glass & façade technology research group
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UNIVERSITY OF CAMBRIDGE
Department of Engineering

The Glass & Façade Technology (gFT) Research Group provides solutions to real world challenges in the field of structural glass and façade engineering through fundamental and application-driven research

Bi-annual Newsletter

Spring/Summer 2014 Issue

Recent News

1 The gFT research group has recently secured a research award from the Institution of Structural Engineers. The awards are presented to individuals or teams to encourage high quality research with the involvement of industry. In this case the funding will be used to investigate FRP-glass composite behaviour in collaboration with industrial partners. The judges agreed that "the project was deemed to have many potential benefits and potential for widespread application." Details of the outcome of this research will be published by the end of 2014.

2 Qian Jin has graduated with a PhD in Engineering after successfully completing her four year research project within the gFT research group at the University of Cambridge. Her research focuses on the whole-life value based multi-objective optimization of facades. A copy of her thesis and papers can be found on the gFT website.

3 Marco Zaccaria of gFT recently visited the Technical University of Denmark for a short term scientific mission, hosted by Dr Nielsen in order to investigate the stress relaxation of fully toughened glass with a finite element analysis script. Similarly, gFT hosted Sandra Jordão, assistant professor at the University of Coimbra and Manuel Santarsiero, PhD student at EPFL. The topic of Sandra's visit was the behavior of structural glass pre-tensioned systems. Manuel investigated the elastic and viscoelastic response of adhesive polymers (SentryGlas and TSSA) under compression stress state by means of indentation testing. All exchanges were funded by the European Research Network on Structural Glass.

Mechanical performance of full-scale steel-glass composite panels

Fig. 1: Bending test rig with a full-scale specimen (a) full view; (b) connection of specimen to frame and (c) rubber-padded steel loading plates.

Shelton Nhamoinesu of gFT has recently completed experimental investigations on steel glass composite panels as part of his PhD project with the support of TATA steel, Permasteelisa and EPSRC. The tests involved 3.5m by 1.5m full-scale steel-glass composite panels bonded by a high strength two-part acrylate adhesive and subjected to short-term flexural loads where the glass bends about its minor axis (Fig. 1). Three different specimen configurations were tested; (i) double glazed one-way spanning – Specimen A1 & A2; (ii) double glazed two-way spanning – Specimen B1 and (iii) single glazed one-way spanning – Specimens C1, E1 and E2. A non-composite Specimen D1, with a geometric configuration similar to the composite single glazed specimens was also tested for comparison.

In addition, a non-linear numerical model for predicting the flexural response of the composite panels was constructed and compared with the experimental results.

Test results revealed that high strength adhesive bonding of steel-glass panels mobilises a significant degree of composite action; Fig. 2 shows that double glazed composite panels exhibited high strength and stiffness up to initial failure. Furthermore, the panels achieved substantial and sustained post-fracture strength and stiffness. The non-composite single glazed layered panel with no adhesive bonding had a very low stiffness and low load carrying capacity compared to the composite single glazed panels.

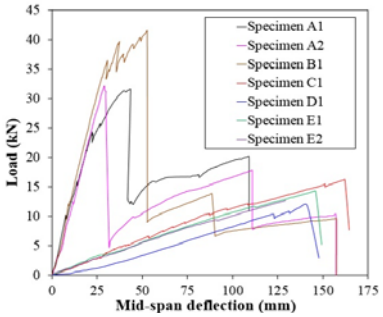


Fig.2: Plots of Load (kN) vs mid-span deflection at centre of top glass panel (mm) for bending tests of all specimens.

The numerical model (Fig. 3) of the steel-glass composite panels generally showed very good agreement with the mechanical response of the panels.

Further work is however required to characterise the long-term performance of the high strength acrylate adhesive used for bonding the panels. More research is also needed to predict the post-fracture performance of such composite panels.

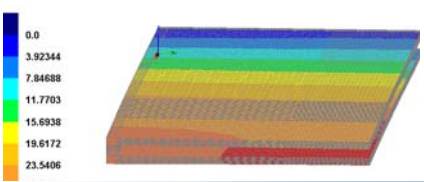


Fig. 3: FEA Model for double glazed one-way spanning composite specimens showing the displacement contour plot when the first glass panel is expected to fail.

Adaptive Building Envelopes for High Performance Buildings

"...An environmental diode, a progressive thermal and spectral switching device, a dynamic interactive multi-capability processor acting as a building skin...trading energy surplus for energy need...adapting itself to provide best possible interior conditions..."

There is no better description and architectural inspiration on the concept of the adaptive building envelope than this Mike Davies' vision described in his article "A Wall for All Seasons", in 1981. Although many adaptive/dynamic building envelope materials and systems have been developed, there is still no clear understanding of what the ideal adaptiveness of a façade should be in order to minimize energy consumption and maximise indoor environmental comfort (Fig. 4).

