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DAMAGE AND FRACTURE OF CONCRETE AND BRICK WALLS AFTER EXPLOSION

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ABSTRACT

The paper deals with the application of numerical methods to describe the fracture in brittle materials loaded by explosion. The term of explosion means a rapid release of the energy followed by pressure wave propagation. The mutual interactions of the air and obstacles (brick or concrete walls) at the interface determine the structure response, its damage evolution and fracture. The crack evolution and failure of materials are obtained for two materials and the models used are three dimensional.
The loading history induced by TNT blast is subjected to the surface of brick and the concrete structures by submodeling technique. It is the efficient way to study the local part of a model with more refined mesh based on interpolation of solution obtained from global model with relatively coarse mesh. In models the global mesh should be quite dense to obtain the proper results of stress waves in the surrounded air. The numerical technique is useful for more accurate solutions in the local region but only in the cases when the local regions have negligible influence on the global solution. In the cases under analyses these assumptions are met. The explosive material and the air together with deformable wall structures are the parts of the global model. For numerical efficiency the computations were divided into two parts. The first ends with the distribution of pressure at the walls' surfaces while the second deals with the criteria of fracture and describes the failure of the walls. For the concrete the cumulative fracture criterion (CFC) also studied by the authors is used. The CFC in integral has the form as follows:

$$t_{c0} = \int_0^{t_c} \left(\frac{\sigma_F^{eq}(t)}{\sigma_{F0}^{eq}} \right)^{\alpha(T)} dt \qquad \text{for} \qquad \sigma_F^{eq}(t) > \sigma_{F0}^{eq},$$

where t_{c0} is the longest critical time, $a(T)$ is parameter for constant temperature connected with energy activated during separation process and σ_{F0}^{eq} is quasi-static equivalent tensile strength of concrete. The influence of strain rates on the concrete tensile strength is reflected with the accuracy as in Fig. 1. The example of failure pattern in concrete wall loaded by explosion of 100kg of TNT in 1 m distance from the rear surface is presented in Fig. 2.

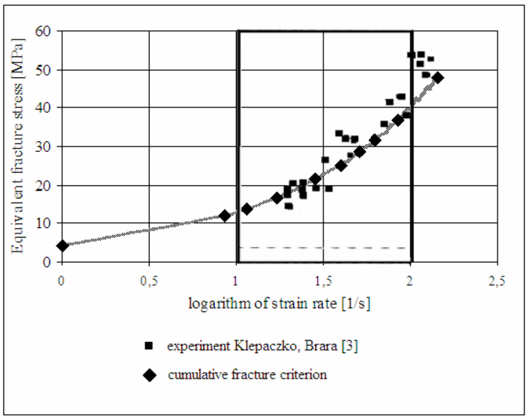

Figure 1. Influence of strain rates on tensile strength of concrete

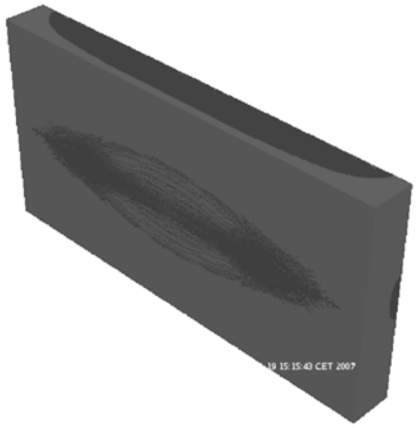

Figure 2. Failure pattern of the concrete plate

In the case of masonry structures the crucial attention is focused on assessing the global failure of the structure by disintegration of the masonry elements. That means the destroying of a continuous bond between brick and mortar phases. Assessment of this mechanism enables to estimate the damage of the structure. Two different types of brittle materials are discussed. The authors introduced the proposed discrete model into the Abaqus environment and showed the motion of separate bricks under the blast wave. The global one-layer wall stability is presented as an outcome.

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