Durability of reinforced concretes by the combined action of carbonation and chloride ingress

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Abstract

Analyzing the change of concrete pore structure due to carbonation and, also, considering the decrease of chloride binding capacity and the release of combined chloride ions, we established a comprehesive theoretical model which can reflect the influence of carbonation on chloride transport.

1. Introduction

The ingress of chloride ions is often signicant in marine atmospheric environment where the supply of chloride ions due to salt spray and carbonation of concrete take in place simultaneously. For instance, the entrance of cross-harbour tunnels, is subjected to severe salt spray condition, and at the same time, it also needs to bear the carbon dioxide pollution whose concentration is 5-6 times higher than that in most of other on-share environments. A similar concern may be made for structures in modern cities where a large amount of deicing salts is poured down in winter and the concentration of carbon dioxide is high because of pollution and trac. Given the interaction of carbonation with the durability threat caused by the transport of chloride ions is considered, both chloride ion transport and carbonation need to be taken into account in the development of a simulation tool.

2. The influence of carbonation on chloride transport

We consider the influence of carbonation is reflected in three aspects: (1) the reduction of the chloride ion binding capacity of concrete which accelerates the transport of chloride ions for all types of concrete. (2) The change of the connectivity and tortuosity of concrete due to the change of the critical aperture and porosity which influences the equivalent chloride ion diffusion coefficient significantly. (3) Although carbonation and chloride ingress take in place simultaneously, it should be noted that the diffusion of chloride ions is much faster than the speed of carbonation. I.e., before carbonation, concrete usually contains Friedel's salt due to the chloride ion bound inside of concrete. Once the Friedel's salt reacts with carbon dioxide during carbonation process, chloride ions are released to pore solution in concrete. These released chloride increases the free chloride concentration significantly higher than that in a simple diusion of chloride ions from the surface to inside.

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3. Experimental verification

In the literature[1], the experiments respectively tested the situation of carbonation and chloride ion distribution in fly ash concrete specimen and ordinary Portland concrete specimen. Firstly the specimens were set in the chloride solution; and then they were set in CO2 accelerated carbonation chamber. The equivalent diffusion coefficient of concrete specimens in chloride solution can be calculated by the concentration distribution of the same specimens which were set only in chloride solution but did not carbonize; in the accelerated carbonation chamber, the diffusion coefficient can be calculated directly by the temperature and humidity. The experimental data and numerical results are shown in Fig. 1 and Fig. 2, respectively. The test of carbonized specimen was carried out 56 weeks; and no carbonized specimen was carried out 52 weeks. We can find that carbonation accelerates the rate of chloride ions transport, and the releasing effect of bound chloride significantly increases the concentration of free chloride ions; the experimental data and numerical curves are very close, which proves the accuracy of our modeling approach.

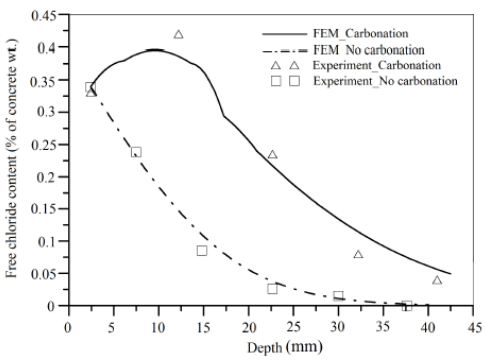

Fig. 1 The experimental data and numerical results of fly ash concrete

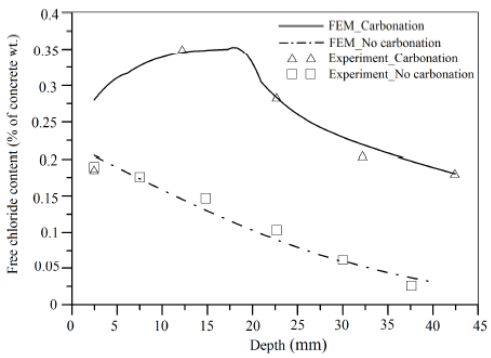

Fig. 2 The experimental data and numerical results of Portland concrete

4. Conclusions

Carbonation influences the transport of chloride ions in concrete signicantly. We build a model for the combined effect of carbonation and chloride ingress, and it was wel verified by experimental data.

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참고문헌

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