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TRANSITION RADIATION IN HIGH-SPEED LINES APPLICATIONS

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ABSTRACT

The constant growth of high-speed lines and the rapid evolution of train vehicles gave raise to a number of specific related problems and have motivated a significant amount of scientific work. This paper deals with excessive ground and track vibrations induced by high-speed trains when moving from a region to another with a very different vertical stiffness of the system track-foundation. These vibrations degrade rolling equipment and track and raise questions related to the vehicle stability and passengers comfort. Vertical stiffness change can be caused by sudden change of geotechnical foundations and/or structural solution, [1].

First insight into a problem of induced vibrations can be acquired from simplified models that permit estimates of the response to a moving load travelling over a supporting structure. When the supporting structure changes, additional vibrations, called transition radiation are generated. In this paper analytical transient solutions of the dynamic response of one-dimensional systems of finite length with sudden changes of foundation stiffness and subjected to loads moving with constant velocity are presented. Load mass is directly included in discrete way according to the actual position of the vehicle. No restrictions on load velocity and material or mass damping are imposed. Also number of foundation stiffness discontinuities is arbitrary. Finite beams are considered, however last supports are adapted in order to eliminate reflecting waves. Methods of global modes of vibration superposition and integral transformations are used in the way similar to [2]. Displacement method for frame structures in dynamics is used to join parts with distinct foundation stiffness [3]. Results are expressed in terms of vertical displacement. Procedures are programmed in Matlab and Maple. Obtained results are used (i) to study influence of the abrupt change on critical velocities in a parametric way and (ii) to perform optimization of vertical stiffness parameters to mitigate the transition radiation.

In order to compare the results presented in [4] and for the sake of good visualization of induced vibrations and transition radiation, high test force of 1MN and unrealistically weak foundation is implemented, $k_1=427\text{kN/m}^2$ is introduced in the soft region and $k_2=854\text{kN/m}^2$ in the strong one. The beam models two standard rails UIC60. Results for

one force moving over one foundation stiffness jump is presented in the figure below.

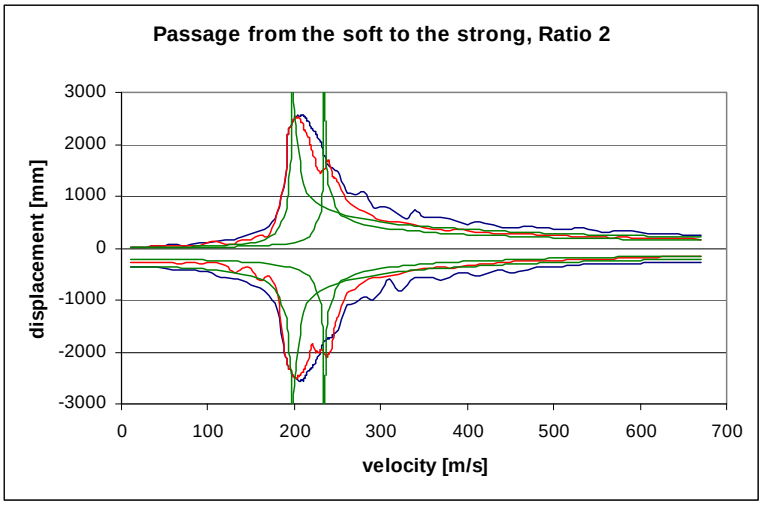

Figure 1: Maximum downward and upward displacements with respect to velocity for force passage from the soft to the strong region of ratio 2, maxima in the soft part (blue curves), maxima in the strong part (red curves) and maxima from steady-state solutions on homogeneous foundation (green curves).

It was concluded, that the there are two factors adversely affecting the response: (i) the stronger region exhibit both critical velocities in passage from softer to stronger region, which implies that the strong region of critical velocity 235.0m/s also gained critical velocity of 197.6m/s; (ii) it is clearly seen that maximum displacements are highly amplified as compared to the homogeneous situation, which, in the upward direction, has negative influence on vehicle stability and, in the downward direction augments foundation soils settlement and may induce track irregularities.

Further, optimization of vertical stiffness parameters is performed to mitigate the adverse effects. Optimal stiffness distribution to a given set of loads is obtained by generic probabilistic meta-algorithm, simulated annealing. Cost functional involves minimization of maximum downward as well as upward displacements. Dependence of the global optimum on several combinations of leading parameters of the simulated annealing procedure, like neighbourhood definition and annealing schedule, is also studied and analyzed. Results and conclusions have direct application on knowledge of ground vibrations induced by high-speed trains.

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