Thermal and structural assessment of novel GFRP-glass sandwich facade components via numerical simulations

Chiara Bedon[1*], Fabio Favoino[2], Carlos Pascual Agullo[3], Alessandra Luna Navarro[4] and Mauro Overend[5]

[*] Corresponding Author

[1] Department of Engineering and Architecture, University of Trieste, Italy, chiara.bedon@dia.units.it, tel. +39 040 558 3837

[2] Eckersley O'Callaghan, United Kingdom, fabio@eocengineers.com, tel. +44 20 7354 5402

[3] Glass & façade technology research group, Department of Engineering, University of Cambridge, United Kingdom, carlospascualagullo@hotmail.com

[4] Glass & façade technology research group, Department of Engineering, University of Cambridge, United Kingdom, al786@cam.ac.uk, tel. +44 7843 855 942

[5] Glass & façade technology research group, Department of Engineering, University of Cambridge, United Kingdom, mo318@cam.ac.uk, tel. +44 1223 332659

Abstract text

Introduction & motivation - This poster showcases new early investigation results on novel GFRP-glass sandwich façade component and follow the previous investigations performed at the Glass & Façade Technology Research Group (University of Cambridge, UK) [1]. These sandwich structures are made of two tempered glass panes separated by, and bonded to, glass fibre-reinforced polymer (GFRP) pultruded profiles. The main objective is to develop a novel façade component able to meet strict modern building envelopes requirements with a slimmer and lighter sandwich systems that is high structurally and thermally performant.

Design optimization & research goals - The optimal design of novel GFRP-glass sandwich systems should take into account a combination of geometrical, thermal and mechanical properties for each component, as well as their reciprocal interaction. To this aim, their potential and feasibility is assessed via coupled thermal and structural Finite- Element (FE) numerical simulations and compared with traditional equivalent systems.

Methods & preliminary results - The exploratory investigation is carried out in ABAQUS [4], by taking into account a wide set of geometrical and mechanical configurations of technical interest for GFRP-glass sandwich assemblies. As a reference study, a modular unit with 1.5×3m size, composed of 10mm thick glass panes (5mm the middle layer) is taken into account, including variations in:

- GFRP frame members (cross-section features and size, hence stiffness)
- adhesive joints providing the GFRP-to-glass bonding (size and type)
- spacers (size and type)

For each sandwich configuration, two separate FE simulations are then carried out in ABAQUS, including a static analysis (with 1kN/m^2 the assigned wind pressure) and a thermal simulation. The typical FE model is hence properly described, so to take into account the actual mechanical and thermal interaction of all the module components. In doing so, a FE model representative of 1/4 each module is used for parametric simulations, taking advantage of its symmetry.

Major FE outcomes and sensitivity of the so observed thermal & structural performances to input parameters are then critically discussed. In doing so, reference geometrical configurations (i.e. with metal frames) are also taken into account for comparative purposes.

Preliminary results are collected in the graph, for few selected configurations only from the full parametric study, as compared with traditional facade solutions with metal frame. The maximum reaction force at a single facade module support is represented as a function of the deflection measured at the centre of glass, including the corresponding U-values. As shown, despite further comparative studies are required, the well-promising structural and thermal performance of the explored GFRP-to-glass solutions can be noticed, hence suggesting further investigations and developments on this novel design concept..

Acknowledgments - The ongoing COST Action TU1403 is gratefully acknowledged for providing financial support for a Short-Term Scientific Mission of Dr. Bedon (April 2016) at University of Cambridge, as well as for facilitating scientific networking and collaboration between the involved researchers.

Keywords

GFRP-glass sandwich, structural performance, thermal performance, design optimization, numerical modelling

Event Theme

4 – The Architectural Challenge

References

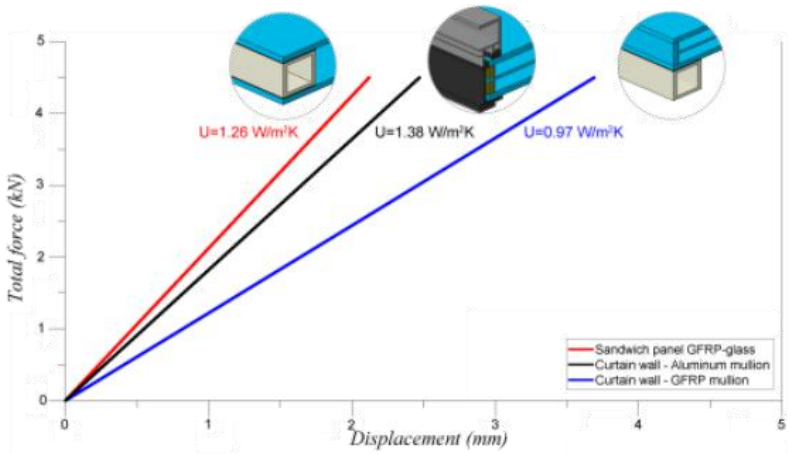
[1] C PASCUAL, J MONTALI, M OVEREND (2017). Adhesively-bonded GFRP-glass sandwich components for structurally efficient glazing applications. Composite Structures, 160: 560-573

[2] C BEDON (2016). Review on the use of FRP composites for facades and building skins. American Journal of Engineering and Applied Sciences, 9(3): 713-723

[3] C BEDON, C LOUTER (2017). Numerical analysis of glass-FRP post-tensioned beams - Review and assessment. Composite Structures, 177: 129-140

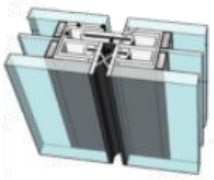
[4] ABAQUS computer software.6.14, Simulia, Dassault Systems

Mechanical and thermal response of sandwich panel and curtain wall configurations

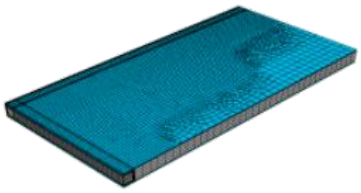


GFRP-Glass sandwich panel

Mock-up



Schematic view



Numerical model