# Application of Numerical Methods for Analysis of Propagation of Vibrations generated by Moving Load

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Summary: Two numerical methods are presented to analyze dynamic response of the free field nearby railway lines induced by the specific moving loads acting on the surface of a layered and homogeneous halfspace with different material properties. A three dimensional (3D) modelling approaches are performed by Thin Layer Method / Flexible Volume Method (TLM / FVM) and by Boundary Element Method (BEM). An extensive numerical investigations have been carried out on the influence of different parameters on the effectiveness of open trench barriers at the ground surface in reducing adverse effects of high frequency vibrations.

## 1. Introduction

The ground vibrations as they are caused by the passage of a high-speed train or giant lorries are an environmental concern, as waves propagate through the soil and interact with neighborhood buildings, where they may cause malfunctioning of sensitive equipment and discomfort to people and even damage to nearby buildings or secondary structures. The rapid extension of the high speed rail network throughout Europe has initiated a lot of research on prediction models for train induced vibrations. This study leads to the response of the structure to the ground excitations and the ground response to a specific moving load on the soil surface. The reduction of the structural response is achieved by reducing the ground vibrations using a trench and a wave-impeding barrier. Analytical and numerical models using the finite and boundary element method are under development to predict wave propagation and dynamic soil-structure interaction (SSI) due to the passage of a train. Track stability and vibrations generated at trans-Rayleigh train speeds for trains running on soft soils are subjects of particular interest [VER97].

## 2. Scope of this Study and Analysis Procedure

Elastic wave propagation and dynamic soil-structure interaction due to moving loads on rigid and ballast track supported by different soil stratification (homogoneous linear-elastic half space with soft and stiff soil layer-soil layer over bedrock) will be invistigated using two different three-dimensional numerical approaches. The first model is based on the Thin Layer Method / Flexible Volume Method and the analysis is performed in the frequency domain. The second model is based on the Boundary Element Method and the analysis is also carried out in the frequency domain. The movement of the load is simulated by means of Fast Fourier Transform. The results of both approaches will be compared with the analytical solution for a steadily moving point load [BAR96]. For the computational effort of this considered problem, the computer program SASSI [LYS88] based on the theory of the Thin Layer Method and SSI3D [SCH88] based on Boundary Element Method will be used. For carrying out a parametric study, the key parameters controlling the dynamic superstructural response including the effects of soil interaction will be used as different sets of material properties (Rayleigh wave velocities & shear wave velocities, mass density, Poisson ratio) for the rigid track and the soil. The influence of different velocities of a moving load on the displacements will be compared for two cases. The geometry and the discretization size for the numerical models are also important parameters for this research. The effectiveness of measure on reduction of the ground vibration and the structural response is also investigated.

## 3. Numerical Results

The 3D response of an elastic half-space under a vertical line load is obtained by a Thin Layer & Flexible Volume Method and compared by analytical solution (Figure 1). The amplitude of moving source is 1 kN and the total length of load path is 21m. The constant velocity of the source are 90 km/h, 180 km/h, 360 km/h and 540 km/h, respectively. Taking advantage of symmetry, only a half of the model is discretized. Due to symmetry of the model, the load is applied on the upper node of the intersection line of symmetry plane. The half-space is idealized with four horizontal semi-infinite layers with the same thickness ($4\times h_i$=0.3m), laying on ten additional layers with thicknesses varying with frequency. The soil density is 1700 kg/m$^3$ and the propagation velocity of shear waves is taken as 110 m/s. The observation locations where are perpendicular to the load path are chosen as distance of 2m, 4m and 8m, respectively. The use of boundary elements takes into account the wave propagation to infinity in the half-space. As the area of the discretization and dimension of the element play an important role in the boundary element method when the domain extends to infinity and full-space fundamental solution is used [DOM93].

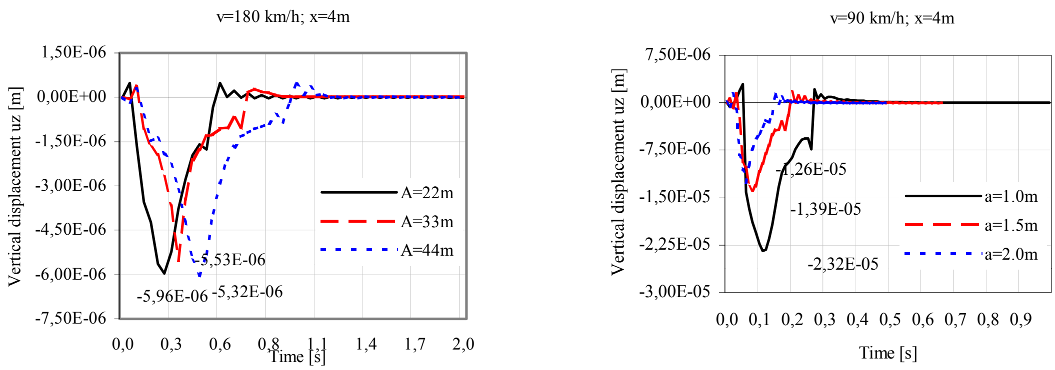


Figure 1 Influence of the discretization area of the surface and size of the element on vertical displacement for homogeneous half-space (BEM)

**4. Conclusions**

Both numerical approaches are presented to model a moving load on a surface on elastic half- space and on a rigid track on a half-space. Good agreement is obtained in comparison with an analytical solution. Displacement amplitudes increase for softer soil but also for a velocity approaching the critical velocity of the system. The results show that a wave barrier is very effective to reduce ground soil vibration in the vertical direction as well as the horizontal direction which is parallel to the load path. However, it would substantially amplify the soil vibration in the perpendicular direction to the load path.

**5. References**


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