EXPERIMENTAL OBSERVATIONS OF THE PERFORATION OF GLASS BY THE 7.62-MM NATO BALL ROUND

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Abstract: An experimental programme was conducted to investigate the mechanics of perforation of the 7.62-mm NATO Ball round through multiple glass array. Two separate experimental trials were conducted using a multiple glass array as a target. In the first experiments, the spacing in between the glass plates and the areal density were varied. In the second trials, the plates had no spacing in-between and the areal density was fixed. Results indicating the nature of the penetration mechanism are presented with specific reference to the formation of the cone of comminuted glass that propagates from the front plate subsequent to its perforation.

INTRODUCTION

To date, almost all bullet-resistant glass comprises glass laminates with rubbery interlayers (such as polyurethane or polyvinylbuterate (PvB)) and a polymer as a backing layer, usually polycarbonate. The interlayers provide a flexible separation between the layers of glass and serve to contain the glass array. The backing layer is used to prevent spall at the rear face of the target. Depending on the threat level, different combinations of these layers form an array to prevent perforation by the projectile. While manufacturers do trial different materials, few manufacturers in the world are deviating from this basic approach. For these types of transparent armour systems, the penetration and subsequent perforation mechanics is fairly well documented.

What is lacking however, is an understanding of the perforation mechanics of spaced glass systems where arrays of glass are constructed with air gaps in-between (such as a common double-glazing system). This paper presents an experimental programme that describes the perforation of a 7.62-mm NATO Ball round through multiple-glass arrays (spaced and non-spaced). It is the authors' intention to show that the perforation mechanics are significantly affected by even small changes of the construction of the glass system.

Because it was the authors' intention to test principles rather than optimise a specific transparent armour system, all experiments were conducted without the use of any adhesive layer and confinement.

EXPERIMENTAL PROGRAMME

For this programme, two separate experimental trials were carried out.

In the first set of trials, the areal density and the spacing in-between glass plates were varied. Four float glass plates (supplied by Pilkington plc) were used, spaced at 0.0, 1.5, 2.5 and 5.0 mm by gluing aluminium spacers at the four corners of the plates. For each system the thickness of the plate remained the same while the spacing between the individual plates was varied. The thicknesses under investigation were 3, 4, 6, 8 and 12 mm. Each plate had a cross-sectional area of 120-mm×120-mm square.

Furthermore, a second experimental trial was undertaken using plates of thicknesses 2, 5 and 10 mm. This time the plates were tested with no gap and the areal density of the glass was kept constant. The target arrays were arranged as three different systems, 3×10-mm, 6×5-mm and 15×2-mm plates with a constant areal density of 75 kg/m^2. Each experiment was repeated twice. A diagram showing the typical target configuration for each trial is shown below in Figure 1.

In each experimental trial, no adhesive or cover plate material was used.

For each target configuration a 7.62×51 mm NATO ball round (nominal mass=9.65g) was fired at the centre of the plates using a standard 7.62-mm proof barrel. The measured velocity of the round was 809±10 m/s. A CORDIN model 220 high-speed digital camera was used to record the perforation of the plates. A measurement of the front ejecta formation was carried out on the image captured at a nominal time of 500 µs after impact.

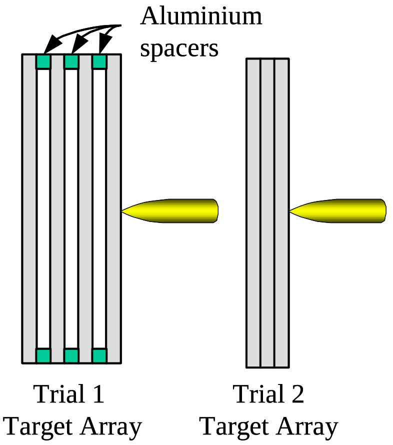

Figure 1. **Typical target configuration for each trial.**

OBSERVATIONS

On impact, the glass material in contact with the projectile fails due to shear-induced microcracking. Due to the relatively low fracture toughness of float glass, only a small proportion of the kinetic energy of the projectile is transferred to the glass for the generation of new fracture surfaces. Instead, a far greater proportion of the kinetic energy is transferred into kinetic energy of the glass fragments.

At the front surface a "splash" of comminuted glass occurred as the projectile penetrated into the first glass layer. This material continued to expand radially and in the opposite

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