**Project Deliverable D – Conceptual Design**

GNG1103

Group 13

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**Abstract**

*This document contains conceptual designs for a low-cost, modular, heated sidewalk for The Office of Campus Sustainability that can efficiently melt snow as it falls and is safe to walk on even during a heavy snowstorm. The designs are based off of previous benchmarking and design criteria developed in previous project deliverables. The conceptual designs are analyzed and evaluated in order to decide what initial designs are going to be developed further as the project progresses.*

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# Introduction

The purpose of this document is to generate a conceptual design for each subsystem required for the development of our product of a modular heated sidewalk. This document will briefly cover some of the decisions that were reached in previous project deliverables as context for the designs and choices in this document. Each team member’s conceptual designs for the subsystems will be shown with a short description accompanying them. The subsystems will then be analyzed and organized in such a way that the benefits and drawbacks of the subsystems are easily identifiable. A design for the subsystems will then be chosen based on the individual designs generated, considering how it will fit into our eventual prototype and then final product.

## Related Work

Based on the need’s identification done after the first client meeting, a problem statement was developed to encompass the needs that the product must fulfill. We need to design a low-cost, modular, heated sidewalk for The Office of Campus Sustainability that can efficiently melt snow as it falls and is safe to walk on even during a heavy snowstorm.

Based on the design criteria and target specifications different power sources and materials were examined and benchmarked against each other. Here, different existing products were compared based on their performance while keeping in mind the practicality and price that this project is constrained to. The conceptual designs in this document will keep the preferred existing products in mind in order to keep efficiency and practicality at the forefront of the decision-making process.

# Conceptual Designs

Conceptual Design One

**Power:**

Map

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Figure 1 Power subsystem design by Bobby Lachambre

This design utilizes a ground fault circuit interrupter which is imperative as the modular sidewalk will be deployed outdoors. The GFCI will shut off the power to the wire when it senses an imbalance between outgoing and incoming current. This will ensure safety as power will be halted if the wire comes into contact with water. This is standard for electrical appliances used outdoors and the university buildings should already have this infrastructure in place. The wire in the design is a standard electrical/extension cord that has been manipulated so that the wires that carry the current are exposed so that it can connect with the rest of the circuit. The electrical cord should cost between $10 and $20.

**Heating:**

**Map

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Figure 2 Heating element subsystem design by Bobby Lachambre

This design uses carbon fiber tape, iron-on no-sew hem tape, and silver conductive wire glue. The idea of this design is that an exposed wire is attached to the carbon fiber tape using the conductive glue. The resistance in the carbon fiber should be enough to produce sufficient heat, but low enough that the electrical current will travel throughout the circuit. The hem tape will keep the carbon fiber attached to the mat. The carbon fiber should cost $6/ft, the glue should cost $12.30/mL, the hem tape should cost $7.53/30ft.

**Mat:**

**Map

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Figure 3 Mat subsystem design by Bobby Lachambre

This design has a mat made with rubber on the bottom and texturized polyester on the top. The polyester has a melting point of 220◦C, well over any temperature that it would be exposed to. The polyester is also textured for safety so that there is more traction for people that walk on it. The rubber has a melting point of 180◦C, also more than acceptable for this project. A 3ft x 4ft mat with these materials retails for $15.

Conceptual Design Two

**Top Material :**

On the top, the surface is rough enough to walk on without risk of falling. The central heating system is covered by a material that can transfer heat well, and compactly distributes it uniformly. The space between the top surface and the heating system is tight to transfer energy efficiently. At the bottom, there is a grooves on the base to hold up the heated energy, which prevents energy diffuse to the ground.

