Trellis Final Report

Presented to: Underwood Center for the Arts

Team 2: Kyle G. Romero, Byron Cornelius, Patrick Lynch, Evan Herod

12/16/2009

5702 50th St. apt# 206
Lubbock, TX 79404
December 7, 2009

Jane Henry
Title
Department
511 Avenue K
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Dear Jane,

Here is Team 2's final report for the future trellis on the East side of the LHUCA building. This report will explain in detail our view of the trellis constructed from a center pivot irrigation system. The parts and construction is explained in great detail along with multiple finished product diagrams and projected costs chart as well as the projected timeline of construction. We believe we have developed a wonderful and customizable trellis, providing both cosmetic theme and function of shade and landscape.

With the generous donations of both farmers and community service this project is not only cost effective, but fun to customize. With the use of the center pivot irrigation system the theme of West Texas can be incorporated into any and all decoration. The simplistic design makes for a short term project and light on stress.

We believe this trellis will fulfill all your needs and hopes for your new stage to come. We thank you for the opportunity to present this project and for the time taken in communication and adhering to our needs, in order to best fit this design to your needs.

This project has been a pleasure to work on and coordinate with your office and coworkers at the Louise Hopkins Underwood Center for the Arts. It has been a fantastic learning experience for our team both as students and future engineers. If you have any questions about this project and its details, feel free to contact one of our team members reachable by phone (512)799-1942 or email address patrick.lynch.@ttu.edu.

Sincerely,

Kyle Romero Byron Cornelius Evan Herod Patrick Lynch

Lynch, Patrick
Romero, Kyle
Herod, Evan
Cornelius, Byron

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Abstract

The purpose of this paper is to detail the implementation and design of a trellis shade providing structure for the Louise Hopkins Underwood Center for the Arts. It will discuss design choices, materials, cost, and benefits of the design that will be created. The trellis will be designed to cover an area between the main building and several smaller buildings. It will provide shade, a place for climbing plants such as ivy to grow, and a means to redirect water from rainfall away from people standing beneath the trellis, and towards a water collecting system, such as a cistern.

Introduction

Our team is proposing to design a trellis shading structure for the Louise Hopkins Underwood Center for the Arts. The trellis' design will utilize design aspects and materials from a center pivot irrigation system, which is the most prevalent irrigation system in use in West Texas.

The trellis will be designed to provide several functions for the art center. It will provide shade for patrons. However, at the same time, it will allow some light through its partially translucent roofing materials. It will also provide a structure for climbing plants to grow on, such as ivy, which will further enhance the shade provided by the trellis, as well as potentially increasing the aesthetic value of the structure. Additionally, the one final function that the trellis will provide is a method of collecting and routing rain water to a nearby water-catching device, such as a cistern. This will provide two benefits: preventing patrons underneath the trellis from getting wet in the event of a rain storm, as well as allowing rain water that would otherwise be lost to evaporation to be recaptured for use.

Background

One of the goals of this project is to use recycled materials in as many ways as possible. Therefore, it is desired to use donated center pivot irrigation sections as the support structure for the trellis. A center pivot irrigation system is illustrated in the following figure:

Figure 1: Center Pivot Irrigation System[2]

A center pivot irrigation system is an above ground irrigation system that consists of lengths of pipe connected between motorized towers that rotate the assembly in a circle around a field. This allows even distribution of water to the crop, and requires minimal human intervention due to its cyclical nature. Due to the fact that this system is already designed to provide for the transport of water, it was chosen as the main structural support for the trellis. These are also in common use throughout West Texas. Therefore, it should be easy to acquire out of commission sections of the irrigation system for use in the trellis, at little to no cost.

Aesthetic Improvements

The trellis support structure draws inspiration from the center pivot irrigation systems, which are the prevalent form of irrigation on the Great Plains. See Figure 1 for a visual representation of one such system.

Spans of a recycled center pivot system will be used as both the structural support for the roof of the trellis (which will be further detailed in the Design section of this paper), and as the vertical surface for climbing plants to grow on. Using a recycled center pivot system in the trellis design will provide several aesthetic benefits. For one, it shows the desire of the Underwood Center to have a low impact environmentally. Secondly, it showcases a piece of technology that is of particular importance to the Lubbock area, due to the fact that many area farmers depend on these systems for their livelihood.

As previously mentioned, the recycled center pivot system will provide the vertical surface for climbing plants to grow on. This will greatly improve the overall look of the trellis, because it will make the structure seem more integrated into nature. Generally, green plants are more soothing to the eye than metal. According to *Gardens for the* Future, "The designs of gardens and landscapes create a link between culture and nature at the most primary level."[3] Therefore, ideally, any addition of plant life to the center will be beneficial, because it creates a greater connection to nature for patrons of the center.

It will also allow the appearance of the trellis to evolve over time as the plants grow and spread over the structure. According to the book, *For Your Garden: Arbors and Trellises,* "Simply put, gardens are visually improved by the addition of vertical elements."[4] Therefore, it can be anticipated that the trellis structure will greatly enhance the Underwood Center for the Arts in a visual sense. The following figure gives a sense of what it would look like to be walking underneath the trellis.

