Project Deliverable D - Conceptual Design

February 13th, 2020
Group D1 - Construction

Introduction:

This document functions as a concise summary of possible conceptual designs for our greenhouse based on the problem statement established in Deliverable B. These designs will also be based off of both, the benchmarking conducted, as well as the specific design criteria requirements (such as cost & size) that were developed in Deliverable C. The document also functions as a collection of potential solutions, which are presented by each member of the group, for design problems. These proposals will then be individually analyzed one at a time by the group and determined whether their implementation into the construction will prove beneficial.

Problem: Structure

The design of the greenhouse is dependent on multiple factors. One factor that comes into play with the design of our greenhouse is the hydroponics team. The hydroponics team would like the greenhouse to have certain minimum specifications in order for their system to function in the greenhouse. This is why there are different ways the structure of the greenhouse can be designed.

Solution (Karl):

Due to errors in the construction of the base, the roof frame should incorporate 64 inch members of wood (which were previously supposed to be longer) to support the plastic roof material that will channel the rainwater to the gutter. Additionally a door that is near the corner of the greenhouse (on the far left or right space of a wall section) will make the orientation of the hydroponic apparatus more flexible.

Solution (Tanish):

From the research that has been done in the first three deliverables, we were able to see that there are many different ways to create a greenhouse. One way that I observed building a greenhouse while researching is to build the structure in the shape of a dome. A dome has many different benefits. One benefit is that a dome allows more light to come into the greenhouse. Another benefit is that the shape of a dome allows water to be collected at the base of the greenhouse as when rainwater falls it will slide down the side of the greenhouse and into the collection gutter at the base. Although the dome shape may be more complex, it will help the plants in the greenhouse have more sunlight to grow more efficiently.

Solution (Ethan):

The flexibility that the hydroponics team requires can be obtained through a simple, open interior design. A square greenhouse with a base of 6’x6’ will provide simple dimensions so that orientation of components relative to the walls of the greenhouse does not matter. The single plane roof design will also provide a large upper cavity to install hydroponics equipment without taking up valuable space for growing plants.

Problem: Water Collection

There should be a system to collect rain water and if possible, collect the snow that accumulates in the winter, which can be used for water when filtered. The same system should be able to store and distribute the collected water.

Solution (Jack): ***SINGLE STREAM***

To collect water efficiently, I propose that the roof is indented so that the water that lands on the roof is combined into one single stream that leads directly to the hydroponics system. However, this would only work if the roof of the house is angled in a way that allows the force of gravity to push the water towards the rear of the greenhouse.

Solution (Tanish): ***GUTTER SYSTEM***

To collect the water, a gutter system will be installed all around the structure so that water falling off each edge of the roof will be collected, therefore maximizing water collection. The gutter system will increase the cost, but it is worth the money because it will improve the overall efficiency of the system for the user.

Solution (Ethan): ***Single-plane Roof***

A single-plane slanted roof design will provide a very simple yet effective rain catching solution as any rain that strikes the roof can slide downwards into a single gutter for collection and storage. Short rails can protrude from either side of the room to prevent water loss by water running off the sides of the roof by guiding all the water into the gutter. The single-plane roof design will also reduce complexity of construction, and create less pieces that need to be transported to the final destination.

Problem: Portability

The greenhouse must be able to be taken apart and put back together with ease so that it can be transported and reconstructed by a group of students.

Solution (Jack): ***NUTS AND BOLTS***

In order to create a relatively portable system, it may be useful to be able to detach the walls and ceiling from the general structure. A simple form of doing so includes the use of nuts and bolts to attach each component together. With this strategy there is minimal use of tools and an efficient form of removal and reconstruction. This also keeps the children from needing to use dangerous tools such as hammers to build the greenhouse.

Solution (Karl): ***SCREWS AND HINGES***

I suggest hinges with screws to hold perpendicular parts of the frame together. This will allow for easy assembly with a standard joint for all parts of the structure. However this will slightly increase the cost of the greenhouse but it should fit our budget nevertheless.

