Stereotomy 2.0: The Rebirth of a Discipline that Never Died

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Abstract

NNJ guest editors Giuseppe Fallacara and Maurizio Barberio introduce the papers in the special issue of the *Nexus Network Journal* dedicated to Stereotomy 2.0.

The interest around stereotomy started to reawaken in the early 1990s, in the context of research about the history of construction. This new favorable cultural climate has made it possible to rediscover the discipline, for both its historical value and its unexpressed design possibilities. However, the research contained in this special issue of the *Nexus Network Journal* are focused more on the design principles of stereotomy rather than the exclusive historical or geometrical value of the discipline.

While “Stereotomy 1.0” comprises the early development of the discipline primarily related to stonecutting, the new discipline, “Stereotomy 2.0”, goes beyond this early concept to embrace contemporary design paradigms and materials. This relatively new field of research, called “digital stereotomy”, was born in 2000 at the Politecnico di Bari (Italy) and has since spread throughout academic community worldwide. The diffusion of parametric modeling and digital fabrication tools created the ideal conditions to design and build new stereotomic architectures, which are typically characterized by considerable architectural and geometric complexity.

Our aim with this special issue is to organize the work of academics, architects, engineers and researchers who have, in different ways, dealt with “stereotomic design” over the past 18 years. Stereotomy is, in fact, no longer a historical discipline that recalls the distant past, but has once again become subject of study in several research centers in the world, as one of the cutting-edge disciplines of digital fabrication and design.

The articles included here mark the state of the art of the most advanced research on the subject and is a tribute to the dual nature of stereotomy, that is, its being

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constantly contemporary while remaining rooted in the tradition of knowledge. The whole sense of this collection of contributions is developed with this in mind. The theoretical basis on which all the interventions present in this volume are based are explained in the article by Giuseppe Fallacara and Maurizio Barberio, “An Unfinished Manifesto for Stereotomy 2.0”, whose aim is to describe the historical background and the birth of this relatively new discipline.

It is useful to underline that by the term “stereotomy 1.0”, we intend, in continuity with the historical reading of the discipline, the wise use of a specific constructive technique that allows to build discrete (i.e. composed of a multitude of elements) architectural systems in stone and wood distinguished by the wise use of geometry and the high quality of construction materials used. From the mechanical point of view, the difference between stereotomic architecture in stone and those in wood is that the former is subjected almost exclusively to compression, and the second is subjected to bending and tensile stresses. However, in studying the evolution of the discipline, it is not unusual to find buildings which have used “hybrid” stereotomic systems, that is, having wall or vaulted systems reinforced with metallic or wooden elements, which make up for tensile stress. This hybrid use of materials, especially for the vaulted stone structures in which the metal reinforcement was hidden in the abutments and not openly shown, was at first strongly criticized by the pure stereotomists, who believed in the perfection of the geometric calculation able to uniquely solve the aesthetic and static demands with just one material. The criticism arose because the great, openly declared challenge of stereotomy was to build lithic structures that were very daring, from both the aesthetic and the static-mechanical point of view, thanks to the use of the *art du trait géométrique* and without any need of hidden metal prostheses to support the static performance of the architectural system.

In reality, the use of metal reinforcements hidden within the masonry was a practice already in use for the construction of Gothic cathedrals. The restorations of numerous Gothic monuments in northern Europe have shown that the core of most of the high piers of Gothic spans were reinforced with suitably shaped metal bars. Although having a different conceptual aspiration, Renaissance stereotomy, practiced by the French master *tailleurs des pierres*, was totally influenced by the legacy of technical know-how and experience inherited from the builders of medieval cathedrals of large and bold works in stone. The great eighteenth-century French cathedrals show the dual Gothic-stereotomic attitude in the use of vertical structures typical of Gothic achieved with the skillful art of stereotomic stone cutting. One of the most interesting cases is certainly the Church of Saint-Sulpice in Paris, where the recent restoration of the façade made evident the wise technique of the metal reinforcement hidden in the masonry masses of the high towers of the façade designed by Giovanni Niccolò Servandoni.

