Group Infrastructures & Structures A, Presents:

Developing Thermal-Controlled Formwork for Winter Concrete Pours

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Project Partner: Traine Construction

Background

A concrete form is a temporary mold that holds poured concrete in place while it hardens and cures. It shapes the concrete into the desired structure, such as a wall, slab, or column. During the curing process, maintaining optimal conditions is crucial for the concrete to achieve its maximum structural integrity. One key factor in this process is temperature, as it plays a significant role in the rate of hydration and the final strength of the concrete.

Concrete cured in -5°C for the full 7 day period can lose up to 41% of its potential strength!

Need Statement & Project Motivation

A way to address the difficulties of ensuring proper curing of concrete for foundation walls in Canadian residential buildings for temperatures below 10 °C, where such temperatures compromise structural integrity, and increase construction timelines and cost.

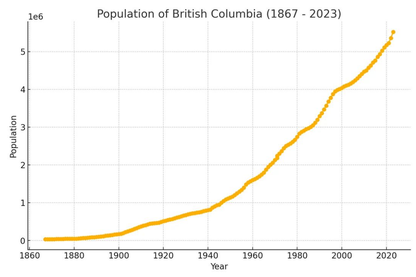


Fig. 1 Population Growth in BC

In 2023, British Columbia recorded a population growth rate of 3.3%, its highest since 1971. To meet the rising demand for housing, our partner Traine Construction and Development is rapidly building multi-unit residential complexes in expanding urban centres like Kelowna.

With construction continuing year-round, winter conditions pose economic, technical, and logistical challenges for concrete placement. Current practices, using tarps and blasting heated air, are energy-intensive and inefficient, leading to significant heat loss.

Our Objectives:

Scope: Design a modular heating system tailored to Peri gang formwork for wall construction, in line with Traine's standard practices

Goal: Improve cost-effectiveness through increased energy efficiency and system reusability

Design Features

To leverage our diverse skills, the team was divided into three groups. Key features developed include:

Technical:
Designed thermal blanket with a hooking system that interlocks to fit form dimensions

Electrical:
Low-power resistive heating cables, drawing only 3.06 A at 120V, consumes 44% less power per unit area compared to similar market product

Material:
Dual-layer combining a polyurethane core and a durable polyester skin. Material sustainability considered through GRANTA screening

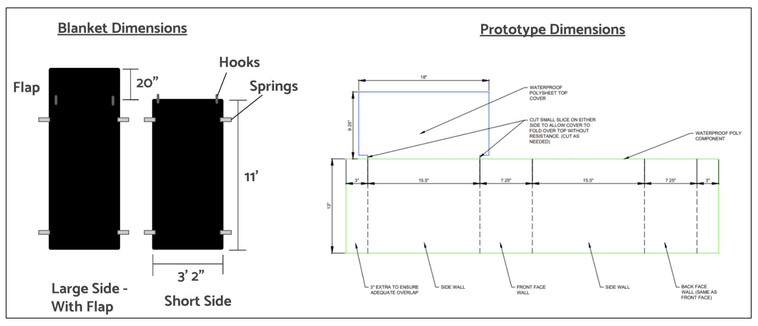
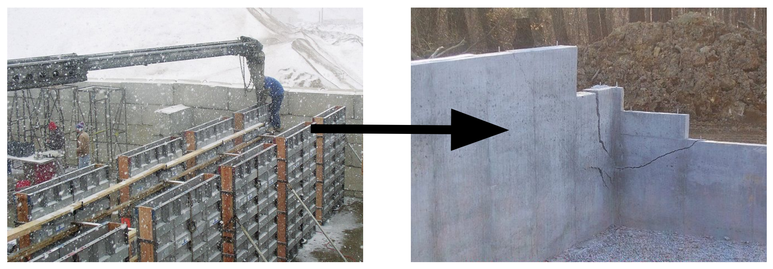