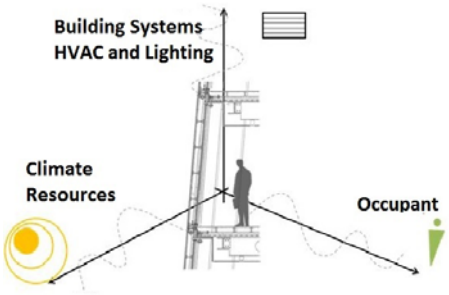


Fig. 4. Domains of interactions of the ideal adaptive building envelope.

Fabio Favoino's PhD project aims to address these unclear issues in order to direct R&D towards the development of optimized adaptive building envelopes. The research activity of the first year of this PhD project, funded by EPSRC and Wintech ltd., is presented in the PhD First Year Report, together with the research plan for the next two years, which was recently submitted to the Board of Graduate Studies of the Department of Engineering.

The first part of the report, titled "Adaptive Building Envelopes for High Performance Buildings" provides a general framework and review of the state-of-the-art adaptive materials and systems. The second part presents the quantitative methods to evaluate the energy and environmental envelope together with different evaluation tools and software. Finally different research areas and priorities are listed highlighting the main aim and objectives of this PhD.

The first results of this project (Fig. 5) were presented at the Building Simulation and Optimization 2014 conference in London, UK. The paper is entitled "The route to ideal dynamic glazing façade".

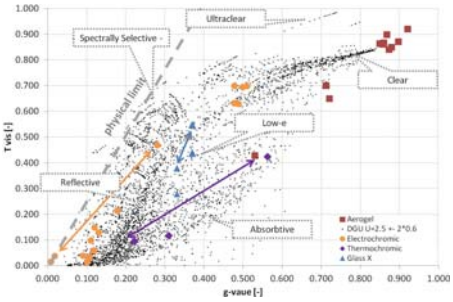


Fig. 5. Performance of smart windows compared to conventional static DGUs.

Successful conclusion to European Research Network on Structural Glass

The Challenging Glass Conference held in February 2014 in Lausanne, Switzerland, marked the conclusion of the 4-year European Research Network on Structural Glass (TU0905). The network funded by the EU's Framework for Cooperation in Science and Technology (COST) was launched in April 2010. The network attracted over 80 participants (researchers and practitioners) from 25 countries.

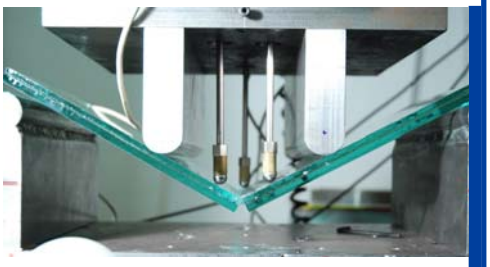
There are several useful outcomes from the Network ranging from an education pack on structural glass containing the state-of-the-art design recommendations and sample calculations; training schools for early stage researchers; knowledge transfer between leading research centres in Europe by means of short term visits and longer term strategic collaboration. Four working groups were set-up during the course of the Network:

- WG1 Predicting complex loads on glass structures
- WG2 Material characterization and material improvement
- WG3 Design methods incorporating risk analysis and post-fracture performance (Fig. 6)
- WG4 Novel glass assemblies

Details on the achievements of each these working groups is available in the:

- COST Action website: www.glassnetwork.org
- Proceedings of the Challenging Glass 4 & COST Action Final Conference
- COST Office website: www.cost.eu

The gFT research group was one of the instigators of this COST Action and was actively involved in several of the initiatives. Some of these will continue beyond the official end of the network in the form of project-specific research collaborations and joint teaching initiatives. Other façade-specific research collaborations will be continued and extended in a new COST Action on Adaptive Facades (TU1403) that the gFT research group has helped to secure. This is expected to be officially launched by the end of 2014.



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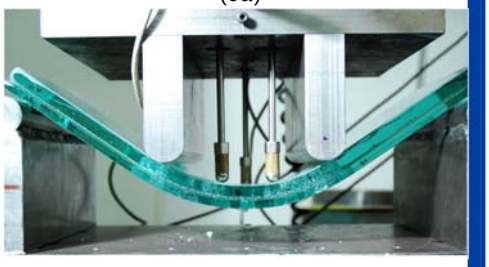

(6b)

Fig. 6: Two modes of post fracture performance single crack fracture (top); multiple crack fracture (bottom).

Online Resources

A new page has recently been launched in the gFT website. This contains links to the electronic resources that have been developed in our group that may be downloaded freely including: 1) Façade process map 2) Interconversion between viscoelastic material functions. The resources can be accessed at www.gft.eu.com featuring user instructions and further information about the resource.