PCI FOUNDATION REPORT

PRECAST CONCRETE ENCLOSURES

ELECTIVE COURSE

SPRING_2021

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Sam Fox School of Design & Visual Arts | School of Architecture
Washington University in St. Louis

Summary

In the fall 2020 I wrote the curricula for Precast Concrete Enclosures. The course was awarded $50,000 for a 4-year PCI Foundation grant. The elective course laid the foundation for an applied research project in partnership with Gate Precast, a nation-wide leader company in architectural precast. The primary goal of the course is to enable students to design and materialize full-scale building envelopes using precast concrete. This is an excellent opportunity to expose architecture students to the precast industry practices and familiarize them with this construction system. The materialization of real-scale prototypes requires collaboration with industry partners as it provides access to resources that are not generally available at higher education institutions. This partnership enables students' exposure to real applications and products while advancing my ongoing exploration of concrete envelopes. The seminar was taught for the first time in SP20 but, due to COVID-19 health recommendations, the students were not able to be on campus and produce the panels. However, students had extra time to refine their design, developed comprehensive drawings and construction documents. No funds were spent during SP20 and the grant funding was rolled over to the next academic year. During SP 2021, students were able to experience the entire process: design, document and materialize full-scale molds. They spent approximately 5 weeks working on the panel design and two more weeks developing the corresponding documentation for fabrication. During those intense weeks of design, students shared their work with Gate's engineers and plant personnel and received very useful feedback on their design ideas via Zoom. This was a crucial stage in order to advance their design toward a feasible outcome. Important topics such as panel size, thickness, structural integrity, reinforcing and many other issues were discussed engaging students with Gate's expertise. The molds were manufactured at WashU during the second half of the semester using different materials as well as digital fabrication tools such as CNC and 3D printing. Digital tools are very helpful and open endless possibilities in terms of design ideas. However, when fabricating full-scale molds, several tasks have to be done manually. Students spent endless hours working on their molds following the advice from Gate to make sure they can resist the weight and pressure of fresh concrete. The molds were successfully finished on time and then transported to Gate's plant in Ashland City, TN for concrete casting. The original plan was to take students to the plant and participate on the concrete casting and demolding. Unfortunately, by the time the molds were ready for casting, the University had a travel ban in place that put on hold all student out of town travel. However, I was able to travel and be present at the casting and demolding stages. I took numerous photographs and videos of the entire process, which I shared with all students. Documentation and images of the materialized mockups are attached to this report.

The experience was truly incredible. Students were very excited with their outcome and most importantly very thankful of this unique experience. People at Gate's plant were very impressed with the quality of the molds the students made. My experience as a coordinator of a class that involves fabrication of full-scale building envelopes in partnership with Gate Precast was excellent. Gate's availability, predisposition for help and provision of resources was remarkably outstanding. I would like to make a special mention to Scott Robinson, Lee Baker and Daniel Thompson for their time and help during the entire semester.

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Course Premise

In contemporary construction practice, building enclosures are sophisticated assemblies conceived through complex processes that merge design, science, technology and craft. The outermost layer of the exterior wall is the most exposed to natural forces and therefore it needs careful attention as it must work effectively over the lifetime of the building.

The design of building enclosures must be evaluated in terms of function, aesthetics, feasibility, durability, maintenance and cost. Concrete has a long history as a building material. Although, Romans used of the material is widely known, concrete provided modern architecture a versatile material to explore new kind of structures and assemblies. In the last few decades, precast concrete has grown within the building industry as a viable alternative due to its strength, durability, reliability, resiliency and cost. As newer technologies emerged, concrete has experienced several improvements, among which the reduction of its thickness is maybe the most remarkable. New concrete technologies have stretched the material to unprecedented thinness diminishing its weight while maintaining its strength and integrity.

Scope

The primary goal of this fabrication seminar is the construction of full-scale mockup pieces that function as part of real building envelopes; this is an opportunity for hands-on experience. Students will design, develop and build enclosures out of different types of precast high performance concrete assemblies as critical components of building envelopes. The course will be developed in partnership with Gate Precast, a leader company in the precast concrete industry. Supported by a grant from the PCI Foundation, students will have a budget of $12,500 to design and prototype precast mockups of building envelopes.

Students will start by conducting research and analyzing historic and contemporary buildings, focusing on its skin properties and configuration. Then, they will proceed to identify a specific environmental condition/s and develop an enclosure as a response to such condition/s, advancing the design through detail drawings and study models, culminating in a full-scale mockup mold. Construction of the molds will be done at Washington University's facilities combining digital and analog methods of fabrication, including CNC milling, laser cutters, 3D printers, vacuum formed plastic among other methods as well as a fully equipped wood shop. Once the molds are finalized they will be transported to Gate's architectural plant in Ashland City, TN for reinforcing and concrete cast; culminating with the demold of full scale-precast mockup pieces. Students will tour the facility and participate in the entire fabrication process, including mold preparation, reinforcing, casting, demolding, handling and finishing process of the final panels.

Structure

The class is divided into five stages. Students will be asked to work in groups of three students which will collaboratively develop, document, construct and install their assemblies.

Stage 1-Research: compile precedents on building envelopes. Look for different sources of inspiration not limited to concrete building, any envelope material is valid as an initial inspiration. The goal is to become familiar with both built and unbuilt projects and develop a comparative analysis. Aspects of the envelopes to consider: geometry, ergonomics, materials, dimensions, color, texture, and environmental impact among others.

