Evaluation of Adhesion of Cement Based Protective Mortars Overlayed on Corroded Concrete Host

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Outline

- Background
- Aim
- Lining System
- Approach
- Corrosion Classification of Sewer Environment
- Materials and Methods
- Results
- Summary

Background

- Mortar linings such as calcium aluminate cement (CAC) and geopolymers have potential to protect assets from microbially induced concrete corrosion (MICC).

- Use of such linings are limited by lack of performance data.

- Practical guidelines to promote adhesion of the mortars are limited.

Aim

Establish surface preparation requirement to promote mortar adhesion on corroded assets

Assess adhesion of lining mortars over time in live sewers with varying corrosivity

Lining System

Types of Lining:
- CAC (100% CAC/Siliceous aggregates)
- Geopolymer

Surface Repair Mortar

Corroded Host

Field Application Approach

Steps for Rehabilitation

1. Condition Assessment

2. Surface Preparation

3. Qualifying Clean Asset

4. Shotcrete Application of Mortar

5. Finishing

6. Monitoring

Test Beds and Conditions

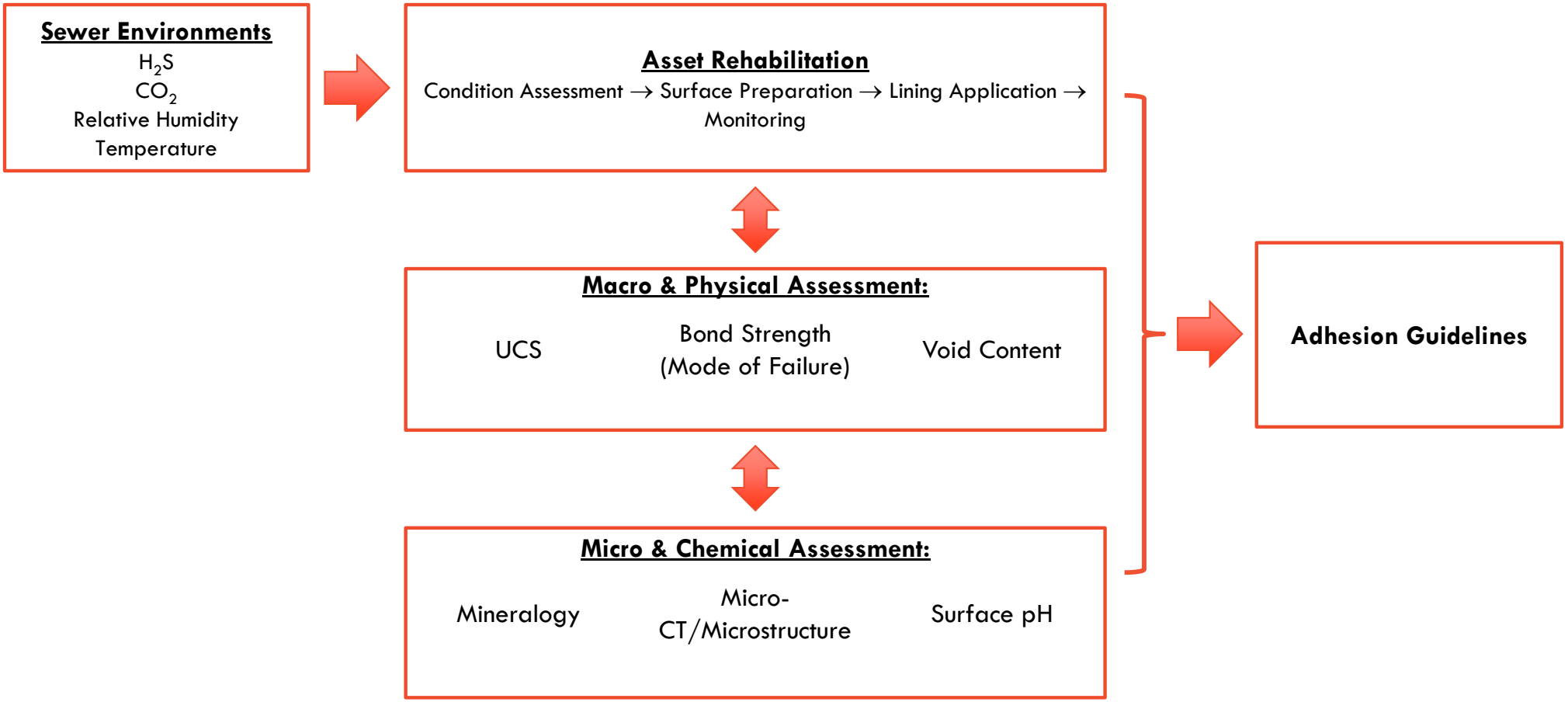
Location	Asset	Asset Age (years)	H_2S (ppm)	CO_2	Temperature (°C)	Relative Humidity (%)
Adelaide Brisbane Melbourne Perth Sydney	Manholes (x14) Pipes (x2)	18-81	1.6-170	2520-13925	15-30	95-99

Corrosion Classification of Sewer Environment

Corrosion Classification	Corrosion Impact	Environmental Conditions			
		H_2S (ppm)	CO_2 (ppm)	T_g(°C)	RH (%)
Category 5	Very High	>155	<2500	15-28	95-99
Category 4	High	135-155	2500-4000	15-28	95-99
Category 3	Medium	70-135	4000-9300	15-28	95-99
Category 2	Low	15-70	9300-9400	15-28	95-99
Category 1	Very Low	<15	9400-9500	15-28	95-99

(WSA 201-2021)