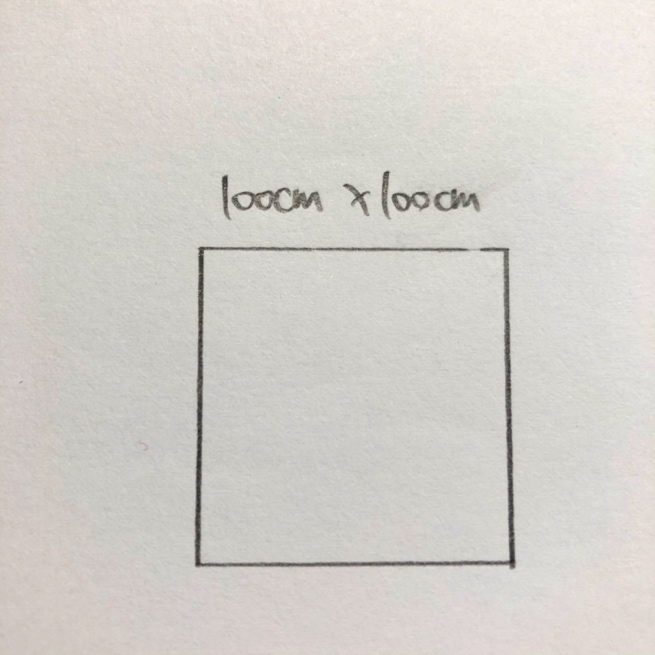


Figure 4 Top view of sidewalk by Yalin Tuo

In this conceptual design, the heated sidewalk is a square shape with 100 centimeters long side length, we can change the size to fit the road shape. Also, the top should be made of highly frictional material because we need to store it. The rough sidewalks surface also prevent people get falling.

**Inside:**

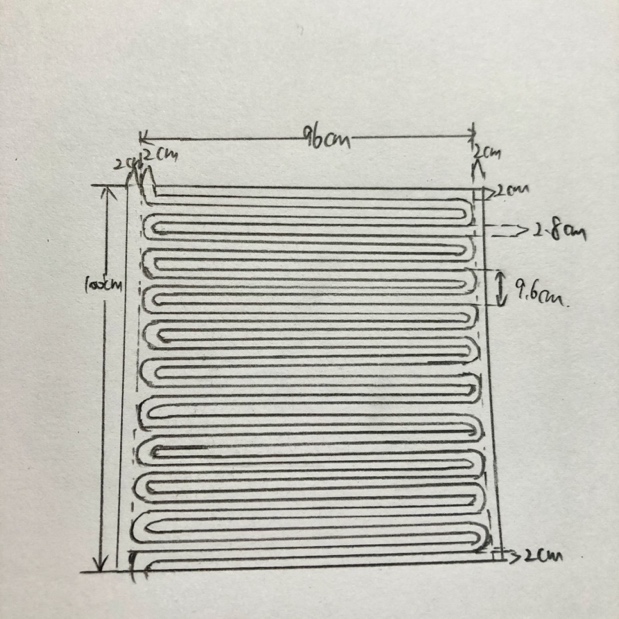


Figure 5 Inside Design for Sidewalk by Yalin Tuo

The turning line is the pipes. The heated pipes are 2 centimeters in diameter. The space between turning pipes is 2.8 centimeters long, which means from the first turning point to the next is 9.6 centimeters long. And the gap between lines and the outer edge, both left and right, is 2 centimeters, which is the same value of space between the top surface and the centrally heated pipes. In fact, there are two joints to connect other modular sidewalks. The length and size can change based on the road shape. The joints can transfer the power to other segments. This heated system has no secondary or extra power to assist. As the pipes break, we must repair the system.

