TECHNICAL PAPER 236

CEMENTITIOUS COATINGS TO RELINE SEWERAGE INFRASTRUCTURE FROM H_2S ATTACK

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Corroded Sewer Infrastructure

Concrete man holes are an integral part of all sewerage systems. The corrosion initiator is Hydrogen Sulfide (H_2S) gas which, if not addressed, leads to sectional loss of concrete and can ultimately lead to failure of the structure.

The economic impact of all corrosion and it's degradation of sewage infrastructure and other assets in Australasia is estimated to be 3 to 5 per cent of GDP each year, which represents an estimated annual cost of approximately AUD$982 million.

Ref: Corrosion Challenges – Urban Water Industry. ACA Australasia.

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The Concrete Corrosion Process

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When dissolved oxygen in a system falls below 0.1mg/L, water becomes anaerobic allowing bacteria to reduce dissolved sulphates in the system to Hydrogen Sulphide Gas (rotten egg smell).

Hydrogen Sulphide is then converted to Sulphuric Acid by air-borne Thiobacillus bacteria.

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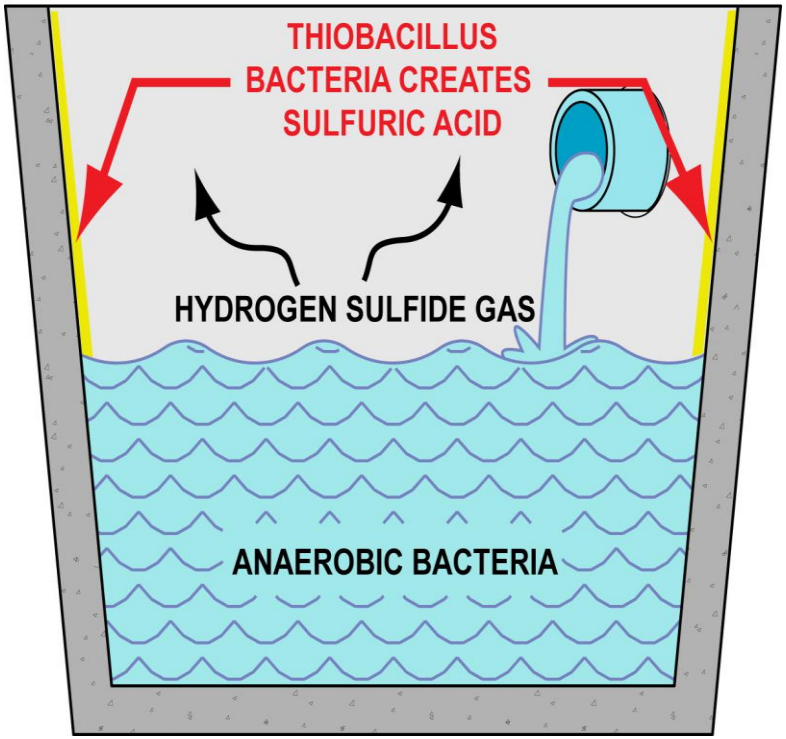
The Concrete Corrosion Process

This bacteria thrives in warmer temperatures and attack cement paste resulting in major corrosion of concrete structures and ultimately corrosion of the reinforcing steel if present. The acid attack also corrodes mass concrete placed without reinforcing steel.



Selection criteria – what to consider when selecting a protective coating system for aggressive exposure

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Manholes have very high humidity and are generally damp giving them a consistent time of wetness.

Is the lining system tolerant of surface moisture & high humidity?

Concrete repairs are generally required to reinstate the concrete cover after it has been attacked

Can the lining system be applied to green repair mortars?

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Selection criteria – what to consider when selecting a protective coating system for aggressive exposure

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Reinstatement of concrete can delay the application of the protective coating – cure time and loss of water

Can the asset be off-line for a length of time while the concrete cures and moisture within the matrix reduces to level where coatings can be applied?

The asset owner wants the structure back on line quickly so costs associated with sewer diversion and traffic management is minimised

Is the lining system designed for fast return to service?

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Selection criteria – what to consider when selecting a protective coating system for aggressive exposure

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Environmentally friendly systems - Volatile Organic Content Free- Low levels of hydrocarbon solvents

Is the system compliant?

Fit for purpose

Is the specified lining system resistant to H_2S attack and will the chosen lining provide a long term corrosion barrier?

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Some limitations of alternative systems

Novolac and Chemical resistant epoxies:

Very high cost for product and application

Some can't be applied to damp substrates or over freshly placed (green) repair mortars (return to service time is compromised)

Can't be applied in environments subject to water pressure from the outside face of the structure. (restricts use on manhole applications)

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Some limitations of alternative systems

Moulded Polyethylene Lining & PVC Linings:

High cost for installation

Can’t see substrate condition behind the liner

Annulus can be under attack – not visible

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Some limitations of alternative systems

Polyurea's:

Can't be applied to damp substrates or in humid environments, or over freshly placed repair mortars (limits use in manholes)

Can't be applied in environments subject to negative water pressure from the outside face of the structure (restricts use in manholes)

Fast gel time (6-10 seconds) limits adhesive bond strength to concrete, thus possible delamination is a concern.