Stage 2-Design: study possible configurations and geometries for your proposed building envelope. What kind of building enclosure do you envision? Think about building type, orientation, level of exposure and privacy, specific environmental conditions, etc. When designing a concrete piece that needs to be mass-produced, weight and size becomes a limiting factor. Mobility and transportation of the piece should inform the design. Repetition and standardization is a challenge that needs consideration. Is it possible to create a customizable system while limiting the number of pieces needed to a minimum?
Consider the use of textures, colors, patterns and surface treatment not only as an aesthetic factor but also as a performative aspects of the piece.

Stage 3-Mold Documentation: Document the pieces precisely for accurate materialization. Explore the most convenient material and mold method for your piece.

Stage 4-Mold Making: with the piece/s carefully documented, you will proceed to construct the mold. The use of the existing digital fabrication tools available in the school is highly encouraged. Students will have the opportunity to get familiar with these tools and their possibilities to acquire knowledge about the limitations in size and materials for the formwork. Consider to build a reusable form that allows multiple concrete casts.

Stage 5-Concrete Cast: with the molds constructed and ready, we will transport them to Gate's plant in Ashland City, TN. Gate will help with the mold set up, reinforcing, concrete mix preparation and pouring. Students will have the chance to discuss with Gate different concrete mix options and finishes and experiment with different aggregates and pigments. This will be an opportunity to be environmentally sensitive exploring the use of different aggregates from recycling materials. This may influence the final texture and color of the piece, allowing the pattern to differentiate pieces if needed in the design. Once the concrete is cast and cured the pieces will be demolded. The precast pieces are also susceptible of different types of finishes such as sandblasting, acid etching, polishing, etc. We will study the most reasonable and efficient way to anchor them to a substructure for temporary exhibit in the plant's yard.

Learning Objectives:

- Investigate contemporary building envelopes
- Develop a design-build approach to building enclosure design
- Research and experiment working with precast concrete and other materials
- Understand the capabilities and limitations of concrete and other materials to make informed decisions about material selection and its different performances
- Incorporate sustainable principles in material selection and recycling
- Acquire drawing, representation and construction techniques capable of building a full size mockup pieces
- Develop ability to create molds for the construction of repeatable pieces
- Gain experience working in collaboration with industry partners and professionals

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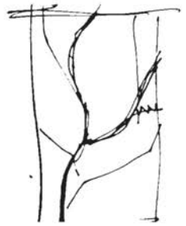
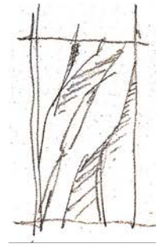
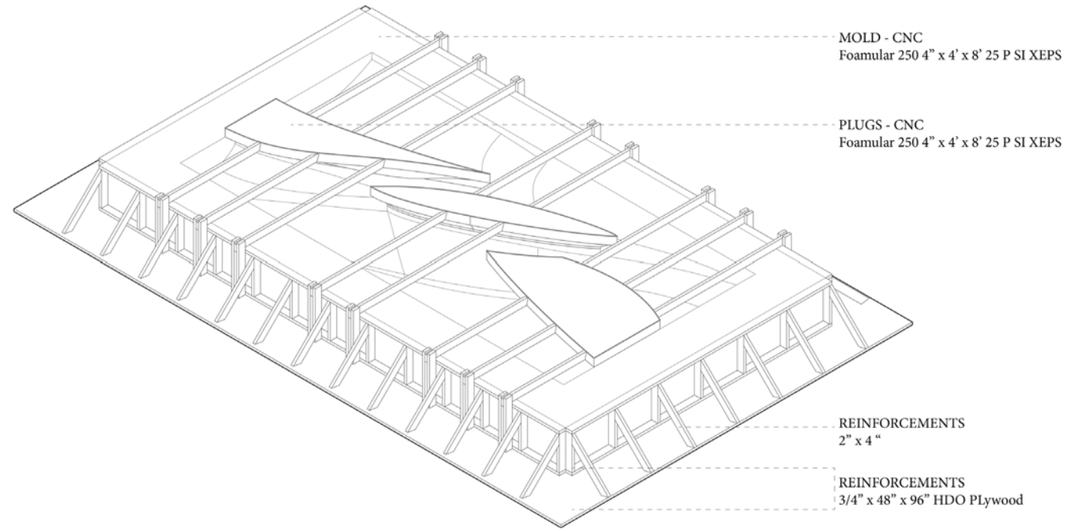
STUDENT WORK

