GNG1103

Design Project User and Product Manual

SHWAG Mat

Submitted by:

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Table 1 - Acronyms

Acronym	Definition
AKA	Also known as
HV LED	High voltage light-emitting diode
LED	Light-emitting diode
SHWAG	Safe, Heated, Waterproof, Accessible and Great
UPM	User and Product manual
PVC	polyvinyl chloride

Table 2 - Glossary

Term	Acronym	Definition
Passive User	PU	A user who absent-mindedly uses the product due to its implementation in a space which they use/have access to.

1 Introduction

The task we were given was 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. Some of the assumptions made for this prototype are, that the interior heating cord would work in low temperatures. That the temperature would not affect the grip of the mat. That there would be enough room on either side of the mat to mount it with pegs. And that there would be enough power available to keep the mat running efficiently.

This document outlines the User and Product Manual (UPM). This UPM provides the necessary information to the individuals responsible for implementing and caring for the mat, as well as the individuals who passively use the mat, to understand how to use and maintain the SHWAG Mat.

The UPM is organized in parts. The document first talks about the problem, the needs of the user, the key aspects of the product, and warnings that come with the mat. Next, it talks about the setup, the considerations, how to access all of the components, how the systems are organized, and how to deactivate the mat. It then goes to explain how to use the four systems of the mat. Then there is the troubleshooting and support, with maintenance and considerations. At the end, it talks about the documentations of the product, how it was built, the materials used, the different prototypes, and the testing done on each prototype.

2 Overview

The university of Ottawa's main method of clearing sidewalks during the winter months is with rock salt. This is an unsustainable practice whose actual cost is much higher than it would appear to be from just the price of the salt/application, due to the damage done on the infrastructure and environment. The university has asked for a sustainable solution which would minimize the amount of salt used on campus sidewalks.

The solution required is a modular, scalable heating mat which could be quickly installed on sidewalks during the winter and easily removed during the warmer months. It should increase the accessibility of people with mobility disabilities during seasons with snow. This device should be easily repaired by the university if it were to be damaged or need repair. The device needs to be able to be stored easily and compactly as excess storage space is not readily available. The device should have a grip which keeps the user from slipping when wet. These needs were the blueprint for the Shwag Mat.

Figure 1 - Final Prototype

The Shwag Mat which has been constructed uses affordable materials and is an effective design. The product delivers on the needs above with precision. The device is easy to use repair. It has a strong grip which prevent slippage as well as having a completely accessible interior. The product will automatically activate when the temperature reaches a temperature in which snow will last.

The main casing of the mat is two rectangular sheets of twin-wall plastic which is held together by a small zipper. On the two long edges of the case there are straps which are connected to buckles which would secure one mat to the next. The other two edges have small loops which could be used to mount the mat to the ground using a peg. The interior of the mat consists of a heating cord which would conventionally be used on a water pipe. The cord plug comes out of one end of the mat and can be plugged into an extension cord or electrical outlet.

The Shwag Mat can be turned on simply by plugging it into an average electrical outlet. It has a male connector coming out of one end of the mat.

2.1 Cautions & Warnings

The user of this mat should be cautious of where they are putting the Shwag Mat. The mat should not be placed in the path of any door which is not at least 1.5 inches off the ground as the mat may interfere with the opening of said door. The Shwag Mat is designed to be mounted to the ground near grass or loose dirt. The Shwag Mat may be less effective if placed in a location which prohibits the mount to be used.

3 Getting started

3.1 Set-up Considerations

The Shwag Mat consists of two main subsystems. The first is the exterior or casing of the mat. The second is the interior of the mat. Each of these subsystems is equally important in the proper functionality of the mat. Before setting up the Shwag Mat, users are encouraged to consider the setting in which the Shwag Mat will be used. The Shwag Mat is intended to be used on a sidewalk, particularly one which has grass or loose earth on at least one side. The setting should be somewhat flat, with no large concavities in the ground as the mat is flexible and could be damaged by such settings. When using the Shwag Mat is important to consider that the Shwag heating mat is specially customized for the sidewalks on the campus of University of Ottawa, so it is not guaranteed to be suitable for all other types of sidewalks. Additionally, the mat requires access to a standard electrical outlet.

3.2 User Access Considerations

The main user groups of the Shwag Mat will be the individuals responsible for the mats implementation and care and the individuals who passively use the mat. These two roles play a different part in what the mat is capable of.

For those who own or are responsible for care and set up of the mat, it is important to follow the setup instructions and requirements when implementing the Shwag Mat. These individuals should be aware of the use of the mat and regularly check on its functionality and be aware of the errors which could occur during regular use of the mat.

