URBAN BLAST WAVES:
A SEMI-ANALYTIC SOLUTION FOR INTENSE EXPLOSIONS
WITH RIGID WALL REFLECTIONS

by

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ABSTRACT

Modeling blast waves in urban environments presents unique challenges. The confinement introduced by buildings leads to much higher overpressures in some areas and much lower in others. For intense explosions, reflections from buildings coalesce with the incident shock, forming a Mach stem and changing the shape of the shock front. This altered shock wave exhibits a slower decay in shock strength, causing a significant departure from free-field solutions.

Much of the analytical work on modeling intense explosions was done in the 1940’s and 1950’s, during the height of atomic bomb research. The similarity solution of Taylor, von Neumann, and Sedov yields a closed-form solution for a point blast in air in the absence of obstructions. Since that time, experimental and numerical work has been done on more complex geometries, but analytic results for confined shocks have progressed little.

The aim of this research is to provide a semi-analytic solution to the point blast problem for a geometry that approximates the confinement of urban environments. We consider a point source between two rigid plates (simulating a hemispherical blast at ground level on a street lined with tall rigid buildings). Using well-established approximations to the Sedov solution, we solve for the flow variables in terms of the shock shape. Then, building on the work of Kompaneets and Korycansky involving shocks in non-uniform media, we derive an analytic solution for the shape of the reflected shock front as a function of time and position. We then consider the interaction of the reflected waves and the asymptotic behavior of the solution. These results are compared with numerical results from CTH hydrocode for model verification.

Keywords: BLAST REFLECTION, BLAST WAVE, KOMPANEETS, KORYCANSKY, METHOD OF IMAGES, POINT BLAST, SHOCK FRONT, SHOCK INTERACTION, SHOCK REFLECTION, SIMILARITY SOLUTION