Some limitations of alternative systems

CAC (Calcium Aluminate Cement):

Generally applied at a minimum thickness of 25mm (thickness of material can limit access)

Can’t be applied over green repair mortars.
New concrete requires significant surface preparation to provide a key for bonding

Some limitations of alternative systems

CAC (Calcium Aluminate Cement):

Some are sacrificial systems, which can deteriorate over time and require relining after approximately 10 years at a rate of 1-1.5mm per year (redundant material flows into the system)

For sacrificial products, degraded material can potentially cause long term damage to mechanical equipment / pumps etc).

Epoxy and Polymer Modified Cementitious Coatings

Advanced cementitious coatings are two-component, cementitious/epoxy modified, highly chemical and abrasion resistant products.

A combination of cement and polymer technology designed to minimise porosity (total volume of voids within the matrix) and water permeability (rate of flow of liquid through the matrix) thus maximising physical characteristics of epoxy and durability of cement.

Epoxy and Polymer Modified Cementitious Coatings

Applications –
Manholes, pump stations, sedimentation tanks, inlet works, sewage tanks, wet wells and digesters

Epoxy and Polymer Modified Cementitious Coatings – Features and Benefits

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High chemical resistance including Hydrogen Sulphide Gas (H_2S) up to 200 ppm, Hydrochloric Acid (20%). Sulphuric Acid (20%), Hydrocarbons

Application to green and damp concrete in humid environments

Application over repair mortars once final set is achieved (generally 6 hours)

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Epoxy and Polymer Modified Cementitious Coatings – Features and Benefits

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Application to Concrete, Masonry / Brick and Steel substrates

Fast Return to Service with the asset able to be put back on line after 1 hour cure

Service design of 25 years*

When applied to a suitably prepared substrate to achieve a defect free coating film with a minimum thickness of 2mm, advanced cementitious coatings will achieve a 25 year design life provided the exposure conditions do not become significantly more onerous and the application is subject to regular inspection with any identified defects reinstated.

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Epoxy and Polymer Modified Cementitious Coatings – Features and Benefits

Resists 10 bar (100m) positive/negative head of water pressure

VOC / Isocyanate free , UV resistant water based technology

High abrasion resistance of <0.05mm (tested using aaccelerated abrasion method in accordance with BS 8204: Part 2: 2002 Annex B)

Epoxy and Polymer Modified Cementitious Coatings – Features and Benefits

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Application by brush, trowel and airless spray equipment

When applied at 2mm thick, advanced cementitious coatings have been tested to provide the equivalent of an additional 100mm effective concrete cover for resistance from Chloride induced corrosion

Ref: Taywood Engineering / Vinci Testing. *Test data available on request*

High resistance to freeze thaw cycles (-36°C to 180°C).

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Summary

Correctly formulated and tested advanced cementitious coatings have more than 30 years of performance track records in the sewage and waste water industry.

This performance proves that this technology is an ideal solution to protect reinforced concrete and masonry structures from Chloride induced corrosion and Hydrogen Sulfide (H_2S) gas attack.

Advanced cementitious coatings provide reinforced concrete structures with effective cover increase for resistance against chloride induced corrosion. These advanced cementitious coatings ensure the intended design life of the structure is both achieved and extended.

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Track Records

- Essendon Wet Well Re-lining, Victoria
- TasWater Clarifiers, Launceston
- Melbourne Water, ETP Digester Roofs 1 & 2
- Melbourne Water, WTP 25 West, Pond No:1 Ring Beam
- Melbourne Water, WTP Pump Station
- Wannon Water Sewer Inlet Works
- Tweed Heads Shire Council Manhole Re-lining
- Geelong City Council Manhole Re-lining
- Ramsay Creek Pump Station, Rockhampton
- Banana Shire Council Manhole Re-lining, Qld
- Kempsey Shire Council Wet Well
- North Richmond WTP, NSW
- Glenelg STP Sedimentation Tanks, SA
- Biloela Sewage Clarifier Re-lining, QLD
- North Warrandyte Sewer Siphon, Yarra Valley Water
- Merri Creek Manhole Relining, Victoria
- Moonee Ponds Wet Well Relining, Victoria
- Sunbury STP
- Wollongong STP Digester Relining, NSW
- Gladstone STP, Emergency Storage Tank A01, QLD
- Palm Island STP, QLD
- Alexandrina Council, SA (12 manholes, 2 pump stations)

