

Design and Pre-Construction Services for an Outdoor Patio and Pergola

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Planning a project in any industry is one of the most important steps of the process. In the construction industry, the quality of work completed during the preconstruction phase of a project can be the difference between a successful and unsuccessful project. No one step is more important than the other. This paper outlines the process of designing an outdoor pergola with a permeable paver system as well as providing pre-construction services. First, the design of the structure was created in collaboration with a local non-profit to ensure both feasibility and desirability for both parties. Next, a quantity take-off was performed which is essential for developing a better understanding of the project. It is also necessary to create an accurate budget and schedule. After, a detailed budget was developed utilizing the quantity take-off and local prices of materials. Last, a schedule outlining the steps of construction necessary to finish building the structure in 11 weeks was built. In addition, considerations when building the structure are included. This was incorporated to communicate ideas that are important for a successful construction phase. Allowing for another student to pick up the guide and build the structure in the future.

Key Words: Outdoor Pergola, Preconstruction, Design, Permeable Pavers, Shade Structure

Introduction

During my time in San Luis Obispo I have cherished the beautiful weather and outdoor scenery along with the amazing people in the community. Even more so I have loved learning about Construction Management at Cal Poly. For my senior project I wanted to give back to the community and build something that allows people to experience what I love most about the Central Coast. However, due to the unfortunate circumstances of COVID-19 the construction of an outdoor patio and shade structure for a local non-profit was no longer feasible. Instead, I decided to design and perform the pre-construction services of such a structure. This entailed creating the design, conducting a quantity take-off, creating a schedule, and compiling a budget.

Effects of a Pandemic

COVID-19 rapidly spread in a way that was only possible because of the globalized nature of the world we live in today. These unprecedented times bring about unprecedented problems. The presence of COVID-19 in the United States was not fully realized until late March of 2020. It was around that time local and state authorities began placing restrictions on travel and implementing “shelter in place” orders. Only essential businesses could continue operating and even those businesses had to adapt to reduce the risk of transmitting the virus. As a student planning the construction of an outdoor patio and shade structure for a local church, I quickly realized my plans could be in jeopardy. After talking to the church about the safety of the community and feasibility of building on the site during a time of sizeable uncertainty, we came to the conclusion to postpone the actual construction of the project and instead create a detailed plan for the future. My experience is not unlike what is happening to many construction companies in the industry. Owners are deciding to hold off on their future projects and companies are looking to put themselves in a secure position as worries about the longevity of the economy begin expanding. The problems I experienced during my project are only a microcosm of what the industry is currently going through.

Design Process

The design process for this project began with understanding the space I had to work with. This meant I needed to find a local nonprofit organization that had space and a need for the project I was proposing. Mountainbrook Church in San Luis Obispo was a perfect fit. After coordinating with their people, we walked the site and determined that the area for the project would be roughly 400 square feet.

My next step was creating a design for the flooring system and the shade structure. Originally, I wanted the floor to be a concrete slab that had a decorative stamp design. However, after looking at multiple different options I decided the floor would be a permeable paver system. I came to that conclusion because the permeable pavers were a more environmentally friendly option since they reduced water run-off from the site and are still capable of delivering a decorative finish. The design for the pergola shade structure was more difficult to nail down. Both the church and I wanted a design that was pleasing to the eye and would allow plant life to grow onto the structure as shown in Figure 1.



Figure 1. Design Inspiration for Shade Structure

After being completed, the design was reviewed by professionals in the construction industry to ensure the structure would be structurally sound and withstand the test of time. In order to effectively communicate with the church what the finished product should look like; I built the model in SolidWorks as seen in Figure 2. I also utilized SolidWorks to create dimensioned plans and elevations that can be found in Appendix A. The pergola shade structure is to be built with pressure treated lumber, fastened together with Simpson Strong Tie connectors, and have a permeable paver system. The foundation system of the structure had to be hand drawn and is shown in Appendix D.

