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SPECIAL THANKS

To all student groups and volunteers who helped to make this conference a special event.

Interstitial Latency in Design-Build Architecture Education

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Abstract

This paper presents two design-build projects that encapsulate a two-phase process broadly outlined as "design and build." The collected work spanned multiple seminars and studio courses at the University of Cincinnati, Beijing Jiaotong University, and Nanchang University. Both projects progressed from client proposals, concept design, detail development, construction documents, scheduling, coordination and culminated in a series of completed constructions. The paper illustrates the latent discoveries and learning that occurred in these design-build projects through the more blatant lenses of the design process by serving as both architects and builders. The first project consists of six multi-level steel and wood structures, including three short-term residences, a tea house, a bathhouse, and an observation tower coupled with extensive landscape development. The second project is a public restroom. Both projects are sited in rural villages in China.

First, we describe the *design* stage, where the conceptual models were generated with the local context, community issues, and proposed architectural interventions. The concepts are represented through digital models. These designs were later developed into physical mockup models without a reference to the craftsmanship required of the onsite build process. As a result, the drawings and mockup models serve as the immaterial representation of form but do not fully define the materials and strategy necessary for full-scale making. The intangible form of the virtual model carries in the early the design information and intent from the conceptual design forward to the following phases.

In the *build* stage, students participated in the manifestation of the immaterial through onsite construction, experiencing first-hand the transformative potential of a series of diverse activity-based programmatic structures in a rural community. This phase emphasized the construction and exploration of craftsmanship with local resources and materials, producing an outcome that stimulated new activities in the village. By immersing students in the complete design-build cycle, the projects demonstrated the power and possibility of interstitial spaces between phases in the design process.

Students were empowered to consider the various responsibilities architects, engineers, and builders provided in practice. This pedagogical method actively questions where the latent effects of translation between immaterial and material can be learned from both architects and builders. Simultaneously, the projects engaged in a large-scale rural revitalization effort, providing an alternative paradigm for redevelopment. A downstream effect of the teaching methods contributes to the discourse surrounding revitalization and growth in rural communities by exploring a path to instigate positive change through a synthesis relationship of architects and builders.

Keywords: Design-Build, Architect as Builder, Community Engagement, Rural Development

Background

Digital modeling and fabrication tools have been extensively developed in the past decades. In architectural design education, digital fabrication tools allow students to materialize scale models without considering the constraints of the full-scale building process. The "distinction and interconnection of physical representation and physical prototyping" have been addressed in the architecture and interior design curriculums repeatedly. (Tang. 2011) However, within and beyond our disciplinary academic environs, the production of architectural "representations" often serves as a terminal point for the individual architect/designer in the production of an actual building. This 'blatant' disconnect causes the division between the design intent of architects and the implementation requirements for builders as two professions in practice. Therefore, the fundamental challenge of offering full-scale design-build projects in architecture courses lies in the

educator's ability to emphasize the physical world constraints and the 'latent' design adjustments that are necessary during construction. The difference between the architectural representation and the actual building process is a major contributor to the difficulties inherent in educating students in a design-build methodology that requires an in-situ feedback loop of external sources of information to build the physical form. "When this is extrapolated out of the immediate studio context and worked on with a community outside of the College, the level of complexity only increases." (Tang, Hamaker, Mitchell, 2021)

Dialogues have been developed among faculties and students at the University of Cincinnati (UC), Beijing Jiaotong University (BJTU), and Nanchang University (NCU) to answer this challenge. The UC+BJTU team participated in the UIA-CBC design-build project called "Pear Orchard Cabin" in China in 2019. The UC+BJTU+NCU team participated "Yuzhang Construction" workshop in 2020 and completed another design-build project, "rural public restroom." Several co-teaching strategies were introduced to UC, BJTU, and NCU students as a series of design-build investigating design pipelines and platforms that focus on making architecture through scaled models, simulated construction, material experimentations, and full-scale construction. Digital representation (immaterial process) and fabrication (material process) are considered hybrid activities where students engaged from scaled model in the studio to full-scale build on the actual site.

