A Reflection on Pre-Fabricating Exterior Partitions for a Single-Family Home

Michael-Jeremiah R. Eseed
California Polytechnic State University
San Luis Obispo, California

In the wake of a fire in Weed, CA that destroyed nearly 150 homes, a non-profit organization called Great Northern Services (GNS) reached out to Cal-Poly San Luis Obispo about a service-learning opportunity that involved designing a single-family home and prefabricating the exterior partitions in San Luis Obispo. In Fall 2017, interdisciplinary teams of students delivered design proposals in the Integrated Project Delivery studio. The selected design was then finalized into a permitted set of drawings and planning for the prefabrication began. The extent of the prefabrication was limited to the framing and sheathing of the exterior walls. The length of each panel was changed from 6'-11" to a custom length for each to optimize panel weight, material usage, and maintain the studs at 16" on center. The prefabrication took place in the Simpson Strong Tie Demonstration lab at Cal-Poly, where space was allocated between other building labs and projects. An estimate was prepared, and material was sourced from a local lumber supplier. The panels were stacked in the construction management plaza as they were built. They were loaded vertically into a 40-foot shipping container, which was then shipped to the project location.

Keywords: Prefabrication, Modular, Residential, Service-Learning, Planning

Project Background

On September 15, 2014, a fire began in Siskiyou County near the city of Weed, CA. The fire, named the Boles Fire, burned 516 acres of land. 157 single residences and 8 commercial properties were destroyed. 4 single residences and 3 commercial properties were damaged. The fire was fully contained on September 20th, 2014. One of the structures that were destroyed was the Great Northern Services headquarters. Great Northern Services (GNS) is a non-profit organization that was founded in 1978. They work to foster housing, rehabilitation, and community infrastructure in the cities of Dunsmuir, Mt. Shasta, Weed, Dorris, Fort Jones, Etna, Yreka, Tulelake, Montague, and Siskiyou County. After their headquarters burned down, they decided to repurpose that plot of land to build a housing subdivision. GNS saw this project to be a suitable service-learning opportunity for students working in the built environment, so they decided to contact the College of Architecture at California Polytechnic State University, San Luis Obispo. An agreement was made that a senior-level design studio would be focused around delivering design proposals for a single-family residence, the first residence in the new subdivision. The design studio chosen for the project was Integrated Project Delivery, an interdisciplinary course that included students from the architecture, architectural engineering, and construction management departments. The studio took place in the Fall quarter of 2017, and in the end GNS selected one design they preferred the most. Once the design was chosen, a set of drawings to be issued for permitting was completed. This set of drawings was used in the next phase of the project: prefabrication.

The exterior walls of this project were designed to be framed in paneled sections that could be assembled separately in an off-site location. Once the panels were built, they were shipped to the project site, erected onto the building
foundation, and fastened together. Students from the construction management department were responsible for planning and coordinating this effort, as well as building these panels by hand. In the Winter quarter of 2018, one group of students began this effort. However, the prefabrication was unable to begin due to unfavorable circumstances. Those circumstances changed in Winter of 2019, and the effort began again with a different group of students. The project was completed in Spring of 2019.

Project Goals and Objectives

The objectives of this project were as follows:

1. Create a schedule for construction.
2. Prepare material lists.
3. Create a tabulation of market-priced material costs.
4. Create (a) logistics plan(s) for construction, rigging, and shipping.
5. Procure materials; coordinate delivery and storage on campus; and manage materials inventory and work in progress.
6. Build exterior partitions per the project design.
7. Produce a reflective end-of-project paper.
9. Deliver the exterior partitions on time.

The goals of this project are as follows:

1. Produce exterior partitions to a suitable trade quality standard, demonstrated by achieving objectives 2, 4, and 6.
2. Demonstrate timely performance management by achieving objectives 1, 4, 5, and 9.
3. Prepare appropriate documentation for the client, demonstrated by achieving objectives 2, 3, 4, and 8.
4. Reflect on learning outcomes, demonstrated by objectives 7 and 8.

