Summer School, 2021

Bamboo-Bam

Digitally Fabricated Freeform Space Structure

University of Art, Digital Craft House (DCH)
Virginia Tech, Material and Design Laboratory (MaD Lab)
University of Tehran

Sample of the Bamboo Structure
Bamboo Auditorium / Instituto de Vivienda, Urbanismo y Construccion de la USMP

Introduction

"Structural engineering science radically transformed its ontology and methodology from a typological to a topological paradigm. This implies a radical reset of the categories that guide engineering practice. The modern forms of engineering rationality based on system types are now exposed as inefficient while the rationality of older structural forms based on slowly evolved traditions is now revealed by the new paradigm."

Patrik Schumacher

Project Understanding

Complex form desirability, combining simulation techniques and novel fabrication methods, leads modern design practice to the nonstandard freeform buildings. On the flip side, convenient methods of construction for these types of buildings which are mostly subtractive consuming a huge amount of metal, are extremely expensive, inefficient, and ecologically destructive. These facts encourage researchers to investigate the space structure field in order to find more efficient, eco-friendly, and affordable solutions. This research tries to find a way through the Bamboo material and Integrated Computational Design and Fabrication.

Workshop Goal

During this workshop, students will research and examine processes used by **Bamboo Material Systems** and **Integrated Computational Design and Fabrication** to design and fabricate a more-than-30sqm freeform space structure.

Skills you will Practice

- How to design and construct a freeform space structure.
- Structural design approaches (Basics for FEM, Karamba3D, Graphic Statics).
- Prototyping.
- Developing a simple BIM modeler for nonstandard building.
- Digital Fabrication (Introduction to use digital fabrication tools).

Bamboo

The use of bamboo as a building material has occurred in construction of vernacular architecture across cultures and continents for quite some time. Most of traditional houses in Indonesia and Asia use bamboo both as structural and non-structural building material. The use of bamboo in traditional houses is due to the fact that it grows abundantly in tropical rain forests. But after the Industrial era has begun, the use of bamboo as building material become obsolete. Bamboo is considered as a sustainable, cost-effective and ecologically responsible alternative construction material. It is also considered as low-class material, even called as “the poor man timber” by many modern builders (Lobokivov, 2009). People tend to choose brick, concrete and steel as structural and construction materials for modern building.

As a construction material, bamboo has favorable mechanical characteristics. Having compressive strength quite similar to concrete, its tensile strength can be as high as 300 MPa that exceeds that of steel. Bamboo fibers have often shear strength higher than wood, allowing to cover wider spans. Bamboo can also be curved without breaking, making it suitable for free form structures.

Thus, this project is dedicated to bamboo, considering it as an ecofriendly, affordable, and mechanically strong material.

Theoretical Premise

Computational Design

Working on free form architecture, space structures are one of the principal structural systems explored within computational design area. In this type of structure, usually, all of the elements are unique and they have to be designed and modeled by computational methods.

In addition, bamboo is not a standard material (it has different thickness, radius, and shapes with anisotropic behavior) and that's why it is not possible to design a bamboo structure by convenient methods. It is essential to find a way to ignore its variable shape or scan all of the elements and design considering the physical properties of each element.

In this research project, students try to develop an algorithmic tool for form-finding and detailed BIM modeling.

Digital Fabrication

Aforementioned, this structure contains unique elements. Therefore, fabricating the elements by digital design tools such as CNC machines or 3D printers upon the system design is inevitable.

Based on the selected system and designed details, students may develop a custom instrument to manufacture the final elements.

Process

Chapters

ALL OF THE SESSIONS, EXCEPT THE ONES CONTAINING LOCATION, ARE ONLINE.

Chapter One, Study

About the Research Workshop (Ramtin Haghnazar)

- Part I: Introduction.
  Bamboo: State of the Art: Potential and Challenges (Jonas Hauptman, Sara Saghafi).
  Freeform Space Structure, systems and manufacture (Ramtin Haghnazar).
  Form Finding, computational methods (Seyed Ali Derazgisoo).
  Usage of Coding in Complex Structure Fabrication (Danial Keramat).
- Part II: Technique and System Design, details for freeform space structure.
- Part III: Materiality, how to used bamboo in the medium of building.
- Part IV: Design methods, form finding and form generating.
- Part V: Material Study, search for available bamboo and its properties in Iran.

Chapter Two, Design

- Part VI: Presentation about Digital Fabrication Facilities, and Intro to Structure.
  Standard Devices, robots, CNC, printers and etc. (Hanie Omid).
  Custom Devices, arduino (Mehran Masoudi).
  Intro to Structural Design (Mohammad Hassan Baqershahi).
- Part VII: System design and prototyping (define the joints and construction properties).
- Part VIII: Design Development, Form finding method.
- Part IX: Design the structure.

Chapter Three, Fabrication Preparation

- Part X: Presentation.
  Parametric BIM Modeling (Mehran Masoudi, Danial Keramat).
- Part XI: Developing the BIM modeler.
  Intensive Grasshopper Class - if needed (Danial Keramat).
- Part XII: Developing the custom tools for fabrication.
  Custom Digital Fabrication Class – if needed (Mehran Masoudi).
- Part XIII: Final Prototyping.
  Location: Digital Craft House, Karaj, Iran.