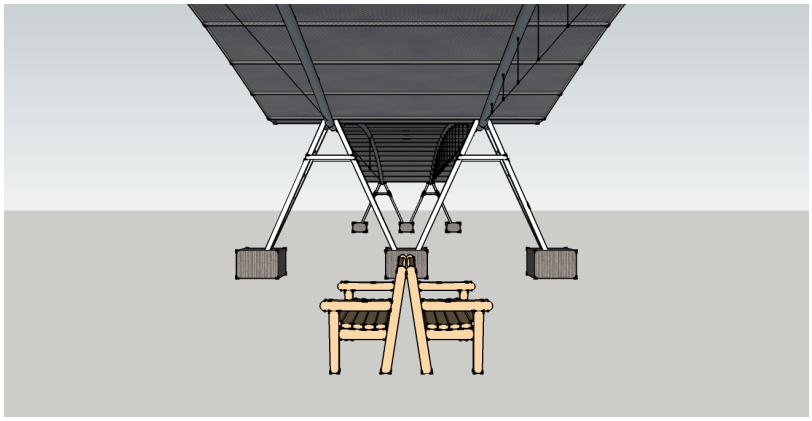

Figure 2: Ground level view, taken from underneath trellis roof

At the top of the figure, the spans of the center pivot are visible, connected horizontally by steel cross bars, and covered in the plastic roofing panels. Further down towards the center of the picture, the concrete blocks designed to support and lift the trellis are apparent. Also, benches appear as a demonstration of possible additions to the trellis post-construction.

Functional Improvements

In addition to the aforementioned aesthetic improvements the trellis will provide to the Underwood Center, it will provide several new functional enhancements to the facility. For starters, it will provide a nice shaded area for patrons of the center to walk and enjoy their surroundings while still being outside. The roof, while impermeable to water, will still allow some light through, which will further promote the growth of climbing plants. These improvements will make for a much more enjoyable experience for patrons of the center.

The trellis will also be integrated into the water catching capabilities of the facility. Currently, water from the roof of the main building is dumped onto ground level. In order to keep patron's feet dry in the event that they underneath the trellis during a rain storm, water will be redirected onto the roof of the trellis from the roofs. The roof of the trellis will provide a surface for naturally collecting water, by directing

water that falls onto it to the natural low points of the roof caused by the curvature of the center pivot irrigation center. Drains at these low points will allow water to flow into collection basins at ground level, which will further direct water towards the proposed playa lake and cistern. Therefore, the trellis will greatly increase the ability of the center to collect and channel water so that it may be used at a later time for productive purposes. Now that the functions that the trellis will provide have been thoroughly explained, the physical description of the trellis will now follow.

Design

Design Incorporation

The design of the trellis will incorporate two side-by-side sections of a refurbished center pivot irrigation system. These sections will span the length of the main building forming a T-intersection that will also cover the area between the Cafe building and the main building. The length of the trellis along the main building will be 240 feet long and the width of the trellis will be 20 feet (as shown in the figure below). The center pivot irrigation system has spans of pipe 160 ft in length between the towers. Due to the fact that two towers will sit side by side at each point there will be two walkways which will allow pedestrians walking underneath the trellis to walk in both directions without interfering with each other. In the center of the pathway benches will be placed to allow patrons of the LHUCA to enjoy the shade and atmosphere provided by the trellis. The use of the center pivot irrigation system will bring a West Texas look to the trellis that compliments the overall look of the courtyard. The underside of the trellis supports the growth of ivy that will add to the aesthetic beauty of the courtyard.

Figure 3: Trellis Incorporation into LHUCA[5]

The above figure is a bird's eye view of the LHUCA facility. The turquoise shaded areas, with measurements marked, represent the area of the facility that will be covered by the trellis. As can be seen, the trellis will be quite a large structure once it is constructed, at 240 ft x 20ft for the main span.

Technical Description

The Trellis proposed to be built at the LHUCA will be constructed in two phases. The first phase will include the erection of the main trellis which will run north to south through the center of the site. The second will run West to East along the northern property line.

The main trellis will shelter a walkway that travels from the porte cochere on 5th street down to the covered drive on Mac Davis Ln. The distance covered by this section of the trellis will be three hundred and nine feet. The main structural component of the trellis will be six segments of a recycled central pivot irrigation system. They will be assembled in two separate strands. Each strand will be a series of three segments that run parallel to each other and the length of the trellis. These two strands will be separated twelve feet from pipe to pipe on center. See Figure 1 for an illustration of the structural support system of the trellis.