Solution (Steve Cai) : *wind proof rope*

Depending on the weather, which is windy and the wind is strong, we can use the wind proof rope to fix our greenhouse. This kind of rope is just like the rope we use on the tent. Attach the rope to the roof and fix the other end to the ground. This design can keep the greenhouse stable and not be damaged by the wind.

Solution (Ethan): *Impact driver and Screws*

A battery powered impact driver can drive screws into wood with ease, as well as remove them. If screws are used to assemble the parts of the greenhouse during initial construction, they can be quickly and easily unscrewed for disassembly and transportation. Impact drivers are small and battery powered, so they can be transported easily and used in remote areas (extra batteries should be packed). Upon arriving at the destination, the impact driver can be used once again to drive screws into the wood to strongly and securely attach all the parts of the greenhouse structure.

Problem: Security/Pest Control

There must be an enclosed system so that animals cannot access the produce. It also must be ensured that the greenhouse is secure from other possible threats, such as thieves.

Solution (Jack): *LOCKS*

Overall, the greenhouse must only be accessible to the user. As a result, a method that can be used to keep animals from accessing the produce inside the greenhouse is to simply ensure that there are no crevices along the edges of the structure of the house. Similarly, the only way to access the greenhouse is through a door, and in order to prevent others from entering the door will have a simple slot for a lock and key or combinational lock. There would be nearly no change in cost to insert small lock holes and therefore presents a promising solution.

Solution (Tanish) *FENCING*

Although a fencing system would not necessarily protect the greenhouse from thieves, it would provide an effective solution against animals that hope to enter and consume the produce inside. As a result this idea should only be considered if there is enough money in the budget for additional components.

Solution (Marcus) *RAISED PLATFORM*

A raised platform is a simple and cheap method for stopping small animals from being able to easily get into the greenhouse. This design would involve four pillars on each corner of the rectangular base and a small staircase at the door. To make it so rodents can't just use the stairway it can be made separate from the actual greenhouse that way it can be removed/placed when necessary. This is also

beneficial in that it also acts as a prevention tool for stopping small children from wandering into the greenhouse.

Solution (Steve Cai) Siting

A good location is as important as all other solutions. We are not supposed to locate the greenhouse near the bushes or the outside of the settlement, because the wild animals usually don't live around the human village, and build the greenhouse near our user is facilitate them to use, to repair and they can protect the greenhouse from the damage by animals.

Problem: Heat Loss

Solution (Marcus): *INSULATION*

One method to keeping the greenhouse at required temperatures is to insulate the walls and or the ceiling. A popular choice for insulation is polycarbonate sheets for multiple reasons. The first is that it is both a lightweight and flexible material making both transportation as well as construction easier. The material is also long lasting and it is UV-resistant and is not susceptible to weather as well as both freezing and hot temperatures. A 10mm thick Polycarbonate panel has a 1.89 insulating capability and a 4.55 thermal conductivity, note you want a high insulating value but low thermal conductivity number. A cheaper option of a 4mm thick panel has values of 1.43 and 5.27 respectively still allowing for a cheaper alternative.

Solution (Marcus): *DENSE BASE*

When taking heat loss into consideration often the base of a structure is overlooked due to the fact that it is on the ground and not exposed to air. However, in below zero temperatures the ground will freeze and will actually cause a loss of heat through the flooring. The base is even more important for our construction since we are building a greenhouse and we will have plant roots that we can not allow to freeze. A simple yet efficient solution to this problem would be to thicken the foundation with another wood layer. This method does not require the more expensive use of an insulating material and can also work to prevent rodents from possibly digging through.

Solution (Jack): *ELECTRONIC HEATING SYSTEM*

In order to ensure that the heating within the greenhouse remains at an ideal temperature during the winter period, a solar powered heating system could be installed along with the hydroponics system. This solution would provide the most ideal conditions for plant growth all year round. Similarly, power could be stored during the summers in order to re-use during the colder seasons. However this will lead to an increased overall cost for the system, so this option will be considered if other components are able to save money.