For those using the mat passively, it is important to be aware how the mat may affect clothes or footwear. The grip on the mat could cause damage if clothing is rubbed vigorously against it. It is also important that users are cautious of gaps between mats as there will be about 6 inches (15 cm) of space between the two mats.

These precautions and warnings and the awareness of them is the responsibility of the users who are responsible for implementing the Shwag Mat system.

3.3 Accessing the System

When first receiving the Shwag Mat, inspect exterior of mat ensuring all components are secured and sealed. On the short end of the mat near the plug, slowly unzip the mat revealing interior ensuring the zipper functions as expected. Inspect the interior of the mat for damage and return the zipper to original position before plugging in. Always make sure the zipper is closed before using the Shwag Mat as it is only meant to be active when sealed.

Once the mat has been inspected and closed, plug the device into the wall. The mat needs no extra work to activate. Once the initial mat is plugged in, continue to follow the same procedure to set up other mats and plug them into the outlet which extrudes the same end as the power cord on the initial mat. These mats should be connected in a long line for as long as needed.

3.4 System Organization & Navigation

The Shwag Mat is designed in way which maximizes user accessibility to its subsystems. It is organized simply and clearly. As previously described, there are two main subsystems to the Shwag Mat. These subsystems are described below.

3.4.1 Mat Exterior/Mat Casing

The exterior casing of the mat is mainly composed of two sheets of twin-wall plastic sheets. These sheets make up the bottom and top of the mat. To hold these sheets together is a small plastic zipper on three sides and a thin piece of fabric on one. This zipper allows for full access to the interior of the mat (see section 3.4.2). along each edge there are two straps which come out and have different pieces looped through them. On the two long edges there are buckles on the straps which allow mats to be safely secured together. On the other to edges there are loops which allow for the mat to be pinned to the ground. On one of the short sides, there are two wires coming out of the mat. One wire is an electrical plug which can be plugged into an outlet to power the mat. The other wire is an outlet which allows other mats to plugged into it allowing for the mats to all be powered easily.

3.4.2 Mat Interior

The interior of the mat is composed of a small number of components. Along the bottom of the interior there is an aluminum foil lining which acts as a heat reflector. On top of the aluminum foil is a coil of a pipe heating cord which acts as the heating element in the mat. This cord is wound and spliced to allow power to be passed to multiple mats at once.

3.5 Exiting the System

When deactivating and dismantling the Shwag Mat it is important to do so cautiously. The first thing to do is to disconnect the mats from each other one by one starting with the furthest from the initial power source. After unplugging each mat examine the mats before returning them to the place of storage.

4 Using the System

The system can be described by 4 main features: the connectors, the stability method, the maintainability design, and the heating.

4.1 Connectors

Each mat connects to the next one by using 2 buckles. Simply connect the female buckle to the male buckle for both buckles. To disconnect, push in on both sides of the buckle, then pull them away from each other while still pressing down. Additionally, there are both male and female electrical outlet wires protruding from one side of the mat. These can be connected from one mat to the next to allow for power to be passed along the chain of mats.

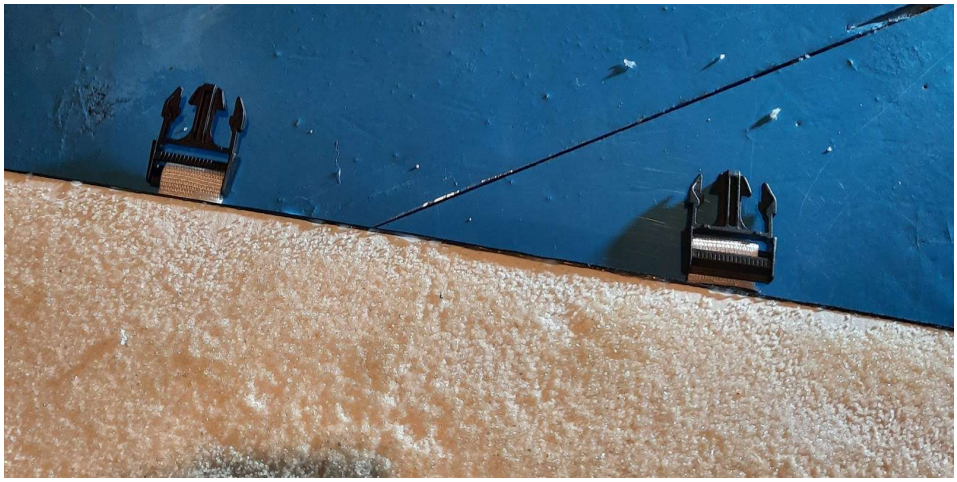

Figure 2 - Mat buckles

4.1.1 Electrical Connectors

The electrical connectors between mats are a simple subsystem. They are constructed by splicing together the preexisting power cord for the heating cable and the outlet end of an extension cord.