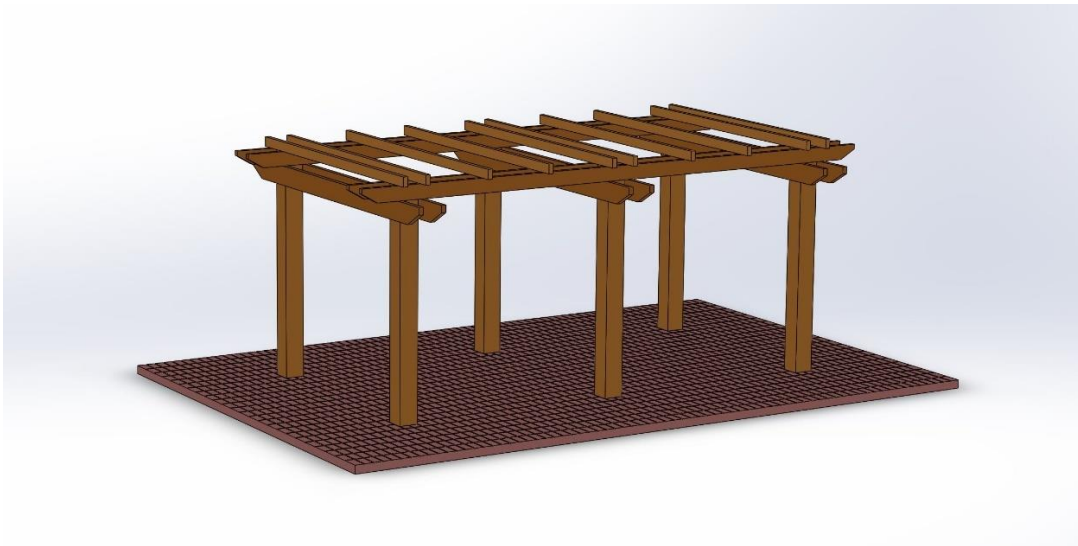


Figure 2. Final Project Design

Pre-Construction Process

Quantity Take-Off

The first step of a quality pre-construction process is performing a quantity take-off, or QTO, of the project. A quantity take-off helps one expand their understanding of the project scope. When performing the QTO for this project I acted as if I walked up to the site and started working on the project from there. Starting with site prep and ending with finishes. This helps reduce the chance of leaving out any project scope and results in a more accurate QTO. It also forces one to begin thinking about their sequencing for a schedule. The quantity take-off sheet can be seen in Appendix B. A quality QTO is also the beginning of an accurate budget. Another reason why a quantity take-off is critical to the success of a project.

Budget

After completing the QTO, I moved onto creating a detailed budget for the project. An accurate budget is essential to keep a project on budget. Equipped with a thorough budget, a project manager can track the costs incurred throughout the duration of construction. This helps keep a project on

budget which is vital for companies looking to run profitable projects. For this project, all necessary supplies are available at the local Home Depot or lumber yard. All items in the budget, except the labor line item, are priced using Home Depot’s website. The labor line item is an estimate of costs for tools and equipment needed for the excavation of the foundation and pouring of concrete. It also covers the cost of tools needed to build the superstructure. Below, Table 1 shows a simplified breakdown of the budget. A more detailed breakdown can be found in Appendix C. It is also important to note that the budget reflects the exact number of items necessary for construction.

Table 1

Cost of Lumber.....	\$927.42
Cost of Paver System.....	\$6,081.65
Cost of Concrete.....	\$1,175.00
Cost of Hardware.....	\$813.88
Cost of Landscape.....	\$500.00
Subtotal.....	\$9,497.95
Taxes.....	\$949.79
Overall Project Cost.....	\$10,447.74

A more detailed breakdown can be found in Appendix C. Also, the budget in the deliverables contains hyperlinks to the manufacturer’s website for each hardware line item. Lastly, I built the budget to function as an order sheet. For example, the budget illustrates what size lumber and how many pieces are required. This helps streamline the procurement process of construction. I used an average 10% tax rate for the project. Resulting in the overall cost of \$10,448 to build the project. When fundraising for the construction of this project, one should aim to raise at least \$11,000. This will help cover any unforeseen costs that may arise.

