Project Deliverable G: Prototype II 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 documents the testing of 2 of our final designs' subsystems. In order to ensure the safety of our product users, much thought has been put into the method of texturing the top of our tile. The use of a spray-glue coating along with glass sand has proven to be an effective method of providing traction to our design. While our tiles will not be placed under an incredible amount of stress, we should expect that up to around 4 people at a time could possibly be standing on it at any given moment. Our interior support design will very likely be more than adequate, given the requirements.

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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 explores the team's efforts towards the next prototype. We have developed all of the systems forward and finished testing a few of them. This has allowed us to refine our goals and designs. Additionally, we met with the client this week, receiving good constructive feedback which will aid us in our testing process.

Feedback

After our client meeting 3, the feedback on our design was positive. Our client commented on our prototype design and asked questions to get a better understanding of our heated sidewalk. He was interested in the support structures, accessibility, material, size, and a power switch.

From our client meeting 2, we took the client's feedback for water drainage into account. We thought that implicating channels in the mat for water to drain out was the best solution. Another feature that we considered after our client feedback was a power switch. The client expressed how a power switch to turn off the mats was important to the design. From this feedback we came up with the idea to put a switch near the plug that can be used to turn the mats on and off. With this idea in mind, we also thought that adding an LED light to indicate when the mat was on was important to our design.

The feedback we received from the client meetings was very beneficial to our group and gave us a better understanding of concepts and ideas that we had not considered. Moving forward with our prototyping, we will make sure that we take into account the feedback we received.

Updated Bill of Materials

Over the course of the past two deliverables, our design has undergone some changes. This means that our BOM also had to be altered. The largest differences include the inclusion of a triac as opposed to a mosfet for circuit control and the use of stainless steel wire for heat as opposed to nichrome wire. The switch to stainless steel is important as it will allow for our device to not get as hot. Since we have no need for extreme temperatures a more shallow temperature climb is good for us.

Part	Qty	Description	Vendor	Unit Cost	Extended Cost
Arduino Uno	1	Controls electronics	We have one	0	0
Temperature Sensor	1	Senses the temperature	Amazon Link	15.20	15.20
Stainless Steel Wire	1	Heating element	Amazon Link	17.09	17.09
Circuit Wire	2	Insulated wire	Home Depot Link	1.50	3.00
Material for Casing (PVC)	2	Durable casing	Buying at Home Depot	10.53	21.06
Arduino AC-DC power converter	1	Power arduino	Getting from Habib	0	0
OptoIsolator	1	Send signal to AC circuit	Getting from Habib	0.00	0.00
Triac	1	Control of heater	Amazon Link	8.10	8.10
Power Cord	1	Connects to tiles and power grid	We have one	0	0
Hose Nozzle (Male and Female)	1	Keeps power connectors in place	Amazon Link	1.73	1.73
Hose	1	Power cord protector	Home Depot Link	10.16	10.16
Coating	1	Spray On	Buying at Home Depot	14.97	14.97

Calculations	
Subtotal	91.31
Tax	11.87
Total	103.18

Prototype 2

The second prototype which the team worked on was planned to develop our subsystems. Particularly the casing and the heating. Throughout the week we have been purchasing and collecting the parts that we need to construct these subsystems. Due to difficulties with acquiring certain materials, along with the limited time given, 2 subsystems have been thoroughly tested.

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	To test the grip of the cover.	Specific Subsystem Physical Test	Results will be recorded by sliding a shoe across and recording	1 hour
2	To try and build a model circuit with the circuit parts that have arrived and test functionality.	Physical temporary model. Using a breadboard.	Test functionality of each component and see if they work. Specifically the temperature sensors.	30 minutes
3	Test supports for the main body interior.	Physical Model. Using different shapes to test support of person while leaving room for heating wire	Record stability of different support layouts to see what feels most stable.	1 hour

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

Physical Model 2 - Grip

The main focus of our second prototype is to test some subsystems of our design. The first subsystem which was tested was the grip on the top of the mat. The grip was made using a glass sand and Gorilla Glue Spray. The test of the grip strength was done using a 12 inch incline of the 18x24 piece of Twinwall polymer.

