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DIGITAL TEA HOUSE

Japanese tea ceremony as a pretext for exploring parametric design and digital fabrication in architectural education

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Abstract. This paper reviews the Digital Tea House, a joint workshop in August of 2010 held at the University of Tokyo, Department of Architecture, together with Columbia University GSAPP. Three pavilions for hosting ceremony were designed and built in less than one month, in an attempt to bridge technology and culture not only through design but also fabrication. Issues addressed in the process included applications of computational design, interpretations of tradition and culture in spatial or activity oriented expressions, structural stability, to practical solutions for quick physical materialization. Three teams comprised of 6 to 8 students, each a blend of different nationalities, ultimately produced 3 full-scale tea houses with the same software, primary material, budget, and principal fabrication method.

Keywords. Digital fabrication; academic workshop; computational design; design-build; tea house.

1. Introduction

Digital Tea House is a joint workshop held at the University of Tokyo, Department of Architecture, together with Columbia University GSAPP, with the aim to design and build three pavilions for hosting tea ceremony. The three-week workshop is an attempt to bridge technology and culture not only through design but also fabrication. A wide range of issues was addressed in the process from applications of computational design, interpretations of tradition and culture, structural stability, to practical solutions for quick physical

materialization within limited time and budget.

The workshop was divided into two parts: First part introduced computational logic and concepts, which led to the second part where explorations related to Japanese tea ceremony culture served as a pretext for further exploring digital design and fabrication. Three teams, each comprised of 6 to 8 students, ultimately produced three full-scale tea houses to test out their concepts, methodologies and materials. Baseline for common software (Rhinoceros and Grasshopper), principal material (50 sheets of 9mm and/or 12mm thick 3x6 plywood), fabrication method (CNC routing), and budget (up to 150,000 JPY, approximately 1,500 USD, per team, excluding plywood and CNC fabrication costs) served to make comparisons and analysis during the process and later in three distinct outcomes.

1.2. TEA HOUSE AS CULTURAL BACKDROP

"The Japanese people in the 16th century created new culture which consisted of such elements as the 'Tea House,' 'Sukiya Style Architecture' and the 'Wabi-Sabi' aesthetic of transience. What these people did can be considered a reorganization of all products where the body is used as the reference. [...] They thought that relying on anything else as the reference would only add to the confusion. Therefore, they mercilessly discarded the traditional standards and cultural hierarchy that was used in Japan to that point. The 'Tea House' represented an exceedingly avant-garde type of architecture at the time"[1].

From the reference to the body, the tea house evolved into a microcosmic situation where host and guest(s) meet and at the same time an intellectual device through which one is made aware of the natural phenomena occurring outside. The traditional tea house is composed of a variety of elements, including *shoji*[2] screens or bamboo slats that serve as light filter that underscore gradations of light. In addition, a small wooden sliding door at *nijiriguchi*[3] entryway, *tatami* mats that signify where one may sit, and a recessed alcove *tokonoma*[4] for hanging scroll and flowers are typically incorporated.

2. Pedagogic approach and significance

The workshop provides a point of reflection within the academic setting to consider consequences of computational design when applied to physical reality of making, rather than stressing on the form-finding aspects of computational design. The pedagogic significance lies in the engagement of a continuous process, with a constant feedback loop between the software and material characteristics as a process of operation. As a result, each of the pavilion's physical presence and their feasibility on multiple levels could be evaluated

and reconsidered throughout. Such process is subject to simultaneous assessment of technology and working with the highly sophisticated parts it can produce.

Yet for most students, inexperienced in construction, the temporariness of pavilions relieved them of some issues, including protection from weather, foundations, and structural stability over an extended period of time. It also encouraged material experimentation, intuitive predictions for structural elements, and trial and error approach in detailing and assembly.

2.1. PRACTICABILITY OF PARAMETRIC DESIGN

Among architectural design students at the university, the emphasis is placed too often on the strength of concept with little regard to how the project may develop into actual construction or relate to its immediate context. The result can be an outlet where anything goes, whether unrealistic or unrelated to issues of economy, society, or culture. The use of parametric design can possibly promote this tendency, where students can easily produce forms too complex to control.

Constraints including structure, material, budget, time, assembly, site, and function help avoid the risk of designs that are impossible to be realized. For instance, students coped with possible spans of given plywood structure while considering how long they would have to be temporarily supported during assembly. As a combination of creativity and technical means, architectural design is incoherent without one or the other. When parametric design is integrated into a process with framework of real-life constraints, its advantages are beyond mere stylistic choices or visual effects.

