Study on the influence of anticorrosive coating on chloride ion erosion resistance of concrete

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Abstract. With the development of The Times and the progress of the society, more and more buildings have been built, more and more roads and bridges have been built, that is to say, the number of concrete structures is increasing. While concrete is convenient for our life, we also find that in the service of concrete structure, its durability sometimes fails to reach the designed service life. Especially, concrete buildings in coastal areas are corroded by chloride ions for a long time, which causes damage to the concrete structure. An effective way to solve this problem is to apply anti-corrosion coating on the concrete in service. This paper aims to introduce the influence of different anticorrosive coating systems on chloride ion erosion resistance of concrete. Through drilling samples of concrete specimens with dry and wet circulation in 10% NaCl solution, the content of chloride ion in concrete powder was tested at different depths. By comparing the experimental data of these three different anticorrosive coatings, we can find that polyurethane coating has the best chloride ion resistance, the next is polyurea coating. Both of them protect the concrete from chloride ion erosion.

1. Introduction
With the introduction of more and more concrete products in today's society, the durability of concrete has also come into people's eyes, especially the durability of concrete in coastal areas is a difficult problem. In many ways to solve the problem of concrete durability, concrete anticorrosive coating is the best way. We improved the traditional anticorrosive coating system and constructed two different anticorrosive coating systems: Epoxy primer, Epoxy intermediate paint and Acrylic polyurethane finish; Epoxy primer, Epoxy intermediate paint and Polyurea paint. These two coating systems can effectively solve the problem of chloride ion erosion resistance of concrete, so as to effectively improve the service life of concrete.

2. Experiment

2.1. Experimental material
The cement used in this experiment is ordinary Portland cement P.O 42.5, which is produced in jidong cement co., LTD. All properties of this cement meet the requirements, and its physical properties are shown in Table 1; The water-reducing agent is basfaphthalene water-reducing agent sold in shenyang. It is white powder and soluble in water; The experimental water is urban water in Shenyang; The sand used in the experiment is medium sand; In the experiment, 5-10mm and 10-20mm gravel were used in the gravel field, and 5-20mm continuous grading gravel was synthesized according to the ratio of 3:7; The fly ash is grade I produced in shenyang, and the specific chemical composition is shown in...
The slag is S95 slag produced in Shenyang. The specific chemical composition is shown in Table 3; The strength of the concrete is C40 concrete.

### Table 1. Physical properties of cement

| Raw material | MgO (%) | Insolubles (%) | SO₃ (%) | Loss (%) | Initial setting time (min) | Final setting time (h) | Sulfate resistance | The hydration heat |
|--------------|---------|----------------|---------|----------|---------------------------|------------------------|-------------------|------------------|
| The national standard | ≤5.0 | ≤1.5 | ≤3.5 | ≤3.5 | ≥45 | ≤6.5 | _ | _ |
| Measured value | 3.0 | 0.57 | 3.5 | 0.2 | 60 | 6 | Mid | Mid |

### Table 2. Chemical composition of fly ash /%

| component | CaO | SiO₂ | Al₂O₃ | Fe₂O₃ | SO₃ |
|-----------|-----|------|-------|-------|-----|
| content   | 2.86| 59.67| 28.31 | 3.92  | 0.62 |

### Table 3. Chemical composition of slag /%

| component | CaO   | SiO₂  | Al₂O₃ | MgO   | SO₃  | Fe₂O₃ | K₂O | Impurities |
|-----------|-------|-------|-------|-------|------|-------|-----|------------|
| content   | 51.28 | 27.56 | 9.99  | 5.79  | 1.91 | 0.64  | 0.59 | 2.24       |

2.2. Production of Specimens for Testing

(1) The cured concrete specimen is polished with sandpaper, and the defects such as empty drum, floating slurry and oil stains on the concrete surface are polished and removed to form relatively regular concrete test blocks for simple chamfering.

(2) Apply an epoxy sealant primer with a thin coating of about 50 μm. After the primer coating is naturally dried, putty is used to fill the surface defects of the specimen to make it smooth and smooth.

