Inconvenient:
Not environmental friendly, consumes limited resources

Alternative solution:
Use of the natural soil present in the right of way of the line with an appropriate stabilization
Advantages:
Save granular material
Re-use of soil considered as waste
Inconvenient:
Unknown mechanical behavior especially for the fatigue behavior (100 years of service life)

The fatigue behavior of stabilized soils needs to be studied

Definition of a stabilized soils

In situ soil

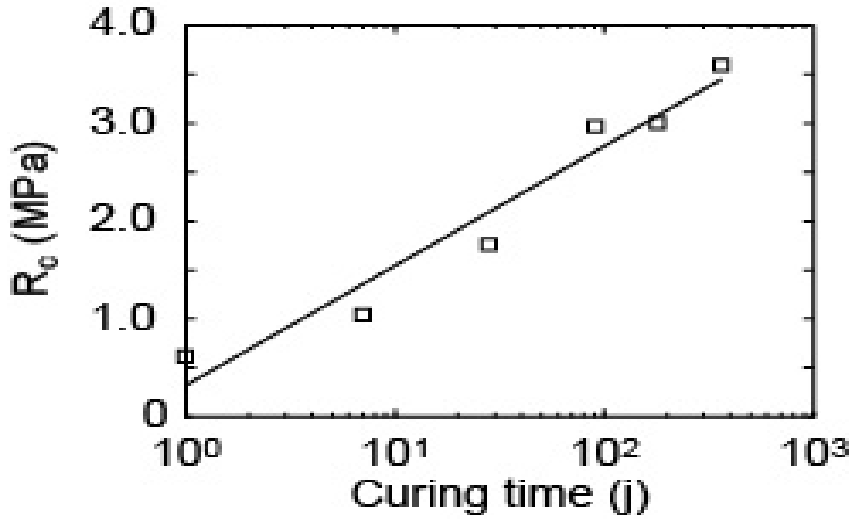
+

Hydraulic binder
(1 to 5%)

