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MATERIAL MODELLING FOR CONCRETE PLATE SUBJECTED TO BLAST LOAD

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ABSTRACT

The growing threat of terrorist attacks, industrial accidents and breakdowns have to be taken into consideration in the design process, especially for the structures of special meaning, localized in areas where above mentioned threats are expected (Meyer [1]). The possible consequences of such a load include large deformations, extensive plastic flow, cracking, spalling, various mechanisms of failure and impacts between parts of the loaded structure.

The elasto-plastic material model with damage for concrete has been implemented in this study and validated through the numerical simulation of the dynamic response of the concrete plate loaded by a far-field explosion (Agardh [2]). The main goal of the choice of material model was to obtain the relatively simple algorithm, reliable and easy to implement into commercial finite element computer code. The model has its own point of departure on the continuum damage mechanics, based on the thermodynamics of irreversible processes (Lemaitre [3]).

Nonlinear mechanisms of degradation of concrete under tensile or compressive loading conditions are characterized by two independent scalar internal damage variables. This option deals with tensile and compressive concrete behaviour in a unified fashion, where the same material model is adopted for any load combinations. Rate dependency, which is a very important factor in analysis of blast loaded structures, has been accounted for as an almost natural extension to the plastic-damage model, introducing a viscous regularization of the evolution laws for the damage variables (Faria and Oliver [4]).

The detailed description of the material model, its implementation into ABAQUS/Explicit computer code, and the procedures of numerical verification were published in the monograph [5].

In order to verify the implemented material model for concrete the well circumscribed experimental tests performed by Agardh [2] were simulated numerically. In the tests four series of three fiber reinforced concrete square plates (1.2 x 1.2 m) with steel bars reinforcement were subjected to various amount of blast loading in a shock tube. Due to the biaxial symmetry, in the numerical model only 1/4 of the plate was modeled (Fig. 1), with adequate boundary conditions.

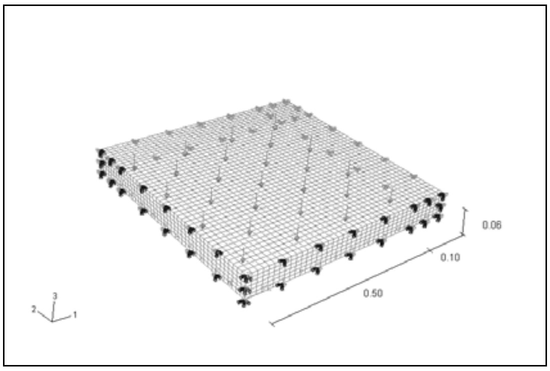

Fig. 1. Finite element model of the plate

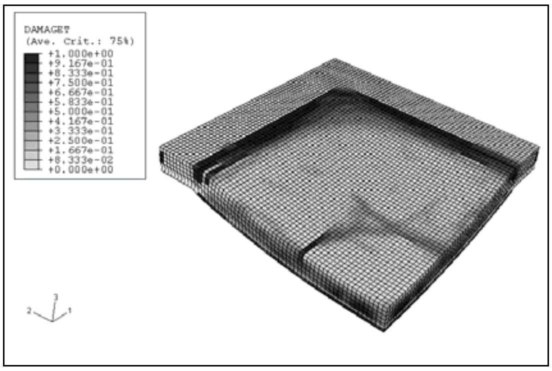

Fig. 2. Distribution of scalar damage parameter for compression

The whole set of test configurations was simulated, i.e. from load produced by an explosion of a small amount of explosive (no damages) until the extremal loads (large amount of explosive) resulting in heavy damages. Figure 2 presents an example of final distribution of scalar damage parameter for compression (load 2.0 kg PETN, the resulting peak pressure 0.77 MPa, impulse duration 70 ms). Figure 3 shows the deflection of the plate center in time, compared with numerical simulation of the experimental cases.

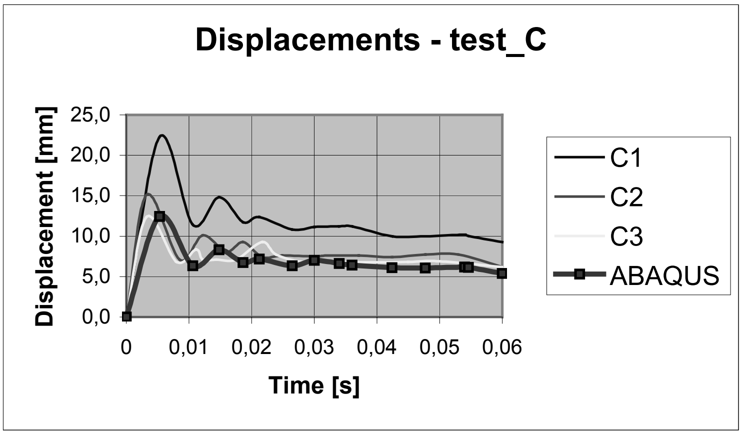

Fig. 3. Displacement of the plate center. Experimental data and numerical results

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