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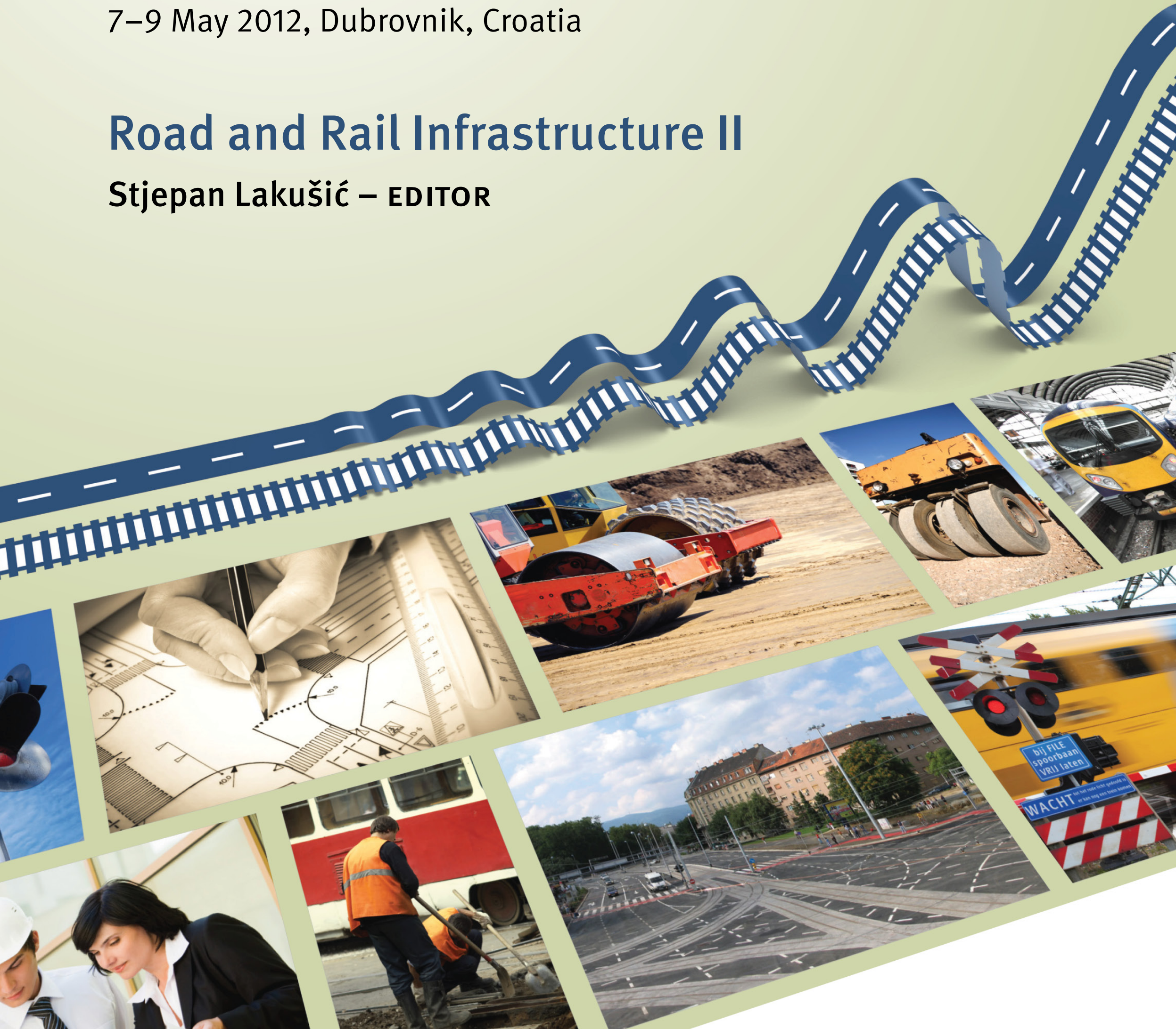
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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Road and Rail Infrastructure II

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FWD APPLICATION TO RAILWAY TRACK–BED LAYERS CHARACTERIZATION

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Abstract

The evaluation of the railway track condition represents one of the most significant parts of maintenance planning. Generally, only the track geometry is measured and then, during the maintenance process, the parameters of the track layout are restored, through tamping and levelling processes. Nevertheless, one of the main causes of track geometry deterioration is related to the track–bed condition. An evaluation of track stiffness can contribute to identify foundation problems and to adopt adequate maintenance actions.
In order to identify structural problems, a continuous monitoring of the track through non–destructive load tests can be performed. The Falling Weight Deflectometer (FWD) equipment is commonly used to evaluate pavement´s condition and, due to its advantages, has been recently used also for railway platform evaluation. Thus, various FWD tests were performed during the construction of a new railway section, designed for high speed traffic. Three test campaigns were undertaken on different months, aiming to study the climate effect, and also different load levels were applied on each test point, in order to analyse the non–linear response of the track–bed layers to load level.
Based on the FWD tests results, the elastic moduli of the track–bed layers are back–calculated and, consequently, the stiffness variation along the track can be estimated. This enables the identification of possible settlements caused by foundation.
The main results obtained so far are presented in this paper, together with proposals for future developments.