=

Stabilized soil

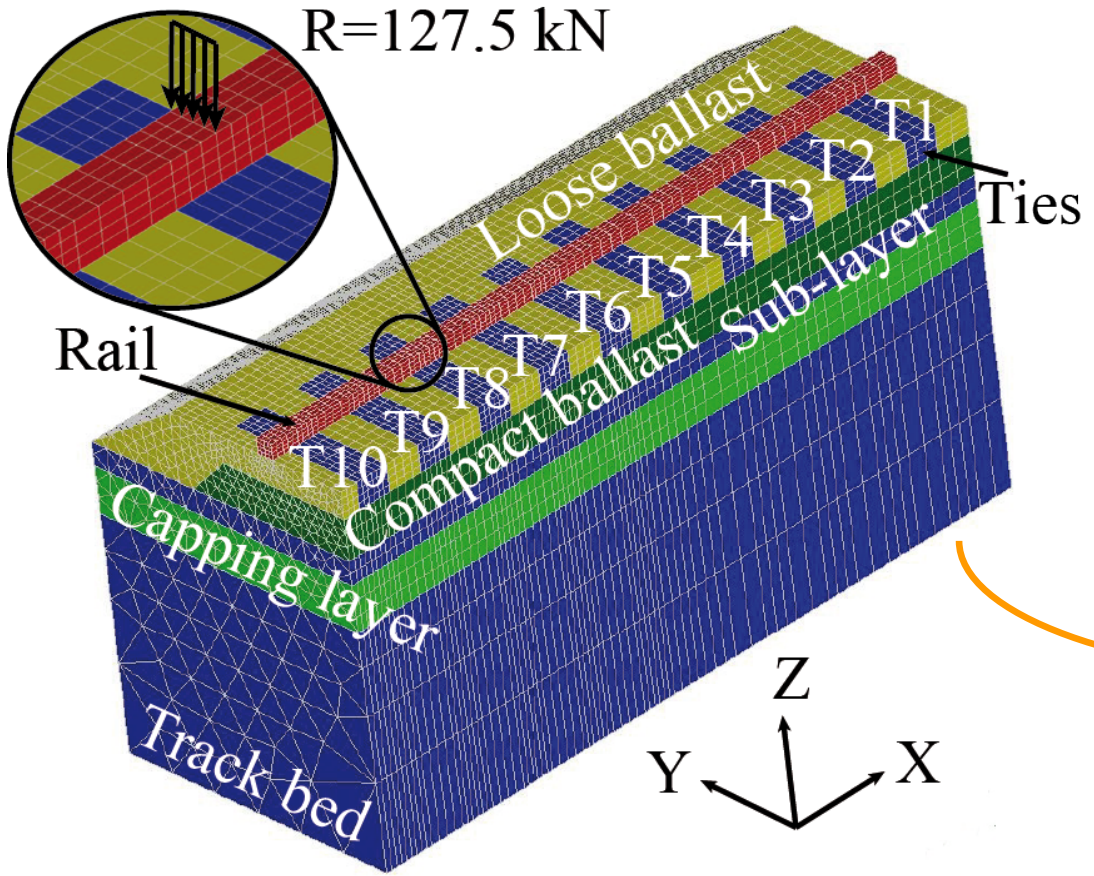
Operation of mixing

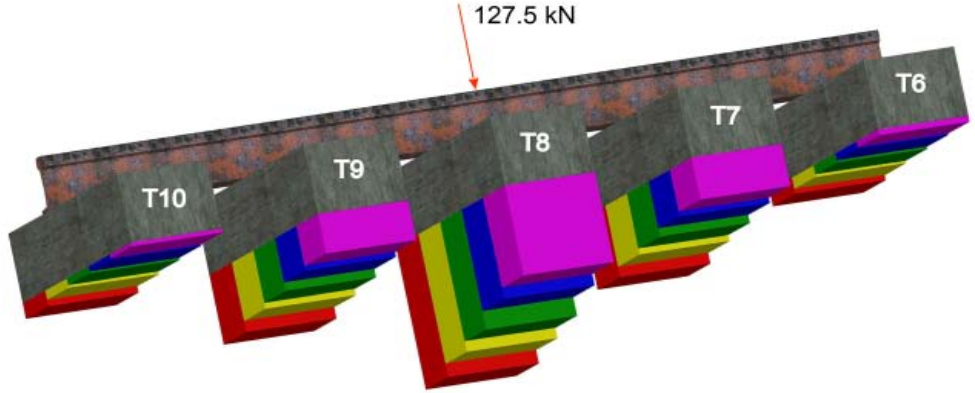


UCS vs time for a regolite of micashiste with 5% of CEM III

Are mechanical performances of stabilized soils compatible with stresses in the capping layer?

