**BLAST PROTECTIVE FAÇADES**

**Introduction**

In our everyday life terrorist attacks due to blast are carried out with the intent to create panic, fear and shock in our society. In a blast event, the primary cause of injuries is the glass fragmentation that, projected inside the building, can affect the occupants.

Architectural tendencies lead to maximizing the transparency and natural daylight through the building and this is achieved by using full height glazed façades, creating in such a way a design paradox. “Hardening” buildings by minimizing glass surfaces areas and reinforcing the structure not only place restrictions on architectural freedom but also on occupants interaction with the built environment. Physical protection should also be considered a sustainable constraint in every building design.

Façades are the layer making the difference: a lot of components and different materials assembled together to create a physical separation between outside the building and its internal environment where occupants live or work. By understanding how these components interact as well as component material behaviour beyond the elastic range and under high strain rates, a fully glazed façade can often be economically achieved providing transparency, protection against the blast shock wave itself as well as glass fragmentation hazard reduction.

Protective façades represent an effective measure for the social and financial risk mitigation and they are often included into counter terrorism offices programs to build a resilient urban environment. Latest recommendations from western governments are towards a reduction of the financial exposure to insurance companies by means of mitigation risk analysis, with a consequent effect of a release of funds for investments in the short period.
Philosophy

Current blast design is driven by the balance between protection requirements and typical façade performances. The Permasteelisa Group approach is the “True Balanced Design” that, rather than designing each component at the maximum capacity, as suggested by the well-known “balanced design approach”, is conducted considering the dynamic interaction between the major components of the façade. In this way, Permasteelisa’s approach states that the optimal design solution comes from the balance among the structural integrity of framing members, the control of the glazing hazards and the minimization of the load transferred to the primary structure, once all the components are modelled in combination in order to capture the effects of their mutual interaction.

*True balanced design approach as intersection among design area for structural integrity (red), glazing hazard control (blue) and dissipative design for reaction to primary structure minimization (green).*
Technologies

In order to allow for economical building design yet provide appreciable levels of protection, blast enhanced façades are engineered to dissipate rather than resist blast loads. As a result, reaction load paths in a dissipative curtain wall façades subject to blast differ markedly to that of façades designed to elastically resist wind pressures. The evolution of Permasteelisa’s technology is offering the 3rd generation of applicable solutions. In this way, by combining the available different levels of “blast resistance technology” a wide variety of blast loads situations can be covered taking advantage from the beneficial effects of the flexible behaviour of the supports on the glazing response. All façade types are suitable for blast enhancement, but each one must be upgraded with respect to its critical component failure.

For instance, typical curtain wall unitized systems must be provided with additional devices to allow large deflections without panel disengagement, while slender framing elements usually adopted at podium area are likely to be governed by instability issues. Cable-net façade enhancement strategy involves the adoption of dissipative connectors in order to reduce the force to the cables and the ground as much as possible. The use of dissipative brackets gives the possibility to “adapt” a façade, designed only for wind loads, to offer protection against a wide range of possible low/medium threats. Or, as the blast load varies with the distance and the height, the solution applied in the different levels of the building can be differentiated under variable load conditions using the appropriate technology. The Permasteelisa Group used in-house developed numerical tools in order to support the design during the different phases of the project. All tools have been properly calibrated and validated by means of full scale shock tube and arena tests. All the major outcomes of the research have been therefore integrated into the proprietary software Testudo® for the unitized panels and into a tool integrated with the commercial software Sofistik® for cable-net façades.
Blast Energy Dissipative Components and Progressive Enhancement

The façade brackets serve to connect and transfer curtain wall panel reaction to the building. Excessive reactions due to blast loads may result in the structure requiring costly strength enhancement. The addition of a dissipative bracket serves to both reduce reactions to the main structure as well as reduce the risk of glass fragments hazards. A dissipative bracket can be designed as a fuse: so it is an efficient solution, giving the fact that the entire mass of the façade is mobilized to effectively dissipate blast energy. The main advantage being that dissipative brackets permit greater freedom in balancing the properties and size of the framing and glazing enabling greater cost savings and architectural flexibility.

The fundamental concept at the basis of the façade blast enhancement is that each façade is resistant to a certain level of threat. The upgrade of a conventional façade can be achieved by means of a progressive enhancement of its critical components:

- the majority of risk areas with a “low to medium” level of threat can be covered, with a limited impact on the cost of the façade, against conventional loads;
- on the contrary, once the design threat increases to a “medium to high” load, it requires the upgrade of framing cross section and glazing, which leads to a significant increase of costs.

The Permasteelisa Group has investigated design methods and dissipative components to be utilized in different façade types, from unitized curtain wall to cable-net façades.

Thanks to this experience, our blast enhancement solutions are tailored to each project and, therefore, they offer the best value for money to our clients.

Green Area: 70-80% of the total area requiring buildings with blast enhanced façades

Threat scenario in Canary Wharf | London and progressive façade enhancement
Project References

HEARST TOWER, NEW YORK, NY | USA

99 BISHOPSGATE, LONDON | UNITED KINGDOM

BATTERY PARK CITY, SITE 26, NEW YORK, NY | USA

HERON TOWER, LONDON | UNITED KINGDOM
BLAST PROTECTIVE FAÇADES

Customers’ Benefits

- High level of protection (minimized injuries to people)
- Minimum impact of the blast requirements on the aesthetics and other façade performances
- Reduction of the load transfer to the building
- Use of dissipative brackets to upgrade a façade designed for standard loads (for example during refurbishment) without impacting the building structure.
- Cost-effective solutions for the different levels of design threat

<table>
<thead>
<tr>
<th>Parameter</th>
<th>First generation (Resistant Façade)</th>
<th>Second generation (Enhanced Façade)</th>
<th>Third generation (Protective Façade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Design type</td>
<td>Stiff</td>
<td>Ductile</td>
<td>Dissipative</td>
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<tr>
<td>Target threat</td>
<td>Medium-High</td>
<td>Medium-High</td>
<td>Low-Medium</td>
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<td>Aesthetics</td>
<td>Strong Impact</td>
<td>Mostly Preserved</td>
<td>Highly Preserved</td>
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<td>Load transfer</td>
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<td>Reduced</td>
<td>Minimized</td>
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<td>Building Enhanced</td>
<td>Building Enhanced</td>
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<tr>
<td>Sustainability</td>
<td>- -</td>
<td>+</td>
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<tr>
<td>Cost effective</td>
<td>- -</td>
<td>++</td>
<td>+++</td>
</tr>
</tbody>
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