GNG1103

Design Project User and Product Manual

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Table 1. Acronyms

Acronym	**Definition**
SMS	Snow melting system
UPM	User and Product Manual

Table 2. Glossary

Term	**Definition**
Cell	Referring to the individual sidewalk unit
Automated (automatic)	Self running or self operating requiring no further user or external input

1 Introduction

This User and Product Manual (UPM) provides the information necessary for operators to effectively use the Snow melting system (SMS) and for prototype documentation.

This report will include an overview of the design thinking process, the steps taken to reach our final product and how to use it. Firstly, the empathise step of the design thinking process was utilized through meetings with our client, Jonathan Rausseo, where he expressed the university's trouble with the current snow melting system. From that information, the team was able to define the problem and list the needs of the client. During the ideate stage of the design thinking process, we designed various concepts, and we gathered feedback from our TA, client, and Professor. After a general design was chosen, among the various concepts, prototypes of different levels of detail were built to improve spatial understanding of the design. Then, the last stage was to test our design.

This document also provides a guide on how to use, clean, store and maintain the final product developed. This is intended to help anyone that plans to set-up, run, or maintain the snow melting system.

Our goal was to produce a safe, low-cost heated sidewalk to remove snow and ice around campus streets which would be modular, scalable, durable, low maintenance and can be stored away, when not in use, around campus. The design needed to be simple, easy to use, efficient and include a manual override/kill switch. We were given the chance to create inexpensive prototypes to test various aspects of our design and meet with Jonathan to ensure that our design worked and met all the specifications of our client.

2 Overview

Snow and ice on sidewalks lead to injuries and accidents. Salt erodes roads and buildings and is harmful to animals and environment alike. Current ways of reducing snow have proved to be inefficient, harmful and expensive.

The University of Ottawa spends a lot of money (over $1 million) annually on the purchasing of rock salt and the clearing of snow during the winter. While rock salt is considered the cheapest material for snow clearing on campus, it has its disadvantages including but not limited to: reducing the service life of infrastructure; damaging the trees, grass and wildlife on campus; contaminating surface water and running off into rivers and lakes; and impacting the fertility of soil, rendering it unproductive. There exists a need by the university of ottawa for a more efficient and inexpensive way to reduce snow and ice on sidewalks without the use of any salt. As a group we were instructed to create a heated sidewalk design which would solve many if not all issues with conventional ways of melting winter ice. Specific requirements presented include scalability, storability, portability,stability, water-wicking and non-slip.

Our product ensures the most responsible way of solving the snow and ice issues in and around the sidewalks. It is environmentally friendly and ensures the adequate temperature in order to melt snow. Our unique and optimal design ensures proper water evacuation, portability, ease of repair, friction for non-slip surface and scalability.

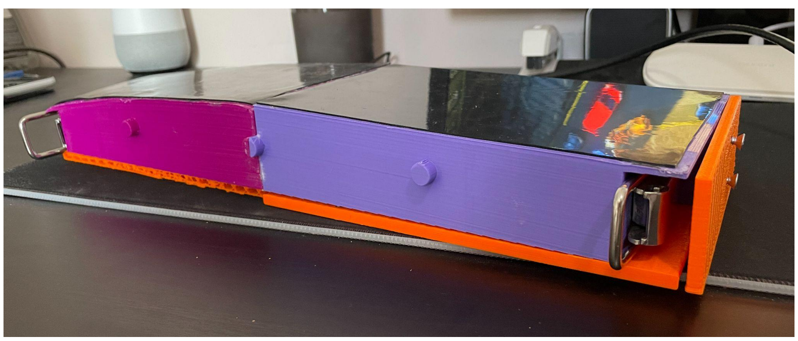


Figure 2.1 - Final prototype

Our sidewalk uses a smart plug for you to be able to activate, deactivate, set timers and create schedules of when you would like your heated sidewalk to be on or off. This can be accessed through different apps which are on the app store on IOS and Android. The heated cable runs throughout the sidewalk cell which then is plugged into the smart plug which is plugged into the wall. When you would like to activate your sidewalk cell you only have to go onto your app and turn it on.

