GNG1103

Design Project User Manual

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Greenhouse User Manual

Submitted by

Construction D1

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Abstract

To begin, this greenhouse is intended for the people of Barriere Lake to grow their food within a sustainable and enclosed environment. With this in mind, this paper includes the steps taken to develop the greenhouse, future plans and maintenance. Each following section will explain in detail the processes that led towards the chosen solutions, and what is expected from the outcome. Various visual figures and testing procedures will be presented to further demonstrate the process and changes to the design. Overall, each part of this paper will contribute to the final design of our product that will be given to the people of Barriere Lake.

Table of Contents

List of Figures

List of Tables

Part:	Cost:	Quantity:	Total Cost:
4’*8’ OSB	$15 (Scrap)	2*	**$0**
Metal Brackets	$2.50	20*	**$50**
Plastic Sheets (Roof)	$23	3	**$69**
50”*90” Vinyl	$3	10*	**$30**
2”*3” Plank	$3	40*	**$120**
8’ Gutter	$20 (Scrap)	1	**$0**
Paint	$9	1	**$9**

Table 1 - Bill of materials

Tools and Equipment Used	Drill
	Table Saw
	Hammer
	Tape Measure
	Nail Gun

Table 2. Tools and Equipment Used

1. Introduction

The overall purpose of Greenhand Construction was to construct a greenhouse structure for the people of Barriere Lake to use as a produce growing structure for families. Correspondingly, our structure prioritizes safety and attempts to maximize efficiency to appeal to all possible family situations. Furthermore, our greenhouse will be made using basic tools in order for the local school children to reconstruct the general structure as a project.

The need for a greenhouse in their area stems from the current state of their environment. From what was shared, Barriere Lake has little to no soil in their area but rather vast amounts of sand. As a result, they do not have the necessary resources to grow enough food to last through the long winter season. Similarly, they are a relatively poor community, which means they cannot afford to order produce from out of town. Consequently, they must grow their own food with what they have readily available.

In order to overcome these issues, we believe that we have created a design that meets their needs without exceeding their community's financial and technological limitations. We feel that our design is better than others because it uses simplistic features to increase efficiency and lower cost. Additionally it will require very little maintenance and will have elementary components that can be repaired if needed without use of any specific equipment.

However, due to unforeseen events involving COVID-19, the greenhouse has not been completely finished, but the major components have already been constructed. As a result, the following paper will include only information that was available up until the quarantine. This will include: the making of our prototype, how the prototype is used, possible maintenance and future work.

2. How the Prototype Was Constructed

As most projects do, our greenhouse began with a brainstorming session which focused on what we saw as the most urgent problems provided by the client. With this in mind, we developed a list of these issues and began to individually create solutions for each part. These components include: the general structure, the water collection system, the system's portability, and pest control. The following paragraphs will present examples of solutions that were discussed.

General Structure:

As expected, the structure has many relevant factors, however the decisions of the hydroponics team was exceptionally influential. The hydroponics team would like the greenhouse to have certain design specifications in order for their system to function properly. As a result we attempted to leave as much room as possible for the hydroponics installation as well as a maximized water collection surface.

Our first design option included a square greenhouse with a base of 6'x6' to provide simple dimensions so that orientation of components relative to the walls of the greenhouse do not matter. Additionally the single plane roof design will also provide a large upper cavity to install hydroponics equipment without taking up valuable space for growing plants. Whereas our second design option utilized the shape of a dome which was discovered through our research. 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.

In the end, we decided upon the single planed roof design in order to preserve our idea of simplicity. Similarly, it was a more ideal solution for the hydroponics group because that way all of the water would flow to one side of the greenhouse and they were able to incorporate gravity into their design. This way we didn't overcomplicate the system so it is easier to transport.

Water Collection System:

In order for the hydroponics team to acquire the water necessary to operate their system, we had to create some sort of design that would guide rain water and possibly any melted snow

to their system. So essentially, we had to channel all water that lands on the roof into one single stream.

After already deciding on the single planed roof, our design ideas were created to work in unison with the roof. Therefore our first idea includes an indented roof that would create somewhat of a triangular shape down the roof, thus channelling all of the water into a single stream. However, our second option included a gutter system that would be installed at the back of the slant, and would collect all water runoff.

After close analysis, our group decided to use the gutter system in order to lower the cost from additional wooden planks without sacrificing the system's efficiency. Additionally, having a gutter system would allow us to change the orientation of the gutters to compensate for the movement of the water.