In a second, more advanced phase of the development of the stereotomic discipline, the combined use of stone and iron was no longer considered “shameful” but was rather indeed “virtuous”, as it was based on the scientific awareness of the characteristics and behavior of building materials. This change in attitude is exemplified in two ways: on the one hand, the construction of the large reinforced jack arches of the Louvre and Soufflot’s Pantheon in Paris; on the other, in the

design experiments of Eugene Viollet le Duc. In the first case, it is clear that the level of awareness of building shapes and materials, well exemplified by Rondelet's well-known plate on jack arches, is so deep that it can be considered the precursor of the invention of reinforced concrete. In the second case, the design process begins unmasking the metal reinforcement, which acquires an aesthetic dignity equal to that of the noble stone, with the two materials engaging in an experimental dialogue. The scientific characterization of the two materials will lead, on the one hand, to the natural emancipation of the metal frame in the evolution of large metal structures and pavilions of World's fairs, and on the other hand to the large-scale diffusion of reinforced "liquid stone" in the form of the structural continuum of the reinforced concrete. This rapid and non-exhaustive reading of the evolution of the construction techniques that leads to reinforced concrete from stone is intended to prove that, at its base, stereotomy has played a fundamental role thanks to its intrinsic nature of experimentation and continuous challenge to the rational reduction of the stone mass in favor of structural lightness and aesthetic virtuosity.

Philibert de l'Orme can be considered the historical identifier of stereotomy as a powerful tool for architectural design. He had a deep, constant longing for "lightness" in his works, which can appear to defy the laws of gravity, turning the rigid stone material into an "elastic" one, in terms of both aesthetical effect and structural response. In this regard, the celebrated vaults realized in the chapel and hallway of the Château d'Anet are paradigmatic. The most famous one is the conical vault-trompe "suspended in the air" of the Cabinet du Roy. De l'Orme inaugurates the long season of building separated from the ground. His vaulted spaces magically seem suspended in the air thanks to the awareness of technical advances that allows him to stand out and mark the overtaking against the legacy of the Italian architecture of the precedent centuries. This cultural declaration, that is to go beyond the intrinsic limits of statics and materials, will mark the stages of the progress of stereotomy until today and, as we will describe later, will represent the true nature of stereotomy. Rather than being relegated to a simple technique discipline, stereotomy may be defined as a constructive philosophy based on the continuous research and re-interpretation (of materials and forms) of the built environment. For us, stereotomy is not only a technical discipline but also a fusion of theoretical-practical notions that contribute to the definition of a holistic thinking about the arts of designing and building, which implies great technical precision and profound theoretical knowledge.

The important contributions presented in this special issue underline this aspect, contributing to expanding its application in the context of contemporary architecture, which is strongly influenced by digital design and manufacturing tools. Reading one after the other the contributions present in this publication, it is therefore possible to note how stereotomy can assume many connotations related to materials, aesthetic and static-mechanical properties.

To best articulate the articles included here, we have divided the issue into five "universes" of research: computational, speculative, material, structural and geometrical. We have chosen to use the term universe, rather than point or aspect, to indicate a large space within which the discipline can move in multidisciplinary freedom and be articulated in a way that is non-univocal and open to continuous

interpretations and rewriting of meanings. The descriptive sequence of the five universes also represents a order useful for better understanding of the current state of the stereotomic discipline in its theoretical and applicative valences.

The computational universe comprises research related to computer-aided design and fabrication. “Computational Tessellation of Freeform, Cut-Stone Vaults” by Matthias Rippmann and Philippe Block, describes new discretisation approaches for the tessellation of freeform masonry architecture, taking into account structural, fabrication and construction requirements as well as aesthetical considerations. “MayaVault—a Mesh Modelling Environment for Discrete Funicular Structures” by Vishu Bhooshan, David Reeves, Shajay Bhooshan and Philippe Block, describes the development of a custom software add-in called Maya Vault, which is the transposition of the Thrust Network Analysis geometric form-finding method into the mesh modelling environment of Autodesk® Maya.

The speculative universe regards topics related to theory. “Recovering Cannibalism in Architecture with a Return to Cyclopean Masonry” by Brandon Clifford, Wes McGee and Mackenzie Muhonen, which interrogates a “cannibalistic” methodology from the past known as Cyclopean Masonry in order to translate this valuable method into a contemporary digital procedure. The work contextualizes the techniques of this method and situates them into procedural recipes which can be applied in contemporary construction. A totally different reading is proposed by Fabio Tellia in “Stereotomy and Architectural Design at Foster+Partners”, which outlines the great potential that the stereotomic constructive principles codified in the classical treatises retains even in a deeply transformed context like contemporary architecture. To do this, the paper describes the analogies between the stereotomy principles used in the past and some of the projects designed by Foster+Partners, providing an unprecedented point of view on the subject.

