Design-Build: A Real-World Experimental Pedagogy for Architectural Education

HONGXI YIN
Washington University in St. Louis

BAOYUE WANG
Washington University in St. Louis

JIAN ZHU
Washington University in St. Louis

In 2016, Team WashU was awarded a $50,000 teaching grant from the Prestress/Precast Concrete Institute (PCI) and a $300,000 start-up grant from the Office of Chancellor Mark S. Wrighton of Washington University in St. Louis to develop a two-year design studio and seminar courses based on the U.S. Solar Decathlon student competition. The Solar Decathlon series of architectural design studios were part of an academic program closely collaborated with building industry sponsors. This program created new learning networks that combine education and research activities into a holistic, valuable hands-on student design experience. More than 100 WashU architectural students were involved at different stages, including the collaborative design and building process of a solar decathlon house. The project provided our students' unique opportunities for explorations of high-performance precast concrete designs at an advanced level of creative inquiry, design integration, and technical resolution through a systematic approach. In Fall 2017 we delivered one of the most visually appealing, affordable, comfortable, sustainable, and energy-efficient homes for the Solar Decathlon competition. This project was an excellent demonstration of how prefabricated, self-sufficient, and resilient houses can mitigate climate change. The Solar Decathlon house of Team WashU, the Crete House, was awarded the second place in architectural design in the 2017 U.S. Solar Decathlon competition.

107th ACSA Annual Meeting Project

Design-Build: A Real-World Experimental Pedagogy for Architectural Education

Crete House: Solar Decathlon 2017 Team WashU

Studio I: Conceptual Design Studios

This studio in Fall of 2015 and Spring 2016 focused on developing creative architectural concept, plans, and unique precast concrete components and joint technologies that were not only compatible with all the structural systems.

Studio II: Fabrication Studios

This studio took place in Fall of 2016 and Spring of 2017 and mainly focused on BIM and the design processes to develop innovative architectural solutions for precast concrete components and their assembly. The studio closed the gap between the conceptual design and final realization

Studio III: Construction Studio

This studio took place in Fall of 2017, students constructed and operated a 1,000 sq. ft. solar-powered house to demonstrate its sustainability and resilience.

Solar Decathlon Competition

The students shipped the Crete House in pieces and reassembled them in Denver, Colorado in September 2017. The students took the leading roles in guiding the local precast companies in the erection process and laid the footings, exterior walls, core, and all other precast components.

Spring 2016 — Fall — Spring 2017 — Fall 2018

Pedagogy - Construction design

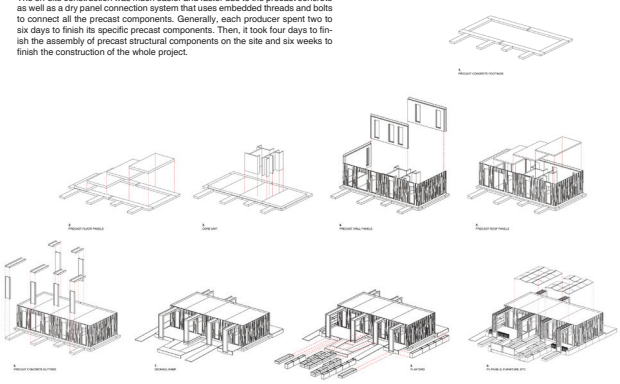
University-wide Education Integration

The Solar Decathlon project created many opportunities for educational experiences and multidisciplinary project-based collaborations. We had spent a significant amount of time investigating an array of new courses and course modules throughout different colleges and departments in the university. Student learning in the studio was primarily arranged in the design phases of the project, and intensive participation was deployed in the fabrication and construction phases. In conjunction with all the stages of the project, new design+research type seminars were developed and added in WashU March program and Engineering School; and meanwhile many existing technology courses were integrated by taking the house as the context of course material, resulting in learning, experience, and credit for WashU students, as well as being part of the house design.

Schools / Departments	Courses Name	Health	Landscape	Art	Structure	Mech. Const	Electrical	Materials	Finance	Market	Construction
Sam Fox School of Design and Visual Arts	Conceptual Design	■					■		■	■	
	High Performance Enclosures	■					■		■	■	
	Surface, Texture, and Furniture	■					■				
	Design & Build I & II	■			■				■	■	
	Net Zero Building Seminar	■				■	■		■		
	Communication Design Studio (Option)	■									■
	Landscape Design Studio (Option)		■								■
	Structure I & II	■			■						
	BIM in practice	■				■	■		■	■	
	Advance Building Systems					■	■				
	An Introduction to Digital Fabrication								■	■	
Electrical and System Engineering	Sustainable Energy Systems					■	■				
	System Design Project					■	■				
Energy, Environmental and Chemical	Electrical Engineering Design Projects					■	■				
	Sustainability Exchange					■	■		■		
	Special Topic: Energy& Building					■					
	New Produce and Process Development								■		
	Sustainable Air Quality		■								
Construction Management	From Concept to Construction								■	■	
	MCM/M.Arch Capstone Project										■
	Project Cost and Resource Analysis										■
	Business Development for Construction										■
Brown School/Center for Aging	Transdisciplinary Problem Solving in Public Health	■									
	MPH practicum (urban design-focused)	■									
	Livable City: Behavioral Studies & Public Space	■									
	Public Health Seminar	■									

