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Mass customization with additive manufacturing: new perspectives for multi performative building components in architecture

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Abstract

Innovative production methods and advanced manufacturing techniques slowly but certainly seem to find a way to be introduced in Architecture thanks to the progressive tools for computational design which enhance digital fabrication processes and programming. In this context Mass Customization refers to the possibility to evolve from already existing systems to the novel ones that can be personalized, without increasing their cost and causing the new technologies to emerge.

Among various manufacturing techniques, Additive Manufacturing (AM) is considered a revolutionary technology that offers a new freedom in Architecture and expands the range of possibilities for design, production and performances of novel architectural forms, construction systems and materials employed. The main advantage of Additive Manufacturing is the quasi total freedom in organizing material deposition, where the matter can be placed only where structurally needed and in that way provide interesting scenarios in the optimization of construction components and new forms of printed tectonics.

This paper will analyse an experimental case study of a 3d printed clay brick designed and manufactured with innovative technologies in order to respond to the new requirements of market and introduce new perspectives of Mass Customization with Additive Manufacturing for the design of Multi Performative Building Components.

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Keywords: Mass customization; computational design; multi performative building components; additive manufacturing.

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1. Introduction

Architecture quite often seems to be resilient to changes. Therefore, advanced manufacturing techniques and innovative production methods appear to be neglected or postponed within this field. This is due to traditional construction methods and consolidated processes of production which are driven by economic issues more than the effective need for innovation and improvements. However, emerging construction processes are more and more influenced by novel design methodologies that enable new ways of manufacturing. Among them, computational design, early stage engineering, topology optimization and material distributions are the most significant ones [1]. In this context *Mass Customization* refers to the possibility to evolve from already existing systems to the novel ones that can be personalized, without increasing their cost and causing the new technologies to emerge. Among various manufacturing techniques, *Additive Manufacturing (AM)* is considered a revolutionary technology that offers a new freedom in Architecture and expands the range of possibilities for design, production and performances of novel architectural forms, construction systems and materials employed. The main advantage of Additive Manufacturing is the quasi total freedom in organizing material deposition, where the matter can be placed only where structurally needed and in that way provide interesting scenarios in the optimization of construction components and new forms of printed tectonics. In this sense, Additive Manufacturing can arguably match the economic viability of fordist and lean production, together with a very high level of customization and precision related to a mutual dependence between computation and advanced manufacturing techniques, giving a new competitiveness to Architecture Engineering Construction (AEC) sector. Particularly, in order to meet requirements of nowadays performative and competing design-to-fabrication techniques, it is important to produce elements, components or overall integrated systems with highly specific characterisation, while keeping its cost lower.

2. Innovative technologies for mass customization

Mass Customization can theoretically be considered as an oxymoron, since it is putting together the two seemingly contradictory notions like ‘mass’ and ‘customization’ [2]. It focuses on the idea that personalizing industrial production is gaining a higher relevance either in the design concept, either in the production and construction phase, raising the possibility to develop Innovative Technologies.

Innovative Technologies for Mass Customization in Architecture are at least two: **computational design** and **advanced manufacturing techniques.**

2.1. Computational design

Computational Design is a contemporary technique that enhances overall design-to-fabrication processes by incorporating various material, structural and geometrical data to compose, describe and inform architectural design and performances. This means that the process is no longer linear, assessing properties and performances when the design phase is over, but reiterative, where information are exchanged and connected to design from the very beginning.

Computational Design can give at least three possibilities:

- to engineer a specific form from the early concept of the Design Process;
- to customize machines and tools for the materialization of a specific design;
- to activate certain embedded properties of a material more than others as a main driver of performative design.

Designers are therefore able to combine and develop multiple tools and create geometrically complex structures, optimizing various parameters to control whether the inputs or the analysis results. The knowledge of a proper coding language, such as Python, C# or Visual Basic, opens up wide range of possibilities for scripting desired geometries and creating custom made tools or plugins with highly specified properties and performances. The