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THIN-SHELL CONCRETE FLOORS FOR SUSTAINABLE BUILDINGS

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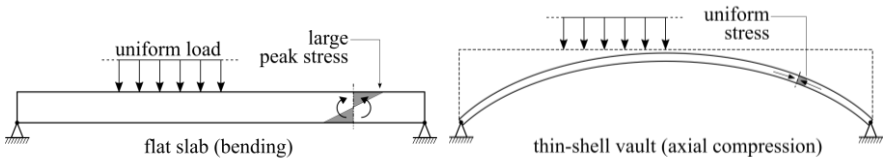
BACKGROUND

In the UK, the construction and operation of buildings contributes to approximately half of all CO_2 emissions. As the operational efficiency of new buildings steadily improves, the total life-cycle CO_2 comes to be dominated by the construction materials. The building structure itself is the largest single contributor to embodied CO_2, of which the majority is typically contained within the floors (Foraboschi *et al.*, 2014).

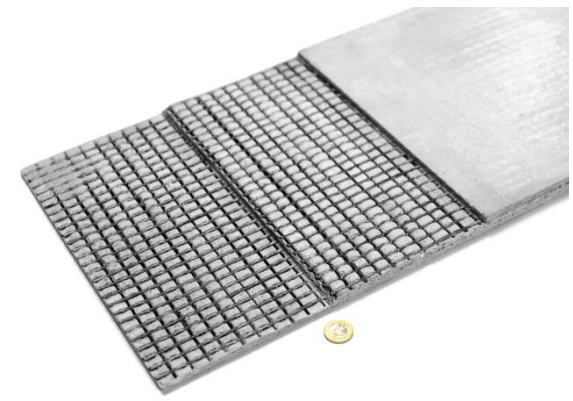
A typical concrete-framed building features reinforced concrete flat slabs as the floor structure, chosen due to their fast construction time, simple formwork, and low structural depth. However, the uniform slab thickness does not acknowledge the force distribution within the structure, leading to large reinforcing steel requirements and inefficient use of materials.

This project explores an alternative approach to concrete floor slabs using vaults, with the aim of minimising embodied energy.



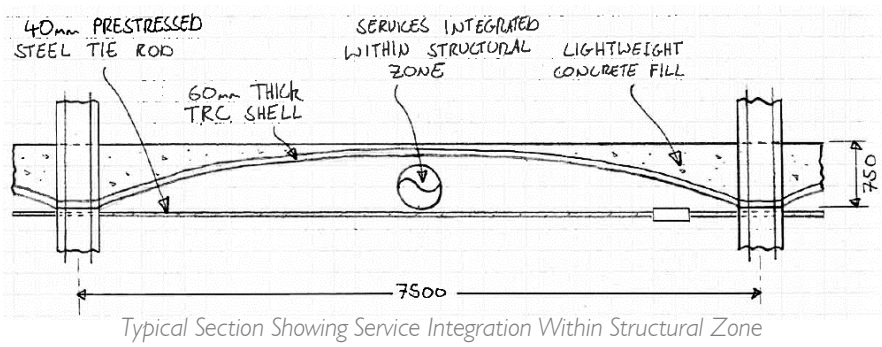
Large Stresses Caused by Bending are Minimised by Replacing a Flat Slab with a Thin Curved Vault

PROPOSAL

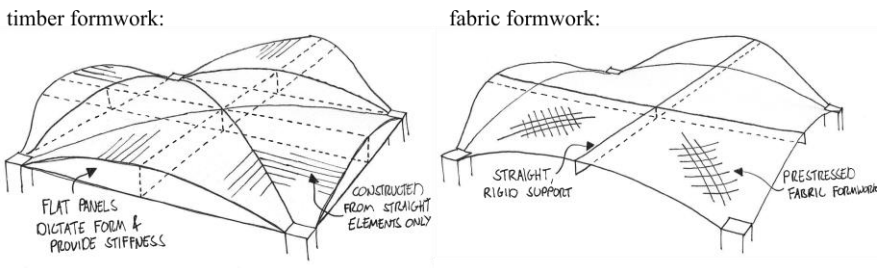


Textile reinforced concrete (TRC) combines glass, carbon or basalt fibre reinforcing meshes and fine-grained concrete in alternating layers to create a material with a high tensile strength and ductile structural response

In the proposed system, a thin, curved TRC shell spans between column supports to create a vaulted ceiling. TRC is well suited to forming curved shell structures due to the flexibility if the reinforcement, and since there are no cover requirements for corrosion protection, the minimum section thickness is smaller than for conventional steel reinforcement.