Assessment Approach

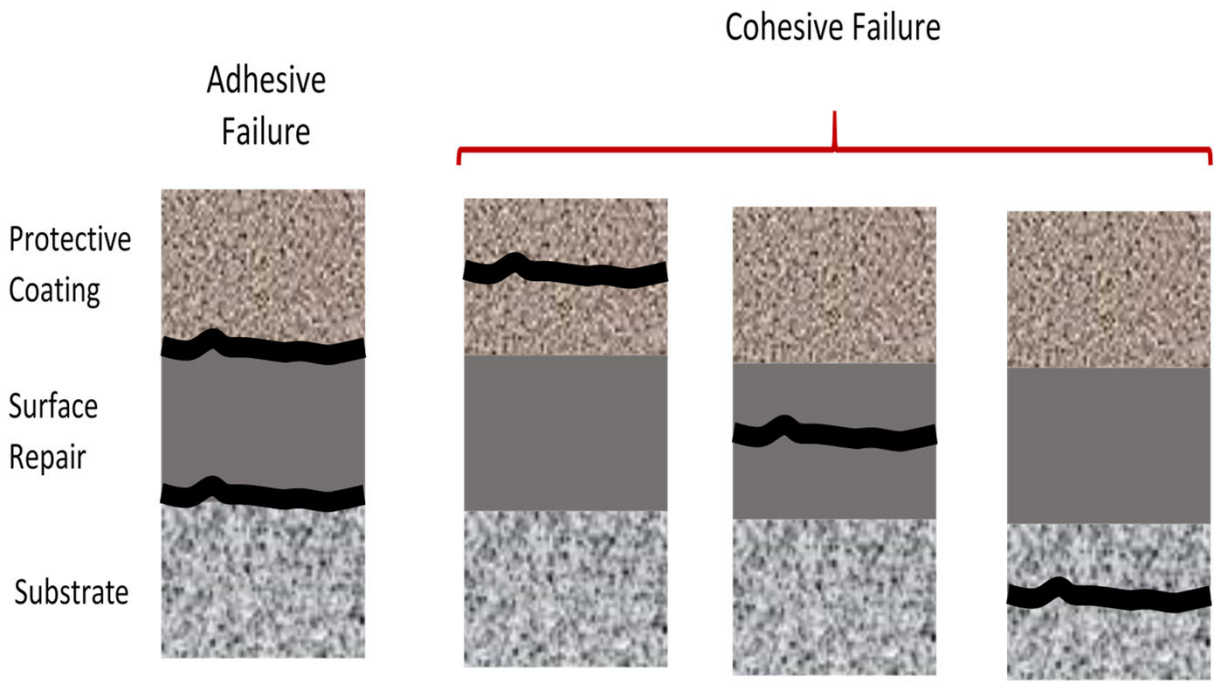


Materials and Methods

Bond Strength Test

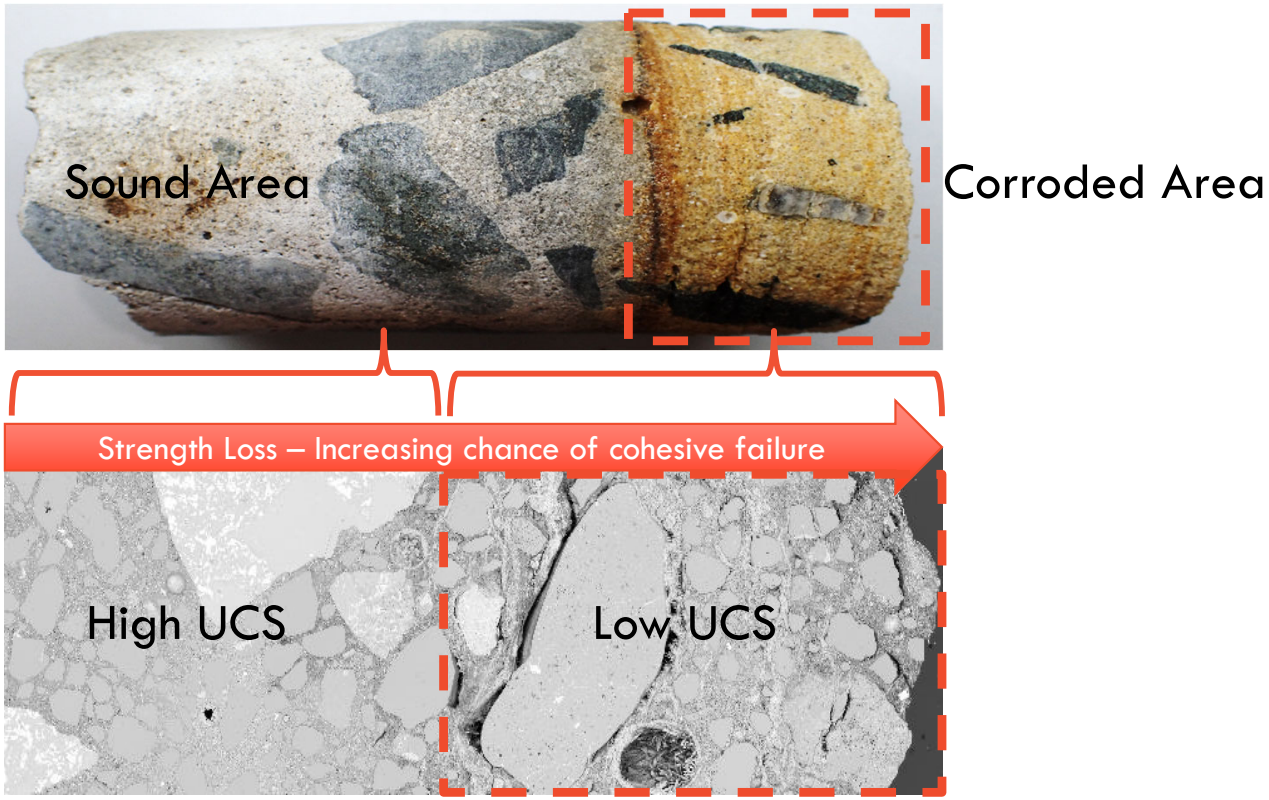
ASTM C1583

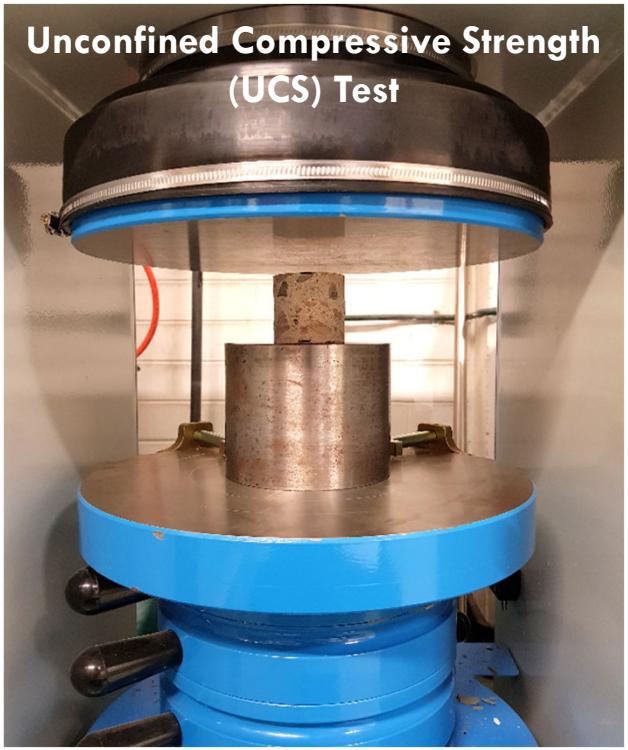
Modes of Failure



Materials and Methods

UCS



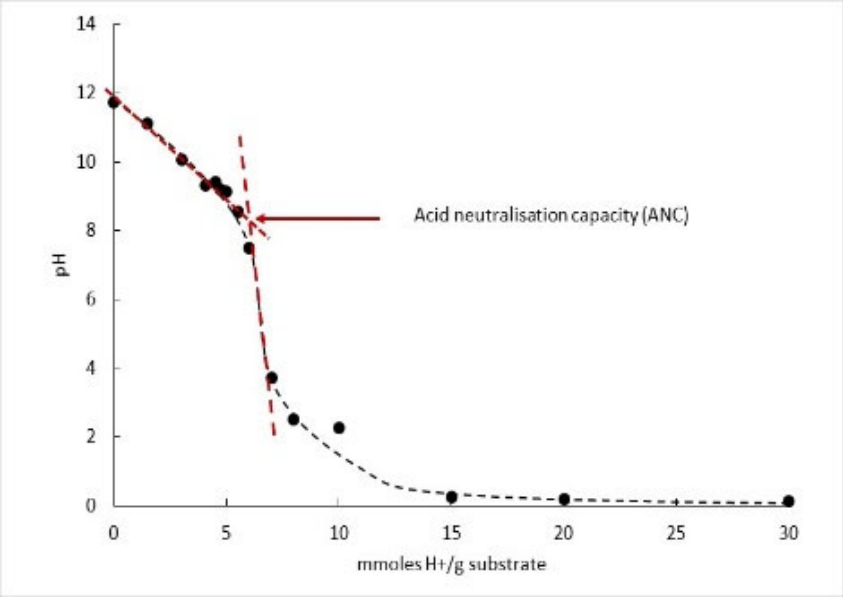