4.2 Stability

The stability of the product comes from the 4 loops near each corner of the mat. Firmly plant a peg into the ground through each of the loops to stabilize the product.

Figure 3 - Stability loops

4.2.1 Stability Loop Mounting

To mount the mat down, you lay the loops on top of a section of loose dirt and tie it down using a tent peg or other similar mounting peg. These loops ensure the mat will not slide around on the ground when stepped on.

4.3 Maintainability

The maintainability of the product comes from the ease of access to its internal components. The purpose of the zipper is to keep the inside of the product safe, while also being easy to reach. Be sure to fully open the zipper before attempting to open the mat. Do not power the mat until the zipper has been fully closed.

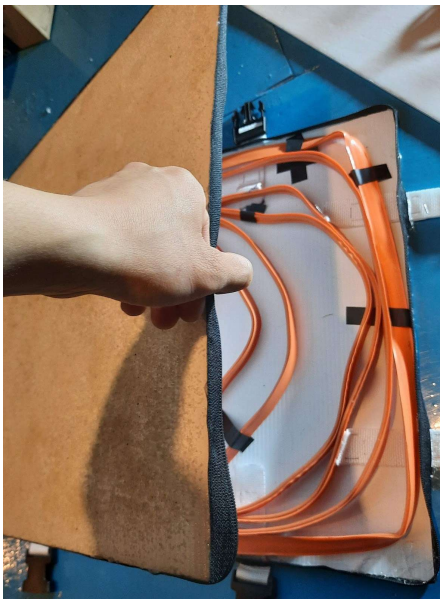

Figure 4 - Opening the product after unzipping

4.3.1 Zipper

The zipper subsystem is very simple. A zipper has been attached to 3 edges of the mat to allow for it to be opened completely. The side that has been left with no zipper is perpendicular to the direction the mats are placed in. This allows multiple mats connected in series to be opened and inspected at the same time.

4.4 Heating

Due to its automated features, little input is required with the heating cable. There is a manual switch on the cable, which allows the user to turn on the cable even if the temperature is not below its threshold. Do not keep the cable on using the manual switch for longer than 20 minutes.

Figure 5 - Heating subsystem

4.4.1 Heated Cord

The heated cord in the Shwag Mat is a repurposed cord originally used to prevent pipes from freezing in the winter. It has a built-in thermometer which is used to control it. It heats slowly but once it has reached a hot enough temperature it will begin to melt snow and ice.

5 Troubleshooting & Support

The most common issue to occur with the shwag mat would be loss of grip due to wear. Refer to *maintenance* (5.2) for more information on this. Over time the heating cable inside the mat may curl out of shape or move towards one side of the mat. In this case, open the mat (refer to *maintenance* (5.2) on accessing the mat after use) and reposition the cable to allow for more consistent heat transfer.

If you believe that the electric system of a mat is not working, start by plugging in the mat and manually turning on the heating cable. If this works fine, attach a small household appliance (lamp, pencil sharpener, hair dryer) to the next cable connector and check if it works. If one or both tests fail, contact support (5.4).

5.1 Error Messages or Behaviors

Handle the straps of the mat which are to be pegged into the ground with care. Do not attempt to remove the pegs from the ground by lifting the straps. Handle the zipper with care near the start of the zipper and the end. Do not manually heat the mat for longer than 20 minutes.

5.2 Special Considerations

The heating system of the mat is automated, but also includes a manual power switch. Should you believe that the mats power system is faulty, the quickest way to check is with this switch. In addition, this can also be used to activate the heating of the mat should the temperature sensor not work. Do not use the manual switch to heat the mat for longer than 20 minutes. Do not power the mat until the zipper has been fully closed.

5.3 Maintenance

To maximize the life expectancy of the product, only have the mat deployed when required (AKA the winter months). Clean the product as required when the time comes to for storage. The zipper is to be lightly brushed with a wet cloth before opening, to prevent damage. Depending on the amount of use, the mats grit texture may need to be reapplied. This is done by applying a layer of spray-on glue, then applying a layer of grit. Adding 1 layer after each season should provide enough traction.

5.4 Support

For assistance with any instructions included in this manual or an issue not included, feel free to email pholo029@uottawa.ca for further assistance.

6 Product Documentation

Throughout out designing of the SHWAG Mat the team has considered many different materials and products. The team generated numerous conceptual designs through SHWAG Mat based on the client's interpreted needs and design criteria.

