From rapid prototyping to real building: methodologies for upscaling additive manufacturing prototypes to functional architectural components

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Abstract

The manufacture of architectural components in ceramic materials mediated by computer-controlled additive manufacturing (AM) technologies has highlighted several positive aspects of their application, namely the ability to perform customised design solutions or high performance complex geometries, adapted to the context of the design problem they want address. However, taking into account the technical and logistical limitations that Liquid Deposition Modelling (LDM) entails, such as having technical constraints in terms of in-situ production area, also the need to fire the material at high temperatures or even the production time per element, this type of manufacturing does not yet know applications in real context that attest its added value.

Based on the data taken from previous research works developed at Advanced Ceramics R&D Lab [1], where only small scale prototypes has developed, and researches that try to evaluate the applicability of 3D printing for large scale construction [2], this paper intends to list and describe methodologies and good practices for the execution of architectural ceramic components produced by AM at full scale, transporting this technology to the "initially thought" context.

The research methodology comprises the analysis of the small-scale models produced so far and subsequent production of the same elements at real scale, to understand what data can be inferred and transported to the production of real scale models. In the opposite direction, the inverse methodology is also tested with the production of models directly at real scale and later production of models at reduced scales, to cross data with previous tests. This cross-information results in a set of assumptions that can assist in the development of large-scale parts.

The study focuses on and enumerates the variables that should be considered in each situation. What are the advantages of implementing small scale prototypes? What are the parameters and factors to consider when planning to build at a real scale? What data can be inferred from reduced scale prototypes and transported to large-scale production? What are the biggest constraints? In addition to that it addresses material issues such as thickness, height, plasticity index and material composition, as well as modelling issues, showing the influence of geometric variations on the final piece, pointing out situations that should be avoided and situations that should be privileged.

Keywords

Ceramic 3D printing, additive manufacturing, ceramic retraction, parametric design, computational models.

References

[1] https://www.aclab-idegui.org/

[2] Peters, B. (2014). *Building Bytes: 3D Printed Bricks*. In: Gramazio, F., Kohler, M., Langenberg, S. (Eds.). (2014). *Fabricate 2014: Negotiating Design and Making*. London: UCL Press.