Research on Durability Technology of Concrete Structure Based on Corrosion of Steel Bars and Dissolution of Passive Film

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Abstract: In most cases, the corrosion and passivation film dissolution of steel bars in reinforced concrete are the causes of the decrease in durability of concrete structures. In the construction of islands, the use of high-durability concrete structures is critical, so this article proposes to explore the durability of concrete structures on the basis of exploring the corrosion of steel bars and the dissolution of passivation films to provide technical support for implementing marine strategies.

1. Introduction

With the determination of China's marine strategy, large-scale development and construction of islands is imperative, and research on concrete durability technology in the marine environment has become a hot spot and focus in this field [1]. Studies have confirmed that reinforced concrete structures reduce their service life due to premature performance degradation, often not because of insufficient strength, but because of insufficient durability. At present, there have been more mature studies on the deterioration of the durability of concrete structures caused by single environmental factors such as chloride ion intrusion and carbonization [2]. However, it is worth noting that the actual performance of concrete in the actual environment due to poor durability is mostly the result of the synergistic effect of load, environment and climate. This is inevitably different from the deterioration law of concrete structure under a single environmental factor. The coupling effect of environment and load is not a simple superposition of single factor effects. Therefore, this article proposes to study the new technology to improve the durability of concrete structure on the basis of in-depth exploration of the mechanism of the coupling effect on the macroscopic performance degradation of concrete structure.

2. Analysis of surface corrosion of steel bars in concrete

2.1. Sample production

The specimen is in the form of length × width × height = 360mm × 100mm × 100mm reinforced concrete specimens, 2 pieces of HPB300 grade steel bars with a length of 300mm and a diameter of 12mm lying in the diagonal position, the concrete strength is C30 grade, and the protective layer thickness is 20mm , The specific size and the form of reinforcement are shown in Figure 1.

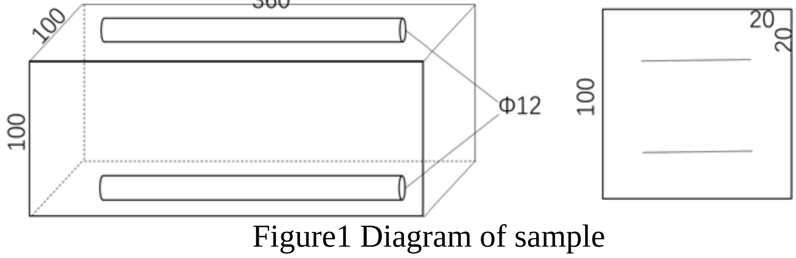

Figure1 Diagram of sample

After the test piece is made, move it to the curing room. One group uses artificial seawater for continuous immersion to simulate the marine underwater environment. The other group is placed in a dry-wet cycle device to simulate the marine tidal environment. Soak for 2 days, dry for 2 days,

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and water temperature 20 ± 5 ℃[3]. Each group prepares 6 sets of test pieces under the same test conditions, and breaks a set of test pieces for testing every 8 weeks.

Table1 Test specimen grouping table

Number	Concrete type	Maintenance method
A1	Seawater sea sand concrete	Continuous soaking
A2	Seawater sea sand concrete	Wet-dry cycle
B1	Ordinary concrete	Continuous soaking
B2	Ordinary concrete	Wet-dry cycle

2.2. Experimental instruments and methods

(1) Statistical method of steel corrosion rate

After the chloride ion erosion test in the simulated marine environment is completed, the press is used to sample the specimens at 8-week, 16-week, 24-week, 32-week, 40-week, and 48-week, and the samples are taken out. The embedded steel bar is wrapped with cellophane on the surface of the steel bar. After delineating the outline of the corroded part, remove the cellophane and paste it on the graph paper. Use formula (1) to calculate the steel bar corrosion rate:

$$R(\%) = \frac{A_n}{A_0} \times 100 \tag{1}$$

In the formula: R——Reinforcement corrosion rate (%);

A_n——the corrosion area of reinforcing steel in n weeks (mm^2);

A_0——Reinforcement surface area (mm^2).

(2) Statistical method of steel bar weight loss rate

After the test piece is broken, remove the steel bar in the test piece, scrape off the concrete adhered to the steel bar, pickle the steel bar with 12% hydrochloric acid solution, rinse with clean water, then neutralize with lime water, and finally rinse with clean water. Dry the steel bars for 4 hours, weigh each steel bar (accurate to 0.01g), and calculate the weight loss rate of steel bar corrosion according to formula (2).

$$\eta_i(\%) = \frac{W_{i0} - W_i}{W_{i0}} \tag{2}$$

In the formula: η_i——weight loss rate of each steel bar (%);

W_{i0}——The initial weight of the steel bar, the unit is gram (g);

W_i——The weight of the steel bar after breaking, the unit is gram (g);

i——Rebar number.

