Project Deliverable H: Prototype III and Customer Feedback
GNG 1103F – Engineering Design
Faculty of Engineering – University of Ottawa

Team 3 F01

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Abstract

Our goal is to create a modular heating tile which is cheap to produce and simple to store during the warmer seasons. This report goes over the subsystems which have been tested and implemented in our third prototype, where we focused on our heating system. Our mat is heated using a heating cord which automatically activates in the cold weather, and also shuts off after reaching a certain temperature. In order to increase the heating rate of our mat, along with its efficiency, a layer of tin foil has been placed at the bottom of the inside of our mat, under the heating cord. The mat was also tested for wheelchair accessibility, and failed to operate entirely as intended. Future plans include the addition of supports inside the mat, as our original design had to be changed due to the change in heating element, and improvements to the wheelchair accessibility.

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Introduction

The purpose of this document is to show the next step in the design process that our team is working on. The task at hand is to develop a modular product which will remove snow and ice from the campus sidewalks at the University of Ottawa. This would be a replacement for salt which causes severe damage to infrastructure and the environment.

This document outlines our final prototype. This prototype is a culmination of the work we have done throughout the semester. We have continued to develop the systems and completed the testing of our prototype. The main focus of this prototype was the interior/heating portion of the mat, along with wheelchair accessibility.

Feedback

From our previous client meetings we have considered the feedback and thought of ways to incorporate it in our design. The client brought up some important features that we had not considered like water channels for drainage of water and a power switch.

The design we thought of for water drainage is to add channels in the mat. This is important to the design because if there is a large amount of snow/ice on top of the mat, this can be damaging if the excess water has nowhere to go. The solution to protect the mats heating components from the water is to have the channels.

The other design we thought of incorporating is a power switch that will be located close to the electrical plug. This power switch will be able to turn on/off all the set mats that connected to a specific electrical plug. In addition, we thought it was important to include a way to indicate when the mats were on and off. Our idea was to include LED lights on the mat that will light up when the mat is on and turn off when the mat is off.

The feedback provided from the client is very useful for us to consider because it adds a new view point to our design for ideas we might have not considered. The ideas brought up from the client were helpful however with our budget and materials we were unable to integrate a proper drainage system into our final design. Even though we weren't able to add all of the ideas we came up with from the customer feedback, this was still an important part of our design process.

Prototype 3

Due to the global pandemic, components that were ordered have been back-ordered or not arrived in the time frame which was expected. This has caused our team to make some rapid and last minute alterations to the design. The heat source has again been changed from a steel wire controlled by an arduino to a simple pipe heating cable with a built in thermometer to control the temperature. Additionally, we have altered the connectors from a tooth like edge to just a simple clip. This change was actually both cheap and logical as it allows for easy use by installers and a secure connection. We have used straps and loops for easy installation as well. This will allow for secure fastening to the ground.

Though these changes were not ideal, our team has made them work in the end. We have worked around these difficulties while still maintaining many of the design criteria that were requested by the client such as modularity and accessibility to the interior.

Prototype Plan

Table 1 - Prototyping Test Plan

Test ID	Test Objective (Why)	Description of Prototype used and of Basic Test Method (What)	Description of Results to be Recorded and how these results will be used (How)	Estimated Test duration and planned start date (When)
1	Test that the cord heats up	Use the tester on the cord to see if the heating element is working	A quick manual temperature check to see if the cord is functional.	> 5 minutes
2	Test Zipper subsystem for proper functionality	Test to see if the zipper holds the casing together and works to open and close the mat.	Record difficulty or lack thereof in repeated use of the zipper.	10 minutes
3	Test heat reflector material	Use a heat source (space heater) to determine if aluminum foil will reflect heat.	Check temperature on either side of material connected to aluminum to see if temperature shielding was effective.	10 minutes
4	Test for wheelchair accessibility.	Different forms of transportation with wheels (bike, skateboard, scooter) will be rolled onto the mat to test how well they fare with the thickness and grit of the mat.	Any problems that will be encountered will be recorded and we will attempt to fix them by adjusting our design.	20 minutes

Stopping Criteria: All objectives complete, or the time limit is reached (2 days), or we run out of material.

Prototype 3 - Comprehensive Mat

The next prototype that was built by the team was the most comprehensive of any so far. It includes the grip subsystem that was developed in the last prototype as well as a zipper to hold the mat together. Inside the mat is the heating cable and a sheet of aluminum foil to reflect heat towards the top of the mat. It also has clips and straps for mounting the sidewalk to the ground on the sides. Below are photos of the mat before the aluminum was added under the mat. We have removed the support structure that was tested in the previous deliverable as it was not compatible with the sudden design alterations which were made. This will be a future subsystem to work on before our final deliverable.