Electrical

When first beginning our concept generation for the SHWAG Mat, Nichrome wire, conductive wire, and PTC heating were considered for heating the mat. After making analyzing and evaluating the heating elements against the design criteria it was found that the Nichrome wire was the best heating element for the mat. However, due to budget constraints and materials not arriving in time for the construction of the final prototype, we ultimately decided to change the heating method to something more accessible. In the final prototype the heating element used is a heated cable that is used to heat pipes from freezing. The heating cord is powered by a plug that comes out of one end of the mat and can be plugged into an extension cord or a standard electrical outlet.

Connection and Stability

Our team generated a few designs for connection and stability. Our customer needed a mat design that was stable and portable. We explored different connection designs like puzzle, vertical teeth, play mat, side bars with teeth, computer connection, and hose wire. After analyzing and evaluating the connecting methods against the design criteria the team found that the hose wire, the side bars with teeth, and vertical teeth were the most efficient. The hose wire is safe for power transfer and simple to connect. The side bars with teeth can be securely connected and have good stability. The vertical teeth are a simple design and can be securely connected together.

A few ideas for connectors that were not as efficient were the computer connector, the puzzle connector and the playmat design. The computer connector did not have a secure connection. This would make the design easy to disconnect and stop the flow of electricity. The puzzle connector is not a simple design. This would make the assembly extremely time consuming and it would be expensive to create. The playmat design was neutral on the secureness of the connection, but it lacked stability, which would make it easy to move around after it was installed.

After analyzing all design options, the team concluded a few design options were not feasible due to part availability. Ultimately the team chose to use buckles because they were readily available. Materials were a challenge to procure due to COVID restrictions and closures. The decision to use loops instead of side bars with teeth to connect to the sidewalks was also due to accessibility and the unavailability of parts at the time of construction.

Exterior and Interior Casing

Due to the difficult times which have been terrible for the economy, the first fully functional model had a difficult time in acquiring materials. Despite already having sand glass on-hand, the casing material was chosen to be twin-wall plastic. This was due to it being the best option for our budget and also being one of the only options. Despite this, the mat can comfortably hold up 1 person or a biker, which is as much as could fit on it at once anyways. As with the casing, the opening method was also changed from a waterproof zipper to a normal zipper due to its price.

We also considered using a PVC material. The main advantage of PVC would be its strength, being able to hold up around 4 people given it's big enough. Regardless of what material is used, the next step would be to add supports to the interior of the casing. The addition of supports would drastically increase the integrity of the mat and would slightly increase the rate of heating in the mat.

6.1 BOM (Bill of Materials)

Part	Qty	Description	Vendor	Unit Cost	Extended Cost
Twin-wall Plastic Sheets	2	Used for the main body of the mat	Home Depot	10.53	21.06
Gorilla Glue Spray Adh.	1	Used to adhere grip to top of mat	Home Depot	14.97	14.97
Strap	1	Used to create straps for buckles and connecting sheets	Fabricland	6.99	5.24
100" Zipper	1	Used to connect sheets and allow opening of mat	Fabricland	13.59	10.19
2 pack of plastic rings	2	Used to create mounting loops	Fabricland	2.10	3.15
Buckle	2	Used to connect mats to one another	Fabricland	3.80	5.70
Extension Cord	1	Used to create electric Modularity	Walmart	3.98	3.98
Heating Cord	1	Heat the mat	Amazon	23.06	23.06
				Subtotal	87.35
				Tax	11.36
				Total	98.71

6.2 Mat Exterior/Casing

6.2.1 Equipment and Material list

For the exterior casing, the following equipment was used to construct the model in the current prototype.

- 2 sheets of 18x24 twin-wall plastic
- 1 70-inch zipper
- 2 cups of glass sand (medium coarseness)
- 1 can of adhesive spray
- 2 full large buckles
- 4 small loops
- 1 long 1” strap
- Hot glue gun
- 1 pack of hot glue sticks
- Stapler and staples

6.2.2 Instructions for Assembly

1. First, lay out one of the twin-wall plastic sheets on the ground. It is helpful if you have a sheet underneath to protect the ground.
2. Spray a thick layer of spray adhesive onto one of the layers of the sheet. Sprinkle a thin layer of glass sand onto the top of the mat to create an even rough texture. Re-apply another layer of adhesive.
3. Repeat Step 2 3-4 times until grip is satisfactory and entire sheet is covered thoroughly in glass sand.
4. Once glass sand and adhesive have been applied, it is time to create the straps for the buckles and mounting loops. Cut 4-foot-long pieces of strap and 4 6”-long pieces of strap.
5. Loop the long straps around the small mounting loops and fasten the strands together with staples to create 4 pieces of mounting loop-straps.
6. Loop the short straps around each side of each buckle and fasten to create 4 pieces of buckle-straps.
7. Once these 8 strap combinations have been assembled, lay out the second sheet of twin-wall plastic.
8. Connect two mounting loop-straps to the short end of the piece. Fasten them with hot glue and ensure they stick out a good amount. Repeat on the other short end with the remaining mounting loop-straps.
9. Connect two buckle straps about 6 inches from the edge on the long edge in the same way that the mounting loop-straps were secured. Repeat on other edge.