(3) Statistical method of corrosion pits on steel surface

After the steel bars were pickled, the large metallographic microscope ZEISS (see Figure 2 (a)) of the School of Materials Science and Technology of Jiangsu University was used to observe the pits, and the image analysis system was used for size calibration and quantity statistics, as shown in Figure 2 (b). Count the number and size of corrosion pits on the surface of steel bars in specimens of different ages, including the diameter (D) and area (S) of the corrosion pits.

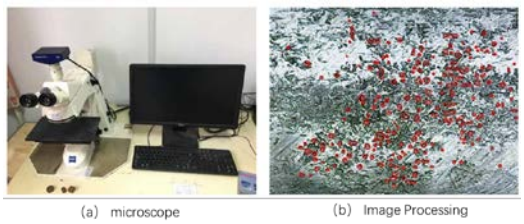

Figure 2 ZEISS metallographic microscope system

2.3. Experimental results

(1) Analysis of the change of steel rust accumulation rate

Through the comparison of the obtained results, we found (Table 2) that the rust build-up rate and weight loss rate of each specimen are basically proportional. It is higher than -35.10%, -37.14%, 15.24%, 26.26%, 12.12%, and 9.45% respectively under the soaking condition. In the early stage of immersion, the area of the steel bar in the concrete specimen will be larger, but in the later stage, the oxygen will be fully diffused with the condition, and the corrosion area of the steel bar will be larger under the dry and wet cycling conditions. At the same time, under the same rust deposition rate, the simulated marine tidal zone has a higher weight loss rate, that is, a greater corrosion loss rate of the steel bar section, the lower the safety factor of the structure and the worse the durability properties.

Table 2 Reinforcement corrosion rate (%)

Number	8w	16w	24w	32w	40w	48w
A1	9.97	16.26	26.3	33.01	35.97	44.4
A2	6.47	10.22	30.31	41.68	40.33	49.6
B1	0	0	0	1.98	3.41	10.03
B2	0	0	0	3.22	5.54	12.55

(2) Analysis of the weight loss rate of steel bars

It can be seen from the results obtained (Table 3) that for marine concrete, the steel bars in the fractured specimens have begun to corrode and produce large areas of rust at 8 weeks, while ordinary concrete only appears part of the 32-week fractured specimens Rust spots, but not enough to cause mass loss within the sensitivity of the test balance. After comparison, we found that during the 48 weeks of continuous corrosion of reinforced concrete specimens, the average growth rate of reinforcement corrosion in the dry-wet cycle curing method was 0.00927% / week, and the average growth rate of reinforcement corrosion in the immersion curing method was 0.00702% / week.

Table3 Steel corrosion weight loss rate of specimen (%)

Number	8w	16w	24w	32w	40w	48w
A1	0.042	0.151	0.214	0.256	0.286	0.337
A2	0.064	0.169	0.259	0.391	0.405	0.445
B1	0	0	0	0	0.021	0.056
B2	0	0	0	0	0.012	0.045

3. Analysis of the characteristics of the dissolution curve of the steel passivation film in concrete

3.1. Experimental instruments and methods

The electrochemical test uses a three-electrode system, the test instrument is the AUTOLAB-AUT86742 model electrochemical workstation produced by Metrohm Switzerland, and the reference electrode is a saturated calomel electrode [4].

3.2. Experimental results

(1) Analysis of the polarization curve characteristics of corroded steel bars

Figure 3 is the polarization curve image of the steel bar under different seawater erosion methods. At the beginning, the characteristics of the polarization curves of the four specimens at this time are basically the same, the slope of the anode polarization curve is gentle, and the slope of the curve is small, that is, the slope of the anode Tafel is small. In the later period, the characteristics of the polarization curves of the four groups of test pieces are basically the same, the slope of the anode polarization curve is steep, and the slope of the curve is large, that is, the slope of the anode Tafel is large. At this time, it is more difficult for the steel bar to continue to corrode, indicating the production of corrosion products Accumulation has a certain degree of impediment to the continuation of corrosion. The cathode current intensity and corrosion current density of the dry-wet cycle group and the immersion group did not change much in each stage, and the cathode reaction rate remained constant.