Modeling of the HSR structure (1/2)



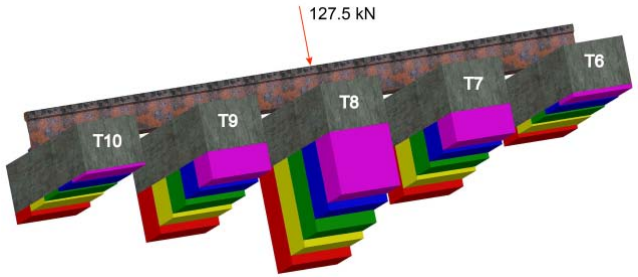


FEM modeling is not well appropriate for sizing studies

→

Discretization of the loading under the ties

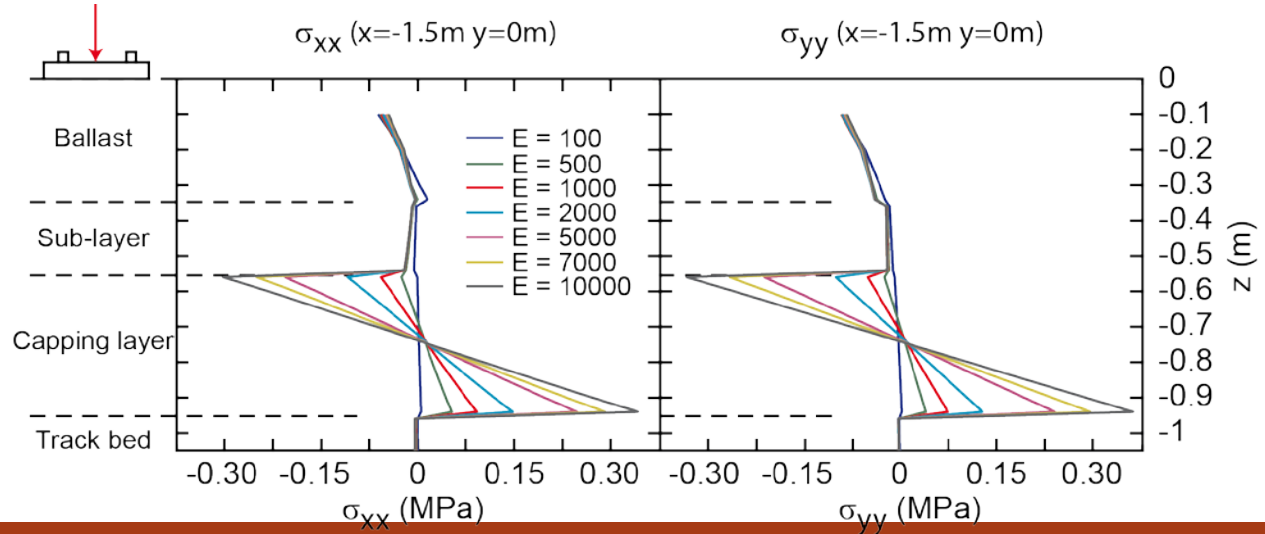
Modeling of the HSR structure (2/2)



