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Explosion Mechanics of Aluminum Plates Subjected to the Combined Effect of Blast Wave and Fragment Impact Loading: A Multicase Computational Modeling Study

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Abstract : For many decades, researchers have been focused on understanding the dynamic behavior of different structures and materials subjected to fragment impact or blast loads separately. The explosion mechanics, as well as the impact physics studies dealing with the numerical modeling of the response of protective structures under the synergistic effect of a blast wave and the impact of fragments, are quite limited in the literature. This article numerically evaluates the nonlinear dynamic behavior and damage mechanisms of Aluminum plates EN AW-1050A- H24 under different combined loading scenarios varied by the sequence of the applied loads using the commercial software LS-DYNA. For one hand, with respect to the terminal ballistic field investigations, a Lagrangian (LAG) formulation is used to evaluate the different failure modes of the target material in case of a fragment impact. On the other hand, with respect to the blast field analysis, an Arbitrary Lagrangian-Eulerian (ALE) formulation is considered to study the fluid-structure interaction (FSI) of the shock wave and the plate in case of a blast loading. Four different loading scenarios are considered: (1) only blast loading, (2) only fragment impact, (3) blast loading followed by a fragment impact and (4) a fragment impact followed by blast loading. From the numerical results, it was observed that when the impact load is applied to the plate prior to the blast load, it suffers more severe damage due to the hole enlargement phenomenon and the effects of crack propagation on the circumference of the damaged zone. Moreover, it was found that the hole from the fragment impact loading was enlarged to about three times in diameter as compared to the diameter of the projectile. The validation of the proposed computational model is based in part on previous experimental data obtained by the authors and in the other part on experimental data obtained from the literature. A good correspondence between the numerical and experimental results is found.

Keywords : computational analysis, combined loading, explosion mechanics, hole enlargement phenomenon, impact physics, synergistic effect, terminal ballistic
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