

【DESCRIPTION】

ENHANCED PROTECTIVE FILMS SYSTEM AND MOUNTING METHOD THEREOF

Field of Invention

Embodiments of the invention relate generally to an enhanced protective film system, which can protect facilities and infrastructure against high impact events, e.g. explosions and attacks, and more specifically to a window protection system and a mounting method thereof.

Background

Buildings are often blast-resistant to at least a certain extent against high impact and dynamic events, e.g. car-bombs, mortar and rocket attacks. Buildings can have the blast-resistance enhanced. This enhancement is required and often mandatory in certain locations for various reasons such as risks of terrorist attacks. As window installations cover a major part of the facade of buildings, one important aspect of blast-resistant buildings is to provide sufficient reinforcement and protection for the windows.

Existing blast-resistant windows systems are problematic as they either do not offer adequate levels of protection or they destroy the aesthetics of the buildings upon installation, or they make windows lose there transparency.

Detailed Description

The objective of this invention is to provide an enhanced protective film system and a mounting method thereof.

The enhanced protective film system according to the invention is installed in conventional window panels and provides protection against high velocity air blast impacts causing glazing debris hazards.

For the above purpose, the enhanced protective film system comprise two transparent film layers, wherein, the first layer 1 is a layer of flexible film with appropriate tensile strength and high percentage elongation, the second layer 2 is composed of at least one layer of film with higher tensile strength.

Said first layer is the polymer material layer (polymeric material) generally that refers to any polymer material that may be cast, extruded, rolled or pressed into a wide thin film-like product up to 8mm in thickness. Said polymer material layer is a layer of transparent film with tensile strength greater than 2000psi and 100 percent elongation. It is to be understood that a polymer is a substance composed of molecules with large molecular mass composed of repeating structural units, or monomers, connected by covalent chemical bonds. Suitable examples of polymers that may be used in embodiments of the invention include, but are not limited to, polycarbonate, polyethylene terephthalate, polypropylene, silicone, and polyvinyl butyral. The polymeric sheet selected for use should be relatively flexible, i.e. not rigid and able to absorb energies from impact/shocks as measured by tensile strength and elongation. The relatively flexible polymer material layer is able to resist tearing due to impacts from shattered or broken fragments of the glazing in the event of an explosive blast.

Said second layer of protective film layer (high tensile strength film) may have one- or multi-layer and each layer is manufactured from polymeric material.

Examples are polyester, polyester terephthalate, which include, but are not limited to, biaxially-oriented polyethylene terephthalate (boPET) polyester films, polycarbonate, polystyrene and polymers of acrylic such as polymethylmethacrylate. Each layer of protective film layer selected for use should have high tensile strength, greater than 9000psi to increase rigidity of the window protection system. The protective film layer should also at least be relatively transparent and can be up to 0.6mm thick. The protective film layer provides additional tensile strength and deflection reduction capability of the window panel.

Said enhanced protective film system further includes reinforcement structure 3. Said reinforcement structure is connected firmly with edges of the first layer (polymer material layer) and the second layer (protective film layer), in order to keep such edges of the two layers attached to window frames or supporting structure, e.g. walls, in a stable manner.

The reinforcement structure may be selected from the group consisting of metal/plastic strapping, angle steel, combined anchors, anchoring cables, cable catcher system (steel cable system) or anchoring device. Said anchoring device include, but are not limited to, fasteners as illustrated in FIG 5, including fastening screw (such as anchoring screw 14, crossing screw 15, self-tapping screw 16 and masonry screw 17) or square nail 18. Said anchoring device can be used individually or jointly with metal/plastic strapping or angle steel to couple the first and second layers to window frames, supporting/walling structure or reinforcement structure. The reinforcement structure may be installed on opposing sides of a window panel in either vertical or horizontal orientation or around the entire perimeter.

The reinforcement structure can be connected simultaneously with said polymer material layer and protective film layer and make them attach to or embed in the supporting structure (e.g. wall) that fixes the window frames and supports the window panel and window frames in either horizontal or vertical orientation or around the entire perimeter of polymer material layer and protective film layer. Generally, the reinforcement structure (e.g. anchor cables) may be attached to or embedded in the supporting structure bordering the window panel, e.g. one or more anchor cables may be embedded in the supporting structure in a direction traversing the width or length or both directions of the window panels. One or more anchoring devices may be provided to couple the polymeric layer and protective film layer(s) to the reinforcement structure. It receives the impact blast loads from polymer material layer and protective film layer(s) and transfers the impact blast to the supports or wall structure. The above said polymer material layer, protective film layer(s) and reinforcement structure are coupled by anchoring system or adhesive, and used in combination to significantly reduce the transfer load from the window panel to supporting structure and to absorb and dissipate shock energy in the event of impacts.

