Local blast wave effects in interaction with structural elements

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Abstract

Nowadays, one can see that the risk of terrorist attacks is at high level. Bombing attacks are the most common of terrorist activities and its number is still growing. The problem of blast wave interaction with structure and its destructive effect was already presented in many papers. The numerical studies of such problems seems to be the most popular and common approach to assess structure response. Two main types of methods of blast loading numerical simulation can be distinguished: one family with the application of pressure loading and the other with a description of detonation, blast wave propagation in fluid domain and fluid structure interaction using Computational Fluid Dynamic methods (CFD) or Multi Material Arbitrary Lagrangian Eulerian formulation (MM-ALE). Thanks to the second approach the very effective and accurate studies are possible to be performed.

The main motivation of the proposed paper is to present and prove that the proposed advanced coupled analysis provides the new possibilities in analysis and studies of local deformation caused by interaction with blast wave. Such studies were performed for two different structures made of materials characterized with dramatically different stiffness, e.g. hyperplastic and steel. Additionally, the evaluation of blast influence on the structure integrity was carried out by comparing the results derived from cases with different explosive mass, location of initiation point and shape. It was proved that not only the mass of detonated charge has influence on structure behavior, but also its shape as well as the initiation point of detonation, which can significantly change the extent of structure damage. Initiation at the back of explosives heavily increased average pressure during interaction with structure and cylindrical shape of a charge also increased the energy adopted by structural element. Additionally, it was shown that the blast wave pressure distribution on the structure surface is different and the highest values occur in the nearest distance of a charge. During investigations it was also observed that the pressure value of reflected wave is several times higher than the front wave (incident) pressure, which confirms the theoretical assumptions. Such analysis was possible to the fact that very detailed discrete models of tested structural elements were developed and validated. The mechanical properties of tested elements were assessed within various strain rates: from quasi-static conditions to strongly dynamic ones. The obtained results showed good accuracy in terms of erosion characteristics in FE models by comparison with actual structure response.

Keywords: Blast modeling, Local effects, ALE, Coupled Analysis, Simulation,