Framing Exterior Partitions for the Great Northern Services Housing Project

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In the wake of a fire in Weed, CA that destroyed 150 homes, Great Northern Services (GNS), a non-profit organization, reached out to Cal-Poly San Luis Obispo about a service-learning opportunity. This opportunity 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 panel. This optimized panel weight, material usage, and maintained 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.

Key Words: Prefabrication, Modular, Residential, Carpentry, Planning

Introduction

During the Fall 2017 quarter, a non profit organization, Great Northern Services (GNS), reached out to the Construction Management department with an opportunity to participate in an upcoming service-learning project. The students enrolled in the Integrated Project Delivery Studio (IPD) at the time were tasked with submitting a set of design documents for a one story, single family home. There were multiple designs submitted from multiple teams for GNS approval. The selected design was then sent to the permitting agency for construction approval. Once GNS had a permitted set of drawings, they reached back out to the department looking for a group of students to work on the next steps of the project. Students would need to coordinate the construction and transportation of the panels from the university campus, to Weed, California.

In Fall 2018, one year after the original project proposal from GNS, interviews were held by campus faculty and students to select the coordination and construction team. Once selected, the team of three students and one professor would have until the end of the academic year to facilitate the procurement of materials, build a schedule, an estimate, construct the partitions, and coordinate shipment to the jobsite in Weed. At the jobsite in Weed, students from a local college would be selected to erect the panels and finish the construction of the home.

Process

Beginning in the Winter 2019 quarter, I began work with the new project team to get the Weed GNS project underway. We knew we would need to create a list of deliverables and milestones to make sure the project would move forward without delay. We decided to create a coordination schedule as well as a construction schedule. Construction was scheduled to begin at the start of the Spring 2019 Quarter. After creating a list of activities and approximate durations, a forward and backward pass of the construction schedule was done to estimate the milestone and completion dates. A forward pass allows one to determine the earliest possible completion date based on the given durations. A backward pass gave us the latest completion date based on the given durations and activity sequencing. The project was broken by quarter, with all the logistics and coordination scheduled for Winter 2019, and construction and shipping to happen in Spring 2019.

Winter 2019: Logistics

Once we determined activities and finalized the schedule, we split the work into what we felt was the most logical order. Activities were then assigned to each student to take care of. My personal role early on was to research and coordinate the shipment of the panels. During this process we received our first curveball from GNS. The drawing set we had been looking at for our quantity takeoff calculations was not the most recent set. This meant our lumber quantity calculations were inaccurate, the total shipment weight was subject to change, and the total shipment size was subject to change as well. Once we received the updated plans, we were able to restart our calculations. During this phase of the project, we decided to alter the panel dimensions. Changing the panels from modular panels 6'-11" in length, to one-off panels at or around 12'-0" in length allowed us to save a lot of time and materials during construction (Figure 1). Using a 12'-0" standard dimension allowed us to optimize our material procurement, lower the number of panels we needed to construct, maintain the standard 16" stud spacing, and reduce material waste.