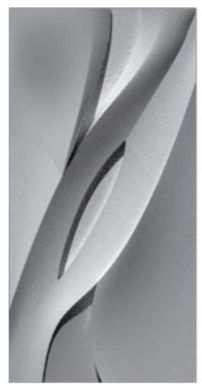






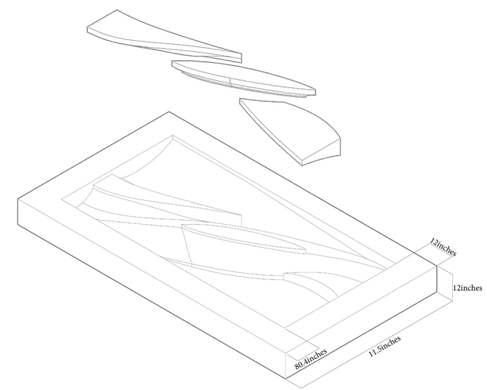
A

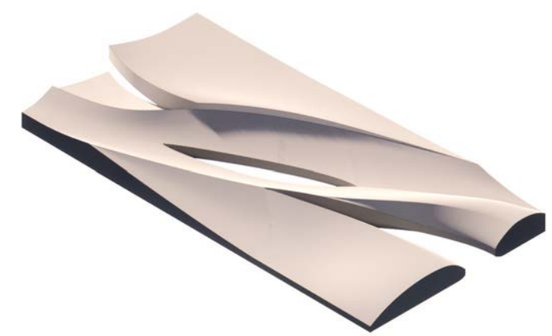
B

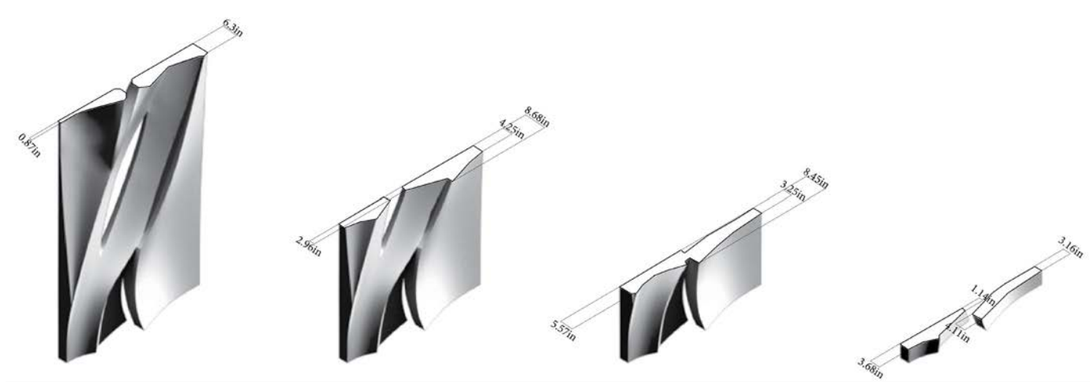


C

Team 1







Students: Raquele Cardozo | Natsuko Nozaki | Robert Tian

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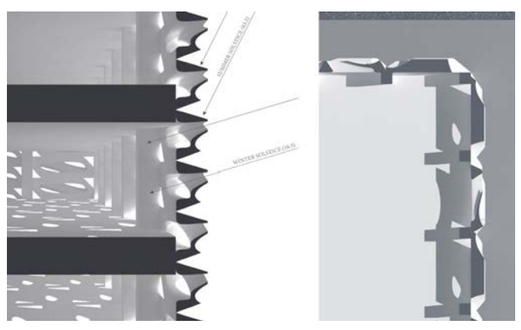
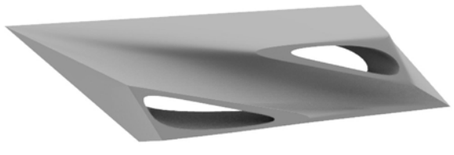
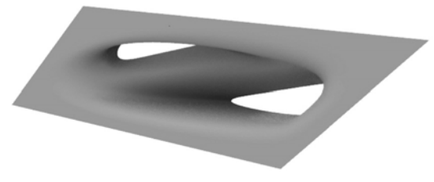
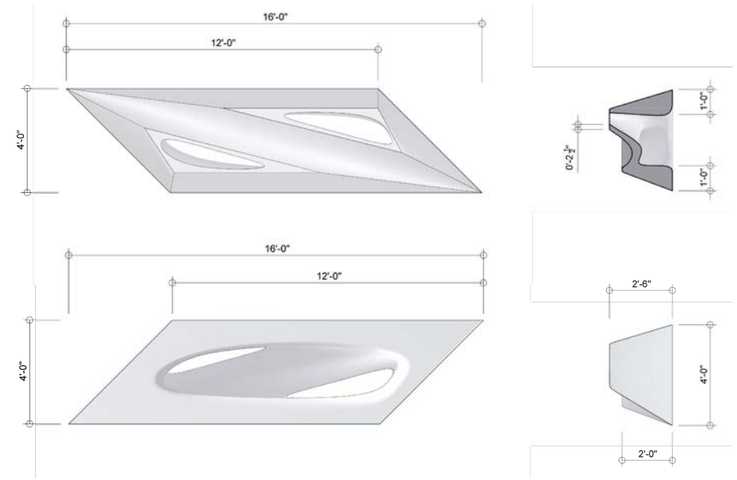
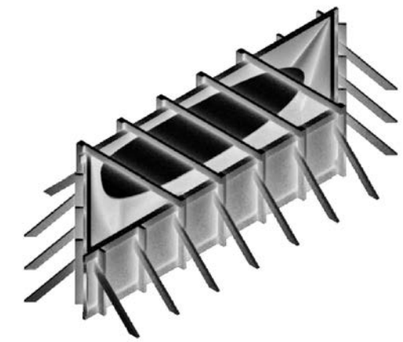
Team 2

