Modelling: Conceiving, Testing, Defining, Convincing

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Modelling in the broadest possible sense refers to the conceptualization of a system using general rules and concepts. More particularly, modelling may refer to the production of mathematical models, physical models, and also 3D models. For mathematical models, we consider systems that allow interpretations of reality and that contribute to previewing new scenarios. For physical models, we intend scale models (including full-scale models) that are material representations of the actual object. For 3D models, we intend virtual representations, via CAD software, of any three-dimensional object.

Although we may consider physical or virtual architectural modelling separately, we should be aware that they tend to be integrated via digital fabrication processes, which allow for easier production of full-scale models, as is the case of the fabrication of building components, or even the whole building itself.

In this issue of the *Nexus Network Journal*, we will show the usefulness, even the indispensability, of models in architectural design, intended as either the global process of design or more specifically as the actual set of three-dimensional objects, either physical or virtual, that architects produce as a fundamental tool for design.

The issue opens with “[Álvaro Siza on the Role of Models in Architectural Design](#)”, an interview with the Portuguese architect conducted by João Pedro Xavier and Sylvie Duvernoy. Siza, who was awarded the Pritzker Prize in 1992, attests to indispensability of models among the myriad of tools the architect has at his disposal.

Then, we will cover the history of architectural and engineering models. These papers will show how modelling can be useful to intervene in and correct structural deficiencies; how a special kind of model contributes to the study of relief perspectives; how models can be extrapolated from literature; how architectural design can be a process of optimization; will look at the first steps of computer-aided design software, highlight a few practices by which the production of physical models is obtained without any computer tools, and illustrate many others where the production of virtual and physical models depend on each other, with digital fabrication being essential for its concretization.

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In “[Physical Models and Innovation in Architectural and Civil Engineering](#)”, Bill Addis gives us an overview of the use of models in both creative fields, demonstrating their decisive role in the design process, mainly when structural innovation is taking place, which is often connected to spatial innovation. Among the presented examples, Addis highlights the tensile structures of Frei Otto made with a polyester membrane, and the use of prestressing in reinforced concrete, which was first developed by Eugene Freyssinet. Also quite interesting are the mentions of experimental models for either structural or acoustical behaviour, such as the scale model for the Smithfield Poultry Market in London, used to test its structural resistance, and the scale model of the Staatsoper in Berlin, used to certify the improvement of its acoustical performance, which was the main objective of its recent renovation.

The decisive role of geometry in the structural behaviour of masonry arches has been well known since the works of Robert Hooke. However, several limitations, such as the life cycle of materials or other kinds of accidents resulting from reckless additions or adverse environmental conditions, might affect their resistance. Vittorio Paris, Giuseppe Ruscica, and Giulio Mirabella Roberti, in “[Graphical Modeling of Hoop Force Distribution for Equilibrium Analysis of Masonry Domes](#)”, aim at introducing a research strategy to manipulate hoop forces by graphically implementing a function describing their distribution on masonry domes, which are essential to detecting these failures and contribute their correction. The Pantheon in Rome and Santa Maria in Ciel d’Oro in Montefiascone are the chosen case studies.

Leonardo Baglioni and Federico Fallavollita, in “[Generative Models for Relief Perspective Architectures](#)”, present the Relieve Perspective Camera (RPC), an innovative tool that is embedded in a proposed method of investigation convincingly applied to the case study of the relief perspective in the Avila Chapel in Santa Maria in Trastevere in Rome, designed by Antonio Gherardi in 1678. This study starts with a 3D laser scanning survey of the existing building, which, through RPC, is transformed into a draft model of the illusory architecture. From this model, the authors can disclose what would have been the ideal model conceived by the architect, and applying RPC once more, they reach the final stage where it is possible to compare the ideal model and the survey model. This is a quite effective methodology that can be extensively applied to study and read these impressive architectural relief perspectives, this is, three-dimensional structures “able to create the illusion of great depths in small spaces”.

In literature, the action takes place in different spaces, and sometimes there are very precise descriptions of their configuration, often imaginary, but sometimes based on actual architecture. In “[Methodological Notes on Modelling Reconstructions After Literary Architecture](#)”, Fabio Colonnese found in Giovan Battista Marino’s *Adonis* a thorough description of the Palace of Love and Venus, and based on the data provided by the poet, and taking into consideration possible contemporary references, attempts analogies to built architecture and a 3D modelling reconstruction of the building as described in the poem.