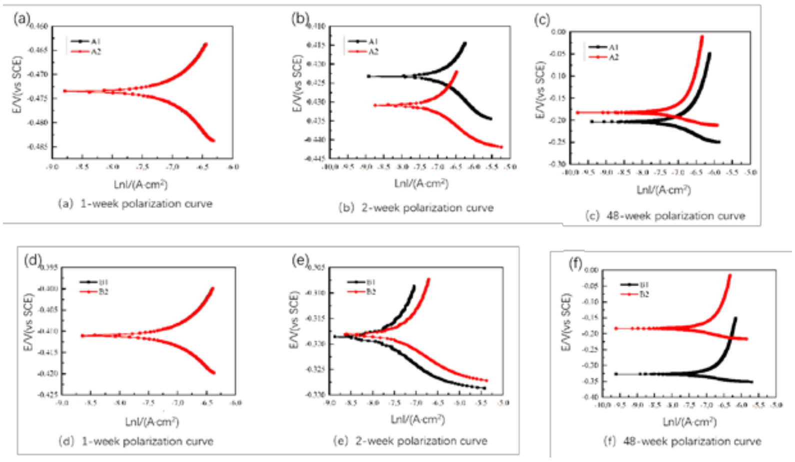

Figure 3 Characteristic analysis of the polarization curve of corroded steel

(2) Analysis of changes in self-corrosion potential of corroded steel bars

Comparing the changes of the self-corrosion potential of the steel bars in the two kinds of concrete, we found that the self-corrosion potential of the steel bars in the previous samples B1 and B2 was lower than that of A1 and A2, indicating that the potential difference between the cathode and anode is greater and the steel bars are Corrosion is more likely to occur in sand concrete, which is obviously related to the chloride contained in the aggregate and mixing water.

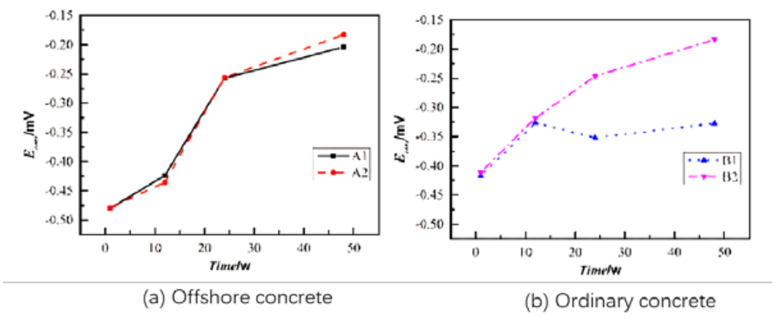

Figure 4 Self-corrosion potential of two types of concrete reinforcement

4. Reinforcement corrosion and depolarization protection technology

The current rust inhibitor is a widely used method to prevent corrosion of steel bars [5]. The rust inhibitor is essentially a chemical compound, which is used in concrete structures to prevent or relieve internal reinforcement. The effect of corrosion. In this paper, the application of migration-type rust inhibitor as surface protective coating, with FRP tendons as the concrete admixture.

The molecular structure design principle of the migration-type rust inhibitor: the main film-forming material of the rust inhibitor has moderate molecular length and structure size; the rust inhibitor molecule contains benzene ring or unsaturated double bond or triple bond; the molecule also contains electronegativity Large N, S, P heterocyclic molecules have multiple active adsorption centers. The ratio of hydrophilic groups and hydrophobic groups in the rust inhibitor molecule is appropriate; there are 2 polar groups in the rust inhibitor molecule.

The production of FRP tendons mostly adopts the extrusion method. After the multi-strand fiber is glued with the matrix material, it is extruded and drawn by a special mold. The production process is shown in Figure 5. In order to increase the cohesive force between FRP bars and concrete, FRP bars are often surface-treated in the form of sand, ribs, deformation, and fabrics.

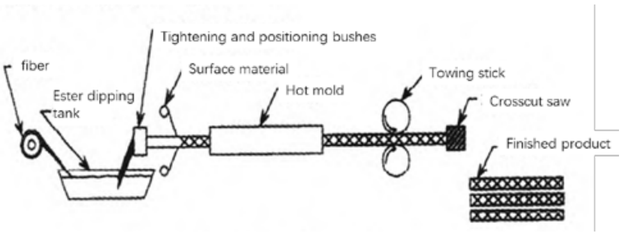

Figure 5 production process

The durability of concrete specimens with FRP bars instead of traditional steel bars and coated with migration-type rust inhibitors was evaluated using ultraviolet aging test, temperature resistance test, pitting potential test and carbonization depth test. The results show that the aging performance test is completed at 12 000 h Afterwards, the 60 ° gloss of the test piece coating still reached 48.9, the temperature change resistance performance was relatively superior, and the corrosion resistance was good.

Acknowledgments

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References

[1] Zhu Yaofeng, Mao Jianghong, Jin Weiliang, et al. Durability status and improvement method of concrete structure of an island building complex in Ningbo [J]. Building Structure, 2018, 48 (02): 19-23.

[2] Gao Ge, Xiao Min. Related factors and control measures affecting the durability of concrete structures [J]. Contemporary Chemical Industry, 2018, 047 (003): 539-543.

[3] Yang Bo, Gao Rundong, Xu Qingfeng. Experimental study on durability of permeable concrete in complex erosion environment [J]. Civil Engineering and Environmental Engineering, 2018 (3): 53-60.

[4] Yu Fengrong. Study on mechanical properties of stainless steel reinforced concrete members after corrosion damage [D]. 2017

[5] Chen Qing, Tang Hao, Li Zhen, et al. Impedance spectrum characteristics and reinforcement performance evaluation of reinforcement in inorganic repair materials [J]. Journal of Materials Science and Engineering, 2019, 037 (001): 91-95.