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

The Glass and 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 Research Newsletter

Spring/Summer 2015

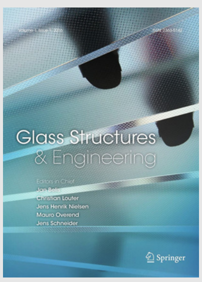
Recent news

1 gFT welcomes three new researchers Isabelle Paparo, Dr Carlos Pascual Agulló and Dr Marco Donà. Isabelle's and Marco's research will focus on the structural performance and connections of freeform FRP building envelopes and is funded by Newtecnic. While Carlos's postdoctoral research will focus on a new generation of a multifunctional FRP-glass composite panel that has the potential to integrate architectural, building physics and structural requirements in a single component.

2 Dr Shelton Nhamoinesu has successfully defended his PhD on "Steel Glass Composite Panels" after completing his research within the gFT Research Group. His project was funded by TATA Steel and EPSRC.

3 gFT researcher Corinna Datsiou has received an award for her presentation on the "Design and Performance of Cold Bent Glass" at the 17th Young Researchers' Conference organised by the Institution of Structural Engineers. Her PhD is funded by Eckersley O'Callaghan and EPSRC.

4 Call for papers: Glass Structures and Engineering. This high-level scientific journal addresses all aspects of structural glass research and applications and is expected to be published at the end of 2015/ start of 2016.



Towards optimised smart glazing

The development of adaptive building envelope technologies, which adapt to changing outdoor and indoor environments and preferences, is considered a crucial step towards the achievement of the nearly Zero Energy Building target. It is currently not possible to accurately evaluate the energy saving potential of innovative adaptive transparent building envelopes, thus posing a barrier to systematic development of innovative adaptive building envelope technologies.

A paper, titled "The optimal thermo-optical properties and energy saving potential of adaptive glazing technologies" was recently published by F. Favoino and M. Overend from the gFT, together with Dr Jin from Tonjii University in the international journal Applied Energy.

The main aim of this work is to present a method and a simulation framework for devising optimal adaptive façade technologies. This is applied to the case study of optimal adaptive glazing properties, evaluating their energy saving potential in an office building, under different climates and orientations. The method uses an inverse performance - oriented approach i.e. devising the optimal adaptive properties that minimize the total primary energy use of a building. A frequency analysis on the set of optimised adaptive properties is also performed to identify salient features of ideal adaptive glazing, which could be used to guide future product development.

The results show that high energy savings are achievable by adapting the transparent part of the building envelope alone, the largest component being the cooling energy demand. Important features of the optimal thermo-optical properties are identified. One of these, is that a unique optimised technology, that can vary its thermo-optical properties between a limited number of states could be effective for different buildings, in different climates and orientations.

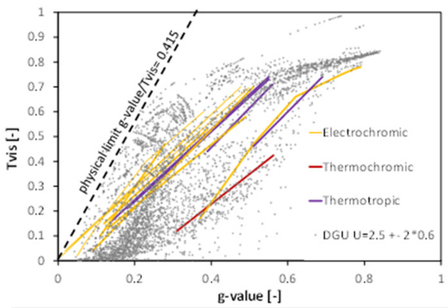


Fig.1: T_{vis} and g-value of smart glazing technologies compared to commercially available static DGUs.

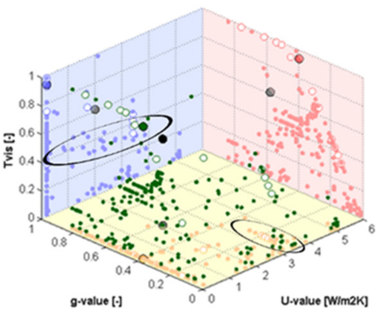


Fig. 2: Ideal thermo-optical properties

(Reference: grey big dot; Yearly: green big dot; Monthly: white dots; Min: green small dots) and their projections for Rome ideal glazed façade south oriented. Dashed circles represent concentrations of optimal solutions in certain areas.

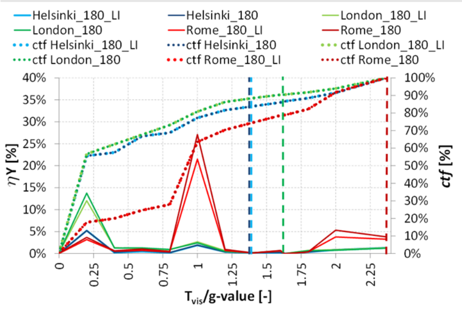


Fig. 3: Frequency analysis for South oriented ideal adaptive glazing properties: Tvis/g-value

Replace or...repair?

