SCALING BLAST WAVE EXPERIMENTS ON MODELS TO LARGER BUILDING CONFIGURATIONS

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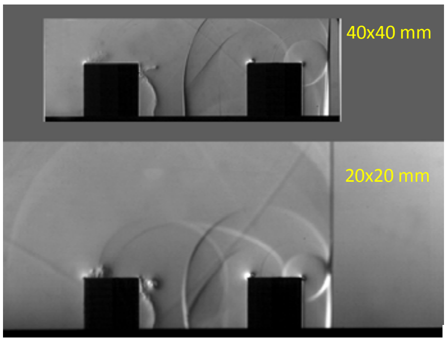
Small-scale experiments are performed in the shock tube STT of ISL in order to experimentally simulate the blast and shock actions of explosives and/or detonations on infrastructures, like houses, buildings and other. The experiments are done with small-scaled geometry arrangements and the objective of this work is to extrapolate these results to real dimensions. For explaining the developed similarity algorithm two shock tube measurements are considered:

- two houses with 20 mm × 20 mm and d = 40 mm distance (model case 1) and,
- two houses with 40 mm × 40 mm and d = 80 mm distance (model case 2).

These building arrangements are seen in the image for the two house structures: cases 1 and 2. By stretching (case 1 → case 2) or compressing (case 2 → case 1) by a factor of k = 2, affine similarity pictures of each other are obtained for the same flow Mach number M_2 and Reynolds number Re_2/m. Comparison of these pictures show that the affine transformation assumption is fulfilled under these conditions and the flow topology can be assumed to be similar whether it is stretched or compressed by k. For that reason it is legitimately allowed to approximate these flow considerations from the small scale shock tube models to a full size house with for example a stretching factor k = 200, i.e. two houses of 4 m × 4 m and d = 8 m (real case 3). In all cases the speed of sound c must have the same value. Stretching e.g. the space coordinates from case 1 to case 2 results in a double speed of sound c in case 2. For this purpose, the time scale in case 1 must be doubled to maintain an unchanged speed of sound c, when comparing the two. For the full size case of example 3, the time scale of case 1 must be enlarged by k = 200 to keep the speed of sound c constant.



Affine stretching procedure

The transformation procedure used allows estimating the pressure distributions as measured with model cases 1 and 2 for comparison with one another and proves the similarity transformation assumed. Multiplying the time scale of model case 1 by k = 2, the pressure-time-distributions now overlap quite well supporting the theory of time stretching. Extrapolation from small scale case 1 to case 3 (full size structures) makes it necessary to stretch the time by k = 200, demonstrating that for a full size house the stress takes much longer than the time taken in the small shock tube experiment. The pressure load can also be calculated for the full size houses by using the small-scale measured pressure distributions, which are practically unchanged by stretching/compressing. The transformation algorithms will be explained in the contribution to the conference on Military Aspects of Blast and Shock, MAPS 21.