The purpose of this project is to build a total of 10, 8-foot-long concrete benches. These benches will be stationed at the San Luis Obispo Botanical Garden located at 3450 Dairy Creek Road, San Luis Obispo. The design consists of a large block style bench with composite Trex boards layered on top for comfort upon sitting. The structure consists of a rebar cage made of #3, 12”x18” stirrups at 16” O.C. There is a foam core in the middle of the rebar cage to allow for lighter weight benches and also to minimize the cubic yards of concrete used per bench. This paper will highlight the steps taken by the team in order to design, build, and install the benches onsite, as well as personal deliverables, obstacles, and lessons learned throughout the project.

**Key Words:** Concrete, Formwork, Benches, Foam Insulation, Rebar

**Introduction**

This senior project consists of a team of six (6) Cal Poly Construction Management undergraduates building a total of ten (10) concrete benches for the non-profit San Luis Obispo Botanical Garden. After the SLO Botanical Garden reached out to our department for help on this project, many students responded with interest in helping and completing our senior project. I had previously been in contact with the Botanical Garden regarding completing my senior project, so these connections with the Cal Poly department, the Botanical Garden team, as well as the other prospective project students gave me the role of the communicator and middle man of the project. We were given an empty slate for this project, as the owner did not have much in mind in terms of plans besides the fact that they needed a seating area for forty (40) people. This area was to have amphitheater style seating, where it could be used as a venue for many different events, including weddings and other celebrations. After a site visit our team was split up into two teams, design team and project team, where each person was given a distinct role. From here, the project began and our team worked our way through the steps of the design and construction process in order to complete the project within the schedule and budget. Figure 1 below shows the conditions of the original site, where the benches are to be placed.
Project Scope

The scope of this project mirrored all of the steps of a larger commercial project, but compressed into one small project. Our team was responsible for the following:

- Site Plan
- Schematic Design
- 3D BIM Model
- Material List
- Estimate
- Rough Schedule
- Procurement
- Bench Construction
- Bench Delivery / Placement

The Process (Steps)

After our first site visit, the team kicked off with a design meeting with the owner, where we discussed preliminary design expectations for the benches. After coming to a conclusion on a rough design, the design team sketched a schematic design of the bench, as well as a 3D BIM model of the bench. This can be seen below by Figures 2 and 3. The concrete benches are 1’6” X 2’ X 8’ with Trex board on top to provide maximum comfort when sitting. The rebar cage is made up of #3 12”x18” stirrups with a foam core in the middle. The team worked together with the owner to gain insight on wants and needs, and also worked with Dan Knight to figure out the constructability of these benches.
Figure 2 – Schematic Design

Figure 3 – Schematic Elevation
After the design was approved by both the owner and the structural engineer, a site plan was created. Once all parts of the design and site plan were approved, the team put together a material list and estimate and began placing orders for procurement of materials. After materials arrived, we built the plywood forms, rebar cages, and braced the forms with PTDF 2x4’s. Figure 4 below shows the constructed forms for the concrete benches, some without the top braces yet to allow for access to the rebar cages. Alform Plywood was used for these forms. This is different than normal plywood because it is easier to strip, stronger, and more reusable. Although Alform plywood was initially more expensive, the overall benefits outweigh the initial cost.

![Figure 4 – Bench Forms](image)

From there, we transported these heavy forms to the Cal Poly concrete lab, where pouring was to take place. The arrival of the concrete mixing truck and hours of pouring and finishing led to the completion of the concrete portion of the benches and the start of stripping of the formwork, as seen by Figure 5. Composite decking boards will be placed on the top of the bench, as seen by Figure 5.1 below. We chose composite boards over PTDF or any other lumber because the composite boards are more weather resistant and require less maintenance over time. These benches are to be placed in an outdoor amphitheater area and are to last many years before maintenance is required.
Figure 5 – Exposed Benches

Figure 5.1 – Trex Top
Deliverables (Personal)

As stated earlier, my position on the team was known as the middleman. I had similar roles to that of a project engineer. One of my responsibilities included communication efforts with the owner on behalf of the project team. This included getting the owners approval on different aspects of the project, setting up meetings with the owner to further discuss issues or next steps, clarifications on the permitting process, project update clarifications, and also sending order quotes and confirmations to the owner. I was also in charge of putting together a rough estimate and final material list for the procurement of project materials. This was done through a quantity take-off of the schematic design and site plan, as well as an estimation of formwork materials. The final material list can be seen below in Figure 6. This led to requesting quotes, ordering materials, and also communication efforts for material pick-up and delivery.