Learning Objectives

The objective of these two design-build projects was to allow students to work with local communities and actualize their 'blatant' design concepts at full scale. Commonly, design proposals that are produced within academic settings are purely speculative and are rarely if ever built physically on a 1:1 scale. Throughout the project's design and construction phases, not only did the students gain practical construction experience, but they also practiced their skills by wearing two hats as an architect and a builder. The projects intended to challenge architecture students' critical thinking and problem-solving capabilities that encapsulate the 'latent' learning within a real-world context. It is one of designers' and architects' vital skills to troubleshoot various conflicts and issues during the project's construction phase. Within a limited time frame and budget, students and faculties from three universities overcame multiple challenges, and together, they designed and built a series of structures with the help of the local community.

Project "Pear Orchard Cabin"

In the summer of 2019, the "UIA-CBC International University Construction Competition" was organized by the International Union of Architects[1] (UIA). Using the site of Siyang Village in China, the competition selected fifteen winning teams. The teams had to design and build a permanent structure of up to 100 square meters, suitable for rural life. The buildings were required to promote the social events of the village and support various programs associated with the pear orchard. UC+BJTU was one of the winning teams. The project's design and build period lasted eight months, including a two-week onsite install, with two UC courses stretched across two semesters in 2019.

Design

The initial design concepts were developed in the third-year Architecture Digital Media Skills course at UC in spring 2019, which began by promoting ideation through learning from the rhythms of the landscape and using inspiration from rural life. The Chinese team members visited the orchard in Siyang Village and documented the different needs of farmers and tourists in the scenic site. They also surveyed the site's typography, grid system[2], natural habitat including tree species, ages, and the produce grown in the fields.

The course focused on how architects' creativity and imagination could serve the local community and augment the environment and social activity. More than twenty proposals were developed to address the demands of the village administration, farmers, and tourists. One critical goal was to promote the pear orchard's unique tourist attractions by introducing architectural interventions. The seasonal activities that attract tourists include viewing flowers in spring, picking fruit in autumn, and observing the daily work of local farmers. Several proposals developed time-sharing concepts that addressed the needs of tourists and farmers in different seasons. All proposals were presented through digital (immaterial) and physical (material) artifacts. Some proposals included full-scale joint prototypes to demonstrate the feasibility of construction and onsite assembly.

The faculty advisors and jurors selected a proposal for the final submission through an internal competition and review. A proposal with a minimalist design, called "A Millet in the Sea of Flowers," was revised and submitted to the UIA competition as the joint proposal from the UC+BJTU team. After numerous iterations, the team designed several "tiny cabins" scattered across the pear orchard, including several structures that exceed the height of the treetops as observation decks. (Figure 1)

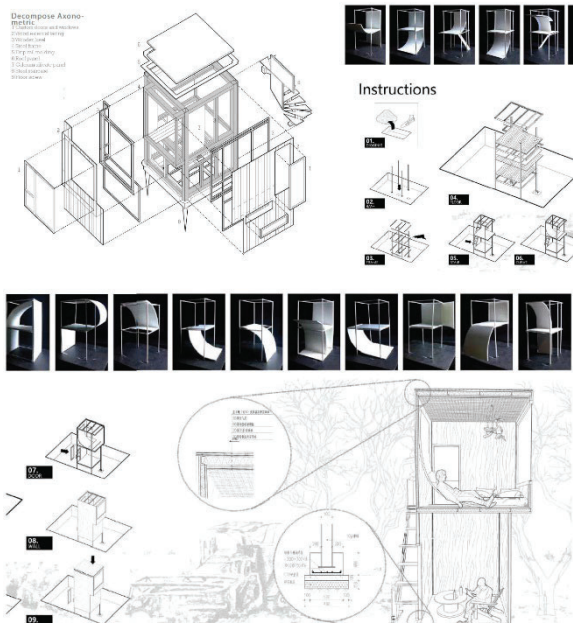

Figure 1. Drawings of cabins and construction process.