**Gap**

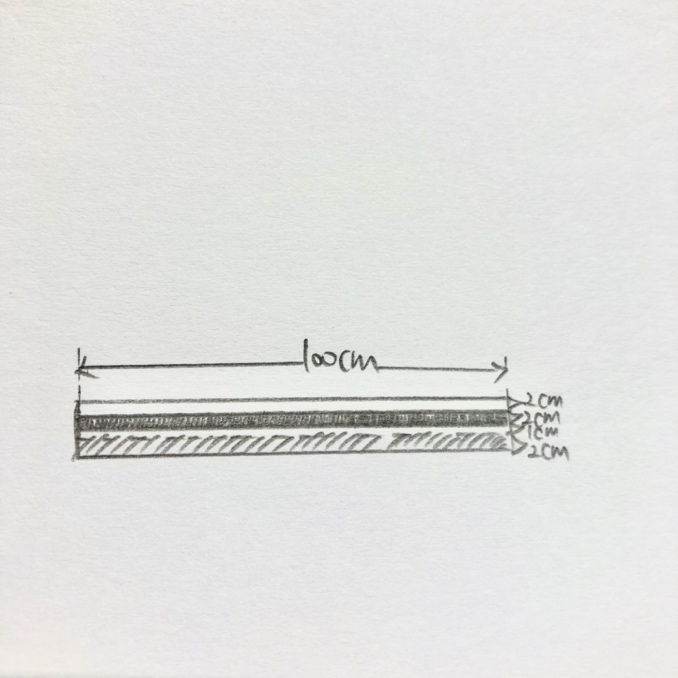
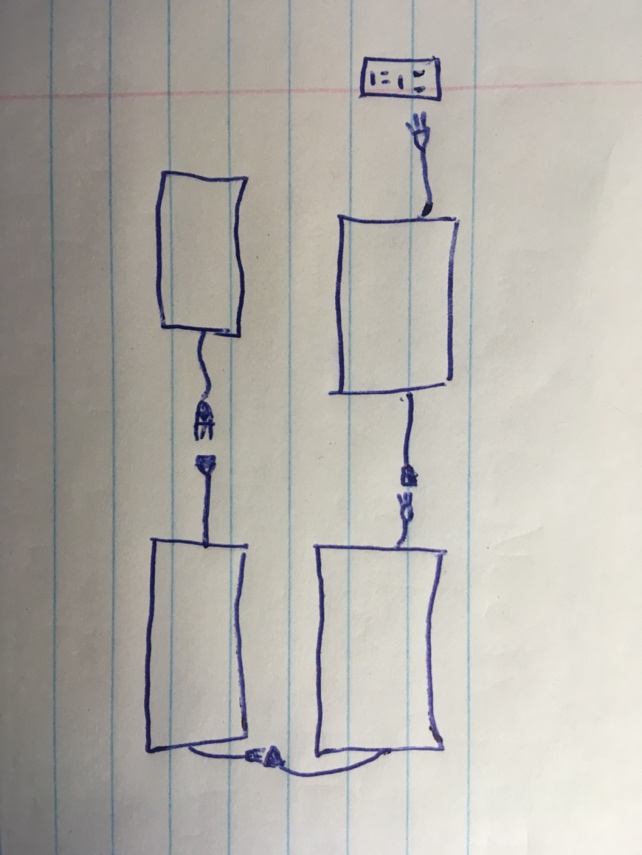


Figure 6 Sideview of the sidewalk by Yalin Tuo

The dark central part is the pipes, and the other part with shade is the bottom cover. We can see that there is a bottom to cover the sidewalk, the gap is 1 centimeter, and this wrap cover is 2 centimeters height 100 centimeters long. This heat protection below the pipes can keep the central energy, which boosts the efficiency of the heated system to melt snow. However, the wrap cover of heat protection will incur extra cost. Since the budget is limited, we might choose this efficient way in a different future design.

Conceptual Design Three

**Power Cord Connectivity:**



**Figure 7 Power Cord Subsystem Design By Kris Keon**

Each mat will have a plug with a male and female end. The mats will therefore be able to be plugged into one another in series. This will limit the number of power outlets and extension cords required to use the mats. The first mat will be plugged into any standard wall outlet. Then the electricity will travel through the heating coil of the first mat into the female ended cord. This cord will then be plugged into the cord of the second mat and the process repeats itself. Further research will have to be done to determine the load of each mat and therefore the number of mats that can be connected in series to one power outlet without exceeding the maximum load of the outlet.

**Connecting Tabs:**

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**Figure 8 Connecting Tabs Subsystem Design By Kris Keon**

Each of the mats as well as having connecting power cords should also have connecting tabs. This way you are able to connect all of the mats on a sidewalk to make one uniform walkway. The tabs can be a T-shape. This will make them easy to assemble and disassemble but still making them very secure. Adding connecting tabs like this will ensure that all the sections remain together and that there are no gaps between sections making it safer for pedestrians and a lot more accessible for wheelchairs and strollers.

**Anti-Slip Textured Surface:**

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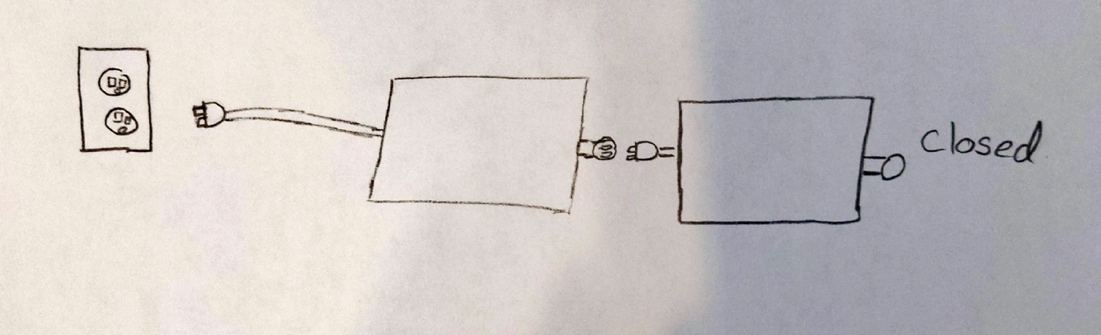
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**Figure 9 Textured Surface Subsystem Design By Kris Keon**