Portability:

Early on, it was made very clear that 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. So to ensure that the process is rather simplistic, we generated ideas that would help to facilitate the destruction of the greenhouse.

Initially, we thought about using hinges to put the whole structure together because this seemed like the most efficient option. But, this would cost extra to purchase enough hinges to put the whole structure together. Afterwards, we thought about using nuts and bolts to put the pieces together, but this appeared to be somewhat of a tedious effort. Next, we moved to screw installation with an impact screwdriver. This proved to be effective but it would be tiresome to remove all of the screws.

Finally, we decided to use screws and an impact driver to connect the greenhouse pieces. This is because the hinges would be too expensive and the nut and bolts would take too long to assemble and disassemble. Although the screws would not come out of the wood easily, it would significantly decrease the amount of time needed to construct the greenhouse.

Pest Control:

To ensure that the produce being grown within the greenhouse is safe, we were tasked with ensuring that the structure is an enclosed system. With this in mind, we had to develop ideas to create barriers for any rodents that attempted to enter the greenhouse.

Our first idea to reduce the amount of rodents that will attempt to enter the greenhouse was to raise the greenhouse onto a platform so that it sits above the ground. This way, there will be an additional obstacle for any pests. Next, we thought about adding chicken wire along the inner base of the structure so that smaller rodents couldn't fit through any possible cracks in the system.

After all, we just decided to use both options to reduce the risk of pests by as much as possible. It would add a little bit more to the overall cost, however it would be worth the money so that the produce within the greenhouse is safe.

Ultimately, our final design is a compilation of all of these chosen solutions. Knowing this, we used this list to guide the construction of our greenhouse based on what we thought was most important.

2.1 Bill of Materials

While thinking of how the greenhouse was going to be constructed, a bill of materials needed to be made in order to keep track of all the materials used to construct the greenhouse. The bill of materials created is found in Table 1. An issue while making the bill of materials was that most of the materials used to construct the greenhouse were given to us during the labs. This means that the values listed in Table 1 are either from what was found through research of our own or what the professor told us. Thus, to an extent, the value of the greenhouse will be accurate, but if one were to go out and buy these materials themselves, it may cost a bit more than expected.

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Table 1. Bill of Material

From Table 1, it is concluded that the total cost to build the greenhouse prototype is $278. The asterisks highlighted in Table 1 are to reiterate the fact that the greenhouse was still in the prototype phase and final construction has not been completed. If final construction had been completed, the quantities highlighted in Table 1 are subject to change.

2.2 Equipment List

To create the greenhouse prototype different tools and equipment were used. Listed in Table 2 are essential to the construction of the greenhouse prototype;

Tools and Equipment Used	Drill
	Table Saw
	Hammer
	Tape Measure
	Nail Gun

Table 2. Tools and Equipment Used

The tape measure is used to measure the pieces of wood used to construct the greenhouse. The table saw is used to cut the wood used to construct the greenhouse. The drill and nail gun are used to join pieces of wood together.

2.3 Instructions

To construct the prototype greenhouse, the first priority is to collect the materials needed to make the individual components of the structure. From Figure 1, it is determined that building most components of the greenhouse requires the use of 2 x 3 inch wood studs or planks. The next task should be to mark the wood planks with the dimensions of the green house, as shown in Figure 1. Then with the wood marked, cuts can be made to the wood studs using a table saw. All safety rules and regulations should be looked at and understood before using any heavy and potentially dangerous equipment, such as a table saw. The first