Construction Process

The on-site construction was much easier and faster due to the precast concrete as well as a dry panel connection system that uses embedded threads and bolts to connect all the precast components. Generally, each producer spent two to six days to finish its specific precast components. Then, it took four days to finish the assembly of precast structural components on the site and six weeks to finish the construction of the whole project.



Fabrication - Student Rubber Mold Making

Ductal® concrete has ultra-high performance, and its strength is six to eight times greater than that of conventional concrete. Ductal is reinforced with metal fibers that make it resistant to bending and breaking under major transformations (such as pressure or dilation). It is resistant to external damage, such as abrasion, pollution, weathering, and scratching, and is designed to meet the challenges of CO2 footprint reduction and energy efficient buildings while providing an architecturally and aesthetically pleasing visual impact.

Production - Fabrication in Factory

Team WashU has explored supports from building industry, architecture and engineering consulting firms, and HVAC equipment producers. These partners provided in-kind or reduced rate supports regarding building materials, equipment, professional service, and education. Some of these industrial partners also kindly open their facilities and laboratories for the development and testing innovative components and systems to be applied the solar house. With these professional industry partners, a more robust, collaborative learning environment was created for training future leaders in the field, as well as developing new knowledge and products. Activities included guest presentations by industry professionals, field trips to manufacturing facilities, and the provision of technical resources to the students used for their class work.

Practice - Construction Led by Students

We shipped the Crete House in pieces and reassembled them in Denver, Colorado in September 2017. The students took the leading roles in guiding the local precast companies in the erection process and laid the footings, exterior walls, core, and all other precast components. The students came to the competition site in several groups at different time intervals to develop the interior finishing and commissioning. Each group normally included five to eight students for a few days, who then handed off the work to the next group, thereby maximizing the number of students able to participate in the construction and competition.

Innovation - Sustainability and Resillience

Resilience

Structural integrity and resilience were the primary design consideration for a solar house. The material and structure of our house provided long service life, robustness, sustainability, life safety, durability, recyclability, and resistance to disasters. Our house offered useful tools, techniques, and information through applied research and development that help the residents and the community to survive many types of natural disasters such as hurricanes, tornadoes, and floods.

Sustainability

The Crete House aim to maximize sustainability and resilience through an integrated approach that enables the independence of energy, water, and food. The design minimized energy use through innovative passive design and produced power from solar as much as possible. The Crete House demonstrated the right community collaborative food supply through a home garden system. The home gardens of our house produced its occupants' food using a large street-facing plant bed. Ideally, these individual home gardens encouraged other neighbors to grow plants and reinvigorate the ecosystem that may have been displaced through construction. The home garden of the house was irrigated using a roof catchment system. The roof catchment system received water from all of the roof surface areas. The water was then purified and stored in a utility tank for the use of the grey-water system.

Dynamics for Living Adaptability

The Crete house was designed to adapt to the changing needs of the household over the lifetimes of its residents. The universal design enabled the house to respond effectively to the needs of residents without any additional cost or changes to the existing structure and services. The home has flexible space configurable for three primary life stages: a young couple, a couple with children, and a senior assisted-living couple. The house could be expanded and contracted with each life stage to serve young couples, families and older adults best. The design balanced living and work. The movable building service core and furniture maximized flexibility, switching quickly from a home to a workplace and a modern mixed-use residence.

Conclusion

Our vision for the Solar Decathlon competition was focused on affordability, feasibility, attractiveness, mass customization, sustainability, and resilience. The student teams realized this vision by integrating the delivery of the building processes through the house's structural, enclosure, mechanical, and control systems. With the strong support of Washington University and its academic schools and our industrial partners, Team WashU brought together highly talented, qualified, and dedicated students, faculty, and professionals and will produce a significant contribution to the heritage of the Solar Decathlon.

Washington University in St. Louis
Sam Fox School of Design & Visual Arts
SAM FOX SCHOOL OF DESIGN & VISUAL ARTS