Metro Vancouver Aerial Photo

UBC x Metro Vancouver Collaboration

DEVELOPING A SUSTAINABLE COATING MATERIAL FOR UNDERGROUND INFRASTRUCTURE

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THE UNIVERSITY OF BRITISH COLUMBIA

metrovancouver

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Part 1:

Metro Vancouver SIF Program

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SUSTAINABILITY INNOVATION FUND

Overview

- Funded by GST rebates
- Staff are encouraged to engage external partners in the development of proposals for sustainability projects
- The SIF Program has launched a number of innovative projects that forward sustainability principles, involving partners from the academic, private sector, and other industries.

Circular Economy / Resource Recovery

Emissions Reduction

Environmental Protection

SUSTAINABILITY INNOVATION FUND

Strategic Benefits

The funds:

- Provide proof of concept funding to develop, validate and de-risk innovation
- Promote cost-sharing with other orders of government and other industries

Innovation success can:

- Yield economic development returns
- Drive entrepreneurship from academic & private sectors
- Advance greater regional prosperity

SUSTAINABILITY INNOVATION FUND

Project Criteria

- ✓ Contribute to the region's sustainability by reducing emissions, protecting the environment and/or advancing regional resilience
- ✓ Demonstrate an innovation or continuous improvement approach
- ✓ Consider partnerships that will lead to innovative solutions to Metro Vancouver's challenges, particularly through applied and/or translational research within the region's academic institutions

Part 2:

Multiphase Composite Coating

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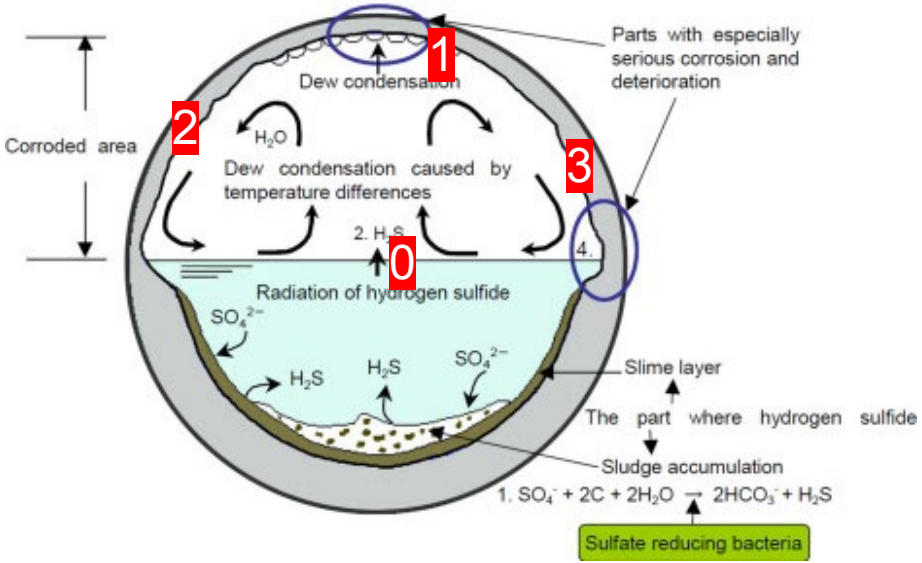
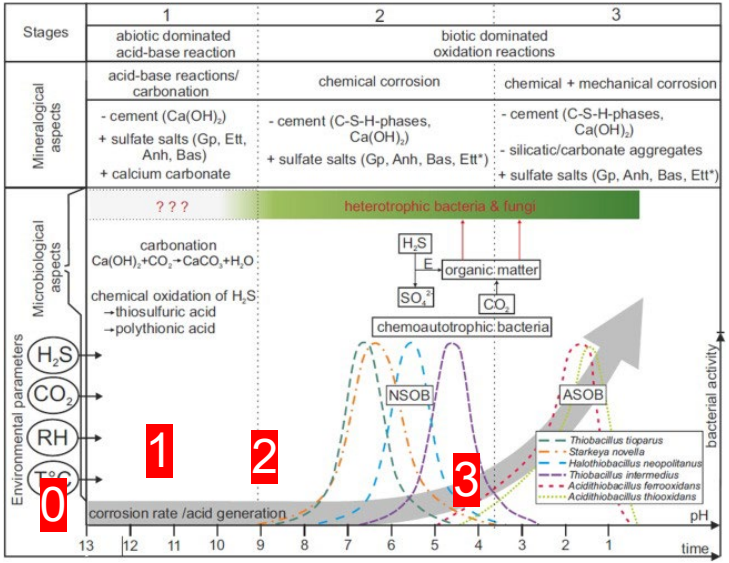
PROBLEM TO SOLVE