Figure 1 - Ramp Set Up

A boot was rested at the top of the ramp and allowed to slide down. Putting the tile at an angle allows us to simulate the motion of stepping on our tile using a reproducible method. The amount of time required for the boot to reach the bottom was recorded. This test was repeated multiple times for different amounts of glass sand and glue. The results are tabulated below.

Table 2 - Grip Test

Type\Trial Time (s)	1	2	3	4	5
0 Layer(s)	0.79	0.72	0.66	0.79	0.66
1 Layer(s)	1.18	1.12	0.99	1.25	1.19
2 Layer(s)	2.51	2.43	1.78	2.68	3.07

The extra layers clearly increased the frictional force against the boot. This can be seen by the increased slide duration. The boot also would not slide at all without intervention multiple times. Part of the reason that our design is so effective is due to the type of shoe used. That being said, these tiles are only going to be used during the winter months, meaning it's safe to assume that the majority of people will be using shoes which provide enough traction. Adding any more layers to the tiles produces diminishing returns, and much of the sand begins to scrape off. This would cause damage to the interior flooring of buildings.

Figure 2 - Boot on Grit stopped by Static Friction (2 layers left, 1 layer right)

As shown in figure 2, the shoe stays in place due to the static friction being high enough to keep the boot from sliding. This is good, as it shows that the grip is doing exactly as we hoped. After performing the test on 2 layers of grit, we decided that this was satisfactory and would provide enough grip to the mat.

Physical Model 2 - Interior Support Layout

The second part of the physical model was to try a layout of interior supports. This was done using the plastic sheets and a foam material. This support material is only temporary to test the validity of design. The goal of the supports is to provide a small air gap between the top and bottom of the mat to put the heating wire in. This gap does not need to be large, in fact it is preferable if it is not because that means the mat is more solid. In addition, a smaller amount of air in the mat will increase the speed at which heat transfer from the inside of the mat to the outer surface will begin. The chosen layout is pictured below.

Figure 3 - Interior support Layout

Figure 3 shows the main idea that the support layout will follow. However, as previously stated the material used for support will definitely need to be reconsidered as it does not handle heat well at all. The foam curls and melts at mid heat temperatures and therefore would not be ideal for our implementation. It does however serve as a good place holder as it has a very desirable thickness and is very easily shaped. It also does prove the above design valid for stability. Below are images of the thickness of the mat and a picture of someone standing on the model.

Figure 4 - Mat w/Supports extra photos

This layout proved to give a desired amount of support for a person to stand on the mat at different angles without cause and depressions in the material. We will be replacing this foam material with a more reasonable material by the next prototype.

Physical Model 2 - Circuit

The final part of this second prototype was planned to be a small circuit to test the functionality of the temperature sensors. However, these have yet to arrive in the mail. We are currently waiting on some other components to be delivered to further our prototyping and testing. This aspect of our product will have to be postponed to the next prototype.

Wrike Task Plan Update

The following link is a snapshot of our Wrike gantt chart. The chart shows our teams progress on our prototype and all the assigned subtasks. This week we focused on testing the grit on our prototype 2 and making sure we have all the materials ordered for our final prototype. We then assigned subtasks accordingly to group members.

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=AGZhYnHgh6zZMjV3wUbr66XSDrcVxWbo%7CIE2DGNJSGE2TOLSTGE3A

Conclusion

The second prototype was created with the purpose of proving and testing feasibility of partial subsystems. So far we have completed the analysis and testing of the casing subsystem, which includes grip performance and interior support layout. Since components of the circuit are still in the mail, we are temporarily unable to test this part. In the next prototype, we will complete circuit testing and merge all subsystems into a fully functional model.