An Alternative Formulation for Flexible Track Models in Railway Dynamics

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Abstract

The dynamic analysis of modern railway systems involves complex multidisciplinary problems for which the most recent computer codes for railway applications, in general, only allow the studying of a particular phenomenon at a time, each with its own complex mathematical model. By analysing such phenomena independently, it is not possible to capture all the dynamics of the complete railway system and the relevant coupling effects. For instance, the dynamic performance of railway vehicles is, in general, studied considering that the tracks are rigid. Hence, it is difficult to capture all physical phenomena involved in the vehicle-track interaction if the track deformation during the trainset passage is not considered. The main goal of this work is to develop detailed and reliable three-dimensional track models for railway applications, which include the flexibility of the rails and of the substructure. The vehicle and track models are integrated in a common tool and the methodologies developed are analysed in several operation conditions. Future developments of this work include the validation of the flexible track models by performing experimental tests and in close collaboration with the industry.

Motivation:

The inclusion of flexible track models is very important to study the dynamic behaviour of railway vehicles in realistic operation scenarios, especially when studying the impact of train operations on the infrastructure and, conversely, the damages on vehicles provoked by the track conditions. This topic has a significant economic impact on the vehicles maintenance and also affects the life cycle costs of tracks. The work developed here can support the development of solutions with technological relevance that give answer to the industry's most recent needs contributing to improve the competitiveness of the railway transport.
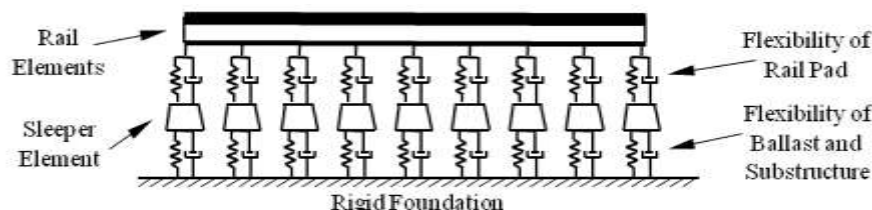

Figure 1: Schematic representation of the Alfa Pendular trainset

Description of Work:

The dynamic analysis of railway vehicles requires the construction of reliable and computational efficient models to represent the vehicle, the track and the wheel-rail interaction. It is proposed here to use a finite element methodology to model the rails as beams supported in a discrete manner by spring-damper systems that represent the flexibility of the pads, sleepers, ballast and Substructure

[1,2], an depicted in figure 1. The railway vehicle is represented by a multibody dynamics methodology with Cartesian coordinates. Instead of using the traditional approach, in which these systems are handled independently, here they are integrated in a common and reliable tool, where the interaction between the vehicle and the track is considered. For this purpose, advanced computational tools and more complex methodologies able to be handled in a co-simulation environment, where all physical phenomena can be integrated, are developed. The wheel-rail contact formulation used here allows obtaining, online during the dynamic analysis, the contact points location, even for the most general three-dimensional motion of the wheelsets with respect to the track. The methodology proposed to build flexible track models is demonstrated by comparing the results obtained with this new approach with the ones obtained with ANSYS. Furthermore, the methodology is used to study the dynamic behaviour of the Alfa Pendular railway vehicle, shown in figure 2. Future developments of this work include the identification of the properties of the flexible elements used to represent the track model by experimental tests performed in GRAFT II test facility at Heriot-Watt University. In this way, the models and methodologies developed here can be validated in collaboration with the railway industry and using real data.
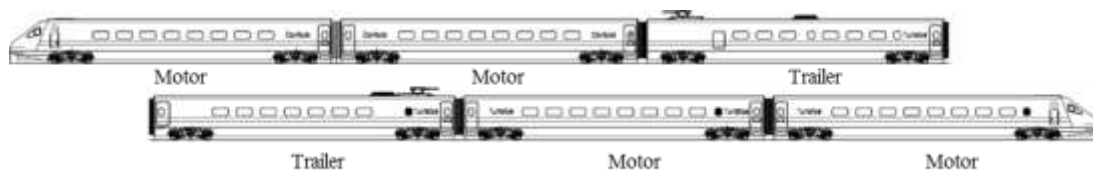

Figure 2: Schematic representation of the Alfa Pendular trainset

References

[1]   Pombo, J., Almeida, T., Magalhães, H., Antunes, P. and Ambrósio, J. (2013) "Finite Element Methodology for Flexible Track Models in Railway Dynamics Applications", *Int. J. Vehicle Structures & Systems*, **50**, No. 2, pp. 43-52.

[2]   Pombo, J., Almeida, T., Magalhães, H., Antunes, P.. and Ambrósio, J. (2013) "Flexible Track Models in Railway Dynamics Using a Finite Element Formulation", *Proceedings of the Fourteenth International Conference on Civil, Structural and Environmental Engineering Computing*, (B. Topping, and. Iványi, P., Eds.), Civil-Comp Press, Stirlingshire, United Kingdom, paper 30,