Coupling FEM and DEM Method applied to 3D and Shells

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Abstract.

The general framework of that study deals with prediction of reinforced concrete structure response under severe local dynamic load such as an impact due to an aircraft, a missile or a near-field explosion. A reliable and efficient design of structures under such a loading needs to take into account local discontinuities due to impact as well as the global response of structure that may have an elastic response far from impacted area.

Generally speaking, these severe loadings lead to fractures and fragmentation localized in one part of the concrete structure. The Discrete Element Method (DEM) (Cundall and Strack [1]) is appropriate for modeling such discontinuities and very well adapted to dynamic problems. This method does not rely on any assumption regarding where and how a crack or several cracks occur and propagate since the medium is naturally discontinuous. Nevertheless, computation time increases with the number of Discrete Elements, and the analysis of large structures with DEM seems difficult. The use of the Finite Element Method (FEM) far away from the impacted area represents one way to minimize this constraint since in most cases, severe degradation phenomena are localized right in the vicinity of the impact. In addition, the Finite Element Method is widely used, and an efficient mesh generation software can dramatically reduce modeling duration, with the potential for faster calculations than when applying a full Discrete Element approach thanks to the facility of handling various discretization sizes.

These facts naturally lead to proposing a coupled Finite Element/Discrete Element approach. Locally, the discrete element method (DEM) is used to analyze discontinuous phenomena such as failures, fragmentation and compaction. The finite element method (FEM) is applied on the remaining structure to reduce both times of computation and modelling. With this coupled method, different structural responses may be predicted such as the missile penetration, damage of the structure and global displacement or first natural frequencies.

Both methods use the explicit central differencing scheme to solve the equation of motion. The coupling use of a bridging domain (Xiao and Belytchko [2]) where the coupling relations are introduced by means of Lagrange multipliers. A temporal relaxation method is used to reduce the spurious reflection due to the discontinuity of the size discretisation between the two approaches (Frangin *et al* [3]).

The method has been developed to couple DE with 3D FE, however it is now possible with Shells. The shell element used is a 4 nodes element based on Reissner/Mindlin model (Reissner [4]). The main idea of this new approach is to define fictive nodes in order to build a fictive 3D finite element. With this fictive nodes, the previously

described method is used. Results of some elastic and static tests tend to validate the model although dynamic tests must be carried out.

References:

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