The mats will have an anti-slip textured surface. Walking on the sidewalk in the winter can be very hazardous as the water and ice can make things very slippery. The mats could be very wet as they are melting the ice and snow, so it is vital to make the surface as grippy as possible. For this the mat should have a textured surface that can both channel the water and provide traction.

Conceptual Design Four

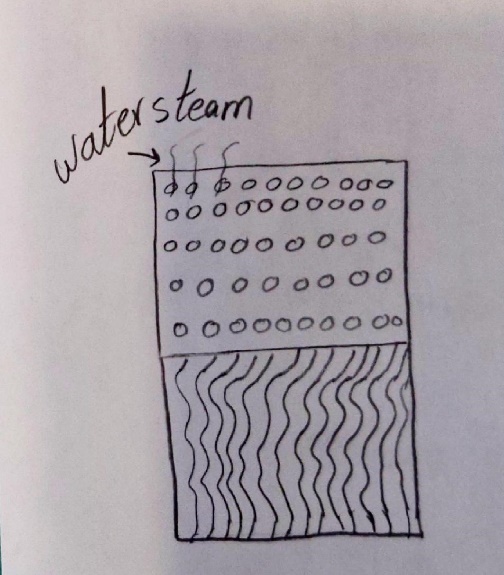
**Power:**



**Figure 10 The power system designed by Verina Tawadros.**

This power system is designed to make all the elements (Mats) connected together to transfer the electricity to all the mats which contain male and female plugs. However, the wire itself is strong and it does not affect by snow, water, or temperature. At the last mat, the plug will be closed in order to not make it danger. The average electricity is 2.5 ampere.

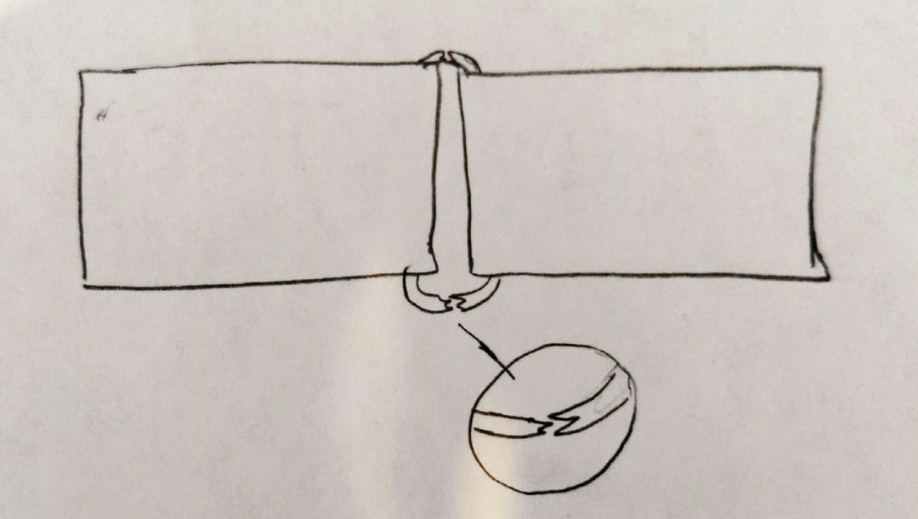
**System inside:**



**Figure 11 The system inside the Mat designed by Verina Tawadros.**

The system inside it is designed to be electric system which produce heat to let the snow melt once it falls on this mat which will melt snow at a rate of 2" (5 cm) per hour, accounting for even the heaviest storms. Also, there are small holes that let the water from the melted snow evaporates right off the mat, as sometimes water on the surface in a cold temperature becomes ice which is more dangerous than snow.

**Surface and Installation:**



**Figure 12 The surface and installation designed by Verina Tawadros.**

The surface is roughness to prevent slip that will make the walking on it more easier and safety. The modular heated sidewalk is consisting of several mats that connected by each other as it is shown in figure 12. There is not needed to install it; just fixed on the ground, stairs or any surface by pressure and it is easy to remove.