For the duration of the entire process — from design, manipulations, detailing, to fabrication — it became apparent that the use of graphical algorithm editor tool allows for instantaneous modifications and influences on architectural conditions and context. At the same time, there is a tendency for oversimplification in such model: When a single line, for example, is further manipulated into endless variety of forms and surfaces, it alone can seem to substitute complex architectural elements. How would these simple manipulations translate to construction? What would this diagrammatic and methodical approach produce when combined with a culturally meaningful function as a tea house?

2.2. FROM CONTEXT-NEUTRAL TO CONTEXT-AWARE DESIGN

How can we bridge the digital environment to the physical environment in which we live? First, the consequences of the designs need to be addressed,

in how every part should to be considered for strength, weight, its assembly sequence, and surface treatment. There are also questions regarding appropriateness and scale of design, which often cannot be resolved in the isolated modelling phase. How to reconcile the disparities is one of the biggest challenges in the learning process; this workshop uses a cultural function of the Japanese tea house as a starting point to address the gap. The often scale-less nature of design through scripting is applied via traditional set of rules to be physically implemented. The development process from context-neutral idea to context-aware architecture calls for multidimensional views.

3. Digital tea house case studies

Three case studies are described in the following sections. Pavilion 'Nami-no-ma' translated the textures and shape of a tea bowl to linear layering of the plywood, while pavilion '130008252010' focused on light patterns and transparency. In pavilion 'Poetry and Parametrics' reinterpretations of traditional rules were applied more literally.

3.1. PAVILION "NAMI-NO-MA (SPACE OF WAVES)"

Guided by strong aesthetic characteristics from the tea ceremony, the expression of the beauty and imperfection of nature is translated to plywood, which surrounds the basic 2-tatami traditional layout of the interior space. Tea house typically offers limited level of openness to the outside; in this interpretation, the varying thickness of the wall becomes the boundary between the tea ceremony taking place inside and the surrounding nature, while the views are controlled by the density and bending angle of each layer. The undulating waves also facilitate functions of *tokonoma* and *nijiri-guchi*, where the largest opening in the pavilion is structurally reinforced beneath the lower curvature to support body weight.

Figure 1 (left). Pavilion "Nami-no-Ma." Figure 2 (right). Interior view.

Efforts to create a more natural and flowing form from the 3-axis CNC routing, which is a flat surface manufacturing, pushed for experimentations with half-depth grooves in specifically calculated patterns on the 9mm plywood. The key challenge was in achieving the desired bend in a continuous curve following a circular geometry of the plan. Enabled by close communications with CNC router operators, tests initially began with grooves of different depths and stitch patterns of varying lengths. The triangulated grooves eventually proved to be the ideal solution for 3-directional curves to be fixated on site, whereas perpendicular grooves only enabled 2-directional bending per panel. The resulting pavilion is a soft envelop for the interior activity, accentuated by modest connections to the surrounding environment.

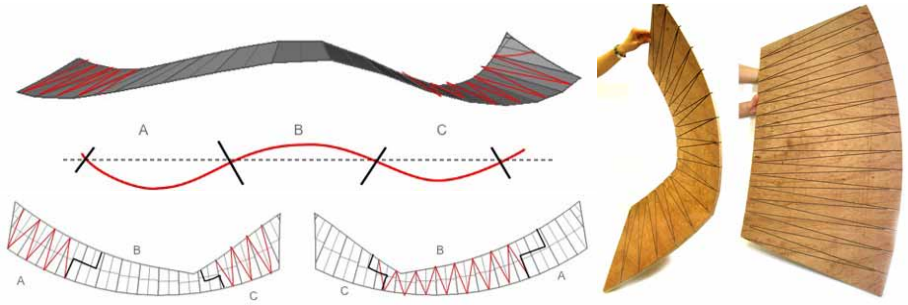

Figure 3 (left). Groove patterns and densities were determined according to the desired bending, while joints were placed strategically to create a continuous curvature. Figure 4 (right). Tests of the groove patterns and bending characteristics with plywood were conducted.

