HOSTEL DETROIT: FABRICATIONS IN ARCHITECTURE

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INTRODUCTION TEST

Both in practice and academia it is often the case that design and construction are considered two distinct and separate phases of any project's realization. This is both ideologically and contractually supported by current pedagogical and practice models. Acknowledging that modes of operation shift during the process of architectural realization is essential. But, it is no longer a valid assumption that design is a separate act from that of fabrication and vice versa. This is especially true as the relationship between design intent and the mechanisms for constructing buildings grow to be inseparable. Emerging technologies aimed at grappling with the dramatic increase in building sophistication and the need for open collaboration increasingly position digital proxies, digital fabrication tools and by extension prefabrication, under the direction of the architect.

Design-build pedagogical models are optimally positioned to take up this charge since their conception and design agendas are frequently inclined toward a degree of experimentation and speculation uncommon to other realms of architectural praxis. It is essential then to reconceive "design-build" as applied material practice in which there is no implied (or explicit) separation between design and build.

The course and project described in this paper emphasized CNC (Computer Numerical Control) prototyping and prefabrication as a means of accelerating the learning process as well as the production process, developing collaboration, craft, efficiency, tolerance and control. For students, a feedback loop was activated between their conceptual design thinking (via digital modeling tools) and praxis (via CNC technology).

In this paper, the authors provide a critical description and evaluation of a graduate-level seminar course which served as a case study for merging advanced digital modeling, CNC fabrication methods and prefabrication techniques in one speculative project.


Figure 1. Project installed at Hostel Detroit

SITE & PROGRAM

In the fall of 2010 the authors began a series of conversations with the director of *Hostel Detroit*, a non-profit youth hostel located in the re-emerging Corktown neighborhood in southwest Detroit. Those conversations led to a seminar course during the spring of 2011. The hostel needed an outdoor building to provide secure bicycle and equipment storage, a covered gathering and socializing space and a functional rainwater collection system to support a series of small scale organic gardens. Adjacent to the Hostel's property are two vacant lots that frequently play host to guests and neighbors. The new building was to make the first gesture in connecting with the adjacent land and activate the Hostel's unique set of urban spaces. Aside from these programmatic requests, no further design directives were given.

METHODOLOGY

Although the budget for the project was small and in some cases limiting, the critical driver in formulating the design and fabrication of the project was the constraint of time. Students had eight weeks to design, fabricate and install the project. Given the site's relative remoteness from campus (around 45 miles) and the availability of exceptional resources in Taubman College's Fabrication Laboratory (FabLab) we decided at the outset to pursue a shared research interest in prefabrication techniques, and realize the project primarily through off-site fabrication. This meant rethinking course instruction and moving both the space of instruction and the space of making to the FabLab where we could extend the model of applied material practice by linking digital environments with materials and processes.

To begin the semester, students first developed core design concepts for the project and the relationship of building to site through a series of physical models and sketches. Students leveraged skill in parametric digital modeling to fluidly connect design intent to fabrication. A parametric model developed early in the term was repeatedly refined and revised in an evolving feedback loop with prototyping and design evolution. The structural module, which in this case was a triangulated framework of custom water jet cut steel gussets and standard dimensional lumber, allowed the units to move quickly from a digital environment into fabrication as a kit of parts which were transported to the site for rapid erection with simple hand tools.

Complimentary assemblies for the cladding and structural deck also evolved within the parametric model. Embedded within the surface of the deck was a series of machined reliefs and channels which located an integrated set of custom fabricated bike racks and movable door panels.

Merging the space of design (classroom) with that of physical making (shop), is a seemingly small spatial distinction but one that has profound implications for teaching and learning—students are continually prompted to recognize digital mediums as part of a spectrum of tooling and to integrate feedback from physical materials and processes in an evolving digital proxy which serves as the locus for design and collaboration.

Traditional design build courses follow a linear workflow which typically bridge multiple semesters in the progression from schematic design to design development and then finally to design documentation and construction. In these models, students stand in for many and varied skilled trades whose discreet work is layered into the project. Students spend a great deal of time on site as work progresses, affording time to build a library of trade skills. Physical resources such as tools and materials must be mobile and generally located on site or delivered to it. The full spectrum of project coordination, travel and transport, inclement weather, site conditions and others must be dealt with in the field. Similarly, issues of insurance and liability for students working off campus remain a persistent problem in many design build programs.

