FREE-AIR BLAST SIMULATION: ENGINEERING MODEL AND MM-ALE CALCULATIONS

L. Schwer[1], M. Ala Saadeghvaziri[2] , James O'Daniel[3] & Timothy M. Madsen[4]

[1] Schwer Engineering & Consulting Services
6122 Aaron Court, Windsor CA 95492 USA
[2] Department of Civil and Environmental Engineering
New Jersey Institute of Technology
University Heights
Newark, NJ 07102-1982 USA
[3] U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180 USA
[4] AMSRD-AAR-MEE-W
Combined Effects Warheads Branch, Bldg 3022
Picatinny, NJ 07806-5000 USA

ABSTRACT

The convergence of structural response and fluid dynamics computational capabilities, in modern commercial software, poses new learning challenges for members of these formerly isolated computational mechanics communities. To this end, solid mechanics calculators need to learn more about computational fluid dynamics (CFD), and, it is presumed, computational fluid mechanicians need to learn more about computational solid mechanics (CSD).

In this manuscript, computational solid dynamics (self-professed) experts, take on the challenge of performing rather trivial free-air blast simulations using three widely available commercial software packages: AUTODYN, CTH, and LS-DYNA. No claim is made that the air blast results reported in this manuscript are the best that can be obtained with these software packages, rather an attempt is made to illustrate the challenges facing those seeking to include coupled CFD simulations in their structural response calculations.

Free-air burst simulations were made using AUTODYN, CTH, and LS-DYNA using a rectangular mesh configuration and three mesh densities. These results are compared with those from a widely accepted engineering model of air blast, i.e. CONWEP. Using the results from the engineering model as a basis, the code results provide both under and over predictions the maximum pressures and associated impulses. Further, the predicted pressure wave forms are shown to vary significantly depending on spatial orientation; the expected result would be identical wave forms in all directions for a free-air burst. This last point is especially important for structural analysts since changing the location of a structure in the mesh will affect the loading on the structure.

It is not unexpected that such results show a directional dependence, since a problem with a spherically symmetric exact solution, when solved numerically, will not be spherically symmetric in anything other than spherical coordinates. The only behavior to be expected is that this directional dependence will vanish as the mesh is refined, like all other discretization errors. Illustrations of estimating the discretization error, using the Grid Convergence Index, are presented for the cases studied.

These discrepancies between the engineering model and commercial software are highlighted in an effort to illustrate to computational solid mechanics practitioners the need for further study of CFD techniques, before launching into complex combined CFD-CSD simulations.