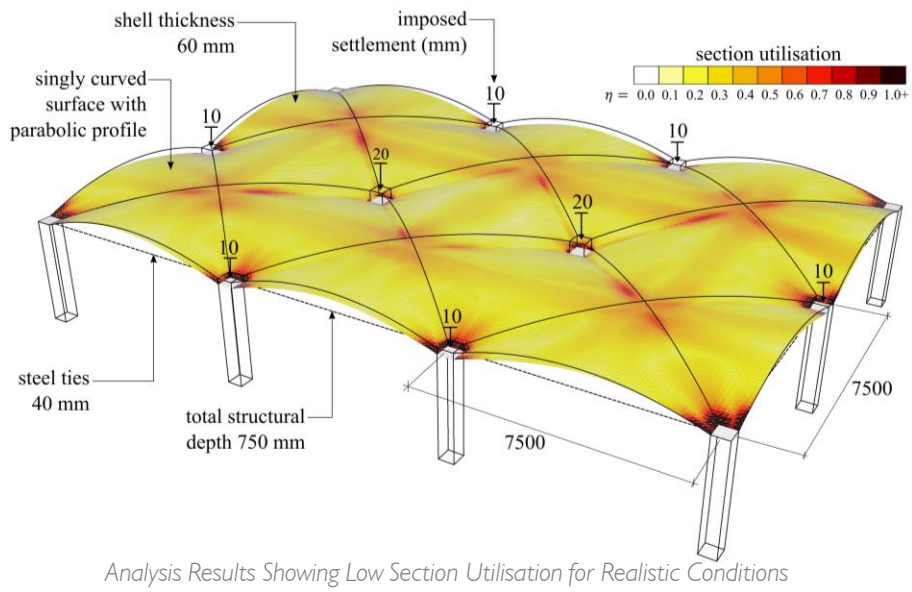


Typical Section Showing Service Integration Within Structural Zone



Proposed Timber and Fabric Formwork Systems

ANALYSIS & RESULTS



Analysis Results Showing Low Section Utilisation for Realistic Conditions

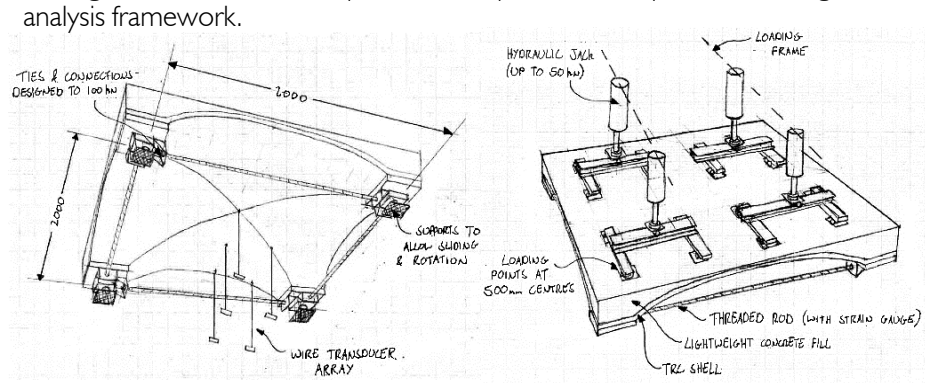
An analysis was carried out for a typical multi-storey office building designed to UK standards. A 60 mm thick TRC section reinforced with carbon fibre (as described by Scholzen et al. (2015)) was shown to be feasible with substantial opportunities for further material savings.

CONCLUSIONS

- The shell's performance relies on precise positioning and prestressing of ties as well as considered analysis of load and settlement patterns
- The structural feasibility of the proposed flooring system has been demonstrated in a preliminary study
- Significant savings in self-weight (53%) and embodied energy (>26%) can be achieved compared to flat slabs

FUTURE WORK

A programme of physical testing has been devised in order to explore construction methods, determine the structural behaviour and verify the predictions of the analysis model. A more sophisticated analysis method will also be introduced and verified through comparison with the test results, leading towards the development of a practical computational design and analysis framework.



Quarter-scale Prototype Test Set-up

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ACKNOWLEDGEMENTS

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