The material universe encompasses reflections on actual construction materials. “Variable Casting of Voussoirs for a Stereotomic Shell” by Pedro de Azambuja Varela and José Pedro Sousa, which describes the a new fabrication method based on a reusable mold technology to be used for the construction of a stereotomic acoustic shell. With the help of robotic technology and flexible moulding, it became possible to create customized heavy blocks discarding the need for disposable one-off moulds for casting voussoirs. “Lightweight Stereotomy with Glass-Fiber Reinforced Plastic” by Justin Diles, which explores constructions made from glass-fiber reinforced plastic, a contemporary lightweight material with the aim of developing stereotomic architecture that employs parts that are exceptionally expressive, rather than exceptionally heavy.

The structural universe is comprises reflections on behavior of materials and forms. “Enhancing the Structural Performance of Masonry Structures by Post-Tensioning” by Leonardo Todisco, Elizabeth Stocks, Javier León and Hugo Corres, which claims the high potential of masonry as a primary load-bearing material when combined with post-tensioning, dealing with arch footbridges and antifunicular structures. Other aspects are addressed in “Revisiting stereotomic principles into modern AEC practice” by Edoardo Tibuzzi, which investigates whether new digital technologies, combined with an increased knowledge of conventional or new materials, and use of new hybrid techniques, has effectively

generated new expressions or interpretations of the traditional “art” of stereotomy, by presenting a selection of projects developed at AKT II in London which highlight the application of stereotomic-derived principles into contemporary AEC practice.

The geometrical universe provides the space for considerations of form. In “New Stereotomic Bond for the Dome in Stone Architecture”, Roberta Gadaleta describes an innovative solution for bonding a hemispherical stereotomic dome in cut stone, optimizing its construction compared to traditional methods, through a five-fold structural geometry of bonding that reduces the number of invariant-ashlars to be produced. The research team of Simon Weir, Dylan Wozniak O’Connor, Rodney Watt, Dagmar Reinhardt, Shayani Fernando and Jason Dibbs, in “Design and Fabrication of a ruled surface vault with the *Exquisite Corpse*”, describes the adaptation of the Exquisite Corpse to the design of a vault, cut using only ruled surfaces. The research is a didactic experiment in which a group of students work collectively on a single drawing, without seeing the work of their collaborators. In this issue’s contribution to the Geometer’s Angle column, Vera Viana, in “From Solid to Plane Tessellations, and Back”, describes the geometrical properties of a class of space-filling polyhedra useful for the field of digital stereotomy who employs topological interlocking blocks as fundamental design parameter.

The final contribution is the conference report “Stereotomy 2.0 and Digital Construction Tools” by Micaela Colella, which describes the event held 16–29 April 2018 at the School of Architecture and Design (SoAD) of the New York Institute of Technology. The event included a workshop and an exhibition of student work, followed by a symposium with international academics and professional speakers. Finally, an exhibition held in the Par Excellence Gallery in New York showed some of the state-of-the-art research on digital stereotomy through physical models, prototypes and posters.

In conclusion, a few words about those who aided us in making this special issue possible. We are truly grateful to editor-in-chief Kim Williams for her outstanding organizational skills, her kindness and infinite patience. We hope to have been able to repay your unconditional trust.

We also thank the committee of peer reviewers, comprised of Alberto Pugnale, Matthias Rippmann, Richard Etlin, Micaela Colella, Roberta Gadaleta, Vera Viana, Daniele Malomo, Domenico D’Uva, Renzo Lecardane, assisted and coordinated by us. The quality and quantity of hints and improvements suggested to the various authors guaranteed the high level of the papers presented here.

A special thank-you is given to Patrik Schumacher for his very important foreword, “Stereotomy 2.0: High-performance Eloquence”. His words bear witness to the importance that this niche topic may have for the future agenda of the avant-garde architectural design scene. Like him, we also believe that beauty is the promise of performance.

Finally, we thank all the institutions and companies that have supported our research over the years, including the Compagnons du Devoir et du Tour de France, and the students and professors of the CESAR Course (Cours de Enseignement Supérieur en Architecture et Restauration) at Politecnico di Bari. Last but not least, we thank our mentor Prof. Claudio D’Amato, who in 1990 founded the School of

Architecture at Politecnico di Bari, starting and inspiring the line of research on stone architecture and stereotomy.

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