(3) After 24h, paint the epoxy intermediate paint. After the first layer of epoxy intermediate paint is naturally dried, paint the second time. The thickness of each layer of dry film is about 110 microns, and the total thickness of the two layers of dry film is about 220 microns.

(4) After 7d, apply the polyurea (polyurethane) topcoat, and apply the second coat after the first coat is naturally dried. The thickness of each dry film is about 40 microns, and the total thickness of the two dry films is about 80 microns.

(5) After painting, put the specimen into the standard curing room for 7 days.

2.3. Test method

(1) Uncoated concrete, polyurea system coated concrete and polyurethane system coated concrete were immersed in 10% NaCl solution soaking tanks respectively.

(2) After completing the cycle every cycle, the coated specimens of different systems were taken out, that is, at day 8, 16 and 24, the concrete powder at 2mm, 5mm, 10mm, 15mm, 20mm and 25mm of the
specimens were respectively obtained with a high-precision coring machine and put into the sealed bag.

(3) The concrete powder samples taken in step (2) were weighed and taken 4g respectively for extraction test. Fill the reagent bottle with 40g of extract, and cover the bottle with the cap and oscillate vigorously until the concrete powder is fully integrated into the extract.

(4) Prepare the sswy-810 rapid determination instrument for chloride ion content: connect the equipment, clean the electrodes, open the test software, select 50ml $5.0 \times 10^{-4}$, $5.0 \times 10^{-5}$mol/L NaCl standard solution and place them in a pre-cleaned and dry beaker, add electrode stabilizer (1ml), and insert the electrodes into the standard solution in the order from thin to thick. After two calibration measurements, a straight line appears in the "calibration curve", which means the electrode calibration has been completed.

(5) Clean the calibrated electrode three times and wipe it dry with filter paper. Add electrode stabilizer (1ml) to each sample before test. Enter sample information into the software.

3. Result and discussion

3.1. Experimental results and discussion on chloride ion erosion of anticorrosive coated concrete

The corrosion form of chloride ion is one of the main causes of steel corrosion in concrete structure, which will also aggravate the freezing-thawing damage of concrete and adversely affect the durability of concrete. Chloride ion invasion of concrete is carried out in several ways, but under different circumstances, a certain invasion mode is the main one. The different ways of chloride ion erosion are actually permeated into concrete with water as the carrier. The permeability of concrete is closely related to its durability, so the impermeability is also an important index to evaluate the durability of concrete.

![Table 4. The variation of chlorine ion content with the change of invasion depth (8d)](https://example.com/table4.png)

| Concrete type       | d=2mm   | d=5mm   | d=10mm  | d=15mm  | d=20mm  | d=25mm  |
|---------------------|---------|---------|---------|---------|---------|---------|
| Coating free system | 0.0315  | 0.0115  | 0.0008  | 0.0001  | /       | /       |
| Polyurea system     | /       | /       | /       | /       | /       | /       |
| Polyurethane system | /       | /       | /       | /       | /       | /       |

As can be seen from the data in Table 4, when the concrete is subjected to the dry-wet cycle chloride ion erosion test for 8 days after curing, the chloride ion content of the uncoated concrete at 2mm reaches 0.0315%, and the invasion depth has reached 15mm. Water-binder ratio is an important factor affecting the diffusion of chloride ions. Excessive water-binder ratio leads to poor compactness of concrete, increased capillary pores and decreased impermeability, leading to the advance of chloride ion invasion into concrete. At the same time, it can be seen that both polyurea system coated concrete and polyurethane system coated concrete were not corroded by chloride ions. It can be seen that the anticorrosive coating has an obstacle effect on the diffusion of chloride ions, indicating that the anticorrosive coating has a significant effect on the corrosion resistance of chloride ions. At the same time, it is not difficult to find that in the uncoated concrete, with the increase of depth, the content of chloride ion is gradually decreasing. Sections, subsections and subsubsections
Table 5. The variation of chlorine ion content with the change of invasion depth (16d)

| Concrete type       | d=2mm | d=5mm | d=10mm | d=15mm | d=20mm | d=25mm |
|---------------------|-------|-------|--------|--------|--------|--------|
| Coating free system | 0.0998| 0.0542| 0.0338 | 0.0025 | 0.0010 | /      |
| Polyurea system     | 0.0085| 0.0024| 0.0010 | 0.0001 | /      | /      |
| Polyurethane system | 0.0045| 0.0015| 0.0001 | /      | /      | /      |