10. Once all 8 straps have been secured, it is time to connect the two pieces of twin-wall plastic. Place the two sheets of twin-wall plastic parallel to each other and stand them on one of the long edges.
11. Slowly hot glue the zipper along 3 of the 4 edges of the two sheets to connect them. Carefully
12. Once the zipper has been attached all around the edge, connect the left-over strap to the remaining edge.
13. The case is finished. Move onto next subsystem.

6.3 Mat interior

6.3.1 Equipment and Material List

For the mat interior there is a small list of materials used to construct it.

- Heating Cable/Cord
- Soldering Iron
- Solder
- Extension Power cord (w/ground wire)
- Aluminum foil

6.3.2 Instructions for Assembly

1. First, ensure strip the wire of the power cord of the heating cord. Beware to not cut through any of the wires. Strip each individual wire inside the main cord (ground, hot, and neutral.)
2. Cut off the plug end of the extension cord. Separate the interior wires. Keep in mind which is hot, neutral and ground.
3. Solder hot-to-hot, neutral-to-neutral and ground-to-ground of the two cables (the outlet end of extension cord and the heating cord).
4. Once the two have been spliced together set aside the heating cable.
5. Lay a sheet of aluminum foil, shiny side up, on the bottom of the heated mat.
6. Coil the wire in a large round spiral. Ensure it is flat. Lay on top of the aluminum foil inside the mat.
7. Begin to spread the coil to evenly cover the whole surface of the interior.
8. Cut two holes in the fabric strap connecting the two sheets of plastic together and pass the wires through them.
9. SHWAG mat is finished

6.4 Testing & Validation

The test and validations were done on all 3 of our prototypes. The first prototype was a low fidelity prototype which demonstrates our teams design features. The second prototype demonstrates the designs for the subsystems more in depth with testing the functionality of said subsystems. The third prototype goes further into testing the subsystems but mainly focuses on the interior heating of the mat.

6.4.1 Prototype 1 Tests

The testing done on prototype 1 is to test the possible design methods for the tile connections, support structure, validity of concept, heating concept requirements, and circuit concepts development. Two prototypes were made during this period, a physical prototype and an analytical prototype.

The physical prototype is a cardboard replica of the conceptual design generated. This prototype included the connection teeth which are used to put the tiles together, the supports within the tile, and a dummy wire.

The connection teeth method is a simple design that is used to keep the tiles in place. The teeth are seen in Figure 6 as the indented connecting teeth. This design was tested to work well because it stops movement perpendicular to the direction of the mats. However, the design was tested to do little to stop movement in the parallel direction. The conclusion of the replication of the connector subsystem is that the connection teeth alone will not be enough to completely keep the tiles in place.

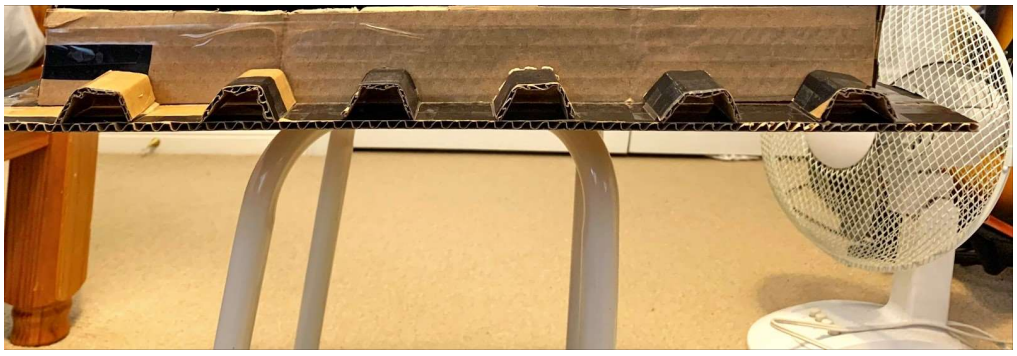

Figure 6 - Connecting Teeth

The support structures method is a concept created to increase the maximum load of the SHWAG Mat and also provide a guide for the wiring placement. This subsystem can be seen in Figure 7. After creating the prototype for this subsystem, there seems to be no negatives with the

support structure. This is a design concept that we will further implement to increase the maximum load of our design.

