Recent news

1 gFT member Kenneth Zammit successfully defended his PhD thesis on Wind Engineering of Glass Facades. In his PhD, Kenneth established more accurate and reliable means of predicting the performance and strength of glass panels in single and multiple wind storm events.

2 gFT member Corinna Datsiou presents her recent research on the "Evaluation of Artificial Ageing Methods for Glass" at the Challenging Glass Conference 5 in Ghent, Belgium.

CGC5

3 The 1st printed issue of the Glass Structures & Engineering journal was published, consisting of 20 full length research papers on a wide range of glass-related research topics and real-world applications.

4 gFT research group member Fabio Favoino has recently achieved his chartered engineer status (CEng) via CIBSE, The Chartered Institution of Building Service Engineers.

5 A booklet on the state-of-the-art of Adaptive Facades was recently published by the Adaptive Facades Network. The booklet, jointly edited by Mauro Overend provides a snapshot of ongoing European research on Adaptive Facades and a summary of other activities supported by the network.
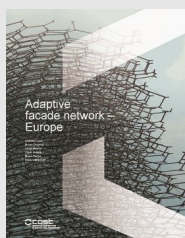
Thermal performance of GFRP-glass façade systems

Up to 30% of worldwide greenhouse gas emissions are generated by buildings services and therefore improvements in buildings energy efficiency have a key role in reducing climate change. Among all building requirements, thermal comfort is the most energy intensive and it is strictly related to the energy flows through the building envelope. Novel sandwich facades systems made of low conductivity. GFRP core profiles, structurally bonded to two outer glass face sheets (Fig. 1a), have the potential to provide slim, lightweight and energy-efficient glazed facades. These façade systems can outperform traditional glazed façades, in which metallic frames (supporting glass infill panels) cause significant thermal bridges between outdoor and indoor built environments.

A CFD (computational fluid-dynamics) model has been developed to study the conductive, radiative and convective heat transfer through the novel GFRP-glass sandwich systems (Fig. 1b) in order to evaluate their thermal performance. The model has been validated by hot-box experiments performed on GFRP-glass panels (Fig. 1c). In the frame region of new GFRP-glass systems, modelled U-values were approximately 50% lower than in equivalent aluminium-glass systems.

In addition, the modelling of the centre of pane area has shown that an intermediate glass pane in between the two outer face sheets could reduce U-values by around 30%. Different height-to-width ratios of the GFRP-glass panels were modelled in order to evaluate variations in the convective heat transfer through the air gap. Larger ratios result in greater convective heat transfer (Fig. 2) and, consequently, lower thermal resistance. These results were in agreement with predictions of classic heat transfer theory.

Further investigations are underway and will consider the effects of glass coatings, different air gap gases and GFRP-glass panel geometries in the thermal performance of the novel GFRP-glass systems.
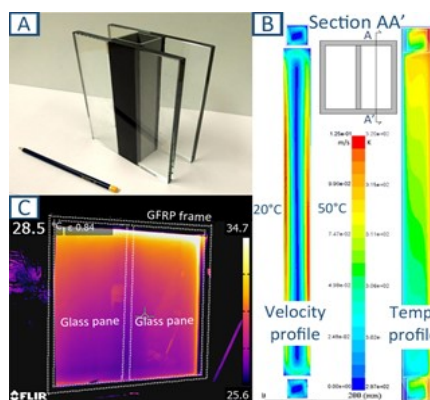

Fig. 1: a. Adhesively-bonded GFRP-glass sandwich specimen, b. Air flow and temperature pattern inside gap in steady state conditions, c. Thermogram of GFRP-glass panel during experiments.
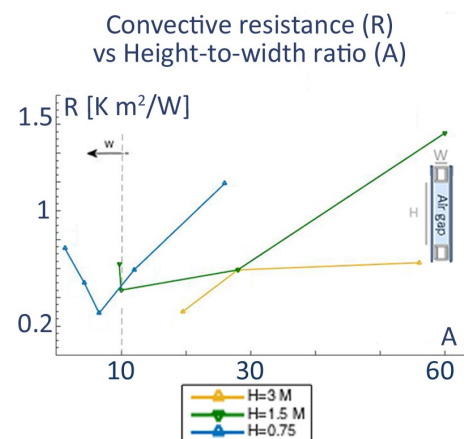

Convective resistance (R) vs Height-to-width ratio (A)

Fig. 2: Thermal resistance of the air gap with different Height-to-width ratio.

Performance Analysis of Dynamic Insulation Materials

Approximately 20 - 40% of energy in the developed countries is consumed in the buildings. Energy consumption has conventionally been addressed by increasing the thermal resistance of the building envelope e.g. high performance/ thicker insulation panels in the opaqueparts of the building envelope.