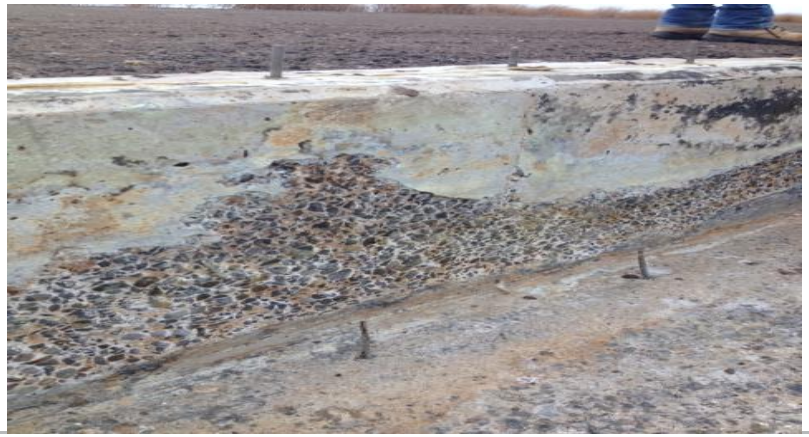
Aberdeen Manhole Relining (60 manholes), NSW

Mount Barker Council, SA (40 manholes)

Track Record

Melbourne Water, Western Treatment Plant (25 WEST – Sewage Pond No.1 Ring Beam) – 2015

Epoxy and Polymer modified Cementitious coatings were used to re-line a 1.2km long (960m2) concrete ring beam surrounding a sewage sediment pond. A floating liner is installed over the sediment pond to reduce odor, however H_2S build up under the liner has attacked the concrete ring beam. Epoxy and Polymer modified Cementitious coatings were specified due to the build-up of acidic gas between the floating cover and the concrete.



Track Record

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Tweed Heads Council, Queensland Manhole Relining – 2013

40 manholes suffering Hydrogen Sulphide (H_2S) attack with up to 30mm (nominal) sectional loss of concrete were originally specified with Polyurea. The majority of the manholes had issues with negative water pressure producing a very damp surface, thus advanced cementitious coatings were chosen due to their ability to bond to damp surfaces and resistance to 10 bar (+/-) head of water pressure.

Exposed aggregate before relining

After relining

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Track Record

North Warrandyte Wet Well, Yarra Valley Water – 2016

Structure suffering from H_2S attack, with up to 15mm (nominal) sectional loss of concrete
was originally specified with Polyurea. The project was scheduled for repair in July and being winter in Melbourne the structure had A very damp surface, thus epoxy and polymer
modified cementitious coatings were chosen due to the ability to bond to damp surfaces and resistance to 10 bar (+/-) head of water pressure.

Completed manhole

Track Record

Banana Shire Council, Queensland, Manhole Relining – 2014

35 manholes suffering Hydrogen Sulphide (H_2S) attack, with up to 25mm (nominal) sectional loss of concrete.

Project was originally specified with (CAC) Calcium Aluminate Cement, however advanced cementitious coatings were chosen due to the lower thickness build-up of 2mm overall compared to a minimum requirement of 25mm for CAC.

Manhole condition to prior to relining

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Merri Creek, Victoria – Manhole Re-Lining – 2016

48 manholes (combination of concrete and brick) suffering from H_2S attack. The brick manholes had no mortar remaining and the concrete manholes has up to 20mm (nominal) sectional loss. The manholes were originally specified with Calcium Aluminate Cement (CAC), however Melbourne Water wanted to extend the design life of the structures by an additional 25 years. Calcium Aluminate Cement (CAC) only had an anticipated design life of 10 years, thus epoxy and polymer modified cementitious coatings were chosen as they could meet Melbourne Water's design life expectations.

Old Brick manhole prior to relining

Completed application

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Track Record

Melbourne Water, Eastern Treatment Plant Digesters No.1, 2 & 4

Cementitious coatings were used to waterproof and protect a 1200m2 floating digester roofs. The existing rubber liners had severe degradation from UV exposure and was leaking. Epoxy and Polymer modified Cementitious coatings were specified due to the high moisture content within the concrete and resistance to H_2S. This technology has very good adhesive bond strength to damp / SSD concrete.

Overview of the digesters

Track Record

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Melbourne Water, Eastern Treatment Plant Digesters No.1, 2 & 4

The projects involved removal of the existing liner back to sound concrete and drummy areas of the existing topping slab repaired with high strength, polymer modified repair mortar.
Due to the high porosity of the topping slab, the concrete was double primed with a water based acrylic bonding agent. Expansion joints were treated with flexible bandage system with 600% elongation


Old membrane being removed


Prepared substrate with acrylic primer applied

Track Record

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Melbourne Water, Eastern Treatment Plant Digesters No.1, 2 & 4

Spray application of the coating

Back in service

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Track Record

Wannon Water, Inlet Works – 2017

Advanced Cementitious coatings were used to re-line degraded concrete exposed to Hydrogen Sulphide (H_2S) attack. Chosen for their ability to bond to concrete damp surfaces and high resistance to chemical attack.