Figure 1.1 - Closed Mat Full Image (BEV)

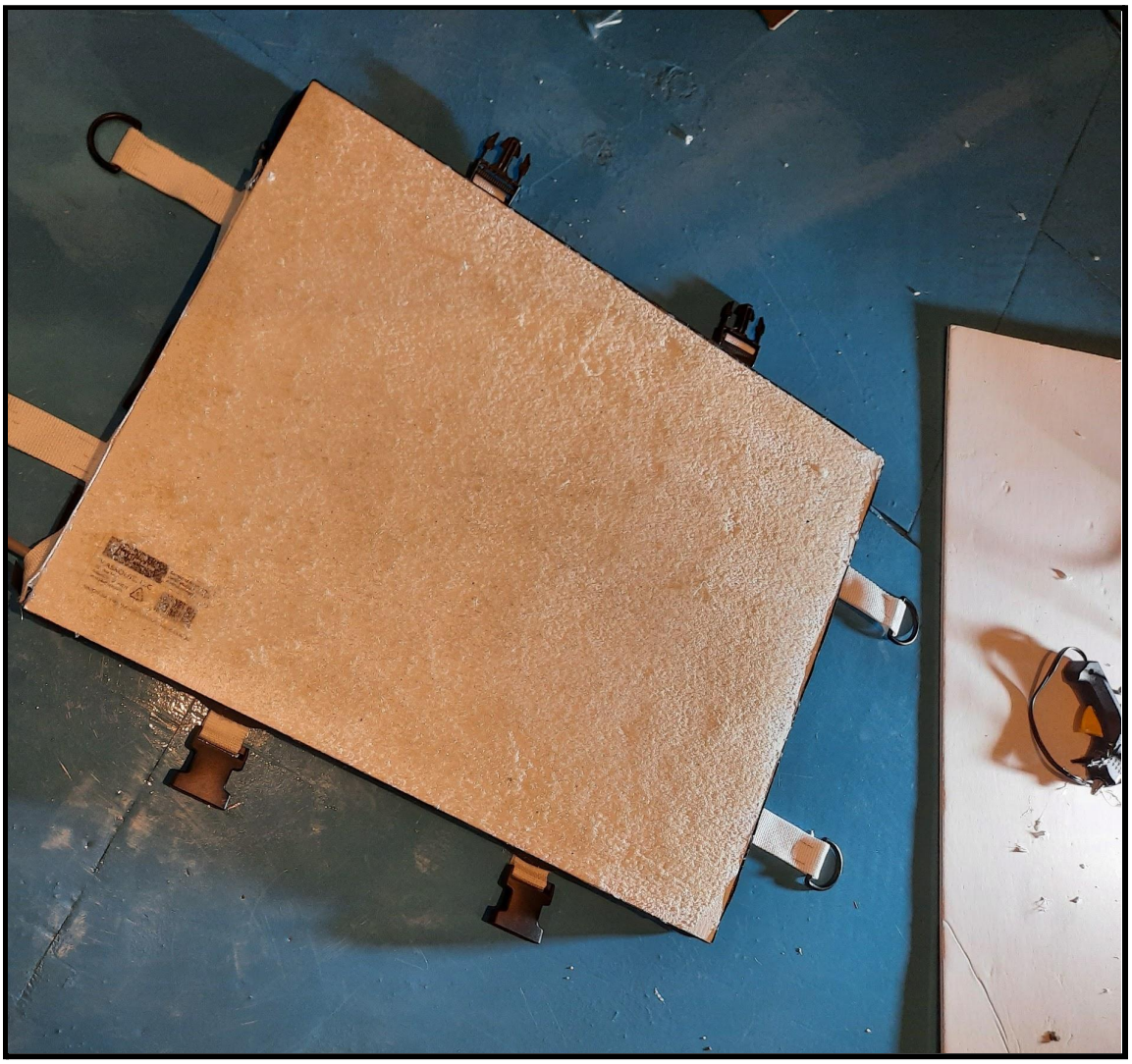


Figure 1.2 - Side Loops for mounting (Side View)