<table>
<thead>
<tr>
<th>Bench Material List</th>
<th>Acceptable Substitutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 CY of Concrete (1 Concrete Truck)</td>
<td>N/A</td>
</tr>
<tr>
<td>8 Sheets Aflorn Plywood (4' X 8')</td>
<td>15 Sheets Regular Plywood Sheathing (4' X 8')</td>
</tr>
<tr>
<td>5 Boxes of Construction Screws (2&quot;)</td>
<td>N/A</td>
</tr>
<tr>
<td>2 Composite Decking Boards (2&quot; X 6&quot; X 16&quot;) (Cheapest Color Option)</td>
<td>N/A</td>
</tr>
<tr>
<td>10 Composite Decking Boards (1&quot; X 6&quot; X 16&quot;) (Brown Color)</td>
<td>10 Trx Composite Decking Boards (0.5&quot; X 12&quot; X 8&quot;)</td>
</tr>
<tr>
<td>Decking Screws (1.5&quot;) (Need 400 Screws)</td>
<td>N/A</td>
</tr>
<tr>
<td>480 #6 Rebar</td>
<td>N/A</td>
</tr>
<tr>
<td>1 Gallon of Formwork Release Agent</td>
<td>N/A</td>
</tr>
<tr>
<td>16 Beams (2&quot; x 4&quot; x 16&quot;)</td>
<td>N/A</td>
</tr>
<tr>
<td>40 12&quot;x18&quot; Stirrups</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Figure 6 – Material List

Although my main concerns regarded communication efforts with the owner and material suppliers, I also took a large responsibility in the construction phase of the project. Putting together the formwork and rebar cages for the concrete benches gave me the confidence with different tools and building methods that I desired when pursuing this project. With very little previous experience in physical construction, being exposed and actually building these benches taught me a lot. From building the formwork, to tying together rebar cages, to actually pouring the concrete, this project proved to be a great learning experience for all team members and gave us a taste of what the future holds.

Obstacles and Lessons Learned

As with any construction project, this project came with a lot of obstacles. The largest obstacle we ran into was the permitting process. Taking this project and beginning work before permits where issued was our first mistake. Being the communicator between the project team and the owner, the task of figuring out permit requirements fell on me. Initially, we were told that if we constructed permanent cast in-place benches, a permit would be required that could take multiple weeks for approval, so we decided to construct the benches offsite and deliver them onsite through the use of forklifts and a trailer. Through many calls with the city and county, it was discovered that two permits would still be required for this project. The first permit is the right to entry permit, it is required because we are bringing heavy equipment onsite. Therefore, the specifications for the rough terrain forklift needed to be approved by the county before using it onsite. The second permit requirement was one that we did not find out until late in the project, after the concrete benches were already poured. It was discovered
that we need a permit for the benches since they are considered permanent and for public use (permanent being over 153 days). Luckily the team, with the help of our SME’s, expedited the permitting process and figured it out in time, after a lot of stress and doubt. The importance of getting permits issued early on in the preconstruction process really showed on this project by pushing our schedule back two weeks and delaying the delivery of the benches.

Another obstacle we ran into was the weight of the benches. We decided to build the benches offsite and deliver them onsite, as we thought that was a loophole to the permitting process. However, we did not change the design of the benches and kept them as if they were cast in-place, the only difference being a sheet of plywood on the bottom of the form. Therefore, the weight of these large concrete benches, not including the formwork, was roughly 4,500 pounds. We knew we would really struggle transporting and delivering these heavy benches to the site, as well as acquiring and small forklift with a large capacity. The forklift needs to be small due to the tight delivery access area. Our solution to this issue was tying a foam insulation core in the middle of the rebar cage. This not only saves money since less cubic yards of concrete are used, but also decreases the weight of the benches to roughly 2,500 pounds per bench. This allows for easier transportation, although the benches will be slightly weaker. This was approved by the structural engineer and turned out to be a great solution for the issue at hand. The white foam core can be seen in figure 7 below.

![Figure 7 – Foam Core](image_url)

**Conclusion**

In conclusion, our team worked hard to design, construct, and install ten, 8-foot long concrete benches for the San Luis Obispo Botanical Garden. After several obstacles and schedule delays, this project
turned out to be a success for all stakeholders involved. This was a great learning experience for all team members and showed us all our potential for larger projects in the future. Thank you to CMAC for the grant that allowed us to buy all of these materials. Thank you to Hayward Lumber, Air-Vol Block and CalPortland for supplying these materials. Thank you to the Botanical Garden for providing some money for the project and trusting us with a project of this size.