INTEGRATING COMPUTATIONAL DESIGN AND TRADITIONAL CRAFTS

A Reinvention of Bamboo Structures

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Abstract. Abstract: This paper searches for an alternative design method of integrating traditional material craft and computational design. It begins by analyzing Chinese philosophical view of nature, and proposes a natural design built method. The paper demonstrates the idea with two bamboo structure projects. In China, bamboo is closely linked to culture values and traditional craftsmanship. The projects research on the formation logic of bamboo system, and employs computational design method to activate the system formation. The projects strive to investigate computational design with unique eastern characteristics, to find out how it can help to reinvent its traditional values, and to search for a unification of formation logic and material sensibility.

Keywords. Craftsmanship; materiality; form finding; bamboo.

1. Introduction

In the view of Chinese Philosopher Laozi, “Dao” or “Way” organizes the naturalness (ziran); therefore, he called for nonaction (wuwei), not to interfere natural’s Way. In such point of view, design is a formation process emerged out of natural forces. This design research proposes to study the “Dao” of bamboo, to understand the material’s intrinsic values and the system forming logics, and to use them to inform the emergence of the material construction. This paper demonstrates two projects working with bamboo structure. Both projects take into account the traditional culture and method of working with bamboo, one borrows the traditional paper umbrella structure prototype, the other adapts the bamboo heat-bending method. Materiality consists of the material’s behavior and its cultural understanding. The projects investigate how materiality affects the material system form finding. Computational design method is used to simulate the formation of the bamboo system.
Laotzi’s eastern thinking has influenced Heidegger’s view on material and technology. Heidegger questions the utilitarian aspect of technology, which is deviated from the true existence of material. He argues for a poetical dwelling, which considers poetry as manifestation of truth restored to its artistic dimension (Leach 1997). This research project investigates an alternative design method of integrating traditional material craft and computational design method, and search for a unification of formation logic and material sensibility.

Computational design technologies expand the performance of bamboo structure. It is not a neutral tool in the design process, but it plays an important role in the forming of a digital/handcraft hybrid system. This research project strives to investigate computational design with unique eastern characteristic, to find out how computational design can help to reinvent traditional values.

2. Bamboo

Bamboo is a traditional material in China. It is closely linked to Chinese traditional culture and material craft. Bamboo has very strong fiber, therefore, in Chinese culture, bamboo symbolizes integrity, endurance, and purity; it represents the characteristics of a Chinese gentlemen. Such characteristics also makes it a common material for traditional craft in China, such as basket, umbrella, and in some area, building structure. Bamboo is also a green material, and it has enormous industrial values. Traditional craftsman has accumulated indepth knowledge and techniques in working with bamboo, and has acquired intimate understanding of its material performance. But because of globalization and industrialization, the handcraft culture is disappearing. This research tries to learn from the traditional craft, investigates the bamboo’s intrinsic values, strives to find a way to inherit and reinvent this traditional value (figure 1).

Figure 1. Traditional paper umbrella craftsmanship.
3. Learning from Material Craft

In traditional material craft, the making of form and materialization is an integrated process. Architecture has been focused on the manipulation of form, and usually the materialization comes after. Achim Menges criticizes the separation of form definition and materialization:

“Since the Renaissance the increasing division between processes of design and making, as proclaimed by Leo Battista Alberti, has led to the age-long development of and increasing dependence on representational tools intended for explicit, scalar geometric descriptions that are the same time serve as instructions for the translation from drawing to building. Inevitable, and with few exceptions such as Antoni Gaudi, Frei Otto, Heinz Isler and some others, architect has embraced design methods that epitomize the hierarchical separation of form definition from materialization. In today’s practice digital tools are still mainly employed to create design schemes through a range of design criteria that leave the inherent morphological and performative capacities of the employed material systems largely unconsidered. Ways of materialization, production and construction are strategized only after a form has been elaborated, leading to top-town engineered, material solutions that often juxtapose unfitting logics” (Menges 2010).

In this bamboo research project, bamboo’s structure performance and traditional craft culture are the driving forces for the emergent of material form. The bamboo research projects are inspired by the traditional way of working with bamboo from rural China such as heat bending and paper umbrella making. We were inspired from such techniques and employed computational design methodology and the result is a reinvention of the ancient material system (figure 2).

As digital software and tools change the way we think, design, and build, they allow us to achieve what was not possible with conventional methods. On the other hand, the sense of human touch is lost. In our bamboo research projects, Cloudscape learns from traditional bamboo heat-bending craftsmanship, and it is digitally form-found with the consideration of the bamboo material behavior; it creates an arbitrary load structure of 40 meter wide, 50 meter long, and 9 meter tall. The Parametric Umbrella is inspired by Chinese Paper Umbrella craftsmanship. It borrows the umbrella structural frame system, and it is reconstructed and reconfigured with computational design logic. Both projects strive to investigate a new design approach with the integration of bamboo material behavior, computational design logic, and traditional craftsmanship.
4. Computational Design Catalyst

