Inception through Inspection: Quality Control in the Simpson Strong Tie Materials Demonstration Lab

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The purpose of this senior project is to create a quality control program in the Simpson Strong Tie (SST) Materials Demonstration Lab using BIM 360. The goal of this program is to help streamline the building process of the six-foot by eight-foot tiny home in Residential Construction Management. The SST laboratory activities have been developed in the true spirit of "learn by doing" and serve as a way for Construction Management (CM) students to interact with the building process directly. Students in the CM department are taught that quality begins at the inception of a job and should be monitored throughout construction and into closeout. Utilizing BIM 360 to perform inspections in the classroom has helped make building the tiny homes more practical and realistic for CM students and lab technicians, all while creating a lasting record of the process that can be referenced in the future. This quality program exposes students to basic inspection practices that they can expect to experience on any jobsite in the future. The advantages of tracking quality have gone beyond the outcome of the tiny home itself, as it encourages the students to build the project to the highest caliber.

Key terms: Quality Control, Construction, Inspections, Checklists, BIM 360

Background

Cal Poly's motto "Learn By Doing" is taken very seriously in the Construction Management (CM) department. Students of the program are exposed to hands-on building activities using power tools and a variety of building materials with the intention of graduating from the program with the "ability to apply problem solving skills and integrate technical knowledge" into their daily routine as industry professionals. The Residential Construction Management course offered by the CM Department focuses on exposing students to the different "materials, methods, and techniques associated with residential… construction operations" and includes topics like "shallow foundations, timber and masonry framing, roofing, and exterior and interior finishes." This is one of the first courses where CM students are exposed to hands-on activities in the Simpson Strong Tie (SST) Materials Demonstration Lab. Students work as "apprentice" carpenters to complete the construction of a six-foot by eight-foot tiny home built with timber framing members, and finished with painted wood and cement board siding (Cal Poly Construction Management).

As a SST Lab Technician and past student of Residential Construction Management, I have been on both sides of the classroom, as a trainee-carpenter and as an assistant to the faculty. I have always noticed how students behave differently in SST due to varying comfort levels with building. Not only are students frequently timid with their decisions regarding construction mean, methods, and practices, but are often unaware of the most important components that attribute to the success of building the tiny home. Students will come into the building activities with minimal guidance and structure for the scheduled building activities, unaware what their goals for the day are, and how those goals can be most efficiently achieved. Working alongside my fellow lab technicians, I have also experienced the stresses and responsibilities of organizing the SST building activities that essentially replicate those of a Superintendent or Project Manager on a real jobsite. After six consecutive quarters of working in the lab, I never felt a true consistency existed in the building process among the classes; although variation is expected with any construction job, efficiency is improved when well-established protocol are followed and adapted as needed. Lab technicians often perform tasks differently or have varying preferences on tolerances for the outcome of the tiny homes. However, I believe that having a log of a typical building agenda and of the required practices and expectations

for the students could serve to benefit the structure of the class and the consistency of the building process from quarter to quarter.

The purpose of this paper is to discuss the process of creating and implementing a quality control program into the SST lab activities. This paper will also review the program's results as assessed by feedback from the student carpenters.

Research on Quality Control

In order to create an effective quality control program to be utilized in the future, research was conducted on quality control measures. Generic layouts and templates for residential construction inspections were reviewed to better understand what actual elements go through an inspection process on a residential construction project. Interviews with members of the construction industry were conducted to discuss what programs have been developed at their companies to manage quality on both large- and small-scale projects. References were explored, like mybuildingpermit.com, smartsheet.com, and inspection checklists from various regions of the United States like Virginia, to seek out the commonalities that exist in the inspection process for any residential home. Many different software platforms that are also used to manage quality and track issues on construction projects were evaluated such as BuildPro used by Shea Homes, FTQ360 used by Largo Concrete, and BIM 360 used by PCL Construction. After extensive review, it was decided the best option for this project and for the sake of adding new knowledge into the classroom setting was to implement a manageable and effective software platform that can be personalized for every construction project. BIM 360 was selected for implementation based on its accessibility and ease of use; Autodesk, BIM 360's umbrella software company, granted a trial license to use for the implementation of this project.

BIM 360 Application

BIM 360 is an Autodesk application used to "connect, organize, and optimize projects" while reducing risk and improving quality. The application itself can be utilized to successfully manage in-house document control and information from in the field. The "Field Management" tool was utilized for this project to create inspection templates, track issues, and keep a daily log of what building activities were completed per class session. Because the program is accessible both on a computer and a mobile device, checklist templates were easily created on the internet-based platform and then utilized through the free cell-phone application in the SST lab. This was a great way to incorporate technology into the SST lab activities as a way for lab technicians to better track the progress and quality of the student carpenters (Autodesk).

Creation and Implementation of Quality Control Program

The first step was to gain familiarity with the software BIM 360. With time, several different checklists were created to help outline the steps to properly build out the tiny home. Many components were considered in the creation of these checklists including the sequential order of construction, installation and manufacturer requirements, and the special considerations to be taken at different steps of the building process. A total of fourteen different checklists were used to track and inspect material deliveries, subfloor construction, wall construction, roof construction, and waterproofing installation.

The implementation of the QA/QC program began on Monday April 22nd, the first day of week four of the 2019 Spring Quarter. Every scheduled day of building, the BIM 360 application was used via mobile device to record how many students came to class and for how long the section worked that day through the "Daily Logs" component of the application. A collection of progress photos helped track what work was accomplished each day as well by using the "Folders" component and creating a subfolder called "Progress Photos." The "Checklist" component of the application was used to hold inspections periodically throughout the building process for the major activities. As students built out different components and activities were completed, each component of interest was inspected for completeness and for issues in quality.

A tool in the BIM 360 application called "Issues" was experimented with throughout the implementation of the quality program. Often, as students build, errors in workmanship arise that are either ignored or forgotten about the next day in the laboratory. This tool was used to catch errors of quality along the way in order for students to stop and correct the issues before construction proceeded. Sometimes, these issues put the students behind schedule for the day, but it proved to be a great way for students to stop and analyze their mistakes, why those mistakes were made, and then problem solve for a solution to fix the issue at hand. Students responded positively to the consistent check-ins and were attentive when a lab technician would go through the inspections or quality issues with them directly.

Implementation of the quality control program continued in week seven of the 2019 Spring Quarter, where lab technicians became more diligent about attaching photos to the completed checklists and incorporating progress photos into the daily logs. The same procedures described above were followed throughout the remaining days of construction in order to maintain consistency in the program.

The final elements of the quality control program were carried out in week ten of the Spring Quarter on June 4th, 2019. Small groups of student carpenters were lead on a final building inspection or "punch list" style walk around the tiny house, similar to one that would be conducted on an actual jobsite with an homeowner. This gave students one final comprehensive interaction with the tiny home and the quality program; students worked alongside the lab technician and individually took photos of quality issues and were asked to write in their own words what the issue was and why it occurred. This activity helped students maneuver through the BIM 360 mobile application, clearly identify quality issues with the tiny home, and debrief the elements of the building process that went smoothly. Each student was then asked to complete a Google Forms survey to provide feedback on the quality program as a whole and their comments regarding its future application.

Final Deliverables

The following final deliverables resulted from this project:

- A collection of progress photos to illustrate the various steps of building the six-foot by eight-foot tiny home
- A collection of daily logs to track attendance and building progress
- Completed checklists used for the following building activities: wall framing, shear wall nailing, subfloor system, roof framing, roof finishes, waterproofing installation, and final building review
- Revised checklists to be more comprehensive for use in future inspections
- An issue log to track outstanding issues in quality
- A six-foot by eight-foot tiny home with painted exterior

Progress photos were compiled to serve as references for future classes with questions on how the steps of construction are to carry out. Checklists used throughout the quarter were signed off by the acting inspector noting what items were reviewed for completion or inspected for quality. Quality control is a continuously improving process, so lab technicians took note of certain items not initially considered in the initial inspection checks. This project resulted in a review or revision of every template used for inspection to make them better fit for the tasks. BIM 360's ability to create an issue log was a great way to track outstanding quality errors or misdone work to be corrected. The issues included in the final deliverables include both issues that were corrected and issues that were caught too late, and for the sake of schedule in the classroom, have been left as outstanding issues. The most important deliverable, the tiny home itself, will be kept in SST until the end of the quarter when it will then be moved to surplus and sold.

Lessons Learned

Completing this project has left me with several valuable new ideas and lessons learned. Not only did I gain experience of my own as an emerging Field Engineer, but I was able to see how a program like the one I have created can benefit other people and the building process.

This project exposed that the residential construction industry is different than the commercial industry in terms of inspection requirements. From talking with my resources, it is clear how less stringent inspections and inspectors can

be on residential sites (Fuentez). With my coworkers having grown-up working small scale residential projects, they admitted they feel the program has a lot of detail for a small six-foot by eight-foot tiny home. That being said, a program like this although helpful and simple, would likely be more applicable on a larger scale job. However, this program provides a great way for students to learn the importance of quality control and systemize the building process. My student survey revealed that the trainee student carpenters who actually built the tiny home felt this program would be very applicable for this course. Students believe this program helped them succeed in completing the construction of the tiny home within the very strict two-week schedule. They felt this program was a great way to prepare them for more complex construction procedures in future hands-on activity courses held in SST as well as for their expected summer internship responsibilities.

Carrying Knowledge into the Industry

After completing this senior project, I am able to say I can carry new knowledge into the construction industry as a young professional working in the field. This project has reassured me of the importance of quality control and on a construction jobsite and I feel I can make a significant impact on the quality program in place at my future jobsite.

I learned how to maneuver a program like BIM 360 in a very short period of time. The application itself is extremely user-friendly and has taught me how to internally track quality on a real construction site. Stepping into the job role of Field Engineer at PCL Construction, I have been notified I will be using BIM 360 on my project to track quality from within. I think my ability to use the software will enable a more comprehensive use of the software on my future project and will be an example of internal tracking that other projects or companies will strive to emulate. Having had the opportunity to use to a software like BIM 360 in my academic institution has truly given me an advantage for my future career path.

My hope with this senior project was not only to benefit personally as I move into industry, but to also leave a lasting impact on students continuing through the CM curriculum. Although carrying new knowledge into the industry is important, I think my greatest success with this senior project was being able to work with students and teach them about something important to me and the construction industry. If this program were to stay as part of the curriculum, I also would feel very accomplished in having left a legacy in my former place of work. This project has been a way for me to explore my interest in the field even further, all while working in a classroom setting and being a role model to young builders.

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