Microbial Induced Concrete Corrosion (MICC)

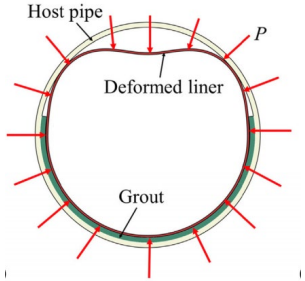


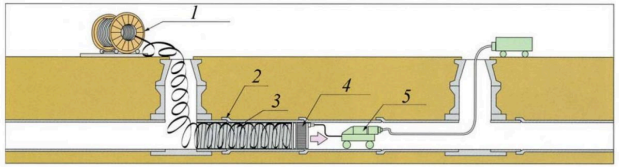


EXISTING SOLUTIONS

But they are not *always* successful

- Replace and remove existing pipes
- CIPPs (1)
- Spiral wound repair
- Shotcrete
- Application of Geopolymers

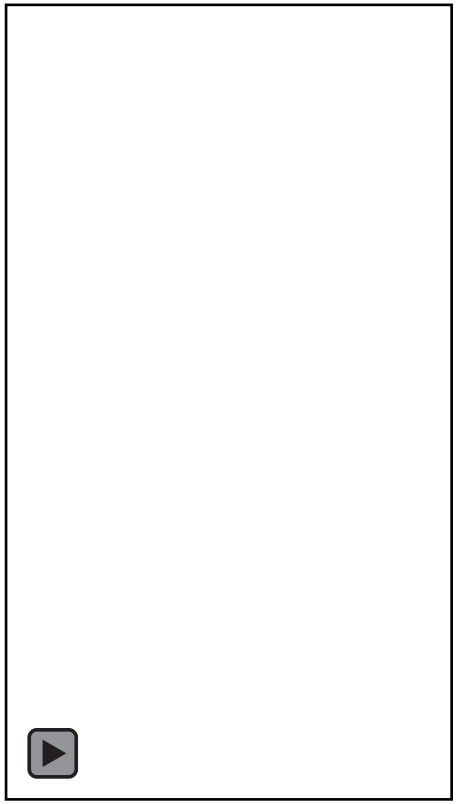




ROLE OF UBC AND MV

Collaboration is key to success

- Metro Vancouver have ideal testing sites
- UBC provides knowledge and learning environment
- Developed alongside around Metro Vancouver
- Industry support from Metro Testing and Engineering



SO WHAT IS OUR SOLUTION?

Sprayable Geopolymer

- Alkali activated materials/geopolymers display many advantages in comparison to OPC based materials
- Make the material sprayable for rapid application
- Only been explored once before with very limited application [2,3]

