

CALCIUM LEACHING FROM COATED CONCRETE

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Abstract

♦ The behavior of coated concrete when exposed to deionized water and sulfuric acid was investigated over a period of three years. Coated concrete specimens with and without holidays were studied and calcium in the leaching solutions was measured. Over twenty types of coatings are under investigation. Test results showed that holidays in the coating played very important roles in calcium leaching from coated concrete. A calcium leaching model was suggested to predict calcium leaching from coated concrete.

1. INTRODUCTION

Calcium is one of the major components in cement binder. Calcium leaching indicates the degree of degradation of coated concrete when immersed in a corrosive liquid. So, modeling the leaching rate of the calcium in coated concrete can help us to predict the degree of degradation of coated concrete structures under ♦ similar conditions. The factors which influence the leaching process include the degree of saturation, pH of the solution, the permeability of coating film, and the holiday sizes.

2. OBJECTIVE

The objective of the project is to model the calcium leaching from coated concrete.

3. CALCIUM LEACHING MODEL

Assume that the rate of calcium leaching from coated concrete is ♦ of the ♦ first ♦ order kinetic and the amount of calcium leached can be represented as follows:

$$dC_s / dt = \alpha(kM_c - C_s)$$

(1)

where M_c is the total amount of cement in the coated concrete, α is the coating related parameter and k is the solution and pinhole related parameter. The cement content M_c in a cylindrical specimen can be calculated by the cement factor (C_f) of the concrete and the volume of the specimen, that is $C_f \cdot \pi R^2 h$. For regular concrete, the factor of cement content is 280 kg cement/m³ concrete (17.4 lb cement/ft³ concrete).

Integrating Equation (1) and substituting for the initial condition at $t = 0, C_s = 0,$

$$C_s = \pi R^2 h k C_f (1 - e^{-\alpha t})$$

(2)

Using Equation (2) with the experimental data, parameter α and k can be obtained.

4. TEST RESULTS AND MODEL VERIFICATION

In order to verify the model, Coating N coated concrete in D. I. water and 3% sulfuric acid were selected and the results are summarized in Table 1, 2, and 3.

From Table 1, parameter k is the function of the type of coatings, pinhole size, and pH of the solutions. It seems that for this coating, there is no relationship between parameter α and pinhole sizes. Hence parameter α can be represented by an average value and parameter k recalculated using the average value of α (Table 2). For this coating, the parameter k varied with pinhole sizes can be modified according to Equation (3). The parameters k_1 and k_2 in Equation (3) are summarized in Table 3. The comparison of model prediction and test data is shown in Fig. 1.

$$\frac{k}{k_0} = 1 + \frac{d_h}{k_1 + k_2 d_h}$$

(3)

where ♦♦ d_h ♦ = ♦♦ pinhole diameter, cm; k_1, k_2 ♦ = ♦ constant.

Table 1 Values of a and k for Coating N

Coating Code	Pinhole Size (mm)	D. I. water				3% Sulfuric acid			
		a $\times 10^{-7} s^{-1}$		k $\times 10^{-5}$		a $\times 10^{-8} s^{-1}$		k $\times 10^{-4}$	
		dry	wet	dry	wet	dry	wet	dry	wet
N	0	1.63	1.16	1.59	1.82	4.85	8.52	11.0	4.50
	3	1.68	1.65	3.36	3.11	4.16	8.47	26.2	8.62
	6	1.73	1.91	4.84	4.29	3.55	7.12	36.0	13.1
	13	---	---	---	---	4.56	7.95	39.4	19.0

Table 8-2 Values of k and the Average Value of a for Coating N

Coating Code	Pinhole Size (mm)	D. I. water				3% Sulfuric acid			
		a $\times 10^{-7} s^{-1}$		k $\times 10^{-5}$		a $\times 10^{-8} s^{-1}$		k $\times 10^{-4}$	
		dry	wet	dry	wet	dry	wet	dry	wet
N	0	1.68	1.57	1.58	1.69	4.28	8.02	9.26	4.55
	3			3.36	3.03			25.8	8.77
	6			4.86	4.28			32.7	12.6
	13			---	---			43.7	19.0

Table 3 Values of k_1 and k_2 for Coating N

Coating Code	Coating Condition	D. I. Water			3% Sulfuric Acid		
		k_1	k_2	R	k_1	k_2	R
N	dry	0.24	0.076	1	0.12	0.18	0.99
	wet	0.37	0.044	1	0.29	0.094	0.99

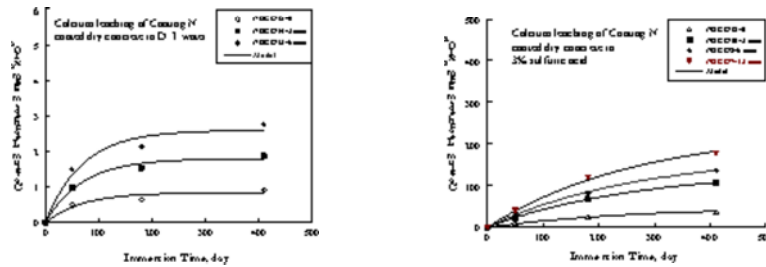


Figure 1 Comparison of the Experiment Data and Model Prediction

of Calcium Leaching from Concrete Coated with Coating N

5. CONCLUSIONS

The model predicts the calcium leaching of coated concrete in water and acid solutions. It can be used to predict the degree of corrosion of coated concrete under different expose conditions.

6. ACKNOWLEDGEMENT

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7. REFERENCE

Liu, J., Performance of Coatings in Wastewater Systems and Verification with Analytical Models, Ph.D. Dissertation, Chapter 8.

If you have any questions, please contact [Dr. C.Vipulanandan](#)
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