Schedule

Lastly, I created a project schedule. The schedule is another key aspect of a complete pre-construction phase. Without a proper schedule one cannot effectively communicate with the owner about the duration and progress of a project. A project schedule is an important tool for the project team. Knowing if the actual progress made on site mirrors what is outlined in the schedule is necessary to complete construction on time. It lets the project team know if they need to up their crew size or work overtime if they are behind. Conversely, they can reduce crew size or utilize workers in another area of the jobsite. Also, If construction is ahead of schedule one can predict a more accurate completion date by analyzing the production rates of the crew.

	Week 1					Week 2					Week 3					Week 4					Week 5					Week 6									
Activities	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su
Material Procurement					x	x	x					x	x	x					x	x	x														
Site Prep																																			
Grading/Excavation																																			
Pour Footing & Set Posts																																			
Install Gravel																																			
Install Bedding Course																																			
Install Paver System																																			
Install Superstructure																																			
Finishes & Landscaping																																			
	Week 7					Week 8					Week 9					Week 10					Finals Week														
Activities	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su	M	Tu	W	Th	Fr	Sa	Su
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Figure 3. Overall Construction Schedule

My technique for performing my quantity take-off allowed me to have a rough sequence for my schedule already established. The project schedule in Figure 3 assumes a two-man crew working for 11 weeks. Assuming a two-man crew allows for three weeks of material procure and still maintain a finish date within 11 weeks. However, it is recommended to begin site prep on week 2. This will help reduce the time that materials sit idle and allow time for unexpected delays. It is best practice to time your material arrival and their installation to have as little a delay as possible. This reduces the chance of possible damage to materials and the amount of material storage needed. The items with the longest lead time are the Simpson Strong Tie connectors. These are the most critical procurement items. If they are out of stock at the local hardware store, delivery time is usually 2-3 weeks. The procurement process for the SST connectors should begin on week 1, allowing ample time for the material to arrive and gives one the opportunity to make additional orders if needed.

Construction Considerations

With any structure there are many considerations that should be discussed before starting construction. In the case of this project there are a few I would like to express. The first deals with the earthwork required. I recommend having PG&E coming out to the site and surveying for any underground utilities and pipes. This will help ensure no pipes are ruptured during excavation. It also illustrates to the non-profit organization that you are thorough and thoughtful while building the project. The process to install the paver system is another important consideration. One should research how to properly install the system hyperlinked in the budget. Improper installation of pavers could jeopardize the longevity of the system. Also, the hardware selected should be installed as shown on the manufacturer’s website. The T Straps should fasten the 2x6 and the 8x8 members together. The Deck Joist Ties will fasten the 2x8 members to the 8x8 members and the Right Angles will secure the 2x4 members onto the 2x6 members. All specifications for the hardware can be found via the hyperlink for each item. I recommend procuring extra Accent Screws and Hex-Head Washers. Ordering extra gives one the security of knowing a faulty or lost screw will not delay the project. Lastly, one should consider the general expectations of the weather during the construction phase. The schedule does not account for major weather delays. However, the procurement phase of the schedule can be crashed if necessary.

Lessons Learned

The process of designing and performing preconstruction services has taught me many things. The most striking was the realization that clear and effective communication is essential in any industry, but especially in the construction industry. The amount of coordination with other people, even for a 400 square foot project was considerable. Throughout the process I have had to express my ideas in situations ranging from other students helping me learn software and discussing design with owners, to explaining my schedule to industry professionals for feedback. In all instances I found that most problems arose when there was a misunderstanding between myself and who I was communicating with. Now take a project thousands of times larger than mine, with hundreds of more moving parts, dozens of subcontractors, an owner, a GC, and imagine how complex the web of communication becomes. This only amplifies the importance of exceptional communication skills in our industry.