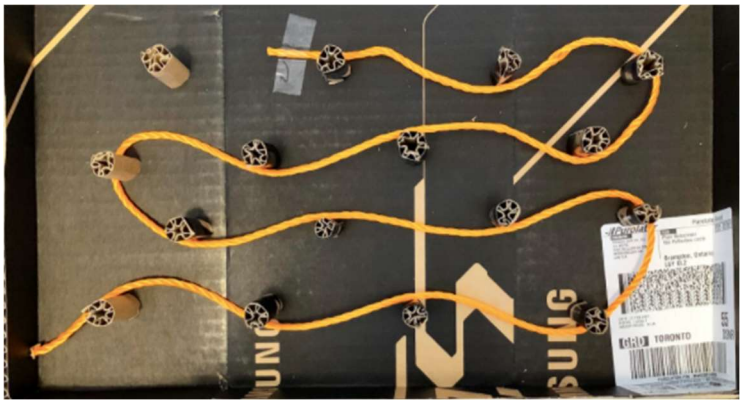

Figure 7 - Support Structure

The analytical prototype is a circuit diagram and an analysis of the circuit that will control the temperature of the mat. Calculations were also included in this prototyping phase to demonstrate how the stainless steel reacts when different current passes through it.

To calculate how stainless steel reacts when different passes through it the resistivity of stainless steel was identified. Next, the power equation for a circuit element was used to calculated how much voltage is required for a given length of steel wire to release a certain wattage. This calculation can be shown as follows:

$$Steel\ Wire\ \rightarrow L = 3.5m, d = 1.016mm$$

$$R = \frac{\varrho L}{A} = 6.9E - \frac{7(3.5)}{\frac{0.001016^2\pi}{4}} = 2.76\Omega$$

$$P = IV\ , I = \frac{V}{R}\ , P = \frac{V^2}{R}$$

$$P_5 = \frac{25}{2.76} = 9.05\ W\ (4.5\ W)$$

$$P_{12} = \frac{144}{2.76} = 52.2\ W\ (26.1\ W)$$

The two subscripts 5 and 12 are used to represent the wattages that would be supplied by 5 or 12 volt power supply. This calculation gives an estimate and a better understanding on which voltage should be used for further prototyping. The 5 volt seems to be a better option compared to

the 12 volts because it is low and easily attainable voltage. This option is also safer because of the lower current, which is important to SHWAG Mat design.

The circuit diagram shown in Figure 8 demonstrates the design of a controlled circuit. This circuit aims to maintain a safe and desirable temperature which is important to the SHWAG Mat design. The main component of the circuit is the Arduino which is connected to an opto-isolator which allows the Arduino to control the AC power flow in the heating wire. There is also a LED that will either connect to the Arduino or a HV LED that is connected in the AC circuit.

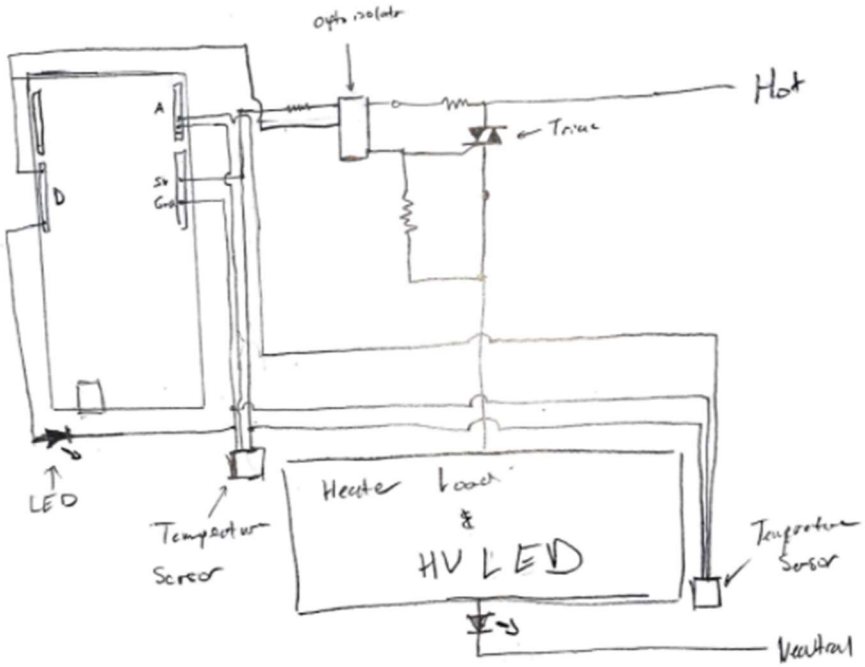

Figure 8 - Circuit Diagram

6.4.2 Prototype 2 Testing

The testing done on prototype 3 is to test the feasibility of the partial subsystems in the SHWAG Mat. Prototype 3 testing mainly focuses on the outer shell of the mat as well as trying to build a model circuit and test functionality. The grip texture of the top of the mat was tested in this phase of prototyping as well as the interior support layout.