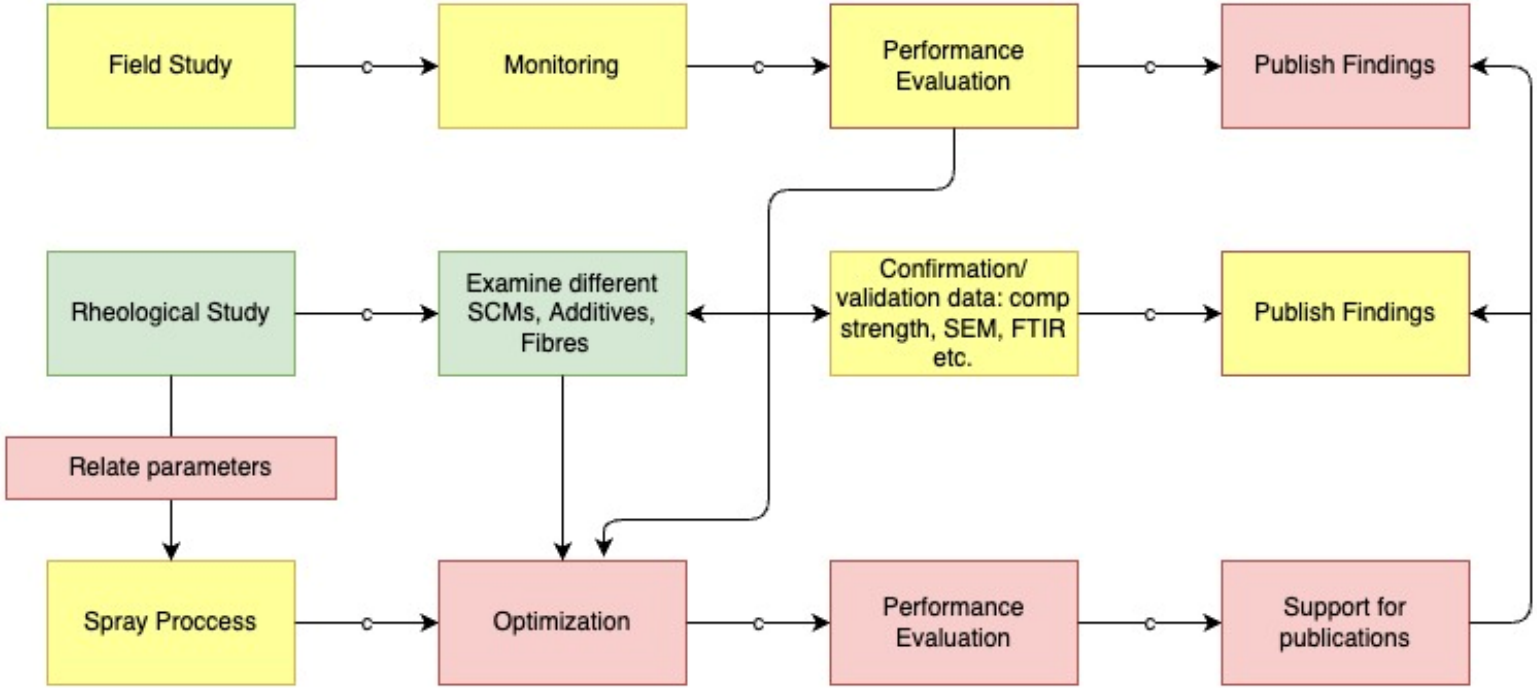
CHALLENGES

Reasons this has not been done before

- Rheological challenges (UBC lab)
- Lack of field study data and effects of calcium (Metro Vancouver)
- Material has not been sprayed before so requires significant work

METHODOLOGY

Three main chapters



CHAPTER 1: FIELD STUDY

Additives

- Testing multiple additives
- Some additives influenced by rheological studies
- Investigating effects of initial coating material

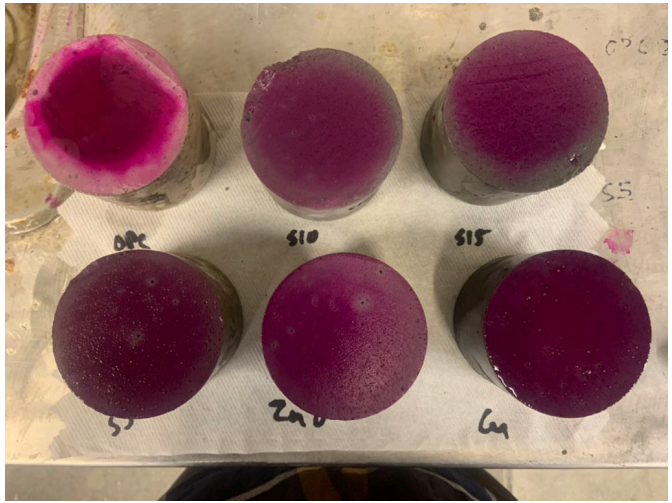
GGBS	5% GGBS
	10% GGBS
	15% GGBS
Heavy Metals	ZnO
	Cu
Xanthan Gum	XG 0.5%
	XG 0.75%
Fibre	Fibre 0.75%
	Fibre 1.1%
	Fibre 1.1%+ XG0.12%
	Fibre 0.5%

