Master of Science Project

Faculty of Civil Engineering and Geosciences — Section Structural Mechanics

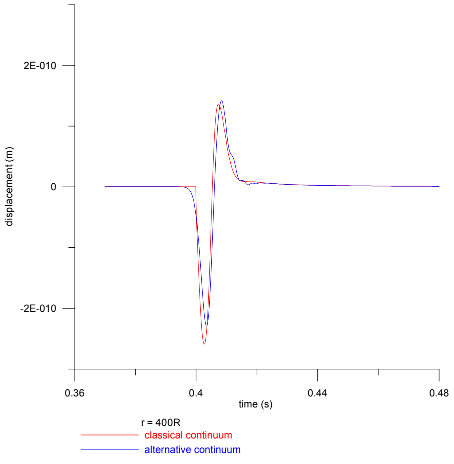
Wave Propagation in heterogeneous materials

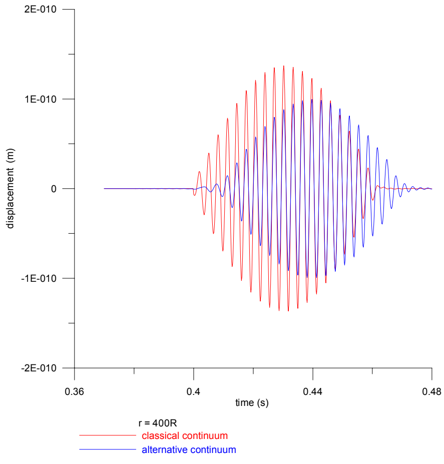
Derivation of a dynamically consistent gradient elasticity model, which takes into account concrete's mesostructure

Elastic waves can be used to determine material properties experimentally. Known examples are the localization of small cracks in steel bridges and the determination of the Young's modulus of concrete. The used models correspond well with the experimental results. In these cases, the materials can be considered as homogeneous. Elastic waves can also be used to uncover the internal structure of heterogeneous materials. The waves propagating through such materials are being scattered by its components and convey detailed information about the material. However, it is very difficult to make use of this information, especially if one wants to know about the material components of a relatively small size.
In this project, wave propagation through concrete is described, taking into account the concrete's meso-structure. On that scale, concrete is considered as a two-phase material, composed of a cement matrix and coarse aggregates. To gather information on the components, it is necessary to use short waves with wavelengths comparable to the size of the components. These short (high frequency) waves are very sensitive to the material internal structure and, therefore, are dispersive, which means that their velocity varies with the frequency.
To describe the dispersive behaviour of concrete, a new model has been developed. The following requirements for such a model are defined:

- A correspondence with the classical mechanical model in the low-frequency bound;
- A direct link with the meso-structure of concrete;
- No anomalies at any frequency in the dynamic behaviour;
- A realistic description of wave dispersion, which is characteristic for heterogeneous materials.

A continuous model is derived by continualization of a discrete lattice, which represents the meso-structure of concrete. A commonly used method in literature and a recently developed continualization method are applied. The response to a pulse-loading situation is compared for these models and the classical mechanical continuum model.





Results for a low-frequency (left) and a high-frequency (right)-spectrum.

In the presentation, the derivation of the models is given, the results to a pulse-loading situation are shown and the main conclusions are drawn. Also, recommendations for further theoretical and experimental research are given.

Pieter Timmerman

Woensdag 28 Mei, 16.30 uur
Civiele Techniek zaal F

Graduation Committee:
Prof. ir. A.C.W.M. Vrouwenvelder
Prof. dr. ir. K. van Breugel
Dr. Sc. A.V. Metrikine
Dr. ir. H. Askes
Ir. J.M.J. Spijkers