

Recent news

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gFT member Isabelle Paparo has been awarded doctoral funding by the Friedrich-Ebert-Foundation (FES) for the next 2 years of her PhD on the structural performance of freeform FRP build-



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Dr Mauro Overend was recently appointed by the European Commission to help draft the Glass Eurocode. He joins 5 other experts from across the EU who have been tasked with drafting the new standard.



3

The 5th Engineered Skins symposium was held on the 9th of September 2015 at the University of Cambridge with a total of 80 attendees. The symposium was kicked off with the thought provoking welcome of Prof Burgoyne, followed by the gFT members' research presentations and the two inspirational presentations of the external keynote speakers, Graham Coult from Eckersley O'Callaghan and Stefan Marinitsch from Seele.

4

Dr Overend was one of the 9 invited speakers at the "Building the World of Tomorrow" event, held at the University of Cambridge and supported by Breathing Buildings. Among others his talk "Current trends in High Performance and adaptive Facades". were designed to inspire and challenge the 100 pioneers and leaders from the construction industry.



5

gFT is now officially represented on LinkedIn.



Adhesively-bonded FRP-glass sandwich structures modelled successfully

Sandwich structures are layered components generally made of two thin, dense and stiff face sheets separated by a thick, low dense and less stiff core layer. This arrangement results in a lightweight structure with much greater bending stiffness, and buckling capacity, than the individual layered components. Building envelopes – subjected to both bending and compressive loads – are therefore ideal candidates for the sandwich construction.

Novel sandwich structures optimized in terms of transparency, durability and fabrication cost could be designed with stiff glass face sheets adhesively-bonded to GFRP pultruded core profiles (see Figure 1). In this new configuration, daylighting is allowed and the GFRP material is efficiently protected from weathering. FRP-glass facade systems investigated in the past used to present only one glass face sheet and therefore did not take advantage of the sandwich effect. However, with two structural glass face sheets the sandwich effect can be activated whilst also the thermal performance of the building envelope can be improved due to the thermal insulation provided by the air cavity between the face sheets.

The analytical prediction, in the early-stage design process, of the structural stiffness of sandwich components is necessary due to the strict requirements in building standards – i.e. structural design is frequently determined by deflection limits. However no analytical model existed to predict the stiffness of sandwich structures with discontinuous

cores (e.g. pultruded GFRP profiles) adhesively-bonded to continuous face sheets. An analytical model of the stiffness of these structures has been developed in an EPSRC-funded project at gFT. The model was validated with four-point bending experiments (see Figure 2). The wider validity of the model has been shown by predicting the stiffness of an alternative set-up, consisting of a long-span (1500 mm) sandwich beam made of a glass core adhesively-bonded to FRP face-sheets. This analytical model constitutes a valuable tool for the preliminary design of FRP-glass sandwich envelopes.



Figure 1: Adhesively-bonded glass-GFRP sandwich structure.

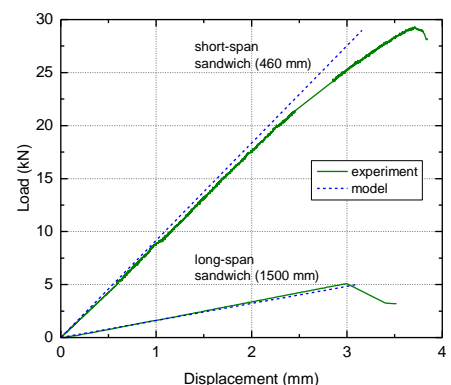


Figure 2: Experimental results and model predictions for two adhesively-bonded glass-GFRP sandwich beams subjected to four-point-bending.

Integrated Early Stage Façade Design

Façades are becoming increasingly complex, due to a variety of performance requirements. Their initial consideration as structural elements that filter the external environment, has evolved into a system with a wider spectrum of performances. Energy efficiency regulations impose higher levels of thermal insulation and air-tightness, while maintaining indoor comfort levels. Comfort, in turn, requires the façade to provide the expected thermal, acoustic and light performance. Additionally, façades must perform over the intended service-life and satisfy architectural requirements.

Therefore, façade design is one of the most interdisciplinary engineering disciplines. Early-stage manufacturability issues are amongst the most relevant aspects in façade design: no high performance design can be achieved without knowing how façades will be manufactured. In common practice, this is usually achieved through a series of design loops between architects / consultants / manufacturers where the relevant knowledge is seldom captured and reused subsequently.

