Research Progress on Corrosion Protection of Reinforced Concrete in Saline Soil Area of China

Hongjian Zhang

School of North China University of Science ang Technology, Tangshan 063210, China.

635998950@qq.com

Abstract

saline soils are widely distributed in coastal, northwest and northeast China. It is well known that the service life of reinforced concrete structures in saline soil area is short and the corrosion damage is relatively serious. However, there are many kinds of saline soils in China, among which chlorine salts and sulphate salts play the most important role in the corrosion damage of reinforced concrete. In this paper, the invasion mode and erosion and corrosion mechanism of chloride and sulfate in saline soil are first expounded, and then relevant research results at home and abroad are summarized, and relevant protective measures are classified and summarized, which provides necessary guidance for engineering practice in the future.

Keywords

saline soil; concrete corrosion; corrosion mechanism; protective measures.

1. Introduction

Generally, the soil whose surface layer thickness is 0 ~ 30 cm and soluble salt content is more than 0.2% (i.e. 2000 mg/kg) is called salinized soil. Saline soil mainly distributes in inland arid, semi-arid area and coastal area. In the saline soil environment, the high concentration of salt has different corrosion, so how to reduce the impact of corrosion and reduce the maintenance costs, has become an important issue to be considered in the design and construction. China's salinized soil covers an area of more than 200,000 square kilometers, accounting for 2.1 percent of the total land area, and with the gradual depletion of land resources, the expansion of saline soil areas and corrosion problems Also caused the universal attention. The main characteristic of salinized soil is that it contains salt, especially soluble salt, which is corrosive to reinforced concrete and affects the durability and safety of transmission and transformation equipment concrete foundation and underground facilities. Therefore, it is urgent to study the relevant technical fields, especially the durability, corrosion resistance, anticorrosion prevention and control of concrete in saline soil area, all of which need to be solved urgently. Therefore, it is very important to study and design the durability of concrete in saline soil environment.

2. Corrosion Mechanism of Reinforced Concrete with Different Types of Saline Soil

There are many ways for chloride and sulfate ions to invade the concrete in the outside environment, including capillary inhalation, infiltration, diffusion and electrochemical migration. Chloride ion and sulfate ion also change the main way of invasion with the change of surrounding environment.

2.1 Corrosion of Reinforced Concrete by Chlorinated Saline Soil

Chloride erosion is one of the reasons for the decrease of the life of reinforced concrete structure. The corrosion damage of reinforced concrete by chloride ion can be summarized as the destruction of passivation film, formation of "corrosive battery", depolarization and conductivity.

2.1.1 Damage Passivation Film

The destruction of the passivating film by chloride ions is firstly reflected in the significant effect on the pH value of the surrounding environment.

In general, in uncarbonated concrete, the pH value of pore fluid can reach about 13, forming a strong alkaline environment. In this environment, a dense passivation film of iron oxide with a thickness of about 5nm will be formed, which plays a good protective role on the reinforcement . However, the passivation film is unstable and depends on a strong alkaline environment to maintain stability. Once the strong alkaline environment changes, the passivation film will be destroyed.

When the pH value of the passive film decreases and is lower than 9. 9, the passivation film begins to be destroyed. Therefore, when chloride ions are close to the surface of passivated film, the pH value of steel bar surface decreases rapidly. With the invasion of air and water, the passivation film gradually destroys and loses its protective effect, and the steel bar begins to corrode.

2.1.2 Formation of "Corrosive Batteries"

With the invasion of chloride ions, the damage of passivation film on the surface of steel bar begins with local points, which make the iron matrix at these local damage points contact with chloride ions. The potential difference between these iron base experiences and the passivation film without erosion is formed. The potential difference also leads to the formation of corrosive batteries. The anode of the battery is the exposed iron matrix, and the cathode is the undamaged part of the passivation film. Because of the potential difference, the negatively charged chloride ions begin to move toward the iron matrix under the action of the electric field, resulting in its erosion is aggravated. With the participation of water and oxygen, the steel bar will corrode, and eventually the whole steel bar surface will form a macro cell corrosion, showing a Species of heterogeneous corrosion forms.