I also learned that cultivating relationships is a necessary skill in construction. One of the ways I found this easiest was to change my perspective. It can be hard to separate from your idea of what the project is, or should be, after spending so much time seeing it from your perspective. However, developing the ability to see the project from the point of view of other people involved not only can increase the effectiveness of communication, but helps build your relationships with other parties. The original design for the project did not meet all the needs of the owners and this is because I had not considered their needs when I first approached them. After some discussion and revisions, we came to a design that not only satisfied the owners, but also met the criteria for a substantial construction project. Understanding the perspective of others is very valuable when in a leadership position. It helps you keep your team motivated, solve problems more efficiently, and most importantly it elevates the relationship you have with others in the industry.

Lastly, I learned the ability to adapt is priceless in the professional world. In my case, I had to adapt to the circumstances of a global pandemic. Several things were affected throughout the duration of this project because of COVID-19. The construction had to be deferred to another student to complete in the future. All meetings that needed to take place had to be conducted through video conferences. Stores had limited hours and stock, making it difficult to locate where supplies could be obtained in the future. This is also happening on a massive scale in the industry and companies must adapt or be faced with going out of business. Some companies are laying employees off. Others are implementing pay cuts across their company to stay afloat. The construction industry is highly reliant on the economy and people's belief of which direction it is headed. With a such a nature, those looking to profit in this industry must be able to adapt or their business ventures will be short lived.

“Appendix A”

See Figure 4 for an isometric view and north/west elevations.

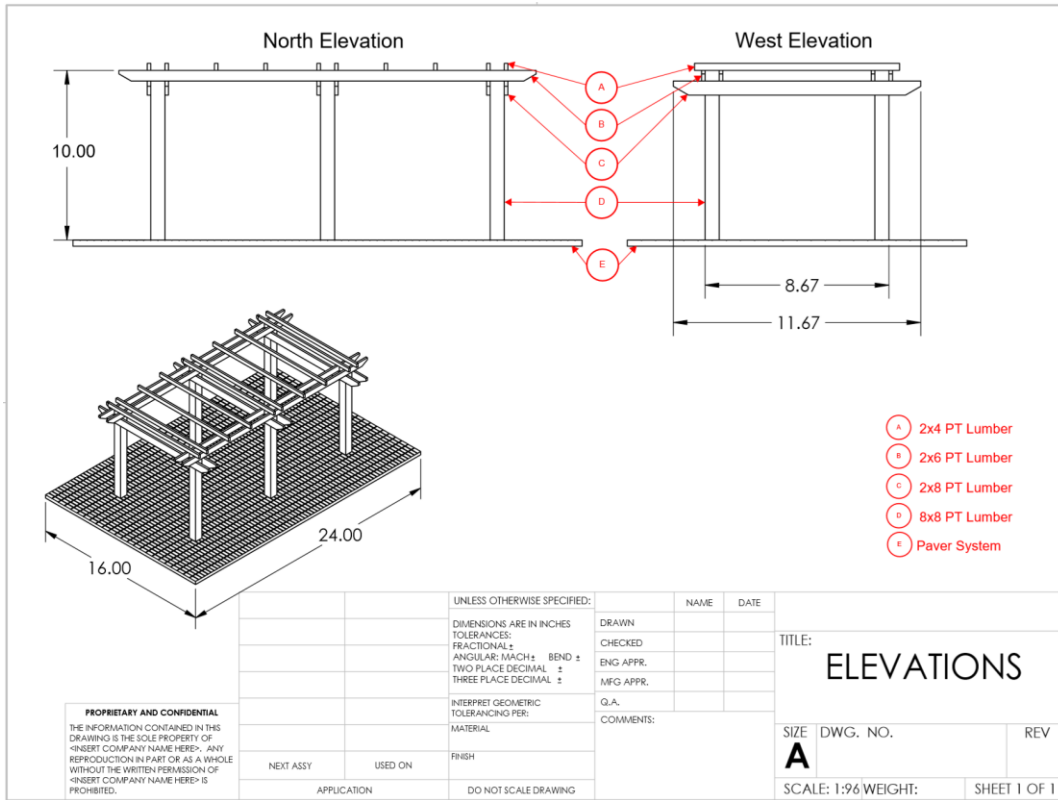


Figure 4. Isometric view and North/West Elevations

See Figure 5 for plan view.

