

Prototype 3: Build and Test

Test Purpose

Our team sets out to develop a cost effective crop growing solution that can be implemented and utilized by individuals living in areas that do not promote the natural growth of vegetation. The crop growing solution will be utilized by a population that is under economic duress and as such water usage, power requirements, and material availability must be taken into consideration. At this time the project team is going through the process of prototyping the testing of our design to solve the above problem. The purpose of a prototype is to represent the design concept with a physical model that can be tested and used to gain user feedback. The reason that we want to test a physical representation of our design is so that we can learn something useful that the design team can utilize moving forward into the next iteration. As this is the third and final prototype, all information we extract from testing and user feedback will be going into the lessons learned section of our final project report. Ultimately, the results of this prototype test will be to gauge the performance of our design.

Test Objectives

The following are the specific test objectives:

1. Ensure the filter has adequate horizontal support
2. Ensure the filter has adequate vertical support
3. Ensure that the growing pipe has the ability to be set down and not roll away
4. Ensure that the water level in the growing pipe is visible from the exterior without opening the pipe

Learning Goals for Prototype Three

With this prototype we are communicating the notion that our design can not be structurally compromised. Appropriate measures must be taken to further stabilize both the filtration device, and the PVC growing pipe. With this prototype we will either communicate that our stabilization methods are adequate, or further measures must be taken to effectively stabilize these essential aspects to our hydroponics system. Furthermore, we also wish to allow the user to view the water level inside the pipe. This is to increase usability.

Possible Results

There are eight main results when analysing the design of our third prototype.

- 1) The filtration device is provided with adequate vertical support
- 2) The filtration device is NOT provided with adequate support
- 3) The filtration device is provided with adequate horizontal support
- 4) The filtration device is NOT provided with adequate horizontal support
- 5) The PVC growing pipe is stabilized to prevent rotational motion
- 6) The PVC growing pipe is NOT stabilized to prevent rotational motion
- 7) The water level in the pipe is visible to the user
- 8) The water level in the pipe is NOT visible to the user

Action Plan for Results

If the results from these prototypes are successful, then our hydroponics system will be structurally stable. By successful, it is meant that the filter is provided with adequate horizontal and vertical support, and the growing pipe does not possess rotational motion. If the water level indicator is successful, it means that the user can easily view the water level.

If any of these conditions fail to meet the criteria, then further steps must be taken to ensure this hydroponics systems structural stability. These further steps could either be the complete redesign of the structural stabilization method, or minor tweaks to the method to ensure effective stability. For example, it may be found that passing a rod through the bucket and the PVC pipe is an effective solution to support the weight of the rocks in the filter; however, this design allows for rotational motion of the pipe around the rod. If this is the case then the rod is an effective solution to ensure vertical stability however, additional components must be added to provide horizontal stability and resist this rotational motion. If there is no way to provide both horizontal and vertical stability with this rod method, then the rod is not an effective solution in providing the filter with stability. If this is the case, another design/alteration concept must be created to provide an effective solution to the filter's stability. As for the water level indicator, the functionality of the system itself will not be subject to error; error will only propagate in the form of a leak caused by the implementation of the system.

From the results of this prototype, it will be determined what are effective ways for stabilizing this prototype. It is possible that some design ideas may conflict others. From the results, and seeing which designs work effectively together, a final stability solution for this device will be created and implemented.

Success and Failure Criteria

Objective	Criteria	Metric	Method of Testing
Horizontal filter stability	Filter does not move horizontally when pressure is applied to various places	Pounds of Force	Observe
Vertical filter stability	Filter does not fall down	Pounds of Force	Observe
Rotational growing pipe stability	Growing pipe does not roll away	n/a	Observe
Water level visibility	Water level of the pipe is visible to the user	n/a	Observe

Prototype Scope

This prototype was built to be focused. The only new functional addition to this prototype is the water level indicator, this function does not determine the functionality of the system however; this indicator is meant only to improve usability. This prototype is considered focused because the only areas of focus are the water level indication, and structural support.

Testing Process

Refer to the success and failure criteria table for criteria that this procedure will be based on.

Objective: test horizontal support for filter

1. Place filter into bucket, ensure that the horizontal steel rod is placed in the corresponding grooves on the bucket
2. Secure the filter by tightening the threaded rods that support the wooden pieces
3. Secure lid on bucket
4. Use hand to push on all sides of the filter pipe to ensure that there is no horizontal movement

Objective: Test vertical support of filter

1. Fill the filter tube with rocks and sand until it is $\frac{3}{4}$ full
2. Place filter onto bucket, ensuring horizontal steel rod lies in bucket grooves

Objective: test rotational movement of growing pipe

1. Place the growing pipe onto the 2 wooden support pieces
 - a. Place one under each end

Objective: test water level indicator

1. Fill growing pipe with water
2. Observe the water level indicator

Measurable Data to be Collected

The only measurable data collected from this prototype is the amount of force that the filter system can withstand. We measured “hand pressure” to be approximately 40 newtons of force and as such 40N of hand pressure was used as the metric for testing our filter horizontal stability. Vertical filter stability was measured by the adding weight to the filter system and measured in newtons.

Observational Data to be Collected

- 1) Observe that the PVC growing pipe is effectively supported to prevent translational and rotational movement.

Materials and Cost of Third Prototype

Maybe ben could do this part since you were the one that purchased all the materials.

