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Research Article

Dynamic Response of Cable-Supported Façades Subjected to High-Level Air Blast Loads: Numerical Simulations and Mitigation Techniques

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A glazing façade subjected to blast loads has a structural behaviour that strongly differs from the typical response of a glazing system subjected to ordinary loads. Consequently, sophisticated modelling techniques are required to identify correctly its criticalities. The paper investigates the behaviour of a cable-supported façade subjected to high-level blast loading. Nonlinear dynamic analyses are performed in ABAQUS/Explicit using a sophisticated FE-model (M01), calibrated to dynamic experimental and numerical results. The structural effects of the total design blast impulse, as well as only its positive phase, are analyzed. At the same time, the possible cracking of glass panels is taken into account, since this phenomenon could modify the response of the entire façade. Finally, deep investigations are dedicated to the bearing cables, since subjecting them to elevated axial forces and their collapse could compromise the integrity of the cladding wall. Based on results of previous studies, frictional devices differently applied at their ends are presented to improve the response of the façade under the impact of a high-level explosion. Structural effects of various solutions are highlighted through dynamic simulations. Single vertical devices, if appropriately calibrated, allow reducing significantly the axial forces in cables, and lightly the tensile stresses in glass panes.

1. Introduction

Modern buildings are frequently clad with futuristic glazing façades. In them, glass panels have not only architectural and aesthetic functions, but constitute structural components able to interact with the supporting metallic systems (frames, connectors, pretensioned cables).

Recently, numerous authors studied the dynamic response of different glass-cladding typologies, giving particular attention to the effects of initial imperfections [1], wind loads [2], or seismic events [3]. In the last years, also the blast-resistance of glass curtain walls received a remarkable increase of interest. Norville and Conrath [4] proposed simplified procedures for the design of blast resistant glazing elements. Larcher et al. [5] numerically simulated the behaviour of laminated glass loaded by air blast waves, by taking into account also the cracking of glass panes. Weggel and Zapata [6] numerically investigated the dynamic behaviour of a nearly conventional laminated glass curtain wall with split screw spline mullions subjected to low-level blast loading. Generally, the principal objective in the design of blast-resistant glazing systems consists in avoiding injuries and minimizing the structural damages. To guarantee these important objectives, the fixing components and the cladding wall should be able to resist the incoming blast wave. At the same time, they should be able to dissipate as much energy as possible, to minimize damages.

In this context, the use of appropriate devices, could improve the dynamic response of the glazing system affected by air blast loading. In [7, 8], the authors proposed two specific typologies of dissipative devices able to mitigate the effects of high-level explosions in the main components of cable-supported façades. The first [7] consists in elastoplastic devices introduced at the top of the bearing cables and able to manifest their main structural advantages in the cables. The second [8] consists in viscoelastic spider connectors