Modelling the effect of air blast on laminated window glass

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Protection of critical e.g. government buildings, shopping centres, infrastructure and trains from damage and destruction by deliberate acts of terrorism and malicious behaviour is important for civil society. Normally, building guidelines do not take these threats into account. There is growing demand for appropriate guidelines for such special cases, to enhance the resilience against explosive incidents. To protect infrastructure a ‘safe component design methodology’ is needed that will draw on experimental and numerical methods as a means to quantify the resistance that structural components can offer to resist explosive loading, and furthermore assess hazards from failure of elements.

To help EU decision makers address this omission and to harmonise standards, a recently commissioned EU Report has summarised best practice for the numerical finite element modelling of blast loading of laminated glass focussing on knowledge gaps. In this 2015 state of the art review, there were several key difficulties that researchers developing numerical models were encountering. For example, sophisticated air pressure shock wave loading in the gas phase is to be two-way coupled with the solid model. The solid model of typically designed secondary laminated glass window includes the window frame and precise attachment conditions and two sheets of glass laminate separated by a decoupling thickness of air, each laminate being two sheets of glass with an interlayer of PVB (polyvinyl butyral) that approximates hyperelastic behaviour. In a recent paper Wang et al. 2018 demonstrated the capabilities of a combined FEMDEM formulation for impact damage of glass-PVB laminate to be simulated realistically. The outstanding challenges to modelling blasting and window safety is that compared with a projectile impact, the loading would be very different in an airblast caused by a nearby explosion. The ‘solid only’ model cannot model the decoupling effect of the air gap and how this would be effective to varying degrees in inhibiting damage in the second laminate sheet on the building’s interior. For this research to supplement purely experimental investigations, coupled dynamic gas/solids models are required.

In AMCG at Imperial College, a FEMDEM based code Solidity is similar to that employed by Wang et al. (2018) and glass fracture is captured well. Furthermore, a coupled gas flow and brittle fracture model for the dynamics of rock blasting and brittle fragmentation has been developed. (Yang et al 2017). An example of capabilities of our codes is shown in Fig. 1 from Yang et al. 2017. The technology developed by AMCG is therefore a very promising approach to thoroughly understand the physical processes at play and hence provide appropriate levels of protection to window design. The PhD project aims to port the technology to this new application of great international importance for peoples’ safety.

Reference

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