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TEST REPORT

CLIENT(S)

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CLIENT'S REF

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TYPE OF COMMISSION

Chloride Ingress due to Salt Water Spraying on Concrete impregnated with RADCON Sealing Agent

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	Restricted		
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1 INTRODUCTION

The test report gives the result from the salt water spraying test on concrete impregnated with RADCON sealing agent. This test report is essentially an english translation of test report 70021 dated 1994-03-07 (minor lay-out changes) with some additional comments.

2 EXPERIMENTS

The salt water spraying test was carried out in accordance with the internal procedure KS 70 116 at SINTEF Structures and Concrete. The quality of the base concrete corresponds to the process code MA (i.e. very aggressive environment) of the Norwegian Directorate of Public Roads, which is class C55 with w/(c+k·s) = 0.40 (w, c, s = mass of water, cement and silica fume, respectively. k = 2) and 5 % silica fume of the cement weight. The air content of the concrete was 5 vol%. The compressive strength of 10·10·10 cm^3 cubes were in average 75 MPa after 28 days curing (under wet burlap after demolding). The specimens were cured for another 2 months in air (3 months age) prior to any treatment.

The RADCON sealing agent was applied on concrete conditioned for one week at 50 % R.H. (dry surface) by brushing wet on wet in excess. The concrete surface was weakly inclining. The impregnation was repeated about 2 hours after the first treatment. Each specimen was weighed immediately after each treatment in order to measure the amount of sealing agent applied. After the salt water spraying test was finished, the specimens were stored at -20°C until they could be cut in sections for chloride analyses.

3 RESULTS

The calculated values for 1) chloride load at the surface, C_0 (% Cl^- of concrete weight), 2) effective diffusion coefficient, D_e (m^2/s), and 3) chloride ingress rate, v_i (g $Cl^-/m^2 \cdot s$), are given in Table 1 in Appendix 1. v_i is the total mass of chlorides pr unit time penetrating a given surface area. This latter parameter is included to improve the evaluation of the effect of different surface treatment agents and/or

different concretes of high quality, where the effective diffusion coefficient alone may give a too inaccurate impression of the chloride ingress.

The consumption of RADCON sealing agent is listed in Table 2, Appendix 1. The calculated apparent diffusion profile is plotted graphically together with the experimental data-points in Figure 1, Appendix 2. The chloride profiles in the untreated reference concrete and concrete treated with the product "RESCON Cl-brems" are depicted in Figure 1 as well for comparison. The testing of the latter two concretes was carried out for the Norwegian Directorate of Public Roads and reproduced with their permission.

4 COMMENTS

For the RADCON treated concrete, the calculated average values for chloride load at the surface; C_0 = 0.32±0.04 % Cl^- of concrete weight, effective diffusion coefficient; $D_e = 3.5 \cdot 10^{-12} \pm 1.3 \cdot 10^{-12}$ m^2/s, and chloride ingress rate; $v_i = 7.3 \cdot 10^{-6} \pm 0.9 \cdot 10^{-6}$ g $Cl^-/m^2 \cdot s$.

For the untreated reference concrete, the calculated average values for chloride load at the surface; C_0 = 0.204±0.004 % Cl^- of concrete weight, effective diffusion coefficient; $D_e = 31 \cdot 10^{-12} \pm 3 \cdot 10^{-12}$ m^2/s, and chloride ingress rate; $v_i = 13.2 \cdot 10^{-6} \pm 0.7 \cdot 10^{-6}$ g $Cl^-/m^2 \cdot s$.

For the concrete treated with "RESCON Cl-brems" (used as reference by the Norwegian Directorate of Public Roads), the calculated average values for chloride load at the surface; C_0 = 0.09±0.02 % Cl^- of concrete weight, effective diffusion coefficient; $D_e = 2.9 \cdot 10^{-12} \pm 2.4 \cdot 10^{-12}$ m^2/s, and chloride ingress rate; $v_i = 1.8 \cdot 10^{-6} \pm 0.3 \cdot 10^{-6}$ g $Cl^-/m^2 \cdot s$.

The effective chloride diffusion coefficient for the RADCON impregnated concrete is about 10 times lower than for the reference concrete, and about equal to the concrete treated with RESCON Cl-brems if the standard deviations for the three parallel specimens in each series is considered. Note that the term efficient diffusion coefficient is used, since the salt water spraying method is based on cyclic wetting and drying. Thus, capillary suction may contribute to the pure diffusion profile assumed in the calculations using Fick's law of diffusion.

The apparent huge difference in chloride profiles revealed in Figure 1, is reflected in the higher C_0 for the RADCON treated samples. Since RESCON Cl-brems is a water-repellant based on silanes and RADCON is a sealant based on silicate with and organic component, the difference is natural if the latter has to rely on a swelling to seal the concrete. Thus, a high initial C_0 value does not necessarily imply a higher concentration of chlorides after a few mm, but the curve appear steeper. In order to investigate these effects further, either longer term experiments, or pure diffusion experiments, should be carried out on both products.

Table 1. Results from Cl^- analyses of impregnated concrete, calculated diffusions coefficient, chloride load and chloride ingress rate.