When testing the grip strength of the SHWAG Mat, the 18x24 piece of Twin-wall polymer was put on a 12-inch incline. A boot was then placed at the top of the ramp and was allowed to

slide down. The amount of time required for the boot to slide down the ramp was recorded and repeated multiple times for different amount of glass and sand glue. The results from the trials are shown below.

Table 3 - 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

After analyzing the results shown in Table 3, it is apparent that the more layers increase the force of friction against the boot. This is shown in the table because when the layers are increased the amount of time it takes for the boot to slide down increases as well. From this data, we can conclude that this is a valid way to provide traction to the mats. However, adding extra layers to the tiles causes the sand to being to scrape off. This can have damaging results to the infrastructure to campus. After testing the two layers of grit, this seems to be the most satisfactory number of layers to provide enough traction without having too many layers that the sand begins to scrape off.

Figure 9 - Boot on Grit Stopped by Static Friction (2 layer of grit on left, 1 layer of grit on right

The interior support systems were created using plastic sheet and foam material. The purpose of the support system is to provide a small air gap between the top and bottom of the SHWAG Mat to put the heating wire. That the smaller amount of air in the mat will increase the speed of the heat transfer inside that mat allowing the outer surface to heat faster. This prototype tests the validity of our design and can be show in Figure 10. The foam serves as a place holder of what thickness is desired in for the final prototype.

Figure 10 - Interior Support Structure

6.4.3 Prototype 3 Testing

The third prototype underwent many changes than initially planned and tested due to parts not arriving in time and accessibility. The biggest change was moving to a pre-existing heating element rather than creating our own. The heating element chosen was a heated cord originally used for preventing pipes from freezing in the winter. This prototype focused on further testing the subsystems and functionality of the heating cord, the zipper, the heat reflecting material, and the wheelchair accessibility.

When testing the functionality of the heating cord, the test button was held to see if the cable heats up at all. The results after holding the button for a minute or so it became apparent that a temperature change was occurring demonstrating that the mat does heat up. This test can be shown in Figure 11.

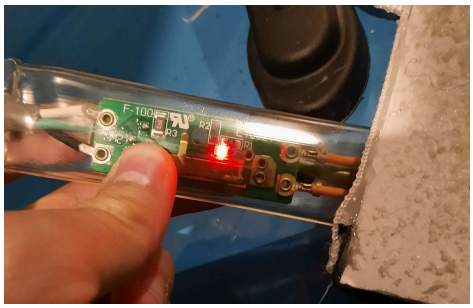

Figure 11 - Cord Functionality Test

Next, the zipper functionality of the mat was tested. Once the zipper was installed it proceed to functioned as planned by being able to unzip and zip up the 3 sides of the mat for accessibility purposes. The zipper was tested to work optimally under a steady slow hand and more awkward with an aggressive pull.

The third test preformed on prototype 3 was the heat reflection functionality. The purpose of this test is show that aluminum foil is a good temperature shield. For this test, an aluminum foil was placed to the face of a piece of plastic cardboard. To test the aluminum foils effectiveness, it was held to a powerful area heater for a short period of time to see what effect it has on the piece of plastic cardboard. After a short period of time the foil was moved away from the heater and the portion of plastic not covered by the aluminum foil was much hotter than the plastic covered with the foil. This shows that the aluminum foil does reflect the heat from the heater from reaching the piece of cardboard. With this knowledge, implementing aluminum foil into our mat is an effective option for making sure the heat of the heating cable is reflected up towards the snow and ice.

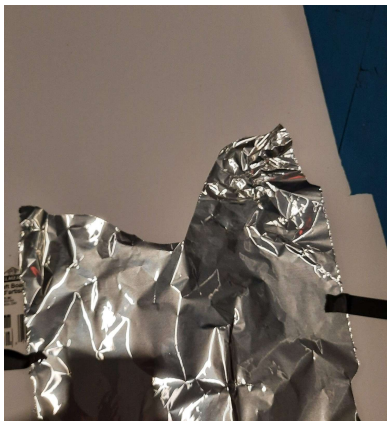

Figure 12 - Aluminum Heat Reflection Test

Finally, the wheelchair accessibility is tested. This is done by rolling different wheeled means of transportation (specifically a bike and scooter) over the mat. This process was done with different downward forces being applied onto the bike and scooter to simulate different weighted people. This process can be shown in Figure 13 and Figure 14.