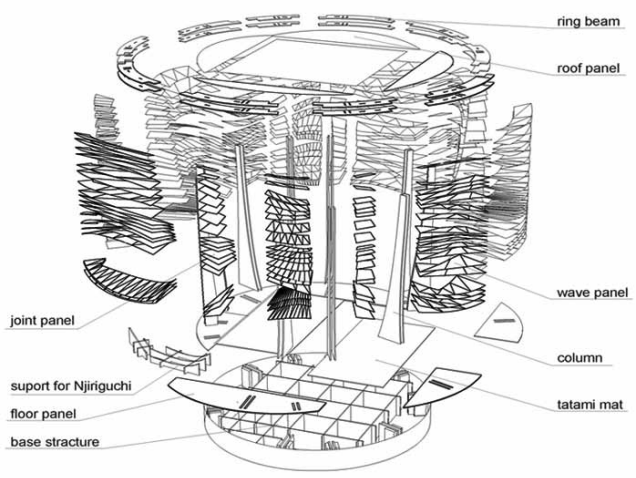

Figure 5. Axonometric drawing shows composition of parts.

3.2. PAVILION “130008252010”

Designed for the precise moment of 13:00 on Aug. 25, 2010, when the tea ceremony took place, the interior space is planned for specific lighting condition where fragmented shadows align with the cut-out straw mat floor pattern, serving as ever-changing ornament but also indicating where host and guests may sit at the aforementioned moment. Angles and depths of 192 triangular patterned sun-shading units over a semi-conical arch structure, leaning forward at 35.5 degrees that is the latitude of Tokyo, have been designed with considerations for the passage of time and changes in sunlight.


Figure 6 (left). Pavilion 130008252010. Figure 7 (right). Interior view.

The external surface of the pavilion is a smooth continuous curvature while the internal surface is irregular, with varying depths of the triangular units. These units posed a challenge in terms of connections due to their wide range of angles; finger joints resolved the issue by increasing the contact surface area, but these joints would have been considered differently with a 5-axis router or a different tool to enable smoother edge conditions where as many as seven angles congregate. Corresponding angled fins made of laser-cut white translucent paper-plastic laminate inserted into each unit further regulated desired lighting conditions. However half of the fins were lacking in the end because of miscalculation of time; while parametric manipulations are almost instantaneous, physical realisation through labour takes much longer.

Pavilion ‘130008252010’ is essentially a shading device, materialising the natural phenomenon of daylight through their tea house. It is a way of visualising something as ephemeral as light via incorporation of the 4th dimension, time, by utilizing parametric software. Although traditional sequential and spatial considerations were somewhat sacrificed by its singular focus, it was also very poignant within the ever-changing interior conditions.

Figure 8 (left). Plywood panels ready for assembly. Figure 9 (right). Assembly process.

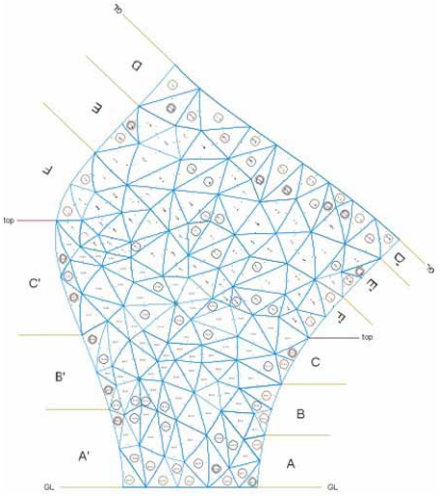

Figure 10 (left). Surface map showing all triangular units, which were divided into alphabetical zones for organization. Figure 11 (right). Exploded isometric.

3.3. PAVILION "POETRY AND PARAMETRICS"

Students from GSAPP focused on the choreography of the tea ceremony sequence by pushing the aspect of parametric design to translate the traditional tea ceremony sequence of separate host and guest entries. Attractor points organized the interior space, each designating a field of influence: Positions of host, two guests, and the *tokonoma.* The spiralling boundary contains the activity within the two *tatami*-mat space. The idea for the design began with one simple module, which can be used to create the entire structural system and facade for the tea house.

Disjunction between limited amount of materials and the preferred geometry were reconciled in the use of parametric adjustments in the Grasshopper script. The method left room for play, which appears in a suspended radial roof enclosure inspired by origami folding and floor patterns created by grooves in the plywood resembling the stepping-stones surrounded by ripples. The wall panels also add to the diversity of surface treatments; the density of groove lines scored on the surface of the panels, either facing outside or inside dependent on the angle, visually indicates the positional deviations. The investigations relating to how the geometry and proportions are brought together in the assembly system.

