SUNSHADE FABRIC FRAGMENT RETENTION RETROFIT FOR BLAST MITIGATION

U.S. Department of State,
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TECHNICAL INFORMATION BULLETIN

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SUNSHADE FABRIC FRAGMENT RETENTION RETROFIT

EXECUTIVE SUMMARY

This Technical Information Bulletin describes the development, testing, design and application of sunshade fabrics as glass fragment retention retrofits for field expedient blast mitigation. These fabrics, properly anchored, can provide increased protection for *existing* office space against flying window glass caused by external blasts.

A blast resistant sunshade fabric is installed as a glazing fragment retention system restrained with steel straps behind existing exterior windows. The straps are anchored only to the floor and ceiling slabs. When subjected to blast loading, the glass window breaks, the fragments are held together by the Shatter Resistant Window Film (SRWF), and the combination is then captured and retained by the sunshade fabric. Steel straps hold the fabric in place and prevent the exterior glazing and sunshade fabric from entering occupied space. The fabric and steel straps deflect into the room, but do not allow the window glass to travel through the occupied space, thus mitigating a major hazard to occupants.

This retrofit has proven successful against a range of blast loadings from realistic threat charge weights. Specifically, this design concept can protect office occupants from large vehicle bombs up to [redacted] when accompanied by a setback distance of [redacted] in buildings that are capable of structurally withstanding that threat. It will also perform satisfactorily in locations with lesser setback and a proportionally reduced charge weight. If a larger explosive detonates, this retrofit still provides improved protection, as compared to non-retrofitted conditions, and will reduce casualties and injuries.

Retrofit installation is accomplished using conventional materials, standard tools, and construction methods requiring minimal technical ability. The effect on façade, mechanical, electrical and other building systems is minimal. Furthermore, installation only encroaches upon the office space immediately behind existing windows, within a distance as close to the exterior window as practical. The concept can be employed as a stand-alone retrofit system or integrated into a total wall retrofit system.

Embedding the straps and framing under floor coverings, in the interior walls, and above ceilings can make the retrofit relatively inconspicuous to occupants. Proper color and pick density selection will minimize visibility degradation through the treated windows.

The retrofit also may restrict access to operable windows. In facilities which utilize operable windows as the fresh air source, or in buildings without centralized HVAC systems, a facility engineer should be consulted in order to ensure these operational facets are properly addressed.

BACKGROUND

The east Africa bombings in 1998 prompted a concerted DOS effort to identify products, and construct systems, that mitigate the effects of terrorist bombing attacks. As a part of this effort, the DS Standards Development and Implementation Branch, is conducting research and development that evaluates conceptual designs for interior retrofit construction to mitigate the vulnerability of existing and newly acquired diplomatic buildings to vehicular bomb threats.

The Embassy Wall Retrofit Program (EWRP) testing is part of a larger DS R&D testing initiative that encompasses site perimeter walls, building walls, structural elements, window systems, and non-structural elements. The US Army Corps of Engineer Research and Development Center (ERDC), under DS/PSD/SDI sponsorship, provides technical, operational, and testing support to the program.

Façades, exterior walls, and glazing of conventional buildings are vulnerable to blast and are major causes of structural and interior damage and hazard to occupants. A primary concern is the glazing in conventional buildings, which is typically annealed glass, highly vulnerable to blast loading, fragmenting into jagged, high velocity shards. The potential for sunshade fabrics, as part of a window fragment retention system, to mitigate this hazard, was examined. Some sunshade fabrics can be utilized, as described in this bulletin, and adopted for use as a retaining shield to contain most, if not all, glazing and other hazardous debris, preventing it from entering occupied space.

The retrofit concept development defines the best framing and anchoring design for these fabrics to fully capitalize on their strengths and value as a glass fragment retention system. As an outgrowth of glazing hazard concerns and successful sunshade fabric retrofit performance, this bulletin has been prepared to document results and describe this field expedient technique. The development, testing, and implementation of this blast mitigation concept, has proven it successful against blast loads for a realistic threat environment.