Figure 13 - Wheelchair Accessibility Test with Bike

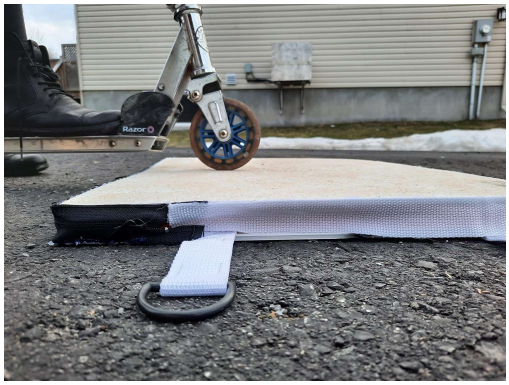

Figure 14 - Wheelchair Accessibility Test with Scooter

After observing the results of the test, the bike (larger wheeled device) had an easier time getting onto the mat with lighter force applied. However, the scooter (smaller wheeled device) had more troubles getting onto the mat when it had a lot of weight or it or when the mat was not properly secured down. From these results it is apparent that the accessibility of the mat needs to be improved for easier wheelchair accessibility.

7 Conclusions and Recommendations for Future Work

The design thinking process for the SHWAG Mat created a product that met the client's needs. It worked effectively to melt ice and snow from on top of the mat. The SHWAG Mats modular design allows it to be installed onto pre-existing sidewalks and emergency exits. When designing the SHWAG Mat we faced some challenges and problems. Throughout our design thinking process, we learned some important lessons about working with a group and being flexible when encountering issues.

The lessons we learned as a group is that teamwork is important. Cooperation between members is essential for getting work done efficiently. We also learned that working at a distance is challenging. It is difficult to construct prototypes when working remotely. We were unable to work together to physically construct our prototype, subsequently one group member took the lead as builder. From this we adapted, and our cooperation worked out.

Additionally, we learned that it is important to be organized. Excellent organization eliminates stress and confusion between group members. Setting subtasks and milestones was critical for keeping on task every week and making sure deadlines were met. Our organizational skills kept our group focused and on task. We had weekly meetings and tasks requiring completion were discussed and checked off.

Another lesson we learned during our designing of the SHWAG Mat is that creativity is essential. We found that being able to think and generate new ideas when plans do not work out was a necessary skill. We were able to demonstrate this skill when the materials for our original design were unavailable. Our ability to change course and redesign our product attributed to our success as a team.

In future works a removeable ramp is a critical feature that needs to be developed. A ramp is needed to increase the wheelchair accessibility because the current model was tested to be ineffective with smaller wheeled means of transportation. 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.

Improving the connection method of the mat, along with the interior system, are some of the most important future works. Using a more effective heating method, along with adding supports, would allow the product to provide more reliable surface temperatures. The current connection method leaves a gap between each mat, which can be a safety hazard. Adding a more permanent texture to the mat would also increase the reliability of the product. While improving upon the products texture, it would also be worthwhile to consider methods of displacing the water, possibly by having inclined grooves etched into the mat.

APPENDICES

8 APPENDIX I: Design Files

https://makerepo.com/Piotr/817.gng1103f3shwag-mat

Table 4 - Referenced Documents

Document Name	Document Location and/or URL	Issuance Date
Deliverable B	https://docs.google.com/document/d/1Lj2zT4uznRSbK58nUvBpIWGFVBuZzUzpP9trOwiYX8o/edit?usp=sharing	25/01/2021
Deliverable C	https://docs.google.com/document/d/1LAsMSRPioqQrP7Om8nyNTIZW6YVCZ41em-bf0UyeoPw/edit?usp=sharing	07/02/2021
Deliverable D	https://docs.google.com/document/d/1UPbnVjzZxhJtpsZOxpkzuz0FoiFYyPgCRqjSRScQUG0/edit?usp=sharing	21/02/2021
Deliverable E	https://docs.google.com/document/d/1AcgWsCtLkkFbdTPxyLb5yYoWee0gqwnPzUFR_CGqc/edit?usp=sharing	28/02/2021
Deliverable F	https://docs.google.com/document/d/1BwR1JSKaXl_kms5sy1lK9F1ejBcCfyoC89vsPzWO-Dc/edit?usp=sharing	07/03/2021
Deliverable G	https://docs.google.com/document/d/1l9QuYFs-5gZ75vs9-A1ZQOTWP0pHF45iIA9MM1-FX6o/edit?usp=sharing	14/03/2021
Deliverable H	https://docs.google.com/document/d/14x5UShl5fBr9gYw7kjDonIOMWfhfDIMdZfHfU4-QzB0/edit?usp=sharing	28/03/2021