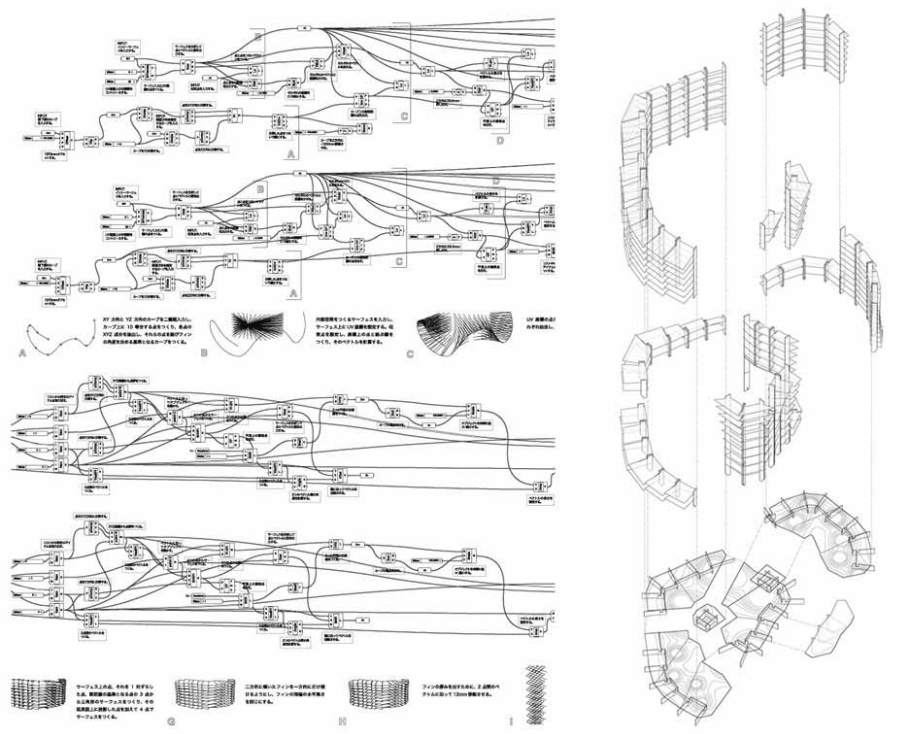

Figure 12 (left). Parts of pavilion "Poetry and Parametrics" Grasshopper file shows the evolution of parametric design. Figure 13 (right). Exploded isometric.



Figure 14 (left). Pavilion "Poetry and Parametrics." Figure 15 (centre) View from above showing origami roof. Figure 16 (right). Interior view during tea ceremony preparation.

4. Conclusion

Conceived and finished in a very condensed period of less than one month, both computational design and digital fabrication enabled the speed and the challenges undertaken in each design. Every decision inevitably affected other aspects of the design and making at once, especially since each pavilion was designed to be movable and reassemble-able several times in other locations. Factors such as joints, or size and weight of preassembled parts, were considered throughout in this engaging process. Eventually students realized the importance of applying materials suitable for both design and fabrication process. Each factor proved to be a constraint that pushed students to look for creative and feasible solutions.

From a cultural point of view, the students brought back the spirit of tea house in a contemporary digital manner reviving the tradition of avant-garde. It points to the importance of implementing pedagogy with not only present technologies such as parametric design and digital fabrication, but also with culture. Through the workshop it was made clear that such traditional values combined with new digital technologies is not contradictory, as exemplified in the tea houses and enforced by the final tea ceremony held inside in the forecourt at the University of Tokyo. On the contrary, the projects of *Digital Tea House* proved to be successful in the interpretation of the long established tradition and aesthetic. Japanese sensibility retains its unmistakably unique character even when it is filtered through the use of these new tools.

Design has evolved alongside technology, with mutually beneficial relationship. The workshop has been a framework for assessment of design and available technology, both of which were then experienced and evaluated by

the students as well as the tea masters and guests. As a result of one of the most significant innovations initiated by parametric modelling software, students were ultimately able to extract, edit, and abstract the traditional aspects pertinent to their works and transform into their contemporary possibilities of what a tea house might be.

Endnotes

1. Fischer, V., Schneider, U.: 2008, *Kengo Kuma: Breathing Architecture,* Birkhauser, Boston, 10.
2. *Shoji* is a vertical screen, typically composed of Japanese *washi* paper stretched over delicate wooden frame.
3. *Nijiri-guchi* refers to a small entryway specific to the tea house, approximately 60cm in both height and width. The tightness of the opening makes the guest crawl through with his or her head down.
4. *Tokonoma,* a small recessed alcove within a room where guests are received, is where flower arrangement and hanging scroll are commonly displayed.

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