THE DEVELOPMENT OF BLAST WAVE CANTILEVER GAUGES

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A study has been made of the response of elasto-plastic and brittle cantilevers when subjected to blast wave loading, with a view to using such devices as passive blast wave gauges. In addition, the deformation of cantilever type structures can be used to assess the characteristics of accidental explosions. The study was restricted to cantilevers that were circular in cross-section and made of readily available Materials A cantilever, when loaded by a blast wave, either deforms plastically, in which case the amount of deformation is the critical parameter, or fractures, in which case the failing or not failing of the cantilever provides the required information.

Two numerical models have been developed to describe the deformation of a dynamically loaded cantilever. Both models assume that the plastic deformation is localized in a region near the fixed end, and that the loading force is a function of the dynamic pressure time history and a variable drag coefficient, which depends on the Reynolds number, Mach number and angle of attack. The first numerical model assumes a rigid-plastic response of the cantilever. This model accurately describes the response only of cantilevers made of 50/50 lead/tin alloy. It overestimates the deformation of cantilevers made of other materials when exposed to blast waves from high explosives and in a shock tube.

The second model assumes an elastic-plastic response. The algorithm is based on the premise that the elastic curvature of the cantilever is limited by the plastic yielding stress of the material and that as the curvature approaches this limit the cantilever rotates by the amount needed to keep the curvature constant and equal to this maximum. The amount of rotation is determined by fitting a fourth order polynomial with a constrained second derivative based on the maximum allowed curvature. The rotation angle is found from the angle derived from the slope of the fitted function at the origin. A rotation by this angle yields a minimum in curvature in the rotated reference frame. This model improved the predictions for cantilevers constructed of aluminum and steel.

The numerical models have been evaluated by studying the response of cantilevers exposed to shock waves in a shock tube, and to the blast waves from the DISTANT IMAGE and MINOR UNCLE events. The response to the shock tube flows was recorded by high speed photography which showed good agreement between the observed modes of deflection and those predicted by the elastic-plastic model. The models also provided good predictions of the deformation or fracture of a wide range of cantilevers exposed to the free field blast waves. These cantilevers were also used to detect any non-radial flows and to study the boundary layers in the blast waves over different surfaces.

It will be demonstrated how the numerical modeling can be used to determine the type of cantilever that might be used as a passive gauge for monitoring the blast wave from an explosion, or for evaluating the deformation of a cantilever exposed to the blast wave from an accidental explosion so as to characterize the explosion.