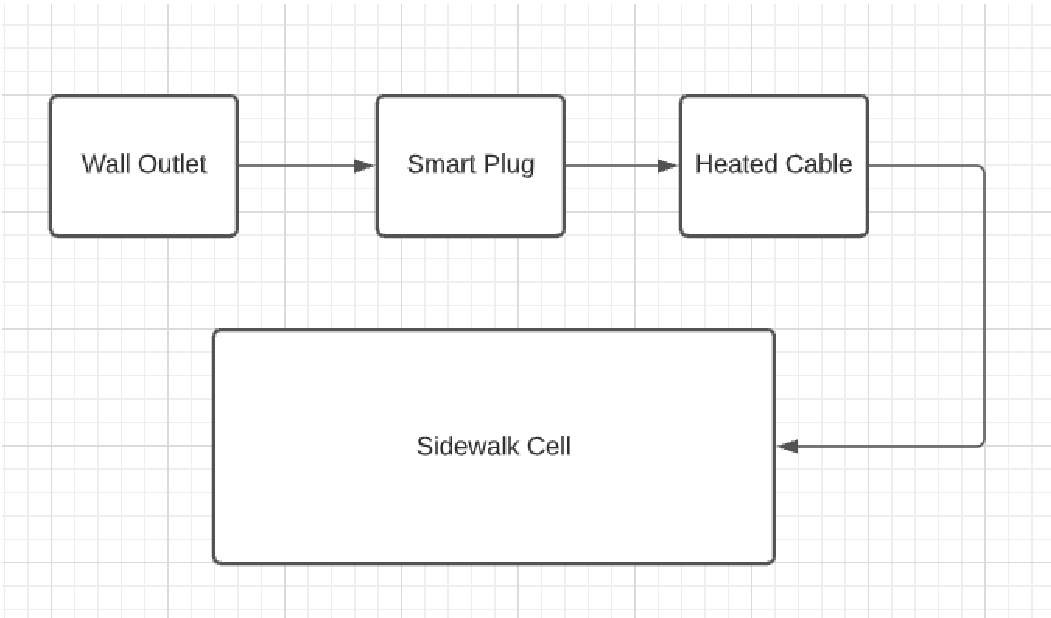


Figure 2.1 - Block diagram showing how the heat gets to the sidewalk.

2.1 Conventions

When a section referring the reader to various appendices it will be indicated by 'Refer to the appendix … on pages …. '. There, appropropriate information can be found.

2.2 Cautions & Warnings

WARNING: Electrical Hazard

This mat must be installed per instructions given in manual.

Follow these important warnings to avoid the risk of fire or shock.

CAUTION: To provide continued protection against electric shock:

a) Route the supply cord and locate the heater so as to be protected from damage

b) Inspect cord before using

c) Unplug heater at receptacle outlet when not in use or before removing

d) Store heater indoors after winter season

*Do not remove or modify the safety device or the plug connected to the mat. The power supply cord is not replaceable.

* Do not drive any form of nails, screws, fasteners, or other objects through the rubber surface of the mat. Use only the brass grommets for attachment.

* Do not cut, slice, trim or otherwise alter the mat.

* Do not plug the mat into an improperly wired or rated outlet.

* Periodically examine the mat for any signs of damage or excessive wear.

3 Getting started

3.1 Set-up Considerations

Set-up for our heating sidewalk is easy and very friendly to users. All you need to do is to position the heating mats to the area you want the snow to be melted on your sidewalk, and connect different cells together by connecting their latches and electrical connections. Then on the end cell, you should plug it into a power supply from the house. And now, it is ready to serve you.

Note, when set-up, you should always connect to power supply in the **last step for your safety.

To disconnect and collect the heating sidewalk when the winter season is over, all you have to do is reverse the process mentioned above. First you disconnect the power supply to ensure safety. Then you dissipate the heating cells by unplugging the electrical connections and disconnecting the latches.

