CEMENTITIOUS COATINGS TO RE LINE SEWERAGE INFRASTRUCTURE FROM H_2S

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ABSTRACT (500 WORDS MAXIMUM)

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

The economic impact of corrosion and it's degradation of sewage infrastructure and 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 (*Report commissioned by the Australasian Corrosion Association (ACA), the report, Corrosion Challenges – Urban Water Industry*).

Other protective linings such as Polyurea, Vinyl Ester and Novolac epoxies provide excellent barrier protection when applied correctly, however these technologies have specific challenges with application as often the environment has very high humidity, with the concrete structure being damp and/or subject to water pressure from the outside face of the structure.

Extending the long-term durability of structures and providing a chemical resistant solution from Hydrogen Sulfide (H_2S) attack is very challenging, particularly when the expected design life of the structure can be >25 years. Issues such as reinstating the effective concrete cover, fast return to service capabilities, the presence of substrate moisture and high atmospheric humidity during coating application all contribute to the complexity, cost and overall performance of the lining application.

This paper explores the challenges and issues with applying protective coatings to degraded manholes and sewerage infrastructure and explores the use of advanced, two-component cementitious coatings as an environmentally friendly and cost-efficient solutions providing long term protection from Hydrogen Sulfide (H_2S) attack.

KEYWORDS:

Concrete, Sectional loss, Long Term Durability, Design Life, Cementitious Coatings

PRESENTER PROFILE:

I have worked in the construction chemical industry for the past 18 years, predominately with concrete repair, engineered coatings, waterproofing and performance flooring, in roles from applicator to technical sales.

My current role is South Asia Product Manager – Concrete Linings, working with consulting engineers, government authorities, asset owners specialist applicators.

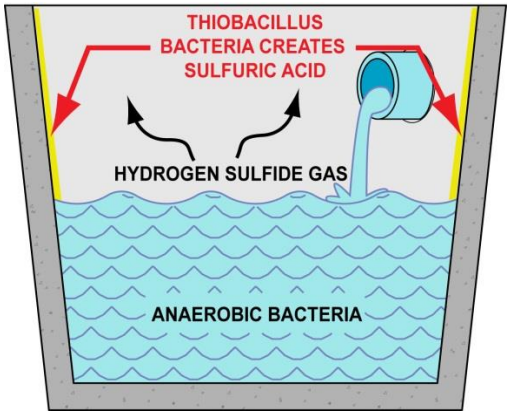
Concrete Institute of Australia | South Australian branch president (2012-2015) and an active committee member from 2002 to 2016.

I am a qualified SSPC Level 2 Concrete Coatings Inspector and NACE Level 2 Coating Inspector

1. THE CORROSION PROCESS:

When dissolved oxygen in a system falls below 0.1mg/L. Reference – Jason Kane, McBerns Paper from 39th Annual Queensland Water Industry Operations Conference & Exhibition "Hydrogen Sulphide Gas in Sewers – The Challenges of Odour and Corrosion" water becomes anaerobic allowing bacteria to reduce dissolved sulphates in the system to Hydrogen Sulfide Gas (rotten egg smell). H_2S is then converted to Sulphuric Acid by Thiobacillus bacteria.

This Thiobacillus bacteria thrives in warmer temperatures and the higher the temperature the faster the rate of H_2S production. The acid produced from the Thiobacillus bacteria attacks OPC (cement paste) resulting in major corrosion of concrete structures, and ultimately corrosion of the reinforcing steel if present. The acid attack also corrodes mass placed concrete without reinforcement.