Due to the effect of corrosive battery, pitting or pit corrosion is formed on the surface of steel bar, and the development of pit corrosion is faster due to the correspondence between small anode and large cathode, which is the main reason for the formation of pit corrosion on steel bar surface.

2.1.3 Depolarization

Due to the potential difference, the chloride ions move to the anode and react with the iron matrix in the anode to form ferrous chloride due to depolarization. During the diffusion of ferrous chloride, which is soluble in water, from the surface of steel bar to the concrete, when the ferrous chloride meets OH^-, it will react and form a precipitate of ferrous hydroxide. Iron hydroxide is unstable and is easily oxidized by oxygen in air to form iron oxides.

After this series of reactions, the chloride ions did not lose, but only acted as transport. That is to say, chloride ions entering into concrete will cause cyclic destruction, which is one of the characteristics of chloride ion erosion. However, the iron matrix was further oxidized to form iron oxides, and the corrosion area was further expanded.

2.1.4 Conductive Effects

The main condition of corrosion battery formation is the existence of ion pathway. Due to the presence of chloride ions in concrete, the ion path increases and the resistance between the cathode and anode of the battery decreases, which increases the flow speed of corrosive ions in concrete, and further increases the corrosion efficiency of the battery. The occurrence of electrochemical corrosion in concrete was accelerated, and the resistance of the two poles was further reduced due to the presence of cations in chloride.

2.2 Corrosion of Reinforced Concrete by Sulphate Saline Soil

Sulfate is a common corrosion medium in concrete working environment. Freeze-thaw failure of concrete in sulphate corrosion environment is one of the typical durability failure types. The corrosion of concrete under sulfate environment mainly includes chemical erosion and physical erosion.

2.2.1 Chemical Erosion

In the process of chemical reaction between sulfate in saline soil and hydration products of cement in concrete, expansion causes loose internal structure and cracks in concrete, which makes concrete lose its cementation property and produce spalling. The phenomenon of collapse leads to the cracking and destruction of the whole structure, and the deterioration of concrete is called chemical erosion. Chemical erosion mainly includes gypsum chemical erosion ettringite chemical erosion and carbon sulfur silica calcium chemical erosion.

2.2.2 Physical Erosion

The sulfate in saline soil does not react with cement hydration product in concrete, but forms corresponding salt crystallization, crystal volume expansion, which leads to cracking and destruction of concrete. This process is called physical erosion. There are three views on the physical erosion mechanism of concrete sulfate: the theory of solid phase volume change of sodium sulfate, the theory of water pressure of crystal and the theory of pressure of salt crystallization.

3. Protective Measures Against Corrosion Damage in Saline Soil

The corrosion of concrete in saline soil area is mainly due to the intrusion of corrosive ions (mainly sulfate ion and chloride ion) into the concrete with water, and a series of physical and chemical reactions take place, resulting in the loss of corrosion resistance of concrete. Corrosion of steel bars, structural damage, affecting service life. Therefore, to improve the corrosion resistance of concrete, it is necessary to improve its own corrosion resistance and prevent the infiltration of water to form a dense, disconnected pore structure.

3.1 Protective Measures Against Reinforcement

Strengthening the protection of steel bars can ensure the strength of the structure and improve the durability of the structure. The protective measures for steel bars are mainly rust-proof coating. When using steel coating, you can choose to use galvanized coating. According to the study of Zuo Jun et al., it is found that the protective effect of galvanized coating is not very good for the steel bars in concrete protection, so the galvanized coating is only recommended to be used in neutral environment. In non-neutral environments, the galvanized coating dissolves due to corrosion and then loses its protective function.

Liu Hong et al. put forward the method of coating corrosion inhibitor on the surface of steel bar after expounding several commonly used methods for the determination of chloride content. A tough, continuous insulating layer is sprayed on the surface of the treated steel bar by electrostatic coating process. This layer of insulation can separate concrete from steel bar, even if chloride ions, oxygen, water and other serious erosion of concrete, the protective layer can also protect the reinforcement for a long time. It is proved by practice that adding proper amount of rust inhibitor to concrete mixture is also an effective measure to prevent the corrosion of steel bar in concrete. The principle is to increase the critical concentration of chloride ion which induces corrosion. It needs to be pointed out that production The quality of product technology determines the effect of rust inhibition.

