EFFECTIVENESS OF SURFACE PENETRANT AGAINST CHLORIDE ION PENETRATION UNDER LOW CONCENTRATION

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1. INTRODUCTION

Bhutan being a mountainous country, northern parts of the country received heavy to moderate snowfall during the winter season. During the snowfall, de-icing salts are spread out on the roads to avoid formation of ice and ensure the anti-sliding properties of road surface. The rate of application might be considerably low compared to Japan, however due to frequent exposure and ageing, our concrete structures might be deteriorating due to chloride-induced corrosion as result of application of de-icing salt. Therefore, to avoid premature deterioration, use of surface treatment is one of the methods which has been attracting attention due to excellent workability and effective preventive measures [1].

However, there is not much data about the effectiveness of surface penetrant against chloride ion penetration into the concrete structures exposed to low concentration of sodium chloride (NaCl). This paper studies the chloride ion diffusion coefficient of concrete structures with and without penetrant.

2. METHODOLOGY AND ANALYSIS

The mixture proportion of mortar specimens (20cm length x 10cm diameter) is shown in Table 1 and it was cured in water for 28days at 20 degrees Celsius. After that, the test specimens (3cm thickness and 10cm diameter) were obtained from prepared mortar specimens. Followed by coating of surface penetrant on test specimens as shown in Table 2 after keeping the specimens for 7days at 20 degrees Celsius and 60% relativity humidity. Then the diffusion coefficient of coated specimens exposed to normal and low concentrations of NaCl was calculated using an electric migration test.

Fig 1 provides an overview of an electric migration test method used. For testing, test specimens of 3cm thickness with and without coating were exposed to 3% and 0.5% NaCl Concentration under the constant 15 Voltage throughout the test duration. A steady state is assumed to be reached once the rate of chloride concentration increase in the anode becomes constant and the flux of chloride ions through the pore solution is determined from Fig 2. The effective diffusion coefficient of chloride ion as shown in Table 3 was calculated from the flux using Nernst-Planck Equation. The effective diffusion coefficient was converted to apparent diffusion coefficient (shown in Table 3 and Fig 3) using equation (1).

$$D_{ae} = K_1 \cdot K_2 \cdot D_e \qquad (1)$$

Where, D_{ae}: Apparent diffusion coefficient, D_e: Effective diffusion coefficient obtained in migration test (cm^2/year), K_1: Coefficient reflecting the equilibrium concentration of chloride ion on the cathode side and at the concrete surface and K_2: Coefficient reflecting the effect of immobilization of chloride ions in the hydrated cement system. When ordinary Portland cement is used ($K_1 \cdot K_2$ = 0.2 exp (1.8 (W/C)) (0.3l≤W/C<0.55 [2].

Table 1. Mix Proportion of mortar

W/C	S/C	Unit Weight (kg/m^3)		
		W	C*	S**
0.5	2.5	279	559	1397

* Ordinary Portland Cement (Density: 3.16 g/m^3)
** Land sand (Density 2.57g/m^3)

Table 2. Types of Penetrants

Case	Classification-Type	Application Quantity (g/m^2)
A	Silane-Type	200
B	No penetrant	0

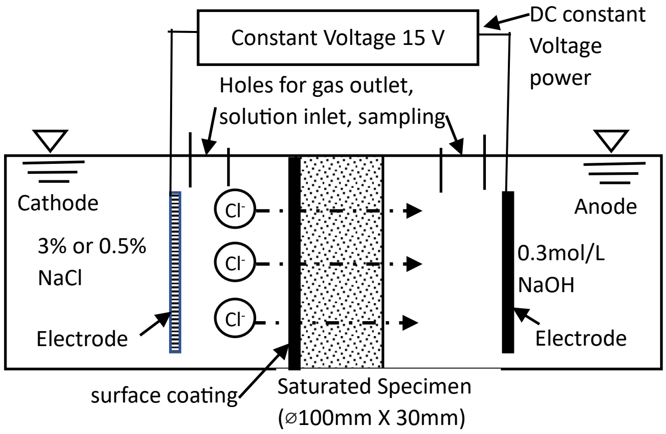

Fig. 1 Overview of electric migration test

3. RESULT AND DISCUSSION

Fig 2, Fig 3 and Table 3 show that the chloride ion concentration and the apparent diffusion coefficient of the mortar specimens are higher for the specimens exposed to the high NaCl Concentration and lower for the specimens exposed to the low NaCl concentration respectively. Also it is evident that the concrete surface coated with Silane-Type surface penetrant had significantly reduced the chloride ion concentration on the anode side and the apparent diffusion coefficient.

Keywords: Surface penetrant, Chloride ion penetration, Apparent diffusion coefficient
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Therefore, it is clarified that the application of the Silane-Type surface penetrant enhances to decrease the chloride penetration even under a low concentration of chloride ions.

