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Summary of Experimental Research on Electric Accelerated Steel Corrosion

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Abstract

The durability of reinforced concrete is of great significance for the construction industry, and it is the key problem of today's civil science research. Under natural conditions, the deterioration rate of reinforced concrete structure is very slow, and the age is long. Corrosion generally goes through more than ten years, decades or even longer time. Moreover, the artificial protection required by the structure and the test record span required by the test are too large and difficult. The method of electrical accelerated corrosion has the advantages of simpleness, high controllability, short cycle and low cost. Therefore, in civil engineering tests, the electrical accelerated corrosion of reinforced concrete members is generally carried out by using the external current to simulate the corrosion of reinforced concrete structures in the natural environment. This method shortens the corrosion time and increases the corrosion efficiency, which saves the economic cost and time cost. Therefore, combined with economy and practicability, the academic circles generally use DC power supply to accelerate steel corrosion.

Keywords

Civil engineering; corrosion of reinforcement; current accelerated corrosion.

1. Introduction

Electrochemical reaction is the essence of steel corrosion. The principle is that the cathode and anode are formed on the exposed surface of the steel bar, and the steel bar and another metal conductor are connected. Under the action of different potential differences, the exposed surface of the steel bar is oxidized. Based on this principle, the accelerated steel corrosion test is carried out. The essence of accelerated corrosion is the process of electrolysis. Foreign scholars Sohail M et al. connected the positive electrode of DC power with steel bars in concrete as the anode in the reaction by introducing an external DC power. The principle of this method is that a DC power supply is used to connect the other end of the steel bar in the concrete structure to connect other types of metal conductors, and the current is introduced to promote the release of electrons on the surface of the steel bar and the anodic reaction occurs. The advantages of the electrical accelerated corrosion method are as follows. (1) The required corrosion specimen can be obtained in a relatively short period of time. (2) The relatively uniform full-section corrosion along the circumferential direction can occur on the surface of the electrical accelerated corrosion reinforcement. Azher and other scholars ' experiments show that the essence of steel corrosion reaction in reinforced concrete structures is electrochemical process, and the reaction formula is as follows :

Anodic reaction : $2Fe \rightarrow 2Fe^{2+} + 4e^{-}$ (1-1)

Cathode Reaction : $O_2 + 2H_2O + 4e^{-} \rightarrow 4OH^{-}$ (1-2)

Total reaction : $2Fe + O_2 + 2H_2O \rightarrow 2Fe^{2+}$ (1-3)

Kang Wanli et al. pointed out that in the process of accelerating steel corrosion by DC power supply, if there is an auxiliary electrode in the cathode of the reaction, the reaction system is a

double electrode reaction system. In this case, the concrete reaction formula of steel corrosion is as follows :

$Fe \rightarrow Fe^{2+} + 2e$ (1-4)

$Fe^{2+} + 2OH^{-} \rightarrow Fe(OH)_2$ (1-5)

$4Fe(OH)2 + O2 + 2H2O \rightarrow 4Fe(OH)_3$ (1-6)

$2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$ (1-7)

2. Introduction Accelerated corrosion method by electrified wire

Wang et al. used the full immersion method and the half immersion method to study and elaborate the corrosion of steel bars in the electrified environment. The results show that the corrosion uniformity of the component obtained by full immersion method is high, and the crack development rate caused by corrosion expansion is low. The corrosion uniformity of components obtained by semi-immersion method is low, and the crack development rate caused by corrosion expansion is also low. Qian Zhongwei studied the mechanical properties of reinforced concrete corroded members artificially made by the method of accelerating steel corrosion through electricity by using full immersion method, half immersion method and surface method. The test results show that the bearing capacity of reinforced concrete corroded members obtained by full immersion method is different from that of natural corroded reinforced concrete corroded members at the same age. The experimental results obtained by semi-immersion method and surface method are in good agreement with those obtained under natural environment. Wu Feng et al explored the corrosion rate of reinforced concrete specimens with different protective layer thickness in 5 % sodium chloride (NaCI) solution by full immersion method, and simulated the crack model caused by corrosion expansion. The specific steps of the test method for accelerating steel corrosion by using an external DC power supply are :

The corrosion steel bar specimen was placed in the solution of sodium chloride (NaCI) concentration of 5 %, and the steel bar was connected with the positive electrode of the circuit as the anode of the electrolytic cell. Connect other conductive metals to the negative electrode of the circuit as the cathode of the electrolytic cell. The connected specimens were placed in sodium chloride (NaCI) solution to form a closed loop, so that the corroded reinforced specimens were electrified and accelerated by an external DC power supply.

3. Adoption of current density

Chen believed that under natural corrosion environment, the corrosion current density of steel bars in reinforced concrete structures was relatively small, generally no more than 10 μA / cm_2. Cheng used four different average current densities of 200, 400, 800, and 1000 μA / cm_2 to carry out the accelerated corrosion test of the specimen. The test results showed that the strength of the current was inversely proportional to the efficiency of the accelerated corrosion of the specimen. In the environment of accelerating steel corrosion by DC power supply, it is generally believed that Faraday's law can be used to convert the current density of the external DC power supply to the rate of steel corrosion. At the same time, it is generally believed in the academic community that the smaller the current density of the external DC power used in the steel bar corrosion specimen is, the closer the corrosion of the steel bar corrosion specimen under natural corrosion conditions is. The study of Grimes showed that when the current density was not higher than 125 μA/cm2, the current density had little effect on the corrosion, expansion and cracking of steel bars. In general, taking into account the cycle factor of the test, the current density used in the steel corrosion test is basically controlled in the range of 100 $\mu A/cm^2$ to 1000 $\mu A/cm^2$.

In the electric accelerated environment and in the natural environment, if the degree of corrosion of steel bars is the same, then the amount of electrons or Fe^{2+} produced by the reaction on the surface of steel bars in these two environments is the same, that is, the electric flux produced by the two corrosion environments is the same. According to Faraday's law, the relationship between the corrosion degree of steel bar, the current of DC power supply and the time of power supply can be expressed by this formula.

$$w = \frac{M \times I \times t}{2F}$$

In this formula, F is the Faraday constant (96500 A·s), M is the molar mass of iron (Fe) (56 g / mol), ΔW is the mass of corroded reinforcement (unit : g), I is the applied current intensity (unit : A), and t is the electrified time (unit : s).

4. Summary

Steel corrosion is an important factor in the durability damage of reinforced concrete structures. Corresponding and effective measures should be taken in construction to avoid the negative effects of steel corrosion on economy and safety. At the same time, the use of DC power to accelerate the corrosion of corroded components is an important means to obtain corroded components in the wood engineering laboratory, which occupies an important position in the actual corrosion simulation of reinforced concrete structures.

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