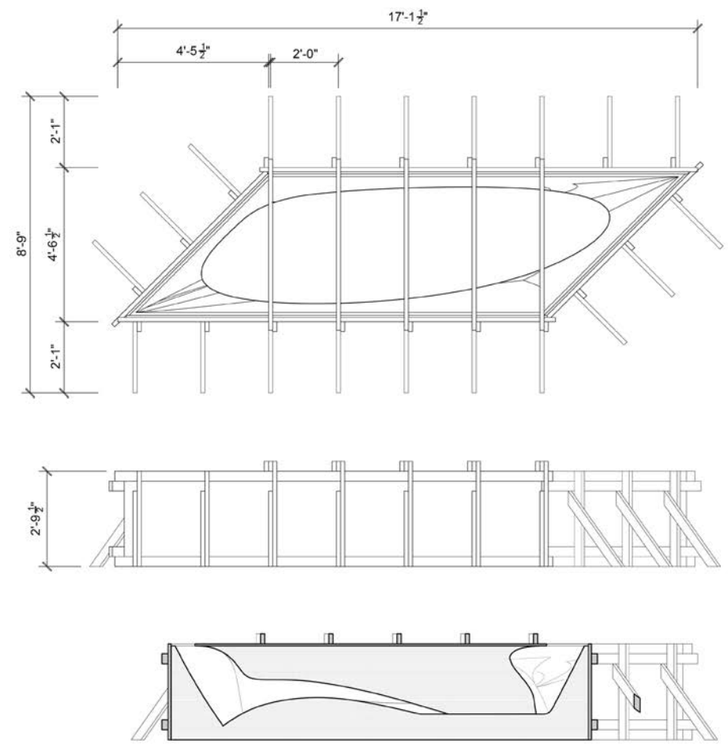


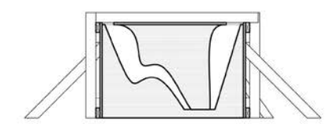


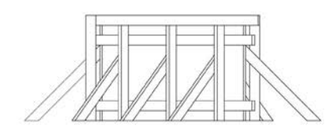












Students: Connor Merritt | Mic Ma | Guorun Yang

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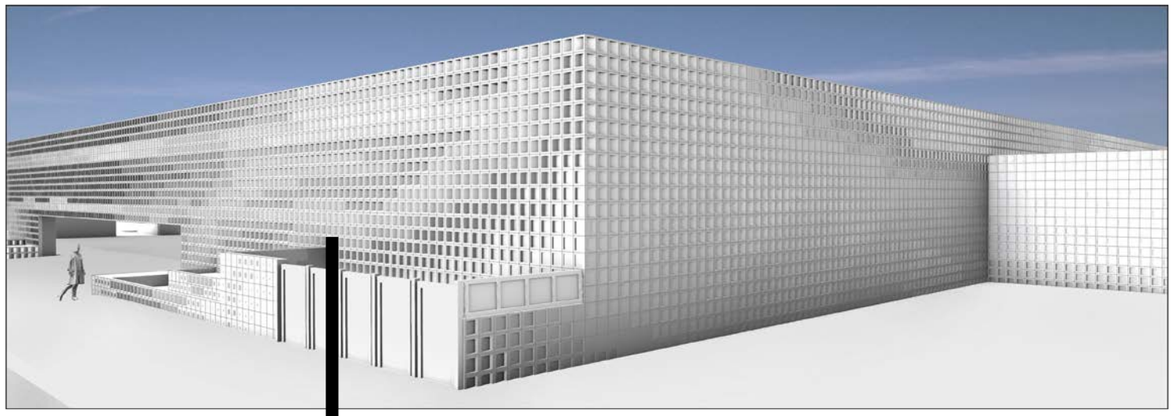
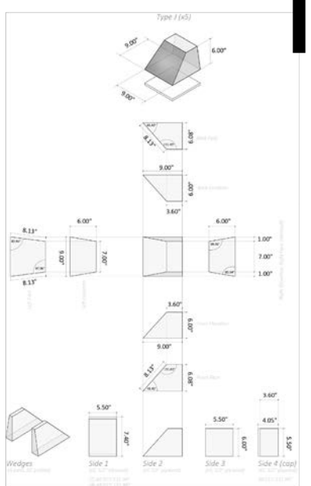
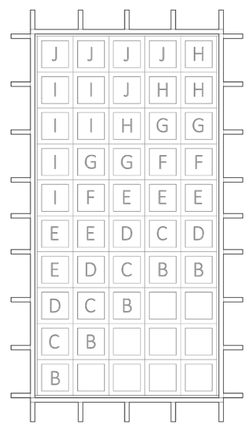
STUDENT WORK



Team 3





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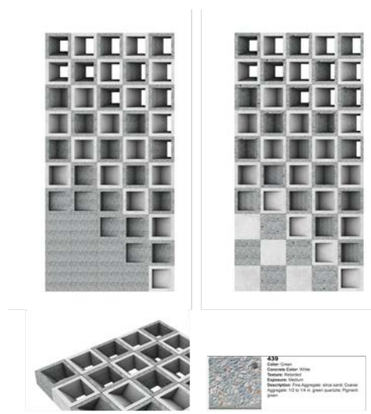