The aerospace, shipbuilding and automotive industries have developed Knowledge-Based Engineering (KBE) approaches for storing and reusing different types of knowledge. KBE interprets design as a holistic process by integrating different design and manufacturing aspects into a single system.

gFT member, J Montali, funded by Laing O'Rourke and EPSRC, is developing a tool for the definition of knowledge-based meta-models of façades that include both design and manufacturing knowledge. The aim is to reduce design errors and lead times while increasing design variability thereby leading to a Mass Customisation approach.

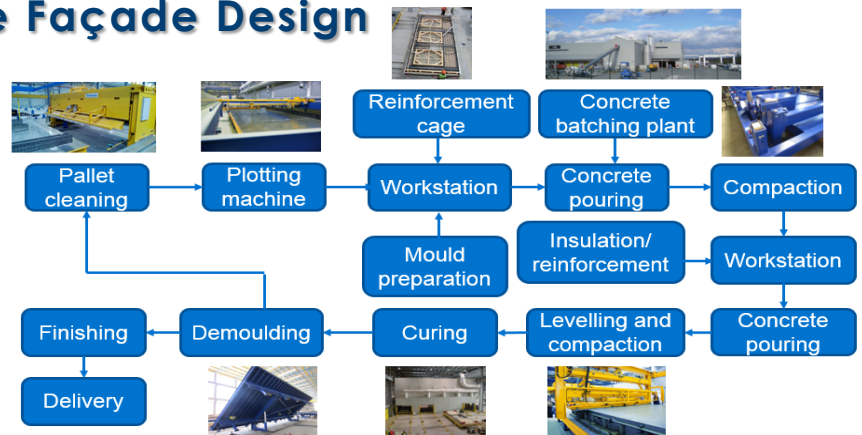


Fig. 3: Manufacturing process of a concrete sandwich panel.

FRP-Based High-Performance Envelopes

Geometrical complex building envelopes are typical in contemporary architecture. The conventional approach during their design is to provide a succession of layers in the build-up, each one addressing a particular requirement (thermal, structural, water tightness etc.). This approach often becomes problematic and costly in geometrically complex envelopes. Fibre reinforced Polymers (FRP) have successfully been used in aerospace and marine industries. Thus, FRP's can potentially provide an integrated, loadbearing and lightweight solution for geometrically complex building envelopes.

The design of the limited number of FRP facades to-date tends to be bespoke and involves costly and time-consuming prototype testing. This research project aims to establish a design method for FRP sandwich panels in façade applications ultimately enabling a more widespread use in façades.

The mechanical performance and the cost were evaluated for a wide range of materials of the FRP industry. It was found that glass epoxy laminate ($v_f=60\%$) face sheets in combination with a closed cell PVC foam core satisfy the design objectives [Fig. 4 a & b].

Prototypes of this FRP sandwich composition will be manufactured and evaluated structurally but also aesthetically.

This testing program will investigate the long-term behaviour of the adhesive bond between the various components as well as the aesthetic deterioration, with the aid of accelerated artificial ageing. Numerical models validated by experimental testing will explore further the design options with FRP Sandwich panels.

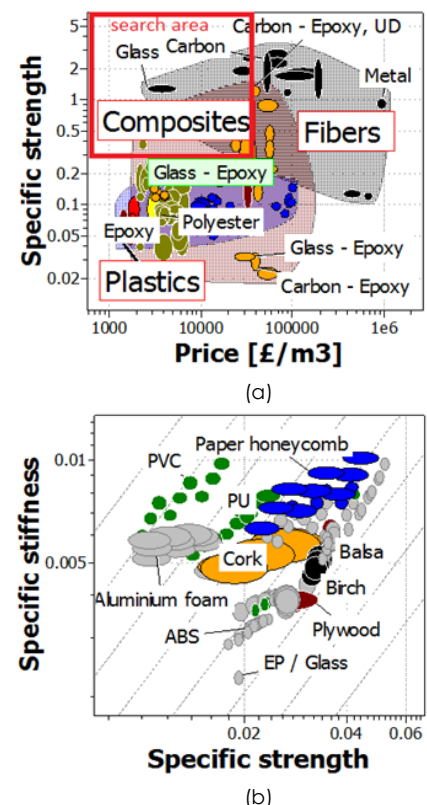


Fig. 4: (a) Strength vs. cost for face sheet materials and; (b) strength vs. stiffness for core materials with quasi-orthotropic glass-epoxy face sheets. Source: CES EduPack ©.

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