Chapter 16

Parametric Morphogenesis, Robotic Fabrication, and Construction of Novel Stereotomic Hypar Morphologies: Hypar Gate, Hypar Wall, and Hypar Vault

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ABSTRACT

The chapter explains the studies the New Fundamentals Research Group is carrying out on the digital update of stereotomy. Between the various experiments, the chapter focuses on the group or prototypes designed by the geometry of the hyperbolic paraboloid, both at the macro (architectural organism) and micro scale (architectural elements). Several full-scale prototypes have been designed and built, using specific parametric codes, to define the geometrical morphogenesis properties of the built structural morphologies. Consequent theoretical reflections are fully explained.

INTRODUCTION

The interest around stereotomy started to reawaken between the early 1990s and 2000s, within the researches about the History of Construction (Evans, 1995; Heyman, 1997; Huerta, 2003; Dunkeld et al., 2006). This new favourable cultural climate has allowed rediscovering the discipline, both for its historical value and the unexpressed design possibilities. The diffusion of parametric modelling and digital fabrication tools has created the ideal conditions to design and build new stereotomic prototypes, which
are typically characterized by considerable architectural and geometric complexity. Stereotomy, in fact, is no longer a historical discipline relegated to the distant past, but it is returned to being the subject of study in several research centres in the world (i.e. Politecnico di Bari, ETH Zürich, MIT Boston, ENSA Paris-Malaquais, University of Sydney), as one of the cutting-edge disciplines of digital fabrication.

Following this path, the chapter explains the researches who the New Fundamentals Research Group (NFRG) is carrying out on the digital update of stereotomy. Between the various experiments, the chapter focuses on the group of prototypes designed using the geometry of the hyperbolic paraboloid, both at the macro scale (architectural organism) and micro scale (architectural elements). Several full scale prototypes have been designed and built, using specific parametric codes to define the geometrical morphogenesis properties of the structural morphologies.

BACKGROUND: DESIGN AND TECHNOLOGICAL CHALLENGES OF STONE ARCHITECTURE

The production of stone architecture faces two relevant challenges: the first is related to theoretical design aspects and the other one is related to technology and fabrication. They are obviously linked, but they must to be faced in two different moments of the design process.

Design Challenges

Design and build with stone is not simple, but not even impossible. In the past, design and build with stone was very common in the largest part of Europe and Asia. Specially in Europe, stone was (and still is) abundantly available and, consequently, the theoretical and practical competences to design and built with this material were largely diffused. This condition has contributed to its knowledge spread, diffusing a proper constructive culture. Instead, nowadays it is possible to observe the absence of consolidated and communicable cultural design practices on the subject. In fact, the researches on the theme are carried out mostly by doctoral dissertations (Fallacara, 2004; Rippmann, 2016; Gadaleta, 2017; Barberio, 2017). To be widely known and diffused, the research should be easily comprehensible and widespread, a goal that the complexity of a doctoral research not always can achieve. Moreover, who wants to try to face the design of an innovative stone architecture, has to surely manage a series of themes (form finding, tessellations, etc.) which need a high time consuming to be master properly, time not always adequately available. Consequently, all this early difficulties, could discourage the designer who finishes to fall back on more reassuring and canonical solutions, because of the lack of robust skills on the subject.

Therefore, it is necessary to start from a basic knowledge which must to be as more clear and replicable as possible. In this way, more designers will be encouraged to experiment. It is possible that they could produce imperfect concepts, but however perceptively similar to the correct and optimized version of the project. It is important to point out that in architecture, formal, structural and materiality are only some of the aspects to consider. Because there are many other to investigate, it is important that the design process remains easy to manage but, at the same time, conceptually rigorous. In the early design phases, during the concept development, it is not necessary to produce a “perfect” idea, but it is important to consider all the main elements of the project, in order to be develop it further without major alterations. The aspects to unavoidable consider from the beginning of the conceptual development of stone architecture projects are: