

Numerical Simulation of Free-Air Explosion using LS-DYNA

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Abstract. The development of advanced computational technologies in recent years has seen studies of the effects of explosions on large structures becoming feasible and, as a consequence, the number of destructive tests and their high cost can be reduced significantly. This paper presents a study of air-burst explosion wave propagation using computational modelling based on LS-DYNA. Incident and reflected pressure waves are investigated, as well as the mesh sensitivity, different scaled distances and the charge shape. The Multi-Material Arbitrary Lagrangian-Eulerian (MM-ALE) representation is used to model the blast, and the results are validated by empirical methods. The effects of parameter values adopted in these methods are studied. The results show that LS-DYNA can effectively simulate an air-burst explosion. Additionally, the mesh size and explosive weight have a large influence on the peak incident and reflected pressures. It is observed that there is an optimum range of the mesh size in relation to the explosive weight, material properties and the scaled distance which can significantly reduce the CPU usage while having reasonable accuracy. Different charge shapes cause different pressure distributions over the air domain.

Introduction

Currently, there is a significant interest in the area of air-blast explosions amongst computational mechanics researchers. The explosive effect can impart damage, ranging from minor to full structural failure. Numerical techniques can be used to model the explosion and structure, so as to study the interaction between them. Recent advancements in computer technology have enabled the ability to implement software in a viable, efficient and cost-effective way to model complicated blast scenarios. As a first step, the capability of numerical methods to capture the applied pressure on a structure with appropriate accuracy needs validation. Amongst relevant software, LS-DYNA has the ability to model blast loading on structures in three different methods.

The first method (LBE) is based purely on a Lagrangian approach using empirical equations, and is quite restrictive. In this method, only the structure needs to be modelled and the pressure is directly applied on it, hence much less CPU usage is needed. The second method is based on fluid-structure interaction (FSI) algorithms by using the Multi-Material ALE formulation (MM-ALE). In this approach, the air as well as the explosive is modelled and the shock front propagates through the air domain. The MM-ALE method consumes a significant amount of CPU time. A possibility is a coupled LBE and MM-ALE method which uses an empirical equation to calculate the blast pressure on an ambient layer. The ambient layer then transfers the pressure to the air domain which surrounds the Lagrangian structure. Using this method can extensively reduce the model size and CPU time. Wave merges and reflections can be accommodated in both the MM-ALE and coupled models.

A number of contributions [1-4] have reported studies of the explosion wave propagation law in air, and proposed some formulae for computation. The TM 5-855-1[5] and UFC-3-340-02 [6] manuals explain the principles of the explosion and methods of calculation.

In order to evaluate the explosive wave propagation precisely including the incident and reflected pressure waves, the current paper investigates the scaled distance, explosive shape and modelling parameters, as well as the mesh sensitivity. The MM-ALE model is used, and the results are validated using empirical methods [4,6]. The effects of parameter values adopted in this method are studied. In contrast to other papers which focused mainly on one or two points surrounding the explosion, in the

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