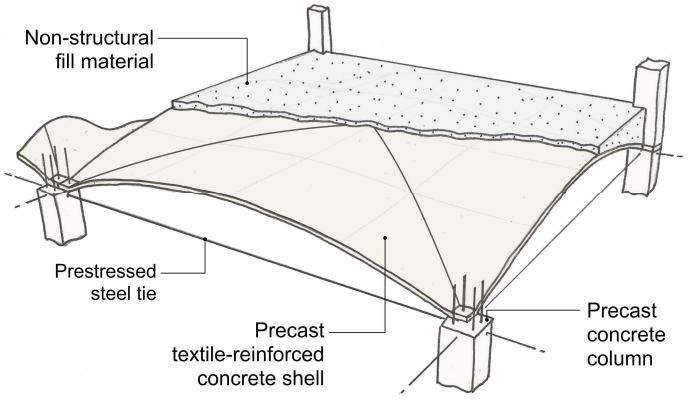
Thin-shell textile reinforced concrete floors for low-carbon buildings

Will Hawkins
University of Bath

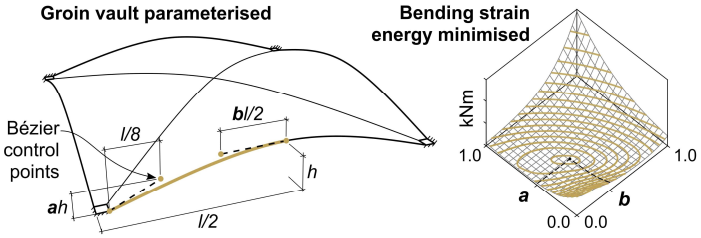
1. Overview

In this research project, a novel vaulted concrete flooring system was developed which dramatically reduces material usage and embodied carbon compared to traditional slabs and beams. The solution features thin shells in compression, steel ties in tension, and a granular fill providing a level floor surface, mass and vibration damping.



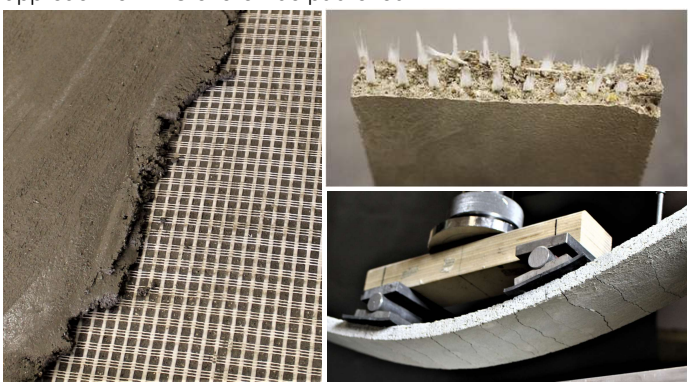
2. Geometry and optimisation

The geometry is that of a groin vault, commonly seen in historical masonry vaults. This simple, singly-curved shape is simple to construct using timber formwork but maintains high stiffness and buckling resistance, and also allows for service integration. Parametric optimisation was used to maximise the structural efficiency of the system, by minimising the total bending strain energy under a variety of worst-case live loading patterns.



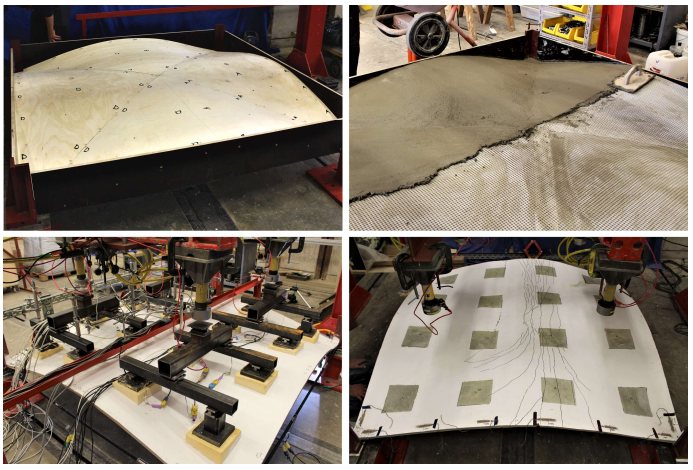
3. Textile reinforced concrete (TRC)

The shell includes two layers of glass fibre textile reinforcement, providing additional bending strength, deformation capacity and robustness. Extensive testing was carried out to determine the structural characteristics of this novel material, and a new design approach for TRC shells was published.



4. Construction and testing

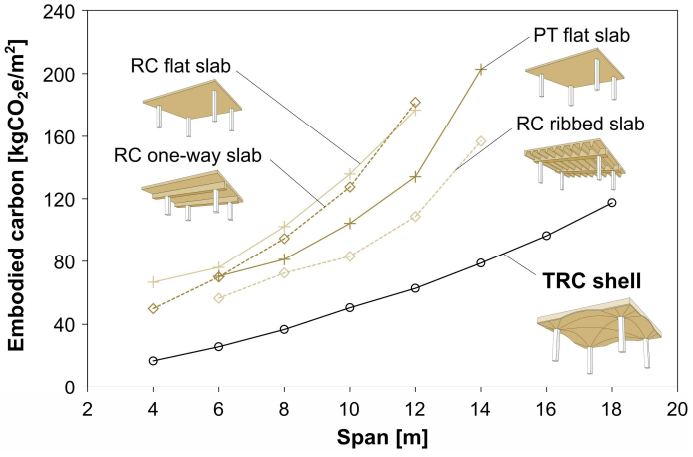
Two quarter-scale test specimens, 2m in span and 18mm thick, were constructed and tested under asymmetric loading. With a high stiffness and ultimate capacity of over 16kN/m^2, the structure was shown to meet typical structural requirements for floors whilst using minimal material. Construction feasibility was also demonstrated using a simple formwork system, and the reinforcement provided ductility for a safe 'soft' failure at the ultimate load.



5. Embodied carbon reduction

A complete design methodology was developed, verified and used to generate feasible designs across a range of spans and floor loads. In all cases, the total rise was one-tenth of the span. These were compared with a variety of traditional concrete floor types, showing significant reductions in embodied carbon across all spans, and the potential for high efficiency at very large spans.

Although continued testing and development is required, particularly concerning fire and vibration performance, this project has demonstrated that efficient vaulted floors can offer a step-change reduction in the embodied carbon of concrete buildings.



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