Waterproofing System for Wastewater Tanks in Petrochemical Industries and Refineries

Introduction

Wastewater of petrochemical industries and refineries contains high amounts of emulsified aliphatic or aromatic hydrocarbons. The industrial wastewater treatment facilities consist of large reinforced concrete tanks, which deteriorate and develop cracks over time, allowing the contaminated effluent to escape, causing a serious environmental hazard. The repair and waterproofing of deteriorated tanks is not easy, mainly due to the difficulty of surface cleaning. The concrete substrate is commonly covered with thick layer of oil and grease, and even after removing these deposits the concrete remains saturated with oil, which is impossible to remove.

The review of the project presents an integrated system, which has been used and proven very successful in the repair and waterproofing of contaminated concrete tanks in petrochemical and oil refining facilities. The waterproofing and repair system, comprising of polymer modified cement bonding agent and an inorganic protective and waterproofing composition is economical and easily applied by qualified waterproofing contractors.

The bonding agent is a two-component, polymer-modified cement based slurry, formulated to bond to oil contaminated concrete and to provide an adhesive bridge between the waterproofing membrane (or repair mortar) and the existing substrate. It can be applied to cleaned, but still oil contaminated concrete, in thickness of approximately 1/16" (1.5 mm). The bonding agent exhibits the following important features important in concrete tank repair and restoration:

- Bonds to a cleaned, but oil contaminated concrete
- Can be applied to wet substrate
- It acts as vapor-retarder, but not vapor-barrier

The similar material is used as rust-proofing of corroded, exposed reinforcing steel.

The protective/waterproofing layer is one-component, inorganic system, which is completely impervious and chemically resistant to in water emulsified hydrocarbons, including polar or non-polar organic solvents such as benzene, toluene, xylene, ketons, mineral spirits, and any other organic solvent either pure or emulsified in water. The impermeability to organic solvents and water is achieved by using advanced composition and an efficient particle packing in the structure of the material. It has been extensively laboratory tested and field evaluated. The material is applied by spraying, brushing or troweling, directly to clean concrete in new construction, or with the bonding agent when repairing and waterproofing of existing oil contaminated concrete tanks. The key advantages of the material can be summarized as follows:

- Chemically resistant and impervious to organic solvents, emulsified aromatic or aliphatic hydrocarbons
- Excellent water-proofing on negative an positive side

- Bonds to wet surfaces
- Efficient vapor-retarder, but not a vapor-barrier
- Easy application

Case History

The first large application has been in waterproofing and protection of waste-water treatment facility in petrochemical plant and refinery Slovnaft, in Bratislava, Slovakia. Slovnaft a.s. Built in early sixties, is one of the largest oil refinery and petrochemical facilities in the Central Europe. As part of its processing a large quantity of industrial wastewater must be treated before being discharged. The wastewater contains large amounts of emulsified aliphatic and aromatic hydrocarbons (oils) of various molecular weights, with solids content varying from 10%-15%. Often, highly polar solvents, e.g. ketons, escape with waste-water. A description of the wastewater treatment technology is beyond the scope of this article. The wastewater treatment facility includes a large number of reinforced concrete tanks. Figures 1 and 2 show typical tanks at the facility. The tanks are approximately 100 meters (328 ft) long, 40 meters (131 ft) wide and 7.5 meters (25 ft deep). Each tank has two separating walls longitudinally within the tank.

Figure 1. The first tank during the repair

Figure 2. The second tank before the repair

The reinforced concrete tanks have developed leaks mainly through cracks, construction joints and expansion joints. There were also leaks in areas of poor concrete compaction and in the section where the mechanical equipment was anchored in the concrete. The leaks, shown in Figure 3 present a serious ecological problem. In addition to cracks, the “low” concrete cover on steel resulted in corrosion of reinforcing steel, causing cracking, delamination and spalling of concrete as shown in Figure 4.

Figure 3. Leaks in concrete tanks

Figure 4. Delaminating concrete due to corrosion of reinforcing steel

The company over the years has been looking for solutions to the problem of the leaks. Various technologies including the use of preformed polymer liners, epoxy and urethane coatings have been employed with little success. The main problem with the preformed liners was the deterioration as a result of freezing water that penetrated between the reinforced concrete tank structure and the liner, eventually destroying the liner. Lack of adhesion has been the main cause for the polymer coating failures.

The key challenge presented in the repair and waterproofing of the reinforced concrete tanks has been "in depth" oil contamination of reinforced concrete tanks. The interior surface of concrete tanks was covered with approximately 12 – 18 mm (½- ¾ in) thick layer of black oily residues, shown in Figure 5., which prevent bonding of virtually any material. Figure 6. shows the tanks after chemical cleaning. The further challenge was to span the existing moving cracks. The cracks and expansion joints move due to temperature changes and, to some extent, by the varying hydrostatic head in reinforced concrete tanks.

Figure 5. Oil and grease deposits on the surface of concrete tanks

Figure 6: The surface of the tanks after chemical cleaning

The solution to the problem was to waterproof the reinforced concrete tanks using the bonding agent described above and application of protective/waterproofing layer to wet bonding agent also included resolving the problem of surface preparation and bonding to heavily contaminated concrete. The detail description of crack and joint treatments is given below.