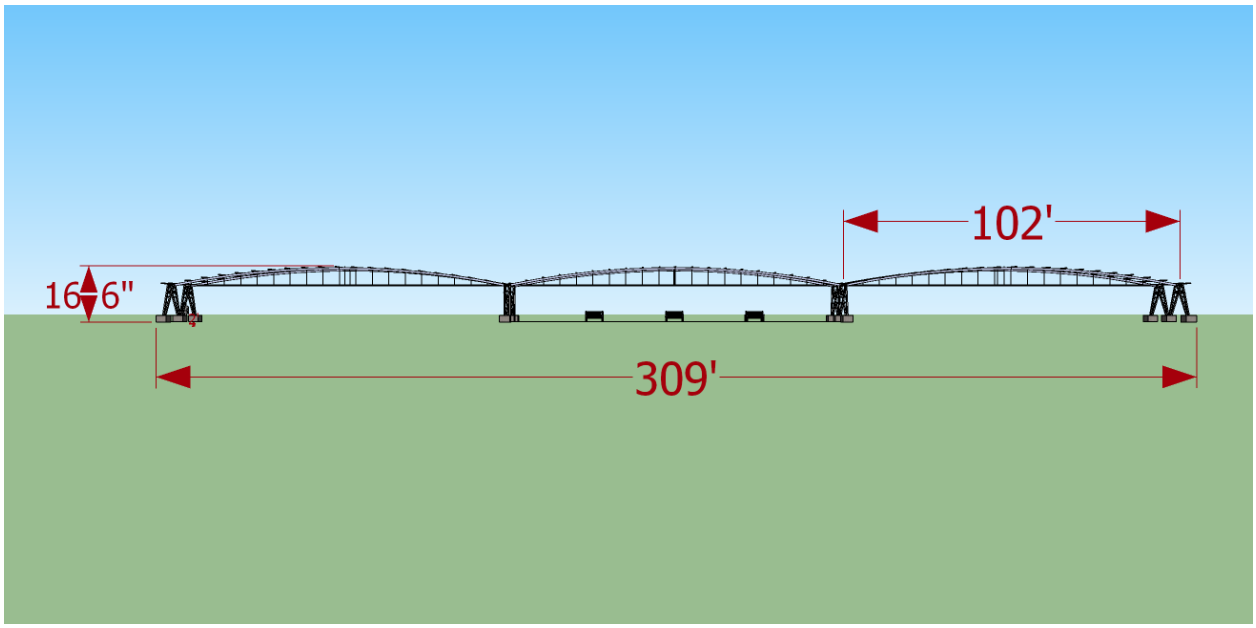

Figure 4: Side View of Trellis

The central pivot irrigation components will be erected on location with a process similar to that performed on farm sites. The assembly process used at the LHUCA will have one variation in which the bases will no longer utilize wheels but rather be placed directly in cast concrete. There will be a total of 12 square bases that have a footprint of one square yard and are roughly two feet high. The reason the concrete bases will have differing heights is so that their upper elevations will remain constant after being placed on the existing topography. The following illustration shows a bird's eye view of the trellis.

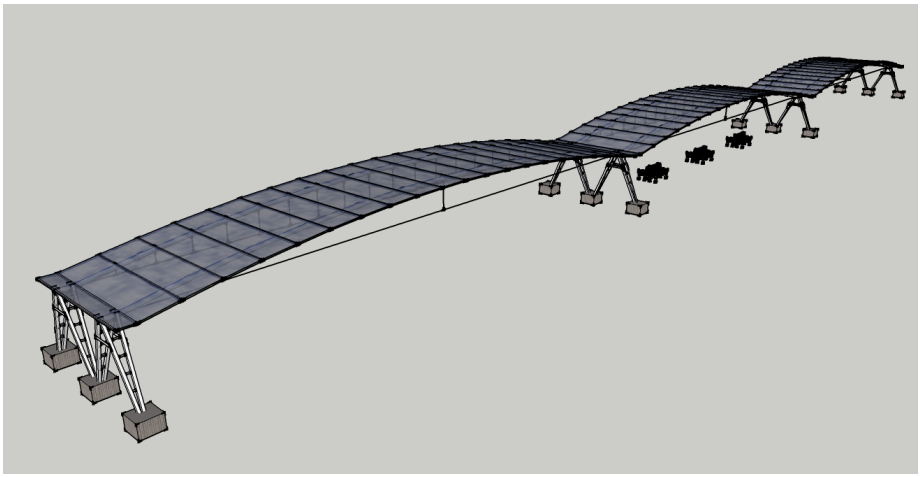

Figure 5: Bird's Eye View of Trellis

After the bases and main structures are assembled, the 2 three-hundred foot strands will be attached by sixty five hollow steel crossbars. The bars will be two inches square and twenty feet in length. These bars will be placed every five feet on the arches and will have a two foot separation above the columns. The crossbars will be attached by the use of a weld. These cross bars will be the support for both the expanded metal and the plastic panels. The expanded metal will be made of aluminum and will be attached in five foot wide segments to correspond to the spacing of the crossbars. The expanded metal will be tied to the underside of the crossbars with an inexpensive tie wire. On top of the cross bars plastic panels will be laid. The panels will also be attached to the crossbars in five foot wide sections with self-sealing roofing screws. The final addition to the structure is the drain systems. Two drain systems with chains to direct the water will be installed at the connection points of the trellis. The following figure illustrates the roof of the trellis, and how it will sit on top of the center pivot sections.

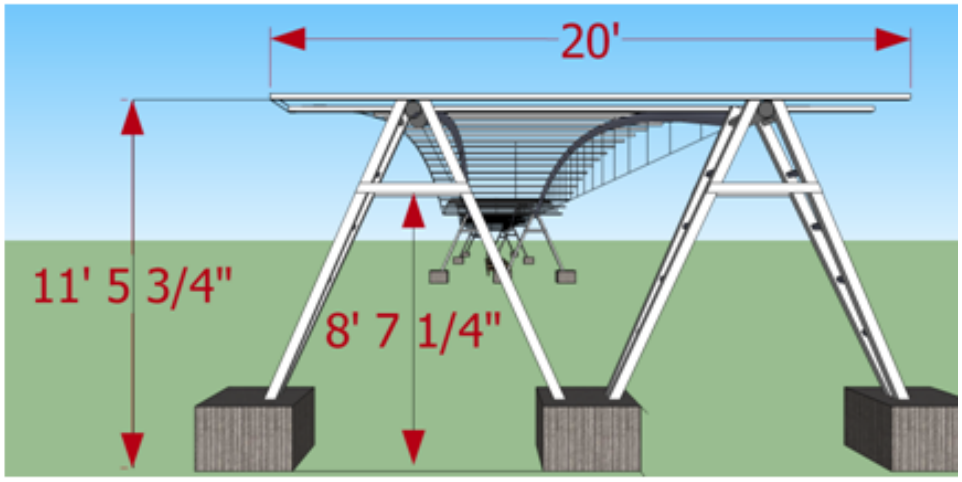

Figure 6: Underside view of Roof of Trellis

For more illustrations, please see Appendix A.

Materials / Cost

This design has much room for customization and adaptation. Depending on the choices of design for this project varies the possible costs to some degree. For this reason the bare minimum prices are offered and if the more extravagant approaches are used then it could change the total price drastically. Sticking to recycled materials such as donated Irrigation systems and "do-it-your-self" portions such as the Rain Chains can cut costs in the minor side of the project. For the most part the main portions of the design such as the polycarbonate paneling and the 20 foot hollow 2inch stainless steel tubing will remain roughly the same. The materials are subject to small changes depending on which supplier is used and whether or not shipping costs are necessary. Only the minimum costs are considered for convenience sake. If a more refined touch is added to the design then the price by all means will change but by an amount marginally acceptable.

Table 1: Costs

Material	Quantity	Cost per Unit	Total Cost
Center Pivot Irrigation	6	Donated	N/A
Concrete	8 yd^3	$12.5	$500.00
Expanded Aluminum	120 sheets	$72.71	$10,7983.00
Tie Wire	600ft.	$12-16	$100.00
Generic Plastic Panels	6000sqft.	$108.8	$20,672.00
Roofing Screws	2750	$.009	$550.00
Rain Chains	3	$50	$150.00
Steel Cross Bars	65	$220	$14,300.00
Total			**$47,070.00**

6 sections of center pivot irrigation

The six sections of Center Pivot Irrigation are assumed to be donated so not initial costs were calculated. They will be used to provide the support structure of the trellis. Two spans of the irrigation system will be placed parallel to each other, connected at the top by steel cross bars.

8 Cubic yards (216cf) of concrete

Several 80lb bags will be necessary in order to fill the needs of 216 Cubic feet. The concrete will be used to create the base support for the trellis. The bases will be formed into large cubes, which will provide enough support to hold the trellis steady. They will also raise the trellis several feet higher to allow increased head room for patrons underneath the trellis.

120 5'x10' expanded aluminum panels or 1200' (5' wide) or expanded aluminum lath

These panels will be used to provide a lattice work for climbing plants to grow on. They will be placed between the framework of the trellis and the roof material, allowing plants to grow below the roof while still being covered.

600' of tie wire

The trellis will require roughly 600 feet of tie wire. The tie wire can be found at any if not all hardware stores. It is relatively cheap at anywhere from $20-$30 per 50 feet of various gauges. The tie wire will be used to attach the expanded aluminum to the framework of the trellis.

6000 Square Feet of plastic panels

Generic polycarbonate paneling can be found online at many custom shapes and sizes. Colors and UV protection can also be included. The polycarbonate panes are the most expensive item on the list of material for the sheer size and quantity of the product required. Initial estimate of a bare minimum generic type pane of 1/8" thickness and 48X96 inch dimensions multiplied by the number of panes necessary to cover the 6000 square feet, came to a low cost of $20,672.00 at a per pane cost of $108.80 found at an online producer http://freckleface.com. The panels will create the roof of the trellis, and will be placed on top of the steel cross bars.

2750 roofing screws with gaskets

Easy enough to find in most hardware stores, these screws, of various lengths, can be bought for a price range of $12-$20 per hundred which puts these screws at a total added price of $330.00-$550.00 according to multiple online stores and descriptions. These screws will be used to attach the plastic panels to the steel cross bars.

3 custom chain drain systems

There are many options for the chain drain systems that can be catered to the needs of each project. Rain chains can be bought donated or created with ease. With just one day and a few volunteers, a proper rain chain can be crafted with basic supplies such as copper or stainless steel chain, hung from an eye hook and drained either to a bucket or drainage system.
However in order to maintain an aesthetically pleasing appearance along with the overall agriculture and west Texas rustic theme, a custom chain drain would be easy enough to acquire. There are a few online sites that offer some particular rain chains that would do nicely. Priced from the low end clearance items to the more intricate designs ranges from $ 99.00 for 8" 10' all the way to $144.00 for the same size. With the purchase of three rain chains $350 could be allotted for a professional set.

On the other hand, self made rain chains can be done much more cheaply, priced near $ 3-16 per foot of chain link, in gauges from 1/8 through to 1/2 according to http://www.stainlesschains.net. Going this route allotting only $100-150.00 for the chains should be plenty. The chains will be used to transport water from the roof collection points to the ground level collection bins.

65 2"X2" 20' long hollow steel square tubes

The steel bars will be used as cross members to connect the spans of the center pivot. If they cannot be purchased locally, then they must be shipped. Initial cost estimates 130 10 foot 1/8inch

wall thick stainless steel 2inch squared crossbars to be roughly $14,355.69. Again depending on your manufacturer and weather local or shipping costs are necessary. These beams will be used as cross braces to connect the two spans of center pivot irrigation.

Timeline

All in all, the trellis will take about a month to construct. Delay times in shipping, weather delays, and difficulties in finding a donor to provide a center pivot irrigation system must all be taken into account. During each phase of the project the progress of the construction must be closely monitored to allow changes to the timeline to be incorporated. Due to the fact that the center pivot irrigation system is already fabricated, and can thus be simply bolted together, construction time will be relatively short and free from much complexity. Special care must be taken to insure that the structure is sound enough for people to walk underneath it, and any repairs or changes to the design must be completed before the structure is opened up to the public. The following figure is a Gantt chart for the proposed project.

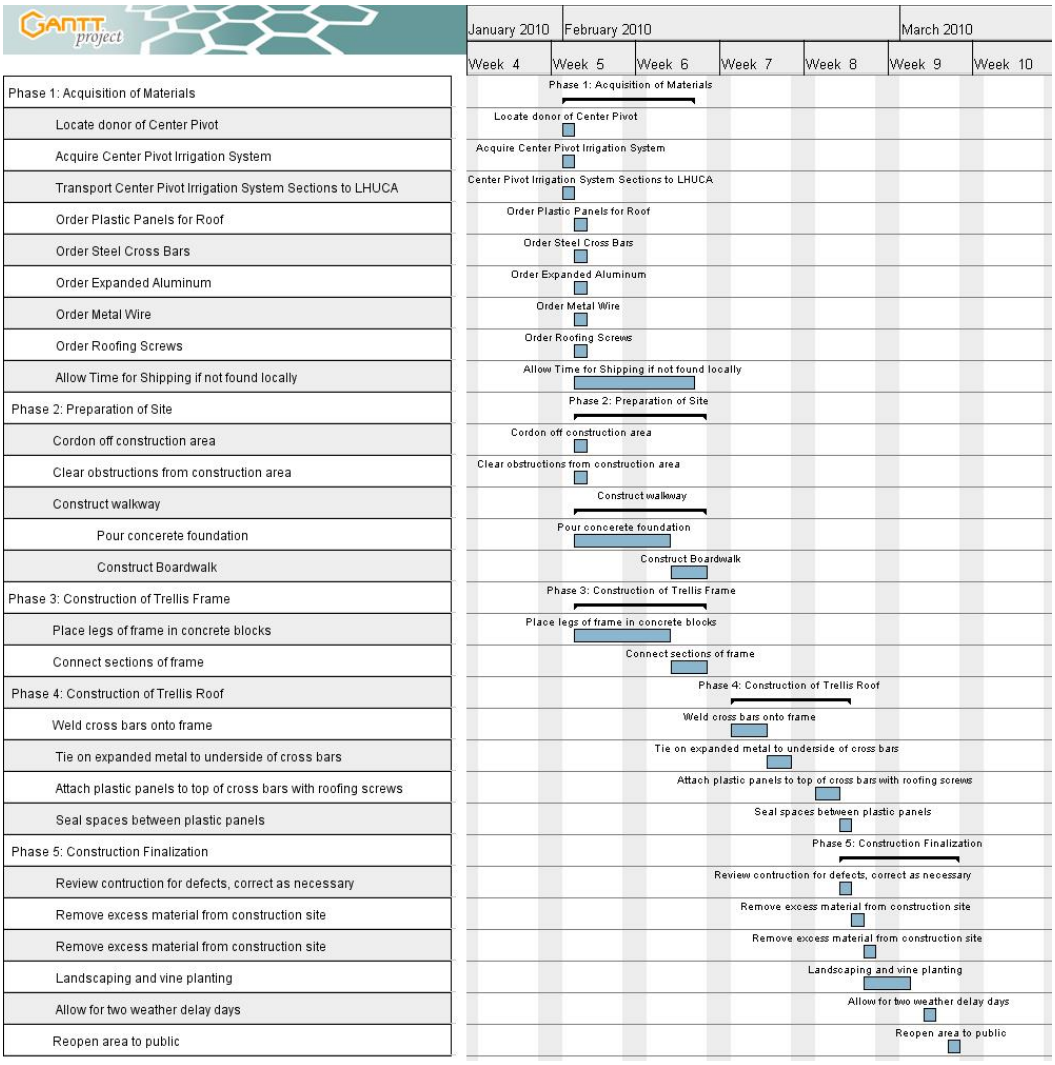

Figure 7: Gantt Chart

Phase 1: Acquisition of Materials

During this phase, the materials necessary to construct the trellis will be acquired or purchased. The first step will be to find a donor to provide the sections of the center pivot irrigation system. Once a donor has been found, the sections can be transported and stored on-site at LHUCA until they are needed during later phases of the project. At the same time, distributors for the various materials needed for the trellis will need to be located, and the parts will need to be ordered. If local vendors for the parts cannot be located, they will need to be shipped, which means the parts could take 1 – 2 weeks to arrive. Once all parts have arrived and been moved to LHUCA, phase 2 can begin.

Phase 2: Preparation of Site

Before construction at LHUCA can begin, the future site of the trellis will need to be cordoned off and cleared of all obstructions. A layer of concrete will need to be laid down in order to provide a level surface for the boardwalk and trellis to reside on. The assembly process used at the LHUCA will have one variation in which the bases will no longer utilize wheels but rather be placed directly in cast concrete. There will be a total of 12 square bases that have a footprint of one square yard and are roughly two feet high. The reason the concrete bases will have differing heights is so that their upper elevations will remain constant after being placed on the existing topography. Once the concrete has been laid, it will need to sit for a week to insure structural stability. Once the concrete has set sufficiently, the boardwalk that will reside underneath the trellis can be constructed. This could take 3 – 4 days, depending on how elaborate a design is desired. Overall this phase will take about 2 weeks. Once this phase is complete, it is time to move onto phase 3.

Phase 3: Construction of Trellis Frame

The central pivot irrigation components will be erected on location with a process similar to that performed on farm sites. After the bases and main structures are assembled, the 2 three-hundred foot strands will be attached by sixty five hollow steel crossbars. The bars will be two inches square and twenty feet in length. These bars will be placed every five feet on the arches and will have a two foot separation above the columns. The crossbars will be attached by the use of a weld. These cross bars will be the support for both the expanded metal and the plastic panels. The expanded metal will be made of aluminum and will be attached in five foot wide segments to correspond to the spacing of the crossbars. The expanded metal will be tied to the underside of the crossbars with an inexpensive tie wire. It could take about a week to get the frame of the trellis assembled. Assembly time will be helped by the fact that the center pivot has already been fabricated and needs merely to be bolted together. Once the frame of the trellis is assembled, the phase 4 construction of the roof can be started.

Phase 4: Construction of Trellis Roof

On top of the cross bars plastic panels will be laid. The panels will also be attached to the crossbars in five foot wide sections with self-sealing roofing screws. The final addition to the structure is the drain systems. Two drain systems with chains to direct the water will be installed at the connection points of the trellis. Once the roof has been constructed, the plastic panel edges will then need to be sealed to prevent water from running between the sections. This phase of the project will take roughly 10 days. Once the roof is constructed, the main portion of the construction project is complete.

Phase 5: Construction Finalization

During the final phase of the construction, the LHUCA facility will be cleaned up and made presentable to the public. Landscaping and planting of vines along the trellis will occur at this time. Also, before being opened to the public, a 2 day review phase should be completed to insure that the trellis is safe. Once all safety considerations have been met, the trellis can be opened to the public. This phase will take about 1 week, and takes into consideration two days for possible weather interference.

Recommendations

As has been illustrated, the trellis that has been designed for the Louise Hopkins Underwood Center for the Arts will be a beneficial and beautiful addition to the facility. Due to the fact that the main part of the trellis will be made from a recycled center pivot irrigation system, the structure will be relatively inexpensive considering all the benefits it will provide.

All in all, the project should take roughly 1 month to construct. Acquisition of the materials should take roughly one week, assuming a recycled trellis is readily available, and all other materials are in stock and can be ordered online. Preparation of the site should take a week as well, however this can be accomplished while the materials are en route. The actual construction of the trellis will take roughly three weeks. Potentially it could be constructed more quickly, but three weeks allows a pace slow enough to ensure it will be built correctly. Special care must be made to insure that the structure is safe for the public.

The trellis, which will provide numerous aesthetic and functional improvements to the Louise Hopkins Underwood Center for the Arts, will be worth constructing. With a total cost of $47,070, the center will get the most bang for their buck, and should be seriously considered for construction.

References

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5. LHUCA. Louise Hopkins Underwood center for the arts phase 1 blueprints. Underwood.pdf. Referenced 12th November, 2009.