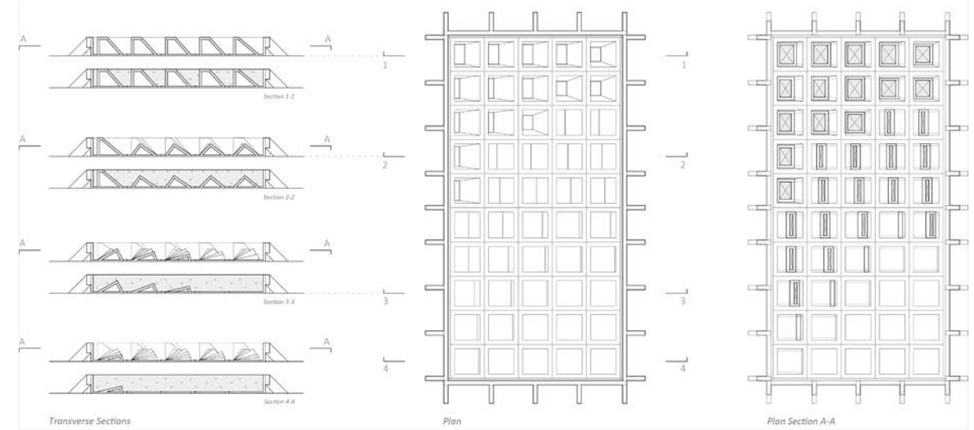

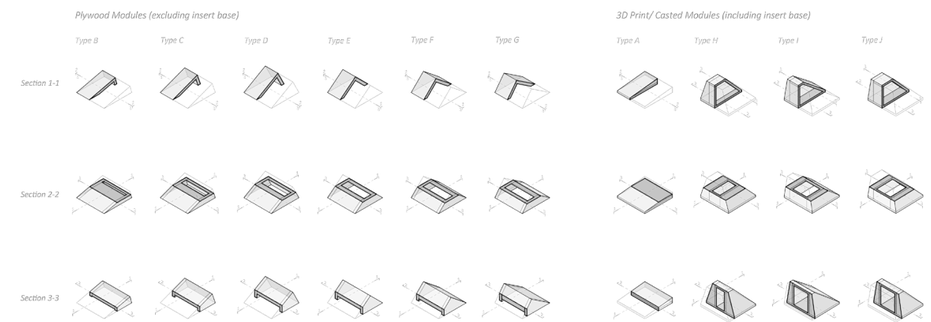

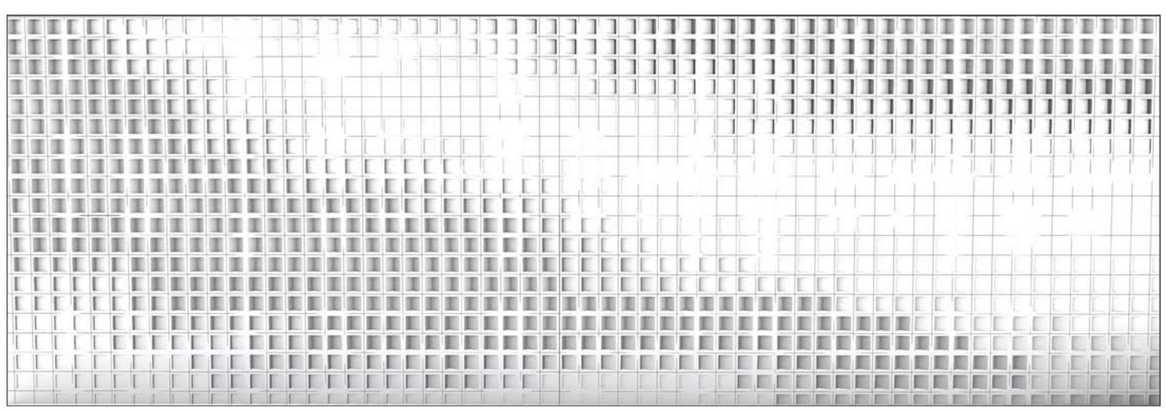

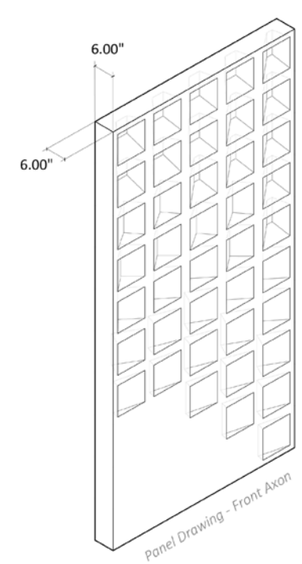

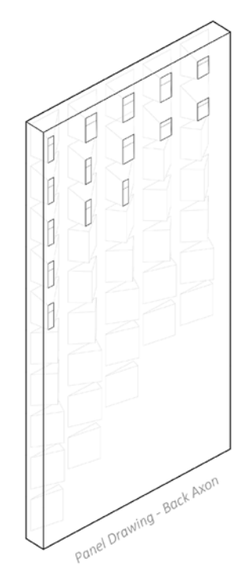

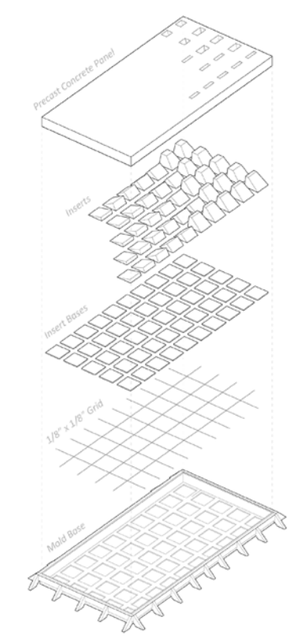

Students: Catherine Chun | Caleb Heusel

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STUDENT WORK

Rendering 01

Upclose to the facade panel it is clear the different relationships the panel possesses: curtain wall, basin, and ...