Application of the load under the sleepers previously determined directly on the ballast surface.

Ballast	E = 200 MPa ν = 0.4	350 mm
Sub-layer	E = 70 MPa ν = 0.25	200 mm
Capping layer	E = 100, 500, 1000, 2000, 5000, 7000 and 10 000 MPa ν = 0.25	400 mm - str1 350 mm - str2 300 mm - str3
Track bed	E = 70 MPa ν = 0.25	2000 mm

Semi-analytical model

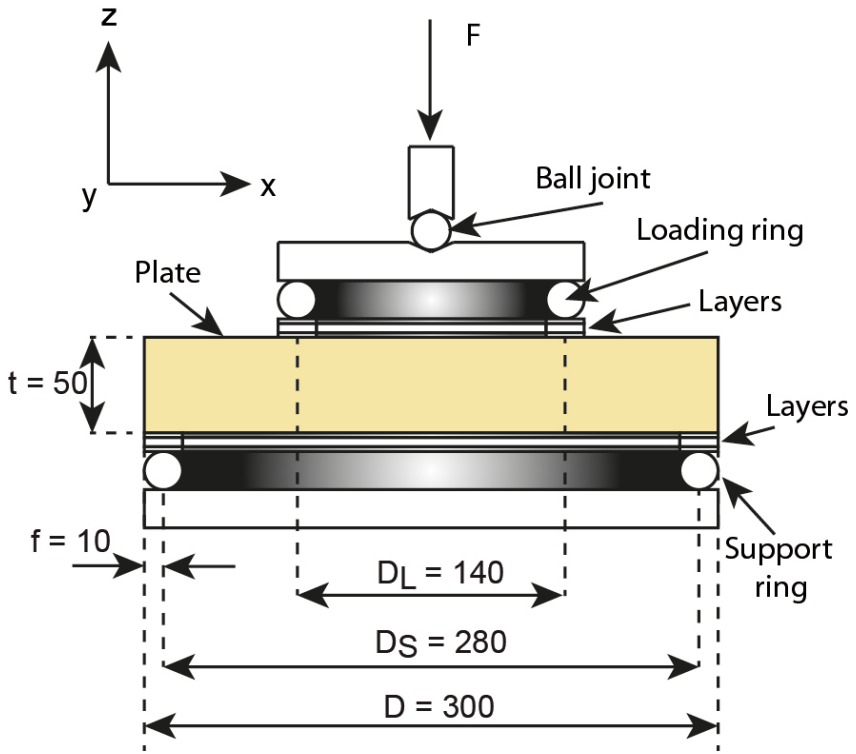


Stresses in the HSR structure

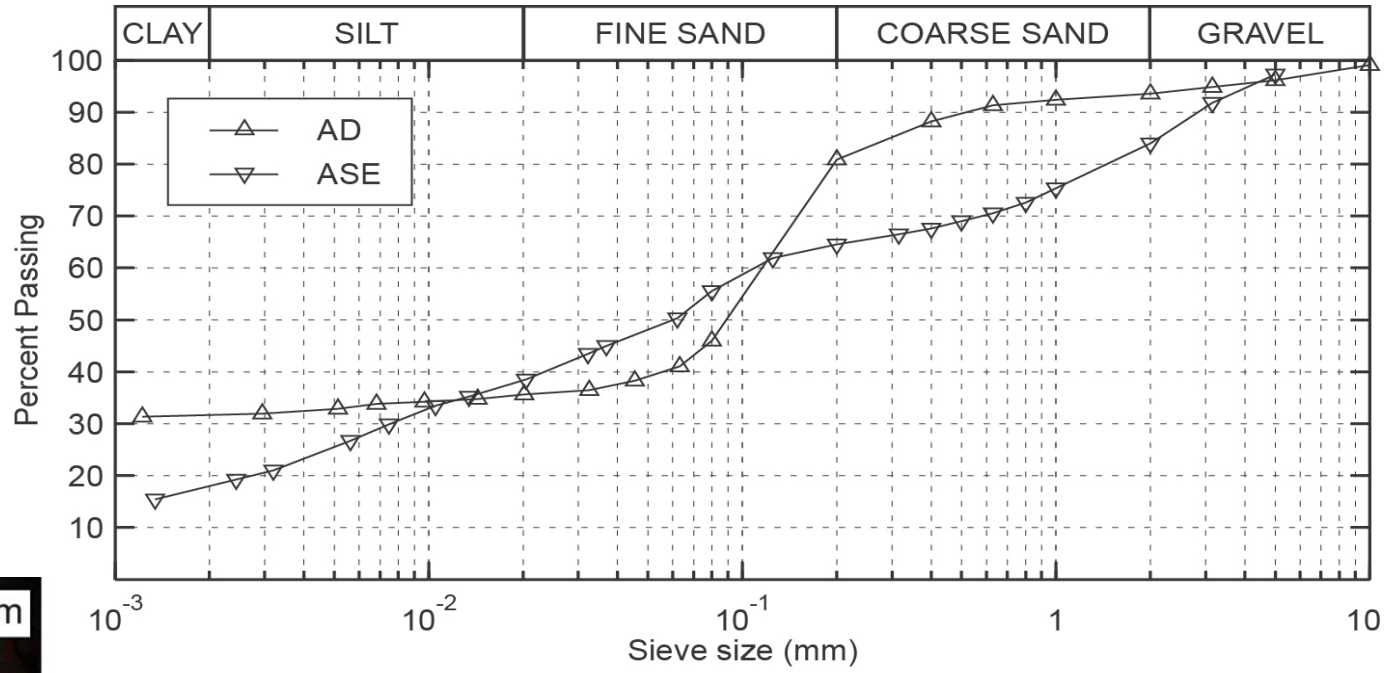
The bottom of the capping layer works in biaxial tension

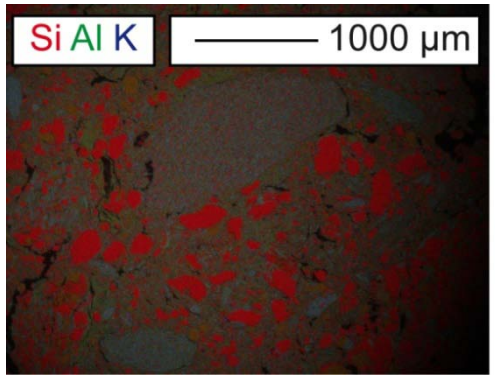
The biaxial flexural test (BFT)

BFT consists in laying a circular plate on a support ring. The load is applied on the upper face through a ring. The test generates a biaxial tension on the lower face delimited by a circle with the same diameter as the loading ring

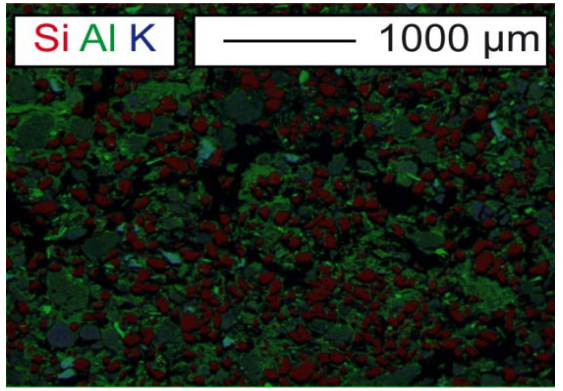


Studied stabilized soils





Stabilized soil ASE
VBS = 0.76 g/100g dry soil
Stabilized with 5% of CEMII
γ = 1.88 g/cm^3 w = 14.3%