Li Hongzhiput forward that epoxy powder coating can be used in bridge anticorrosion measures. The surface of common steel bar is treated with rust removal and hairing, and then heated at 230 ℃. Then, the epoxy resin powder can be directly sprayed on the surface of steel bar by electrostatic spraying. A relatively complete and continuous protective layer of epoxy resin film can be formed by curing for a period of time.

3.2 Protection Measures Against Concrete

In addition to controlling the chloride ion and sulfate ion content in its own material, concrete also requires strong corrosion resistance of coastal engineering cement. In hydration heat bottom, P.O cement or other corrosion-resistant cement should be preferred. Instead of quick hard Portland cement and so on .

Adding nano materials is an effective way to improve the corrosion resistance of concrete. Zhang Hongliang et al. adopted high performance concrete as the benchmark concrete, Six types of concrete specimens were prepared by mixing 1% CaCO3, with 1% CaCO3, 1% SiO2, and 1% CaCO3, 3% SiO2, 1% CaCO3, 1% TiO2, 1% CaCO3, 3% TiO2. The dry and wet cycle tests were carried out in sodium sulfate solution. The microstructure of corroded specimens was scanned to observe different types of specimens. The results show that the concrete mixed with 1% nanometer CaCO3 3% nano SiO2 has the best sulphate corrosion resistance under the condition of semi-immersion.

Double mixing fly ash and water reducing agent is also an effective way to improve the corrosion resistance of concrete. Jiang Weidong et al.tested the anti-corrosion, impermeability, carbonization and freeze-thaw resistance of concrete in laboratory, and carried out field tests on the anti-corrosion and impermeability of concrete in salinized areas. The relationship between the content of fly ash and the durability of concrete is obtained. The method of adding fly ash and water reducer in concrete can improve the corrosion resistance and impermeability of concrete, but the addition of fly ash has a negative effect on the carbonation resistance of concrete, and this formula also makes the frost resistance of concrete worse. . After comprehensive consideration, it is recommended that the concrete with 40% fly ash should be used in salinized area, so that the durability index of concrete is higher.

The permeable high efficiency water-repellent agent is the coating material of concrete surface. It has strong water resistance and high adhesion after the modification of nanometer and different chemical substances with polymer film as the basic material. Anti-ultraviolet and anti-pollution ability. When the coating is condensed, a colorless, transparent and smooth waterproof coating is formed. After the coating is coated with the coating, the coating has good durability, permeability, hydrophobicity, etc., which can completely seal the surface layer of the concrete. Can effectively protect the surface and interior of reinforced concrete structure from sewage, deicing salt, salinized soil and severe environment corrosion damage. "ordinary concrete anticorrosion coating Material "is a kind of concrete surface protection material with sealing, anticorrosion, dust-proof and long-acting durability." Xu Zhenhai et al. studied the coupling effect of concrete with permeable superplasticizer under freeze-thaw cycle and chloride ion erosion. It is concluded that the mass loss of the coating concrete is more than 3.8% lower than that of ordinary concrete. There is no obvious denudation mark on the concrete surface, and the salt freezing resistance of concrete is improved significantly.

The distribution characteristics of chloride ions in concrete coated with epoxy resin system, acrylic acid system and inorganic silane system are analyzed. The durability of concrete structure based on three anticorrosive coatings is compared. Some valuable conclusions are obtained: the amount of chloride intrusion in concrete increases with time and decreases rapidly with the increase of distance from concrete surface. Coating with epoxy resin system, acrylic acid coating and silane coating can reduce the content of chloride ion in concrete, and the rate of decrease is obviously changed from coating to concrete. Compared to concrete coated with epoxy resin, The corrosion resistance of epoxy resin coated concrete is more obvious than that of silane coated concrete. The corrosion of steel bar is delayed and the durability of concrete is prolonged if the concentration of chloride ion on the surface of concrete is low. Therefore, in terms of durability of coated concrete, silicic acid coated concrete is the best, acrylic acid coated concrete is the worst.