Build

The UC students and faculty traveled to China through an independent study course, working with BJTU students, faculty, construction workers, and local villagers to form a "build" team. As part of the UIA-CBC design-build workshop in the summer of 2019, the UC +BJTU team continued to develop the original "micro intervention" concept into a proposal to build six small cottage structures during the 15-day competition. (Figure 2) These new structures allowed tourists and villagers to activate, inhabit, and engage the beauty of the rural landscape. The six buildings were completed using locally available materials in a compressed construction schedule. The design-build team used wood-framed infill elements within heavy steel superstructures in the construction and used locally sourced recycled bricks to build the water collection, retention, and distribution systems. The team also designed a screened enclosure by weaving the off-cut branches of the pear trees into the building façade. Moreover, the team worked with the traditional local craftsman to customize waterproofing / corner / edge details and manage rainwater on the site, solving design problems unseen in the drawing sets and study models. The project won the third prize in the International University Construction Competition of 2019 UIA-CBC and second place in the "Ecological Healthy and Sustainable Design" section at the 2020 Asian Design Awards.

Figure 2: The completed structures are six multi-level steel and wood cabins, including three short-term residences, a tea house, a bathhouse, and an observation tower coupled with extensive landscape development.

The design proposal intends to be adaptive and reproducible through the structure's intervention within the interstitial spaces of the orchards grid while preserving the fabric of the natural landscape. The curvilinear paths connect each programmatic unit to the natural landscape to offer guests an immersive experience when they walk from one cabin to another. To provide visitors with the unique experience of sitting above the orchard itself, the team designed the structures to be higher than the surrounding fabric of pear trees (3 meters /9.8 feet). The two-story-tall buildings rise above the treetops to provide a panoramic view of the pear orchard, the village, and the landscape beyond. With the two-story configuration (5.5 meters/18 feet), visitors can immerse themselves in nature and enjoy the pear flowers in bloom. (Figure 3)

Figure 3. Renderings and completion of the observation decks on top of the two-story-high cabins.

Reflections

Since this design-build project was not contracted with a professional construction company, it was a necessity for the team to work directly with local vendors, trades, and village workers to manage the time constraints of the construction phase. This required remotely coordinated collaboration to develop a detailed set of construction documents, along with a corresponding budget, schedule, and the acquisition of building materials, including steel, timber, doors, windows, tiles, fixtures, and construction equipment. Throughout the process, the team solved many unforeseen (latent) technical and design problems not covered in the project's planning phase (blatant) by fluidly revising the design in the field to meet these unique conditions.

During the onsite construction, the design team assumed the role of the builder, which required the design flexibility to make adjustments to solve unexpected issues continuously. For example, the team had to abandon the regional tradition of concrete block foundations to achieve rapid deployment, minimize damage to the natural habitat, and adapt to the relatively soft soil conditions throughout the orchard. Instead, the team used four large ground screws (earth anchors) for a post and pier foundation. The two-meter-long steel posts were drilled underground to support each structural steel column. The local welders then welded the circular bearing plates to support the steel columns. This approach allowed each of the main building structures to be elevated from the ground.

In another case, the team redesigned the wooden rain screens to accommodate airflow and ventilation of the cavity space below the ground level superstructure of each pavilion to prevent ground moisture and rainwater from infiltrating the first-story wooden infill. This change proved beneficial when a typhoon struck in the middle of the construction and caused high water to threaten damaging the lower level of each structure. Water quickly dissipated due to the designed ventilation space and allowed construction to proceed. (Figure 4)

Figure 4. Students installed wood boards on the steel frame.

