Raised, Heated Floor for Temporary Shelters and Camping

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PROBLEM STATEMENT

Inspired by stories from the Western North Carolina community and efforts by Bald Creek Relief [1], a nonprofit organization in Burnsville, NC, formed in response to the Helene disaster, this project focuses on designing and building a prototype panel for a modular raised heated platform.

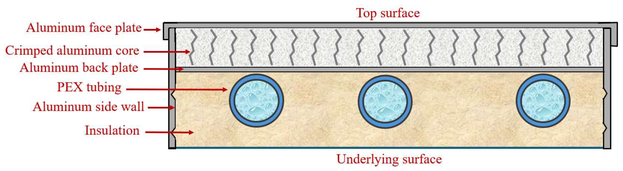
- Create a strong, safe, and cost-effective heating solution for individuals living in tents and other temporary shelters during the colder seasons.
- Key design considerations include creating a modular, environmentally friendly, lightweight, non-flammable, and durable structure.

REQUIREMENTS

Req #	Requirement	Motivation
1	Fire-resistant materials	The product must be safe to use with no/minimal fire-risk.
2	Efficient and long-lasting heat	The product is designed for winter use to keep inhabitants warm during winter temperatures.
3	High insulation	Reducing the rate of heat loss will consume less energy to keep the above structure warm.
4	Strong and stable	Product must be able to withstand a maximum set weight capacity and not move or collapse.
5	Easy to assemble modular/foldable design	For easy shipping, carrying, and assembly.
6	Energy efficient	Energy and heating should be from renewable, environmentally friendly sources to be available where power outages are present as well as reduce global carbon emissions.
7	Lightweight	Reduce shipping costs, open the carrying range for the user, make the assembly process safer.
8	Low-cost	The cost of manufacturing and sourcing the product's components must be as low as possible for the product to be easily distributed and available.

DESIGN

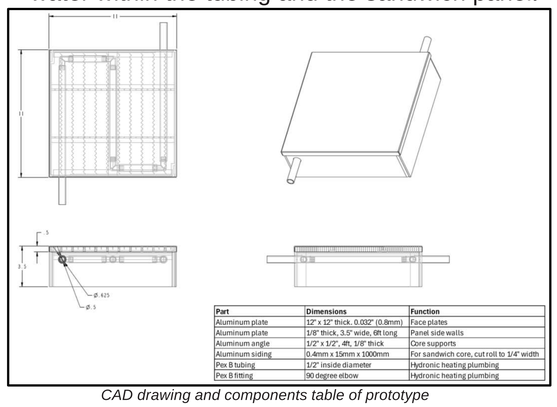
- Mycelium, a root-like structure that is formed from the growth of fungi, was initially chosen as the insulation material due to its high acoustic and heating insulation properties, as well as its low impact on the environment and low thermal conductivity, averaging 0.05 W/m·K [2].
- A sandwich panel design for the topmost layer provides a high strength-to-weight ratio, improved load distribution, reduced weight, and has an increased bending stiffness when compared to a solid sheet of aluminum or steel [3].
- Aluminum was selected for the panel's structure and load-bearing surfaces due to its key advantages, including low cost, lightweight nature, recyclability, and high thermal conductivity.



Cross section of prototype design

FINAL DESIGN: PROTOTYPE

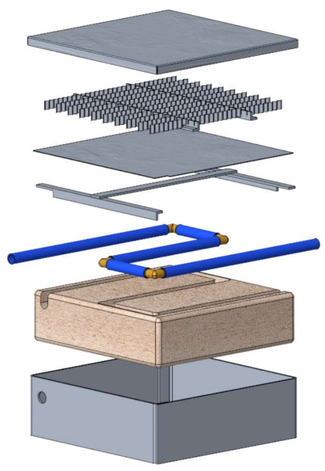
- An 11"x11"x3.5" prototype was built using aluminum for the frame, sandwich panel, and surfaces.
- Aluminum tape was wrapped around the PEX tubing to increase thermal conductivity between the tubing and sandwich panel.
- Heating compound was applied between the wrapped tubing and the underside sandwich panel for additional contact between the heated water within the tubing and the sandwich panel.



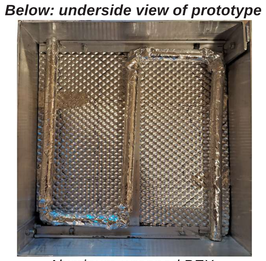
Part	Dimensions	Function
Aluminum plate	12" x 12" thick, 0.032" (0.8mm)	Face plates
Aluminum plate	1/8" thick, 3.5" wide, 6ft long	Panel side walls
Aluminum angle	1/2" x 1/2", 4ft, 1/8" thick	Core supports
Aluminum siding	0.4mm x 15mm x 1000mm	For sandwich core, cut roll to 1/4" width
Pex B tubing	1/2" inside diameter	Hydronic heating plumbing
Pex B fitting	90 degree elbow	Hydronic heating plumbing