Note, when disconnecting. You should always disconnect the power supply **first for your safety.

3.2 User Access Considerations

Please consider keeping the product dry before storage. Always keep a clean and dry surface before switching for the season, so the product can serve you longer and better. Be aware of the safe use of electricity.

3.3 Accessing the System

It is a fully automatic system which runs on it’s own. All you have to do is plug it to a power supply, and keep the surface clean and dry before using and storage. Ensure dry conditions for the installation of the cell ensuring not internal water damage may incur with the electronic internal components.

3.4 System Organization & Navigation

This is a fully automatic system. For all that user has to do is to plug in the power supply. The heating cable will be automatically turned on once the sensor detects the cold temperature. The heating cable will be automatically turned off when the system detects the current environment temperature won’t hold snow or ice on the sidewalk.

2.5 Exiting the System

Unplug the system from the power outlet, ensuring no more current flows through the system. Unlock and release the cell from surrounding cells. Remove the cell store in a dry place.

4 Using the System

The following subsections provide detailed, step-by-step instructions on how to use the various functions or features of the heated sidewalk.

4.1 <Snow and ice melting>

System is fully automated and needs only to be plugged into a power outlet in order to operate its single feature of melting snow ice. Refer to the appendices 2.1-2.5

5 Troubleshooting & Support

For troubleshooting, if one cell has malfunctions. First, unplug the power supply, remove the cell from the heating sidewalk chain, and replace with a new cell. Then plug the power supply back.

After you do that, give us a call at 1-800-000-0000, and our customer service agent can help you to either fix the problem or send you a new one. As simple as that!

5.1 Error Messages or Behaviors

Failure to melt snow or ice on surface:

Sometimes, if the heated cables are not pressed right up against the top surface of the 3D printed part, there might not be any heat coming from the surface. To fix this error you can unscrew the bottom cover to allow access to the wiring on the inside. You will see that the wires are not firmly pressed along the bottom of the casing. You can use zip ties to strap the wires down using the columns in the centre of the casing. You can also use tape or glue to make sure wires are firmly on the base of the cover.

On and Off switch failing:

The on and off switch using the smart plug may turn off sometimes. This can be due to a lack of power coming from the outlet or if the internet is turned off. To fix this error you can try resetting the router and going back into the app and check to see if the switch works. If that does not work, you may need to follow the instructions with the smart plug to restart it and start from scratch.

Cold area on cell:

Sometimes if the wiring is not in the correct area, it may result in cold spots. To fix this error you can first unscrew the bottom cover to allow access to the wiring on the inside. You can then position the wires an even distance apart from one another to allow for full coverage along the bottom of the cell.

5.2 Maintenance

The user should regularly check the heated cables which are stored inside the cell. Also ensure that the rubber layer is not torn or scuffed. Ensure the latches on each cell are locked on a regular basis. Try to minimize the amount of road salt that may end up on the heated sidewalk. If snow remains unmelted refer to appendices 4.1 for troubleshoot instructions.

5.3 Support

For any problems concerning the product or damage, Contact our team at email: …
memorable11@uottawa.ca

https://makerepo.com/CLUO008/802.gng1103w2021memorable11

6 Product Documentation

Document Name	Document Link
Screw Holes.gcode	screw holes gcode
Sidewalk Body 2.gcode	Sidewalk body gcode
Sidewalk Body Sides.gcode	Sides and bottom gcode
Bottom 1.stl	First part of bottom of sidewalk
Bottom 2.stl	Second part of bottom of sidewalk
Screw hole inserts.stl	Screw hole inserts
Side 1.stl	First Latch cover
Side 2.stl	Second latch cover
Top 1.stl	First part of main body
Top 2.stl	Second part of main body

6.1 <Subsystem 1 of prototype>

6.1.1 BOM (Bill of Materials)

	Component	Quantity	Unit cost ($)	Link	Approximate Cost
1	3D printing	1	0	N/A	$0
2	Heating cables	1(18ft)	35.99	Amazon	$35.99
3	Rubber	1	22.69	Amazon	$22.69
4	Latches	2	8.98	HomeDepot	$17.96
Total Cost	------------------	-----------	----------		$76.64 + Tax

