Construction and Building Materials 163 (2018) 921–937

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Review

Performance of structural glass facades under extreme loads – Design methods, existing research, current issues and trends

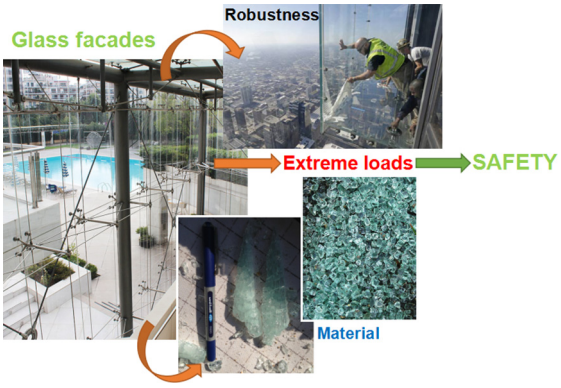
Chiara Bedon [a,*], Xihong Zhang [b], Filipe Santos [c], Dániel Honfi [d], Marcin Kozłowski [e,f], Michel Arrigoni [g], Lucia Figuli [h], David Lange [d]

[a] Department of Engineering and Architecture, University of Trieste, Trieste, Italy
[b] Centre for Infrastructure Monitoring and Protection, School of Civil and Mechanical Engineering, Curtin University, Bentley, Australia
[c] New University of Lisbon, Lisbon, Portugal
[d] RISE Research Institutes of Sweden, Borås, Sweden
[e] Silesian University of Technology, Gliwice, Poland
[f] LTH, Lund University, Lund, Sweden
[g] ENSTA Bretagne, Brest, France
[h] University of Žilina, Žilina, Slovakia

HIGHLIGHTS

- Glass in windows and facades is largely used, for many practical reasons.
- Material intrinsic features make glass facades one of the most vulnerable component of buildings.
- Fail-safe design requirements are mandatory, especially under extreme loads.
- Design methods for some key extreme design actions are analysed.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 22 August 2017
Received in revised form 12 December 2017
Accepted 22 December 2017

Keywords:
Structural glass
Glass facades
Extreme loads
Design standards and regulations
Vulnerability
Mitigation and protection

ABSTRACT

Glass has been overwhelmingly used for windows and facades in modern constructions, for many practical reasons, including thermal, energy, light and aesthetics. Nevertheless, due to the relatively low tensile strength and mostly brittle behaviour of glass, compared to other traditional materials, as well as to a multitude of interacting structural and non-structural components, windows/facades are one of the most fragile and vulnerable components of buildings, being representative of the physical line of separation between interior and exterior spaces. As such, multidisciplinary approaches, as well as specific *fail-safe* design criteria and analysis methods are required, especially under extreme loading conditions, so that casualties and injuries in the event of failure could be avoided and appropriate safety levels could be guaranteed. In this context, this paper presents a review of the state of art on analysis and design methods in use for glass facades, with careful consideration for extreme loading configurations, including natural events, such as seismic events, extreme wind or other climatic exposures, and man-made threats, i.e. blast loads and fire. Major results of available experimental outcomes, current issues and trends are also reported, summarising still open challenges.

* Corresponding author at: Department of Engineering and Architecture, University of Trieste, Piazzale Europa 1, 34127 Trieste, Italy.
E-mail address: chiara.bedon@dia.units.it (C. Bedon).

https://doi.org/10.1016/j.conbuildmat.2017.12.153
0950-0618/

Contents

1. Introduction

The industrialized use of glass as a load bearing material for construction is a relatively recent solution, compared to traditional and consolidated solutions such as timber, steel, concrete or masonry. On one hand, positive arguments related to the thermal, energy, light and aesthetic performance of glass lead to continuously increasing applications including an evolution towards geometrically complex solutions, see Fig. 1. On the other hand, due to the relatively low tensile strength and brittle behavior of glass as a material in load bearing applications and as a result of a need to address large deformations, glazing windows and facades represent a highly fragile and vulnerable component for buildings. This is true especially when extreme loading conditions are expected at the design stage, or could even occur over the lifetime of a given structural system, where glass envelopes provide the physical line of separation from the exterior. As a general rule, multidisciplinary approaches and specific *fail-safe* design criteria, including advanced analysis methods able to take into account the intrinsic properties of glass are required, so that casualties and injuries can be avoided in the event of failure and appropriate safety levels can be guaranteed (i.e. [1,2]).

The current review paper, in this context, aims to present the state of the art of analysis and design methods in use for glass

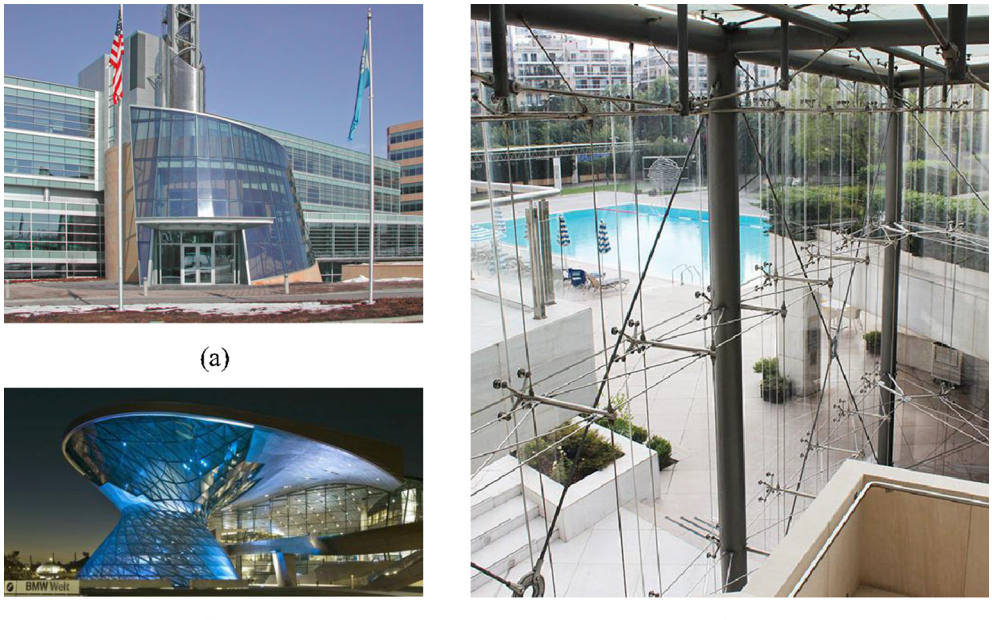


Fig. 1. Examples of glass facades.