In “[Considerations on Optimization as an Architectural Design Tool](#)”, Giuseppe Canestrino addresses the evolution and role of optimization in architectural design with an interdisciplinary approach. For this author, modelling is considered in

lato sensu and is understood to encompass the whole process of design. The new possibilities to work with a large amount of information, and the actual capacity to deal with them, leads to a process of optimization inherent to modelling, which contributes decisively to improve the quality of the design in terms of responsiveness.

In “[Between Form and Information: Early Philosophies of Computer-Aided Design](#)”, Daniel Cardoso Llach dives into the early history of computational design, analysing two different modelling techniques – the modelling plex, developed by Douglas Ross, and the Coons patch, developed by Steven A. Coons—which led to two different ways of understanding design. Llach’s main point is that these two approaches, besides their different technical genealogy, mirror two antagonistic philosophies of design, which are still present nowadays and quite difficult to reconcile.

Gianluca Stasi in “[Research-Integrated Models](#)” develops a design methodology to explore geometrical structures based on the use of models at different scales, which integrate the research for the most suitable form from the very beginning of the process till the construction phase. Even then the process is not closed and, as the author states, “everything is still in play”. This kind of approach is also a means to develop geometrical knowledge and has proved to have, in several situations, a relevant pedagogical value.

In “[Digital Form Finding Using Voronoi Pattern](#)”, Mara Capone, Emanuela Lanzara, Francesco Portioli, and Francesco Flore, inspired by the well-known 3D physical models by Gaudí and Frei Otto, seek to replicate similar form-finding strategies in a digital environment, using algorithmic generative modelling tools to achieve optimized structural shapes. Having chosen the most suitable configuration according to specific functional requirements, there arises the problem of panelling, to which the Voronoi discretization, in relationship with the stereotomy, proved to perform better in terms of membrane relaxation and structural behaviour in comparison to triangular, quadrangular or hexagonal patterns.

Francisco Gonzalez-Quintal and Andres Martin-Pastor’s research on “[Structural Models Based on Minimal Surfaces and Geodesics](#)” is focused on the geometric, formal, and structural adaptation of minimal surfaces. The main outcome was the construction of the Scherk Pavilion, which was achieved throughout an experimental process where hand and digital drawing, as physical and digital models were tested, compared to each other, and perfected with a view to its optimization, both structural and aesthetical. The final shape, an actual model at 1:1 scale, is defined by a set of geodesic lines made in wood stripes, which act as the structural skeleton of the Pavilion, contributing to define the geometry of its minimal surface.

Narrowing the traditional gap between the design and the construction phases is well illustrated in “[Testing and Defining a Complex Design Through Digital and Physical Models](#)”, by Michele Calvano and Matteo Flavio Mancini. Their project of furnishing the lounge bar and restaurant area of the Oasis Skyview hotel in Doha, Qatar, with complex organic double curvature surfaces is based on the interoperability between the models that contribute to the development of the design, from the conceptual model to manufacturing models. During the process, digital and physical models are produced. The former leads to the so-called continuous model,

which is the fine-tuning of the digital conceptual model; the latter to actual mock-ups. Finally, a procedural model paves the way to produce the manufacturing model, an accurate digital image of what will be built.

An architect, Tom Ingleby, and a photographer, Stephen Orlando, united their expertise and interests to design an architectural form using kinesiology studies. In “[Translating Movement into Architectural Form](#)” they describe a design process where the movements of canoeists are captured by the camera using different photographic techniques in combination with analog and digital modelling, towards the definition of an original shell structure named the Flow, a minimal surface constructed in ice. The process combines a poetic approach to design with a precise methodology, where modelling is the key feature all along the process.

By directing her attention to a singular architectonic element—the brick-faced facade of the Tate Modern extension—Alexandra Castro, in “[The Modelling Process of the Tate Modern Brick Facade by Herzog & de Meuron](#)”, discloses the singular design process followed by Herzog & de Meuron in this project, where analog and digital tools coexisted and influenced each other. Anyhow, the final result could not have been achieved without the use of parametric modelling tools, due to the building’s complex geometry and the particular arrangement of the bricks, which is also technically and constructively quite demanding.

This issue of the *Nexus Network Journal* concludes with a Book Review by Pedro de Azambuja Varela of Bill Addis’s book, “[Physical Models: Their Historical and Current Use in Civil and Building Engineering Design](#)”, which is practically a treatise on the history of engineering models, either structural or non-structural, and provides a full overview on the theme.

It is our hope that this special issue of the *Nexus Network Journal* inspires in-depth reflections on the role of modelling and encourages further research.

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