Stochastic heterogeneous continuum modeling of a granular medium. Application to large-scale wave propagation in a ballasted railway track.

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ABSTRACT

We consider in this work the dynamical modeling of ballasted railway track. The dynamical loads caused by the passage of high-speed trains accelerate track deterioration and damage neighbor buildings [1]. Two classes of numerical models are used to (try to) predict the behavior of these dynamical systems: (1) discrete approaches, in which each grain of the ballast is represented by a rigid body and interacts with its neighbors through nonlinear contact forces (with non-smooth contact dynamics and software LMGC90 [2]); and (2) continuum approaches, in which the ballast is replaced by a homogenized continuum and the classical Finite Element Method (FEM, or similar) is used. On the one hand, discrete approaches are today capable of solving a few meters-length of ballast, and the coupling with the underlying layers of soil remains an open problem. On the other hand, homogenized approaches are not capable of representing the heterogeneity of the strains and stresses within the ballast. We investigate in this work an alternative approach using a heterogeneous continuum model, that can be solved with a FE-like method while retaining some degree of heterogeneity. The present work is divided into two parts: (1) the statistical identification of the parameters of the continuum material; (2) large-scale wave propagation in a ballasted railway track. The first part identifies the parameters of our continuum model (average, correlation length, and variance of a random field of Young's parameter) on small cylindrical samples of discrete ballast (solved using LMGC90), with confinement pressure, gravity and a top pressure. The second part of the presentation concentrates on the solution of the dynamical equations on a large model of a ballasted railway track with the Spectral Element Method [3]. The generation of the elastic linear heterogeneous material was made using the stochastic spectral representation. Different trains velocities are analyzed, in subsonic and supersonic regime.

REFERENCES

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