Sample	Distance from surface (cm)	Cl^- content (% of concrete weight)	Calculated results
Radcon-1	0.05	0.257	
	0.15	0.218	
	0.25	0.186	$D_e=3.48\cdot10^{-12}$ m²/s
	0.35	0.144	
	0.45	0.103	$C_0=0.29$ % of concr
	0.55	0.069	
	0.65	0.063	$v_i=6.70\cdot10^{-6}$ g/m²·s
	0.75	0.041	
	0.85	0.031	
	0.95	0.025	
Radcon-2	0.05	0.277	
	0.15	0.250	
	0.25	0.208	$D_e=4.73\cdot10^{-12}$ m²/s
	0.35	0.172	
	0.45	0.144	$C_0=0.31$ % of concr.
	0.55	0.106	
	0.65	0.079	$v_i=8.26\cdot10^{-6}$ g/m²·s
	0.75	0.054	
	0.85	0.053	
	0.95	0.039	
Radcon-3	0.05	0.307	
	0.15	0.268	
	0.25	0.204	$D_e=2.31\cdot10^{-12}$ m²/s
	0.35	0.141	
	0.45	0.089	$C_0=0.37$ % of concr.
	0.55	0.060	
	0.65	0.046	$v_i=6.86\cdot10^{-6}$ g/m²·s
	0.75	0.038	
	0.85	0.028	
	0.95	0.027	

Table 2. Consumption of RADCON sealing agent.

Sample	Consumption (kg/m²)	
	1. treatment	2. treatment
Radcon -1	0.100	0.139
Radcon -2	0.080	0.113
Radcon -3	0.091	0.157

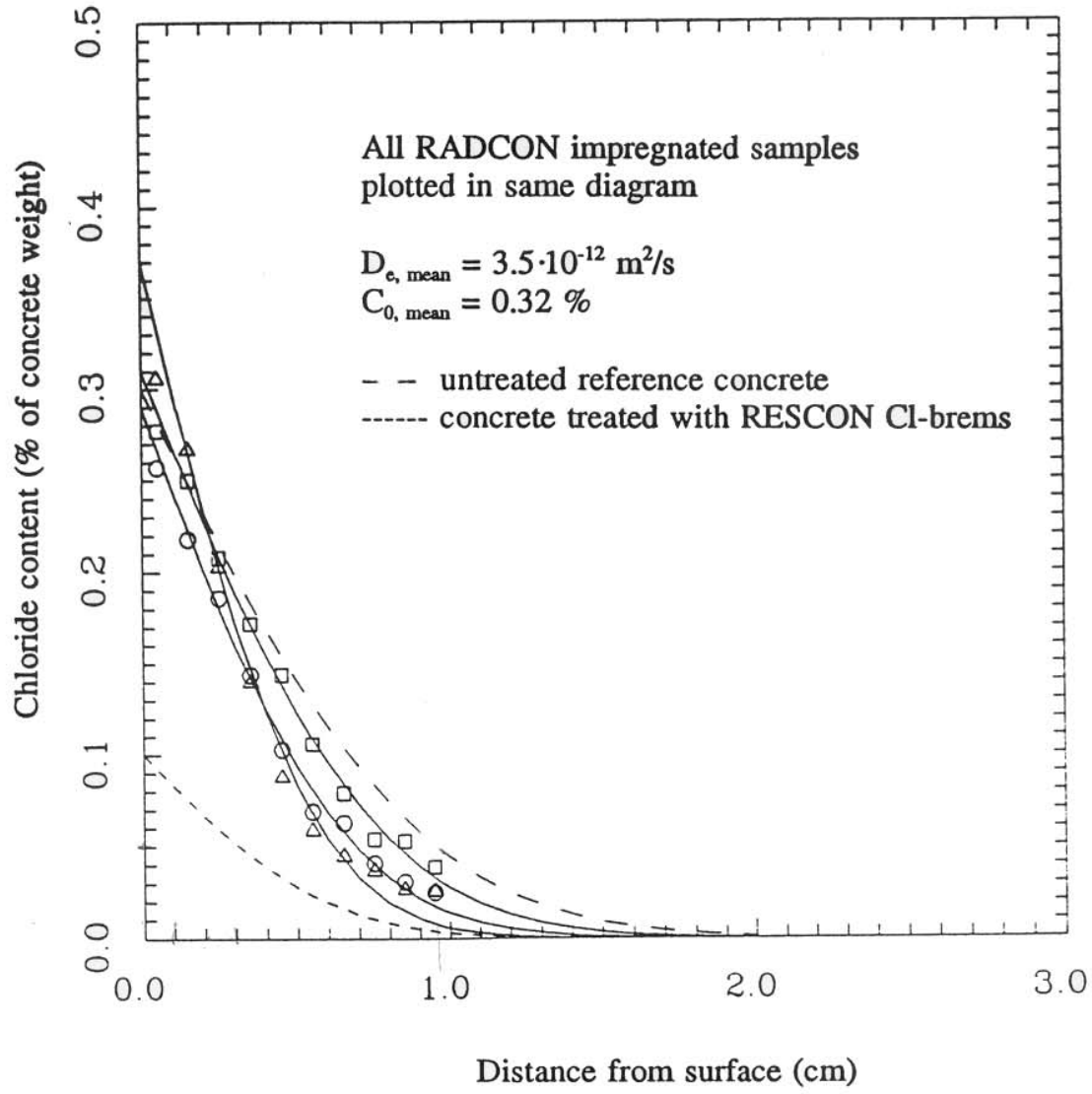

Figure 1 Graphical presentation of the results from the salt water spraying test.