Attenuation performance of track stiffness transitions under different vehicle speeds

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Abrupt discontinuities in the vertical stiffness of a railway track (*e.g.*, due to the presence of a rigid structure, or a connection between ballasted and non-ballasted track), generally induce an amplification of vibrations on both the vehicle and the track. Hence, such critical segments – which are commonly referred as transition zones –, are highly exposed to material degradation, geometry distortion and loss of passenger comfort [1].

In this regard, an extensive research has been performed in the last years in order to better understand the dynamics of track transitions as well as all the processes involved and diverse solutions – usually known as track stiffness transitions – have been proposed to provide a smoother stiffness change between track sections. However, to the best of the authors knowledge, no research has fully studied the effect of vehicle speed and only one value is generally used instead of considering a wider range [2].

The aim of this research is thus to explicitly analyse the effect of train speed on the vibration attenuation capacity of two different track stiffness transitions: a concrete slab wedge and a hot mixed asphalt (HMA) transition.

For this purpose, a 3D FEM numerical model consisting of two different sub-models (namely a track-soil model and a vehicle model) has been developed within commercial software ANSYS. It has been later calibrated and validated with data of a real track stretch of the high speed line Madrid-Barcelona; and has been later used to reproduce three different scenarios (two transition typologies plus a zero case without transition).

Both the track and the soil have been modelled using 8-node hexahedral elements; and the material behaviour has been assumed to be isotropic linear elastic, since the effect of the train does not induce large strains in the soil. Due to the symmetry of the problem, only half of the track has been modelled in the longitudinal direction and a total model length of 54 m (90 sleepers) has been considered. The dimension of the model in the cross section is 10 m, which is enough to avoid wave reflection problems in the boundaries and still ensures an acceptable computational cost. The boundary conditions have been defined according to [3] as a constraint of the perpendicular displacement on each edging plane. Additionally, in order to accurately reproduce tensional discontinuities on the sleeper-ballast contact, it has been modelled with bounded perpendicular D.O.F.s.

For the sake of simplicity, the vehicle has been reduced to a three-mass model, thus accounting for the masses of wheelset, bogie, and car-body. In this sense, point elements have been selected for modelling the masses, which are linked by springs and dampers reproducing the primary and secondary suspensions. The wheel/rail interaction is modelled as a Hertzian spring and a node-to-beam contact, allowing for sliding and loss of contact by means of the Penalty algorithm. On the other hand, a full Newton-Raphson method has been employed for solving the nonlinear equations, while the transient dynamic equilibrium has been addressed by means of a Newmark implicit time integration.

References

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