Stabilized soil AD
VBS = 3.12 g/100g dry soil
Stabilized with 1% of lime and 5% of CEMII
γ = 1.69 g/cm^3 w = 21.5%

Fatigue results

Stabilized soil AD

$\sigma_{f\,BFT}$ = 1.07 MPa

σ_8 = 0.54 MPa

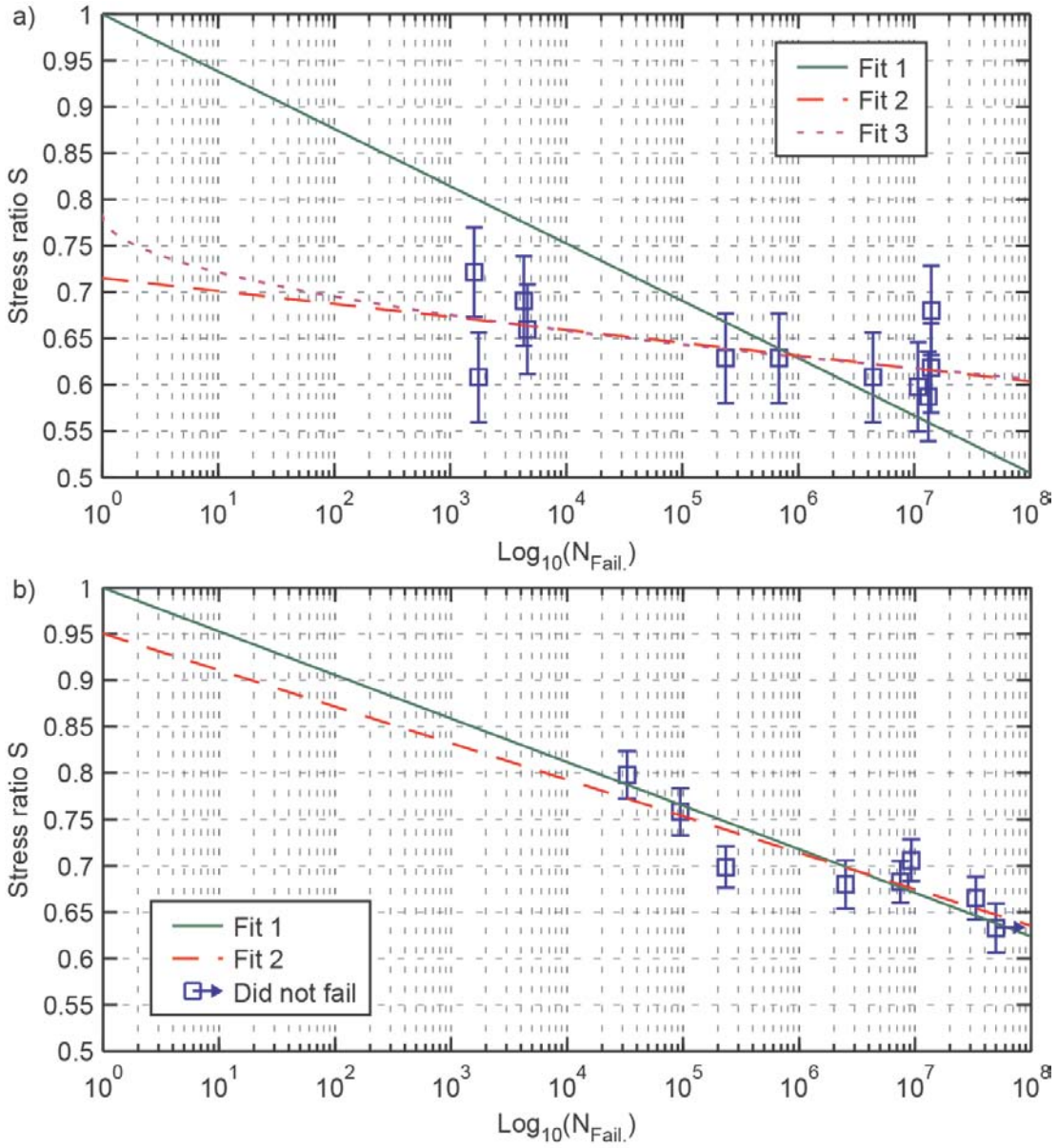
$\sigma_{f\,BFT}$ corresponds to the biaxial strength

σ_8 corresponds to the calculated flexural stress that leads to failure after 10^8 cycles