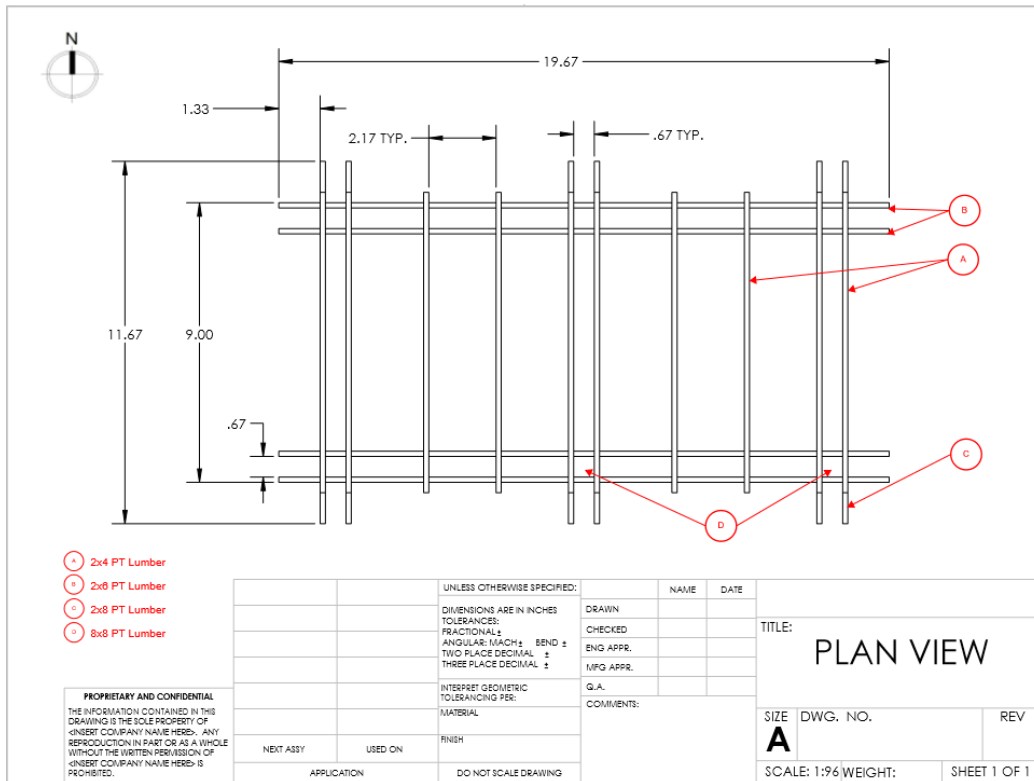


Figure 5. Plan View

“Appendix B”

See Table 2 for QTO Sheet.

Table 2

Lumber	Quantity	Unit
2 x 4	96.66	LF
2 x 6	78.66	LF
2 x 8	70	LF
8 x 8	72	LF
Paver	Quantity	Unit
Gravel	2.37	CY
Sand	3.55	CY
Permeable Paver System	384	SF
Concrete	Quantity	Unit
Concrete	2.5	CY

Hardware	Quantity	Unit
APVT T Strap	12	Ea
APVDJT Deck Joist Tie	12	Ea
APVA Right Angle	20	Ea
Outdoor Accent Screw	160	Ea
Outdoor Hex-Head Washer	160	Ea

“Appendix C”

See Table 3 for Detailed Budget Breakdown.