Fig. 2 Product vs. Prototype Dimensions

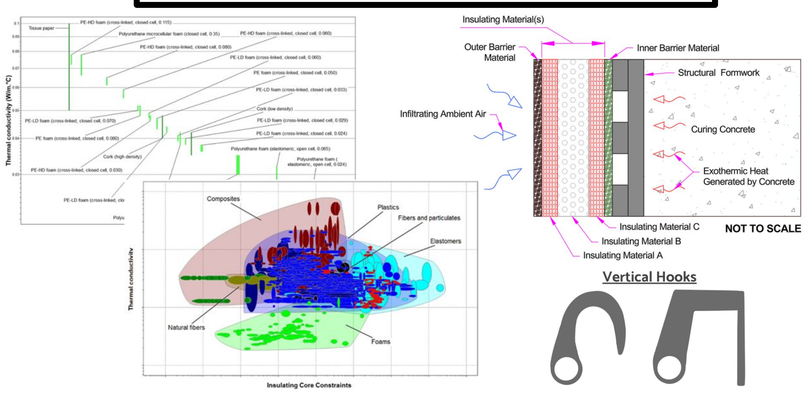
References

[1] Wall Formwork. (2024). Peri Canada https://www.peri.ca/en/products/products-overview
[2] Quarterly Population Highlights. (2024, June 21). Government of British Columbia. https://www2.gov.bc.ca/assets/gov/data/statistics/people-population-community
[3] Husem, M. et al. (2005). The effects of low temperature curing on the compressive strength of ordinary and high performance concrete.Volume 19, Issue 1. Construction and Building Materials. https://www.sciencedirect.com/science/article/pii/S0950061804000893
[4] Jinpeng, D. et al. (2024, July 5). Effects of the Water-Cement Ratio and the Molding Temperature on the Hydration Heat of Cement. https://doi.org/10.1007/s11595-024-2962-y

