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Prediction of Environmental Vibrations due to Moving Train Loads by a Direct Time FEM-BEM Methodology

D.C. Rizos[1,2], J. O'Brien[2] and E. Leon[3]

Summary

This work presents an efficient methodology for the analysis of vibrations in a railroad track system, induced by the passage of conventional and high speed trains. To this end the Boundary Element Method is used to model the soil-tie system within the framework of impulse response techniques [1]. Conventional Finite Element Methods along with Newmark's integration is used for the modeling of the rail system. The two methods are coupled at the tie-rail interface and the solution is obtained following a staggered, time marching scheme in an efficient manner [2]. The methodology accounts for Soil Structure Interaction and traveling wave effects.

The proposed method is implemented in two major steps. The first step of the analysis uses the BEM to calculate the B Spline impulse response functions of the soil-tie system, as shown in Figure 1. This task is performed only once for a given tie geometry and arrangement. The derivation of the B Spline impulse response matrix of a large soil-tie system can be greatly simplified by observing that: (i) a relatively small number of ties contribute significantly to the response of the system, (ii) cross interaction effects between ties is significant only for a few adjacent ties, (iii) the B Spline impulse response of the system due to a load applied at an arbitrary tie can be represented by appropriately shifting in space the B Spline impulse response due to a load applied at a reference tie. The second step engages a conventional direct time domain FEM for the simulation of the rail system and couples it to the proposed BEM solver that performs a superposition of impulse responses. The proposed methodology allows for selection of different time steps in order to fulfill stability requirements of each solver.

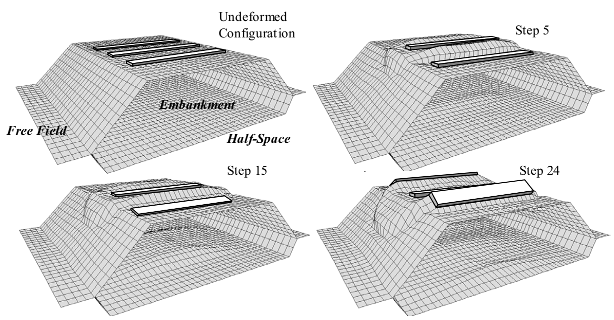

Figure 1: Deformed configurations of BIRF of ground-tie system at selected times

[1]Corresponding Author, email: rizos@engr.sc.edu, voice +1 (803) 777-6166, fax +1 (803) 777-0670

[2]Dept. of Civil and Environmental Engineering, 300 Main, University of South Carolina, Columbia, SC 29208, USA

[3]The Geomech Group Inc., Columbia SC 29205 USA

Application of the method to study vibrations induced by high speed trains has shown, among others, that: (i) Dynamic cross interaction effects between adjacent ties need only be considered between immediate adjacent ties regardless of train speed; (ii) The number of ties that contribute significantly to the system response depends on the train speed and (iii) the relative stiffness of the soil with respect to the rail affects the distribution of the wheel load on the ties.

References

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