Transition radiation in an infinite beam supported by a locally inhomogeneous and non-linear Winkler foundation

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Transition radiation is emitted when a source moves along a straight line with constant velocity and acts on or near an inhomogeneous medium [1,2]. Transition radiation occurs, for example, when a train crosses an inhomogeneity in the railway track, such as a transition in foundation stiffness. As the velocity of the trains becomes closer to the wave velocity in the subsoil, wave radiation is amplified and may cause plastic deformation in the transition zone.

Studies of transition radiation in finite one-dimensional systems with non-linear foundation behaviour are available in the literature. However, studies that properly account for the infinite extent of the system are not. To this end, the system composed of an infinite beam resting on a locally inhomogeneous and non-linear Winkler foundation, and subjected to a constant moving load is analysed in this paper.

The Winkler foundation is assumed to be piecewise linear, and the system thus behaves linearly between non-linear events. Therefore, the solution can be obtained using a mixed time-frequency method [3]. The use of the Finite Difference Method for the spatial discretization combined with derived non-reflective boundary conditions enables us to simulate the behaviour of an infinite system; the computational domain covers the area with the transition in foundation stiffness. To study the features of the generated wave field in pure form, the load velocity is taken sub-critical, excluding other radiation effects.

Results show that the plastic deformation in the transition zone is a consequence of constructive interference of the excited free waves and the so-called eigenfield that moves with the load. Increasing the load velocity, decreasing the transition length (i.e., smoothness) and/or increasing the foundation stiffness dissimilarity leads to amplified free wave excitation, and consequently to stronger constructive interference and larger plastic deformation. The model and solution method presented in this paper can be used for preliminary design of transition zones in railway tracks. Given the stiffness jump that has to be bridged and the maximum train velocity, the optimum length of the transition zone can be obtained such that minimum damage results in the railway track.

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