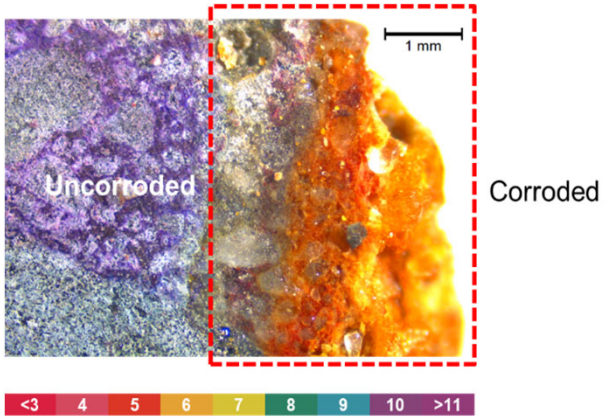
ASTM C39

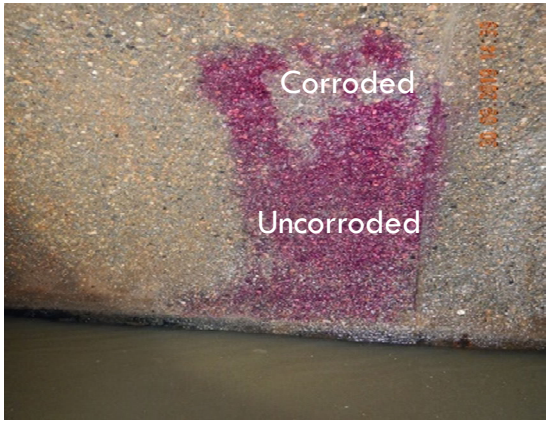
Results

What is Sound Concrete?

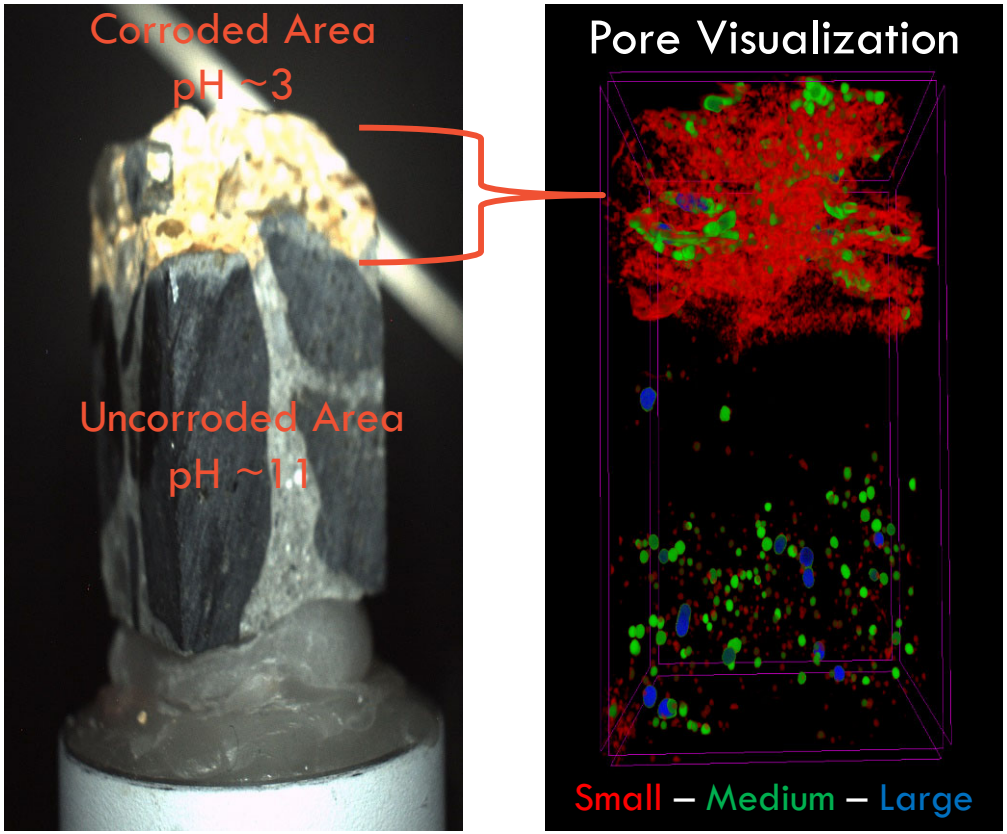
Sound concrete is defined as concrete with pH above 8.0 and has been set to qualify surface preparation.

