Testing Epoxy Coating Materials for Concrete Wastewater Facilities

J. Liu and C. Vipulanandan
Department of Civil and Environmental Engineering
University of Houston, Houston TX 77204-4791
Phone: 713-743-4291 E-mail: JLIU3@Jetson.UH.EDU

Abstract

The aim of this study was to evaluate the performance of epoxy coating materials with a combination of full scale and laboratory tests for applications in rehabilitation and new construction. Full scale pressure chambers (hydrostatic tests) were designed and built to evaluate the application and performance of the coating materials on concrete substrate under a hydrostatic pressure of over 10 m (32 ft.) of water simulating the ground water conditions. Coated concrete specimens with holidays (pinholes) were used to study the chemical resistance under acidic environment modified (ASTM G20-88). To quantify bonding strength between the coatings and substrates two ASTM standard testing methods were used (ASTM D 4541-85 and ASTM C321-94). Results based on the full scale test (five months) and laboratory tests (six to twelve months) of epoxy coatings are discussed. Based on the test results following could be concluded on the coatings (wet coating and dry coating): (1) All coatings passed the application (seven evaluation categories) and performance (six evaluation categories) in the hydrostatic test, (2) All coatings passed the holiday-chemical resistance tests on coated concrete after one month. Most of the coated specimens (both coatings) without holidays passed the test after six months, and (4) epoxy coatings had good bonding with both dry and wet concrete.

1. Introduction

Concrete is the most widely used construction material in large wastewater treatment plants. It is commonly used for below grade wet wells or holding tanks; manholes; sewer pipelines and open top channels. Many municipalities are discovering that particular concrete structures and brick manholes in the wastewater collection and treatment facilities are subjected to corrosive environments and are degrading rapidly. Coating is one method currently being adopted but the effectiveness of this method for rehabilitating lift stations and sewer treatment facilities is still in question. Since several factors in the field can affect the performance of coating, it is important to identify the important factors through controlled experiments where important variables are studied one at a time. In this study, a comprehensive testing program was used for evaluating epoxy coating materials (dry and wet) for concrete rehabilitation.

2. Testing Program

2.1 Full Scale Test

This was achieved by using 900 mm inner pipes and 1600 mm outer pipes with two concrete end plates. Inner concrete pipes were representing a concrete surface under hydrostatic pressure and coating a pipe surface represented most of the difficult conditions encountered in coating structures such as lift stations. Based on federal regulations, 900 mm (36 in.) diameter pipe was the smallest pipe in which a coating applicator can be allowed to operate within the concrete pipe. Pressure chamber used for the full scale test was designed and built by Gifford-Hill & Company, Houston Division, which was representing the American Concrete Pipe Association.

The coated surfaces were visually inspected regularly and information on blistering, sapling, discoloring and cracking were noted and photographed. ASTM D 714-87 was used to characterize the blister size and frequency and will be designated as dense, medium dense, medium or few accordingly.

2.2 Laboratory Test

2.2.1 Holiday Test - Chemical Resistance (Modified ASTM G 20-88)

In this test, 76 mm (3-inch) X 152 mm (6-inch) cylindrical cement concrete specimens were used. Dry and wet specimens were coated on all sides except the base and tested. Two radial holes were drilled into the specimen approximately 15 mm deep. The changes in (1) amount of calcium leached into the in test medium (2) weight of specimen (3) appearance of specimen and (4) pulse velocity (ASTM C 597-83) of the specimen were measured at regular intervals. The three test reagents selected for this study are (1) deionized (DI) water (pH = 5 to 6); (2) 3% sulfuric acid solution (pH = 0.45, representing the worst reported condition in the wastewater system) and (3) 30% sulfuric acid solution (pH = --0.8; representing accelerated testing conditions). Control tests were performed with no holidays.

2.2.2 Bonding Strength

These test were performed to determine the bonding strength (pull-off strength) between the concrete and the coating material over a period of one year by using ASTM D 4541-85 and ASTM C 321-94. Total of twelve tests were performed for each test on each coating.

3. Test Results and Discussion

3.1 Full-Scale Test

The coatings were tested under a hydrostatic pressure of 105 kPa (15 psi) over a period of five months. The coatings were inspected on a regular basis to identify any visible defects and mapped on 4 X 3 format. Each section was evaluated for (i) overall condition (ii) surface texture (iii) blistering (iv) cracking (v) change in color and (vi) quality of finish. In all of these categories the coatings performed well.

3. 2 Holiday Test - Chemical Resistance

Coated concrete cylinders were tested with and without holidays in D.I. water, 3% sulfuric acid and 30% sulfuric acid solutions. Total of 16 concrete coated specimens for each coating were tested. All specimens passed the vapor phase test and after six months.

All coatings passed the holiday-chemical resistance tests on coated concrete after one month. Most of the coated specimens without holidays passed the test after six months. All coated concrete with and without holidays passed the 3% sulfuric acid test up to sixteen months. Less than 10% coated concrete with holidays failed the 30% sulfuric acid test after six months.

3.3 Bonding Strength

Total of 17 Bonding tests (ASTM C321 and ASTM D4541) have been performed up to twenty months. 82% type 1 concrete failure and 18% type 3 bonding failure indicate good bonding strength with concrete.

4. Conclusions

A combination of full-scale and laboratory tests were used to evaluate the performance of epoxy coatings (dry and wet) for coating concrete. Based on the test results following observations are advanced.

(1) All coatings passed the application (seven evaluation categories) and performance (six evaluation categories) in the hydrostatic test.

(2) All coatings passed the holiday-chemical resistance tests on coated concrete after one month. Most of the coated specimens (both coatings) without holidays passed the test after six months. Most coated concrete specimens with holidays passed the 3% sulfuric acid test. Less than 10% coatings (wet) coated concrete with holidays failed the 30% sulfuric acid test after six months.

(4) Coatings had good bonding with both dry and wet concrete.

5. Acknowledgment

This work was supported by the Center for Innovative Grouting Materials and Technology under grants from the City of Houston, National Science Foundation (CMS-9526094) and various industries.

6. References

1. ASTM, Paints-Tests for Formulated Products and Applied Coatings, Annual Book of ASTM Standards, Vol. 06.01, 1995.

University of Houston, Department of Civil and Environmental Engineering4800 Calhoun, Houston, TX 77024
Phone 713-743-4278 Fax 743-4260