

Identification of constitutive behavior parameters for a discrete element model of reinforced concrete

J. Rousseau¹, P. Marin¹, L. Daudeville¹ and S. Potapov²

¹Laboratory 3S-R (Soils, Solids, Structures – Risks), DU BP53, 38041 Grenoble Cedex 9, France

²LaMSID UMR EDF/CNRS, 1 av. du Général de Gaulle 92141 Clamart, France

Abstract.

In our time, where reinforced concrete is widely used in all sort of buildings, a large panel of stresses can be imagined. Under severe loadings due to natural or anthropogenic hazards such as rock falls, aircraft or missile impacts, consequences can be disastrous. Then, it is very important to be able to anticipate the structure behavior under such impacts in order to strengthen the building where it's needed.

Generally, these severe loadings lead to fractures and fragmentations in a part of the concrete structure. To model concrete fragmentation remain uneasy with continuous methods such as finite element. Cracks can't propagate anywhere; paths depend on the main directions of the mesh. To avoid this mesh dependency, we use a discrete element method which naturally describe discontinuities.

The main topic of this paper is a description of the discrete element method used to model reinforced concrete and more particularly how to choose local parameters for concrete. The last part deals with a definition of a steel-concrete interface.

The Discrete Element Method (based on the distinct element model Cundall & Strack [1]) uses spherical rigid elements linked each other with cohesive or contact laws. The element size is variable and the assembly is disordered to represent concrete heterogeneity. To model the nonlinear behavior of the material, a modified Mohr-Coulomb model with softening has been adopted.

Local model parameters are calibrated so as to reproduce macroscopic concrete behavior. This process is nearly the same as that described in Hentz *et al.* [2], and the proposed modifications have simplified the process and improved the reproducibility and accuracy of the macroscopic characteristics obtained. These improvements have also provided a reliable and fast calibration method for parameters of large structures.

A simple and effective process is now available and has been validated to identify local parameters, with quasi-static compression and tensile tests. The reproducibility of results indicates that shape or size of the sample used to identify parameters exerts no influence. The identification for a large sample could thus be performed on a smaller sample extracted from the larger one. In addition, the computation time for model identification is reduced.

To be competitive, every composite material must have a high-quality interface between each material. Reinforced concrete isn't an exception to the rule and mechanical properties of the steel-concrete interface must be studied with attention.

Thus, a lot of searches have been leading on the study of steel-concrete interface (Soh *et al* [3], Cox *et al* [4], Kilic *et al* [5]) and its modeling.

However, the modeling of the steel-concrete interface by discrete elements means the definition of a particular link between a steel element and a concrete element. A

reinforcement bar creates a privileged direction for rupture. Therefore, the new interaction law must take in account the orientation of the steel reinforcement.

Frequently, the experimental reference is the pull-out test. A steel reinforcement settled in concrete and pull out. This test permits to study the steel-concrete behavior and its characteristic parameters. Pull-out tests have been realized to validate this new interaction and compared with experimental ones. Experimental tests are correctly reproduced and complementary tests with various embedding length seem to describe a quite reliable behaviour.

In conclusion, the discrete element model, as defined here, is able to represent reinforced concrete in a reliable way. Thanks to a correct identification of the local parameters, the behaviour of concrete can be correctly reproduced. The concrete model is reliable and reproducible independently of the size or geometry of the sample or the size of the elements. A particular connection between steel and concrete is developed. It makes it possible to model pull-out tests in a relevant way.

References:

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E-mail address: jessica.rousseau@hmg.inpg.fr

Tel.: +33-4-76 82 51 46, fax: +33-4-76 82 70 43