Project Deliverable G – Prototype II and Customer Feedback

GNG1103

Group 13

Bobby Lachambre, Kris Keon, Verina Tawadros, Yalin Tuo

March 14th, 2021

Introduction:

This document is the second document covering one of the many iterations of prototypes that our team will be doing. Here we will outline our plan for this specific prototype, the objectives that we hope to be met with it, and the stopping criteria for these tests. This prototype is a prototype of the heating element of the modular heated sidewalk. We will also go over photographs of this prototype with descriptions for needed detail and clarification. One section will provide an analytical model of the heating element. This model will provide needed scientific data to ensure that our prototype will function properly in theory. Finally, feedback from the previous meeting with the client is provided in order to keep track of the evolution of our design, and some of the problems we may need to address.

The previous prototype, which was outlined in deliverable F, tested the traction that is possible on the polyester top layer of the mat when wet and in freezing conditions. It was determined that sufficient traction was there and that this is an acceptable material design to bring forward to the final prototype.

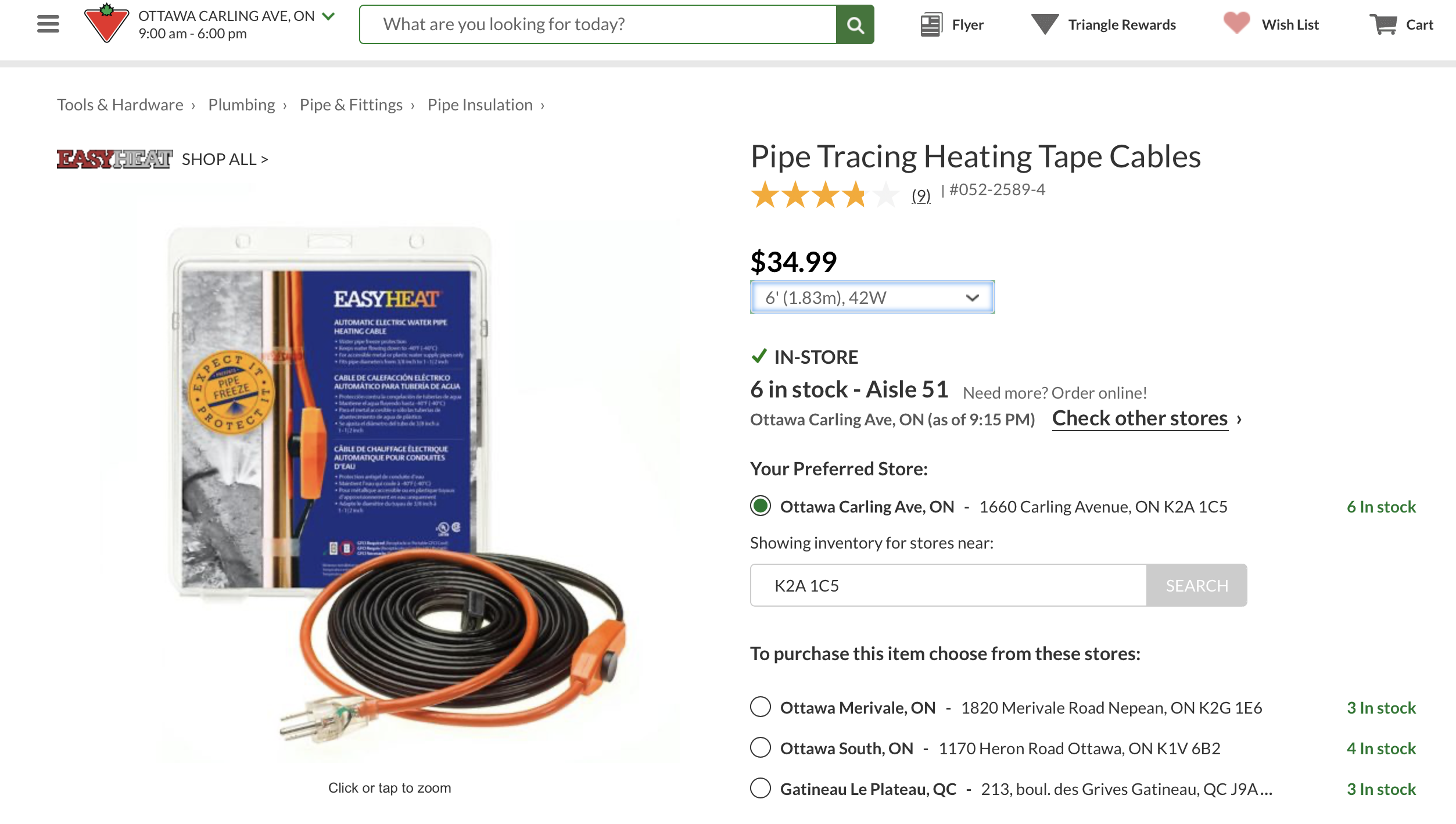
Second Prototype Testing Plan:

The second prototype is the heating element that will be used within the modular heated sidewalk. This prototype will consist of resistance heating wire set up in a coil, attached to an exposed wire from an extension cord with conductive wire glue. The idea behind this design is that the resistance wire will produce heat due to resistance when an electric current is running through it. The conductive glue will attach the exposed wire to the resistance wire and allow the current to pass through.

The objective for this prototype is to be able to heat up sufficiently such that it will allow the mat to reach above-freezing temperatures, even when the environmental temperature is around -25°C. This is required in order to be able to melt snow at the same conditions that the current product being used, salt, can. In order to do this, the correct length of resistance wire must be used in order to produce an optimal temperature. We also must ensure that the design that we have chosen is functional. The test will be over once the tester has determined that the wire heats up sufficiently, and if they can, test that it can reach positive centigrade temperatures in frigid weather.

Prototype and Description:

From the last prototype, we successfully created a model of the sidewalk top. The top section, which is rough, provides friction for people to walk-on. We will replace it with the mat in our final product. Also, we distribute the heated wire as a coil shape so that the heated energy will spread broadly.

For this week's prototype we were going to build the heating coil for the mat, but not all the parts have been shipped yet and the heating wire that they set is way smaller than what we need for the mat. Further brainstorming was done and instead we might purchase pipe tracing heating tape cables to use as the heat source. 

<https://www.canadiantire.ca/en/pdp/pipe-tracing-heating-tape-cables-0522584p.0522584.html?gclid=CjwKCAiA4rGCBhAQEiwAelVti0HW7QJYL6c9Gy1YoY6aXVLx7_TE_oBAPuUmZ750ZVSf---G_BoEpxoCLaUQAvD_BwE&gclsrc=aw.ds>

This will work very well as it is used to keep pipe from freezing in the winter and will therefore do the same for our sidewalk. We will snake the cables back and forth in the mat. There is also a built-in thermostat that will tell the temperature of mat and ensure that it stays above freezing temperatures. The heating cable will therefore turn off on warm days and this will save energy.

Analytical Model:

The heat energy of the prototype is created by current flowing through the resistance wire. We can get power by P=V\*A. The power can be used for heat energy transfer. We need to find the total energy that the heated system created and the energy that melting the snow will use. We know that 1 watt equals 1 Joule per second (1W = 1J/s). To determine how much power applies to heat (Q=C\*m\* △T), we will need to measure a certain snow mass and observe the temperature change during heating. We know the specific heat capacity of snow, then we can calculate the heated energy.

The current of the extension cord is 13 Amps, and the standard voltage in Canada is 110V. The heat that we can get is 1430 watts of heat energy (110V x 13A = 1430 W). The heat energy will transfer to the top mat, which enables to melt of snow. We must ensure that the wires are utilized in such a way that the power can supply enough heat to melt all snow. Using a 3ft x 4ft mat and the snowiest day in Ottawa, we find a volume of 15.6ft3 of snow in 24 hours or 0.44m3. Using the density of fresh snow 70kg/m3, 30.8kg of snow must be melted in 24 hours. Using a temperature of -25°C, the heat energy required to melt all of that snow is 3221680J. In a 24-hour period of 86400 seconds, 37.29 W is required. The outlets clearly give the capability to supply this. The resistance wire must be selected to have the resistance required to make enough heat which will be experimented with in the physical prototype and subsequent prototypes and deliverables.

Feedback:

The client liked the idea of testing the first prototype by adding water on the matt to check that it is not slippery, but he is wondering if we add more water on the surface as a simulation of snow conditions, will it still have enough traction to be safe to run on.

The client encouraged us to ensure that the end wire plugs are safely closed from the water.

Overall, the client liked our first prototype and how we are planning to use a cheaper material for our project.

Conclusion:

To conclude, the first prototype went quite well, and the client liked the functionality and the simplicity of the design. The heating wire that we ordered is not what we believed it would be so we will either order a different one or use the pipe tracing heating tape from Canadian tire instead. This heating tape might work better as it has a built-in thermostat that will help the mat be more energy efficient as this was a concern the client. For the next prototype, we will purchase the mat and then insert the heating coil into the mat between the top layer and the bottom.

Wrike:

