Pouring Concrete Benches for the Amphitheater at SLO Botanical Garden

Makenna Gitchell
California Polytechnic State University SLO
San Luis Obispo, CA

This paper will outline the logistics and construction processes for the construction of ten concrete benches for a new amphitheater area at the San Luis Obispo Botanical Garden. These benches will provide stadium-style seating for around forty guests that the botanical garden staff can utilize for special events, tours and outdoor classes. The overall project team was composed of 6 students broken out into a preconstruction (Anthony Masarweh, Sydnee Greer and Devon Barthmaier) and a construction team (Makenna Gitchell, Brandon Keefer, and Kyler Cruz). As part of the construction team, we were responsible for coordinating material deliveries, building the formwork, pouring concrete, installing the composite decking and transporting the benches from the Cal Poly campus to the garden. This paper will touch on the processes for each of the construction phases, but will focus mainly on the concrete pour and lessons learned from this specific scope of the project.

Key Words: Construction, Concrete, Formwork, Logistics, Coordination

Background

This project is located and the San Luis Obispo Botanical Garden, a local non-profit garden founded as a Cal Poly senior project in 1989. The garden has been home to many volunteer opportunities and senior projects in the past, and has remained in contact with the Construction Management department about potential projects they wish to have completed. Our project team was built with the goal of designing, building and installing benches to form an amphitheater area for the garden to utilize during tours, outdoor classes, and special private events. Our group of 6 students was broken into a preconstruction team, which focused on facilitating communication with the owner and the design development portion, and a construction team responsible for the physical building, transportation and installation of the final product.

Preconstruction
After visiting and surveying the site, we came to the conclusion to build 10 8-foot-long concrete benches to fill the space with enough seats to meet the garden’s future needs. Our preconstruction team hosted design meetings where drawings were developed to meet engineering requirements and satisfy the owner’s needs. This included deliberating between using wood or concrete, the size and orientation in relation to the site, and the color. Though wood would ultimately be faster to build and easier to install, concrete would better withstand the elements over time after being exposed to the rain and sun. However, Chenda, the executive director and our main contact at the garden, did want some wood element because it is warmer for seating. This spurred deliberation on how the wood would be attached to the concrete, and how it can be maintained throughout the lifecycle of the bench since wood ages faster than concrete within the elements. We decided to use Trex as the composite deck material for the seat area, as it can be maintenance easier than regular wood but at the same time offers a warmer seat for guests than just concrete. We came to an agreement on design, a materials list was produced and material was ordered from Hayward Lumber, Cal Portland, and Air Vol Block. Funding for this project was secured through the CMAC senior project grant, supplemented by the garden’s budget and gracious donations from local companies sponsoring our efforts.

**Construction**

**Formwork**

Construction began on May 14th, with developing a design for the formwork. Dan Knight walked the team through the bracing necessary to withstand the forces in each direction produced when pouring concrete, and the team began cutting the lumber accordingly. Due to the volume of concrete needed for each bench, about .75 cubic yards, the pour could be completed in one day with one concrete truck. That being said, the team decided it would be more efficient to build ten individual forms and pour all ten benches at the same time. We used pro-form plywood in hopes they would be easier to strip, and 2x4’s spaced 16 inches on center to form a cage around the plywood. We then suspended a trim piece in the center to form the depressed edge for the future Trex seat and attached bracing to hold it in place during the pour. We built these forms in the SST, utilizing their tools and equipment and stored the completed forms there until the day before our pour. We also built the rebar cages ourselves, tying stirrups every 16” on center, and filled the cages with lightweight foam. The team decided to fill the rebar cages with foam to not only reduce the cubic yards of concrete needed, but to reduce the weight of each individual bench significantly making them easier to transport.

Formwork was completed on May 19th and we transported each form one-by-one to the concrete yard, which was determined to be the best place to pour. The forms were placed strategically throughout the concrete yard in the most level areas that could be reached by the concrete truck chute.

**Pour Day**

On the morning of May 21st, the construction team, two members of the design and a few volunteers arrived early to prep the yard with the necessary tools and strategize the sequence of the pour. With the help of Dan Knight, Cal Portland was to deliver 8 cubic yards of lightweight concrete with a 4-inch slump. The total cubic yards of concrete needed was calculated to be 7.5 CY, but 8 CY were ordered to account for waste factor. The team then cut the Trex that would sit an inch in the depressed side and act as shims for the long-span Trex seating area, and decided to place two screws in each to provide a stronger way for the concrete to bond to them. The team also utilized some 2x4 scraps from the formwork to cut wood screeds and stamps where the “Cal Poly Construction Management 2021”
plaques would later be placed. Once the truck arrived, the team was ready with shovels, a vibrator and finishing tools in hand, and huddled around the first form of the pour sequence. The Cal Portland driver taught Brandon the hand signals for operating the chute, and the first bench began being poured.

