Novel Morphologies of Aluminium Cross-Sections through Structural Topology Optimisation Techniques

It is proposed that improvements to cross-sectional stiffness could provide a range of benefits to aluminium structures. Attributed to the beneficial physical and mechanical features, introduction of design codes, and technological as well as industrial developments, the use of aluminium has increased significantly. However, the extent of application of aluminium in building structures is limited by its low elastic modulus, since it is linearly related to deformations and stability of structural members. In order to overcome the inherent deficiencies of aluminium, advantage has to be taken of the flexibility of extrusion process, which allows fabrication of almost any cross-sectional shapes.

This study investigates novel morphologies of cross-sectional profiles of aluminium beams and columns, through the combination of 2D and 3D structural topology optimisation techniques. The method is based on the principle of optimising the number and size of openings within a design space to achieve an improved weight-to-stiffness ratio. With a focus on post-processing and manufacturability; a series of unique cross-sectional profiles are proposed, along with selection criteria to allow for the additional consideration of cost and aesthetics.

A final component of the research was then to conduct geometric and materially non-linear finite element analysis using ANSYS in order to evaluate the performance of the optimised sections and compare them against conventional and newly designed profiles. The ultimate load capacities and corresponding deflections were recorded for a series of members with varying span-depth ratios and support conditions. During comparison of both beams and columns, some optimised cross-sections have been able to out-perform the comparative conventional shapes of equivalent cross-sectional depth and mass. Although limitations in the methodology have been identified, the effectiveness of structural optimisation in the creation of aluminium cross-sections has thus been proven.

References

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