This invention further provides a mounting method of said enhanced protective film system.

The blast-resistant window includes the window body where the enhanced protective film system is installed on its one side or both sides of the glazing, wherein, said first layer (polymer material layer) and second layer (protective film layer) are parallel to a transparent panel of the window body. The first layer

is close to the transparent panel of window body, and the second layer is separated from the transparent panel of the glazing surface of the window body by the first layer (the polymer material layer).

Said one end of reinforcement structure of the enhanced protective film system is coupled with said first and second layers, and is attached to the structure supporting said window body or is embedded in the structure supporting said window body or in frames of said window body. Further, for a higher level of protection, the left and right edges of the window frame may also be secured to the reinforcement structure (anchoring cables). However, depending on applications, it is to be understood that one or more edges may be secured to reinforcement structures (anchoring cables).

The first layer is juxtaposed to the window panel. The second layer is juxtaposed to and located outside of the first layer. The air gaps around the perimeter of said polymer material layer and protective film layer system are sealed to prevent air from entering such layers.

The method of installing the enhanced protective film system according to this invention comprises that the first and second layers of said enhanced protective film system are installed parallel to the transparent panel of window body, making the first layer close to the surface of the transparent panel of window body and the second layer located the outside of said first layer.

If the enhanced protective film system includes the reinforcement structure, the above mentioned method further comprises that the reinforcement structure is anchored to or adhered to at least two opposing sides of said first and second

layers, is attached to the structure supporting the window body, is embedded in the structure supporting the window body, or is embedded in the frames of the window body.

The method of installing embodiments of the enhanced protective film system varies depending on the blast load. A simple overview is described as follows.

A first step is to form the relatively transparent/clear polymer material layer (the above mentioned first layer) and the relatively transparent/clear protective film layer (the above mentioned second layer), either separately or combined, to the required dimensions of the window panel to be protected. This is accomplished through various forms of cutting and shearing as well as thermoforming.

A second step is to then create fastener holes (hereinafter referred to as holes) for receiving fastening anchors for securing the polymer material layer and the protective film layer to the edges of the window frame, i.e. the holes are drilled at the edges of the window frame. The holes are measured and marked accordingly at the appropriate locations on the clear polymer material layer and the clear protective film layer, either separately or combined. Then the holes are drilled.

A third step is transferring the same hole pattern to the attachment system (e.g. the window frame, the supporting structure, or the reinforcement structure) as required by the engineering design. Alignment of the drilled holes must be made prior to installation of the anchors.

A fourth step is that the edges of the window frame are secured, by mounting screws or other means, to the supporting structure or reinforcement structure (anchor cable). The reinforcement structure (anchor cable) can be embedded in the supporting structure. Edges to be secured can be a minimum of two opposing sides to a maximum of the entire perimeter of the formed clear polymer material layer and the clear protective film layer, either separately or combined.

A fifth step is after the clear polymer material layer and the clear protective film layer, either separately or combined, are secured to the window panel, any air gaps around the perimeter of the polymer material layer and the protective film layer, as well as the gaps between the layers and the transparent window panel, are sealed to form a barrier with the environment to prevent air from entering the layers. For this purpose, a sealant such as a silicone-based sealant may be applied. Optionally, the air gaps may be sealed using aluminum sheet.

Various suitable types of fastening screws (e.g. masonry screw, self-tapping metal screw, machine bolt) and washers are illustrated in FIG 5. It is to be understood that other types of fasteners may be suitable.

The above mentioned enhanced protective film system may include an aesthetic furnishing utilizing shaped and formed sealant, metal, or wood to provide a furnished appearance to the system.

Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the present invention.

Furthermore, certain terminology has been used for the purposes of descriptive clarity, and not to limit the invention. The embodiments and features described above should be considered exemplary.

