Failure Mechanisms of Coated Concrete Subjected to Sulfuric Acid Attack

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Abstract

The aim of this study is to identify the failure mechanisms during the chemical immersion test on coated concrete with holidays. The results are based on over three years chemical test with fifteen types of coatings. The reasons which cause coating failure are analyzed. The analysis indicate that in addition to the type of coating other factors such as holiday sizes, bonding strength and tensile strength of coating are important parameters that influence the performance of coatings when subjected to sulfuric acid attack.

1. Introduction

Concrete can be subjected to attack by various mineral acids which include sulfuric acid, nitric acid, hydrochloric acid and phosphoric acid. In wastewater system, the corrosion of concrete structures is caused by sulfuric acid is a major problem in most areas around the world. By a biologically influenced process, the metabolism of thiobacilli, hydrogen sulfide is converted into sulfuric acid. When concrete is in contact with this acid, the sulfuric acid reacts with concrete to form gypsum and ettrigite. Concrete will expand and spall.

To select coatings for wastewater facilities, one of the most important test is the chemical test (CIGMAT CT-1/modified ASTM G20 -88). When coated concrete specimens contact with continuous sources of sulfuric acid, quantifying the failure mechanisms are important to understand the long-term behavior of coatings.

2. Testing Program

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.

3. Test Results and Discussion

From more than three years of tests on coated concrete specimens, coating failure types include cracking across holiday (mainly alone the length of specimen), spalling, blistering around holiday and erosion(Figure 1).

Major Cracking *across holiday* (Figure 1 (a)) For specimen with holidays, concrete is directly contact with sulfuric acid through the holidays. Calcium hydroxide reacts with acid and forms gypsum and ettrigite. This causes the concrete to expand. Blisters are formed around the holiday. When tensile stress caused by concrete expansion exceeds the failure tensile strength of the coating, cracking occurs. Generally, specimens which have larger holidays crack first. Good bonding will prevent migration of acid along the interface resulting in smaller blisters.

Spalling (Figure 1 (b)) When a coating can't resist sulfuric acid attack itself or sulfuric can easily penetrate through the coating and affect the concrete at multiple locations, spalling occurs. In this situation, sulfuric acid rapidly reacts with calcium hydroxide on the surface of the specimen.

Blistering*(Single/multiple)* (Figure 1 (c)(d)) This type of failure occurs on coatings / linings with good ductility. When concrete expands, coatings / linings deform without cracking. Blisters mainly occur around holidays. In some cases, blisters also occur under the coating film.

Eroding (Figure 1 (e)) In some coatings, the sulfuric acid directly attacks the coating film first resulting in the removal(erosion) of coating.

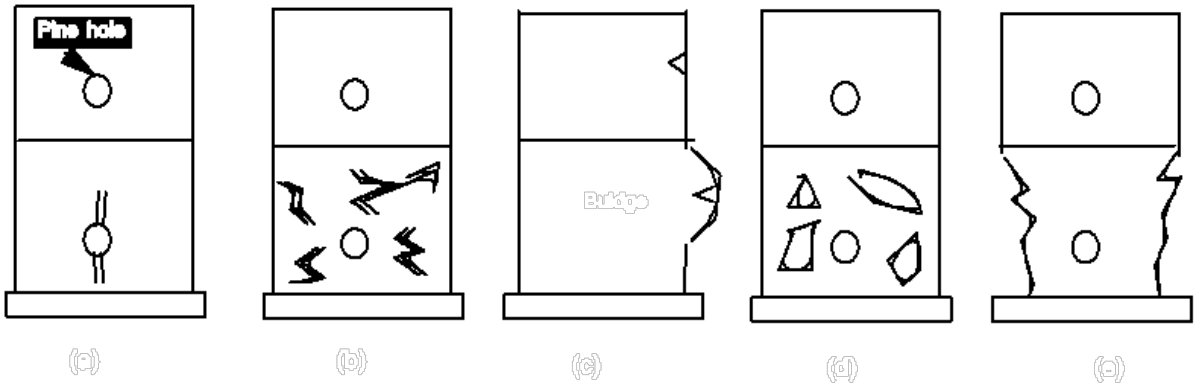

Figure 1 Failure Types of Coated Concrete Specimens

4. Summary

Performances of different coating materials were studied under extremely high concentration of sulfuric acid. Understanding the failure mechanisms of coated concrete can lead to further improvement in the materials.

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References

Vipulanandan, C., Ponnekanti, H., Umrigar, D.N., and Kidder, A.D. (1996), "Evaluating Coatings for Concrete Wastewater Facilities," Proceedings, Fourth Materials Congress, American Society of Civil Engineers, Washington D.C., November 1996, pp. 851-862.

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

If you have any questions, please contact **Dr. C.Vipulanandan**