A Reflection on Project Processes

Scheduling

A schedule was creating using Primavera P6. All the planning and coordination was scheduled to be complete at the end of Winter quarter. Spring quarter was planned to be solely prefabrication. The activities in the schedule were primarily durations set aside to complete a specific deliverable or plan a component of the project. This included time to draft each deliverable, have the project supervisor review it, and have the students revise it. The typical duration for these activities were three days, two days, and one day, respectively. The schedule was an ideal sequence of completing deliverables, however what I did not anticipate was exactly how complex the project was going to be. The interrelation and dependency of each decision or deliverable made it difficult to complete each in a linear fashion. In reality, each deliverable was being completed simultaneously, rather than finalizing one and moving on to another. Because of this, at the end of Winter quarter we found ourselves a bit overwhelmed with the number of deliverables that still needed to be completed. An improvement I will take with me in projects moving forward is not being hesitant to speak up about our progress. There were a few times during the planning process that I felt we were behind or taking too much time to move onto the next step. I hesitated to express my concerns for mainly two reasons. The first is that the other team members seemed unconcerned, so it made me question whether I
should be concerned as well. The second is that I was afraid of my team members reacting negatively, and it would bring down the team chemistry. As I continue to grow in my career, I will make it an effort to be unafraid of the consequences of speaking up if it is for the best intentions of the project.

Weekly Meetings

The project team met once a week to review the deliverables that were in progress, receive feedback from the project supervisor, and collectively work towards a solution to any issues. The atmosphere at these meetings was always comfortable. The project team developed a chemistry that made communicating easy. Even when the project took an unexpected turn and the pressure was on, the team was able to keep a collective sense of poise and sensible positivity. A template for meeting minutes was created to keep track of the content in each meeting. Minutes were consistently taken during the early stages of the project, but as the project progressed, the consistency began to deteriorate. I believe this was partly because the template that was created could not be easily updated in an organized fashion from week to week. As each item developed a longer and longer history of updates, it became unclear what the current status of that item was. This progression eventually led to not taking any more meeting minutes at all. Instead, team members would take notes individually as they deemed appropriate. This experience made it clear how difficult it can be to capture the content of a meeting as it is happening. I found myself often unsure about how to concisely word a bullet point in order to communicate it accurately. Meanwhile, I would miss some details while I was writing and the subject was being discussed. The consequences were realized later when the subject would resurface, and the team was unsure about the final status of it. I come away from this with a deeper appreciation of those who have the responsibility of taking meeting minutes and a reinforced want to improve my written communication skills.

Communicating with Entities on Campus

There were aspects of this project that required coordination with other entities on campus such as getting approval for storing the container on campus, allocating space in the Simpson Strong Tie Demonstration Lab, or getting donations for equipment. This is where I saw the student team members were limited in their ability to contribute. These facets of the project required a higher level of experience and authority that fell solely on the project supervisor. I found that the project supervisor having this much responsibility was inappropriate for a senior project. In a typical senior project, the project supervisor would be just that: a supervisor. However, this project was not a typical senior project, so the amount of responsibility the project supervisor had was appropriate. This was something I had to come to terms with so that I can understand that my contributions were within my limits and responsibilities. The conclusion I have made from this is that it is important to remember these limits, because doing so will eliminate confusion and ill feelings about the contributions of each team member.

Logistics

The logistics of building, storing, and shipping the panels were especially difficult to coordinate. The team discussed many different approaches about each. The discussion I felt that we went back and forth on the most was about transporting the panels into the plaza after each one was built. There were many ideas thrown around. We once considered building a stage that could be lifted, so that the panels could easily slide off the stage and stacked adjacent to it. We also considered finding a location with an overhead bridge crane so that the panels can be lifted and stacked without lifting them manually. The idea of using skid rollers was a prominent one also. The only concern being that they would get caught on the control joints in the concrete. Yet when the time came to finally move the first panel into place, a solution that we decided against ended up being the easiest. We simply slid each
panel onto two furniture dollies, wheeled it out to the plaza, and lifted them onto a stack by hand. There were no issues of the wheels getting caught on the control joints like we anticipated, and the panels were able to balance on the dollies perfectly fine. The lifting was not difficult given that we had an appropriate amount of people helping. It worked so well that it was amusing to think we ruled it out. This exercise taught me to expand the way I go about solving problems. It was clear that we felt limited in our solutions because of constraints that turned out to be not much a constraint at all. When I find myself in a similar situation in the future, I will challenge these assumed constraints to find a solution that I perhaps would have not considered previously.

