



## **Free-form Curved Façades:** *An investigation into the manufacture and properties of GFRP sandwich panels*

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**Overview** | *Composite sandwich panels are becoming increasingly popular in Civil Engineering due to their superior strength and stiffness-to-weight ratio. One of the main barriers to using this material in structural facades is the high cost associated with the use of fixed moulds in the manufacturing process. This project investigates the potential of manufacturing large GFRP sandwich panels via a vacuum resin- infusion process, but without fixed moulds. The properties of panels manufactured using this mould-less method are determined and the results are used to assess the effectiveness of this material on a real-world facade project.*

**Main Outcomes** | *Tests done on the sandwich panels, according to the ASTM standards, showed a good correlation with the results predicted via traditional sandwich theory, particularly when the beams failed via face-sheet tensile failure. However, with shorter beams, the panels experienced local indentation and crushing of the core below the load points which caused a lower failure load than expected. The core also showed visco-elastic effects between the loading bars in 4PB tests. It could, however, be concluded that using the mould-less vacuum technique in the Structures Laboratory did not affect the properties of the final product. The results obtained from finite element analysis in Abaqus also agreed strongly with the results, so analysis was conducted on larger scale panels such as those found in facade applications. These, along with analysis on a 54mm thick full-scale shell, showed that GFRP sandwich panels are a very suitable material for structural facades with deflections remaining within acceptable limits.*

**Future Work** | *The failure modes investigated in this project did not include local indentation which proved to be the critical mode for short beams. This should therefore be looked into further. In order to minimise deflections in the shell structure, extra supports were included to represent load bearing glazing mullions. The feasibility of this suggestion should also be investigated.*

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