Keywords: railway platform, non destructive tests, loading tests, Falling Weight Deflectometer, back–calculation

1 Introduction

The railway evaluation consists generally in monitoring the geometry of the track with dedicated equipment that performs the measurement without contact with the track elements. Based on the results obtained, any track settlements or rail geometry problem detected is solved through tapping and levelling. This process consists in adding more ballast to the existing track in order to re–establish the initial geometry. However, this process does not solve the real causes of the track settlements, such as fouled ballast or drainage problems [1, 2]. In these cases, the tapping will only increase the settlement due to increased weight.
The Falling Weight Deflectometer (FWD) is usually applied for pavements evaluation. Several tests were performed at subballast level in order to study the applicability of this equipment to railway evaluation. The troubleshooting and the main results obtained so far are presented herein.

2 Falling Weight Deflectometer

The Falling Weight Deflectometer (FWD) is presently the device for deflection testing most widely used in Europe, North America and Japan [3, 4] for pavement evaluation. The test load is obtained by dropping a weight from a certain height on a set of buffers. The load is transmitted to the surface through a metal plate and the resulted deflections are measured by transducers resting on the surface, up to about two meters distance from the load centre. This equipment has the advantage that the impact load applied on the surface can be changed by changing the weight, the height and the loading plate diameter. In this way, simulation of various loading levels is enabled. The equipment measures the structure response in 6 to 9 points (see Figure 1), resulting a deflection bowl that reflects the influence of different layers on the structure response.

Figure 1 Falling Weight Deflectometer equipment.

The measurements are performed at equal distances along the infrastructure studied, chosen according to the length of the section to be tested (from 10 to 100 m). The measured deflection bowls, together with the information on layer thickness, are used for the estimation of 'in situ' bearing capacity [3, 4].

3 Load tests on a track platform – case study

3.1 General description

The case study consist of a structural modeling of an experimental field site of a railway infrastructure [5, 6], based on non–destructive load tests performed with FWD at the top of sub–ballast granular layer. In this way, an analysis of the efficiency of the load tests and their applicability and variability was made.
FWD load tests were performed at the top of sub–ballast, different load levels were applied in order to study the response of the structure and to establish the testing methodology.
Different testing campaigns were undertaken, in different months, in order to identify the structural response under different weather conditions, consequently water contents. Several load levels were applyed in order to study their influence on the measured deflections.

The FWD 0.30 m diameter plate was used and minimum 3 drops were applied at each test point. The deflections were measured by nine transducers, one central (do) and the remaining eight away from the center of the load plate by 30, 45, 60, 90, 120, 150, 180 and 210 cm.
A brief presentation of the tests performed and the main results obtained [5] are referred herein.

3.2 Track section studied

The load tests of the case study were performed in a 29 km new railway section constructed in Portugal [5]. The recommendations of UIC 719R [7] were followed, for the design of the platform, in order to meet the requirements for the high–speed traffic. In this case study six sections (S1 to S6) of the railway platform were analysed [6].
The track substructure (see Figure 2) consists in a 0.30 m sub–ballast layer, generally composed by 0.15 m of granite aggregate, well–graded crushed unbound granular material (UGM), as top sub–ballast layer, and 0.15 m of limestone UMG, as bottom sub–ballast layer, except for section 1 (S1) in which both layers consist on granite UGM. Generally, on the top of the subgrade a 0.20 m limestone UGM capping layer was placed, under the sub–ballast, except for section 6, in which the capping layer was 0.35 m thick.
The first five sections (S1 to S5) were built on landfill, with an identical structural solution (Figure 2 left), while the sixth section (S6) was built in excavation and has a different structure (Figure 2 right), as already referred.