XYPEX is a gray powder inorganic material composed of Portland cement, silica sand and a variety of special active chemicals. The mechanism of its action is that the special active chemicals in XYPEX materials merge with water and penetrate into the concrete through the pores of concrete to promote the secondary hydration of incomplete hydrated cement and water to form insoluble crystallization.

XYPEX not only plays a waterproof role, but also prevents the infiltration of chemicals, salts and other harmful substances by blocking the pores and cracks of concrete and improving the self-compactness of concrete structures. Current field test data Less, Fang Yicang has carried on the salt corrosion prevention test under the condition of brine immersion and brine dry and wet cycle respectively, which filled the blank of XYPEX test in the strong saline soil area of China. The results show that the crystal structure of the concrete filled with XYPEX reduces the diffusion rate of harmful ions and delays the corrosion of brine. As the first line of defense, the XYPEX coating has a good anticorrosive effect on concrete.

3.3 Other Methods

Besides the corrosion resistance of reinforced concrete itself, the risk of corrosion can be reduced by changing the surrounding environment. In the saline soil area, the soil layer around the structure can be replaced by external clay, that is, the method of replacing the soil around the structure, and the permeable cushion can be used at the bottom of the structure, because the corrosion effect of groundwater is more obvious when the groundwater is salinized, so, In order to prevent groundwater from corroding the surface of structure through capillary action, the underlying layer at the bottom of the structure should be made of permeable materials, such as sand cushion, sand gravel layer, etc. If a concrete cushion is used at the bottom of the structure, in order to further prevent the corrosion and damage caused by groundwater to the structure, multiple layers of leachate are laid on the cushion Green soaked linoleum, further improve the ability of corrosion resistance.

Zhou Gang et al.in the Saline Land area of Chaerhan Salt Lake in Geermu City, Qinghai Province, when conducting field visits to investigate the corrosion status of concrete structural members in saline soil areas, The effective measures to protect reinforced concrete structures with anti-corrosion and hard materials such as FRP are put forward. FRP coating protection, FRP is characterized by light and hard, not conductive, high mechanical strength, corrosion resistance. However, because the bond between FRP and concrete is not firm, the contact surface of FRP and concrete is removed and the concrete is corroded to some extent.

Wang Yi Hong et al. pointed out that in the second phase of comprehensive utilization project of Qinghai Salt Lake Industrial Group, the pile foundation adopts bag concrete pile, which realizes the goal of preventing the corrosion of concrete pile body caused by salinized soil and brine, etc. In strong saline soil areas, geotextile bags can be used for anticorrosion, especially for bridges and culverts that require high foundation bearing capacity, and large diameter bagged concrete cast-in-place piles can be used. The anticorrosive bag which has better anticorrosion performance in pile foundation is used for anticorrosion.

3.4 Restoration of Concrete after Damage

After the concrete is damaged by corrosion, reasonable and effective measures should be taken to repair it in time, which can be repaired by using anticorrosive mortar and anticorrosive coating. The special anticorrosive mortar patching construction method adopts the conventional plastering method to carry on the paste repair to the pile column. Before construction, it is required to control the mix ratio of the anticorrosive mortar, and the parts with the larger smear thickness can be smeared with thin layers for many times. To prevent the appearance of tensile crack and mortar fall due to the excessive thickness and overweight of anticorrosive mortar. The anticorrosive coating is mechanically mixed to the surface of the concrete structure according to a certain proportion. After curing, it becomes a dense and tough rubber shape. Coating can effectively resist the erosion of chlorine salt, sulfate and other harmful medium, and has UV resistance

The characteristics of weathering resistance can provide a long-term protection for the concrete structure in saline-alkali soil environment. Anticorrosive coatings are usually sprayed by spraying equipment to meet the specified thickness requirements, so that the surface of the smear form a dense, closed, flat surface, which can effectively resist the invasion of salt in the saline soil area. Thus preventing the corrosion of concrete and steel bar caused by salt.

4. Conclusion

A large number of experimental studies have shown that measures such as changing water / binder ratio and adding mineral admixture are effective in improving the performance of concrete reinforcement in saline soil area, and corrosion resistant steel bar is protected by anticorrosive coating. The effect of electrochemical protection is remarkable.

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