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Critical Velocity and Instability of Inertial Objects Moving Uniformly on Layered Track Models

Zuzana Dimitrovová[1,2*]

[1] Department of Civil Engineering, NOVA School of Science and Technology, NOVA University of Lisbon, Portugal, zdim@fct.unl.pt (https://docentes.fct.unl.pt/zdim)
[2] IDMEC, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal

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In this contribution, a new form of semianalytical results related to inertial objects that are traversing homogeneous infinite structures, introduced in previous author's work [1], is used to analyze one-, two- and three-layer models of the railway track. The aim of these analyses is determination of the critical velocity of a moving force and of the onset of instability of moving masses or oscillators.

The new form of semianalytical results is related to infinite structures, but in addition to these derivations, equivalent finite models are presented and solved in order to provide easy validation of the results. For such structures, the eigenmode expansion method is used and therefore the natural frequencies and orthogonality conditions must be derived. Furthermore, due to the coupling of modal equations, a rearrangement of the terms involved is introduced to save computational time. All results, both from finite models and from infinite models, are presented as much as possible analytically using dimensionless parameters, and therefore can be used directly for several combinations of input data.

First of all, the possible range of dimensional parameters is identified. Within these ranges, there are significant differences between the models. While for the one- and two- layer models the critical velocities are well-defined and their number is 1 or 3 [1-3], respectively, in the three-layer model their number depends on parameter values and can be 1, 3 or 5. Regarding the onset of instability, there are also significant differences, not only between the models but also between the cases with one or more moving masses or oscillators. For one-layer model, which is in fact the model of an infinite beam on the classical Winkler-Pasternak foundation, instability of one moving mass has regular behavior and occurs always in the supercritical velocity range when damping is present and at the critical velocity in case of no damping. Two moving proximate masses already introduce severe alterations, because in damped case the dynamic interaction can shift the onset of instability deeply into the subcritical velocity range [2]. The other models introduce other irregularities, even for one moving mass [3]. This contribution will summarize all the differences and common features that exist between these models and within the full range of possible parameter combinations.

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