The initial strategy was to position the chute to pour in the middle of the ten-foot form, and use the vibrator to work the concrete towards the back corners. There was definitely a learning curve to working the concrete with the vibrator to fill around the foam and rebar cage evenly to hold them in place, and in signaling to the driver when to move the chute. By the second or third bench it was clear that the best strategy was to have 4-5 people on each bench with shovels and the vibrator, and a team of 4 following on the previous bench with finishing tools. Once the last bench was poured, all team members were working on finishing. This included edging the exposed perimeter with rounding tools to create a clean smooth edge, the placement and leveling the Trex shims, and placing the stamp for the future plaques to be epoxied in place.

The overall pouring process took about 4.5 hours. The team then covered the benches with plastic to protect the smooth finish and the curing process began. The formwork was successfully stripped the following week, leaving minimal patchwork required on the benches themselves. The benches remained on the bottom form to leave space for the forklift forks to lift and move the benches under the crane in the concrete yard. From there, we slung one bench at a time and used the crane to lift the benches onto the trailer to be driven to the garden.

Transportation

Due to the tight logistics of the garden surrounding the future amphitheater area, the team transported the benches on a trailer along the service road behind the neighboring baseball field, and placed each bench individually via a rough terrain forklift. This piece of equipment was chosen because it can operate within capacity while carrying one bench, which weighs about 2500 pounds, and can navigate the tight gravel path leading from the service road to the amphitheater.

Lessons Learned

Communication

During the initial design development phase of this project, the team was expecting to build the formwork and pour the benches onsite at the Botanical Garden. This way, the need for transportation could have been eliminated and once the benches were poured and stripped, they would already be in place ready to use. However, site constraints due to where the amphitheater was located in relation to access roads would require the team to use a concrete boom to reach the forms, and this required right of entry permits from the city which would have delayed the project by an unspecified amount. Due to only having one quarter to complete this job, the team decided to proceed with building them on campus and transporting the final product. This changed the budget for formwork by adding additional plywood and 2x4 bracing needed along the base of each bench, as well as added cost and logistical challenges for transportation. If the design and communication with the city began earlier in the academic year, we could have potentially gained access to the site for heavy-equipment and could have poured the benches in place.
Rebar Cage Movement

One major challenge faced during the pour was the foam and rebar cages moving within the form. The construction team noticed the foam rising to the top of the rebar cage as concrete filled in under it, as well as the rebar cages moving from the center of the form. This was a problem because if the foam was resting directly against the rebar, it would decrease the structural integrity of the cage. It was also a problem if the rebar was up against the side of the formwork, because it would be visible once we stripped the forms.

With the help of the concrete yard technicians Vince and Timmy, our team used temporary supports to hold the cages and foam in place until enough concrete was placed to hold them from floating to the bench surface. We then poured half of the bench, vibrated the concrete around each side to hold the cage in place, and then came back and filled in the second half. Extra Dobie blocks were also tied to the top of the rebar cages so the foam could not rise within the cage and rest against the top of the rebar. To increase efficiency if we were to do a similar project in the future, we would spend more time prior to the pour securing the rebar cages and foam in place to avoid movement during the pour.

Concrete Workability

Another challenge was the workability of the concrete. Initially we ordered our mix with a slump of 4 inches, which proved tough to move within the formwork and around the rebar/foam. With the advice of the Cal Portland driver and lab technicians, we increased the slump to 7 inches, increasing the workability and accelerating the dispense from the truck. This significantly decreased the time spent pouring the last 5 benches. If the team was to perform this project again, we would start with an initial slump of 7 or 8 inches to save time from the beginning, decreasing the overall duration of the pour significantly.

Conclusion

Overall, though this project did provide a fair share of challenges, the construction of the benches was successful. We poured all ten benches in one day with no formwork fail, with only a small amount of concrete surplus. Our team was able to work together, along with our advisors and the concrete lab technicians, to overcome a variety of obstacles from preconstruction to installation. This project not only taught us lessons about concrete as a material, but the design requirements, estimating, formwork and transportation constraints concrete requires as well. This was a prime example of the learn-by-doing motto of Cal Poly.
Photos

Figure 1.1 – Formwork placed in concrete yard for pour day.

Figure 1.2 – Team members finishing the second bench and pouring the third.
Figure 1.3 – Team finishing the last benches and placing the embedded Trex shims.

Figure 1.4 – Benches poured and finished.
Figure 1.5 – Benches stripped before Trex and plaques installed.

Figure 1.6 – Team posing on successfully completed and installed benches.