The original plan called for calcium silicate boards as a base material to receive a topping skim coat to create a uniform interior. However, the team found the panels could trap moisture within the wall and would require a multi-layer finishing process creating a longer, more labor-intensive installation. Instead, excess exterior cladding wood boards were used to create a "breathable wall" where two layers of slats combined with a staggered joint pattern reduced condensation and water penetration while allowing moisture to exit the assembly. The building's rain shield (flashing) was custom-made with tinplate sourced in a local hardware store and then cut and bent by the team onsite with a portable angle grinder. The team also repurposed unused structural steel C-channel to make the façade track system that houses the pear branch screens that clad the exterior of the tea house.

In the end, the team completed the construction of all six structures with generous help from the local government, construction workers, farmers, and competition organizers. While facing the challenges of limited funds, site conditions, and weather delays, the project met the team, organizers, and villagers' expectations. As a practical application of a shared fragmented farmhouse in the village, the project met the different needs of tourists and farmers. On weekdays, the cabins are used as a temporary cottage for farmers for storing farm tools, working, and resting. In the blooming season of the pear orchard, the buildings are converted into a place for tourists to enjoy an authentic rural experience.

Project YuZhang Public Restroom

Building on the success of the "Pear Orchard" project, the UC and BJTU team participated in a similar project in the summer and fall of 2020, called the "Yuzhang Construction" workshop, to design and build two public restrooms at the Pengyuan village, in Yifeng County, of the Jiangxi Province in China. This workshop also included a collaboration with Nanchang University (NCU) and cooperation with the local village government to carry out the construction. However, due to the COVID-19 pandemic, the UC team participated as a remote partner but could not travel to China to engage in the build phase. The first building was completed by the Chinese team and local farmers in November 2020.

Design

As a part of the "Yuzhang Construction[3]" workshop, an annual project initiated by the NCU School of Civil Engineering and Architecture in 2018, the project was undertaken as a summer co-op course[4] at UC. Based on the concept of "innovation and construction," the workshop promotes the public welfare design and social engagement to serve the selected communities and teach students outside the classroom. The three universities co-taught modules allowing students and faculties to get exposure to the issues in the rural villages and explore how to activate the social life with design and help the local community revitalization and sustainable development. The project incorporated various modeling and simulation methods to test and validate green design strategies such as utilization of local materials and construction methods, passive ventilation, daylighting, and a system to convert human waste to fertilizer. The team proposed glass tiles combined with traditional clay tiles on the roof to reduce lighting energy costs. (Figure 5) The team also proposed an unconventional internally oriented void space to maximize the natural ventilation by splitting the building into two component parts. An air dynamic simulation model was used to evaluate the size of the opening and the best orientation to bring the fresh air into and through the restroom. (Figure 6)

Figure 5: glass tiles for daylighting.

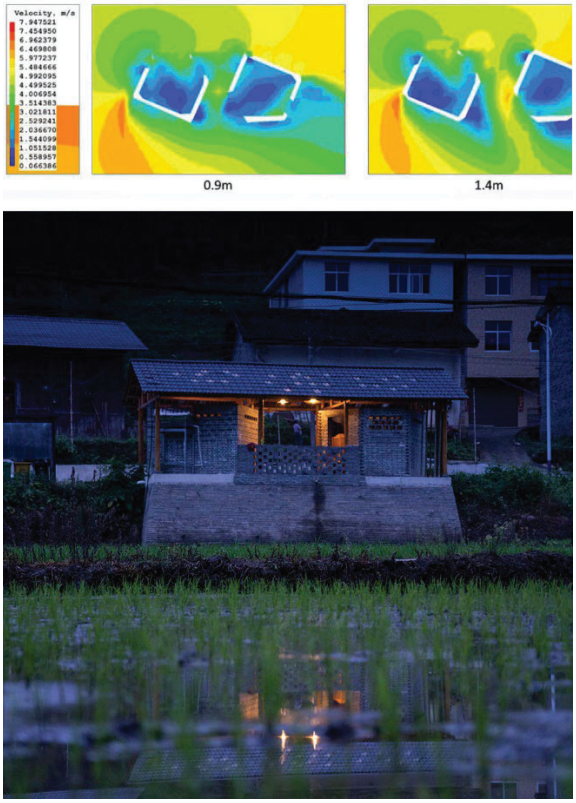

Figure 6: Air dynamic simulation and final constructed restroom.