<u>Surface Preparation</u>

The layer of hydrocarbon deposits were first removed by mechanical scraping. This was followed by high-pressure water washing (approximately 3,500 psi–24 MPa) in combination with a heavy-duty industrial detergent. The cleaning procedure consisted of two steps. The detergent was first spray applied and left to act for approximately 30 minutes. This was followed by a thorough high-pressure hot water wash. The surface of concrete after chemical cleaning is shown in Figure 6. The final cleaning was done by sandblasting shown in Figure 7, and a high-pressure wash. In some areas, at the water level, several days after sandblasting and washing, the emulsified oil from within concrete was released to the surface by capillary pressures, shown in Figure 8. These areas were cleaned again using detergent and the high-pressure water wash. In such cases, it was important to apply the bonding agent immediately after cleaning, to develop bond before additional emulsified oil, see Figure 8, was released to the surface.

Figure 7: Sandblasting after chemical cleaning

Figure 8. Residual emulsified oil “seeping out” of capillaries after sandblasting and high-pressure wash

Crack and Delamination Repairs

All cracks exposed by cleaning were cut and “routed out” with a chipping hammer to form a “groove”, approximately 2 cm (¾ in) wide and 12 mm (1/2 in) deep. The crack was grind into depth of approximately 12 mm (1/2 in) and filled with one component polyurethane. The polyurethane was also applied to the entire area, including “cut” sides. After curing the polyurethane, the bonding agent was applied to polyurethane, and the grooves were filled with micro-silica enhanced, fiber reinforced mortar shown in Figure 9, 10 and 11. The surface the patch was again covered with a thin layer of one-component polyurethane. Delamination repairs varied in depth from 12 mm to 10 cm (1/2 to 4 in). The surface of exposed steel was protected by polymer cement based rust-proofing material. The same material was used as a bonding agent for the micro-silica enhanced, fibre reinforced mortar used in filling the delaminated areas, as shown in Figure 12.

Figure 9. Filling the routed cracks with one component polyurethane

Figure 10. Cracks filled with fibre reinforced mortar bonded with bonding agent to the polyurethane seal

Figure 11. Cracks filled with fibre reinforced mortar bonded with polymer modified cement slurry to the polyurethane seal

Figure 12. Delamination repairs using fibre reinforced mortar and polymer cement rust-proofing .

Expansion Joints Treatment

The original expansion joints were approximately 5 cm (2 in) wide, placed in 50 cm (20 in) thick slab. The original waterproofing was provided by a cast-in concrete water stop. This original treatment failed. Approximately 10 years ago, expansion joints were repaired using a flexible rubber tape, bonded to concrete. All these joint repairs failed again. The repair of the bottom slab joint started with milling off approximately 20 cm (8 in) wide and 12 mm (1/2 in) deep grove over the expansion joint as shown in Figure 13. The expansion joints were cleaned using wet sand-blast and repaired with fibre reinforced mortar, bonded with polymer modified cement slurry. This repair reduced the width of the joint to approximately 4 cm (1 3/4 in). The undamaged existing joint filling material was left in place, and the deteriorated joint filling material was replaced with extruded polystyrene. The 20 cm (8 in) wide area, including vertical sides was coated with one-component polyurethane. This was followed by placement of 2 mm thick layer of oil resistant rubber sheet embedded in to the joint. The joint was then covered with a sheet of stainless steel metal cover mechanically fastened to one side of the joint. The vertical joints were repaired using the same system, as shown in Figure 14.

Figure 13: Expansion joint after milling, before placement of the sealant and the rubber sheet.

Figure 14. Repair of the vertical expansion joint.

Waterproofing and Chemical Protection

The polymer modified cement slurry was supplied as a two-component system, consisting of a bag of dry material and a liquid additive. These were thoroughly mixed using an electrical drill and a mortar-mixing paddle into a slurry form. The slurry was brush applied on the surface of concrete, including the polyurethane treated surface of crack repairs. The protective/waterproofing coating was supplied as one component material. It was mixed with water on site and applied by brushing (or spraying and brushing) into the wet bonding slurry of polymer modified cement slurry. The protective/waterproofing coating was applied in two coats to build a layer of total thickness of approximately 3 mm (1/8 in) and wet cured for three days. The application is shown in Figures 15 and 16.

Figure 15. Application of the bonding agent and protective/waterproofing coating.

Figure 16. Finished interior of the tank

Exterior walls treatment

The exterior walls were protected with two coats of one component polymer modified cement coating, approximately 0.5 mm (20 mils) thick, mainly for aesthetic reasons. The coated exterior of the tank is shown in Figures 17 and 18.

Figure 17. Application of one component polymer modified cement coating to the exterior of the tank

Figure 18. Exterior of the tank after the repair

Conclusion

The testing of all the repair procedures had been successfully carried out in 2004 and 2005. The repair and waterproofing of the facility was carried out in 2006 and 2007 construction seasons.

All the repairs are functioning well to the satisfaction of the client. Before filling the tank, the entire surface was checked for delamimnations and no de-bonded areas were found. After filling the repaired tank with waste-water, a thorough inspection identified two small wet spots on the exterior walls, each approximately 5 cm (2 in) in diameter. There were no water leaks and the repair was a complete success. The key problems, bonding to a heavily oil contaminated concrete substrate, waterproofing, providing chemical protection against acetone and other polar solvents present in the waste water as well as spanning the moving cracks and expansion joints have been successfully resolved.

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