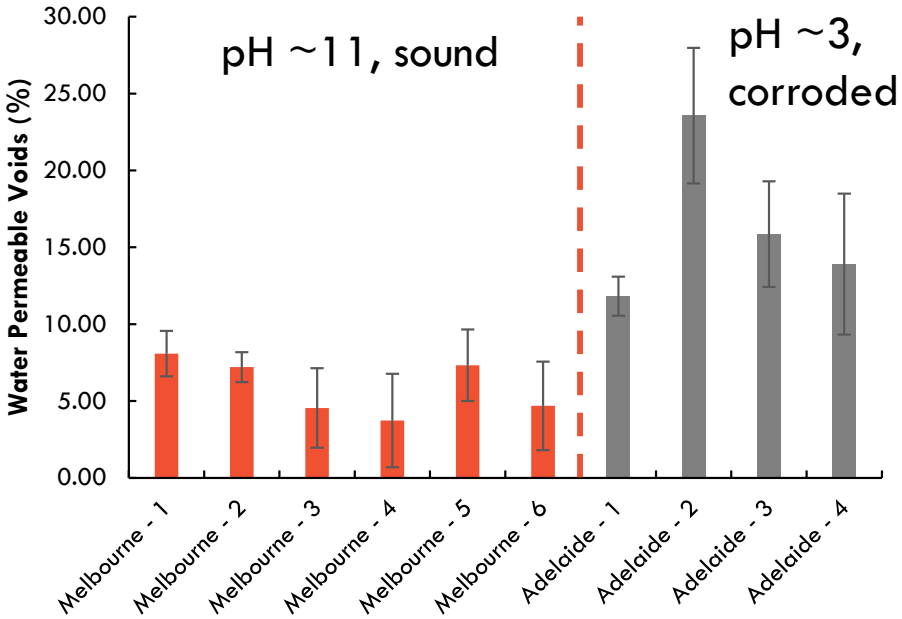






Micro Porosity in Sound and Unsound Concrete

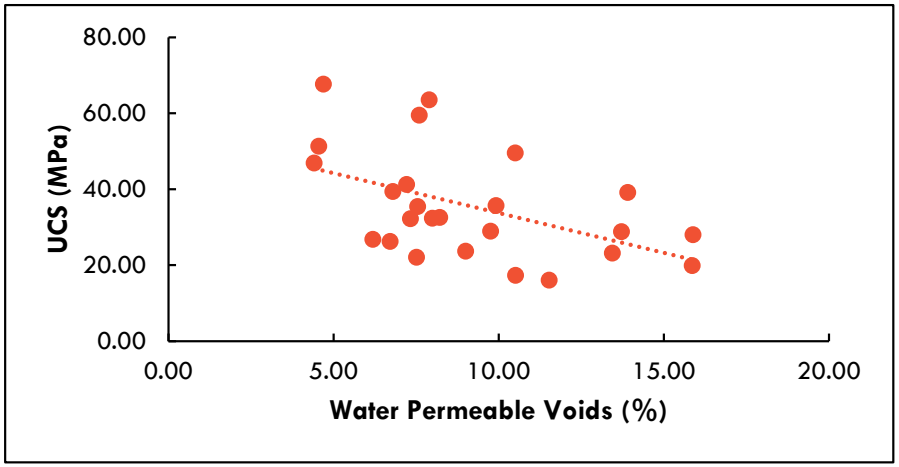


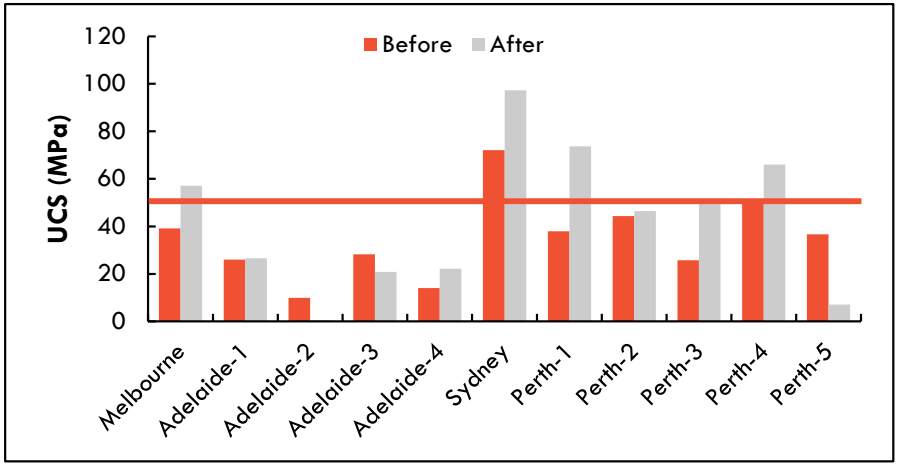


Impact of Porosity in Overall UCS

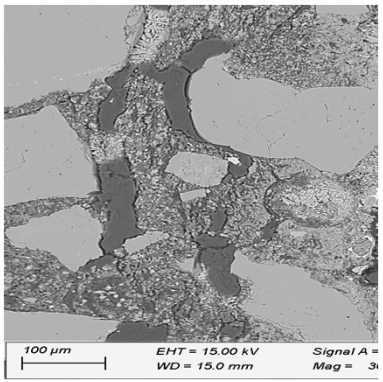
Use of pressurised water to remove laitance material and restore overall part of the overall compressive strength.