Appendix A

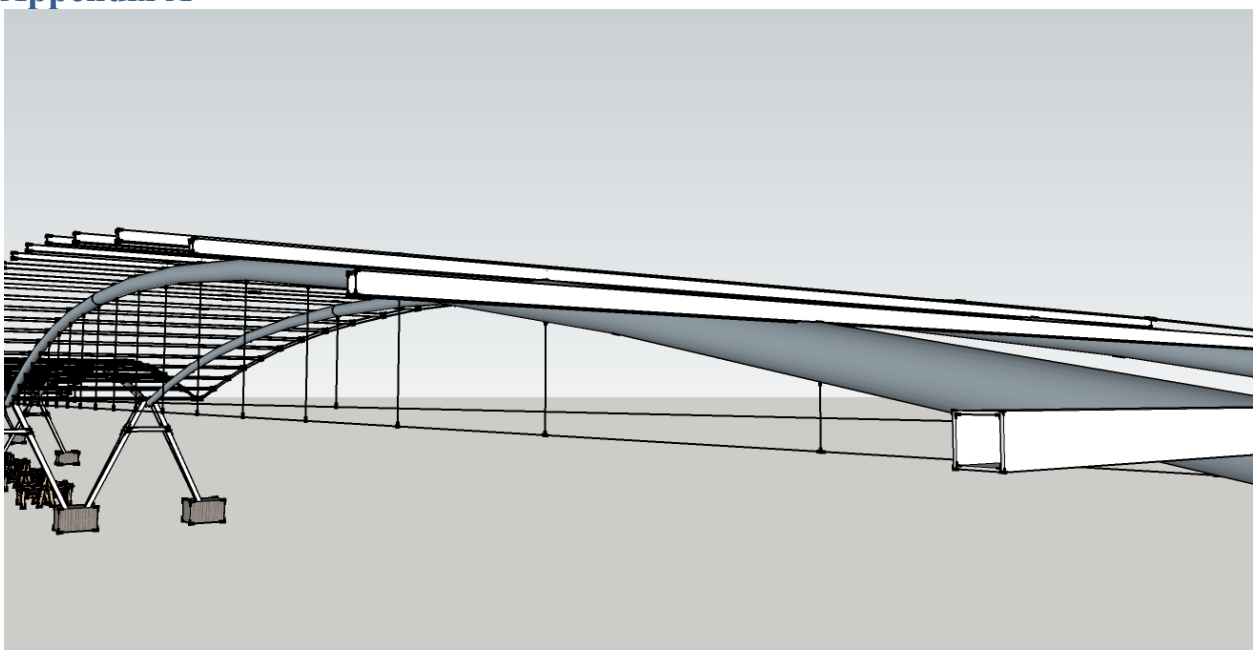

Figure 8: Structural View of Trellis

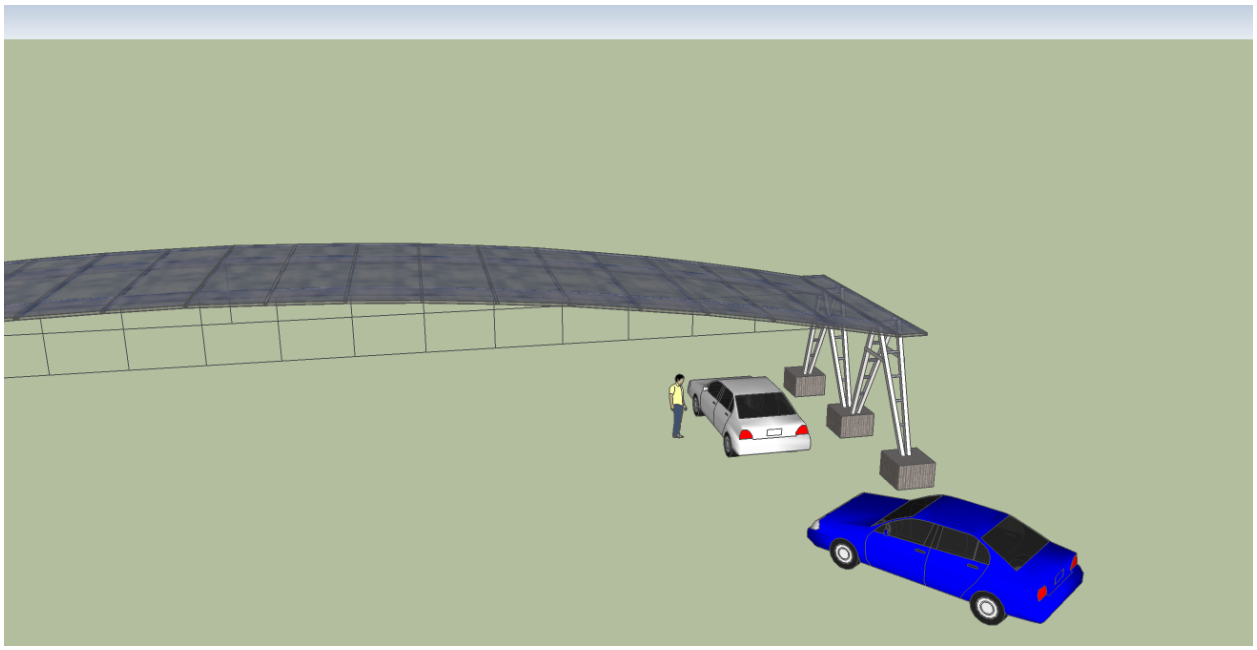

Figure 9: Porte Cochere

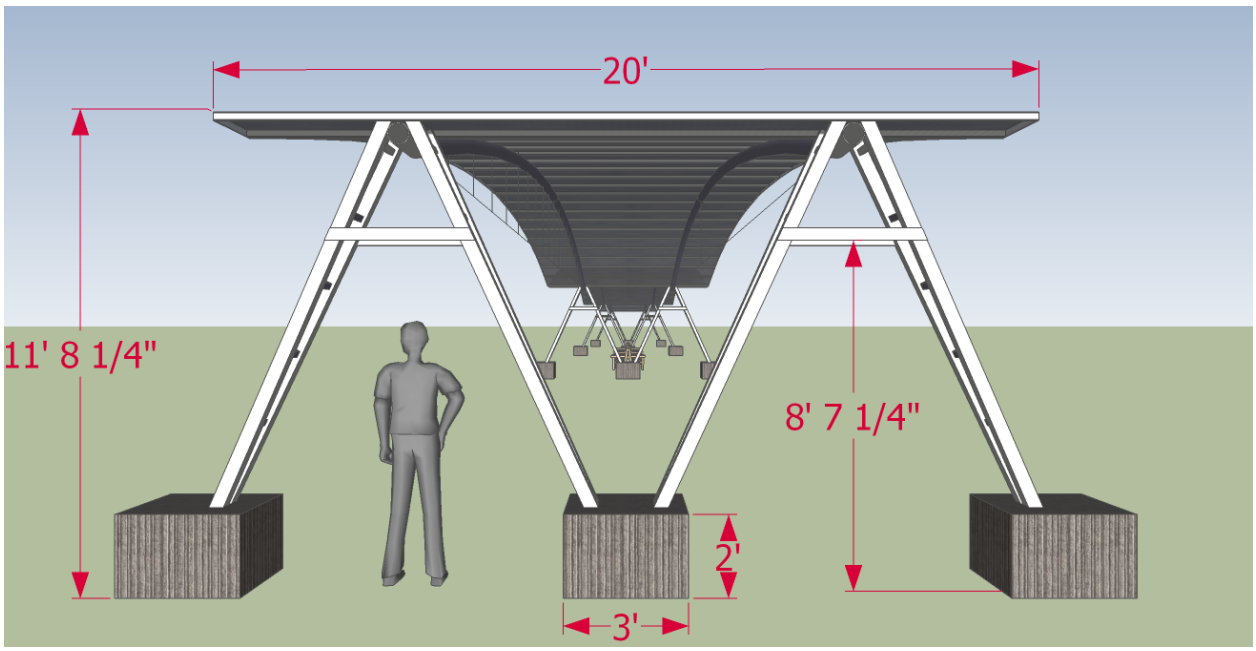

