Study of the behavior of unsaturated fine-grained soils under cyclic loading - Application to the development of a methodology for diagnosis and maintenance of the Trans-Gabon Railway subgrade.

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Context

The repeated moving of trains induces cyclic loading on the railway subgrade soil which, in certain situations (high axle load, adverse environmental context, failure of the drainage system), can lead to a state of failure of the track (photo 1). In the case of the Trans-Gabon Railway line, subgrade instability problems are recorded due to the severe environmental context (high rainfall) and the presence of evolving subgrade soils.
At present, the behavior under cyclic loading, in unsaturated condition, of railway subgrade with fine-grained soils is still poorly mastered.

Figure 1:Derailment of a mineral train in Gabon

Objectives

- To propose a diagnostic methodology to evaluate the in-situ mechanical resistance and the amplitude of plastic strain of the railway subgrade soil, according to the water conditions and the amplitude of cyclic loading applied
- To Estimate, from in-situ measurements, the characteristics of the subgrade soil (water content, dry density) in order to feed the plastic strain prediction model.

Methods

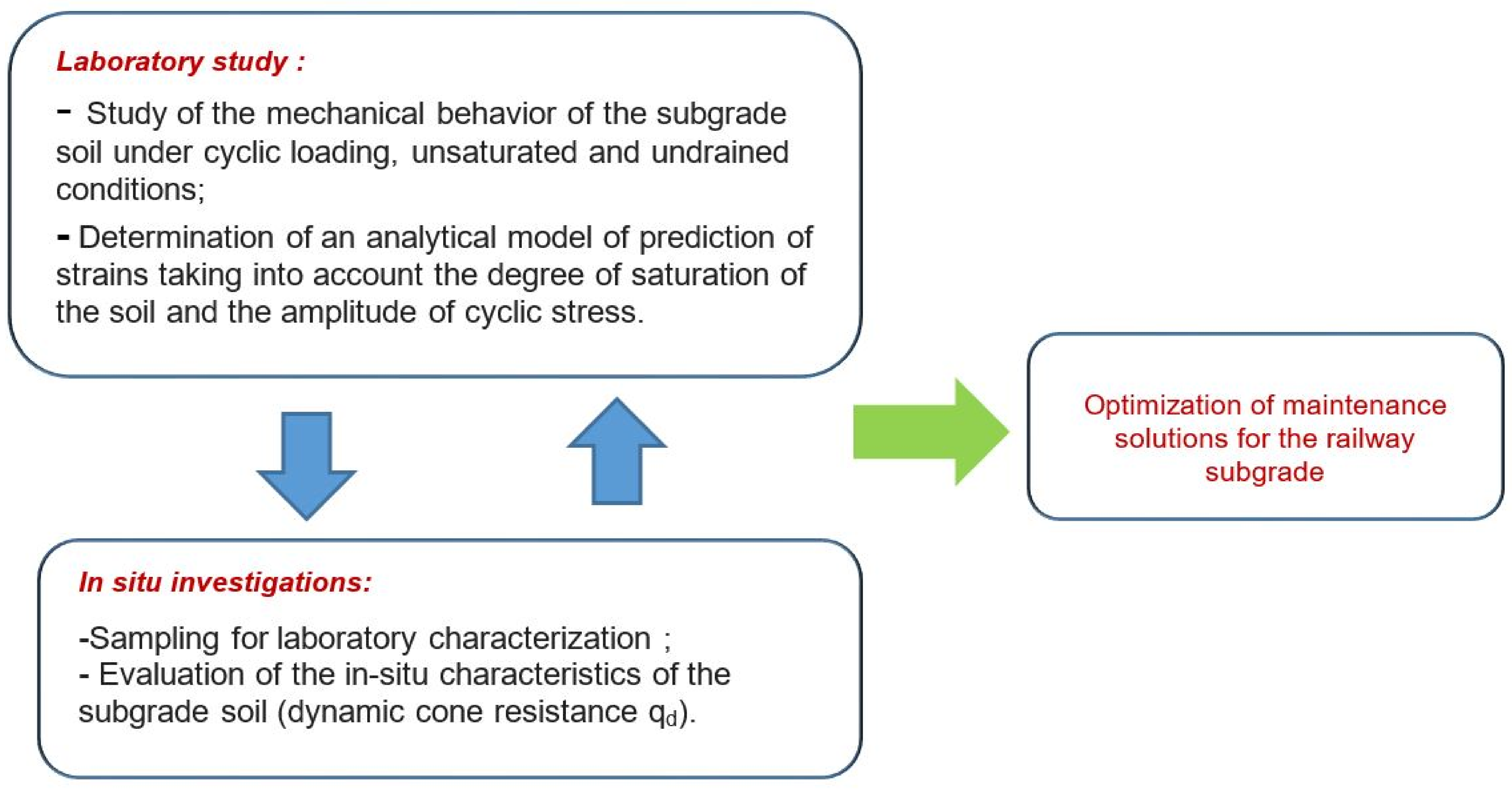

Figure 2:General methodology

Mathematical model

The analytical model for the prediction of the strains that we propose to determine will have to take into account the amplitude of the cyclic loading. (Δq_{max}) and the degree of saturation of the soil (S_r). The model gives the plastic axial strain (ε_a^p) such as [3] :

$$\varepsilon_a^p(N, S_r, \Delta q_{max}) = t(S_r, \Delta q_{max}).f(N)$$

Where f_N is the axial plastic strain according to the number of cycles of the load application to the axle (N) and $t(S_r, \Delta q_{max})$ is the axial plastic strain depending on the amplitude of loading and the soil moisture status.

Materials

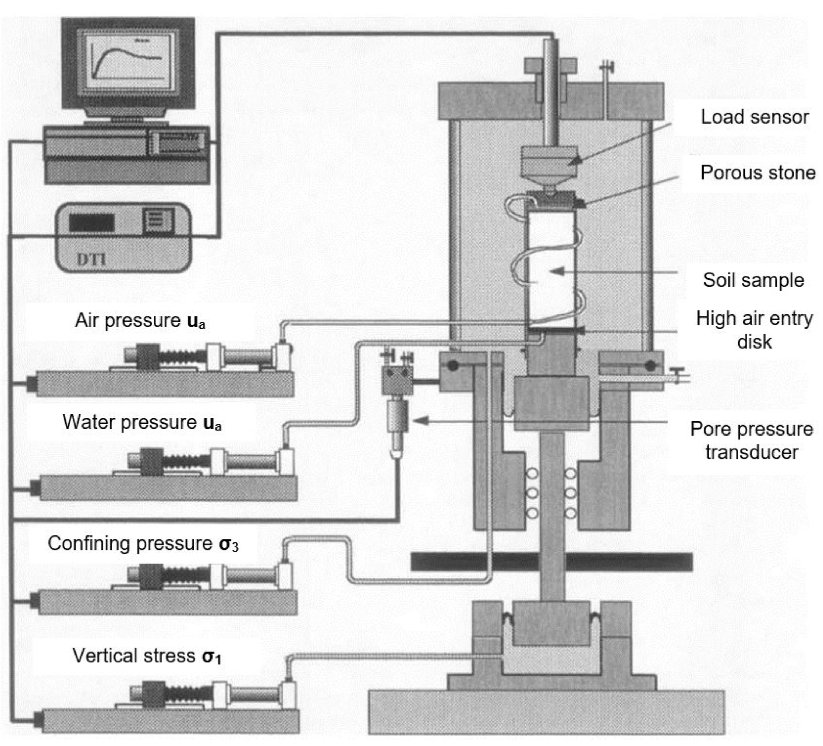

Figure 3:Modified Bishop and Wesley (1975) triaxial cell [1]

Figure 4:Dynamic penetrometer [2]

Studied sites

For this study, we are interested in two areas of the Trans-Gabon Railway line on which recurring problems of instability of the subgrade are often listed. These areas are located on the sites of a geological formation formed during the Lower Cretaceous (Neocomian to Barremian) age, mainly marls, argillites and sandstones. The soil in the two study areas is identified as pelitic alteritis.