Material	Quantity	Cost
threaded 3/8" steel rod	12"	\$0.48
3/8" nut	4	\$0.00
2"x4"	2'	n/a
0.375" Diameter Round Stock	10"	\$0.90
Silicone tube	1	\$5.50
Sand	1 bag	\$5.00

Work to be Done for Prototype Three

For this prototype, wooden and metal supports will be added to effectively stabilize the hydroponics system. Holes will also be drilled into the growing pipe endcap and sealed with clear plastic on the inside. Wooden supports for the growing pipe will also be built.

Test Results

For the testing of our prototype, the first thing we did was test the horizontal support of our filter. We did this by following the testing process that was outlined earlier to observe if there was any horizontal displacement on the filter. After testing, we were able to conclude that the filter support system was capable of withstanding 40N of force applied by hand to all sides of the filter. Next, we observed the strength and support that our latest design provided for the vertical component of our filter. As described in the above testing procedure, we filled the filter three-quarters full of sand and rocks to observe how effectively the steel rods supported the filter. While doing this we observed that the steel rods did not deform, or bend and were able to successfully support the filter. The measured force that was supported by our filter was 100N. Furthermore, we tested PVC containing the plants to ensure there was not any rotational movement that could potentially damage the plants. As outlined earlier, we attached the wooden blocks

to the PVC pipe and applied horizontal pressure to the ends of the PVC and perpendicular pressure to them to observe the effect. After, we observed that the wooden supports supplied adequate support for the PVC allowing no rotational or translational motion. For the final testing of our prototype, we observed how effective the water level indicator was. In doing this we were able to conclude that the water level indicator was an effective and useful component to implement into our design to observe the water level in the PVC.

Third Prototype

Figure 1: Vertical Stability of Filter

In this picture the vertical component of the stabilization device for the hydroponics system is shown. This stabilization device consists of 1 solid metal rod. Holes were drilled on both sides of our PVC filter and our water containment bucket; these holes allow for the passage of the solid metal rod through both the bucket and the PVC pipe. With this design, the weight of the filtration device is supported by a strong metal rod as opposed to the thin lid of the bucket.



Figure 2: Horizontal Stability of Filter

In this picture the horizontal components of the stabilization device for the hydroponics filtration system is shown. The components of this stabilization consist of 2 threaded metal rods, 4 nuts, and 2 hand crafted wooden supports. Holes were drilled in the side of the bucket to allow for the passage of the 2 threaded metal rods. A nut is screwed onto the rod from both the outside and inside of the bucket, to ensure that the rod is tightly fixed in place to the bucket. Half inch deep holes were drilled into the wooden supports to allow the metal threaded rods to securely fit into the wooden supports. By threading the metal rods through the nuts and into the bucket, the rods provide reliable horizontal stability to the hydroponics filtrations device.



Figure 3: Stability of PVC Growing Pipe

Our implemented tactic for the growing pipes stabilization is pictured above. These wooden supports were handcrafted out of a piece of 2x4 lumber. Through the implementation of these wooden stabilizers, the hydroponics growing pipe is rooted to the desired location. These wooden stabilizers prevent the growing pipe from rotating and spilling the precious water. The wooden stabilizers can be adjusted to the users preference, as they are not directly attached to the growing pipe. These wooden stabilizers were cut, and sanded to provide a snug fit onto the pipe to prevent any

rotational motion.



Figure 4: Water Level Indicator

Refer to the image below for the final result.

Three holes were drilled into the endcap of the pvc. These holes were covered with clear plastic on the inside of the cap, and then sealed to it.



Refugee Feedback:

To ensure that our final design incorporated all aspects of customer needs and accounted for customer concerns, we once again reached out to a former refugee by the name of Hasan Wiso. He was given feedback in our previous prototypes, and in this final design we sought to implement solutions to his concerns, and address and final issues he had with our design.

The first adaptation the final prototype has is its adjustment in structural stability. In the previous iteration of the prototype, we tested the silicon integrity in medium velocity winds that occur regularly in the desert climate of Jordan, and found the silicon has sustained slight structural damage. Concerns were raised that the silicon and may be compromised if subjected to long periods of sustained wind. Rather than increase the amount of silicon applied, the group designed additional supports to relieve the silicon of such high amounts of force. To first account for this issue, the implementations of horizontal and vertical supports was conducted and tested. With approximate force rating of 40 and 100 Newtons respectively, the tests were remarked as successful. These adjustments should also account for any concerns of leakage occurring at the

filters attachment point to the hose. See above sections “Test Purpose” and “Test Results” for further information on the implementation of these supports.

Further concerns expressed by Wiso about the final iteration of the prototype is the recurring issue regarding water stagnation. The initial concerns presented by Wiso after the completion of prototype two was the lack of water fluidity in our design, which could lead to growth and contamination within the PVC pipe. We believe the sealed PVC pipe is the best implementation of the PVC system, but accounted for Wiso’s concerns by drilling three holes in the end cap of the PVC pipe, and sealing the cap internally with transparent plastic. These holes would indicate the water level for the users, as well as serve as inspection points to detect the growth of any mold caused by the lack of flowing water. However Wiso expressed further concerns, remarking how the desert climate in Jordan may cause the evaporation of water within the pipe to fog up the plastic, negating its purpose in providing an indication of water levels and possible contamination.

While these concerns are valid, an analysis of the monthly weather patterns in Jordan set average peak temperatures at 27°C to 31°C , while the average low temperature at the same time periods are set at 14°C to 19°C. While this fluctuation seems relatively mild in terms of its differences, the low temperature should reduce PVC temperature by a large enough quantity to allow for condensation of the interior of the pipe, and therefore remove excess water vapour the fogs up the plastic seal. While this solution is not ideal, we believe this solution suits our design most accurately and effectively.