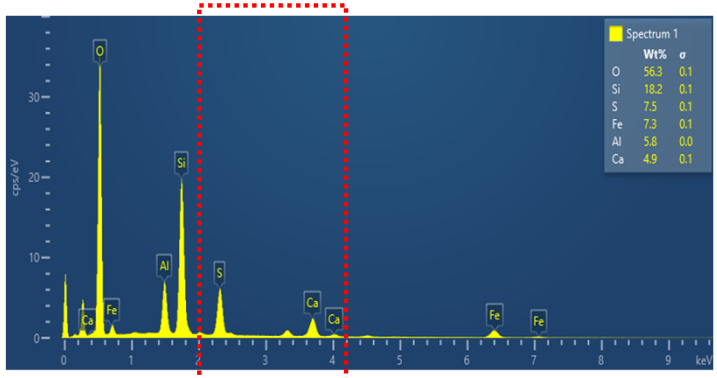
Surface Preparation Method		
Mist/vapour blasting 110-150 psi (with garnet)	Water jetting 2000 – 2500 psi (low pressure water cleaning)	Water jetting 6800 psi (high pressure water cleaning)

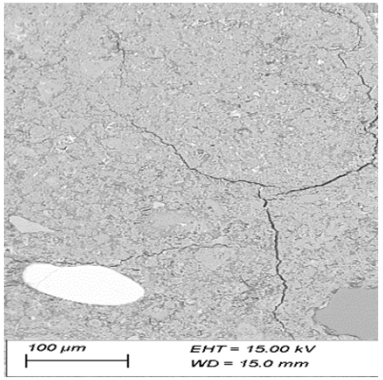


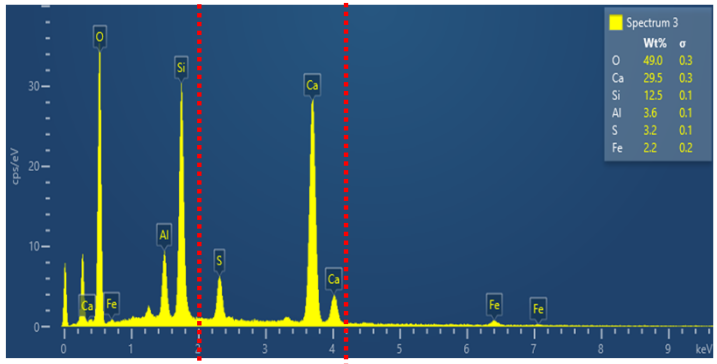


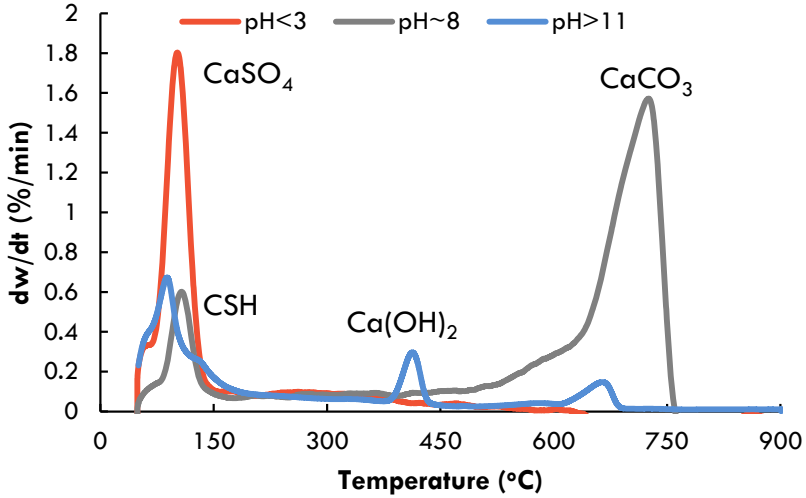
Microstructure





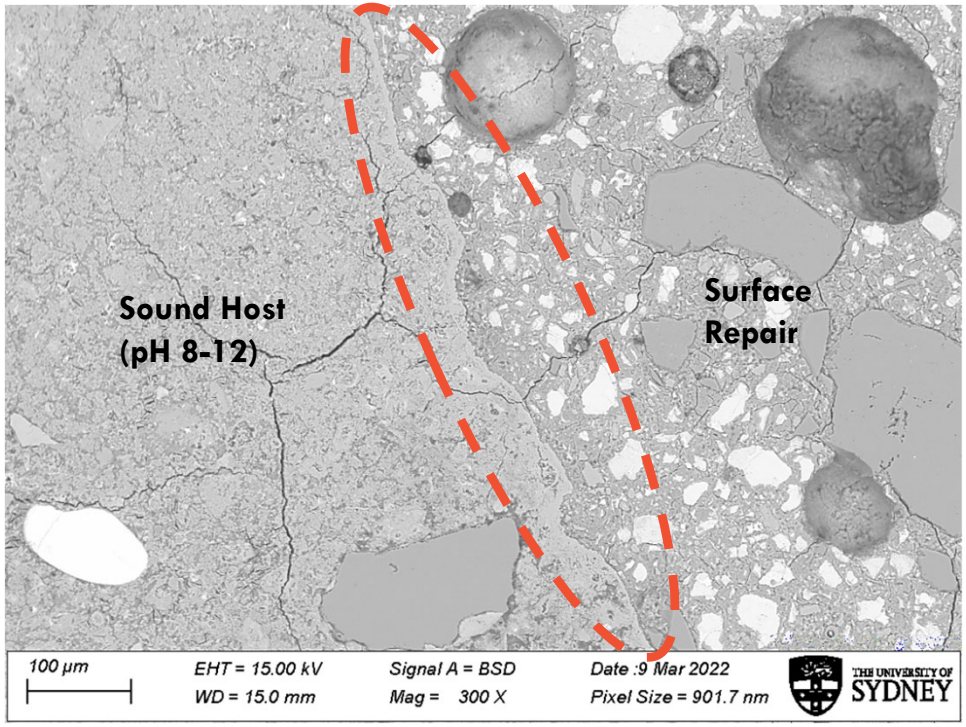






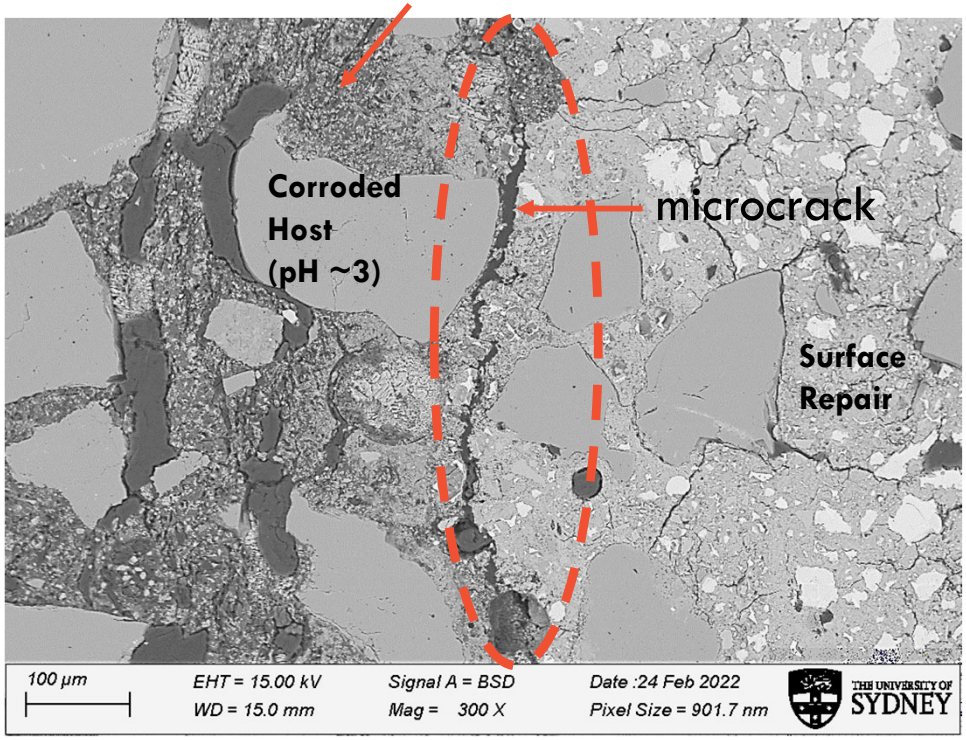