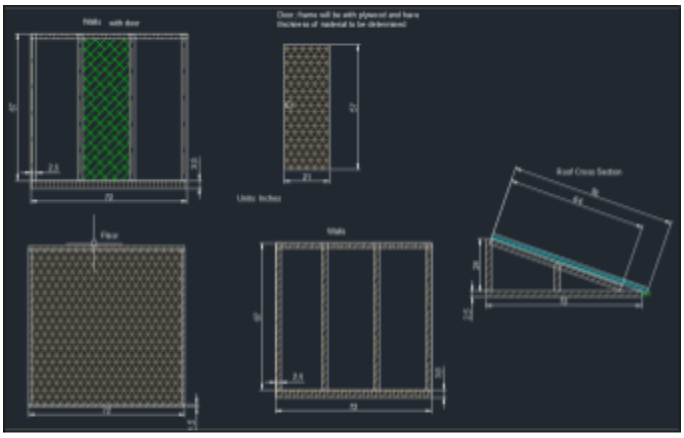

Figure 1. Greenhouse Dimensions

component of the greenhouse that should be constructed is the base. The base is constructed in a fashion that is deemed the most efficient and strong method to build a base. Two 72 inch studs will lay horizontally while two 72 inch studs will lay vertically connecting the studs into a perfect 6x6 foot square. There will be two more studs that lay vertically within the square base, making the base more rigid. These will measure to 68 inches in length and will be placed 2 feet into the square base on each side. This will make the studs be evenly spaced by 2 feet. It is important to remember that whenever a stud is placed within the square base, the center of the stud lies at the 2 foot marking. This will ensure that the studs are evenly spaced. With all the studs set into place, a nail gun will be used to connect all the studs together. Two nails should be used at each connecting point to ensure rigidity. With all the studs of the base connected together, an OSB board can be laid on top of the base and nailed down along the studs using the nail gun. With this step completed, the base of the greenhouse structure has been made and should look like what is circled in Figure 2.

Figure 2. Base

Next, the four walls of the greenhouse should be constructed. These walls are built in a similar fashion to the base with a few exceptions. Firstly, the vertical studs of the base should only be 67 inches long. The shortening of these studs is due to height restrictions of the greenhouse. With this change, the two studs that lay in the middle of the rectangular base will be shorter with a length of 65 inches. After the four walls are connected using the nail gun, in the same fashion as the base, they can be set into place on top of the base. This will involve setting the walls along the four edges of the base. The walls will be held to the base using nails that go through the walls base and into the base of the greenhouse. Temporary supports, as shown in Figure 3, can be used to help hold the walls together before the OSB board is installed, which comes at a later step.

Figure 3. Support

Next the roof trusses are constructed. To construct the truss three pieces of 2x3 inch studs will be used. One piece, which will lay flat along the top of the walls, will be 72 inches in length. Then a vertical piece will sit at one end of the first piece and will have a length of 15 inches. Finally a third piece, which sits diagonally connecting the other two pieces, will be used. Scrap OSB board will be on top of connecting points of the truss, held to the other pieces of wood using the nail gun. Three more trusses of the same manner need to be constructed. These

Figure 4. Roof Connection

trusses will be placed on top of the four walls that are erected on top of the base. Two of the trusses will be placed on top of the fame of the two outer walls. The other two trusses will be placed 2 feet, evenly, from the sides of the greenhouse. To fasten the trusses to the top of the walls, metal brackets which are provided, will be used. The metal brackets will need to be screwed into both the wall and the truss using a drill and some screws. The product of doing this will look like what is shown in Figure 4. With this you have completed all the major components of construction for this greenhouse prototype.

To rigidify the greenhouse prototype several things need to be done. First, the base of the door, which was not completed in this prototype needs to be double framed. This means that the frame which the door of the greenhouse lies along needs to have two studs. This increases rigidity and creates a solid opening for the door. Next, OSB board, which would be 5 - 10 inches wide and covers the bottom of the wall and the base, needs to be installed, using a drill and some screws. The purpose of this is to create a more rigid connection between the base of the greenhouse and the walls, while allowing us to undo the temporary connections that were installed earlier. The result of doing this is reflected in Figure 5. The final piece that should be done to create a more rigid greenhouse is connect the trusses of the roof using 2 x 3 inch studs of wood. These studs will connect the trusses together, and force the trusses to stop moving around making them more rigid. Again the studs will be connected to each truss using screws and drill and a visual representation of this is shown in Figure 6.

Figure 5. OSB for rigidity

Figure 6. Studs for rigidity

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The final steps that were done to this greenhouse prototype was adding plastic sheeting to the roof and painting the exterior walls. Although the greenhouse was not completely finished, thus rendering it a prototype, the last two components that were added to this greenhouse prototype was the plastic sheeting on the roof and the exterior paint. The corrugated plastic sheet was cut to fit the top of the greenhouse. It was then nailed down with screws and a drill. The exterior was also painted, but this is not absolutely necessary to the completion of the greenhouse. Figure 7 shows the plastic sheets on the roof and the exterior of the greenhouse painted.

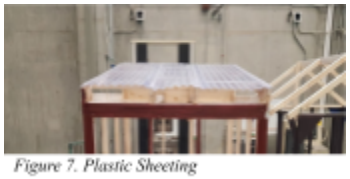

Figure 7. Plastic Sheeting

3. How to Use the Prototype

In order to properly use the greenhouse, there are several factors that should be taken into consideration. Firstly, the location in which it is placed should be revised. Also, proper maintenance on the structure is necessary. Finally, the structure should be maintained and cleaned differently depending on the season.

