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Concrete Mine Thickener Tank Repaired with Hybrid Cathodic Protection

Introduction

In November 2010 Infracorr Consulting (then Ian Godson & Associates) was consulted to provide a repair specification to a 80m diameter coal thickener tank suffering from significant concrete deterioration issues. The 3m high tank at Curragh Coal Mine, located near Blackwater Queensland, was suffering from corrosion of the reinforcement due to chloride contamination from the treatment water in the tank, with severe spalling and delamination especially in the external launder wall. Corrosion surveys also indicated that sections of the main tank walls and the service tunnel beneath the tank were also corroding, with less visible spalling.

Corroded Reinforcement causing concrete spalling in the external launder wall of the tank

Design of Repair

The repair of the tank was to extend the life of the structure for a minimum of 25 years with the main client requirement to minimize downtime of the tank during repair works to a maximum of the programmed shutdown of 2 weeks for other works inside the tank

The corrosion mitigation system chosen was the DuoGuard Hybrid Anode system which uses zinc alloy internal anodes in an impressed current phase (usually 1 -2 weeks) to effectively passivate the steel. At the achievement of set criteria, the power supply and all cables are removed and the anodes are connected in "galvanic mode" at a series of junction boxes, with the galvanic current flowing to maintain the long life corrosion protection. This allows the advantages of Cathodic Protection type protection levels without

the high costs of permanent cables and transformer rectifiers with vastly reduced monitoring and maintenance costs.

The largest challenge was the anode design to protect the very thin launder wall section which was only 150mm thick and reinforced with a single matt of reinforcement. To minimize the risk of drilling through the launder tank wall, the short Duoguard 175 anodes, 44mm long , were designed to be installed into 60mm deep holes of 30mm diameter, with controlled depth drilling to eliminate the risk of penetrating to the operating (full) tank. A dry process gunite overlay of 30mm was then to be placed over the outer surface of the launder wall, providing cover to the anode system.

The works commenced in late January 2011, with hydro-demolition utilized around the clock to maximize the productivity of defective concrete removal which was required to but not behind the bar. The exposed reinforcement was checked for electrical continuity with isolated problems resulting in a 6mm continuity bar being required, tack welded to all vertical bars around the tank. Dry process gunite closely followed the hydro-demolition and continuity work, restoring the concrete to the original profile, with cover to the reinforcement of approximately 20mm. All hydro-demolition and gunite repair was completed during the tank shutdown of two weeks, with the tank re-filled and restored to full operating condition by mid February 2011.

Coal Thickener Tank during 2 week shutdown. Hydro-demolition & dry process gunite progressing around the tank.

Launder wall after hydro-demolition has removed the delaminated and spalling concrete.

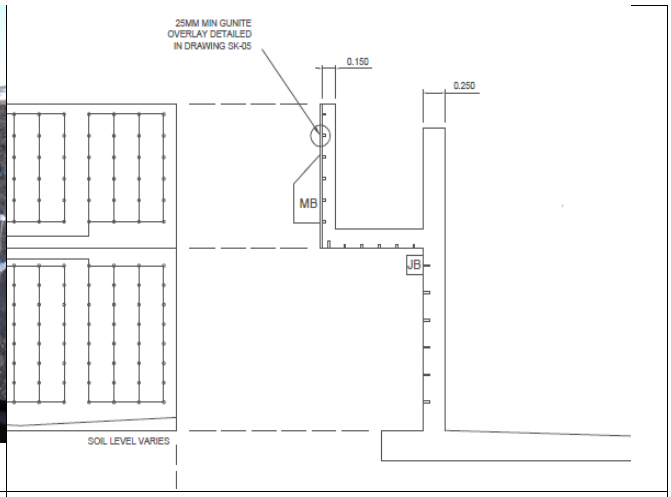
The anode installation was completed progressively around the tank. Permanent reference electrodes (MnMnO2) are installed initially with 36 installed in monitoring areas around the tank. The 30mm diameter holes were percussively drilled initially and soaked with water for 24 hours to maximize the moisture in the concrete. The anodes are installed in the holes in the alkaline paste backfill in batches (sub-zones), checked for isolation from the reinforcement and immediately powered by the temporary transformer rectifiers at 12 volts. The impressed current is maintained at 12 Volt for a minimum of 7 days, with the current recorded daily in each sub-zone. A minimum current criterion of 50 KC/m2

reinforcement area is maintained to ensure the reinforcement is completely passivated. Once the impressed current criteria are met, the system is converted into galvanic mode with the reinforcement negative connection connected to the titanium anode connection in the distributed junction boxes (24 No) around the tank. The galvanic current achieved averaged between 2 to 3 mA/m2 reinforcement. Following the installation of the anode system, the 25mm layer of dry process gunite is applied over the entire outer launder wall.

Evaluation of the system performance is assessed against a corrosion rate criterion based on the Stern Geary Equation, with the targeted corrosion rate to be less than 2mA/m2 steel, approximately equivalent to a 2mm section loss in 1000 years. (This criterion is in the latest European Cathodic Protection standard) This is measured by recording the galvanic current of the sub-zone and completing an instant off and depolarization test (similar to impressed current Cathodic Protection) and utilizing these figures to calculate the actual corrosion rate. The corrosion rates calculated by this means ranged from 0.3 to 0.8 mA/m2 steel, well below our criterion.

The overall system was finalized with the installation of a remote monitoring system that was designed to take galvanic current and depolarization readings and update those to an internet database, allowing considerable travel cost and time savings for the monitoring process.

Anodes Installed in Proprietary Paste backfill ad powered at 12V from the temporary transformer rectifiers



Part drawing of hybrid anode arrangement. The launder wall was treated with short (D175) hybrid anodes with an overlay of 25mm gunite to reduce risk of drilling through the wall.

The installation was complete by mid April 2007, a project duration of approximately 10 weeks. The finalized concrete repair incorporated approximately 500m2 of hydro-demolition/surface preparation and 40 tonne of dry process gunite. The hybrid Cathodic Protection system incorporated approximately 9000 anodes (D175 & D350), 36 reference electrodes and the remote monitoring system. The repair works and Hybrid installation was completed by Freyssinet Australia in joint venture with Marine & Civil

Maintenance PL. The design, supervision, commissioning and monitoring of the works was completed by Infracorr Consulting.

Completed Tank Concrete Surface showing monitoring and junctionboxe.

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