Based on the above mentioned structure and design, the enhanced protective film system according to this invention is capable of resisting, absorbing and dissipating high impact blast loads, reduces glass debris and keeps the window firmly attached to the supporting structure in the event of an explosion. More particularly, the polymer material layer, being relatively flexible, is capable of withstanding shattered/broken pieces of the window panel when an air blast impact occurs. The protective film layer provides additional tensile strength and deflection reduction capability of the window panel. The primary effect is a synergistic polymeric material and engineered anchoring system that significantly reduces the transfer load from the window panel to the structure and absorbs and dissipates the shock energy when an impact is received. Notably, embodiments of the invention may withstand impact/pressure in the range of 10psi-600psi. However, it is to be understood that modifications may be made to embodiments of the invention to increase protection against a higher impact.

Brief Description of the Drawings

FIG. 1 shows an exterior view of a blast-resistant window.

FIG.2 shows a partial interior view of a blast-resistant window of FIG.1, and in particular to a section of the blast-resistant window installation.

FIG. 3A shows a partial side cross-sectional view of FIGs.1 and 2 (the left side is an exterior view and the right side is an interior view).

FIG. 3B is a close-up partial view as indicated in the area A in FIG. 3A.

FIG. 4A shows a configuration of a blast-resistant window according to one embodiment of the invention.

FIG. 4B is a partial side cross-sectional view of FIG. 4A using a mechanical fastener.

FIG. 4C is a partial side cross-sectional view of FIG. 4A using an adhesive as a fastener.

FIG. 5 shows various fastening screws, nuts, screws and washers suitable for use in embodiments of the invention.

FIG. 6 shows a configuration of a blast-resistant window according to another embodiment of the invention.

Mode of Carrying out the Invention

The experimental methods described in the following examples are regular methods without special instruction.

Example 1: the installation of the enhanced protective film system according to the invention and the test of its property.

FIG. 1 to FIG. 3 shows a blast-resistant window of the enhanced protective film system according to the invention. The blast-resistant window includes a window body and an enhanced protective film system, which is composed of a polymer material layer 1, a protective film layer 2, a reinforcement structure 3 and a cover 5 concealing the installation of the reinforcement structure 3.

The polymer material layer is juxtaposed parallel to a transparent panel (glass) 6 of the window panel. The protective film layer is located on the outside

surface (a side of the polymer material layer that separated from the transparent panel of the window body) and juxtaposed parallel to the polymer material layer. The polymer material layer and the protective film layer are anchored to the reinforcement structure 3, which is anchored to a supporting structure (wall) 10.

The polymer material layer is transparent and of up to 5.0mm thickness. The tensile strength and elongation of the polymer material layer are 7600psi and 308% respectively measured by means of ASTM638.

The protective film layer (the second layer) is a transparent polymeric layer with the thickness of 0.175mm. The tensile strength and elongation are 35,000psi and 140% respectively.

The reinforcement 3 is composed of steel cable system comprising steel cable 7 and extrudate 8, and anchoring device 4. The perimeter of the polymer material layer and the protective film layer are sealed by a rubber washer or HS adhesive 9 to form a barrier with the environment to prevent air from entering the layers. The anchoring device including a fastening screw or a bolt may be employed to couple the polymer and protective film layers.

In this example, the enhanced protective film system is installed onto one side of the window panel (interior). The method of installation of the blast-resistant window is described as follows:

- 1) **Creating holes:** fastener holes (hereinafter referred to as holes) are created for receiving fastening anchors for securing the polymer material layer

and the protective film layer to the edges of the window frame. The holes are measured and marked accordingly at the appropriate locations on the polymer material layer and the protective film layer. Then the suitable holes are drilled as required by the engineering design. Alignment of the drilled holes must be assumed prior to installation of the anchors.

2) **Installing:** the polymer material layer is juxtaposed parallel to a transparent panel (glass) of the window panel. The protective film layer is located outside and juxtaposed parallel to the polymer material layer. Anchors on the two opposing edges are secured on the reinforcement structure. The reinforcement structure (steel cable and extrudate) is anchored to a supporting structure (wall) 10. A screw is installed on the reinforcement structure for securing edges of window.

3) **Sealing:** after securing the polymer material layer and protective film layer on the window panel, the air gaps around the perimeter of the polymer material layer and the protective film layer are sealed by a rubber washer or HS adhesive 9 to form a barrier with the environment to prevent air from entering the layers. Then a cover 5 is stuck to the exposing part of the fastening screw to enhance the aesthetics of the installation.