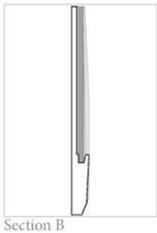
Rendering 02

When flipped upside down, the facade panel acts as a door.

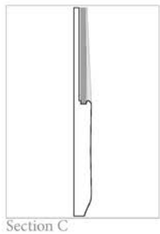
Rendering 03

Exterior Perspective

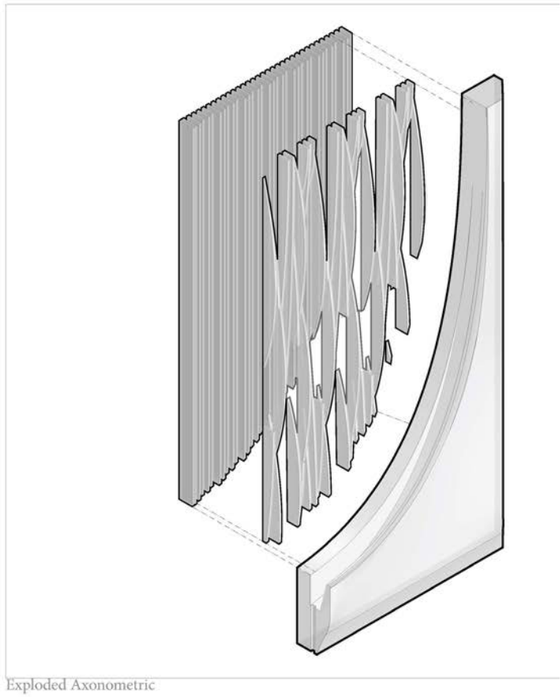
Section A



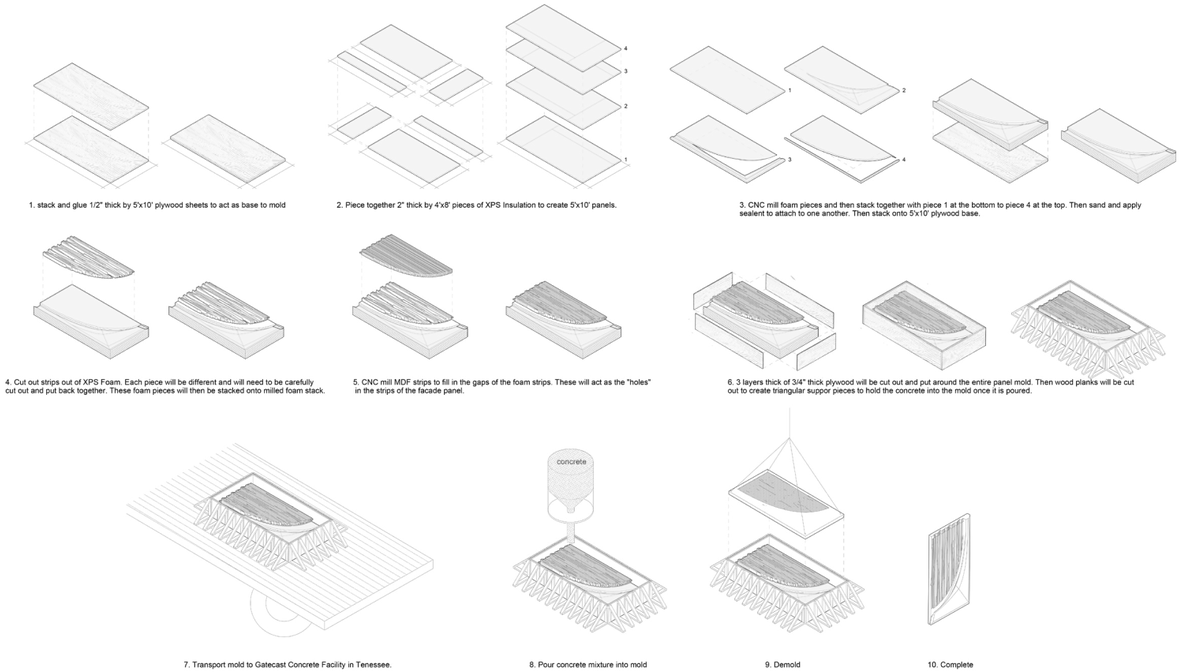
Section B



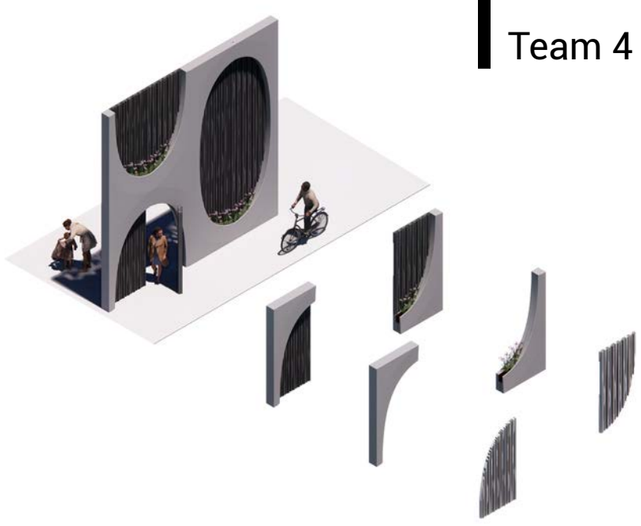
Section C

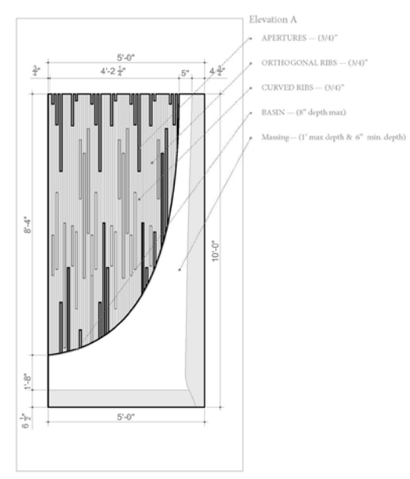


