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PERFORMANCE ASSESMENT SOLUTIONS FOR TRANSITION ZONES EMBANKMENT-BRIDGE RAILWAYS TROUGH NUMERICAL SIMULATION 3D

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Transition zones, bridge, 3D modeling, railways.

EXTENDED ABSTRACT

This work fits into the doctoral theme *"Study of the Behavior of Transition Zones in High-Speed Railways"* in which it is intended to carry out an inventory the types of solutions for transition zones (technical blocks) and assess their performance, either through numerical simulations, as well as through monitoring their behavior. Also it is intended to develop 3D numerical models coupling the action and the structure of the track, which incorporate different design solutions for transition zones. It is also planned, in collaboration with the Department of Polymers of University of Minho, the development of solutions such as composite ties and under rail pads or/and under sleeper pads (USP). Finally, it is also expected that calibration/validation of numerical simulations will be performed throughout an instrumented test.

In this framework it is necessary to know that high speed railways need to be built with design as straight as possible. It means that it should accommodate inevitable situations of railways passing over soft soils and rigid structures, such as bridges. In such conditions where a railway track exhibits abrupt changes in vertical stiffness, such as bridge approach (Sasaoka and Davis, 2005), we are faced with cases of transition zones.

Transition zones can be present serious problems when subject a dynamic loads which can generate impacts that contribute to accelerated degradation of the track and therefore its frequently maintenance, apart from possible decline in their life. According several authors (e.g.: Sasaoka and Davis, 2005), problems at a track transition can be divided into three categories: i) differential settlements; ii) track stiffness case; iii) track damping case.

Although transition zones, as transitions between embankments and bridges, are sections where specific problems arise, and their complexity and resolution are difficult, based on a deep bibliographic study at international level, it was possible to find that in recent years several solutions have been proposed. These proposed solutions, which can be found in Seara and Gomes Correia (2008), have been developed to trying to promote a smooth change in vertical stiffness between embankments and bridges, and so to avoid the problems above mentioned. However, as reported by some researchers, several of these solutions perform below expectation. Thus, numerical simulations of the various solutions could be a first step towards to a better understanding. Therefore, to trying understood the performance of one of several solutions for transition zones under moving vehicle from the embankment section, through the transition zone and the bridge deck, a number of dynamic linear studies of 3D numerical models for a solution composed by two reversed wedges were performed. These simulations, where train/track (wheel/rail) interaction wasn't considered, were carried out using finite element software DIANA, and their objective was to find the best ratio of stiffness between the two inverted wedges, identifying the main differences between them.

Numerical simulations were realized using a punctual moving load, moving at 314km/h. Once the tests were carried out in linear elastic conditions, and the wheel/rail interaction was not considered, then the principle of superposition of effects was applicable. Thus, implementing this principle the simulation of the passage of the Thalys train (fig. 1) was carried out.

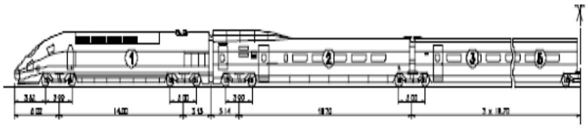


Figure 1: Thalys train configuration

The railway track model incorporated rail, interface, sleeper, ballast, sub-ballast, sub grade, embankment and technical block in transition zone composed by two inverted wedges, soil and abutment. The longitudinal length of the model was 69,9m and the transversal length was 20,0m. These dimensions were used to try to avoid any interference of any reflected wave. With this geometry it was obtained a mesh composed by 91231 nodes and 95543 elements. A global schematic representation of the railway track is presented in Figure 2, and its schematic geometry is presented in Figure 3.