6.1.2 Equipment list

Software equipment used:

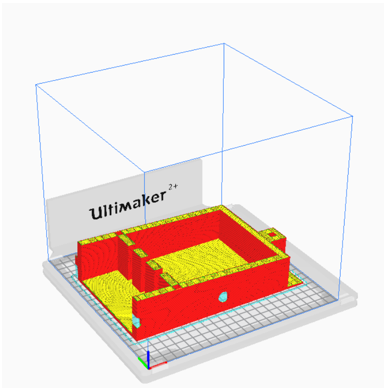
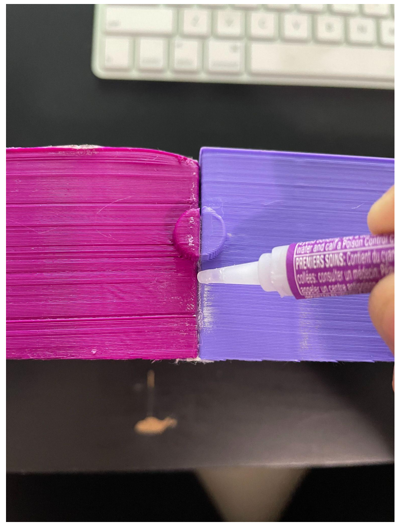
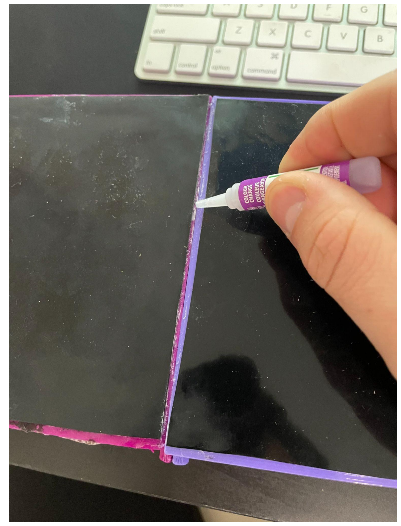
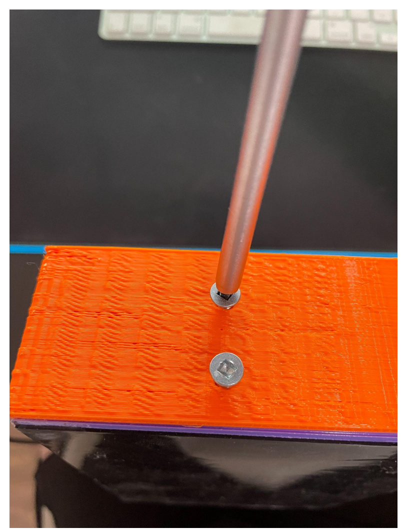
- Shapr 3D
- Cura
- sketchup

Hardware equipment used:

- Pliers
- 3D printer
- Drill

6.1.3 Instructions

Steps for building the final prototype:

		
Step 1: 3D print all parts	**Step 2:** Glue pieces together	**Step 3:** Cut and glue rubber to the surface
		
Step 4: Glue latches in place	**Step 5:** Run cable along inside of cell	**Step 6:** Screw pieces together

Since there are little electrical components in this prototype, there is no electrical work needed when making it. Instead the main problems that may arise will come from the printing of the components. It will take a long time to print due to the lack of speed in a 3D printer. 3D printing is not needed to make this prototype, however, it does make the shape much easier to create than building with your hands. Other materials for the casing of the cell could be metal along with a waterproof coating to prevent water from getting inside of the cell. This was not tested but could be another valid option to go for. The latches we found for the sides of the cell were very large, but if they were smaller, we would have also made the overall size of the design much thinner to compensate. This would make people with wheelchairs or people stepping up the sidewalk have a much easier time when doing so. This would also make the design weight a lot less which is the overall goal as well.

