Optimised Internal Structure for 3D-Printed Sandwich Elements

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Abstract

The paper describes how internal structures for Fused Deposition Modeling (FDM) 3D Printing (3DP) can optimise the structural capacity of large-scale plastic freeform sandwich elements.

FDM enables the mould-less fabrication of plastics, allowing cost-effective production of geometrically complex artefacts. In architecture, FDM can be used for the fabrication of large-scale freeform sandwich panels [1]. To fabricate large FDM 3D-printed elements, wide diameter extrusion is often chosen. This leads to higher strength parts and reduces fabrication-time, but also to heavier components. Thus, achieving structural integrity while maintaining lightness remains one of the biggest challenges of the FDM 3DP. Instead of increasing the material thickness, the research investigates how one can reinforce the overall structure effectively by integrating infill structures in 3D prints.

While conventional infill strategies for FDM are limited to vertically extruded geometries, a more performative inner structure – the valvular lattices are oriented 3-dimensionally in multiple directions – has been investigated in small-scale [2]. However, FDM 3DP of this optimized inner structure requires 3D-printed additive support which slows down the fabrication process. Especially in large-scale fabrication, this increases the manufacturing-time critically.

Building upon this knowledge, the research investigates a strategy of utilizing the 3D infill structures for large-scale applications in order to optimise the weight-to-strength ratio of freeform FDM 3D-printed double-shell structures. Those infill structures eliminate the need for the support and hence minimize the fabrication-time.

The methodology consists of the following aspects: the development of the parametric design of infill structures and related fabrication strategies; the structural evaluation through three-point flexural and compression tests; and the full-scale demonstration of a 3D-printed chaise longue as a sandwich, double-shell structure.

A key achievement was to improve the structural capacity dramatically, compared to the conventionally generated vertical structures while using the same material amount and requiring the same 3DP-time. By applying the strategy into large-scale, the geometrically complex chaise longue was fabricated and proved empirically the structural functionality of the optimally 3D-printed internal structures.

References

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