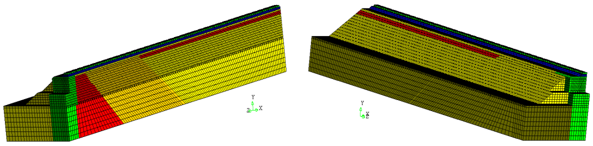
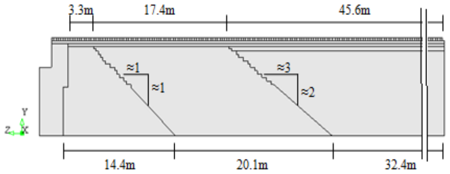
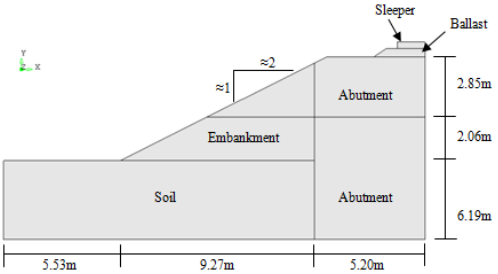


Figure 2: Global view of numerical models



a) Longitudinal
(Note: wedge 1 is located adjacent to the abutment; wedge 2 is the wedge contiguous to wedge 1)



b) Transversal

Figure 3: Identification of the dimensions of the numerical models

The necessary parameters to characterize the behavior of the material were: Young's modulus; Poisson's ratio; density; damping's ratio (Rayleigh damping was considered). In total were performed three numerical simulations whose main differences were:

Model 1: $E_{Embankment} = 60MPa$ $r_{E_1/E_2} = E_1 / E_2 = 1{,}195$

Model 2: $E_{Embankment} = 60MPa$ $r_{E_1/E_2} = E_1 / E_2 = 2{,}0$

Model 3: $E_{Embankment} = 100MPa$ $r_{E_1/E_2} = E_1 / E_2 = 2{,}0$

The results obtained for a punctual load with a value of 100kN moving at 314km/h, from the embankment to a bridge, is presented in Figure 4. Observing the results in this figure it is possible to identify important differences between settlements on embankment zone and on abutment/bridge deck. Through the same figure it is possible to conclude that when the embankment has a Young's modulus with 100MPa, the track exhibits a too large and undesirable stiffness.

Analyzing the passage of the load from the embankment to the wedge 2, it is possible to see that the settlements begin to decrease quickly approximately 5,1m before coming to the top of the wedge 2. It means that the settlements' magnitude only begins to occur when the load is felt at a depth that reaches the material of the wedge 2. Thereafter, the magnitude of the settlements hardly varies until the abutment. Here, the settlements decrease abruptly. Although no significant changes occur in settlements value along the wedges 2 and 1, it is possible to verify that the models 2 and 3 (where Young's modulus ratio between wedge 1 and 2 is 2,0) present a better performance to make the transition to the bridge.

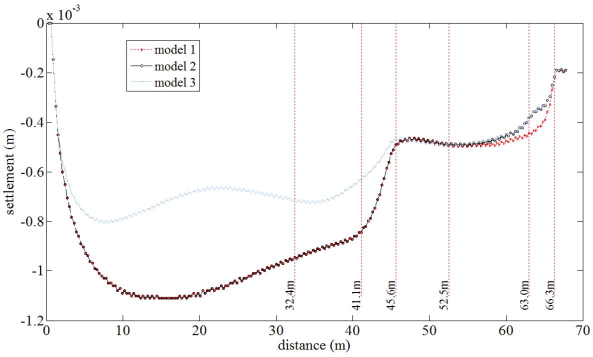


Figure 4: Settlements along the track at each point of the rail at the time of action of the load

Also when the passage of Thalys train was simulated, it was concluded that exist significant differences between the settlements that occur along the embankment and on the abutment. This means that is really necessary to achieve a good solution to make the transition between embankments and bridges, which means to produce a decrease of settlements as continuous as possible, and avoid the bump at the end of the bridge.

ACKNOWLDGEMENT

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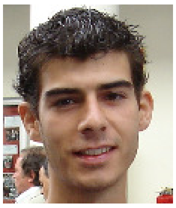
REFERENCES

Sasaoka, D. C. and Davis, D. 2005. *Implementing Track Transition Solutions for Heavy Axle Load Service.* Accessible in 16 of January of 2007, http://www.arema.org

Seara, I. and Gomes Correia, A. 2008. "Zonas de transição de vias-férreas. A importância de uma solução geoestrutural." In *Proceedings of XI Congresso Nacional de Geotecnia.* Coimbra: Portugal. 245-252.

AUTHOR BIOGRAPHIES



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