	CSH, $CaSO_4$ (wt%)	$Ca(OH)_2$ (wt%)	$CaCO_3$ (wt%)	Bond Strength (MPa)
pH ~ 3 corroded	5.52 *(Mostly $CaSO_4$)*	0.31	~0	**0**
pH ~8 interface	2.37	0.60	8.15	**~1**
pH ~ 11 uncorroded	3.09 *(Mostly CSH)*	1.00	1.05	**1.5**

Overlaying Lining on Sound and Unsound Concrete



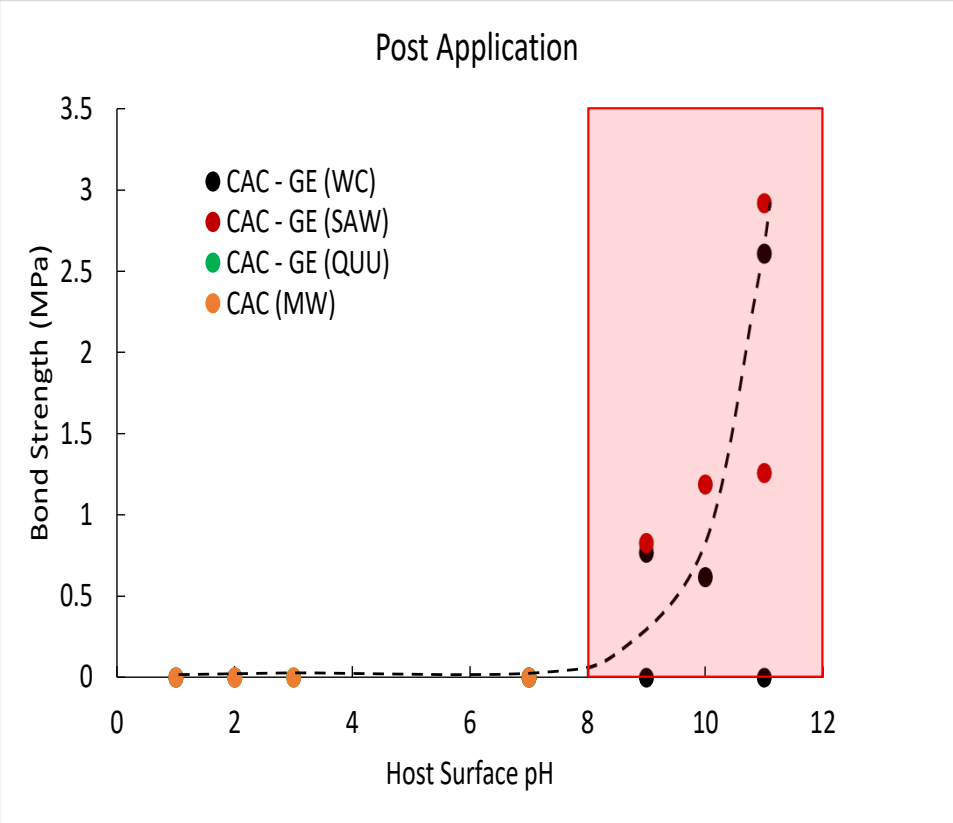
Bond Strength: 1.0 MPa

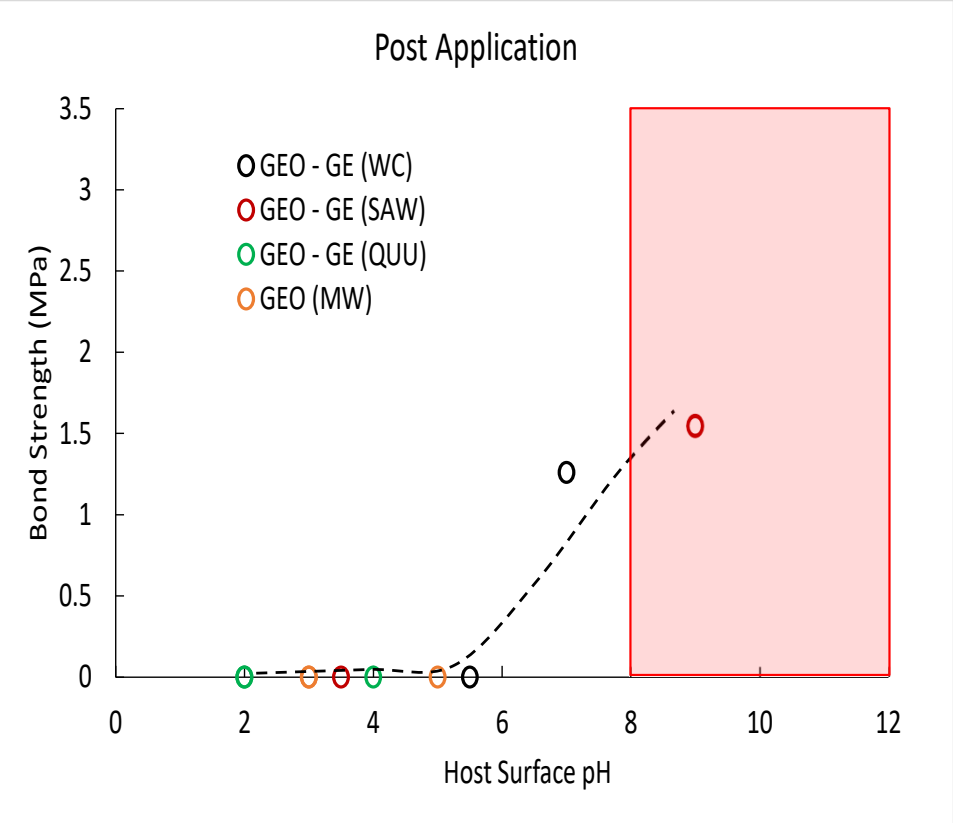
Corrosion products have no hydraulic property