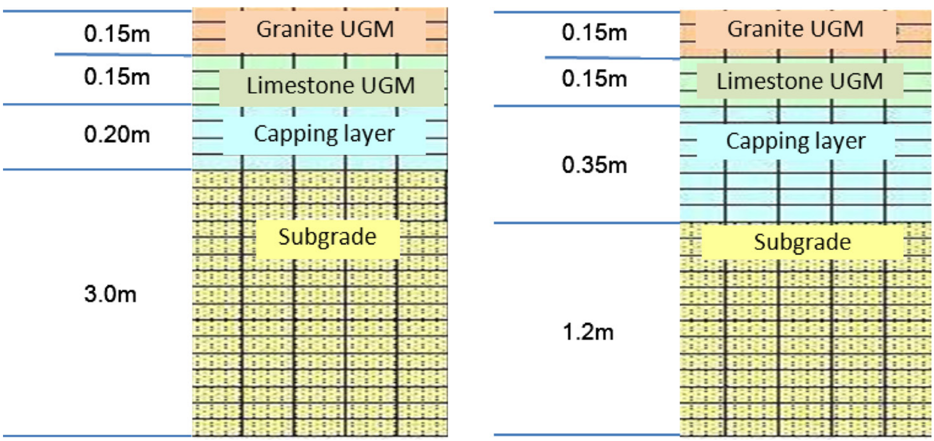

Figure 2 Geometrical characteristics of the track substructures studied

3.3 Load tests performed

Tests were carried out in six sections studied (S1 to S6), at the top of the sub–ballast layer, in November and December of 2008 and January of 2009.
Figure 3 presents, as an example, the deflections obtained in Section S6 during the December campaign, for several loading levels carried out, corresponding to 16, 25, 65, 90, 110 and 130 kN.

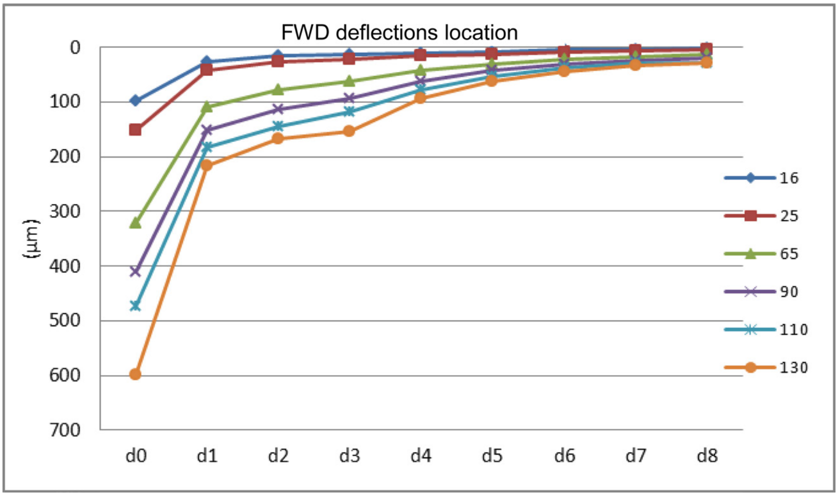

Figure 3 FWD deflection obtained for various load levels at Section S6

3.4 Analysis of the results

From the analysis of FWD tests results for different loading levels resulted that, generally, the values of the granular layers modulus (E1) tend to increase with increasing loading level, except for the highest load (130 kN), where there is a decrease in E1 modulus (see Figure 4) but at the same time an increase in E2.
It can be also observed that the subgrade layers modulus (E3) tends to decrease with the increase of load. The rigid layer modulus (E4) was maintained constant during this analysis.

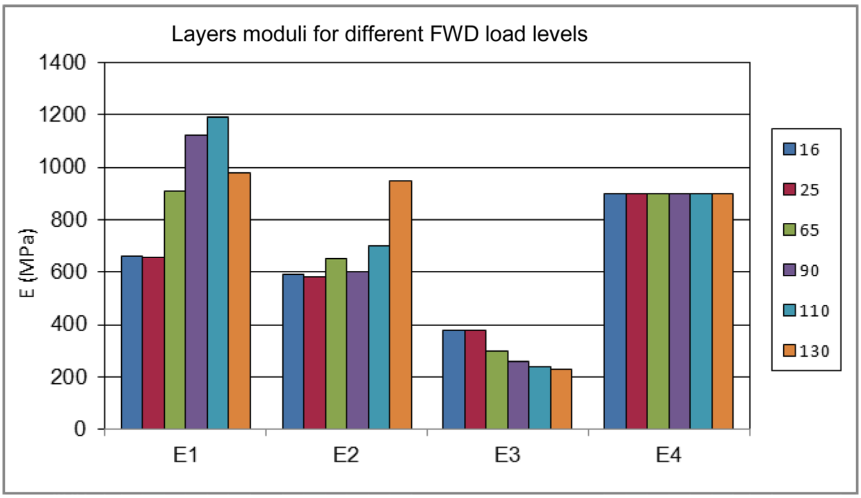

Figure 4 Back–calculated moduli for different load levels – Section S6

The analysis of the results obtained for the three test campaigns undertaken in differnet months (November and December of 2008 and January of 2009) shows that the moduli obtained for the first five sections (S1–S5) are similar per campaign, with small variations (see Figure 5).