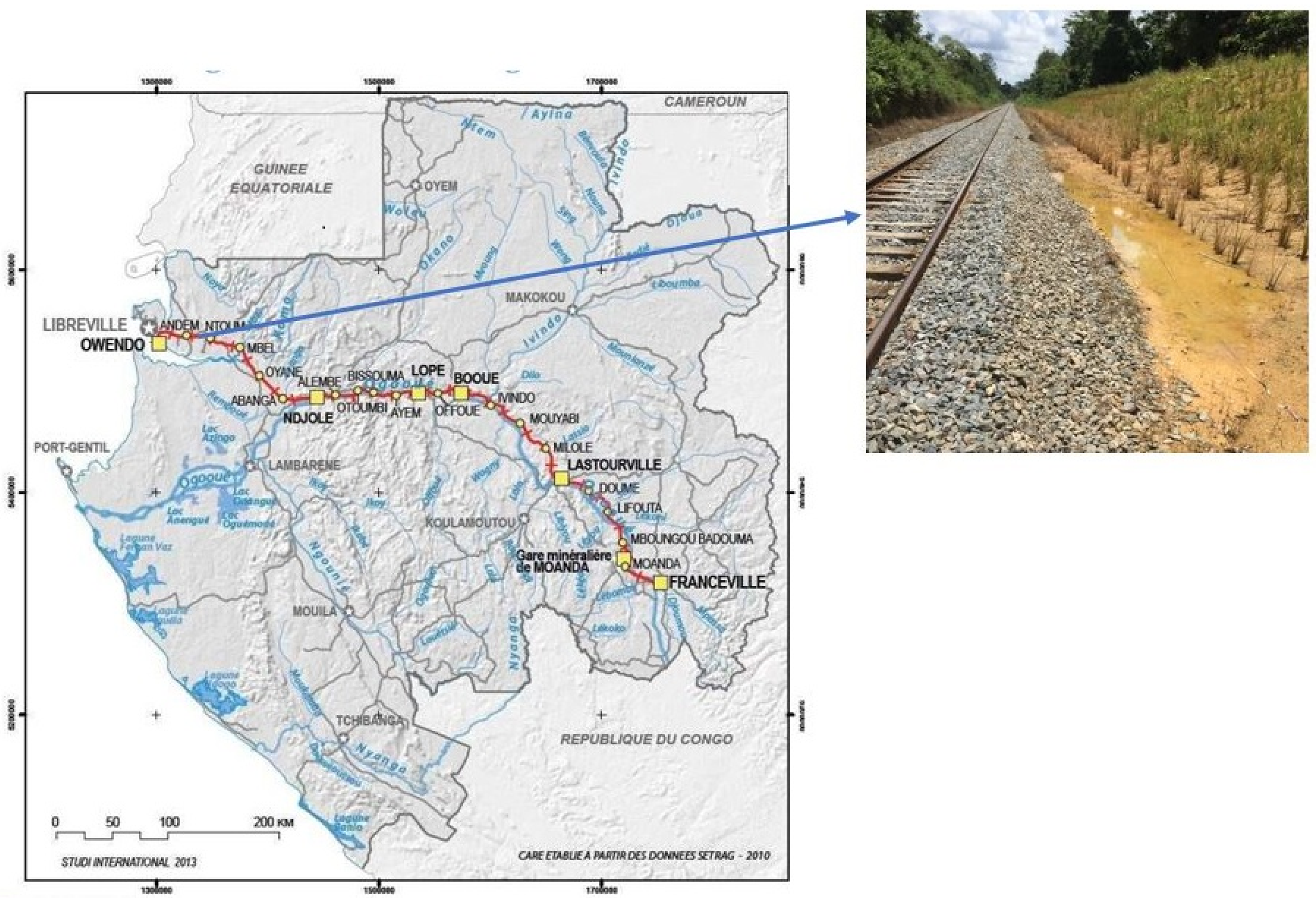

Figure 5:Location of study areas

Expected results

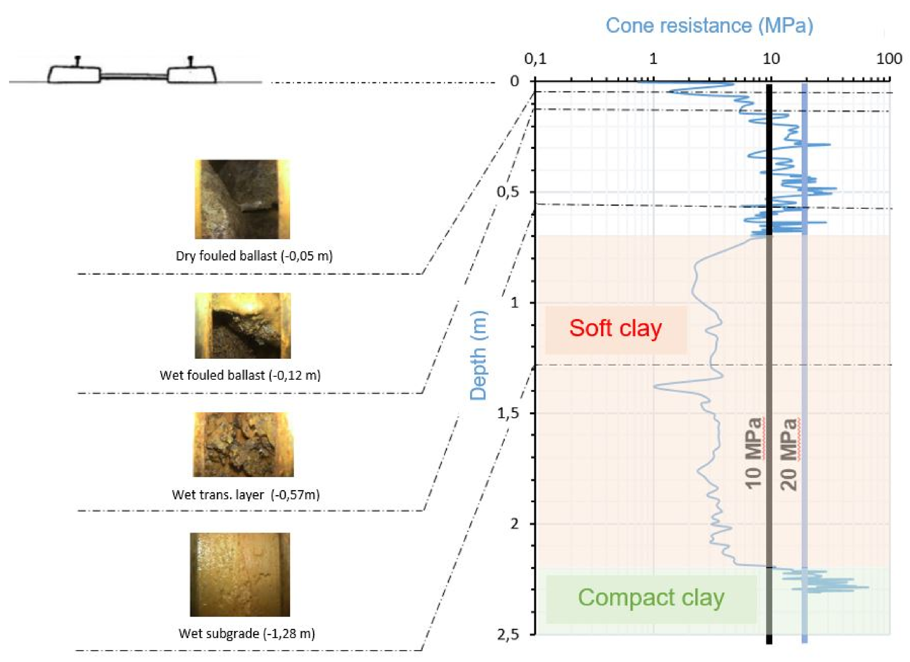

Figure 6:Penetrometric (PANDA 2) and geoendoscopic test coupling performed on the Trans-Gabon Railway line [2]

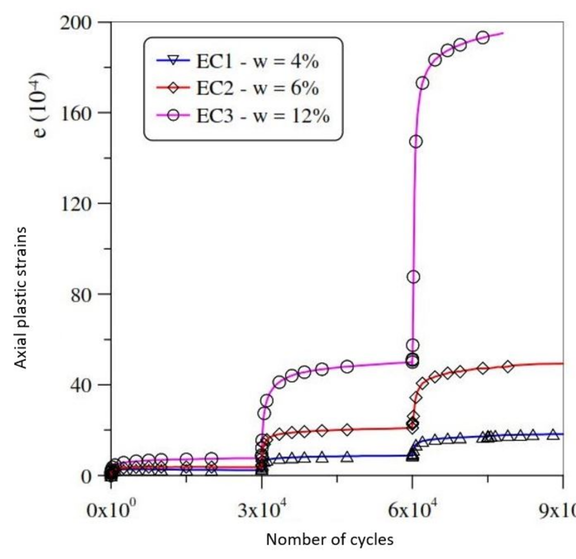

Figure 7:Development of the axial plastic strain with the number of cycles application [3]

conclusion and perspectives

This study should allow us to :

- To provide input data to feed the soil bank database on A3 and A4 class materials (according to the french GTR 92 classification (NF P 11-300) ;
- To produce a model of prediction of plastic strains taking into account the variation of the hydric state, valid for railway subgrade in fine-grained materials

References

[1] F. Geiser.
Comportement mécanique d'un limon non saturé étude expérimentale et modélisation constitutive.
page 311, 1999.

[2] Y. Haddani, P. Breul, G. Saussine, M. A. Benz Navarrete, F. Ranvier, and R. Gourvès.
Trackbed mechanical and physical characterization using panda/ geoendoscopy coupling.
Procedia Engineering, 143:1201 – 1209, 2016.

[3] V. Trinh.
Comportement hydromécanique de matériaux constitutifs de plateformes ferroviaires anciennes.
PhD thesis, Université Paris-Est, 2011.

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