CAD drawing and components table of prototype

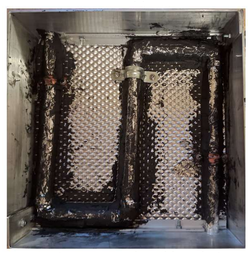
Below: underside view of prototype



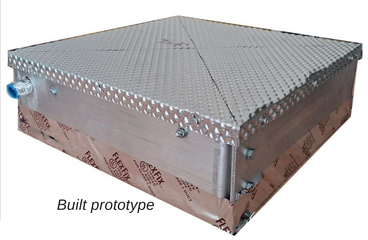
Exploded view of prototype design



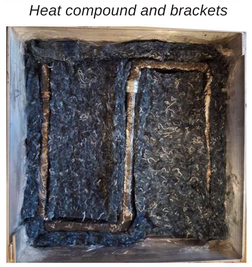
Aluminum-wrapped PEX



Heat compound and brackets



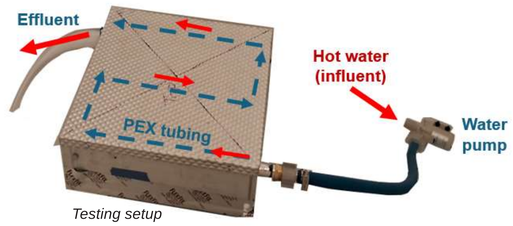
Built prototype



Layer of cotton insulation

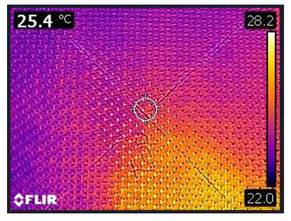
TESTING & RESULTS

- Testing was performed using a small 2 gpm water pump placed in a tub of hot water.
- Three temperatures were recorded: hot influent water, the top surface of the panel, and the ambient air temperature.
- A laser temperature gun and digital thermometer were used to measure the heated water, panel surface, and ambient temperatures.
- A thermal imaging camera was used as an additional visual aid during testing.



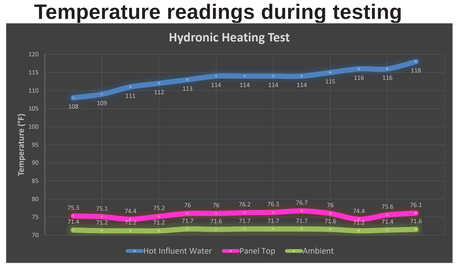
Testing setup

Early testing using spray foam for insulation (no heat compound or aluminum-wrapped PEX)

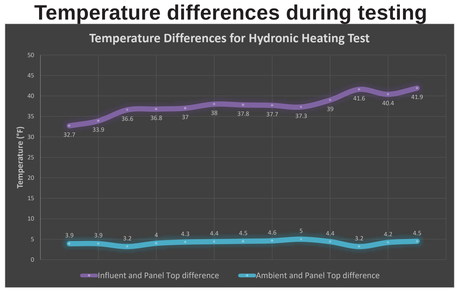


Final testing using cotton insulation, heat compound, aluminum-wrapped PEX, and water pump.

Temperature readings during testing



Temperature differences during testing



SUMMARY AND CONCLUSIONS

- This Capstone project took place during the Spring 2025 semester only.
- Mycelium initially yielded a promising insulation material for this project; however, the results of the growth experiments were not successful and therefore cotton insulation (another eco-friendly option) was chosen as a last-minute option.
- Temperature measurements from single testing event are not sufficient to show relationship between influent water temperature and panel's surface. This was due to the inability to increases the temperature of the tap water in the tub for testing.

FUTURE WORK

- Additional testing using hotter influent water would be beneficial in observing the actual temperature differences and heat transfer of the hydronic heating system and panel prototype.
- Design a load-bearing full-sized modular panel.
- Design the real-world hydronic heating system.
- Design the interlocking mechanisms of the PEX tubing and joints between each modular panel.
- Research and test other environmentally friendly insulation materials.

TEAM & ACKNOWLEDGEMENTS

This research was partially funded by Western Carolina University's Academic Project Grant.
This project would not have been possible without the unwavering effort, encouragement, and support of the project's faculty sponsor, Professor Brett Banther. I am deeply grateful for the opportunity to contribute to a project that has the potential to make a meaningful impact, not only within our local community but also globally, wherever displaced individuals require warm and safe temporary housing.
Inspiration for this research was drawn from the many personal stories shared with me by those directly impacted by the devastation of Hurricane Helene as well as all of the amazing work and acts of kindness witnessed by the many volunteers that took action during this time.

References

1. https://www.baldcreekrelief.com/
2. Gezer, E. D., & Kuştaş, S. (2024). Acoustic and thermal properties of mycelium-based insulation materials produced from desilicated wheat straw - Part B. Bioresources, 19(1), 1348–1364. https://doi.org/10.15376/biores.19.1.1348-1364
3. McMaster-Carr. (n.d.). Sandwich panels. Retrieved February 23, 2025, from https://www.mcmaster.com/products/sandwich-panels/