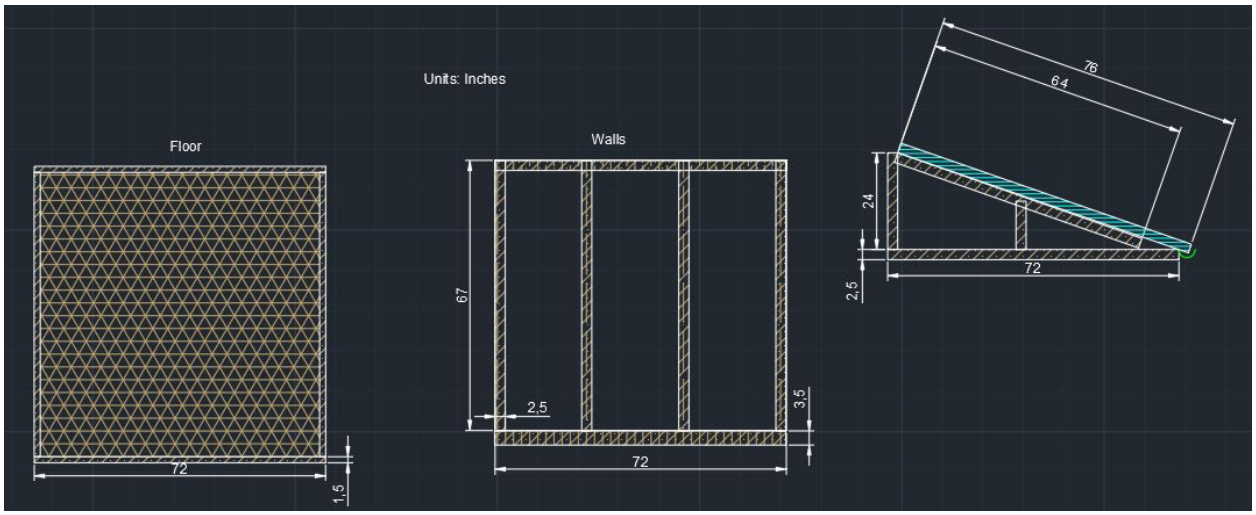
Solution (STEVE CAI): *MAKE SURE EVERY JUNCTION IS SEALED*

This way is similar to the dense base, both of them try to keep the energy inside. As we know the energy will be lost from crevices. However our frame is built by wood and assembly manually. We can't make sure that we build everything properly. So, the repair work seems particularly important. I suggest

that we can use insulation materials such as cotton to fill the gap, and we can put it between the inside wall and the outside wall.

Final Design:

After reflecting on each proposed solution, we have decided upon a specific design that could possibly be changed if any problems occur in the future. The following image is an outline of our greenhouse with expected measurements. Evidently, our structure will consist of a square based prism as our main structure. However, it will also have a triangular based prism as its roof in order to collect the water using gravity. Additionally, our system will use a simple gutter system to collect the water so that the amount of water is maximized by collecting from all around the structure rather than just what goes to the back.



Regarding the portability of the system, our structure will use screws and hinges because those materials are more readily available to us; and screws seem to be more appropriate for a structure of this size. Furthermore, our security system will remain rather simple by using a lock system on the door that allows for the user to use any sort of lock they wish. Likewise, our protection from rodents will remain minimal by simply ensuring that there are no crevices within the design for animals to squeeze through and the structure will be slightly elevated. However we may add some sort of fencing along the base if necessary. Finally, the heating portion of the structure is not essential, so as a result, we will attempt to insulate the structure with the materials that are readily available.

Conclusion:

Throughout this document, several possible problems were outlined that our design must address. Each problem was presented with at least one possible solution. During the remainder of the design process, we will be able to refer to these concise descriptions of problems and their corresponding

proposed solutions. This will allow us to refer to any fixes that may relate to future difficulties. With this in mind, it is understood that our initial design may not be ideal, however this document will allow us to reflect on our mistakes and possibly change our design throughout the rest of the project.