Conclusions

Comparative analysis of EWRP-2 and EWRP-4 shows that in EWRP-2 the banded window system prohibited lateral motion, whereas EWRP-4 provided freedom for the flat bars to deflect toward the center. The ability for the flat bars to deflect laterally toward the center of the opening, as shown in the lower left photo of Figure 6, appears crucial to the success of this retrofit. This dictates the use of independent window retention systems, so that the flat bars are free to deflect rather than being stressed in opposing directions when loading by two windows. For a storefront window, independent window retention systems could still be retrofitted in the EWRP-4 pattern, repeated behind each window for individual performance optimization.

The DB-4 test with [redacted] sunshade fabric had produced successful results for this concept at lesser pressure levels and greater standoff ([redacted]). On EWRP-2, the loading was increased from a similar threat at [redacted] and total system failure occurred ([redacted] fabric ripped at the edge of the flat bars, flat bars failed in tension, and anchor bolts ripped out of anchors). As a consequence of this, both the sunshade fabric and flat bar retrofit design were modified. MechoShade was chosen to replace the [redacted] on this experiment because of its greater strength. Alternate anchoring techniques were utilized. [redacted]

SUMMARY AND CONCLUSIONS

The use of sunshade fabrics as a glass fragmentation retention system retrofit for field expedient blast mitigation is effective, yet simple and versatile. These fabrics can increase protection for *existing* office space against flying window glass caused by external blasts. It is therefore a candidate for a wide variety of field applications. Applications can be as a stand-alone window retrofit or integrated into a total wall/window retrofit system.

The sunshade fabric is installed as a glazing fragment retention system, restrained with steel straps behind existing exterior windows. An independent retention system should be used for each window to permit the critical lateral deflection. The straps are anchored only to the floor and ceiling slabs, and hold the fabric in place and prevent the exterior glazing from entering occupied space.

This retrofit has proven successful against a range of blast loadings from realistic threat charge weights. It will also perform satisfactorily in locations with lesser setback and a proportionally reduced charge weight. If a larger explosive detonates, the retrofit will still provide improved protection, as compared to non-retrofitted conditions, and reduce casualties and injuries.

Retrofit installation is accomplished using conventional materials, standard tools and construction methods requiring minimal technical ability. Effects on other systems are minimal, and it only encroaches upon the office space immediately behind existing windows, within a distance as close to the exterior window as practical. Nonetheless, a facility engineer should be consulted for installation. Installation can be incorporated into the surrounding office finishes to make the retrofit relatively inconspicuous to occupants.

For further information or assistance regarding the integration of sunshade fabric retrofits into larger renovation or upgrade requirements, or to seek additional information regarding other alternatives, please contact [redacted]

Test Fabric: MechoShade Sunshade Fabric

Fabric: MechoShade

Supplier/manufacturer:

MechoShade Systems, Inc.
42-03 35th Street
Long Island City, NY 11101
718-729-2020 ext. 208
www.mechoshade.com
e-mail: joelb@mechoshade.com

Commercial availability:

- Fabric is available in any width from 48 inches to 96 inches wide on special order of 600 or 1,200 linear yards minimum
- Multi-density and multi-color (over 60 colors)

Material properties of fabric tested in EWRP experiment:

- MechoShade fabric is a Kevlar ® blast shade
- Fabric woven from PVC extrusion-coated Kevlar® 29 yarn
- Yarn has UV inhibitors, flame retardant additives and anti-microbial additives in the PVC coating
- Warp yarn is based on 3000 denier Kevlar ® 29 fiber (denier is unit of yarn fineness, based upon standard of 50 milligrams per 450 meters of yarn)
- Fill (pick) yarn is based on 1000 denier Kevlar ® 29 yarn
- Fabric construction is 13 ends per inch of yarn in the warp and either 10 or 12 ends per inch (pick) of yarn in the fill direction (both 10 and 12 were tested)
- Woven fabric is then heat set to stabilize

Maintenance:

- Annual anti-static treatment to minimize dust collection
- Clean with soap and water if necessary