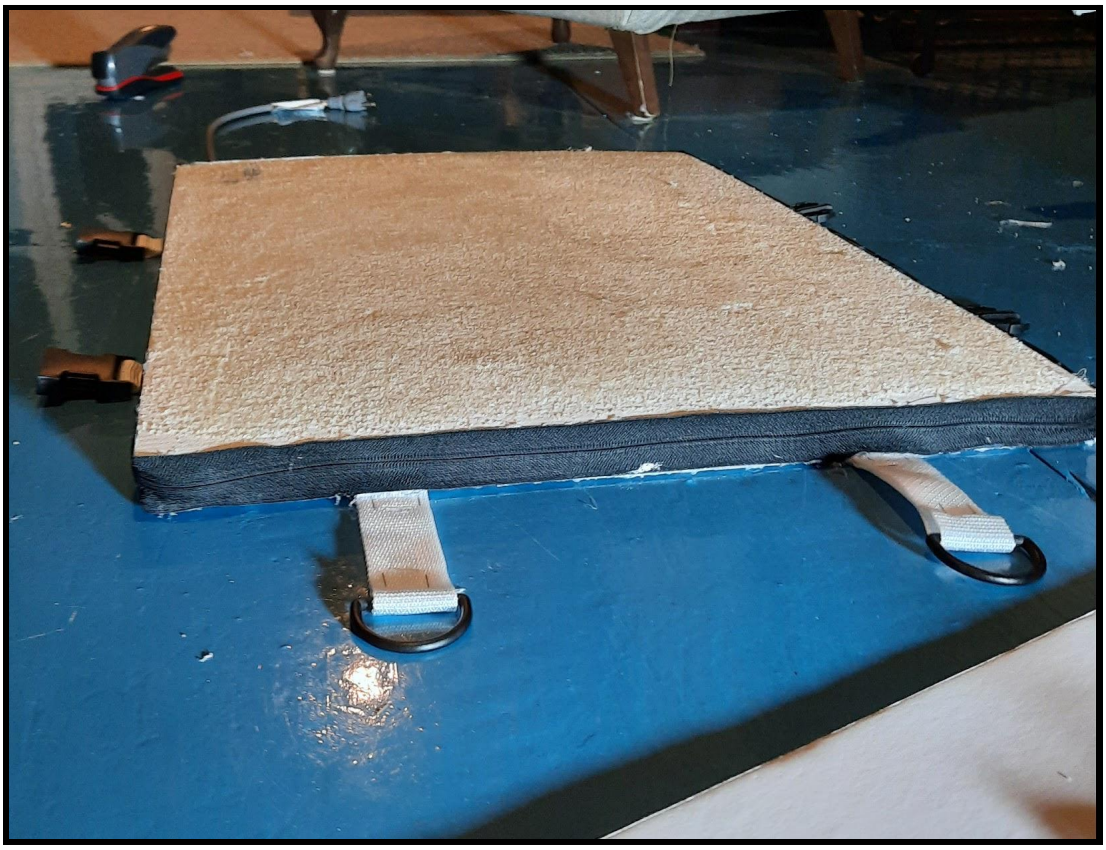


Figure 1.3 - Open and Half Open Mat (BEV)