Based on the above mentioned structure and design, in the enhanced protective film system according to this invention, the polymer material layer is flexible and is capable of holding shattered/broken pieces of the window panel when an impact is received. The protective film layer provides additional tensile strength and deflection reduction capability of the window panel. The primary effect is a synergistic polymeric material and engineered anchoring system that significantly reduces the transfer load from the window panel to the structure and absorbs and dissipates the shock energy when an impact is

received. The enhanced protective film system according to this invention is capable of resisting, absorbing and dissipating high impact blast loads, reduces glass debris and keeps the window firmly attached to the supporting structure in the event of an explosion.

Example 2: the installation of the enhanced protective film system according to the invention and the test of its property.

FIG. 4A and FIG. 4B show a configuration of a blast-resistant window according to one embodiment of the invention. The blast-resistant window includes a window body and an enhanced protective film system, which is composed of a polymer material layer 1, a protective film layer 2 and a reinforcement structure 3. The reinforcement structure 3 is the mechanical fastener (anchoring device) (FIG. 4B).

The polymer material layer is juxtaposed parallel to a transparent panel (glass) 6 of the window panel. The protective film layer is located on the outside surface (a side of the polymer material layer that remote from the transparent panel of the window body) and juxtaposed parallel to the polymer material layer. The polymer material layer 1 and the opposing edges of the protective film layer 2 are secured onto the window frame 11 by the reinforcement structure 3. The extension of the reinforcement 3 is embedded within the wall to securing the top and bottom edges of the polymer material layer 1 and the protective film layer 2 to reinforcement structures embedded in the wall structures. The left and right edges of the polymer material layer 1 and the protective film layer 2 are sealed by sealant.

The above mentioned polymer material layer is a polymeric layer with the thickness of 3.0mm. The tensile strength and elongation of the polymer material layer are 76000psi and 308% respectively measured by means of ASTM D 638.

The above mentioned protective film layer is a polymeric layer with the thickness of 0.2mm. The tensile strength is 35,000psi.

The above mentioned anchoring device may employ the anchoring screw 14, crossing screw 15, self-tapping screw 16, masonry screw 17 or square nail 18 as shown in FIG. 5.

In the enhanced protective film system according to this embodiment of the invention, the polymer material layer is flexible and is capable of holding shattered/broken pieces of the window panel when an impact is received. The protective film layer provides additional tensile strength and deflection reduction capability of the window panel.

In this embodiment, where edges of the window panel are secured to reinforcement structures embedded in the wall structures, it would still be possible to manipulate (open and close) the window. A suitable fastener mechanism may be provided at the edges of the window panel to enable load transfer from an impact received by the window panel to the reinforcement structure.

As shown in FIG. 5, the above mentioned reinforcement structure 3 may be composed of mechanical fastener (anchoring device) and steel plate bar 19

(metal clip). The steel plate bar 19 is installed on the polymer material layer and the protective film layer, and on the two opposing edges of the window panel. The steel plate bar 19 (metal clip) and two opposing edges of the polymer material layer and the protective film layer are anchored onto the window frames by anchoring device. Other methods of installation are identical to those as shown in FIG. 4A and 4B.

For the installation of the enhanced protective film system in FIG 4C, the reinforcement structure (mechanical fastener) 3 could also be replaced by adhesive 12. Other methods of installation are identical to those as shown in FIG. 4A and 4B.

The blast-resistant window as shown in FIG. 5 and 4C is also capable of holding shattered/broken pieces of the window panel, and provides additional tensile strength and deflection reduction capability of the window panel.

Example 3: the installation of the enhanced protective film system according to the invention and the test of its property.

FIG. 6 shows a configuration of a blast-resistant window according to another embodiment of the invention. The blast-resistant window includes a window body and an enhanced protective film system, which is composed of a polymer material layer 1 and a protective film layer 2.

The polymer material layer is juxtaposed parallel to a transparent panel (glass) 6 of the window panel. The protective film layer is located on the outside surface (a side of the polymer material layer that remote from the transparent

panel of the window body) and juxtaposed parallel to the polymer material layer and adhered onto the transparent panel (glass) 6 of the window panel. The above mentioned polymer material layer is a polymeric layer with the thickness of 3.0mm. The tensile strength and elongation of the polymer material layer are 76000psi and 308% respectively measured by means of ASTM D 638. The above mentioned protective film layer is a polymeric layer with the thickness of 0.2mm. The tensile strength is 35,000psi.