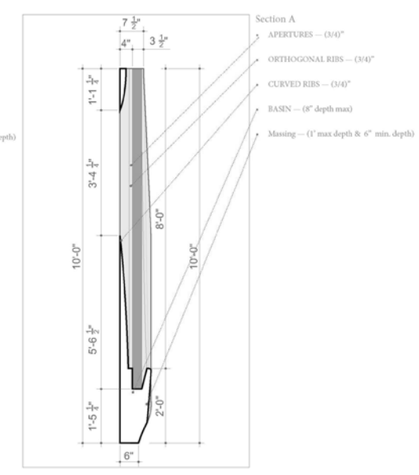
Exploded Axonometric



Team 4







Students: Lindsey Compeaux | Ian McWilliams | Kevin Mojica

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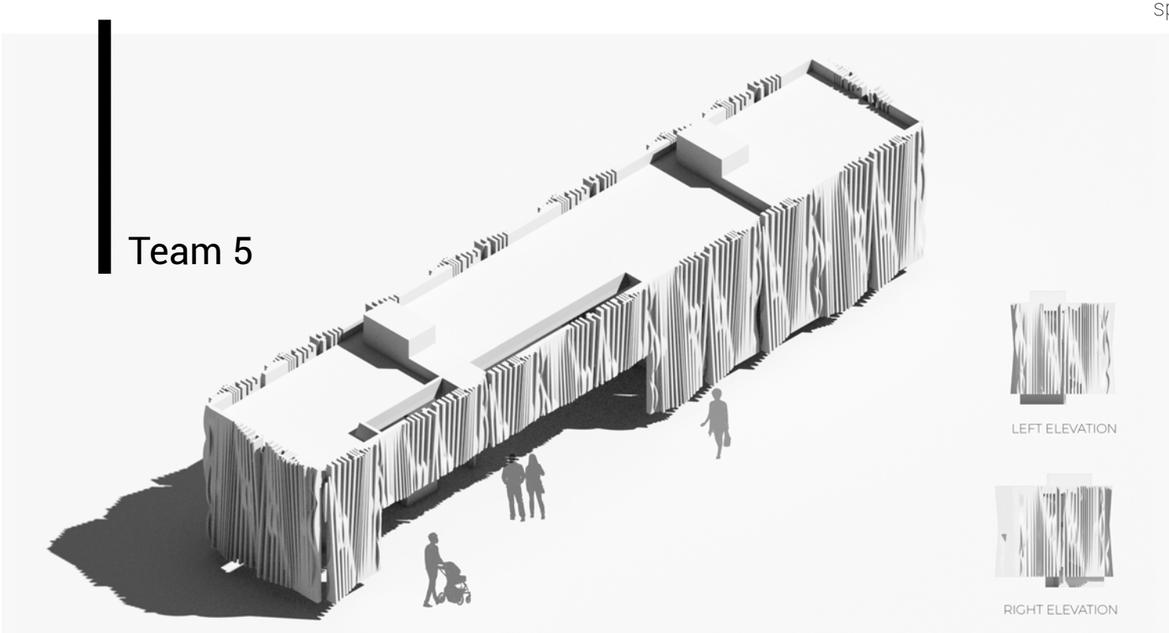
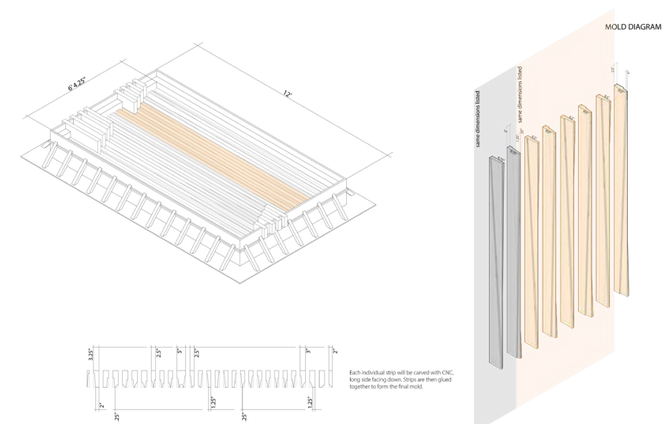
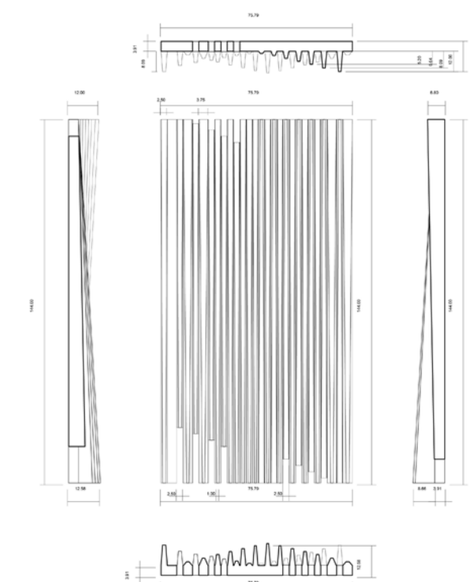
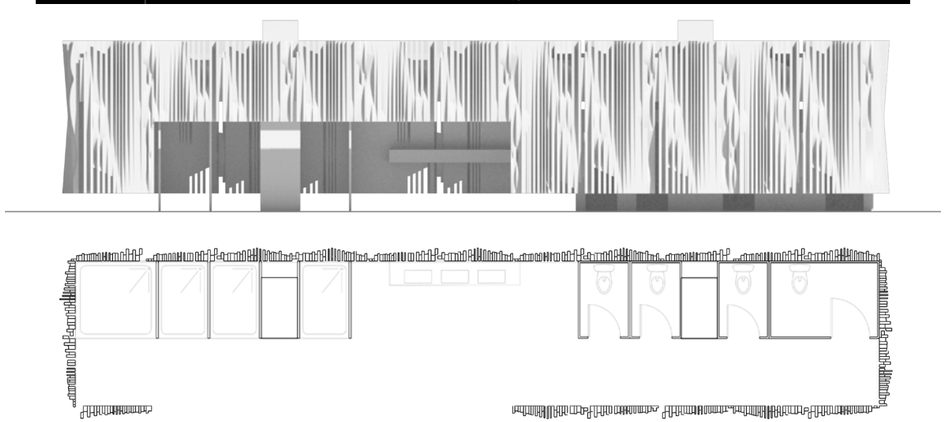
STUDENT WORK