2. FACTORS TO CONSIDER WHEN SELECTING A PROTECTIVE COATING SYSTEM:

When specifying a lining, asset owners and engineers need to be mindful of the many factors which will have an effect on the application and long-term performance of the lining system. These considerations include;

- Manholes have very high humidity and are generally damp – *Is the lining system tolerant of surface moisture and high humidity?*
- Concrete repairs are generally required to reinstate the concrete cover – *Can the lining system be applied to freshly applied repair mortars?*
- Reinstatement of concrete can delay the application of the protective coating – *Can the asset be off line for a length of time while the concrete repairs cure and the moisture levels reduce to a level where coatings can be applied?*
- Generally structures need to be 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?*
- Environmentally friendly systems (VOC Free) – *Is the lining system compliant?*
- Fit for purpose system – *Is the specified coating resistant to acid attack and will the specified coating provide a long term corrosion barrier?*

3. LIMITATIONS OF ALTERNATIVE SYSTEMS:

When specifying a lining, asset owners and engineers need to be mindful of the limitations some types of technologies have, which may affect the application tolerances and long-term performance. These considerations include;

Novolac Epoxy

- 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)

Polyurea

- Fast gel time (4-5 seconds) limits adhesion performance to concrete – delamination is common.
- Can't be applied to damp substrates or in humid environments, or over freshly placed repair mortars (limits use on manhole applications)
- Can't be applied in environments subject to water pressure from the outside face of the structure (restricts use on manhole applications)

Calcium Aluminate Cement

- Generally need to be applied at a minimum thickness of 25mm (thickness of material can restrict access)
- Some are sacrificial systems, which generally deteriorate over time (asset can require relining after 10 years), with the material potentially damaging mechanical equipment once in the network.

4. ADVANCED CEMENTITIOUS COATING TECHNOLOGY:

Advanced cementitious coatings are a two-component, cementitious/epoxy modified systems which have very high chemical resistance as well as high abrasion resistant qualities.

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

This coating formulation provides manhole and sewer infrastructure with the following technical benefits;

- High chemical resistance to Hydrogen Sulfide Gas (H_2S) up to 200ppm, Hydrochloric Acid (20%) and Sulphuric Acid (20%)
- Application to green and damp concrete in humid environments
- Application over repair mortars as soon as the mortar has achieved final set (generally 6 hours)
- Application to Concrete, Masonry / Brick and Steel substrates
- Fast Return to Service with the asset able to be put back on line after one-hour cure
- Service design of >25 years
- Resistant to 10 bar (100m) positive/negative head of water pressure
- VOC / Isocyanate free and water-based technology
- High abrasion resistance of <0.05mm (tested using aaccelerated abrasion method in accordance with BS 8204: Part 2: 2002 Annex B)
- 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 (Taywood Engineering / Vinci Testing)

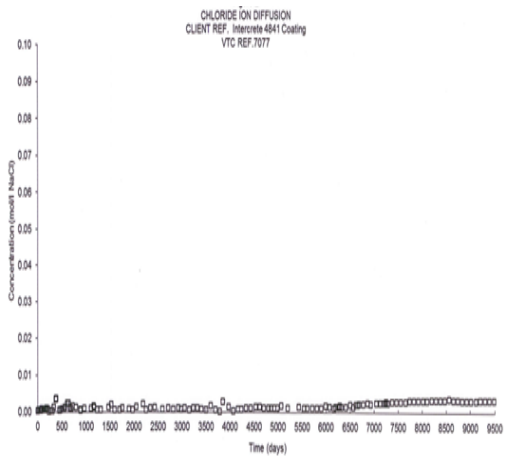


Figure 2. Chloride Ion Diffusion

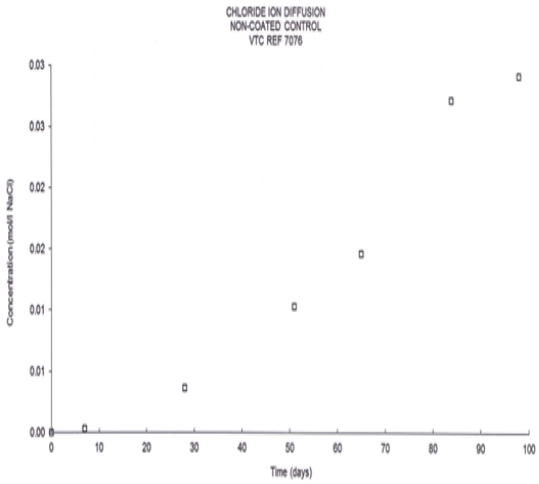


Figure 3. Chloride Ion Diffusion non-coated control

5. TRACK RECORDS:

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

Figures 3 & 4: Depicts degradation to cement paste from H_2S attack

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 odour, 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.