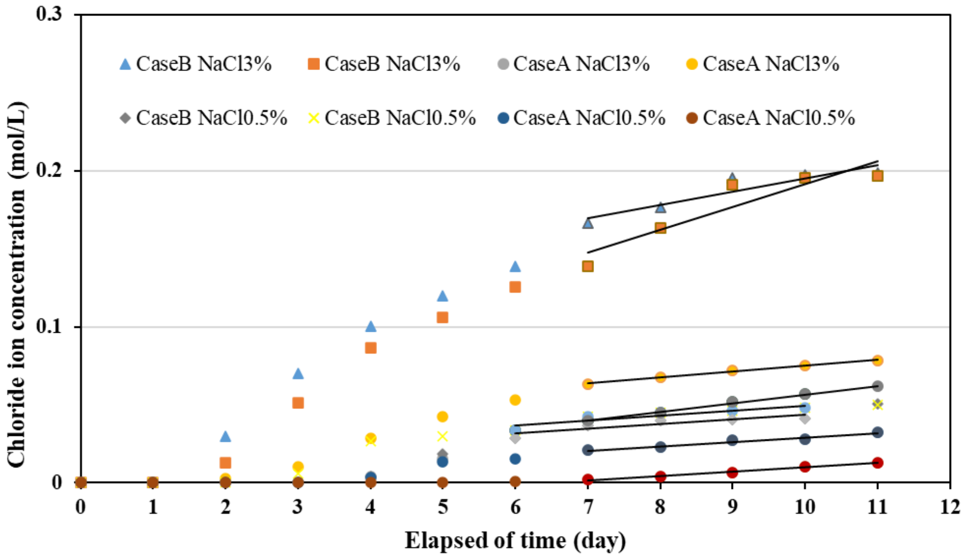

Fig 2. Change in chloride ion concentration on anode side

Table 3. Results of migration test

Type of surface penetrant	CaseB NaCl3%	CaseA-NaCl3%	CaseB NaC0.5%	CaseA-NaCl0.5%
Effective Diffusion Coefficient (cm^2/year)	2.63	0.40	1.61	0.22
Apparent Diffusion coefficient (cm^2/year)	1.34	0.20	0.82	0.11

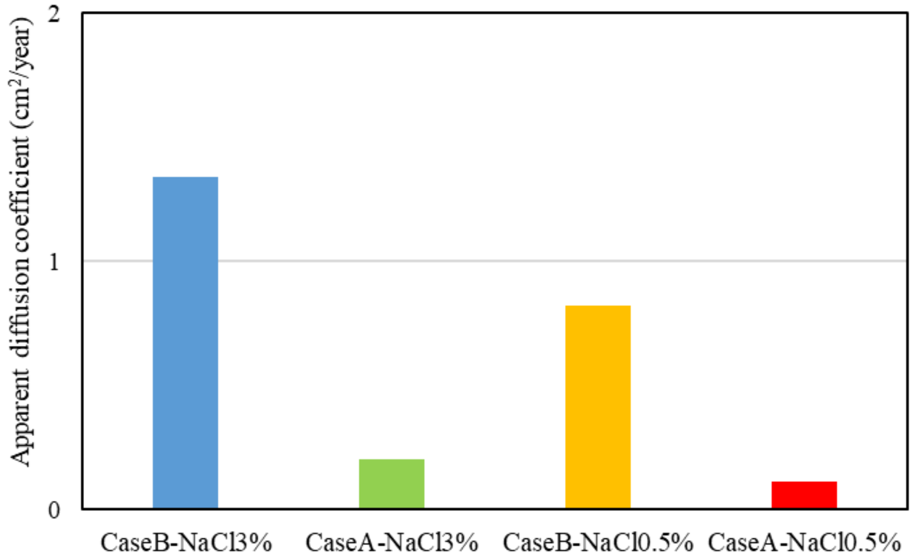

Fig 3. Apparent chloride ion diffusion coefficient of all experiment specimens

REFERENCE

[1] Hanaoka, D., Amino, T., Habuchi, T., Miyazato, S., & Tabata, S.. A study on prediction method of chloride ion penetration into concrete with surface penetrants. *Life-Cycle of Structural Systems: Design, Assessment, Maintenance and Management - Proceedings of the 4th International Symposium on Life-Cycle Civil Engineering, IALCCE 2014*, 950–955 (2015).

[2] Japan Society of Civil Engineers 2012 a: Standard Specifications for Concrete Structures-2012, Materials and Construction, 148-156.

[3] Miyazato, S., & Kuroiwa, D. Determination of chloride ion diffusion coefficient in outer layer of concrete with silicate-type surface penetrant. *Concrete Solutions - Proceedings of Concrete Solutions, 5th International Conference on Concrete Repair*, 409–416 (2014).