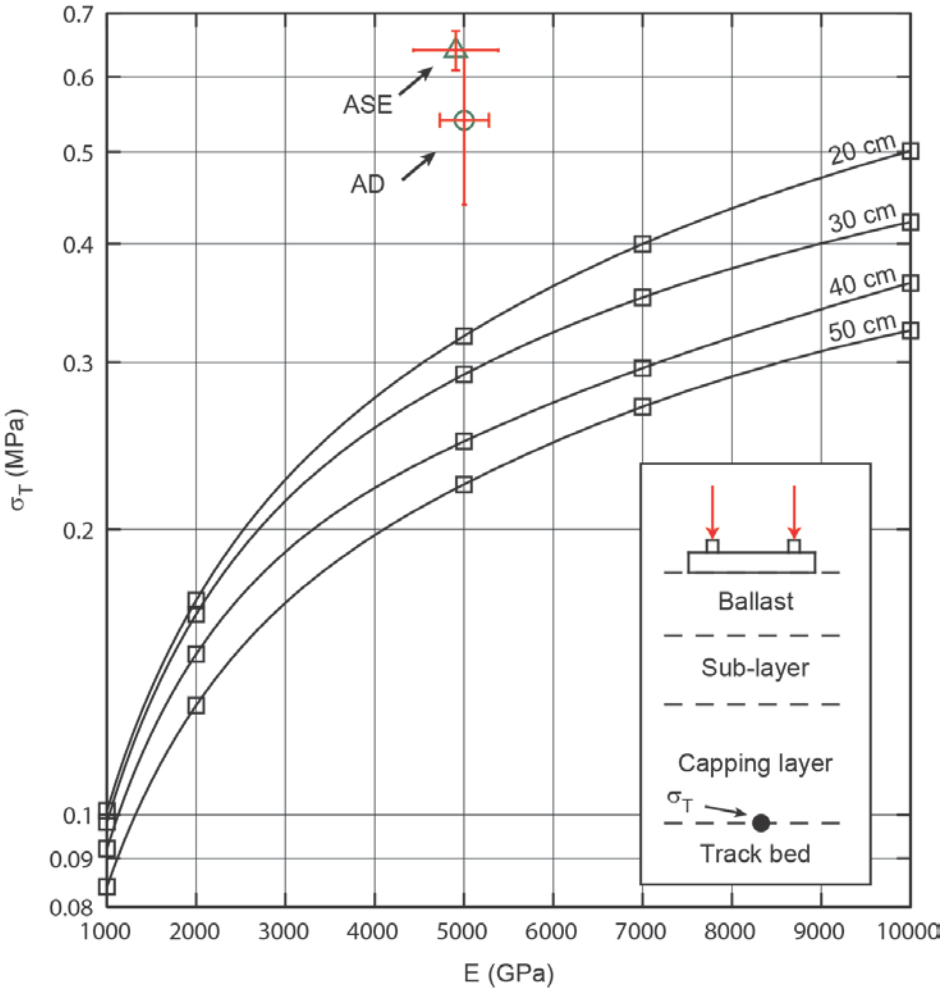
Stabilized soil ASE

$\sigma_{f\,BFT}$ = 1.02 MPa

σ_8 = 0.64 MPa



Design of the capping layer



Computed stresses at the bottom of the capping layer are presented with a semi-logarithmic scale.
The x-axis is the moduli of the stabilized capping layer and y-axis is the maximum biaxial tensile stress σ_T located at the bottom of this layer.

The mechanical properties of AD and ASE are good enough, i.e. performances better than the ones for a thickness of 20 cm

Conclusions

- The BFT is a relevant procedure to study the mechanical fatigue of stabilized soils used in the capping layers of HSR infrastructures.
- Fatigue performances under biaxial flexion were determined for two stabilized soils. Numerical modeling of the HSR structure confirms that, at the laboratory scale, stabilized soils can be considered for a use in HSR capping layers. Results are very promising even if safety coefficients are used in design procedure. Nevertheless, results should be considered cautiously because they stay at the laboratory scale and real behavior in the field must be studied.
- Several environmental friendly solutions are conceivable to rationalize the costs of the structures, rationalize the global thickness of the structure and the nature of the used materials, consider the use of stabilized soils in other layers of the HSR structure (e.g. sub-layer), optimize the use of hydraulic binders (amount, type,…) and enhance constructive applications (compaction rate, materials…) .

For more information

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