InSights

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Glazing Retrofits for Blast Mitigation

By Jon A. Schmidt, P.E., SECB, BSCP

When an explosion occurs near a populated building, flying fragments from broken windows and glazed doors cause the vast majority of non-fatal injuries. Conventional annealed or heat strengthened glass shatters into relatively large, jagged shards that can produce multiple lacerations on anyone unfortunate enough to be sitting or standing nearby when the shock wave arrives. Tempered glass tends to break into smaller "rock salt" fragments, but these are then propelled at high velocity into the room.

Laminated glass offers much better performance and is the preferred solution for new construction. An adhered interlayer of polyvinyl-butyral (PVB) is sandwiched between two panes of annealed or heat strengthened glass. When subjected to airblast effects, the PVB holds the glass together, even if it cracks, and stretches out considerably in response to the overpressure. However, proper replacement of existing glazing systems with laminated glass can be a difficult and expensive proposition, often requiring replacement or reinforcement of framing members and connections as well.

A popular alternative is to apply a polyester fragment retention film (FRF) to the interior surface of the glass, which performs much like the PVB interlayer in laminated glass. The four most common retrofit configurations are as follows.

Daylight-Applied FRF – The simplest, least intrusive and least expensive way to reduce the fragment hazard from glazing is to apply FRF only to the exposed interior surface of the glass *(Figure 1)*. A thickness of 4 to 7 mils is usually sufficient, and there is virtually no impact on appearance or functionality. However, the perimeter of the pane remains vulnerable to shear failure in a blast event, such that the entire sheet of filmed glass could be blown out of its frame and into the building, posing a risk of blunt force trauma. Furthermore, in an insulating glass unit (IGU), only the inboard lite is filmed, so it is still possible for fragments from the outboard lite to pose a hazard to occupants.

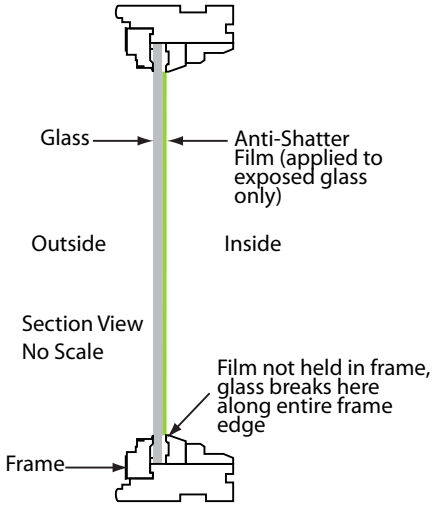

Figure 1: Daylight-applied FRF.

FRF Plus Catcher Bar – One way to improve the protection provided by daylight-applied FRF is to install a rigid bar across the filmed glass, on the interior, either horizontally or vertically *(Figure 2)*. In a blast event, the FRF will hold the glass together, and if it shears off around the perimeter, the pane will wrap around the catcher bar and slap together – likely dislodging a few fragments. Substantial anchorage is required at both ends of the rod, which protrudes into the room and may be an impediment if the window is intended to be operable. Thicker FRF – typically 7 to 11 mils – is required, and for an IGU, fragments from the outboard lite will be largely unimpeded.

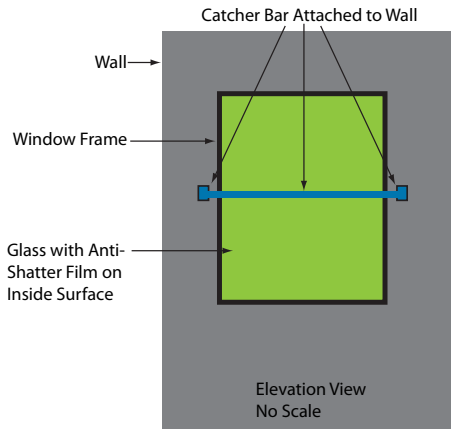

Figure 2: FRF Plus Catcher Bar.

FRF Plus Net Curtain – Another enhancement for daylight-applied FRF is to install a polyester curtain that is hung from a rod above the filmed glass, on the interior, and has weights sewn into it at the bottom, where excess material is housed in a box *(Figure 3)*. Once again, in a blast event, the FRF will hold the glass together; in this case, if it shears off around the perimeter, the net curtain will catch the entire pane and drop it to the floor. Substantial anchorage to the wall is required for both the rod and the box, and

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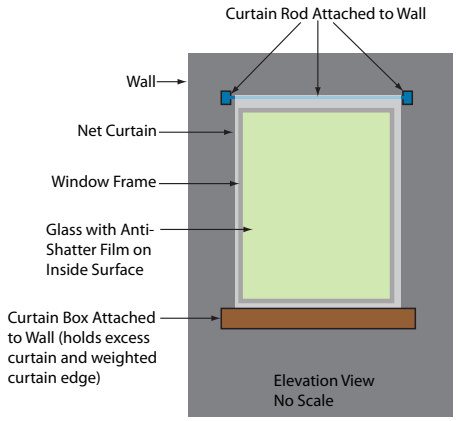

Figure 3: FRF Plus Net Curtain.

the curtain must be removed and washed regularly – hopefully not on a day when an explosion occurs!

Attached FRF – The most effective technique using FRF involves fastening it to the frame around the glass along either two opposite sides or all four sides *(Figure 4)*. Needless to say, it is also the most complex, most intrusive and most expensive option, requiring thicker FRF – 7 mils minimum – as well as mechanical attachment or the application of a structural silicone sealant. As with laminated glass, it may be necessary to replace or reinforce the framing members and connections in order to ensure that the entire assembly is not dislodged from the wall in a blast event.

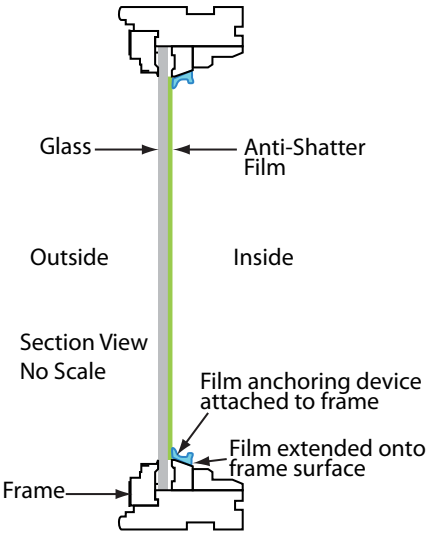

Figure 4: Attached FRF.

One thing that all retrofits using FRF have in common is the limited service life of the film itself – typically about 10 years. When evaluating replacement vs. retrofit, it is important to keep this life-cycle cost consideration in mind. A somewhat larger up-front investment in laminated glass may pay off by eliminating the need for removal and replacement of FRF in the future.▪

Acknowledgment

Much of the information in this article and all of the accompanying figures are taken from the *Window Analysis Guide,* published by the US Army Corps of Engineers Protective Design Center (**pdc.usace.army.mil**) as part of the Help file for its *Window Fragment Hazard Level Analysis (HazL)* software.