Table 3

Lumber	Quantity	Type	Unit Cost	Cost
2 x 4	10	10'	\$ 4.57	\$45.70
2 x 6	8	10'	\$ 10.27	\$82.16
2 x 8	6	12'	\$ 18.27	\$109.62
8 x 8	6	12'	\$ 114.99	\$689.94
			Lumber Cost=	\$927.42

Paver	Quantity	Unit	Unit Cost	Cost
Gravel	2.37	CY	\$ 241.92	\$573.35
Sand	3.55	CY	\$ 276.32	\$980.94
Permeable Paver	384	SF	\$ 11.79	\$4,527.36
			Paver Cost=	\$6,081.65

Concrete	Quantity	Unit	Unit Cost	Cost
Concrete	2.5	CY	\$ 150.00	\$375.00
Labor	40	MH	\$ 20.00	\$800.00
			Concrete Cost=	\$1,175.00

Hardware	Quantity	Unit	Unit Cost	Cost
APVT T Strap	12	Ea	\$ 18.63	\$223.56
APVDJT Deck Joist Tie	12	Ea	\$ 7.56	\$90.72
APVA Right Angle	20	Ea	\$ 1.78	\$35.60
Outdoor Accent Screw	160	Ea	\$ 1.40	\$224.00
Outdoor Hex-Head Washer	160	Ea	\$ 1.50	\$240.00
			Hardware Cost=	\$813.88

Landscape	Quantity	Unit	Unit Cost	Cost
Plants	10	Ea	\$ 50.00	\$500.00
			Landscape Cost=	\$500.00
Summary				Cost
Subtotal				\$9,497.95
Taxes				10% \$949.79
Project Total				\$10,447.74

“Appendix D”

See Figure 6 for foundation detail.

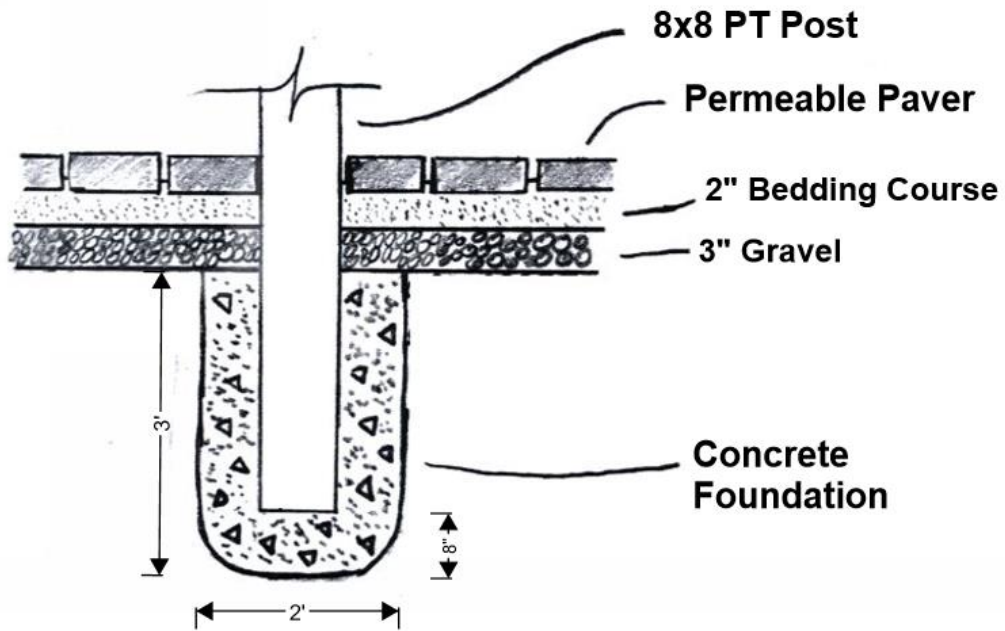


Figure 6. Foundation Detail