In a traditional design-build scenario, a project design is begun in the fall semester, developed during the following term and finally built in the spring and summer following the conclusion of the design and documentation phases. The institutionalized bifurcation of design and build serves to reinforce the apparent divide between design and fabrication as two separate stages of project realization, resulting in missed opportunities to recognize design and making as productive research avenues and as means of theoretical enquiry in which discoveries gained by spending time working directly with materials and processes may be fully integrated in the project.

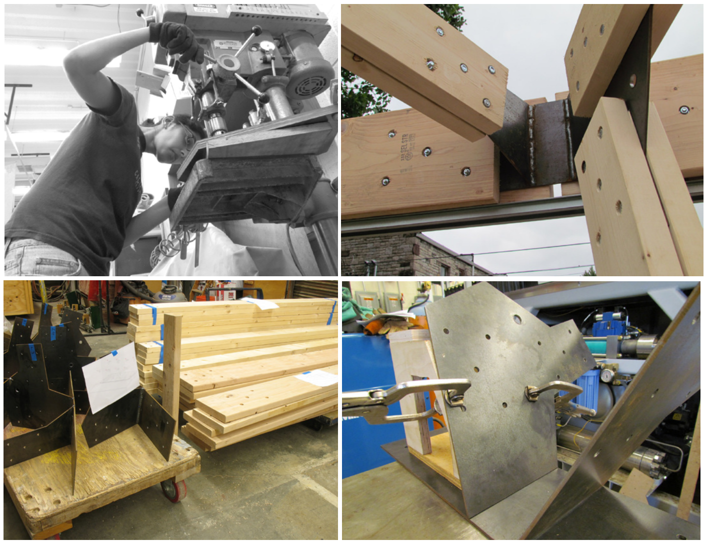

Figure 2. Process, detail & pre-fabricated kit of parts

Prefabrication serves to alleviate some of the traditionally difficult aspects of off-site design and on-site construction. With on-site construction, students dedicate a considerable portion of their working time to transportation and job site set-up. Many critical project tasks are performed in or delayed by inclement weather. On-site construction generally requires the work to progress linearly and certain tasks must be completed before other systems may be brought into place. Legal liability and insurance matters are complicated by students working long hours off campus in more difficult to manage job site environments.

Prefabrication on the other hand allows multiple tracks of design and fabrication to move forward simultaneously. In our case, students worked in teams, developing expertise in one or more aspects of the project and then coordinating those efforts with others, regardless of their chronological delivery to the final construct.

DIGITAL PRACTICES: META-FABRICATION

Students in this course have designed through making (and remaking) the project throughout the term. Given the condensed timeframe of the semester, this is only possible through the development of fluid systems that support rapid transition from design intent to physical making and allow for necessary adaptations to occur in the design medium. For this course, a hybrid parametric digital model or meta-fabrication provided the link between the parameters at the heart of the design with geometry and also provided a site for the embedding of intelligent design features. The digital model which ultimately reflected each component of the structure was modeled either parametrically, as in the case of the structural gussets and wood framework members, or explicitly as in the case of the translucent skin. The structural gussets and the lumber framework were linked to a set of parameters that organized them in space and set their relative angles and dimensional relationships. The Grasshopper model was created such that the overall form and dimension of the shed could be smoothly manipulated in keeping with the design strategy. A schedule of lumber components as well as 2-dimensional drawings of the steel plates was also provided directly from the model's geometry. This allowed us to remain flexible throughout the design process all the way up to the final commitment to a design.

Figure 3. Roof assembly (upper), on site ready to be installed (lower)

