Timber
Robotically Augmented Wood Construction

Course #: 48-410, 510
Location: CFA 200, MMH C4
Instructor: Joshua Bard, jdbard@cmu.edu
Office: MMH 310b
Office Hours: W,F 12:00 - 12:30 (by appointment)

Timber: Augmented Wood Construction forefronts the need for resourcefulness in contemporary architectural practice. The course positions a renewed interest in wood construction (an ecologically sane material appropriate for many building types) relative to emerging technologies in robotically assisted fabrication. As designers recoup this traditional building material, emerging digital technologies are poised to re-frame the what, why, and how of timber construction. In particular the course will investigate robotic steam bending, where a robot’s ability to shape custom framing members and assemble unique parts, is leveraged to construct complex material arrays. Labs, Lectures, and design projects will emphasize tactile investigation, building at one to one, and introduce the fundamentals of robotic motion and tooling protocol.

Course Structure
Timber will promote critical design inquiry through two main projects running in parallel throughout the semester. The projects are intended to reinforce each other with a deep dive into robotic fabrication and a broad survey of wood construction techniques. The studio will split time and resources between the SoA robotics lab and CFA studio, blending the cultures of lab based research and studio based inquiry.

Robotic Steam Bending
The first project is a tensive material investigation combining hands-on material testing and applied robotic experimentation. We will focus on robotic steam bending of natural hardwoods and experiment with applications in complex material arrays (e.g. trusses, space frames). Process work for this project will include 1 to 1 prototypes, scaled physical models, and detailed parametric modeling. The final deliverable for this project will be a full-scale mockup of a steam bent truss.

Timber in the City
The second project will be an extensive design investigation of contemporary wood construction approaches. Student teams will compete in the ACSA Timber in the City competition. Sited in Manhattan’s lower east side, students will be asked to design a ~300,000 sqft. mixed use complex including modular mid-rise residential units, an art museum, and an urban food market. Dovetailing with the themes of the studio, students will be asked to consider innovative, robotically augmented timber construction techniques that might inform contemporary construction trends. A portion of the building will incorporate steam...
bent wood trusses as a structural system and build directly from the hands-on investigation developed in the robotics lab. Process work for the competition will include a research book on robotic wood construction, program R&D for the competition, and schematic design work (e.g. drawings, sketches, models). Final deliverables for the project include an end of semester review and entry into the ACSA competition by May 25th.

**Studio Themes**

**Resource:** Contemporary architectural design is in a constant state of techno-flux. The means and methods of contemporary architectural production face mounting ecological imperatives. Dexterity: perhaps the architect’s most valuable resource.

**Imperfection:** The use of natural material always entails reckoning with irregularities. Imperfection forces a loss of control (on the part of the designer) that standardized industrial building materials tend to eradicate Timber asks students to consider material imperfection as an inherent and generative part of the design process.

**Tectonics:** This studio biases the careful articulation of the architectural frame. Here the frame conditions space, encourages structural performance, and articulates the part(s) to the whole through considered detailing.

**Deformation:** Steam bending natural hardwoods produces complex forms without wasteful subtraction of material or the addition of toxic adhesives. The technique also suggests exciting architectural possibilities for large span structures through bending active systems.

**Objectives** core skills / concepts
- You can test ideas at full scale using material affordance to inform your design process.
- You can program, simulate, and execute basic robot paths.
- You can design and implement custom end of arm tools for fabrication.
- In addition to compelling representation, you can leverage digital tools to construct physical artifacts.
- You can leverage parametric workflows to efficiently manage complex fabrication tasks
- You can detail basic timber frame construction.
- will demonstrate ability in the following NAAB SPC Criteria: A.5,A.7,A.8, A.9, A.11, B.9, B.12, C.1.

**Studio Policies** yes / no
- Technology should be used to inspire and execute your work in studio. Please do not graze on social media or stream content during studio. Texting during lectures – no. Looking up a quick image of an architect whose name is dropped during a review – yes.
- Attendance is essential to your development in studio. More than three unexcused absences will lower your final grade. Missing a review could result in a failing grade for that project. Disappearing for a few weeks while you pledge – no. Bringing a signed doctor’s note regarding a recent absence – yes.
- As architects we invest quite a bit of energy in the built environment. That ambition should be reflected in the way you maintain your studio space. Pushing last week’s lunch under last month’s site model – no. Hanging precedent and inspiration by your desk – yes.
- Computers are really helpful. Until they’re not. Back up your work! Better yet, work in the cloud.