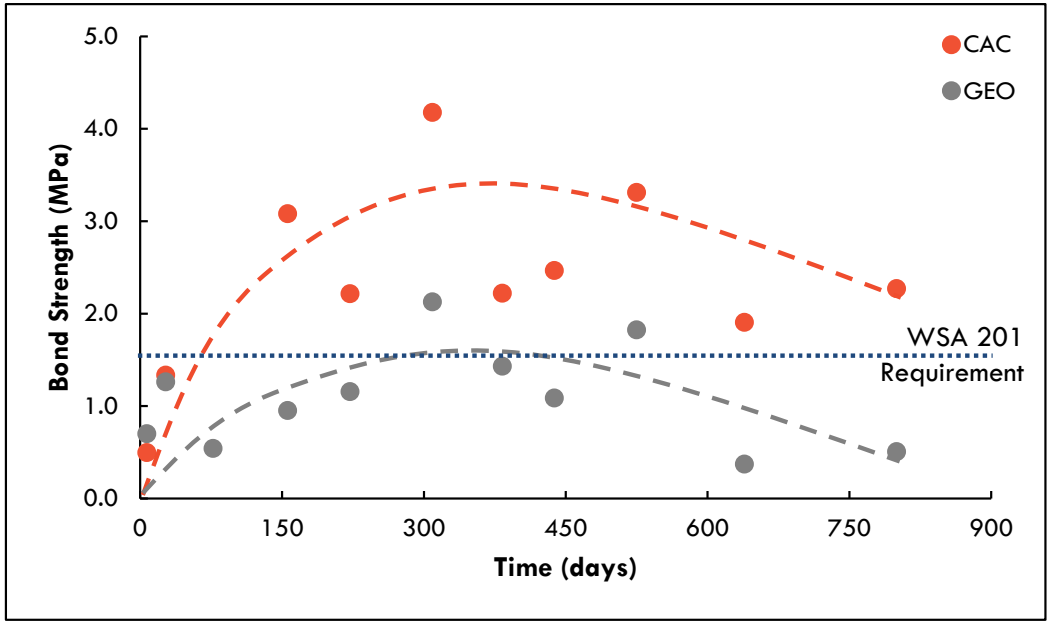
Bond Strength: 0.0 MPa

Bond Strength as a Function of Surface pH at Post Application



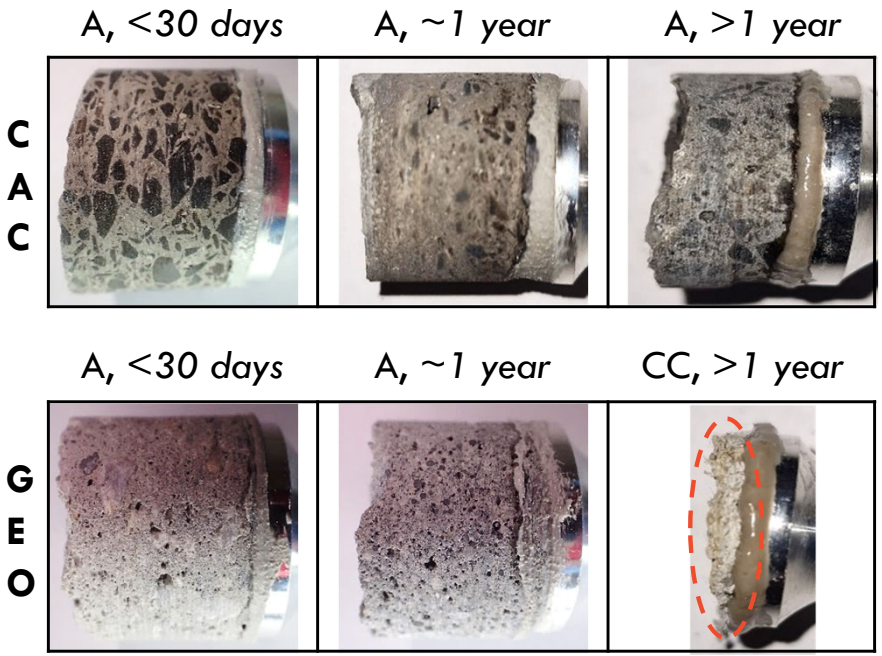


Effect of Time on Lining Bond Strength



- Bond strength increases and declines over time, with adhesive failure as the primary mode.
- With time, mode of failure becomes cohesive failure of coating (notable in GEOs tested).