In the temporal analysis (Figure 6), it is found that the modulus E1 in November tends to be equal to the modulus E2, with minor variations. However, in December and January, the E1 moduli are generally lower than E2 moduli, with greater differences observed in January. This fact may be caused by the significant amount of precipitations that occured in December and January.

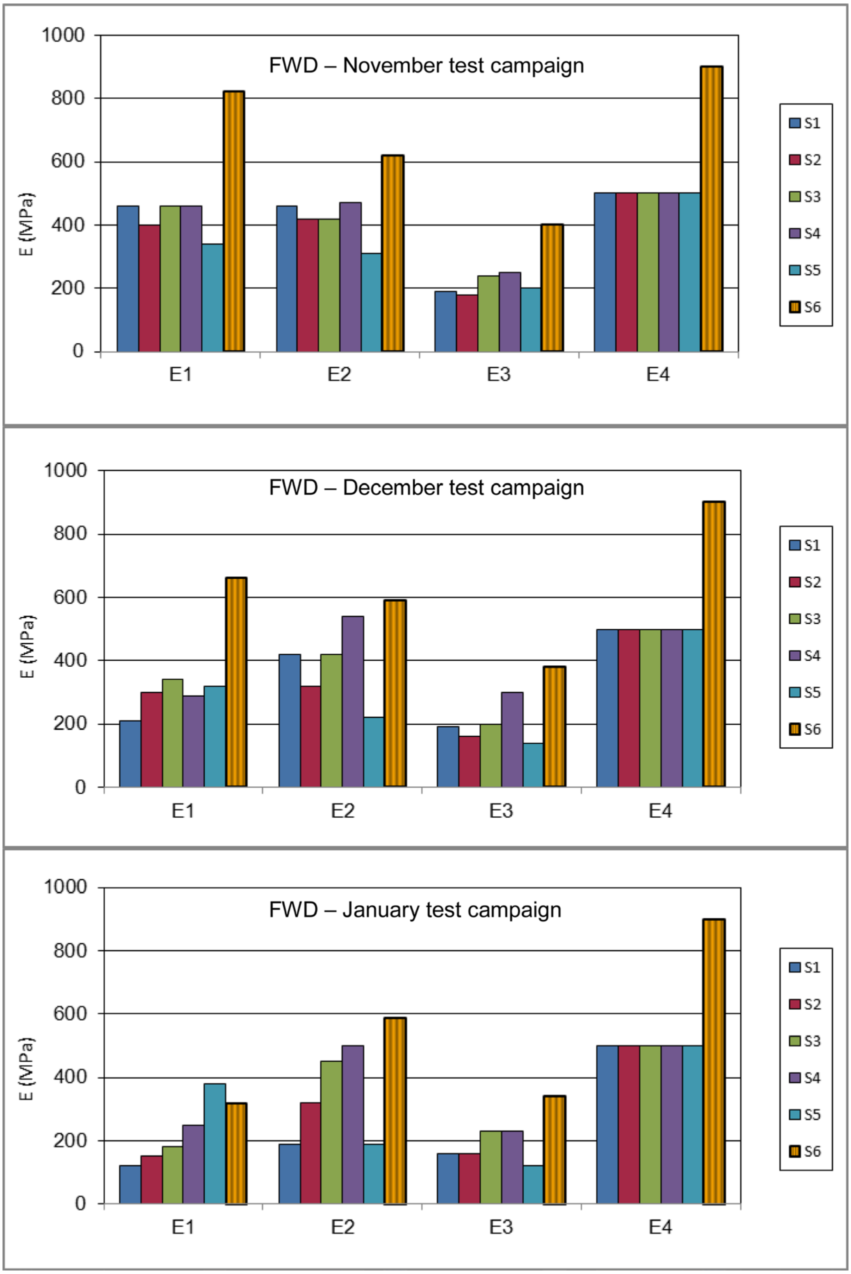

Figure 5 Back–calculated moduli during different test campaigns S1–S6

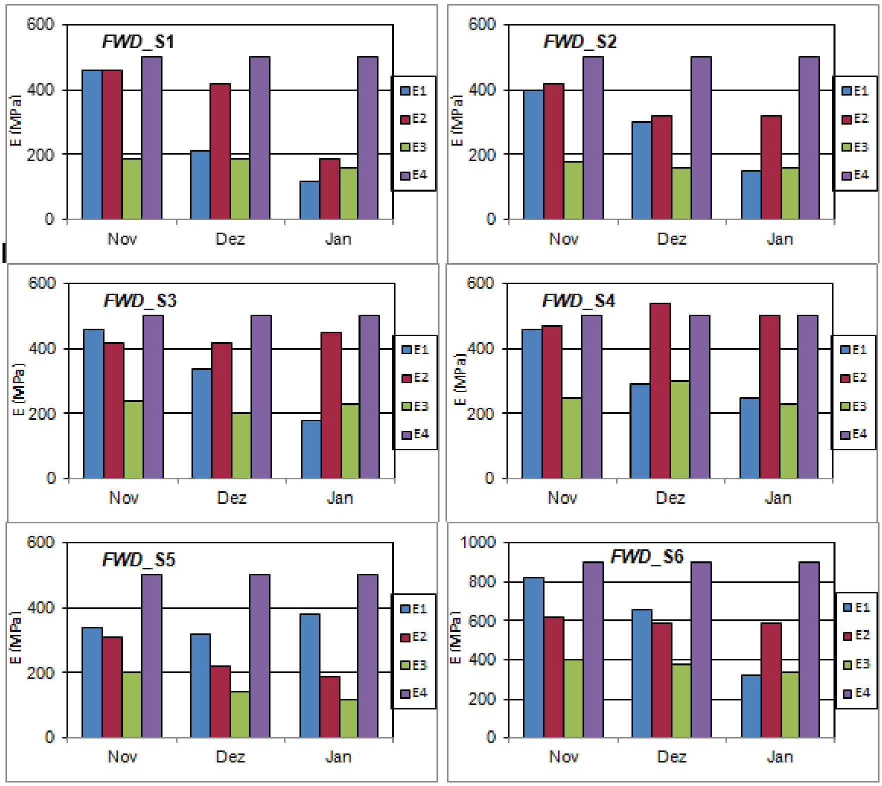

Figure 6 Back–calculated moduli during different test campaigns

4 Final considerations

The application of non–destructive load tests has proven to be an efficient way to obtained continuous information of the platform condition. Several tests were performed in different months during the year and with different load testing levels in order to define the better testing approach for the railway platform evaluation.

Some of the results obtained for structural characterisation of a test section are presented in this paper.

It is expected with this approach to contribute to a better characterisation of the platform, by using the FWD results, as they allow determining the elastic moduli of distinct layers of the track platform. In this way, it is possible to identify the causes of stiffness variation along the infrastructure and to correlate the future in service behaviour with the real causes of possible pathologies, such as track settlements.

As future developments, based on the tests performed during this study it will be possible to define testing procedure for FWD measurements, to study the substructure response under different load levels and water contents conditions and to correlate the test with other loading tests performed in situ, such as Portable Falling Weight tests and Plate Load Tests.