Computational design enhances the design and performance of bamboo system. Cloudscape is a digital designed, hand crafted, pure bamboo structure. It is the graduation pavilion of the China Academy of Art in Hangzhou, China. In this design project, we try to help bamboo to find its true identity. We utilize bamboo’s bending behavior to create a long span structure, which has to accommodate at least 2000 peoples. In China, traditionally bamboo structure is designed and built with the Cartesian grid, ignoring the bending performance of the material. Traditional bamboo weaving crafts such as bamboo basket, involves the bending of bamboo. However, it is operated in a smaller scale and usually required mold to fabricated it.
The difficulty of making large and free-form bending bamboo structure lays in not only the design of double curvature surface, but also in the coordination and bending curvature of bamboo members during the construction. More difficult part of the design experiment is that bamboo structural behaviors varies depend on bamboo’s age, type, place of origin, etc. There is no bamboo structure standard nor preexist data that we can follow. Therefore, in the early design process, we constructed 3 different prototypes to test the bamboo’s material performance, to determine the maximum height, maximum span, and minimum bending radius. Much performance data can be coordinated into the computational model to simulate the free-form bamboo structure with arbitrary loads. In addition, in the Cloudscape graduation pavilion, every single curve has more than 2 different bending direction. Such double-curvature, free-form structure is difficult to design with conventional method. With the help of computational model, we were able to form-find the complex structure form with the fixed edge conditions.
The digital structural model is computed with Karamba, a parametric structural engineering software. It simulates the performance of hanging chain net model to find balance of internal arbitrary stresses. The form is first modeled as a shell, calculated by Kangaroo physical engine. It then computes the gridshell pattern with Karamba under the global condition of gravity. The result is a system of arbitrary 3-dimensional curves, which are the stress lines under the optimum force balance in the system (figure 3).

Digital model also outputs fabrication data, clearly defines the position, length, height of each bamboo, allowing craftsman to construct with traditional low-tech methods. Therefore, computational model plays a critical role in this unconventional bamboo gridshell structure. It preserves the authentic hand’s touch of the bamboo construction, and it also expands the performance of bamboo to create a dynamic space and large span structure.

We invited craftsmen from a local town Anji. Following the shop drawings generated by our computational models, they heat-bend the bamboo on site, and cool it down with water to maintain the bending shape. Bamboo’s intrinsic values are widely expressed in the design and fabrication process, it shows the reciprocal relationships between material, structure, and form.

5. Glocal Design Thinking

Digital design culture can gain benefits from cultural values and traditional craftsmanship. A material’s cultural understanding affects how the material is used and organized. Antoine Picon calls for the memory in our design culture (2010). Globalism contributes production efficiency as well as uniformity to our architecture industry. Unique culture and craftsmanship is lost. Wang Shu and Kengo Kuma found their design inspiration from the culture origin and local craftsmanship, which form their unique design styles. It becomes more important for the new generation of architects to trace our roots, to become a “glocal” citizen, with the understanding of global and local culture. Computational design becomes a new linkage between global and local material practices.

Figure 4. Umbrella system digital model.
The Parametric Umbrella is inspired by Chinese paper umbrella. Paper umbrella is a Chinese traditional craft. It contains deep culture values. Umbrella is not merely an object, and it also represents a space.

The Parametric Umbrella project destroys the sign and objecthood of traditional paper umbrella, turns it into abstract surface in order to generate dynamic spatial system. The umbrella system use mathematic logic to control the variation of bamboo structure and spatial relationship. The system begins with the traditional paper umbrella structure prototype, and it’s controlled parametrically with the anchor points (the columns), the height, and the surface direction (slope). The surfaces are formed mathematically based on those geometric constrains. The final form also emerges out of the materiality of bamboo. It spiral form provides structural rigidity, and created a flexible modular system (figure 4). Through the parametric control, this modular system can easily adapt different site conditions and functional needs; it creates an open, dynamic space that connects people and nature.

The computational design of the Parametric Umbrella has a strong local culture influence. With the intervention of latest design technology, it connects traditional craft and modern technology, local culture and global value (figure 5).

6. Logic and Sensibility
Computational design uses logic and deductive reasoning to construct model. It generates a dynamic system that controls the performances of architecture. The definition of performance, according to Yasha Grobman (2008), contains three dimensions: an empirical dimension, which focuses on directly measurable performances that usually related to physical data such as strength, temperature, the quantity of light, etc; a cognitive dimension, which focuses on the way human cognition can be translated into space, and conversely, the way space can be translated into human cognition; and a perceptual dimension, which focuses on the way
human perception can be translated into space, and conversely, the way space can be translated into human perception. Digital design is able to transcribe the empirical dimension with computer script; however, there is no direct way to engage the cognitive and perceptual dimension. In contrary to Frei Otto, Peter Zumthor takes a different approach in architecture materialization. He uses material to create atmospheres that return materials to themselves rather than some abstract meanings. Is it possible to translate the true materiality, as Zumthor describes “the things themselves”, into computer code? As emerging technologies opens up new design opportunities, the design of form should not be separated from its materialization. Architects have to integrate material performance and sensibility in the design in order not to lose in the digital jungle.

With computer simulation, the empirical dimension of material performance can be integrated in the computation design process. In Cloudscape, intrinsic values of bamboo are used as parameters for digital design. On the other hand, Peter Zumthor argues for the poetic quality of material, which is another performance that digital design rarely able to incorporate. Zumthor asks for a return to the things themselves, expresses the importance of material in the real world:

“The material presence of things in a piece of architecture, its frame. That kind of thing has a sensual effect on me. And that is what I would call the first and the greatest secret of architecture, that it collects different things in the world, different materials, and combines them to create a space like this. To me it’s a kind of anatomy we are talking about. Really, I mean the Word <body> quite literally. It’s like our own bodies with their anatomy and things we can’t see and skin covering us. The body! Not the idea of the body - the body itself!” (Zumthor 2006)

Traditional handcraft possesses intuition and material performance. Unlike computational abstract logic, it is attached to the human body and the material sensation. It adds a human touch to the computational reasoning model, and increases the cognitional and perceptual performance of the system. On the other hand, computational model provide a guideline for the organization logic which increase the material performance.

The bamboo material system promotes some kind of digital vernacularism that forms a hybrid system of digital design and vernacular craftsmanship. It deals with the relationships between handcraft and computer, man and machine, material and form, and provides a unique opportunity for the unification of the abstract logic and the poetic sensibility.

References