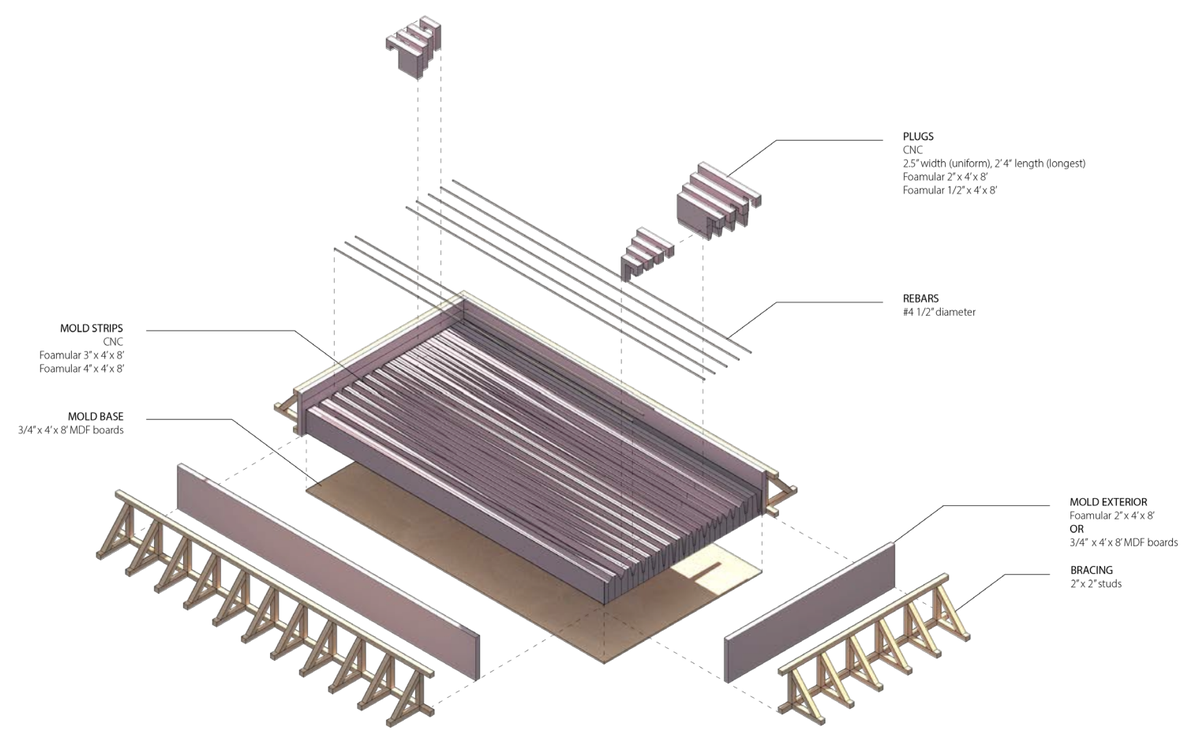
Team 5











Students: Meredith Busch | Lisa Chen | Cody Xie

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