Build

Although the UC team could only act in a remote advisory role in the build phase, we discussed the possible implementation of vernacular material details and construction methods for the new restroom. Building in the village typically uses traditional materials (wood and bricks) with unique craftsmanship. With the help of local masonry workers,' the team recycled hundreds of old blue bricks and repurposed them to construct the retaining walls, permeable restroom massing, and paving. The students learned to use a simple brick knife to split, wipe, knock, and complete masonry work. These traditional materials and craftsmanship gave the recycled bricks a new life.

The team constructed a new retaining wall to allow the new restroom to float above and project out into the adjacent fields while functionally protecting the irrigation ditches and nearby rice fields from construction pollution. Only a small part of the existing slope was damaged due to construction work, material stacking, and road paving. The vegetation on the slope gradually returned to its original state. (Figure 7)

Figure 7. Site slope and natural habitat are preserved and recovered after the restroom construction.

Reflections

Although this project was implemented quickly without a comprehensive hearing with the local community, the involvement of village administration and farmers was well organized from the early planning phase through the final construction. Because the village had never had this type of split massing, dogtrot, or void-in-middle restroom before, it was critical that the merits of the unconventional restroom typology were communicated clearly to all the invested parties, and public opinions were gathered and considered. Pros (social space, programmatic flexibility, daylighting, ventilation) and cons (unfamiliarity, complexity, and cost) were analyzed systematically and engaged in a feedback loop with the design team. After the construction, this new type of split massing restroom with outside washing, resting area, and the green garden was well accepted and increasingly activated by the village. The project responded to the community's immediate pragmatic needs and the opportunities presented by its unique site condition and construction. The restroom is now used for farmers as both a functional utility and a social place to connect. The new public restroom promoted positive changes and enhanced the quality of life in the village.

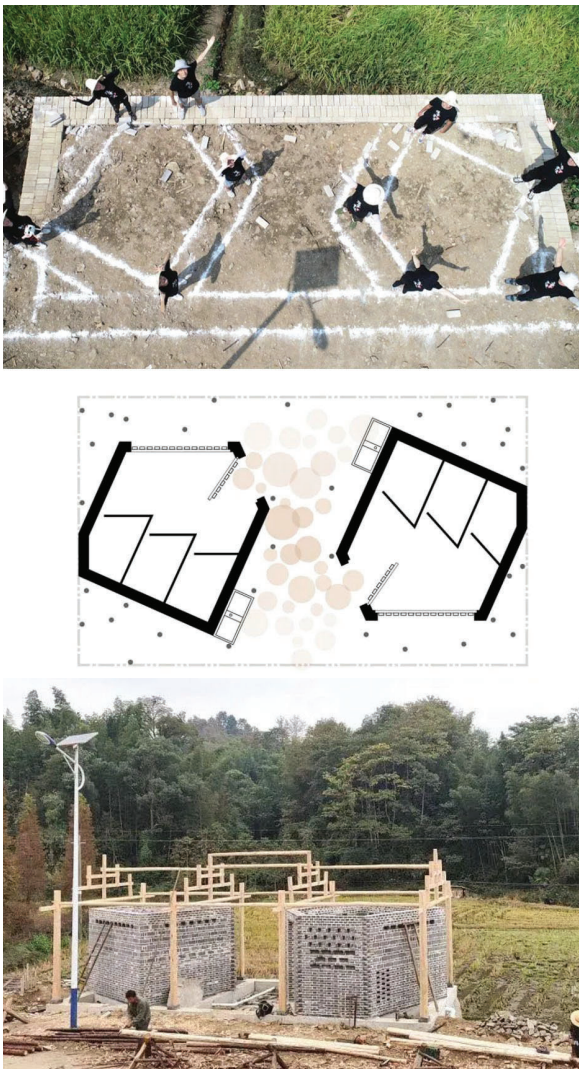

Figure 8. Floor plan and new typology for the restroom.