The next step is to develop testing procedures at the top of the railway track that enable the correlations of data obtained during construction with the structure response during service. In this way it will be possible to follow the track condition under traffic loading.

References

[1] Burrow, M.; Chan, A. & Shein, A.: Deflectometer-based analysis of ballasted railway tracks, Proceedings of the Institution of Civil Engineers: Geotechnical Engineering, 160, 169-177, 2007.

[2] Fortunato, E: Renovação de plataformas ferroviárias - Estudos relativos à capacidade de carga (in Portuguese), PhD Thesis, Porto, Portugal, 2005.

[3] Fontul, S.: Structural Evaluation of Flexible Pavements using Non-Destructive Tests, Ph.D Thesis, Lisbon, 2004.

[4] Fontul, S. & Antunes, M.L.: Optimising the Use of non-destructive tests in pavement evaluation, 9th International Road Conference Budapest, Roads for Sustainable Development, Budapest, Hungary, 2006.

[5] Fontul, S., Fortunato, E. & De Chiara, F.: Non destructive tests for railway infrastructure stiffness evaluation', The Thirteenth International Conference on Civil, Structural and Environmental Engineering Computing and The Second International Conference on Soft Computing Technology in Civil, Structural and Environmental Engineering; Chania, Crete, Greece, 6-9 September 2011.

[6] Kamlesh, G.: Caracterização estrutural de infra-estruturas de transportes através de métodos de auscultação não destrutivos, (in Portuguese) Master of Science Dissertation, ISEL, Lisbon 2010.

[7] UIC CODE 719R, Ouvrages en terre et couches d'assise ferroviaires; Paris: Union Internationale des Chemins de Fer (1994).