Shipping the loaded container of panels proved to be the most problematic aspect of this project. The container was set to be picked up on Monday, June 3rd and shipped to the project location. However, the shipping company was not able to ship the container as agreed. The reason boils down to miscommunication. The shipping company was under the impression that the container would be empty at the time of pick-up. We were under the impression that the shipping company knew the opposite and was ready to ship a fully loaded container. While this situation was stressful and unanticipated, our team and project supervisors maintained that sense of poise that I had mentioned earlier. A work around was eventually reached by work of our project supervisors. This dilemma conjured up in me realistic reactions that simply cannot be replicated in a classroom environment. Such is the benefit of being involved with a project like this, where the consequences are real, and every decision is critical. I see this experience as a valuable precursor to my career in construction, where unpredictability is the nature of the industry.

**Prefabrication in the SST**

Prefabricating the panels in the SST was an incredible hands-on learning experience. One notable takeaway was seeing the progression of skill, quality, and productivity each day. We had another project supervisor help guide us during the prefabrication. Both supervisors had years of carpenter experience, and they had the daunting task of passing down their knowledge to us students in a very short amount of time. The first day of building our goal was to frame a 10-foot by 12-foot stage. Each panel would be built on top of this stage so that they could be fastened to it and made square before the sheathing was attached. Productivity during this time was low because each step and process had to be taught. Sorting lumber, crowning studs, cutting boards, fastening nails, and any other task involved with framing was a brand-new experience for most of us. As the days went on, we began to become more comfortable with each task. Each team member demonstrated their proactiveness and eagerness to be involved. Everyone was stepping in for whatever task that needed to be done. While this allowed each student to try a multitude of tasks, it made for a hectic work environment. No one person was dedicated to a specific task. This blurred the lines of responsibility between each team member. We often found ourselves impeding each other’s work because we would begin a task that another team member has already begun. Another consequence of this free-for-all type of environment was that us students were not able to become specialized in any one task. Through repetition one can become better and more efficient, but we were not able to achieve this by switching from task to task.

This changed however on our third day of building. On this day we recognized that our productivity and workflow process needed to be improved. We decided to delegate tasks to certain team members, and those team members would perform this task for the remainder of the project. Two members were dedicated to laying out the panel and cutting lumber, while three members were dedicated to assembling the panels. What was realized was that in the beginning of the day, the group responsible for assembling the panels were stagnant for a short time because the headers were still being prepared by the other team. Once the first set of lumber was complete, assembling the panel began. The preparation of headers then began for the next panel while the previous panel was being assembled. Since assembling the panels typically took longer than preparing the lumber, a queue of lumber sets for each panel began to form. At this point, assembling a panel was able to begin as soon as the previous was finished. This is when productivity began to increase, and each student become more specialized in their tasks. Thus, the quality of each panel began to increase. Impeding each other’s work was no longer an issue because everyone was clear and confident about their responsibilities. The number of panels built per day increased by one every day we built. It was
fulfilling to see the concept of the productivity and learning curve be demonstrated here. Throughout my career I will look back and consider this experience whenever I am challenged with a new task or responsible for managing productivity.

While building the panels was an enjoyable experience, it was certainly not an easy one. The work was physically demanding even when it was being done in the most favorable conditions. We were working inside a fabrication shop, protected from the sun, and the weather was fair each day. To think that carpenters perform this work in conditions very opposite to this has given me a deep and sincere appreciation for those working in the trades. I anticipate this appreciation will prove to be valuable, as my career will involve managing tradespeople who perform such demanding work. It will heavily influence the way I communicate and cooperate with these individuals, and the way I carry myself around them.