# Benchmarking Designs

# Upon doing some research an existing walkway heater was discovered. This product is made by *HeatTrak®* and is called *Outdoor Snow & Ice Melting Heated Walkway Mat 1/2" Thick 2' x 5' 120 Volt Black* [1]. This product is very similar to what group 13 is designing. The *HeatTrak®* heated walkway is a rollable mat that is spread out on a walkway or sidewalk and then plugged into the wall to power the electric coils in the mat in order to melt the snow. This is a good product but there are a few faults that will be improved in group 13’s design. These include allowing the mats to be plugged into one another in series, using a different heating element and making the mats connectable.

# Taking the ideas from each individual in the group, new designs for the sidewalk subsystems need to be designed. A subsystem for the power source and modularity of the sidewalk will be design such that it utilizes a GFCI to ensure safety. It will also use a “T” shape so that individual mats can be put together easily, and the electrical cords will have a male-female connection on the sides of each of the individual mats. The middle heating section of the sidewalk will be comprised of carbon tape with an electrical current running through it set up in a coiled design to maximize surface area covered. The carbon tape will be able to be connected to from both ends of the sidewalk. The mat top and bottom materials will be made of polyester and rubber respectively. The polyester will have a horizontal zigzag pattern to maximize friction and well as be able to allow water to roll off. The rubber will have grooves to increase friction against the concrete and lower contact area to minimize heat transfer to the ground.

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# Decision Making

Chosen Subsystem Designs

**Power and Modularity:**

Diagram, schematic

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Figure 13 Power and Modularity subsystem

This design utilizes a ground fault circuit interrupter which is imperative as the modular sidewalk will be deployed outdoors. The GFCI will shut off the power to the wire when it senses an imbalance between outgoing and incoming current. This will ensure safety as power will be halted if the wire comes into contact with water. This is standard for electrical appliances used outdoors and the university buildings should already have this infrastructure in place. The wire in the design is a standard electrical/extension cord that has been manipulated so that the wires that carry the current are exposed so that it can connect with the rest of the circuit. The electrical cord should cost between $10 and $20. The individual mats are fitted with “T” shapes in order to be able to connect easily to one another. The mats also connect with a male-female connection at the sides of each individual mat.

**Heating and Middle Section:**

Diagram, schematic

Description automatically generated

Figure 14 Heating and Middle Section Subsystem

This design uses carbon fiber tape, and silver conductive wire glue. The idea of this design is that an exposed wire is attached to the carbon fiber tape using the conductive glue. The resistance in the carbon fiber should be enough to produce sufficient heat, but low enough that the electrical current will travel throughout the circuit. The carbon fiber should cost $6/ft, the glue should cost $12.30/mL. The wires have the ability to connect to both ends of the tape. The subsystem is set up in a coil design so that surface area is maximized.

**Mat Materials and Textures:**

Diagram, schematic

Description automatically generated

Figure 15 Mat Materials and Textures Subsystem

This design has a mat made with rubber on the bottom and texturized polyester on the top. The polyester has a melting point of 220◦C, well over any temperature that it would be exposed to. The polyester is also textured for safety so that there is more traction for people that walk on it. The rubber has a melting point of 180◦C, also more than acceptable for this project. A 3ft x 4ft mat with these materials retails for $15. The top has a horizontal zigzag pattern in order to maximize friction as well as be able to send moisture to the sides, and off of the mat. The bottom has large horizontal grooves in order to maximize friction as well as minimize contact and heat transfer with the ground.

# Conclusions and Recommendations

We will be moving forward with the designs as specified in the *Decision Making* section. The designs were made keeping in mind all of the concepts generated by each of the individual group members. The new designs move forward with the best aspects of each individual design and are optimized to be effective and realistic to produce.

It is recommended that research and tests are done continually to ensure that the current designs are still optimal for what the group can produce. We will continue to look for new developments in the industry and will generate new ideas in order to keep our designs on pace to compete.

# Future Work

Further research must be done into the fabrics of the mat to ensure that we are making the most cost-effective mat that still solves the problem. In this same vein, research must be done on the heating element and how the resistance heating will work. This may require both theoretical and physical research and testing. We must also look into the effects that the modularity will have on the power of the sidewalk circuit and may need to test an actual prototype to be certain that the modularity is functional.

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