Figure 10: Illustrating Walkways

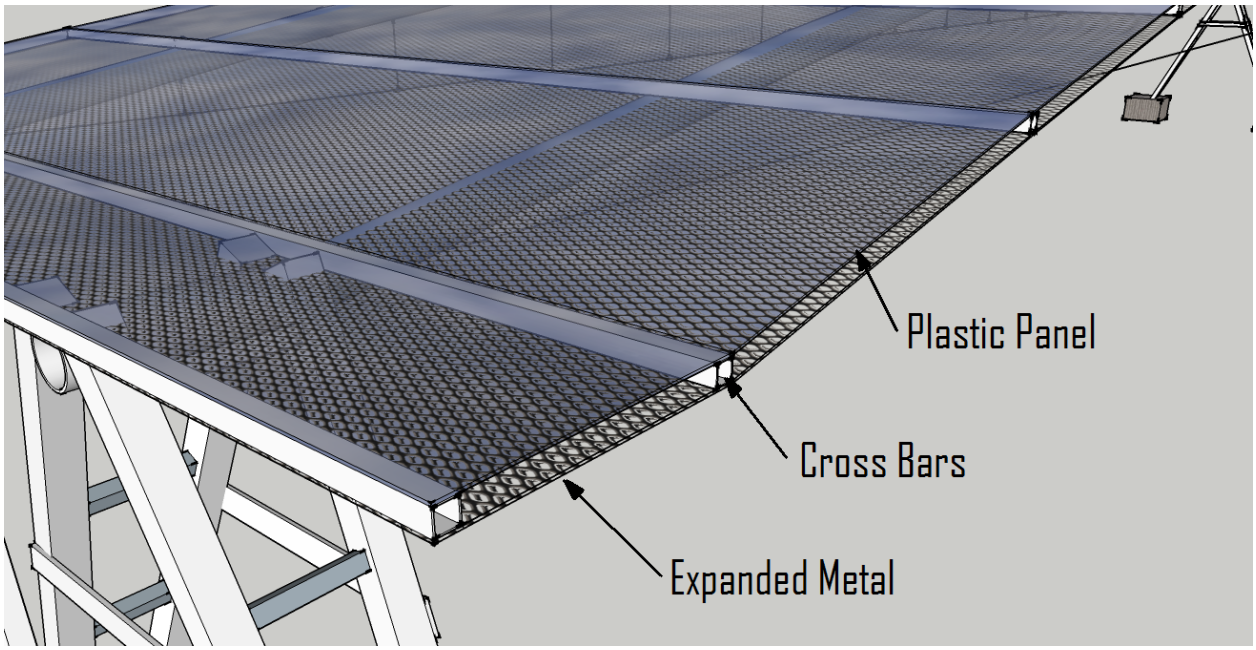

Figure 11: Close up of Roof

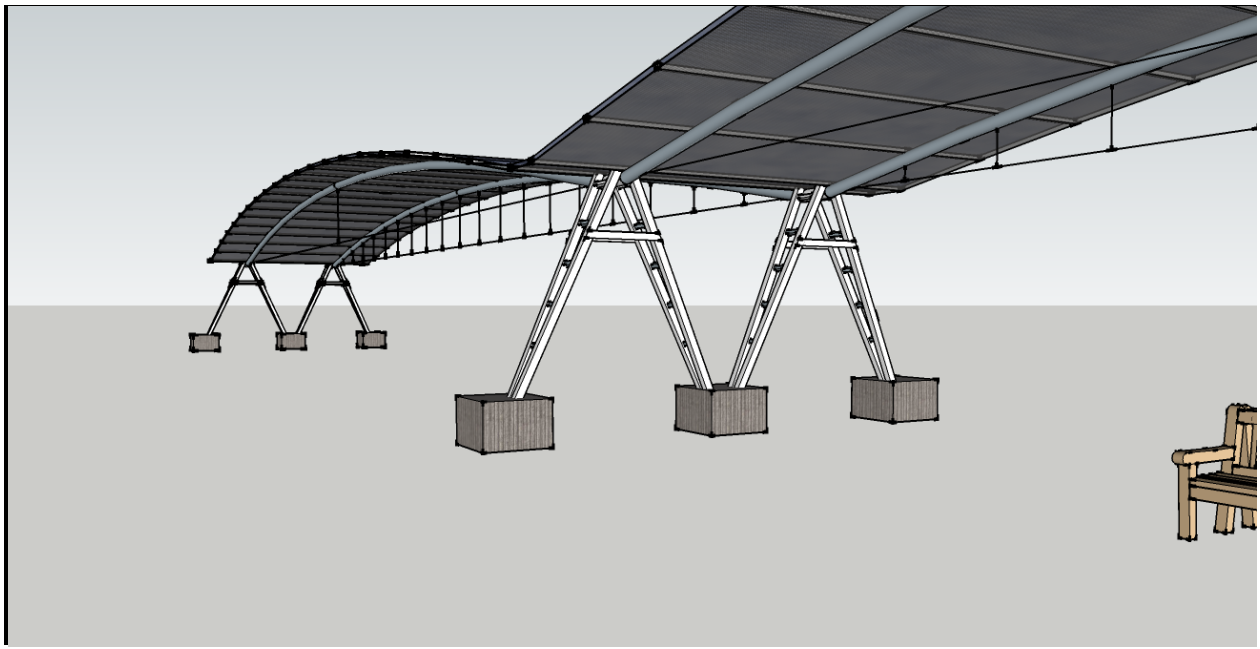

Figure 12: Ground Level View from Outside of Trellis