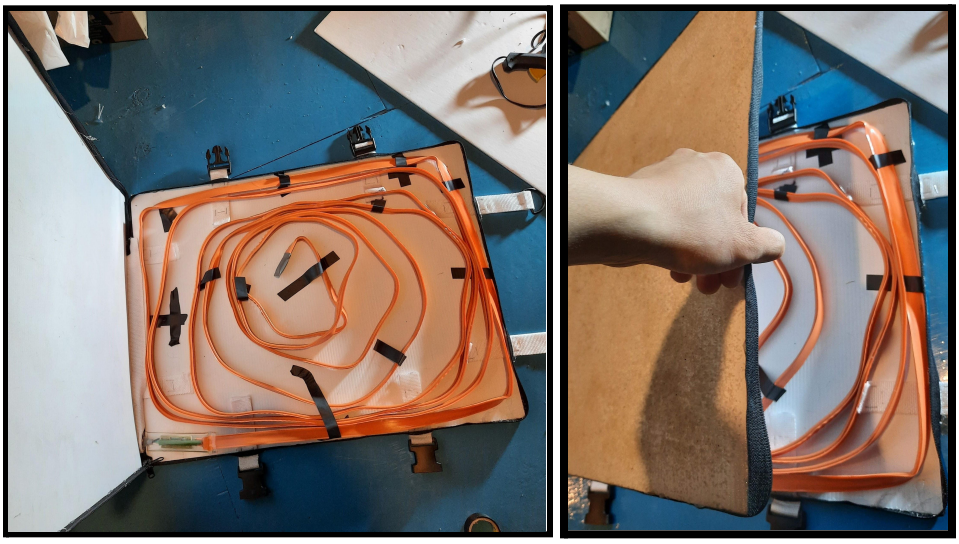
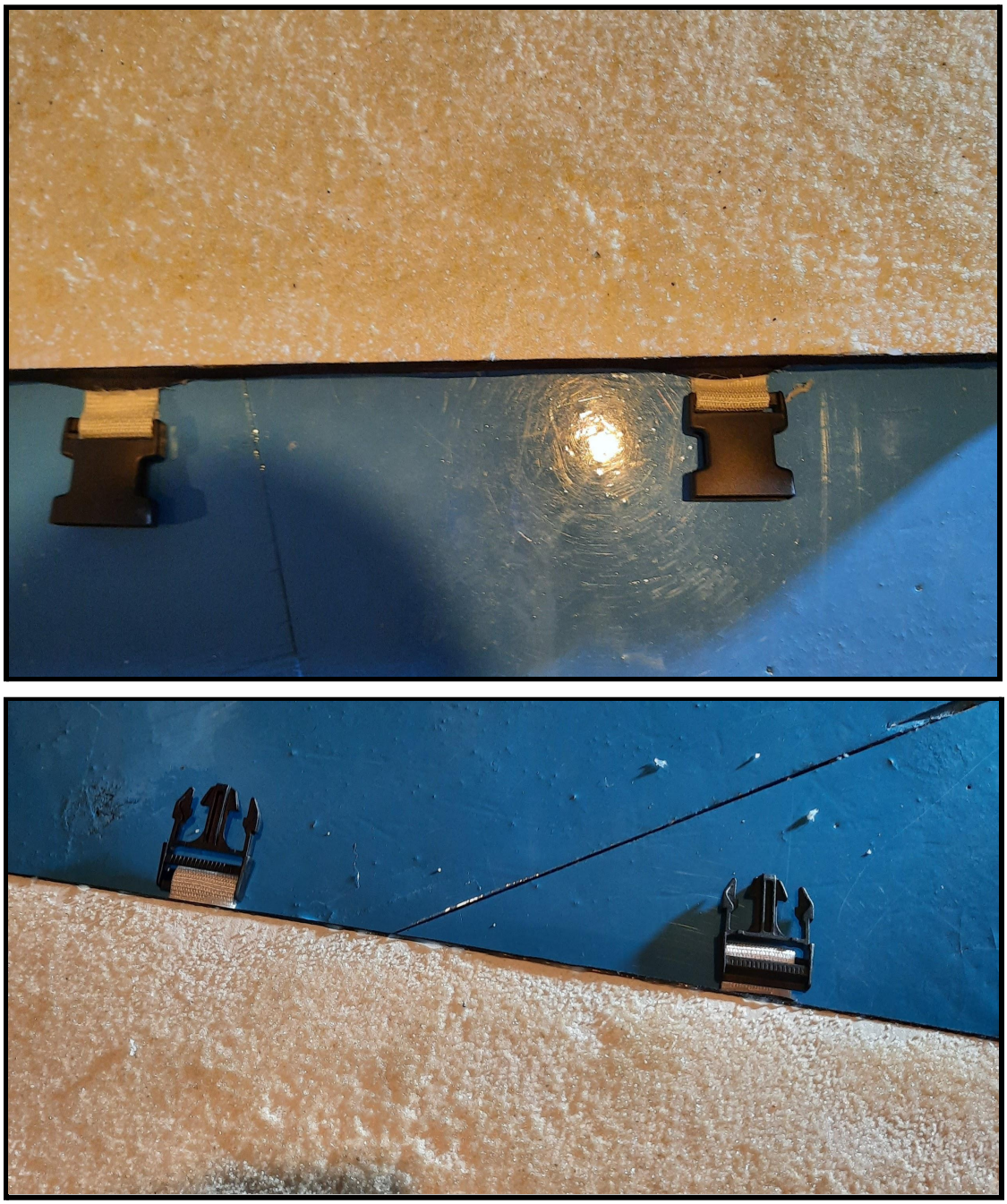