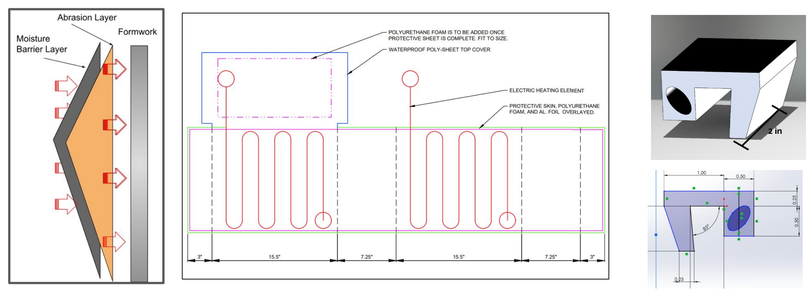
Problem Introduction



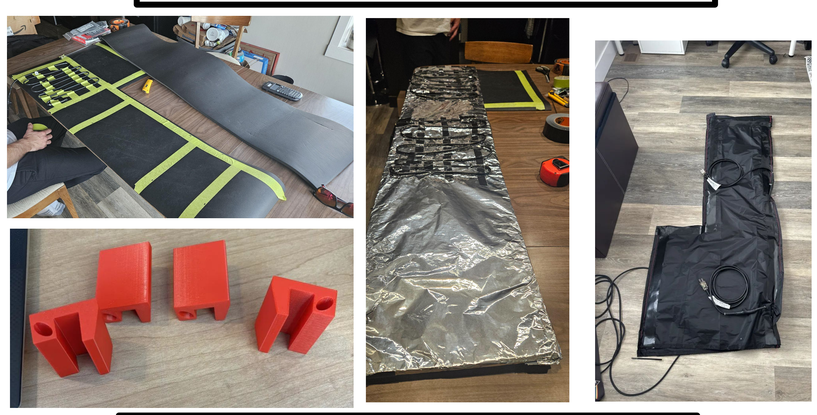
Research & Analysis



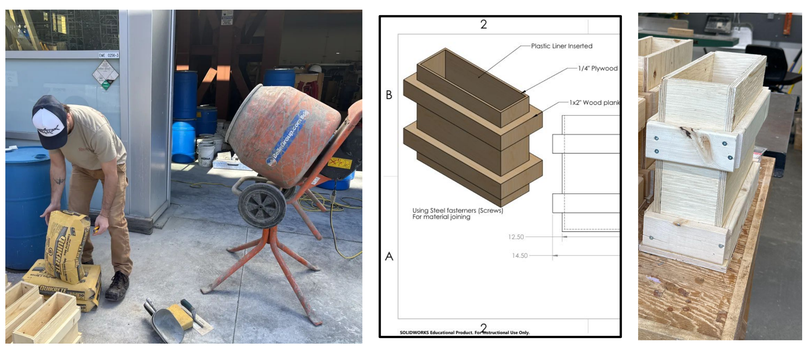
Ideation Phase



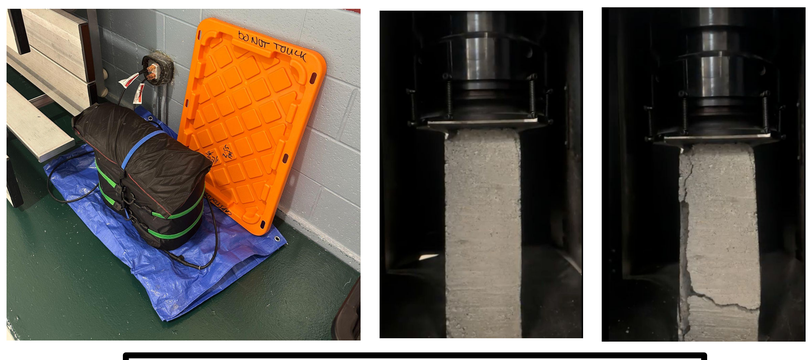
Prototyping



Creating Test Samples



Testing Prototype



Implementation

Product Design

Cost Analysis

Market Comparison

Manufacturing

Methods

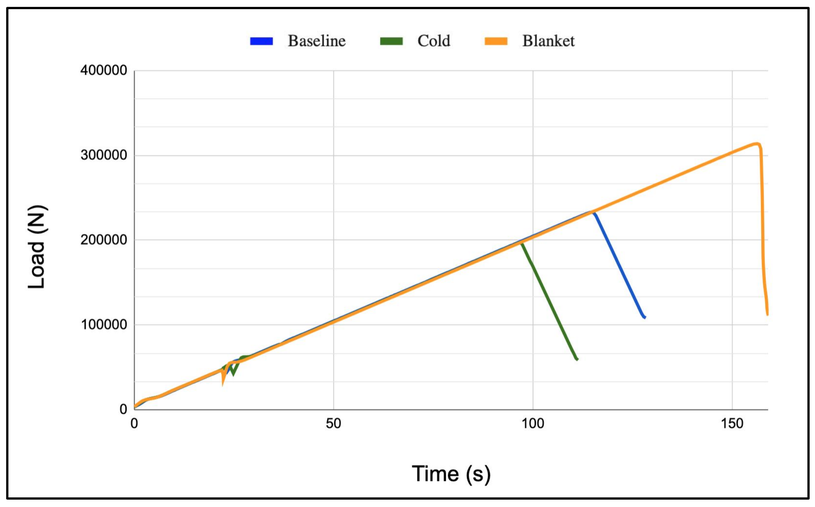
To test the design's effectiveness, we cured three concrete samples identically for 24 hrs, then moved them to different conditions for the remaining 66 hrs, with 90 hrs total cure time.

Concrete Test #1	Concrete Test #2	Concrete Test #3
Baseline Cured at UBC Concrete Testing Facility at ideal temperature and humidity control	**Cold Condition** Cured at Kelowna Curling Club, inside the rink at 4℃, *uncovered*	**Blanket Assisted** Cured at Kelowna Curling Club inside the rink at 4℃, *with prototype applied*

Results

All three samples were tested using the UBC Concrete Lab's Instron compression machine to assess strength differences and evaluate our prototype. A load rate of 2 kN/s was applied until failure.

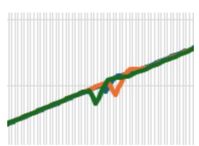
Compressive Test Results



Compressive Test Comparison

	Baseline	Cold Conditions	With Blanket
Surface Area (m²)	0.029715	0.029988	0.029715
Peak Load (kN)	233.0	197.2	313.7
Peak Strength (MPa)	7.84	6.58	10.56
% Difference	---	-15.36%	34.63%

The table shows not only improved strength over the cold-exposed sample, but also a surprising increase compared to the reference sample cured under regular conditions.



The consistent notches in all three tests are attributed to the rubber barrier between the samples and the compression machine.

Conclusion

Our project was a clear success. From day one, the team worked efficiently with the identified problem, developing and testing a solution that produced results supporting our theory and research. We exceeded expectations with the test results and demonstrated the effectiveness of our design.

Next Steps

- Refine cable interior attachment and optimize grid structure based on research.
- Enhance blanket modularity and ensure compatibility with various formwork types beyond wall systems.
- Evaluate manufacturing scalability and cost-efficiency for both small and large-batch production.
- Conduct moisture retention testing on the prototype.

Acknowledgments

We are especially grateful to Traine Construction & Development for their enthusiastic support, guidance, and real-world insights throughout this project. We also thank UBC Concrete Lab for access to testing facilities and to Kathy and Jock from Kelowna Curling Club for allowing us to test our project at the rink.