Coupled CFD/CSD Simulations of Dust Production by Fragmenting Charges Using Stabilized Linear Tetrahedral Elements - COMPLAS 2017

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ABSTRACT

This paper presents the results of coupled Computational Fluid Dynamics (CFD)/Coupled Structural Dynamics (CSD) simulations of internal detonations of cased munitions against reinforced concrete walls. These simulations are part of a test, analysis, and modeling effort studying air blast propagation through breached walls. The coupled CFD/CSD simulations are providing additional insight and details not measured in the tests, as well as developing a synthetic database to supplement the test matrix. The simulations are performed to calibrate the CFD/CSD model and to determine the physic impacting the internal environments, wall breach, and blast propagation through the breach. Here we modeled the response of two reinforced concrete walls to loads from a cased charge, placed in close proximity to the center of wall 1.

In the test, the detonation room (composed of two culverts) incurred a large amount of plastic damage due to the fragments and blast load, and both culverts failed. Test wall 1 initially breached over the middle third, with the wing walls removed by the later time blast loads. Debris from test wall 1 impacted test wall 2, which failed under the combined blast and debris. Initial coupled CFD/CSD simulations modeled the culverts as rigid, non-responding surfaces. These simulations reproduced the damage to the test walls, but the pressure histories matched the experimental data only out to 10 ms. Subsequent airblast reflections were significantly reduced, as if a large amount of energy has been evacuated from the facility. Post-test damage analysis showed significant fragment damage to the culverts, with the concrete stripped to the first layer of rebars. We estimate that the fragment impacts produced several hundred kilograms of dust that was ejected into the room. Repeat simulations, where the culvert response was modeled and the dust was allowed to absorb both kinetic and thermal energy, matched the experimental data significantly better.

Initially, the simulations were performed with standard Finite Element methods (hourglass stabilized Belytschko-Flanagan hexahedral elements). However, the relatively recent developments of stabilized linear tetrahedral elements for non-linear CSD applications (See [1] and references therein) have shown a great improvement on capturing plastic localization zones and, therefore, fracture prediction in benchmarks problems. Hence, this work addresses how the implementation of such techniques improves the accuracy and the computer time savings for real life applications. Finally, comparisons with experimental data are presented to validate the numerical schemes (See [2] for details of the CSD/CFD coupling and fracture/fragmentation schemes).

***Keywords*: I** CFD, CSD, airblast, breach, blast propagation, dust, cased munitions impact; Impulsive; Shock; Protective design; Stabilized FE for plasticity and localization.

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