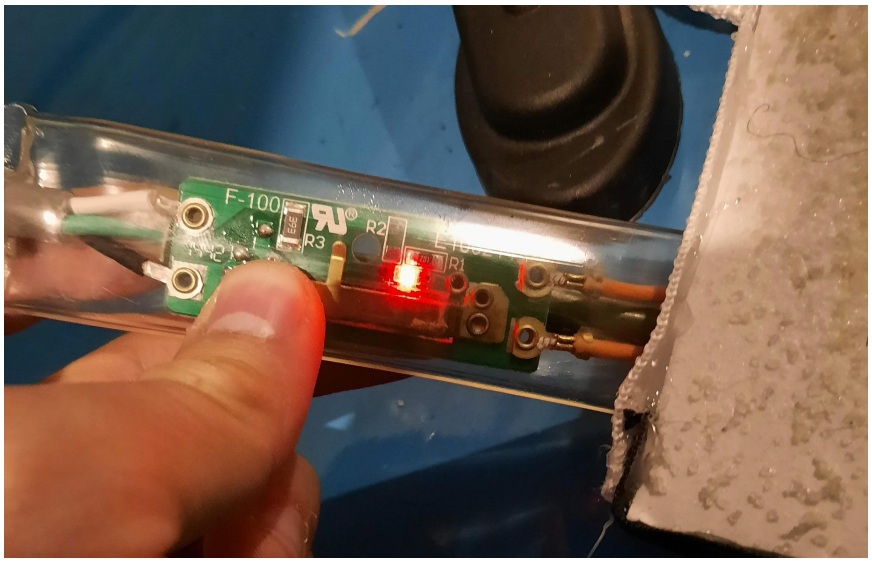
Figure 1.4 - Mat Buckles for Connecting



Prototype 3 - Testing

The first test that was performed was to see how the new heating cable functioned. This was done using the process given on the cable which was to hold the test button and see if the cable heats up at all. This provided good results as within a minute or so, a change in temperature was apparent. Further testing of the heating element will be performed leading up to the next deliverable.

Figure 2.1 - Cord Functionality Test



The second test performed on the mat was to test if the zipper, once installed, was actually usable in the configuration we had designed it in. This was proven by multiple tests of the zipper at different speeds. The conclusion was that the zipper worked optimally under a steady slow hand, rather than an aggressive awkward pull. A good example of the zipper being used can be seen in Figure 1.3.

The third test that was performed was the test on the effectiveness of the aluminum foil as a temperature shield. This was done by attaching a piece of aluminum foil to the face of a piece of plastic cardboard.

Figure 2.2 - Aluminum Foil Test Setup

This was then held next to a powerful area heater for a short period of time. When the piece was moved away from the area heater, the portion of the plastic cardboard which was fully exposed to the heater was much hotter than the piece under the aluminum. This shows that the aluminum foil does reflect the heat from reaching the piece of cardboard. This will be used to direct the heat upwards as opposed to into the cold ground.

The next step in the testing of this prototype was to check if the mat was a fair thickness for wheelchair accessibility. This was done by rolling different wheeled means of transport, specifically a bike and a scooter over the mat. This process was done with different downward forces being applied onto the bike and scooter to simulate different weighted people. The setup can be seen in the following figures

Figure 2.3-2.6 - Wheel Accessibility Test Setup

The tests overall went well, especially with the bigger wheels on the bike or a lighter amount of force applied on the wheeled. Difficulties arose when the scooter had a lot of weight or when the mat was not properly secured down. This leads us to the conclusion that the accessibility of the mat needs to be improved. This is a critical point of our design as it is one of the top prioritized criteria that were defined at the beginning of our iterative design process.

Although our tests went fairly well for larger wheeled devices, there are still other things to consider. Many wheelchairs have smaller wheels and would require a thinner mat. The mat is about 1 inch high. The Accessibility requirements in the National Building Code of Canada 1985 (Page 4, Paragraph 6) requirements for a threshold height is 1:10 ratio of height to ramp for a ramp under 3 meters long. This means that for every 1 inch of elevation, there must be 10 inches of ramp leading up to the edge. This is something that we as a team must address before our final prototype is finished. To make the mat fit with the requirements for wheelchair accessibility, we will need to either decrease the height of the mat or create an effective ramp.

Wrike Task Plan Update

For this project deliverable we focused on making our prototype 3 and testing the prototype to test functionality. We created a prototype test plan as a team and had one of our group members construct the prototype with the assistance of the rest of the group. We assigned subtasks accordingly to the group members who aren't constructing the prototype to writing the project deliverable and conducting research for the prototype.

Our team also started working on the User Guide (PD K). In the Wrike you can see that we have started assigning tasks to group members for different parts of the document. We have progressively started working on the User Guide and writing out the overview and introduction.

Over the coming weeks our team is working on our prototype for design day and our final presentations for design day and in the lecture.

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=WA0KQzcPA732coX2rgVZvfW3MQhN85gO%7CIE2DGNJSGE2TOLSTGE3A

Conclusion

The third prototype provides a close resemblance to what our final design would look like. After testing the grip and interior support layout in our previous prototype, our current design had to be modified largely due to the limitations caused by the current pandemic. The subsystems tested in our prototype include the heating cord, the zipper, the heat reflecting material, and wheelchair accessibility. While the heating cord, zipper, and heat reflecting material seem to work exceptionally well, the wheelchair accessibility could be improved upon.