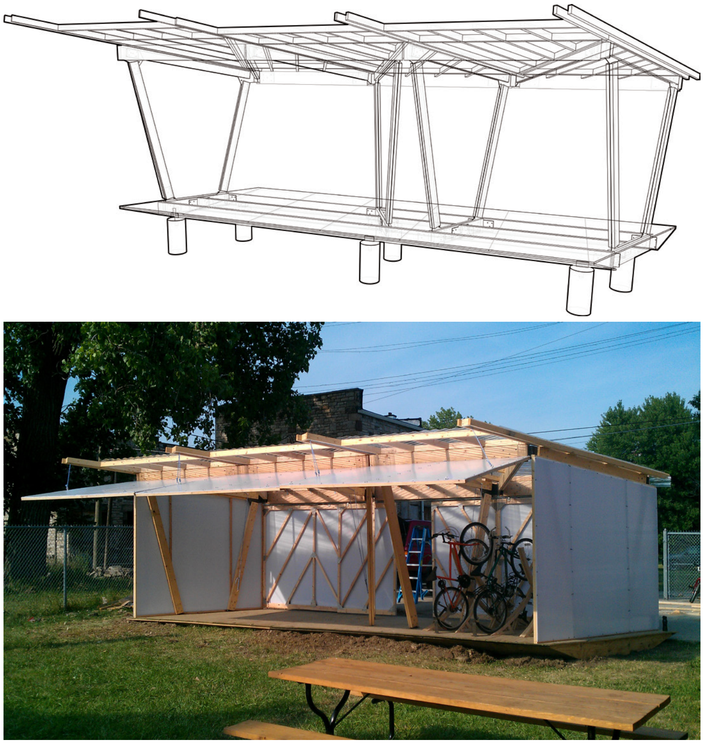

Figure 4: drawing of the structure, photo of the completed project

Figure 5: full-scale prototype (left), bolting the structure together on site

EVALUATION

During the course of the project there were a few key moments that underscored both the effectiveness of fore fronting prefabrication and automated manufacturing processes as well as their difficulties. They serve to illuminate the fact that in any complex project the relationship between material, craft, process, etc. have unforeseen consequences and interplay that effect the timing, budget and design expression of the overall work. While many of these aspects cannot be completely avoided, the strategies implemented in this course allowed us to retain control of the design medium and the processes of fabrication.

For example, on the eve of full commitment to fabrication, we discovered the remnants of a previous building's foundation immediately beneath the proposed site for the shed. In light of accessibility requirements and setbacks we could not relocate the project to another area of the property. The building foundation had to be removed, adding substantial cost and significantly exceeding our budget. However, due to the flexibility of the parametric model and the proposed building system, we were able to remove about 1/3 of the length of the shed, thus bringing the project back under budget. The robustness of the parametric model allowed those changes to be made and updated automatically without the need for additional time to redraw and process the model's geometry.

In another key moment, a decision needed to be made in the process of fabricating the custom steel plates for the gussets. Their process required some 60 unique but similar plates to be cut from large sheets of steel. Each of the individual plates had between 5 and 15 holes sized to accept a structural bolt. We had planned on the use of Taubman College's CNC water jet cutter to pierce the holes and cut the custom profiles. But, in the development of early prototypes, we realized that the automated processing of the bolt holes would increase the fabrication time and cost several fold. We opted instead to produce a single CNC routed drilling template since each plate had the same pattern of holes and perform the drilling operation "by hand" on a drill press where each hole took less time and students could work together to share the task. What this shows is the importance of integrating knowledge gained through familiarity with material and process in the design of any given project. Had we committed to the water jet process in totality prior to prototyping, we would have clearly faced an over budget and behind schedule project, thus jeopardizing other key features of the project.

After finally resolving both the scope and procedure for fabricating the steel gusset plates with a combination of automated water jet cutting and hand-based drilling, the school's water jet suffered an unexpected and rare breakdown which lasted several days and delayed the onset of installation. In the interim, we rapidly sent out requests for water jet cutting quotes from contractors in the area. Those quotes were well beyond the scope of the remaining budget and in some cases exceeded our total machining allowance by a factor of five. So, while the fast-track process of simultaneously pushing several fabrication processes forward at once allows time to be saved when all systems are on line, even one malfunction or delay can become extremely difficult to negotiate within a compressed time schedule and tight budget. In this particular case, it was an in-house resource that began the cascade of events, but it is by no means an isolated circumstance. Contractors outside the university also face similar conditions and may become the source of similar delays and cost over runs.

While the project was ultimately a success—the project was completed, the Hostel was truly happy to have their building and students largely achieved beyond the established learning goals—failure as well as unforeseen conditions in the fabrication both provided significantly high-pressure learning situations.

CONCLUSION

The course demonstrates the unique educational experience that grows from digital approaches to design thinking and full-scale rapid prototyping in making (and remaking) the project throughout the term. Advanced parametric models and automated CNC resources extend the range and scope of project that is possible within a small time frame. This not only opens up applied material practice to a wider range of students, it provides increasingly valuable opportunities to make strong connections between digital practice and physical materials.

Digital practice gives entrée to a range of prefabrication strategies that can streamline many of the critical tasks and difficulties of traditional design-build models of on-site construction. In particular, prefabrication can clearly speed aspects of delivery, but in fact come with additional responsibility for architects to be integrated in the process and well versed in the role and limitations of the materials and tooling that they promote.