**Lab Policies**
Students are required to carefully review and adhere to Robot Lab policies. These may differ from the more general dFab policies. Students should never operate the Lab’s robots without Joshua Bard, Mike Jeffers, or Richard Tursky present. The lab will be made available to students outside of regular studio contact hours. See calendar for specific hours.

**Documentation**
Students are required to carefully document the product and process of all projects through considered drawings, images, physical prototypes, and digital models. Since the course encourages speculative thinking through making, students are encouraged to document failed attempts, detours,
and hunches. We will use the Robot Lab Wiki for ongoing documentation of all projects. Groups should upload project images, videos, code, and rhino files for each project.

**Calendar**
The course calendar is hosted [here](#) on Google. Lab hours, office hours, assignments and deadlines are posted.

**Partners**
- **Timbertrails**: Founder, John Scheafnocker sustainably harvests lumber from his 30 acre tree farm to provide regionally grown building materials.
- **Bensonwood Homes**: Bensonwood has repurposed traditional timber framing techniques using a combination of material craft, and innovative CNC technology. The company is constantly looking for ways to champion wood construction in contemporary building practice.

**Resources**
- [Robot Lab Wiki](#)
- [ABB Rapid Manual](#)
- dfab

**Journals**
- Fine Wood Working, On Bending Wood

**Books**
- Understanding Wood, Hoadley; The Taunton Press
- Wood and Wood Joints: Building Traditions of Europe and Japan, Zwerger; Birkhäuser
- Timber Construction Manual, Herzog; Birkhäuser

**Articles**
- The Case For Tall Wood Buildings, Michael Green
- The Timber Tower Research Project, SOM

**Precedent**
- Sou Fujimoto, Final Wooden House
- Peter Zumthor, Steilneset Memorial & Chapel St Benedict
- Tezuka Architects, Woods of Net
- Frie Otto, MultiHalle Manheim
- Bensonwood
- Drying Shed AA

Shigiru Ban, Pompidou-Metz Art Museum
Hitoshi Abe, Reihoku Community Hall
Aalto
Nihon Minka-en
Toyo Ito, Sumika Pavilion at Utsunomiya, Japan
SHoP Architects, 475 WEST 18TH
Grading Rubric

A excellent Work reflects outstanding achievement in content and execution. Work far exceeds given requirements. Students in this category demonstrate: High self motivation, Independent thinking and expression, Use precedent as a catalyst, Highly disciplined, Willingness to take risks, High ability to focus, Systemic questioning, Self critique and editing, Highest qualities of representation.

B good Work reflects high achievement in content and execution. Work exceeds given requirements. Students in this category demonstrate: Some external motivation, Periodic independent thinking, Good discipline, Beginning to take risks, Good qualities of representation, Periods of focus, Closed-ended questioning, Open to suggested critique and editing.

C satisfactory Work fulfills given requirements. Students in this category demonstrate: External motivation, Cannot extend precedent, Low discipline, Conformity, Short periods of focus, Average qualities of representation, Limited questioning, Dependent on external critique and editing.

D poor Work is less than satisfactory. Work minimally or incompletely fulfills given requirements. Students in this category demonstrate: Lack of motivation, Ignore precedent, Lack discipline, Duplication, Few periods of focus, Low qualities of representation, Little questioning, Non-responsive to external critique and editing.

R inadequate Work fulfills few or none of the given requirements. Work is substantially incomplete. Student missed one or more scheduled reviews.

I incomplete Given only for emergency or medical reasons. Contact coordinator as early in the semester as possible regarding an incomplete.

Evaluation Criteria

Critical Inquiry
+ Syntheses of intensive and extensive thinking / Making connections outside the given scope / Work sacrifices breadth or depth / Takes project as given
- Fragmented work / Inattentive to project aims

Communication
+ Strong verbal and visual communication / Legible verbal and/or visual communication
- Poor verbal and/or visual communication

Creativity
+ Imaginative and risk taking / Inventive
- Normative

Craft
+ High level of craft validates and extends impact of the work / Work is well-made
- Lack of attention to details obstructs the work’s impact

Motivation
+ Self-Motivated / Needs faculty motivation
- Lacks motivation

Voice
+ Voice of individual apparent / Developing a personal voice
- Little personal voice

Editing / Process
+ Learns from critique / Develops through iteration / Develops work under the pressure of deadlines
- Inability to respond to critique / little development of initial ideas

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