As can be seen from the data in Table 5, when the concrete is subjected to the dry-wet cycle chloride ion erosion test, the data of 16 days of deterioration are as shown above: the invasion depth of uncoated concrete reaches 20mm, the invasion depth of polyurea system coated concrete reaches 15mm, and the invasion depth of polyurethane system coated concrete reaches 10mm. At the same invasion depth, the content of chloride ions in each sample ranged from large to small, including uncoated concrete, polyurea system coated concrete and polyurethane-coated concrete. In a short period of time, polyurethane system coating, compared with polyurea system coating, can better prevent the penetration of chloride ions and has better anti-chloride ion erosion effect. For example, at 2mm, the content of chloride in polyurea system coated concrete decreased by about 91.48% compared with that in uncoated concrete, and the content of chloride in polyurethane system coated concrete decreased by about 95.49% compared with that in uncoated concrete. It shows that both coating systems can effectively improve the chloride corrosion resistance of concrete, and both have a certain anti-corrosion effect, and polyurethane coating has the most obvious effect, followed by polyurea coating.

Table 6. The variation of chlorine ion content with the change of invasion depth (24d)

| Concrete type       | d=2mm | d=5mm | d=10mm | d=15mm | d=20mm | d=25mm |
|---------------------|-------|-------|--------|--------|--------|--------|
| Coating free system | 0.1961| 0.1554| 0.0732 | 0.011  | 0.0042 | 0.0018 |
| Polyurea system     | 0.0517| 0.0112| 0.0069 | 0.0041 | 0.0038 | /      |
| Polyurethane system | 0.0215| 0.0055| 0.0001 | /      | /      | /      |

According to Table 6, when the dry-wet cycle chloride erosion test of concrete deteriorated to 24 days, the invasion depth of uncoated concrete reached 25mm, the invasion depth of polyurea system coated concrete reached 20mm, and the invasion depth of polyurethane system coated concrete reached 10mm. At the same invasion depth, the content of chloride ions in each sample was uncoated concrete, polyurea system coated concrete and polyurethane system coated concrete from large to small. For example, at 2mm, the content of chloride in polyurea system coated concrete decreased by about 73.64% compared with that in uncoated concrete, and the content of chloride in polyurethane system coated concrete decreased by about 89.04% compared with that in uncoated concrete. It shows that both coating systems can effectively improve the chloride corrosion resistance of concrete in 24 days of dry and wet cycle, and both of them have a certain anti-corrosion effect, and polyurethane coating has the most obvious effect, followed by polyurea coating.
4. Conclusions
In this paper, experimental studies on the chloride ion permeability resistance of concrete with different anticorrosive coatings were carried out, and the following conclusions were obtained:

- With the increase of invasion depth (2mm-25mm), the chloride ion concentration in each sample decreased gradually. This shows that the distribution of chloride ion concentration from the concrete surface is a decreasing process;
- At the same invasion depth, the content of chloride ions in each sample was uncoated concrete, polyurea system coated concrete and polyurethane system coated concrete from large to small. The results show that the three coating systems can effectively improve the chloride corrosion resistance of concrete, and all of them have a certain anti-corrosion effect, and the polyurethane system has the most obvious effect, followed by the polyurea system coating;
- At the same invasion depth, the chloride content of each sample increases with the increase of the time of dry-wet cycle corrosion. The increase rate of chloride ion content in uncoated concrete with time was significantly higher than that in urea-coated concrete and polyurethane coated concrete, among which the increase rate of chloride ion content in polyurethane coated concrete with time was the slowest. The protective effect of the two coatings did not decrease significantly with the increase of time, and the long-term protective effect was better.

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