Case Studies of Waste Water Structure Rehabilitation – Products, Methods & Outcomes

Concrete waste water structures can deteriorate at a rapid pace when measureable concentrations of hydrogen sulphide gas are present in a local environment. Hydrogen sulphide is formed in sewerage systems when sulphates are reduced by anaerobic bacteria. Whilst not a corrosive agent in itself, through adsorption onto moist exposed surfaces of the concrete it can then undergo oxidation into a weak sulphuric acid solution which over time attacks the concrete. The cement paste is eroded which causes loss of the cover layer.

As our communities have become more sensitive to the odours of sewerage transfer, treatment and storage structures have been enclosed to restrict the release of odours. Containment and the subsequent increase concentration of H_2S gas within these structures has in turn caused accelerated deterioration of the concrete. To protect against these damaging effects engineers have turned to high quality coatings and linings and chemical resistant mortars.

Commonly used coating and lining solutions include:

1. Applied coatings:
   a) Epoxy
   b) Polyuria
2. Linings (generally also including concrete reinstatement). :
   a) PVC
   b) HDPE
3. Surface mortars
   a) Epoxy
   b) Calcium aluminate cements

Surface protection systems can be provided either during construction or after a period of service where significant concrete surface deterioration is detected. As the effects of waste water gasses on concrete are now generally well understood, the majority of new sewerage infrastructure is constructed incorporating surface protection systems.

Photo 1 – Photograph of an un-protected concrete waste water structure showing initial signs of concrete degradation.

Photo 2 – Sewerage manhole following removal of the top slab and before rehabilitation.

For waste water structure rehabilitation it is never a case of one particular protection system being superior to all others all of the time. A rehabilitation strategy should be based on a full and thorough condition assessment of the structure aspects and importantly confirmation of the assets desired remaining service life.

Structure aspects should include:

1. Current condition:
   a. Depth of contamination/ deterioration
   b. Depth of cover to steel reinforcement
   c. Residual thickness of concrete elements
   d. Structural capacity
2. Structure geometry
3. Internal atmosphere:
   a. Turbidity of fluids
   b. Concentrations of gasses
4. Location
5. Access constraints
6. Ground water pressures
7. Flow control scenario
8. Internal fixings (mechanical, electrical and other)

The following section provides a brief overview of rehabilitation strategies deployed to rehabilitate critical waste water sewerage infrastructure and specifically detail the product, methods and outcomes.

Case Study 1 – Rehabilitation of a sewerage manhole using a mechanically anchored high density polyethylene liner.

Photo 3 – Sewerage manhole after rehabilitation utilising mechanically anchored HDPE liner.

HDPE liners are a robust concrete protection system designed to protect concrete structures in chemically aggressive environments, the cast in liner sheet allows for reinstatement of defective concrete areas during the casting process and is easily customised to complex structure geometries.

HDPE liners are factory produced and as such thickness of the liner is tightly controlled, eliminating the risk of pin-hole defects and in turn potential corrosion paths.

The main steps of the rehabilitation process in this circumstance were as follows:

1. Concrete surfaces water-blasted to remove all contaminated concrete.
2. Liner sheets are cut to size, prefabricated where necessary and placed into position.
3. Lightweight formwork installed to secure the liner position during grouting operations
4. Cast liner into position by pouring grout in the annulus between the rear of the liner and existing substrate.
5. Removal of lightweight formwork.
6. Thermoplastic welding of joints in the liner.

The above steps may be varied for different structures even when using HDPE liner as a part of the repair strategy.

Key advantages of a waste water structure remediation incorporating HDPE liner include:

- Long expected life expectancy, 30+ years
- The cast in process allows for reinstatement of defective substrate areas to be completed in conjunction with the protective system
- The liner is flexible which allows it to bridge future cracking in the structure and endure ground water inflow.

Case Study 2 – Rehabilitation of a sewerage drop structure using a chemically anchored PVC Co-Lining System.

Photo 4 – View of the underside of a concrete platform within the drop structure prior to repair.

Photo 5 – View from the of the underside of a concrete platform within the drop structure after repair.

PVC co-lining systems combine the most desirable elements of different materials to provide a level high level of concrete surface protection. The PVC top layer provides a pinhole free extruded membrane which has very good resistance to permeation by most gasses and fluids. The intermediate layer of the system, which is a structural polymer, provides both an extremely effective chemical anchoring and back up protection to the PVC top layer. A cross link activator creates a molecular bond between the PVC and the structural polymer. The structural polymer additionally penetrates the topmost layer of the concrete substrate prior to polymerization which forms a saturated zone which is part concrete and part polymer.

The main steps of the rehabilitation process in this circumstance were as follows:

1. Concrete surfaces water-blasted to remove all contaminated concrete.
2. Reinstatement of deteriorated concrete areas to the original structure profile.
3. Liner sheets cut to size and activated.
4. The concrete substrate is primed for installation.
5. Structural polymer is trowel applied onto the substrate.
6. PVC sheets are laid into position on the layer of structural polymer.
7. Lapped joints in the PVC sheet are sealed with the installation of a sheet bridging seam material.

Key advantages of a waste water structure remediation incorporating a PVC co-liner system are:

- Long expected life, 30+ years
- The system provided is extremely durable with a long term performance history.
- Complex structure geometries and internal equipment and fixings can easily be worked around if required.

Case Study 3 – Rehabilitation of a sewerage drop structure using a Calcium Aluminate Cement (CAC) Mortars

Photo 6 – View of the underside of a concrete platform within the drop structure prior to repair.

Photo 7 – View of wall within the drop structure being reinstated using a dry spray applied CAC.

CAC mortars provide resistance to biogenic corrosion through its composition of calcium aluminate cement and calcium aluminate aggregates.

The main steps of the rehabilitation process in this circumstance were as follows:

1. Concrete surfaces water-blasted to remove all contaminated concrete.
2. Installation of stainless steel reinforcement.
3. CAC mortar spray applied to reinstate defective areas.

Key advantages of a waste water structure remediation incorporating a CAC mortars are:

- Can be applied to a damp substrate and the process can be used for both concrete reinstatement and protection.
- Complex structure geometries and internal equipment and fixings can easily be catered for.

The above scenarios illustrate successful waste water structure rehabilitation using three different products and methods, for all structures the outcomes to date (all less than 5 years in service since repair) indicate a substantial extension of service life will be achieved. This reinforces the fact that for waste water structure rehabilitation strategies must be properly developed and detailed by engineers with relevant experience to ensure good outcomes are achieved.

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