GLASS FRAGMENT HAZARD MITIGATION IN TERRORIST BOMBINGS

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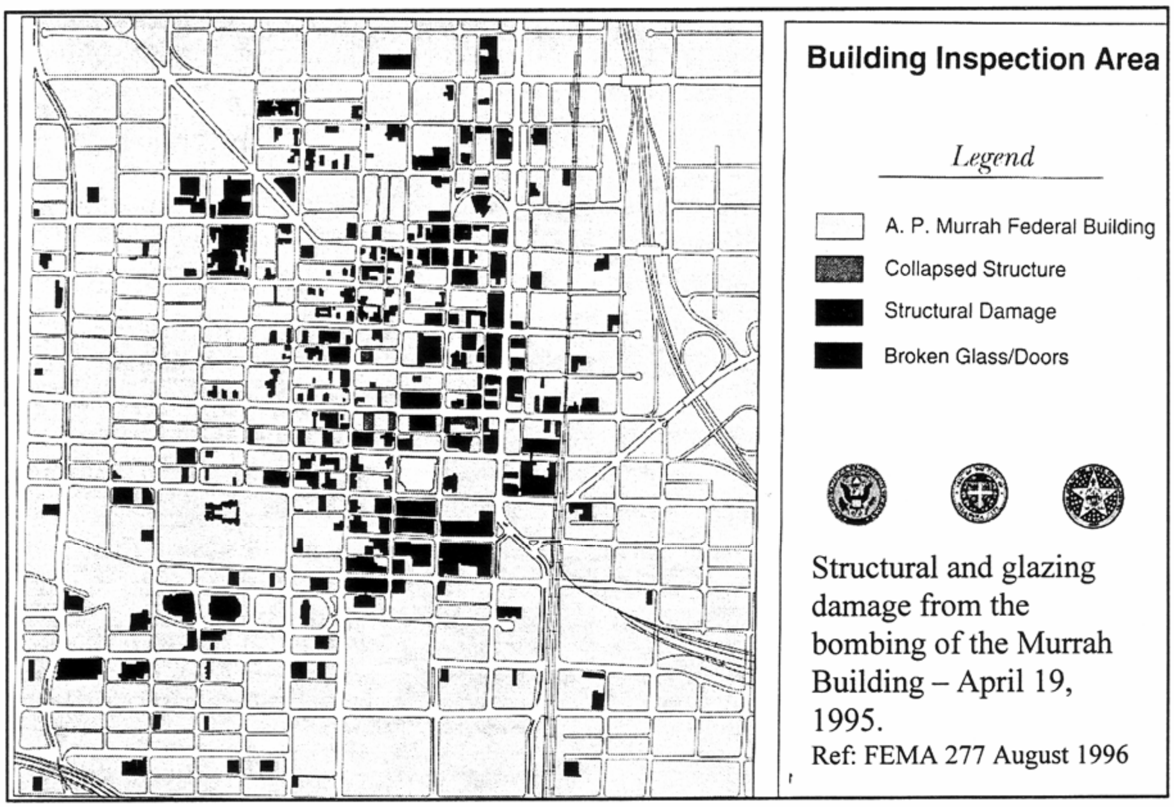
Propelled by the forces of a terrorist bomb, glass fragments may cause large numbers of serious injuries. While heavy structural damage and collapse is generally local in nature, even for a large bomb like that used in Oklahoma City, hazardous glass fragments may pose significant hazards to people in areas far removed from the attack. This was, for example, clearly evident in the vicinity of the Murrah Building after the April 1995 bombing, and again in the August 1998 bombing of the US Embassy in Nairobi.



Structural and glazing damage from the bombing of the Murrah Building – April 19, 1995.
Ref: FEMA 277 August 1996

Window systems consist of the glass pane, gaskets and sealants, the window frame and the anchorage to the supporting wall surface. In order to achieve a given measure of blast resistance, it is imperative that the entire window system be designed to balance the relative capacities of the system components. For example, it makes little sense and may actually introduce additional hazard to design a window system in which the glazing is stronger than the supporting frame or its attachment to the building. In such a case, the glazing may pop out and the entire assembly may be thrown into occupied spaces. A balanced design is required.

The blast capacity of glass, that is the pressure and impulse necessary to cause the glass to fall, is controlled by the type and thickness of the glass and the size of the window opening. Assuming that a window system design is balanced, thicker glass panes will provide higher blast capacities. Likewise, blast capacity is increased as the size of the window opening decreases. Glass material type will also influence capacity. Thermally tempered glass (TTG), for example, has a breaking strength that is approximately twice that of heat strengthened glass (HSG) and nearly four times that of annealed glass (AG). Glass type also influences potential hazards of the glass fragments and shards after glass failure. TTG, for example, will fail in smaller clumps or cube shaped fragments that generally pose a lower hazard than the dagger like shards produced from failing annealed glass. Hence, one effective approach to reducing the potential hazards from window glass is to design smaller, fewer windows with thicker and stronger glass that fails with lower hazard fragment sizes and shapes.

Blast resistant window technology and design procedures are readily available. Such windows have been designed and built for the military, the State Department, and other Government agencies as well as commercial/industrial users for many years. Truly blast resistant windows that are designed to fully resist a blast event provide the highest level of security and safety. However, they tend to be limited in size, expensive and are not always aesthetically pleasing. Hence, while available, fully blast resistant windows may not be practical when the goal is to provide a measure of protection to many hundreds of public buildings. As members of a free and open democratic society we expect and demand that our approach to security not be oppressive or reflect a bunker-like mentality. With the heightened concern about terrorism in this country and the perceived need to protect not only limited high value target facilities but many facilities, an urgent need was created to develop practical and affordable techniques to limit or mitigate the potential hazards from flying glass fragments and shards. In response to this need, the US Government and private industry are developing and testing new technologies to mitigate hazards to people in the vicinity of a terrorist bombing. In cooperation with the US Army Corps of Engineers (USACE), Defense Special Weapons Agency (DSWA), US General Services Administration (GSA) and several private companies, Applied Research Associates (ARA) conducted several tests to assess the capability of methods to reduce the hazards of flying glass shards after failure of the window system. Controlling postfailure behavior does not provide as great a level of protection as designing the windows to fully resist the blast forces, but this approach does provide a practical and prudent means of reducing potential risks.