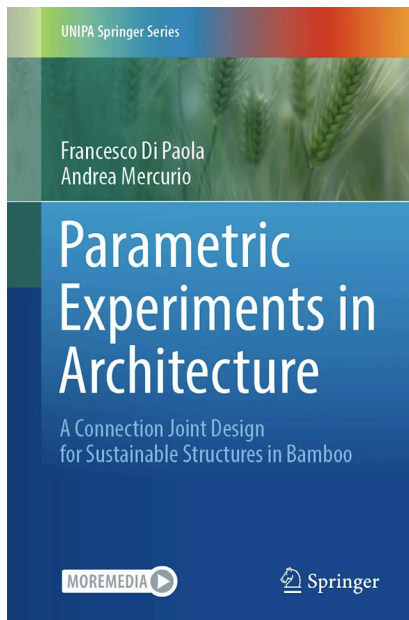


Reviews

Francesco Di Paola, Andrea Mercurio

***Parametric Experiments in Architecture.
A Connection Joint Design for Sustainable
Structures in Bamboo***

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The book by Francesco Di Paola and Andrea Mercurio belongs to a line of research linked to building practices between tradition and innovation. The authors offer a multidisciplinary perspective that reconciles the most advanced techniques of three-dimensional representation and simulation with the science of materials, construction techniques, and structural mechanics. The evolution of the discipline of design, in its transition to the digital age, has highlighted the use of informative 3D models informed by heterogeneous knowledge, thus offering themselves as tools for study rather than for the representation of the buildable. Reading between the lines, we can see how the digital model now offers two main innovations: first and foremost, the possibility of synergistically integrating the components of a project and, consequently, greater computational capacity able to optimize the relationship between the parts. The protagonist of the entire volume, but more generally of the transition from the analog to the digital dimension of architecture, is the concept of parametric modeling, which is suitable for making the designer's choices flexible by transposing reasoning into a function with a certain number of variables. Similar concepts had already been intuited by Luigi Moretti (1906-1973) in the

first half of the 20th century: his writings and projects contain explicit references to 'parametric architecture' and, in particular, to the relationship between form and structure. The first pages of the book analyse some of these general concepts from a historical perspective, recalling, for example, the use of analogue models for structural calculation. In this context, the experiences of Antoni Gaudí (1852-1926) and Frei Otto (1925-2015) are cited, both engaged in researches for optimising the form-structure relationship. These experiments, now referred to as 'form-finding', drew inspiration from nature through the observation of physical models and the materialization of the forces to which they were subjected. Today, digital simulations are inspired by similar principles: this is the case, for example, of the genetic evolutionary algorithms widely used by the authors of the book to create joints for Bamboo structures. The multidisciplinary nature of the volume emerges from the detailed description of the material properties of bamboo, which was used for the research. Ascribed to vernacular architecture, the material demonstrates excellent construction characteristics due to its fire resistance and mechanical qualities: these attributes have led to its intensive use in many geographical areas of the planet suitable for

its growth. Some attention is also paid to its preparation following the felling of the plant, using natural and chemical techniques. Of particular interest to the focus of the volume is the examination of the state of the art in relation to the methods used to join the elements, from traditional ones, based on the use of knotted ropes, to more engineering-based ones, widespread in contemporary architecture, aimed at designing steel joints oriented in space according to the morphology of the structures. The authors emphasize that the use of this material and the construction techniques associated with it, is currently rather limited especially in Europe, due to restrictive regulations because “there are not sufficient assurances regarding the homogeneity of the mechanical behaviour of the culms, even where these come from the same species” (p. 53).

The main difficulty in designing connection joints for spatial lattice structures lies in the variability of the angles that the coupling elements can assume on the rods converging towards the joints themselves. The geodesic domes of Richard Buckminster Fuller (1895-1983), for example, discretised the problem based on the geometry of elementary polyhedra to obtain a defined number of joint types (variable in number and inclination of the rods) useful for optimizing the production and, subsequently, assembly system. In addition to the above, it should also be noted that the use of bamboo for the construction of the rods involves a possible variability in their diameter; adding an element of complication compared to the use of standardized components for the

construction of the edges. Clearly, it is not only a question of considering the geometric complexity of the structure, but also of evaluating a stress distribution that is as homogeneous as possible, given the shape.

More specifically, the authors' goal is to find a design solution that takes into account a number of factors: dry assembly of the structure, in order to simplify assembly and disassembly operations, so as to ensure dimensional adaptability to a specific range of bamboo rod section diameters; the adaptability of the rods that converge at the node in generic directions, to offer the designer the greatest possible formal freedom; the formal continuity between vertices and edges, so that the latter can offer continuity of curvature from a formal point of view and, at the same time, structural balance. The research described led to a solution through a design approach focused on VPL (Visual Programming Language) modelling methodologies and the use of evolutionary genetic algorithms, adopted to optimize the shape of the joints in terms of their mechanical efficiency, under an applied stress. In other words, the FEM analyses conducted guaranteed the morphological solution of the joint optimized in terms of deformation, based on the forces acting on and the displacements undergone by the element. The digital model thus obtained was used to support the creation of a prototype joint made using 3D printing, hypothesizing a possible spatial lattice structure module with rods made from *Bambusa vulgaris*, one of the species of bamboo found in the Botanical Garden of Palermo.

The experience gained by the authors in the field of structures with regular

geometries led to further experimentation, this time based on free-form shell morphology, with critical references to the solutions adopted by the Deconstructivist movement. The geometric-design choice for the discretization of the free-form started from a tessellation based on the Voronoi diagram, once again a tool used today in the digital field, but strongly linked to the analysis of natural forms. The subsequent stages of the formal and structural optimization process, as described earlier in the volume, ensured the definition of the joints and rods of the lattice in space, this time characterized by elements that were all different from each other, due to the irregularity of the surface generated. Further examples at the end demonstrate the effectiveness of the process, according to a logical structure that aspires from the particular to the generalization of a method, whose complexity is resolved according to parametric principles.

This contribution is therefore part of a line of research of great interest in the contemporary world, which aspires to reconcile traditional materials and construction techniques, computational design (based on algorithmic optimization) and digital fabrication itself. Underlying these experiences is a remote attitude, on the borderline between engineering and architecture, inspired by the observation of natural forms and the laws behind them, now translated into the digital realm adopting parametric algorithms. Experiences of this kind can only arise from a collaboration between different fields of knowledge, blurring the boundaries between aesthetic characteristics and technological efficiency.

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