A more responsive insulation that adjusts its physical properties in response to operating conditions could further improve building energy performance. Examples of responsive facades include partitioned multifunctional smart insulation, phase change material wallboard and switchable glazing. The purpose of this study is to quantitatively analyse the energy-saving potential of such adaptable insulation for building envelopes. The thermal performance of an adaptable facade hinges on two aspects: first, the magnitude of heat transfer through the façade and second, the effectiveness of control systems that actuate the adaptable façade.

The research was undertaken in three steps: (1) the theoretical study on heat transfer was reviewed and the influence of meteorological conditions, building design and its operation on heat transfer through facades was studied; (2) a programme to understand and test the performance of different control strategies ranging from basic on-off control to advanced model predictive control was developed; (3) existing building performance simulation software was coupled with the control algorithms to assess the energy-saving performance of adaptable insulation in different climate and operating conditions.

The outcome of this study showed that the energy-saving potential of such adaptable insulation is insignificant when the period of switch between conductive and insulated states is more than couples of days.

Significant energy savings were achieved at higher switching frequencies, e.g. every 10 minutes. In this case study, energy savings of approx. 12% are achieved in an office building in a temperate climate (according to Köppen climate classification) compared to the benchmark building with static insulation.

Monthly cooling loads reduction in % (July)
- Internal Heat Gains=75W/m2
- Internal Heat Gains = 31W/m2

Fig. 4: Monthly cooling loads reduction due to switchable insulation in different climates.

*Köppen climate classification: Am (Tropical monsoon climate); BWh (Hot desert climate); Csb (Mediterranean climate-warm); Dfb (Humid continental climate); Dfc (Subartic climate) **Internal heat gains = Occupants + lighting + equipment.
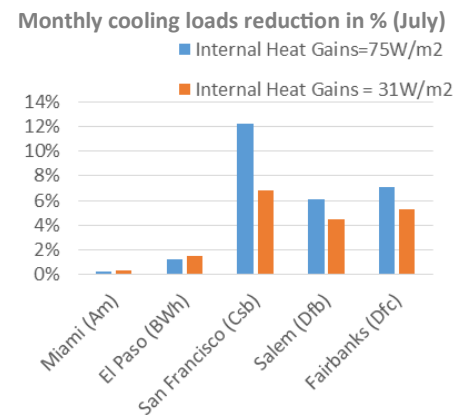
Load Bearing Capacity of GRC to metal bracket connections

Glass reinforced concrete (GRC) façade panels are relatively thin elements made of a mix of mortar and glass fibres which provide a degree of bending strength, significantly higher then plain unreinforced concrete and sufficient to disperse of conventional steel bar reinforcement. Another advantage of this material is its production process which consists in spraying the GRC paste into a mould surface, allowing for free-form geometries. As a result, GRC panels are now used as building envelope components in building with complex geometry where more traditional materials would be prohibitively expensive to manufacture.

Embedded connectors are used to attach the GRC panel to the supporting structure. The design of the connection between GRC and connectors is still not covered by standards and consequently requires project-specific designs. The performance of the connection between a bespoke steel bracket and the GRC edge rib was evaluated in the context of a real world application (the Grand Theatre of Rabat). The behaviour and stress distribution of the connection under axial and transversal force was first numerically analysed (Fig. 5a,b)and showed a good agreement with the experimental (Fig. 5c) tests. During the experiments, both pull-out and shear loading conditions showed an initial crack at the midspan of the tensile side and subsequently a cone failure. This was due to a combined effect of bending moment and localised shear stress. Finally, the pure pull-out strength was determined by testing a specimens with negligible bending effect given by reducing the span of the specimen. Compared with the previous longer specimen tests, only the cone failure and an increased strength was observed.
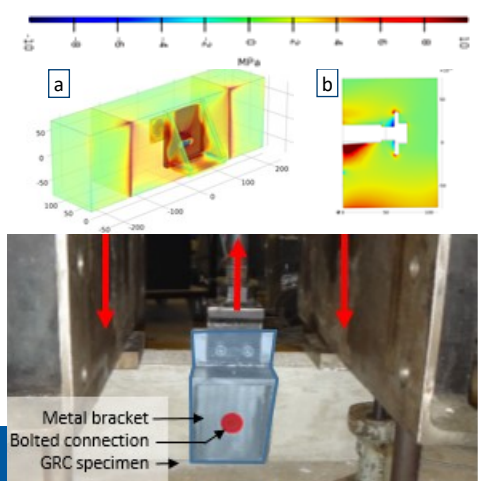

Fig. 5: a. Numerical model – shear test, b. Cross-section (only GRC), c. Experimental set-up (transversal force).