Bullet-Resistance of Glazing Using Glass and Polymers

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Abstract

The current global political circumstances and the concomitant increase in security concerns give rise to heightened expectations regarding the building envelope. Transparent areas in façades are essential for daylight entrance and the interaction between the interior and the external environment but represent a risk to building occupants in the case of blast events or attack with firearms. Conventional glazing such as monolithic glazing and laminated safety glass lack resistance to bullet attack due to their brittle fracture behaviour. Glass shows favourable properties in terms of scratch resistance and strength. While the lamination of numerous layers of glass panes provides enhanced resistance against bullet attack, higher dead loads result, necessitating thicker frames and fittings. The integration of glass with polymeric glazing material effectively reduces the total dead load and nominal thickness of security glazing with a resistance against bullet attack. Bullet-resistant glazing is classified in accordance with the European standard EN 1063. A test specimen is subjected to a series of three shots fired in a triangular configuration using specified types of weapons and ammunition. The present paper focuses on the topic of bullet resistance by glass panes, polymeric sheets and composite panels. In initial experimental tests, monolithic test specimens of annealed glass, toughened safety glass, polycarbonate sheets and polymethylmethacrylate sheets are investigated. The thicknesses of the materials are in a range that will cause a bullet to penetrate. This enables to measure the velocity before and after penetration of the test specimen, as well as to calculate the absorbed energy. Finally, the materials can be characterised in the context of ballistic impact. By recording the mass of the outgoing fragment and the projectile using ultra-high-speed imaging, it is possible to analyse the effect of the materials on velocity reduction. The combination of individual layers with and without lamination by thermoplastic polyurethane interlayers allows for the recommendation of a favourable composition in the cross-section. As result of the research, bullet-resistant glazing with reduced nominal thicknesses can be predicted and processed to slim insulated glazing with high thermal insulation.

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Keywords

bullet-resistant glazing, security glazing, composite panels, laminated safety glass

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