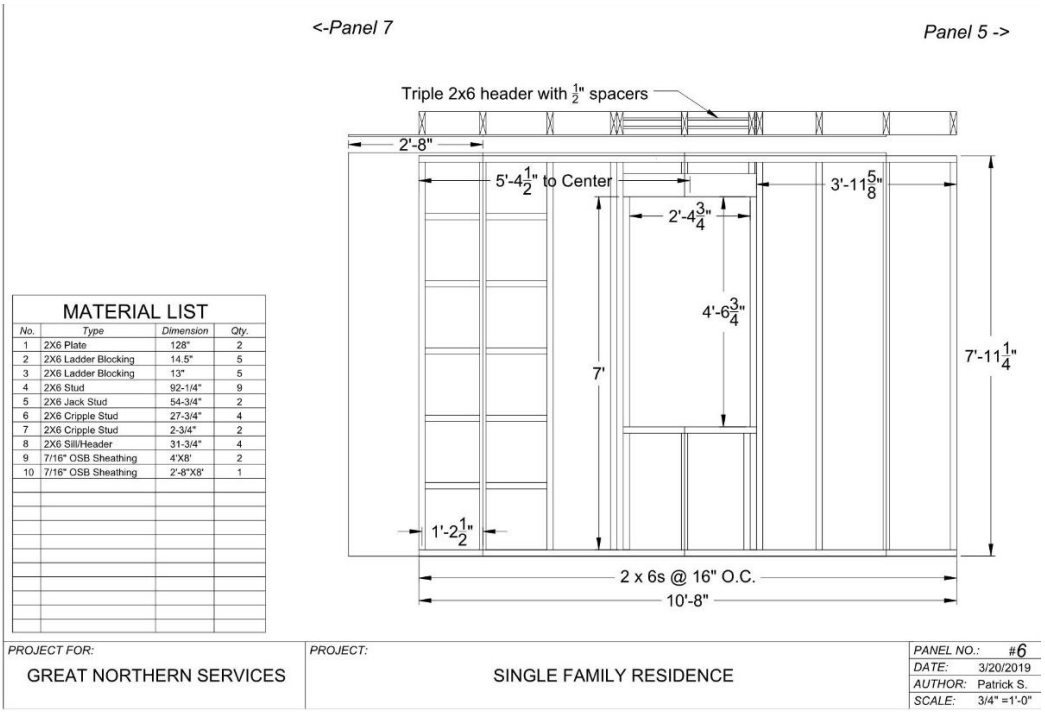

Figure 1: One-off spool drawings

To redesign the construction plan and create the longer panels, the boundaries of each partition had to be redrawn in order to ensure that they would still fit together as the original plan had intended. Once the boundaries had been drawn, a detail of each panel needed to be drawn and dimensioned. 25 panel spool drawings were created, showing all dimensions for doors, windows, and blocking. These spool drawings were used to tabulate the lumber that would need to be ordered for this project. At this point we encountered our second curveball. The lumber supplier that had agreed to donate the material for the project was no longer answering our calls. When we reached our critical date for lumber procurement, the donation company was abandoned and the material was ordered from a local lumber yard.

Spring 2019: Construction

The shipment of the panels had not yet been finalized by the start of construction, but there was a plan in place, so construction began as planned on the second week of the Spring 2019 quarter. The first step was to build a stage on the floor of the Simpson Strong Tie Demonstration Lab. (Figure 2**).** The stage allowed us to fasten the panels in place. This would to ensure they remained perfectly square while the sheathing was fastened.

Figure 2: Construction Stage

Once the stage was complete, production of the partition panels could begin. We tracked productivity as number of panels constructed per day, compared to man hours used. We also tracked our material usage compared to what was estimated on the spool drawings drawn in the Winter. As the panels were built, they were wheeled out into the courtyard and stacked in preparation to be loaded into the shipping container and sent to Weed (Figure 3-4).

Figure 3: Loading on dollies

Figure 4: Stacking panels

Once all the panels had been framed, sheathed, and stacked, we called the container company to have a 40’ open-top shipping container dropped off on campus. We reached out to the campus electrical department and requested an operator and a boom truck to come help us load the panels into the container. After a quick lesson on rigging and hand signals per our safety plan, we began staging the stacks of panels within the reach of the boom. One by one, the panels were loaded into the container and fastened for shipment. Per the schedule we created in the Winter quarter, the container arrived on a Friday morning, and was loaded on the following Saturday. At this time the team was thrown the final wrench in the plan. The company that had agreed to pickup and transport the container the following Monday backed out. At this time the project team reevaluated the work that needed to be done to organize shipment, and began making calls. One proposed solution was to unload the container, lift it onto a flatbed truck trailer, and reload it since the boom truck did not have the capacity to lift the loaded container. Another proposed solution was to roll the container down the slight hill into a wider area, where a larger crane could be used to lift the loaded container onto the flatbed. This was scheduled for the Monday following Spring Commencement.

Lessons Learned

During the process of this project, the team had many conversations about the expected lessons that would come from the work we were doing. It would have been impossible to anticipate how much we would learn from this project. Trying to implement the lessons we had learned in the various classes we had taken proved to be a challenge. Many of us could not remember the specific lessons from our classes and had to be retaught a lot of the construction techniques. The most important lesson learned, applicable to far more than construction, was to have plan B, C, and D ready for when things take a turn. Thankfully this wasn’t a huge problem for the GNS project until the final stages. Unfortunately, when it did become a problem, it had a large impact on our schedule and caused delays. The second important lesson learned is that there is no replacement for time and experience in industry. Regardless of the experience any of the students had from other carpentry projects in the past, or from the hands-on lab classes at the university, the professors worked more productively than all three of us students. Years in the industry had taught them how to work accurately and quickly. As time progressed, the students worked faster and with less error, but it was clear that years in industry had taught our supervisors how to cut their work time into a fraction of that of an amateur carpenter. There were also many tricks of the trade that were passed down from the supervisors to help quicken the process, or eliminate a step that was prone to errors. Some of these tricks became our project standards and would then be passed along to any volunteers. The final lesson taken away from this project is that more hands-on deck does not always mean more productivity. In fact, we quickly found our point of diminishing returns when we noticed volunteers standing around, or multiple people doing a job that only needed one person. Overall this project went very smoothly, and serves as a great baseline for future interdisciplinary project-based projects on campus.