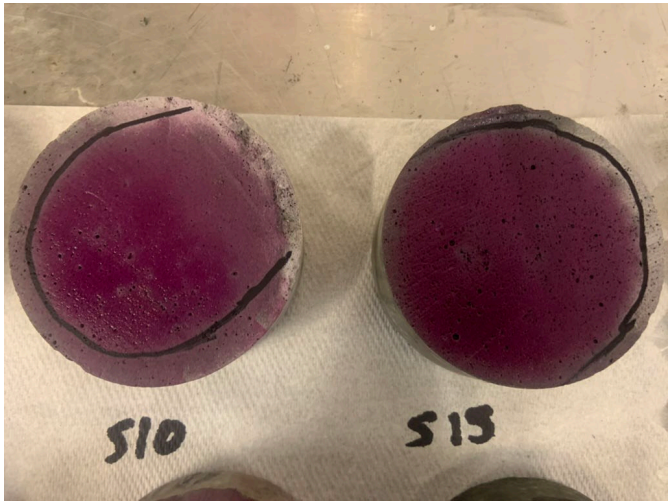
CHAPTER 1: FIELD STUDY

Planning and samples

CHAPTER 1: FIELD STUDY

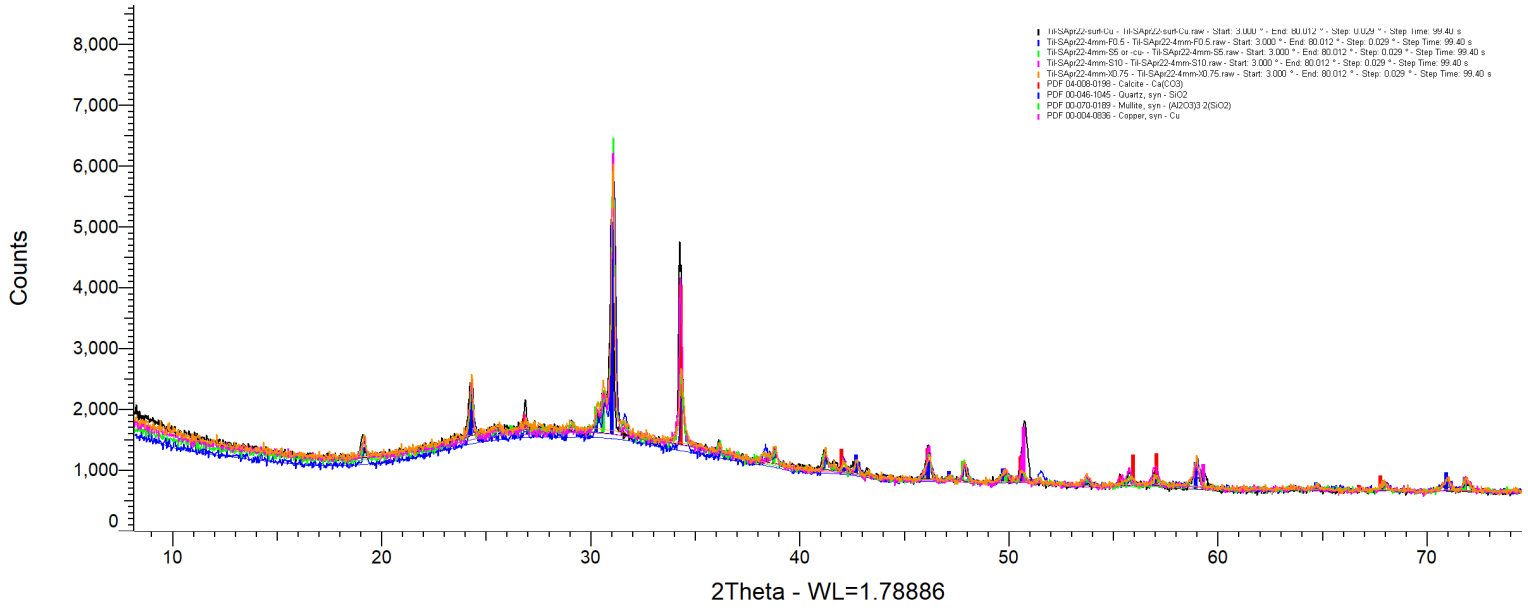
Results to present





CHAPTER 1: FIELD STUDY

Results to present



CHAPTER 1: FIELD STUDY

Results to present

- No significant MIC effects ***yet***

		ph	
Name	**Sample Code**	**surface**	**4mm**
Cement paste	OPC	12.55	12.58
Zinc Doped	Zn	9.18	10.18
Copper Doped	Cu	9.75	10.58
GGBS 5% (control)	S5	10.14	10.47
GGBS 10%	S10	9.49	10.26
GGBS 15%	S15	9.3	9.1
Xanthan Gum 0.5%	X0.5	9.6	10.15
Xanthan Gum 0.75%	X0.75	9.8	10.18

CHAPTER 1: FIELD STUDY

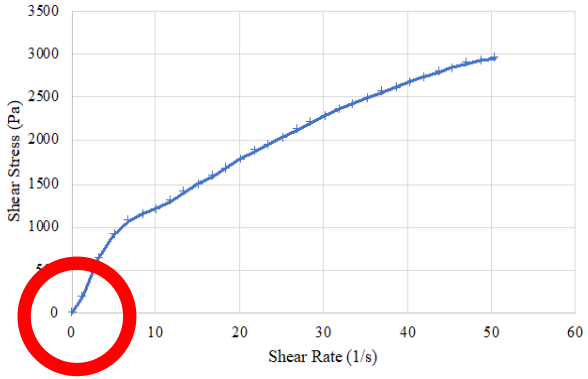
Results up to now

- Test methods developed from Khan[4] and Wu[5]
- Initial results have not provided enough data
- No huge change in samples
- While this means there is nothing interesting to show, it does imply that the materials are working

CHAPTER 2: RHEOLOGICAL INVESTIGATION

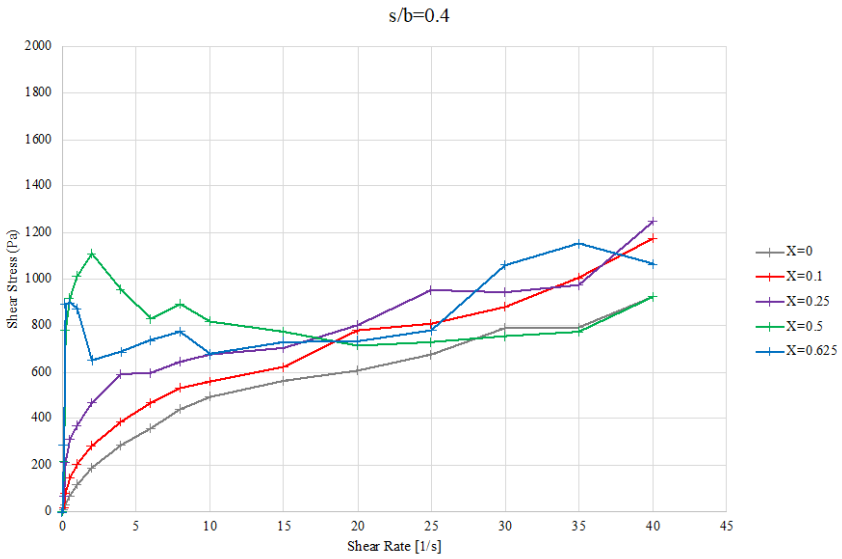
Problems with geopolymer rheology

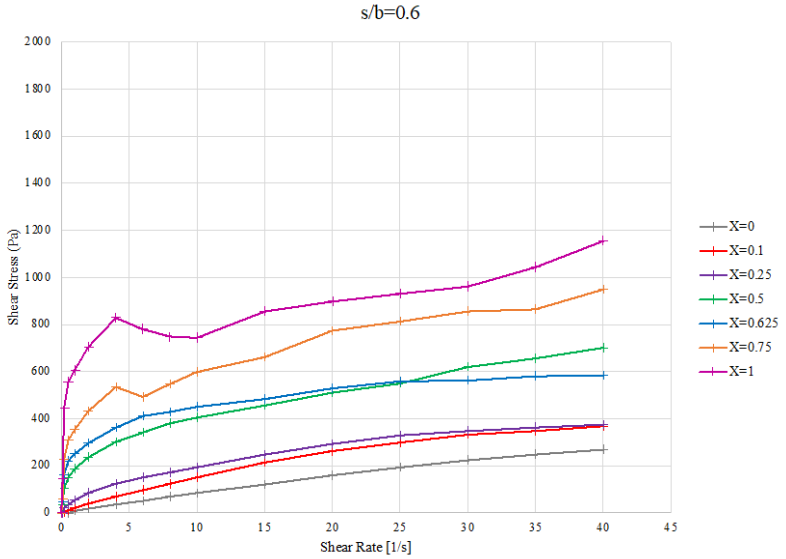
- Key issue with geopolymers is rheology
- They experience shear thinning but **low yield stress**
- High viscosity