Firstly, the location of the greenhouse will have a severe impact on the efficiency and functionality of the system. Overall, the greenhouse should be placed in a more open area so that there are no obstructions that may interfere with sunlight access or rain water reaching the roof. If this is not accounted for, then produce inside the greenhouse may not grow properly or at all. Additionally, the structure should either be placed relatively close to any water sources so that if there is a dry season it can still be used or close to homes so that it has easy accessibility.

Furthermore, the greenhouse may experience some harsh conditions and need minor repairs to the outer structure. Knowing this, I think the users should have additional wood pieces ready with maybe just nails and a hammer so that they can quickly patch up any holes that may be created. They may also want to add more stability to the structure depending on the strength of the wind in their area. If they wish to do so, they should just add additional supports along the sides of the structure that dig into the ground.

Subsequently, during seasons in which there may be a build up of either snow or leaves, the roof should be shoveled or raked often to ensure that the maximum amount of water is able to enter the hydroponics system. Also, anything that builds up on top of the structure will interfere with sunlight access which will halt the growth of any produce. Plus, a large mass on top of the system is unlikely to cause any damage to the roof, however it is always a good idea to clear it to maintain its ideal condition.

Other than basic maintenance, the greenhouse should work independently. But the hydroponics system is likely to need some work done to it often, whereas the greenhouse itself will only need work every few weeks to ensure optimal efficiency.

4. How to Maintain The Prototype

The greenhouse will require seasonal maintenance of different components. Primarily, there will be damage due to exposure to the elements and damage by animals attempting to dig through the house. The chicken wire will prevent animals from entering but they can still chew through the transparent and weaker components of the greenhouse. This will require patching up of the damaged areas and regular checks.

The screws that hold the structure together should be changed every few months as they become rusty due to exposure to the outdoors. Never reassemble the structure with rusty screws.

Lastly, when the structure is disassembled in its components avoid exposing to rain. When it is put together the roof and surrounding material protects the wood.

5. Conclusions and Future Work

Since the greenhouse was left incomplete due to unpredictable circumstances, there is still work to be done before it can be delivered to Barriere Lake. One aspect of the greenhouse that must be added is a frame around one of the walls that would allow the implementation of a door as well as the door itself. On top of this, if we had decided to raise the base to try and help against the rodent problem, then we would also have to build a small detachable staircase.

Another part of the greenhouse that is still required to be built and installed is the gutter system that would run along the lower section of the slanted roof. Our hydroponics team we are working with had made a suggestion to not have the gutter completely horizontal but instead slanted it to some degree so there would be a faster flow of water to their system.

The last planned feature of our greenhouse that we did not get to was the remaining plastic sheets that would be covering the four walls surrounding the greenhouse. We had already done the roof of the structure using nails and would carry over this same technique for the walls. It was then debatable if insulation would be required since our client had informed us that it would be difficult to have the greenhouse maintainable in such drastic colds during their winters.

A final undetermined aspect of the greenhouse that we may have added but was not a priority was a possible chicken wire fence surrounding the entirety of the greenhouse. This would be added based on recommendations by the client if she thought that the raised platform would not be enough to prevent rodent problems.

Each member of the team had mentioned prior lessons that they have learned during the process of working together on the greenhouse. These included:

• “It is essential to have a lot of background information and examples.”
• “Prioritizing certain components can improve the quality of work immensely.”
• “Measurements and conditions of materials will not be ideal, but this is expected. It will not affect the functionality.”
• “Having a clear plan of how the work will be divided among team members prior makes things simpler and more functional when it comes to the actual construction days.”
• “Remember to double check all measurements to ensure that they are inline with the design.”
• “Create multiple backup ideas for each component so that there will never be a loss of time in the lab due to a lack of preparation.”

In the end, even though there had been a couple of mistakes during the construction process of the greenhouse, we were still on schedule for completing it on time and being able to implement everything that we thought necessary. This meant that we may have had time to add aspects that were not necessarily functional.

6. Bibliography

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7. Appendix: Design Files

All design files can be found using the following link:

https://makerepo.com/jredm082/greenhand-construction-construction-1

The files found using this link will provide insight into our thought processes while developing this prototype. Each deliverable includes a specific topic of focus which was discussed throughout that week.