Numerical simulation of chloride ion erosion of reinforced concrete structures in marine environment

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ABSTRACT

For studying the coastal corrosion of reinforced concrete structures and analyzing the chloride ion erosion rules of different regions, this paper proposes a numerical simulation method of the chloride ion erosion of coastal reinforced concrete structures. We considered the effect of environment temperature, relative humidity, concrete age, bound chloride ion and convection, established the corresponding theoretical formula combining with domestic and foreign research. With the program, we simulated a bridge pier in a Bay Bridge. The results show that the numerical simulation method can simulate the chloride ion erosion well.

1. Introduction

Under the marine environment, the chloride ion erosion is a major factor leading to the decline of reinforced concrete structural durability. After the chloride ion invasion the concrete, it will significantly reduce the PH value, and produce electrochemical reaction with concrete, caused the depolarization and damage the passive film[1]. When the chloride ion concentration of reinforcement surface reaches a critical value, steel reinforcement began to depassivation. Currently, the analysis of concrete durability and chloride ion penetration level is mainly using the empirical formula and experiment test. Due to the type and condition of coastal structures very much, these two methods are insufficient to meet the needs of actual engineering design. Therefore, the development of numerical simulation method based on the principle of chloride ion penetration has important significance for durability analysis and design of coastal structures.

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2. Finite Element Model

This paper based on the physical development tool of COMSOL, directly definition partial differential equations and boundary conditions, coupling the temperature field and relative humidity with the chloride ion diffusion, simulating erosion of chloride ions. We take a pier of bay bridge as an example, establish a two-dimensional numerical model.

Factors affecting the critical chloride ion concentration are very complex, including the amount of cement, environmental conditions, oxygen supply, and the actual concrete alkalinity and so on. Fig.1 shows the time course curves of the chloride ion concentration in four different regions of the steel reinforcement outer surface. We can clearly find that four regions chloride ion concentration reaches a critical time respectively are: tidal zone is the shortest, about 25 years; followed by the splash zone, about 45 years; then is soak zone, about 65 years; atmospheric zone is much larger than 100 years.

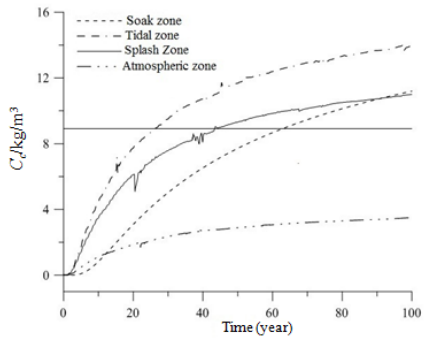

Fig.1 the time course curves of the chloride ion concentration in four different regions

3. Conclusions

This paper based on the physical development tool of COMSOL, coupling the temperature field and relative humidity with the chloride ion diffusion, simulating erosion of chloride ions, developing a numerical simulation program of chloride ion penetration. Then take a pier of bay bridge as an example, do the 2D numerical simulation use this program. The results show that this method can simulate the chloride ions erosion process for coastal reinforced concrete structures, can be applied to the actual anti-corrosion design of coastal engineering.

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