Semana de Engenharia 2010
Guimarães, 11 a 15 de Outubro

COMPARISON OF IN SITU PERFORMANCE-BASED TESTS METHODS TO EVALUATE MODULI OF RAILWAY EMBANKMENTS

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KEYWORDS
Compaction control, continuous , "Portancemètre", deformability modulus, calibration, embankment.

EXTENDED ABSTRACT

The present research work is carried out in the framework of a PhD thesis entitled "Compaction and its influence on the structural behaviour of high speed railways". One part of the current PhD research aims to develop technical specifications related to compaction control. In this context recent compaction control methods will be evaluated, such as, impact tests (Falling Weight Deflectometer – *FWD* and Light Falling Weight Deflectometer – *LFWD*), the soil stiffness gauge (*SSG*) and Spectral Analysis of Surface Waves (*SASW*) (Stokoe et al. 1994), and continuous compaction control methods through "Portancemètre" equipment (Quibel 1999). Also, devices will be embarked on roller drum and in layers being compacted and vibrations measurement during compaction will be performed in order to study the interaction between the roller drum and the material being compacted.

To reach this goal, an experimental program was developed in three parts, namely, a full scale trial performed on a railway embankment and another trial carried out in a road embankment and a laboratory test campaign. Trials allowed carrying out different studies using spot tests and continuous compaction control. Moreover, the instrumentation of the embankment and road layers enabled to measure vibrations and strains induced by the compaction equipment and load traffic. Additionally, a laboratory tests program was performed. It was intended to characterize the materials and to support modeling behaviour of materials and the interpretation of field tests in a more phenomenological way.

In this paper focus will be given to full scale trial performed on a railway embankment. This was carried out in the aim of a national research project POCI/ECM/61114/2004, entitled "Interaction soil-rail track for high speed trains", financed by the Foundation for Science and Technology, which met its goal of establishing a protocol between the National Railway Network (REFER) and four national research institutions to develop the knowledge concerning the methodology for the construction and control of the railway embankments and rail track layers for high speed trains. One of the objectives of this protocol is to establish a methodology for quality control of compacted layers by different available test methods, promoting continuous compaction control. This objective was met by constructing a trial embankment, which took place near the new *Évora* railway line, about 2.5 km from the "Monte das Flores" railway station, and running tests between October and November of 2006. Description of the trial embankment, the experimental program and the different tests carried out for evaluation of the moduli, including static plate load test (*SPLT*), *LFWD*, *SSG* and "Portancemètre", will be made and some correlations between results of these tests will be presented.

An experimental plan for the evaluation of the physical and mechanical properties of the studied materials was developed. Two types of materials were tested: soil for the embankment layers and aggregate for the sub-ballast layer. Due to length constraints, only some results for soil material will be presented in this paper. The soil material used is classified as clayey sand (*SC*) with liquid limit (*LL*) of 32% and plasticity index (*PI*) equal to 11%. The optimum moisture and maximum dry density obtained from modified Proctor test was 8.6% and 20.5kN/m3, respectively. The several layers of the trial embankment were compacted with the state conditions and geometric characteristics summarised on Table 1.

Table 1: State conditions and geometric characteristics of soil layers

Moisture content (%)	Thickness (m)	Layer's dimensions (m)
w_{opt} -2	0.30	50 x 6
	0.40	25 x 6
	0.50	50 x 6
w_{opt}	0.40	50 x 6
w_{opt} +2	0.40	50 x 6

The experimental plan consisted of spot tests, the sand replacement method, water content, *SPLT* following AFNOR NF P91-117-1 and DIN 18134 standards, *LFWD, SSG*, and a continuous test "Portancemètre". Each layer was tested for different compaction energy levels corresponding to 4, 6, 8, 10 and 12 passages of the vibrating roller.

The determination of the strain modulus with different kinds of tests was possible by establishing correlations and verifying equipment calibrations using static plate loading test *(SPLT)* as a reference. Figure 1 shows soil correlations close to unity observed between the "Portancemètre" modulus ($E_{Portancemètre}$) and *SPLT* modulus, based on the AFNOR standard (E_{V2_AFNOR}) for a compaction energy level corresponding to twelve passages of the roller.

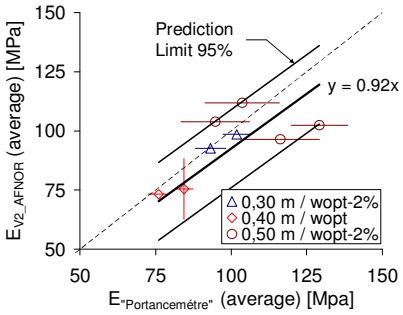

Figure 1: Comparison of $E_{Portancemètre}$ and E_{V2_AFNOR} moduli for a compaction energy level corresponding to twelve passages of the roller

The correlation between static plate loading test based on the AFNOR NF P94-117-1 standard (E_{V2_AFNOR}) and "Portancemètre" ($E_{Portancemètre}$) moduli was close to unity, which means that, for this material, results given by these tests are approximately the same. These results validate the calibration method used and indicate the huge potential of this equipment for the continuous stiffness evaluation on earthwork platforms. A reasonable correlation between E_{V2_AFNOR} and E_{LFWD} was also noted (fig. 2), and a poor correlation between E_{V2_AFNOR} and E_{SSG} modulus was observed (fig. 3).

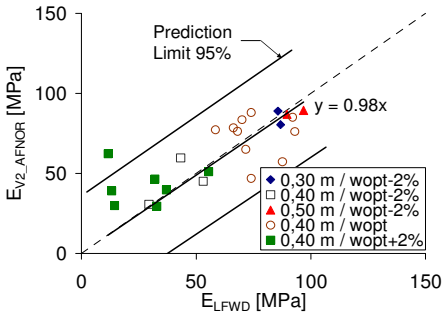

Figure 2: Comparison of E_{LFWD} and E_{V2_AFNOR} moduli for a compaction energy level corresponding to twelve passages of the roller

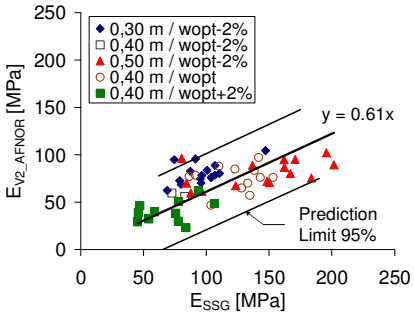

Figure 3: Comparison of E_{SSG} and E_{V2_AFNOR} moduli for a compaction energy level corresponding to twelve passages of the roller

A correlation close to unity between E_{V2_AFNOR} and E_{LFWD} moduli was also observed, despite higher scatter of the data (fig. 2). This suggests that this kind of test (*LFWD*), which is easily managed, has practical utility although being a spot test. The relation of E_{V2_AFNOR} to the E_{SSG} moduli yielded data with a large scatter, and the modulus was approximately 40% greater for the *SSG* test results (fig. 3). The results from this equipment should be treated with caution.

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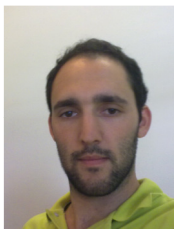
ACKNOWLDGEMENT

The authors wish to thank to Portuguese Foundation for Science and Technology (FCT) the support given through the doctoral grant SFRH/BD/32571/2006.

AUTHOR BIOGRAPHIES



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