Conclusion

Both of the design-build projects provided students a glance into the possibilities of synthetic relationships between architects, engineers, and builders. The design drawings and prototypes have been used as a communication tool, a physical "representation" to gather feedback from other designers, engineering consultants, local workers, and stakeholders who work side-by-side with students as they engage in the act of actualizing their speculative designs. Architecture students must understand how local builders' processes can support and influence their tectonic principles.

Between the 'blatant' stages of *design* and *build*, numerous discussions, iterations, pivots, and napkin sketches explored a simulated construction processes to consider the critical moments and factors within the final act of materialization. Although this interstitial or in-between phase is inherently informal, it allowed the structure, envelope, finish, systems, and material properties to be carefully studied by adapting the design to the available materials, budget, and construction methods. This necessary layer of 'latent' discovery enabled the translation of the immaterial to the material as the team changed strategies that speculated on issues of construction and assembly.

In both cases, the projects could benefit by finding even more time to spend coordinating designers and builders. In the "Public Rest Room" project, the complexities of brick patterns needed to be simplified to ensure high levels of expediency, quality, and craft by the local masonry workers and student advisors. The truss system was built based on the conventional methods rather than the proposed irregular columns and frames due to the construction cost and time constraints. The design-build process will always be heavily dependent on the onsite construction personnel's skill level, who often had their own workflow to handle joints / details and the designer's ability to communicate the methods developed in their investigations clearly. In future projects, the design phase should work to include local village builders earlier in the discussions of the load-bearing structural systems and material assembly details to deliver comprehensive design artifacts for the builders to engage with. It is this latent learning about the process that can create work that deviates far less from the design intent.

The "Pear Orchard" project provides successful precedents in coordinating architects, engineers, and builders. Because the cabins required intense assembly work onsite, including large amounts of welding, which requires complex coordination of power supply, heavy rigging (cranes), electric welding equipment, and welders' schedules, the design team developed the three "residential" cabins, tea house, and restroom with identical steel superstructures that allowed the customized building skin to be added as a modular wooden frame later. Students cut and assembled the wood frames adjacent to the site and then quickly installed them into the steel superstructures as they were completed.

Through these two projects, the students also learned about the possible impacts of architectural interventions driven by the local communities. We discussed the responsibilities of architects, engineers, builders, and the community stakeholders, using architecture as a vehicle to bring value and public awareness to enhance rural life with limited budgets and resources. How can architects and architecture students actively participate in facilitating the dialogue between groups who might have different goals and

expectations? These investigations outside of the relative safety of the studio allowed both students and educators to reflect on the academic architectural design process with "building," not just "representation" as the ultimate outcome.

End Notes

1 Other organizers are the Siyang County People's Government, China Building Centre, Tianjin University, under the guidance of the Teaching Steering Sub-Committee of Architecture, Ministry of education of the People's Republic of China.
2 The farm and pear trees are organized as a grid system, The distance between each latitudinal row is about 6.5 meters, and the distance between each longitudinal row is about 4.2-6 meters.
3 The Yuzhang workshop has completed the mill building construction in Xikeng village in 2018 the rice bridge building in Tianqiao village in 2019.
4 UC Co-op experiences are career-oriented, transcripted, and compensated. They require academic preparation, faculty mentorship and assessment, and guided student reflection that integrates the experience to student learning goals and their academic curriculum. https://www.uc.edu/campus-life/careereducation/get-experience/co-op.html

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