SWELL: Structural Experiments with Heat Moldable Plywood

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SWELL was an experimental installation completed in the spring of 2018. In this "Responsive Structures" Design Build course, students investigated the structural, spatial and organizational capacities of a heat-moldable plywood product manufactured in Finland. The course advanced a structures-based approach to material investigation. Reversing the prevalent use of plywood as cladding fastened to framing elements, students were challenged to develop a habitable, self-supporting system using only plywood.

Heat-formable plywood:

Thermoformable plywood is made from layers of FSC certified cross laminated birch veneers. Birch, known for its high strength and stability, is layered and adhered with a non-formaldehyde engineered adhesive that can soften with heat, and reset when cooled- multiple times if necessary. Students used a 3-layer panel with a 4.5 mm thickness.

Structure:

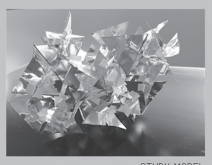
Students developed a triangular, notched panel unit through model-based structural experimentation. The structural capacities of the plywood were tested through different curvatures and configurations.

Students learned how surface deformation (through parabolic curvature) increased the buckling strength of the panel by 2.7 times. They began with an idea for a 6-panel module based on a hexagon, which evolved in a more stable, interlocked 4-panel modules which became the building block for interlocked "mega-modules" that organize the structure. The non-parallel orientation of each of the pairs of panels further stabilized the module. Students stacked and offset these mega-modules into a structurally sound yet spatially rich matrix to construct the installation.

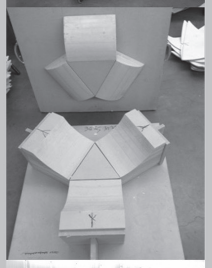
Fabrication:

The course merged both digital and manual techniques for the panel production and assembly. After students refined the panel design, they cut 600 identical panels on the CNC router, and fabricated a two-part mold using laminated MDF sheets. Panels were then placed in an oven set to approximately 95 degrees. Baking the panels for about 2.5 minutes softened the glue enough so that the veneer layers could slide and deform within the mold. Students experimented with different temperatures and baking times to determine the optimal results, refining their production technique with multiple prototypes. Once baked, the malleable panels were individually pressed and cooled within the heavy mold to produce their curvature.

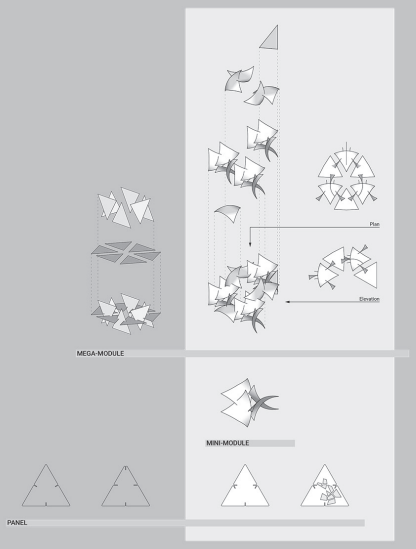
The final form of "SWELL" was inspired by the wave-like forms of blowing leaves within the tree-lined site, interspersed with pink and purple-colored "blooms" held aloft within the structure. The undulating, porous space emerges from the ground, creating a habitable passage and view from the main path to the museum. Some of the panels were perforated with a leaf-like pattern, creating varied densities and a nuanced filtered light, while also reducing the wind load on the structure.



STUDY MODEL

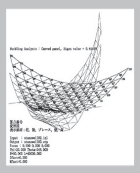


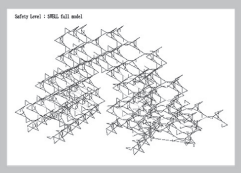
OVEN, MOLD, AND PANEL PRESSING



MODULE EVOLUTION

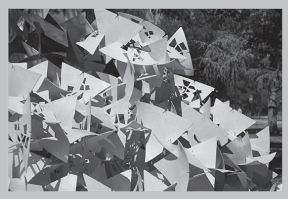
Students developed a triangular, notched panel unit through model-based structural experimentation. The structural capacities of the plywood were tested through different curvatures and configurations. Students learned how surface deformation (through parabolic curvature) more than doubled the strength of the panel. They tested different configurations for the panels to optimize structural performance, eventually developing a structurally sound yet spatial rich matrix of panels. These units were configured into structurally rigid 4-panel modules that became the building block for interlocked "mega-modules" that organize the structure.

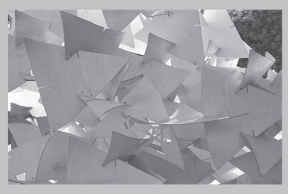




STRUCTURAL ANALYSIS

Left: parabolic curvature of the panels increased the buckling strength of the panel by 2.7 times. The 4-panel module stabilized when each pair of panels were not parallel.
Right: safety ratio diagram of full assembly, organized in triangular frames. 30% perforation was allowed for panels displayed in blue.





MEGAMODULE PROTOTYPE

BUILD

SWELL was an experimental installation completed in the spring of 2017. In this "Responsive Structures" Design Build course, students investigated the structural, spatial, organizational and poetic capacities of a new, heat-moldable plywood product manufactured in Finland. The course was a cross-disciplinary collaboration including students from the Architectural Design, Structural and Mechanical Engineering departments. The form of "SWELL" was inspired by the wave-like forms of blowing leaves within the site, interspersed with pink and purple-colored "blooms" held aloft within the structure. The undulating space emerges from the ground, creating a habitable passage and view from the main path to the museum.

swell