DISCRETE ELEMENT MODELING OF IMPACT ON A CONCRETE SLAB

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To design concrete structures to protect against severe impacts, models with high predicting abilities are required. Prediction models deal with four major quantities which measure the local impact effects on a concrete structure: the penetration depth, the scabbing limit, the perforation limit and the ballistic limit. Many available protective design guidelines recommend the use of empirical approaches for the assessment of penetration, scabbing and perforation [1]. The available empirical formulae were mainly developed by data-fitting of test results. These formulae generally provide reliable and straightforward tools to design protective concrete structures. However, some of them are dimensionally non homogenous, and thus, unit dependent, which provide little physical meaning of the local impact event. In addition, the application range of the formulae depends on the performed tests. Theoretical and analytical approaches, such as numerical studies can be conducted to overcome the shortcomings of these empirical formulae to get a better understanding of the problem.

The Discrete Element Method (DEM) [2], which is an alternative numerical method to continuum-type methods, is used to study the behavior of concrete structures submitted to rigid impacts. Nevertheless, when one uses a DEM model, one has to address the issue of the modeling scale: the DEM is well adapted to the modeling of granular material, where an element represents one grain. Another way to use the DEM consists in using a higher scale model, which considers that the whole assembly of elements must reproduce the macroscopic behavior of concrete [3].

In this work, the CEA-EDF impact tests were studied [4] and simulated at the structure level. These tests on a reinforced concrete slab at a real scale were done at different impact velocities. The results were compared with experimental results: quantitatively, both numerical and experimental results are coherent. Moreover, using parametric studies, the numerical models have given interesting insights on the role of the reinforcement during the perforation process in a better way than the classical predictive empirical formulations. The numerical simulation results have shown that the reinforcement ratio has little influence on the penetration depth since the impact velocity is far from the ballistic limit at which the target is perforated. However, the reinforcement ratio has a strong influence on the missile residual velocity and on damage in concrete in case of perforation.

References

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