5.2 Banana Shire Council, Queensland – Manhole Relining – 2014

Figure 5: Manhole with significant deterioration from H_2S attack

2014 – 35 manholes suffering from H_2S attack, with up to 25mm (nominal) sectional loss of concrete were originally specified with Calcium Aluminate Cement (CAC). Epoxy and Polymer modified cementitious coatings were chosen due to the lower thickness build-up of 2mm compared to a minimum requirement of 25mm for CAC, thus significant cost savings were achieved. The manholes have been inspected one year after application with no degradation from acid attack reported.

5.3 Melbourne Water, Eastern Treatment Plant, Victoria – Digester No:5 – 2015

Figures 6 & 7: Overview of the digester

Figure 8: Old membrane being removed

Figure 9: Prepared substrate with primer applied

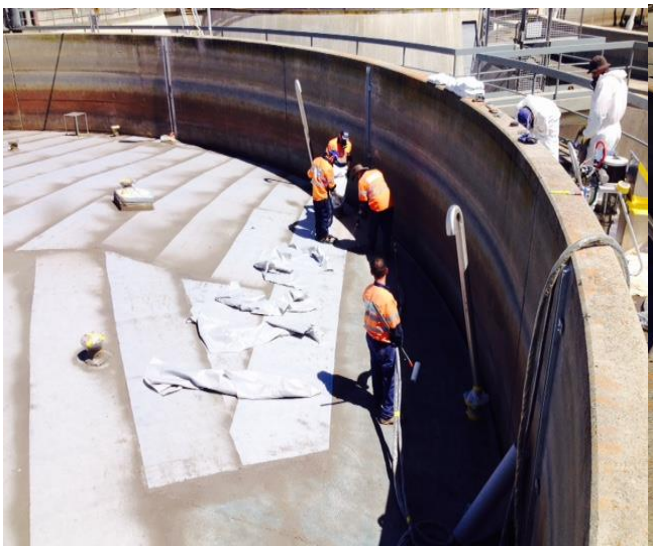


Figure 10: Applicators inlaying geotextile fabric

Figure 11: Mixing the waterproofing membrane

Figure 12: Geotextile installed, awaiting top coat

Figure 13: Digester back in service

Cementitious coatings were used to waterproof and protect a 1200m2 floating digester roof. The existing rubber liner has 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. The concentration of H_2S was minimal due to the structure having an open top.

5.4 Tweed Heads Shire Council, NSW – Manhole Relining – 2013

Figure 14: Manhole with exposed aggregate from H_2S attack

Figure 15: Manhole relined

40 manholes suffering from 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 water pressure from the outside face of the structure producing a very damp surface, thus epoxy and polymer modified cementitious coatings were chosen due to their ability to bond to damp surfaces and resistance to 10 bar (+/-) head of water pressure.

5.5 Merri Creek, Victoria – Manhole Re-Lining – 2016

Figure 16: Brick manhole with lime mortar degraded from H_2S attack

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.

5.6 ***North Warrandyte, Victoria – Wet Well Re-Lining – 2016***

Figure 17: Manhole relined with Advanced Cementitious Coating

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 2016 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.

5.7 Wannon Water, Victoria – Inlet Works Re-Lining – 2017

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

6. CONCLUSIONS

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

This performance proves that this technology is the ideal solution to protect reinforced concrete and masonry structures from chloride induced corrosion and H_2S attack.

Cementitious/epoxy modified lining systems provide reinforced concrete structures with effective concrete cover increase for resistance against carbonation and chlorides induced corrosion. These cementitious systems ensure the intended design life of the structure is both achieved and extended.

ACKNOWLEDGEMENTS

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REFERENCES

Australasian Corrosion Association (ACA).
Jason Kane, McBerns Paper from 39th Annual Queensland Water Industry Operations Conference & Exhibition