Glass used in buildings is often exposed to sources of surface damage which can have a significant effect on its appearance and strength. Research from non-construction sectors suggests that the flaws in glass can be repaired successfully by transparent polymeric resins, but the amount of strength recovery and the reasons for the increase in strength are not fully understood and are not easily transferable to building applications.

In a recent study at gFT, more than 300 soda-lime-silica glass specimens covering three surface flaw scenarios, three repair scenarios and two post-repair exposures were tested. Contact angle measurements and post-failure fractographic analyses were also performed to assess the extent of resin penetration into the surface flaws.

The test results showed that resin repairs can have a very significant effect on the appearance of the flaw (Fig. 3) and can also increase the strength of the damaged glass, but the strength recovery falls very significantly short of the strength of undamaged glass (Table 1).

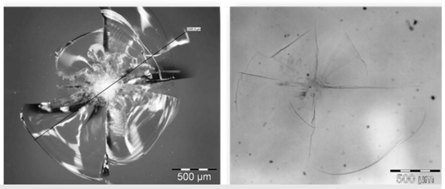


Fig.3: Typical indented glass specimen; (left) unrepaired; (right) resin-repaired.

The acrylic resin used in this study had the lowest viscosity and consistently outperformed the epoxy resin. The largest strength recovery was observed for the linear scratches that were exposed to air after acrylic resin repair (Table 1). Subsequent exposure to water had an adverse effect on the strength of repaired specimens. Finally, the statistical analysis showed that the mean strength values often reported in literature are not always representative of lower fractile values required in engineering design applications (Table 1). Further details on this study are available in a scientific paper entitled "The effectiveness of resin-based repairs on the inert strength recovery of glass" published in the June 2015 edition of the Journal of Construction and Building Materials.

*Table 1: Strength values relative to as-received undamaged glass for series repaired with acrylic resin and tested after air-exposure (*Design strength based on the probability of failure=1/1000)*

	INDENTED GLASS		SCRATCHED GLASS		WEATHERED GLASS	
	Strength		Strength		Strength	
	Mean	Design*	Mean	Design*	Mean	Design*
Damaged state	18%	23%	25%	14%	70%	15%
Repaired state	24%	22%	34%	42%	76%	21%
Repaired/damaged ratio	1.3	0.9	1.3	3.1	1.1	1.4

Thermal performance of glazed curtain wall systems

The optimisation of curtain wall thermal performance can lead to a reduction in the building's energy consumption with a simultaneous increase in the levels of occupant comfort and improved façade durability.

Recent investigations at the gFT focused on different aspects of the thermal performance of curtain wall systems in order to achieve higher performance. This work was performed within the European project S+G "Innovative Steel Glass composite structures for high-performance building skins".

Numerical and experimental investigations were used to develop high performance connections between the glazing and the curtain wall framing system. Their performance was then evaluated and compared to state-of-the-art connections. The profile of the surface temperatures and the U-values of the design options were obtained numerically. Optimisation of the material selection and the design of the connection followed, involving the use of spacers with higher performance or sealants/ gaskets to minimise condensation risk. It was found that the thermal linear transmittance (ψ-value [W/mK]) can be reduced up to 50% by using thermoplastic spacers instead of common aluminium ones (Fig. 4).

Experimental investigations by gFT involved the use of a climatic cell of the TEBE research group at the TU of Torino. The aim of the experimental analysis was to investigate the effective improvement of the performance in the connection options and to validate the FEA model.

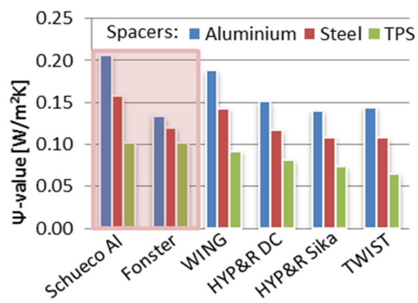


Fig. 4: Ψ value over the variability of spacer used. Reference designs highlighted.

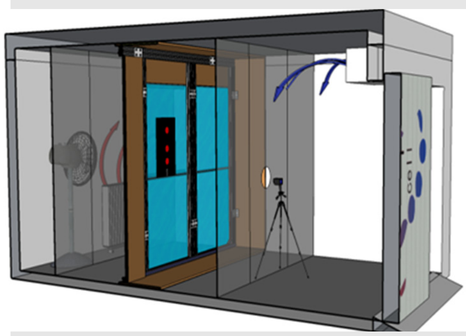


Fig. 5: Climatic cell configuration, showing the glass façade installed.

" Structures and Buildings' " issue on Structural Glass

The current (July 2015) issue of the Institution of Civil Engineers Journal, Structures & Buildings is entirely devoted to Structural Glass. This themed issue was edited by Mauro Overend and contains papers ranging from the mechanical properties of glass, to connections and from buckling of glass elements to how finite-element analyses effectively in the design of real-world structural glass projects.