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Chloride Diffusion in Concrete under Temperature Gradient Condition in Arid Climates

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Extended Abstract

Chloride ion diffusion in reinforced concrete structures is a major serviceability concern. This is because the chloride ion interaction with the steel bars will ultimately shorten the service life of the structure. Environmental factors such as temperature, relative humidity, and temperature gradient (TG) could influence the chloride ion diffusion process. More so, concrete properties such as porosity and permeability significantly determine the resistance of these concrete structures to chloride ion diffusion. In arid climates, high atmospheric temperatures are usually recorded especially during the summer. For concrete structures located at proximity to seawater, nuclear reactor containment buildings (RCBs) for instance, atmospheric adsorption of chloride ions to the walls of the RCBs creates chloride ion concentration gradient (CG). Usually, RCB facilities are maintained at air-conditioned temperatures internally. As such, a TG situation is created through the RCB walls. Previous studies have shown that the chloride ion diffusion increases significantly in concrete when the CG and TG are in the same direction [1, 2]. However, none of these studies have extensively examined the effect of water-to-cement (w/c) ratio on chloride ion diffusion under CG and TG conditions. As a result, the objective of this study is to investigate the effects of varying the w/c ratio on chloride ion diffusion of concrete under combined CG and TG conditions.

To achieve this goal, concrete samples with varying w/c ratios of 0.45, 0.55, and 0.65, having a constant aggregate-cement ratio of 3.0 were cast and cured for 28 days. Thereafter, these samples were exposed to chloride ion diffusion tests under three exposure conditions – two isothermal conditions, i.e., room temperature at 22 ℃ and elevated temperature at 50 ℃, and one TG condition (50 ℃ at one end and 22 ℃ at the other end) for 30 days. The concrete samples were sliced at 10 mm thickness up to 50 mm depth and then pulverized. Using the potentiometric titration, the total chloride ion content through the concrete depth was profiled. The chloride ion diffusion coefficients were obtained by fitting the error function solution of the 1D diffusion equation to the experimental data while the thermodiffusion coefficients of the samples were obtained by fitting the experimental results to the modified Fick's second law. The findings of this study show that the chloride ion content in samples exposed to TG conditions are 1.4 to 1.8 times higher than values obtained for isothermal conditions at the same temperature. Also, this chloride content increases as the w/c ratio increases for all conditions. Finally, the thermodiffusion coefficient increases by approximately 13 % and 32 % when the w/c ratio changes from 0.45 to 0.55, and then to 0.65, respectively.

References

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