

# P38 Trajectories and Hazards of Fixed and Free Secondary Fragments

*David Ornai<sup>1,2</sup>, Eden Maimon<sup>3</sup>*

*<sup>1</sup>Department of Structural Engineering, Ben-Gurion University of the Negev*

*<sup>2</sup>Protective Technologies Research & Development Center, Ben-Gurion University of the Negev,*

*<sup>3</sup>Department of Mechanical Engineering, Ben-Gurion University of the Negev*

## **Abstract:**

Secondary fragments may be created when an explosion occurs near equipment or work tools, for example, in ammunition and explosives (A&E) facility. The fragments may be part of the equipment such as a cantilever beam that is referred as fixed or a tool that is lying freely on a table. Since, in most of the cases, the explosive is not connected to the fragment, the initial velocity is much smaller than Gurney's velocity. The literature about the secondary fragments is limited only to three types of steel that their toughness is determined (the area bounded by stress-strain curve). Only clamped-clamped beam and cantilever beam are considered as fixed secondary fragments with suitable parameters. There are also ranges where the initial velocities are not determined. A conservative approach had been developed, in which, the initial velocities of free fragments are calculated by the reflected impulse,  $I_r$ , evaluated by the Kingery-Bulmash method, divided by the fragment mass,  $M$ . When the fragment is fixed, the energy required to tear its supports is reduced from the induced kinetic energy and the initial velocity can be evaluated for every kind of material with known toughness. The fragment trajectories are assumed as straight lines. The fragments are losing their velocities due to drag forces in relation to their shape and size. The hazards to people and to explosives initiation are determined by the energy and momentum criteria and the required protection can be designed. SECONDARY-FRAGMENT software had been developed based on MATLAB graphical user interface. The research was sponsored by the Israel Ministry of Economy.

## **Notes:**