6.2 Testing & Validation

The testing done on the final prototype:

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)
1	Testing for heating cable temperature	Measure surface temperature of the cable under different conditions using prototype 3 heating cable plugged in.	Using a thermometer, measure the temperature of the cable under various cold temperatures using time increments (1min, 5min, 10min).
2	Test if the cable fits inside the casing	We will be using the third prototype to determine if the heated cable fits inside the casing.	Using the third prototype, open the casing and confirm that the heated cable fits snug inside the casing while still being effective and heating the surface effectively.
3	Testing water adhesion and runoff to the surface	Using the slanted surface of the prototype, we will determine if water runs off its surface in order to prevent water accumulation. Prototype needs to be completely unplugged.	Using the surface of the prototype, pour water on it while in a laid position, capture water and measure the amount remaining on the surface. Also, observe any remaining water on the surface.

4	Cell structural strength	Using various amounts of weight, the prototype will be tested for its max load capacity.	Adding additional weight to the cell will determine the exact point at which it begins to bend or fracture
5	Test if the thermo sensor can turn on/turn off the heating cable in different temperature settings.	Since the outdoor temperature is getting higher, we will be using a cooler with ice cubes and a physical thermometer to simulate the cold temperature environment. Record the cooler's inside temperature, then put the thermo sensor along with the heating cable into the cooler while connected to the power supply to make the test.	Put ice in the cooler to cool the cooler's inside temperature down at first. by changing the amount of ice cube to adjust the temperature. we will start from lowest temperature to higher temperature, which means from more ice to less ice. After the cooler has been cold, we record the temperature with our physical thermometer. Then put the cable with the thermo sensor in, to see if it could turn on the heating cable.
6	Test friction of rubber surface on casing	Using our third prototype we will use our rubber pad and adhere it to the surface of the casing in order to determine that it is safe and is not slippery.	We will put the rubber at different angles in different conditions (dry,wet). We will test to see if there is enough friction on the rubber so that we can ensure no-one will slip on it and that it is safe.

Results for…:

Test 1: After 35min22sec, 0.78kg of snow was melted off the surface of the cell.

Test 2: Heating cables have proven to fit within the cell casing assuring room for additional components.

Test 3: 100% of presented water onto the surface evacuated from the angled surface of the cell. Slight diagonal runoff was observed but majoritarily horizontal runoff to the side was observed.

Test 4: Cell was capable of withstanding weight above 200lbs. Further testing needed.

Test 5: Cable initiation observed in cold temperatures.

Test 6: Surface rubber proved extremely frictional, wet conditions proved to have slight to no effect on the friction of the surface to boot and shoe outsoles.

7 Conclusions and Recommendations for Future Work

During the duration of this project our team learned some valuable lessons regarding our heated sidewalk prototype. We learned the importance of benchmarkings, planning and time managnment.In the future we look forward to making a real life size prototype that the university can scale and use in the winter. We would also consider making each cell thinner to ensure that the heat can move quicker to the surface of the cell. In addition we would like to use a better material for the casing of the cell itself, and possibly look at creating a custom cell for stairs as well.

Due to having a limited budget and strict timeline, various aspects of the device development have been put to rest. Further prototype iterations would have been explored and possible transition to a metal alloy body of the main cell which could have been introduced as a way to increase stability and strength in the cell structure and possibly cut production time by a large amount. Various other components could have been in development such as alternative surface rubber composition and possibly a new locking mechanism to ensure the interlocking and safety of the cells. All these alterations would have been beneficial but not necessary for this project at this time with current constraints imposed.

8 Bibliography

HF 50-120 Passageway Mat
https://kemf.ca/product/heated-passageway-mat-20-x-48/

Heated Snow Melting Walkway Mat
https://heattrak.com/products/heated-walkway-mat-30-x-60

SNOW MELTING HEATED MATS
https://canadamats.ca/products/snow-melting-heated-mats?variant=19831799382145

Pressure plate tiles for electricity production
https://pavegen.com