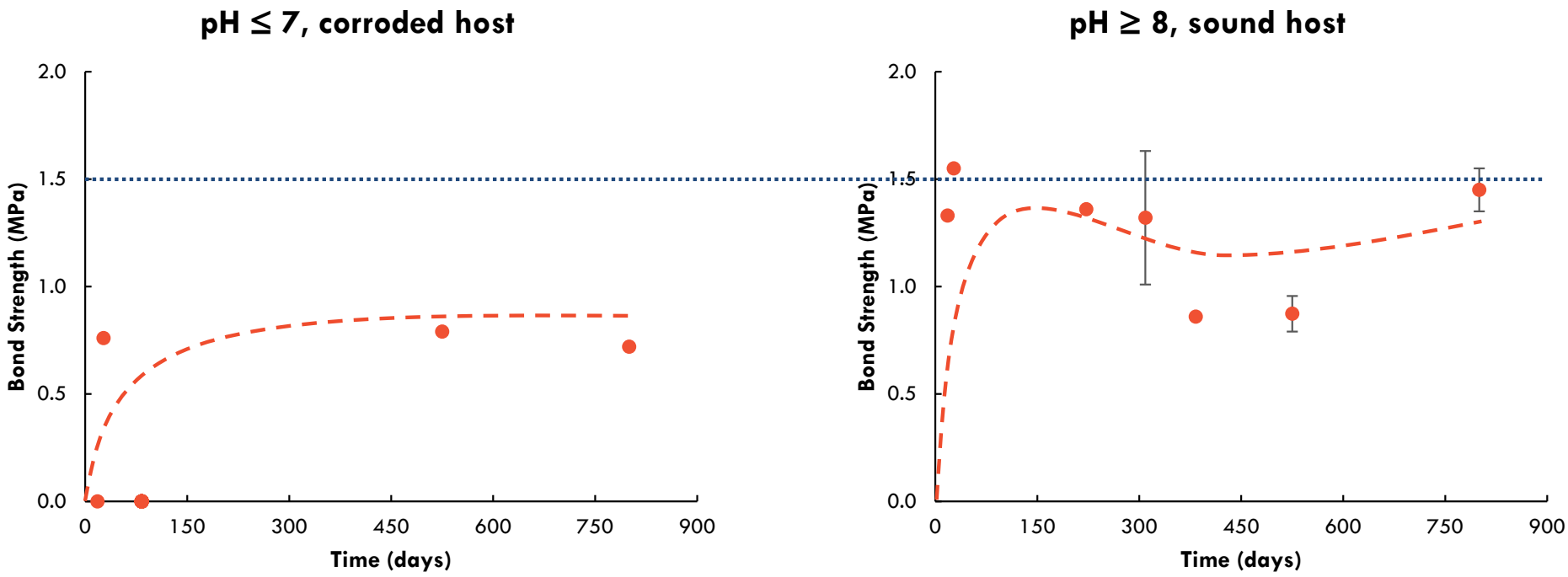
Primary Mode of Failure



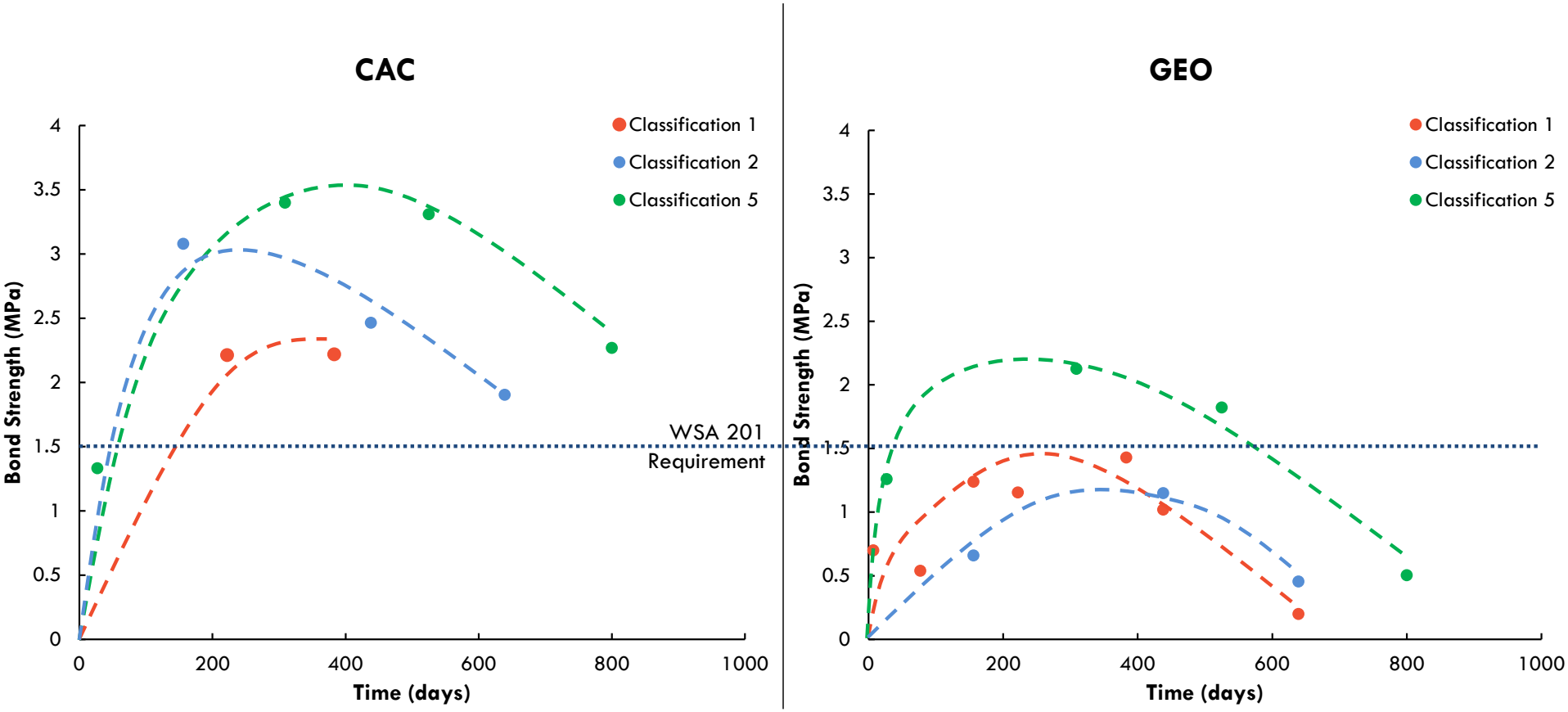
A: Adhesive
CC: Cohesive, Coating

Effect of Surface pH and Time

Corroded host surface induces premature failure and limits bond strength.



Effect of Corrosion Classification on Bond Strength



Summary

- **Surface Preparation Requirement**
  - Sound concrete is defined as concrete with pH > 8.
  - Unsound concrete with pH < 8 is characterised with non-hydraulic corrosion products, low strength and high porosity.
  - Field test verifies reliability of sound concrete definition.
- **Effect of Sewer Corrosivity and Time on Bond Strength and Modes of Failure**
  - Bond strength increases then declines with time. Early mode of failure is by adhesive failure, with longer term, bond failure is occurring by cohesive failure of coatings.
  - Type of coating impacts bond strength. CAC > GEO for tested products.
  - Impact of corrosion classification suggests CO_2 may have greater impact than H_2S on bond strength.

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