Chapter Four, Construction

- Part XIV: Material Preparation (Shopping, Cutting, and etc.).
  Location: Digital Craft House, Karaj, Iran.
- Part XV: Fabricating elements.
  Location: Digital Craft House, Karaj, Iran.
- Part XVI: Assembly.
  Location: University of Art, Tehran, Iran (TBD).
- Part XVII: Presentation (Video clip and Booklet).

Workload and Teams

Students will work in **three different groups** containing **two teams**, and each team at least contains **five member**s. Except for the final week, other tasks distribute among teams, thus each teamwork four weeks in the first 10 weeks. In summary, the weekly workload for each student is between two to five hours weekly.

Time Table

Week	Task	Tutors	Group #1	Group #2	Group #3
1	Presentation	Part I			
	Practice		Part II	Part III+V	Part IV
2	Correction		Part II	Part III+V	Part IV
	Presentation	Part VI			
	Practice		Part VII	Part V	
3	Correction		Part VII	Part V	
	Practice		Part VII		Part VIII
4	Correction		Part VII		Part VIII
	Practice			Part IX	Part VIII
5	Correction			Part IX	Part VIII
	Presentation	Part X			
	Practice		Part XI		Part XII
6	Correction		Part XI		Part XII
	Practice			Part XIII	
7	Correction			Part XIII	
	Extra Time				
8	Practice		Part XIV		
9	Practice				Part XV
10	Practice		Part XVI	Part XVII	Part XVI
11	Practice			Part XVII	
12	**Final Review**				

- Presentation: presentation by tutors (Presentation by Jonas Hauptman is in English).
- Correction: presentation by students (In English).
- Extra Time: is time for undone tasks or is a break.
- Final Review is in English by the presentation Team.

Tutorial Team

Supervisor

Mohammad Reza Matini

- Assistant Professor, University of Art.
- PhD, ITKE Stuttgart.
- MS of Architecture, University of Tehran.

Tutors

Ramtin Haghnazar

- PhD candidate, University of Tehran.
- MSc in Architectural Technology, University of Tehran.
- BA of Architecture, University of Teran.
- Co-founder, Dahi Research Group (Computational Design and Fabrication).

Jonas Hauptman

- Assistant Professor of Industrial Design, School of Architecture + Design
- Director of the Materials and Design Laboratory (MaD Lab)
- MFA, Metalsmithing, Cranbrook Academy of Art
- BFA, Sculpture, Rhode Island School of Design

Sara Saghafi Moghaddam

- PhD student, Virginia Tech.
- MSc in Computational Design, Georgia Institute of Technology.
- Master of Architecture, Politecnico di Milano.
- Bachelor of Architecture, University of Tehran.

Amirreza Ardekani

- Adjunct Professor, University of Tehran.
- PhD in Architecture, University of Tehran.
- MSc in Architectural Technology, University of Tehran.
- BA of Architecture, University of Teran.
- Co-founder, Sepidar Design Group

Computational Design Specialist

Mehran Masoudi

- MSc in Architecture, University of Tehran.
- BA of Architecture, University of Tehran.
- Co-founder, Dahi Research Group.

Danial Keramat

- MSc in Architectural Technology, University of Tehran.
- BA of Architecture, Shahid Bahonar University of Kerman.
- Freelance Architect.
- Researcher, Dahi Research Group.
- Designer, Arxe Design Studio.

Hanieh Omid

- MSc in Architectural Technology, University of Tehran.
- BA of Architecture, University of Teran.
- Researcher, Dahi Research Group.

Yasaman Ashjazadeh

- Master of Architecture, University of Tehran.
- BSc in Interior Design, Soore University.
- Co-founder, Dahi Craft.
- Partner, Arxe Design Studio.

Fabrication Specialist

Javad Allahgholi

- MSc in Architectural Technology, University of Tehran.
- BA of Architecture, Shahid Bahonar University of Kerman.
- Co-founder, Dahi Research Group.
- Partner, Arxe Design Studio.

Seyed Ali Derazgisoo

- PhD Student, Art University of Isfahan.
- MSc in Architectural Technology, Tarbiat Modares University.
- BA of Architecture, University of Art.
- Co-founder, Dahi Research Group.
- Manager, Sital Sakht R & D Section.

Structure Specialist

Mohammad Hassan Baqershahi

- PhD Student, University of Tehran- Empa, Structural Engineering Research Lab.
- MS in Structural Engineering, University of Tehran.
- BS in Civil Engineering, University of Tehran.
- Structural Designer, Shakhes Sotun Parsian Consulting Engineers Co.

References

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- Lobokivov, M., Lou, Y., Schoene, D., Widenoja, R. (2009). The Poor Man's Carbon Sink: Bamboo in Climate Change and Poverty Alleviation. Rome: FAO.
- Schumacher, P. and L. Zheng (2017). "From Typology to Topology: Social, Spatial, and Structural." Architectural Journal, Source journal for Chinese scientific and technical papers and citations (590).