In this configuration, the polymer material layer, being relatively flexible, is capable of holding shattered/broken pieces of the window panel when an impact is received. The protective film layer provides additional tensile strength and deflection reduction capability of the window panel.

In this embodiment, none of the edges of the polymer material layer 1 and the protective film layer 2 are secured to reinforcement structures embedded in the wall structures. In this configuration, the use of fastening screws for securing the polymer layer and the protective film layer would not be required.

Industry Application

Embodiments of the invention are suitable to be deployed in buildings and structures as protection against blasts and explosions, in window, full height glazing assembly, and curtain walls. They are capable of holding shattered/broken pieces of the window panel when an impact is received, and provide additional tensile strength and deflection reduction capability of the window panel. In addition to the enhanced level of protection, embodiments of the invention are particularly advantageous in retaining the transparency of the window panel. Also, the installation will not affect the aesthetics of the building

and its interior. Further, installation of embodiments of the enhanced protective film system invention requires little additional space.

【CLAIMS】

1. An enhanced protective film system comprising two transparent film layers, wherein, the first layer (1) is a layer of flexible film, and the second layer (2) is composed of at least one layer of film with high tensile strength.
2. An enhanced protective film system according to claim 1, characterized in that said first layer is a polymer material layer of transparent film with tensile strength greater than 2000psi and 100 percent elongation.
3. An enhanced protective film system according to claim 2, characterized in that said first layer is manufactured from the materials selected from the group consisting of polycarbonate, polyethylene terephthalate, polypropylene, silicone, and polyvinyl butyral.
4. An enhanced protective film system according to claim 1, characterized in that said second layer is composed of at least one layer of transparent film with tensile strength greater than 9000psi.
5. An enhanced protective film system according to claim 4, characterized in that said second layer is manufactured from the materials of polyester and/or polyester terephthalate.
6. An enhanced protective film system according to claim 5, characterized in that said polyester is polycarbonate and/or polystyrene and polymers of acrylic; said polyester terephthalate is polyethylene terephthalate.

7. An enhanced protective film system according to any one of claims 1-6, characterized in that said enhanced protective film system further includes reinforcement structure (3); said reinforcement structure is connected firmly with edges of the first and the second layers.

9. An enhanced protective film system according to claim 8, characterized in that said reinforcement structure is anchored or adhered to edges of said first and the second layers.

10. An enhanced protective film system according to claim 9, characterized in that said reinforcement structure is selected from the group consisting of metal/plastic strapping, angle steel, combined anchors, anchoring cables, cable catcher system and anchoring device.

11. A blast-resistant window comprising the window body, characterized in that said enhanced protective film system according to any one of claims 1-10 is installed on one side or two sides of transparent panels of said blast-resistant window.

12. A blast-resistant window according to claim 11, characterized in that said first and second layers are parallel to a transparent panel of the window body and are installed the same side of transparent panel of the window body; wherein, the first layer is adhered to the transparent panel of the window body, and the second layer is adhered to a side of the first layer that is separate from the transparent panel of the window body.

13. A blast-resistant window according to claim 12, characterized in that if the enhanced protective film system includes the reinforcement structure, said reinforcement structure is anchored to or adhered to said first and second layers; said reinforcement structure is also attached to the structure supporting the window body, is embedded in the structure supporting the window body, or is embedded in the frames of the window body.

14. A method of mounting said enhanced protective film system according to claim 1 comprising the first and second layers of said enhanced protective film according to any one of claims 1-6 are installed parallel to the transparent panel of window body, making the first layer attach to the side of transparent panel of window body and the second layer is adhered to a side of the first layer that is separate from the transparent panel of the window body.

15. A method according to claim 14, characterized in that said method further comprises that the gaps between said first and second layers, and the gaps between the layers and the transparent window panel are sealed.

16. A method according to claim 7 comprising that the first and second layers of said enhanced protective film according to any one of claims 7-10 are juxtaposed parallel to the transparent panel of window body, making said first layer attach to the transparent panel of window body and the second layer is adhered to a side of the first layer that is separate from the transparent panel of the window body; the reinforcement structure is anchored to or adhered to at least two opposing sides of said first and second layers, is attached to the structure supporting the window body, is embedded in the structure supporting the window body, or is embedded in the frames of the window body.

17. A method according to claim 16, characterized in that said method further comprises that the gaps between said first and second layers, and the gaps between the layers and the transparent window panel are sealed.