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DEM-BEM Coupling in Time Domain

Andre Pereira[*], Jerzy Rojek[†], Guilherme Barros[*] and Gernot Beer[‡]

[*] Engineering School and Laboratory for Computational Simulations (LSC)
Universidade Federal Fluminense
Campus da Praia Vermelha, 24210-240 Niteroi, Brazil
e-mail: andremaues@id.uff.br, web page: http://www.lsc.uff.br

[†] Institute of Fundamental Technological Research, Polish Academy of Sciences
Pawinskiego 5B, 02-106 Warsaw, Poland
email: jrojek@ippt.pan.pl, web page: http://www.ippt.pan.pl

[‡] Centre for Geotechnical and Materials Modelling
The University of Newcastle, , Australia
and Institute for Structural Analysis, Graz University of Technology, Austria
email: gernot.beer@tugraz.at

ABSTRACT

In this work, a coupling strategy to combine the discrete element method (DEM) and the boundary element method (BEM) in time domain is proposed. This allows us to simulate transient problems considering both discontinuous and continuous media, respectively. Discontinuous behaviour of materials cannot be adequately modelled by continuum-based models, i.e. by the BEM or the finite element method (FEM), whereas the DEM can naturally represent discontinuous behaviour [1]. The DEM, similarly as the FEM, has serious limitations in handling infinite domains. On the other hand, the BEM is well known as a powerful procedure for modelling wave propagation in unbounded domains since the radiation condition at infinity is satisfied automatically by the fundamental solution [2]. The DEM-BEM coupling is an efficient methodology to solve dynamic problems involving infinite domains with localized discontinuous behaviour. The zone where discontinuity exists is modelled with the DEM and the rest of the domain is represented with the BEM.

The coupling algorithm employs a staggered solution scheme. The DEM time integration scheme has been modified in order to obtain strong coupling on the DEM-BEM interface. The coupled solution scheme has been verified on a simple benchmark problem of wave propagation in a rod. The bar subjected to axial pulse loading was divided into two regions modelled respectively with the DEM and BEM. Compatibility and equilibrium on the interface between the methods was guaranteed, placing the center of the DEM particles coinciding with nodes of BEM and ensuring that the masses of these particles and forces are equal.

Numerical tests have been performed to investigate stability, accuracy and efficiency of the coupling procedure. The stability of the DEM solution requires the use of small time steps, while the BEM solved in time domain requires sufficiently large time steps. Numerical studies have shown that there exists an overlap of time steps required by the two methods which makes the coupled solution feasible. The BEM-DEM interface may cause spurious wave reflections. Numerical tests have shown small wave reflections, which, however, have not affected the consistency of the results.

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