CHAPTER 2: RHEOLOGICAL INVESTIGATION

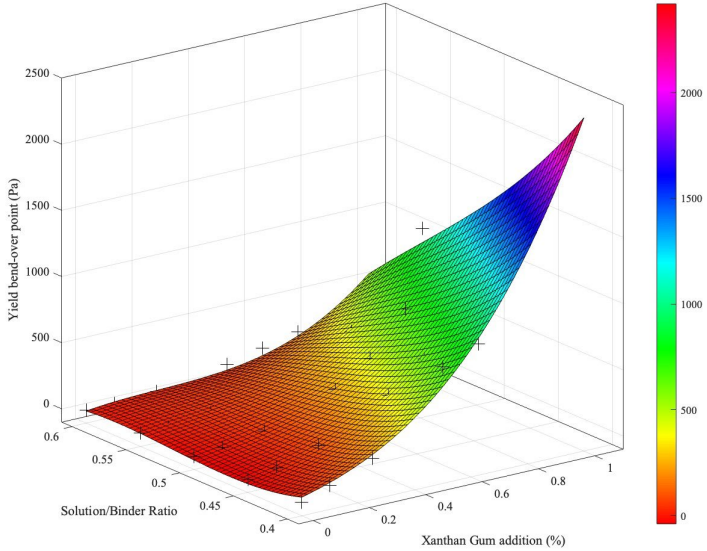
Rheological Modifiers used to increase yield stress

