THE ROLE OF THE SUCTION PHASE IN THE VULNERABILITY OF STRUCTURES TO LARGE SCALE EXPLOSIONS

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ABSTRACT

The common practice of protective structures design to withstand blast waves is based on the loading created by the positive phase of the blast, while ignoring the negative (suction) phase. (see, e.g., the ammunition magazine standards 6055.9STD [1], 4145.26-M [2] and DDESB software BEC [3]). This approach is usually justified since the loading of the suction amounts to a fraction of a bar, whereas the positive phase loading can be much higher, depending on the explosion parameters. The purpose of the present study is to draw attention to the importance of the suction phase loading in the case of large scale explosions, which are characterized by a long duration pulse. As an example, an analysis of the response of an ammunition magazine to an accidental explosion in a neighboring magazine within an ammunition center is presented. The analysis comprises two separate approaches. The first approach is based on classical protective structures practice for reinforced concrete elements, taking into account the dynamic character of the load using single degree of freedom (SDOF) codes. In the second approach, a full 3D hydro-code is employed, which allows to model the structural details of a typical magazine having an earth cover and access openings. The blast wave was calculated for a typical capacity of the donor magazine, several tens of tons of TNT equivalent, taking into account the full interaction with the structure. Both approaches demonstrate that the roof of the magazine is more vulnerable to the suction load than to the positive load. Specifically, it was found that the roof was prone to be damaged due to a dangerous level of an upward motion, while the other parts of the magazine responded safely. This result could be related to the particular design of the magazine, which was considered in this study. However, in contrast with the guidelines of the classical manuals, it is recommended that the suction loading should receive more attention in the design of protective structures.