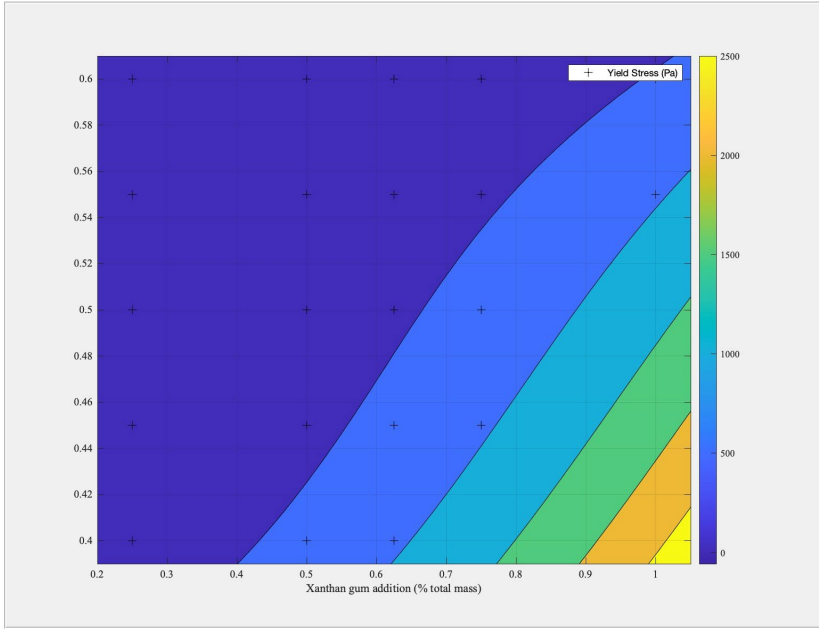




CHAPTER 2: RHEOLOGICAL INVESTIGATION

Rheological modelling

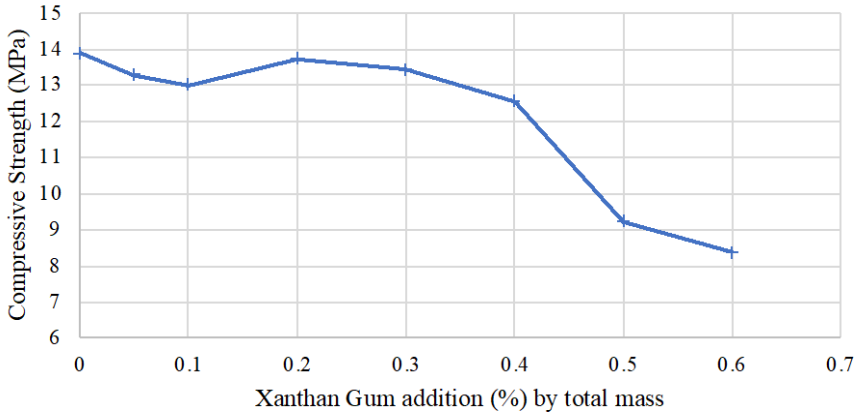




CHAPTER 2: RHEOLOGICAL INVESTIGATION

Influence on compressive strength

- Some negative consequences
- Still to gain understanding of why this is happening



CHAPTER 2: RHEOLOGICAL INVESTIGATION

Plans

- Paper in progress: Use of polysaccharide as a novel rheology modifying admixture for alkali activated materials to be completed over winter
- Additional supporting experiments to be completed
- Inclusion of 3D printing testing

CHAPTER 3: SPRAYING

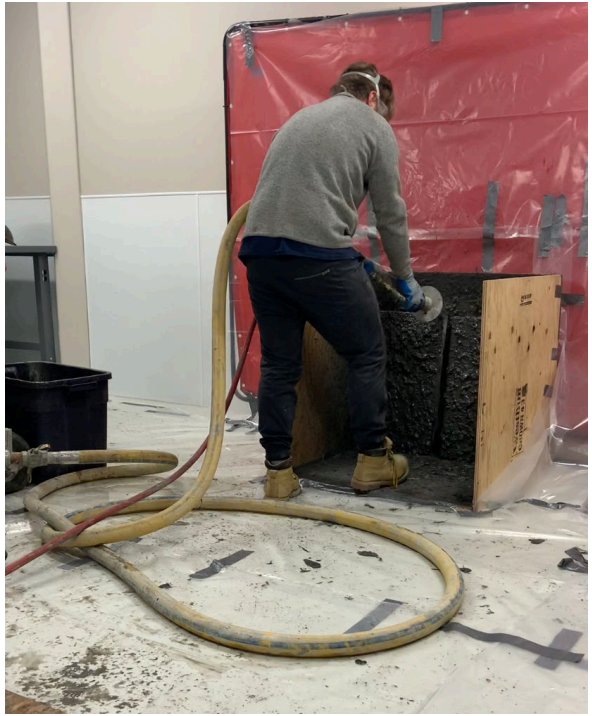
Spray process

- Combine results from previous chapters
- Ensure material is sprayable
- Actualize in field (Metro Vancouver)

CHAPTER 3: SPRAYING

Planned tests

- Initial hopper tests
- Prepare equipment
- Build up thickness
- Strength assessment
- Rebound %
- Pressure loss
- Overhead build up



KEY REFERENCES

Planned tests

(1) Ra K, Sendesi SMT, Howarter JA, Jafvert CT, Donaldson BM, Whelton AJ. Critical Review: Surface Water and Stormwater Quality Impacts of Cured-In-Place Pipe Repairs. J - AWWA. 2018;110(5):15–32.
(2) Milliken Infrastructure Solutions LLC. Structural Testing of Geopolymer Pipe & Culvert Mortar Lining System.
(3) Montes C. Development of a geopolymer-based cementitious coating for the rehabilitation of buried concrete infrastructure. Dr Diss. 2010 Apr 1
(4)Khan HA, Castel A, Khan MSH, Mahmood AH. Durability of calcium aluminate and sulphate resistant Portland cement based mortars in aggressive sewer environment and sulphuric acid. Cem Concr Res. 2019 Oct 1;124:105852.
(5) Wu L, Huang G, Liu WV. Methods to evaluate resistance of cement-based materials against microbially induced corrosion: A state-of-the-art review. Cem Concr Compos. 2021 Oct 1;123:104208.

CLOSING REMARKS

- Work completed under the supervision of Dr. Nemkumar Banthia
- Special thanks to Negar Roghanian

Capilano Reservoir, Metro Vancouver

Thank you

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Together we make our region strong