

Waterproof Measures for Swimming Pools: Use of cement-based permeable crystalline waterproof composite coatings

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With more and more needs of entertainment and leisure for people leisure, the amount of swimming pool, water park and other facilities continue to grow. But In the long term, leakage has always been a major problem to affect the operation and maintenance of swimming pools. Therefore, there is an urgent need for a waterproof, corrosion, and repair function waterproof materials, it should have a good environmental adaptability and technology to improve this situation. Cement-based permeable crystalline waterproof coating is a kind of cement concrete waterproof material, which contains the chemical active substances as water a carrier to penetrate into the concrete. Cement hydration products produce water-insoluble needle-like crystals, it blocks the capillary holes and fine cracks. In this paper, the active master batch is added to the powder by the infiltration crystallization technology in the process of preparing the polymer cement waterproof coating. The effect of the active master batch on the self-healing time of the polymer cement waterproof coating is studied.

1. Introduction

Because of the particularity of waterproof demand in the pool industry, waterproofing has always been a difficult problem in the construction of swimming pool. At present, China's waterproof material types are complex, waterproof technology constantly update. Waterproof materials are made of waterproofing membrane, waterproof coating, plugging materials and other five categories (Xu et al., 2015; Wan et al., 2000). At the same time, the problems of current waterproof material are also exposed due to objective and subjective. Coating with a self-healing or self-closing function has become a research hotspot. Cement-based infiltration of crystalline waterproof coating is born, it is invented by the German chemists in the practice of solving the cement ship leaking water (Jiang, 2007)). The current research on this material is mainly focused on the application of materials, the performance of the coating itself is not specific, especially the crack resistance and bonding properties with the matrix. Now the improvement of coating performance is by adding a waterproofing agent to find a more suitable filler ratio. It has been found that hydrophobic silicone waterproofing agents increase the rate of oxygen diffusion. That is, once the matrix appears cracks, the waterproof effect will be significantly reduced, the internal steel corrosion rate will be higher than ordinary concrete (Tittarell, 2009)). Another study shows that the early waterproofing effect of ethyl silicate is better than that of methyl ethoxypolysiloxane. In addition, some researchers study the curing mechanism of wollastonite-silica sol slurry and find that the fineness of wollastonite will elute Ca^{2+} , which leads to the gelation of the silica sol (Quiroga and Martinez-Ramirez, 2009). A large number of studies have also been conducted on the effect of coating composition on water resistance. The effect of cement usage and water / cement ratio on the mechanical properties and shrinkage of polymer mortar is studied (Fang and Yang, 2002). The effects of styrene, butyl acrylate and methyl methacrylate under different proportions are studied on the water repellency of styrene-acrylic emulsion. It is found that the lower the styrene content, the better the cost, but the cost will increase (He, 2000).

This paper studies a composite cement-based permeable crystalline waterproof material with high adhesion and excellent mechanical properties.

In this paper, a composite cement-based permeable crystalline waterproof material with high adhesion and excellent mechanical properties is studied, and the siloxane is added into the mortar system mainly by selecting the second type of active material. The siloxane will react with the $\text{Ca}(\text{OH})_2$ and f-Ca^{2+} . The formation of water-insoluble needle-like crystals, which increases the internal structure of concrete and cement mortar density to reduce the structure of the porosity. Our subject divide the coating according to the route of corrosive medium through coating, there are coating layer, interfacial transition zone and substrate layer. Through the comparison of the microscopic properties of different layers, the effect of infiltration and crystallization of cement-based permeable crystalline waterproof coating, we analyze the different pore structure, pore size distribution and hydration product.

2. Swimming pool design

In the design of the swimming pool, the program should be determined and optimized based on the requirements of the builder and the basic nature of the environment. After establishing these key elements to be expressed in the pool program, it can reasonably determine the size of the swimming pool, grade, style, so that the design of the swimming pool becomes activity venue of people for sports, entertainment, leisure, fitness activities.

2.1 The need for swimming pool waterproofing

It is due to the particularity of the waterproofing demand of the swimming pool industry, the water of swimming pool should be stored for a long time, the hot and cold water should be alternately transformed. This has been a difficult problem in the construction of the swimming pool, so the choice of waterproof coating is extremely important. meanwhile, as a movement which directly contact with the human body movement, it requires the swimming pool not only has the most basic waterproof performance, but also requires the pool film with anti-breeding bacteria, anti-ultraviolet, and anti-aging characteristics. Therefore, regardless of the production process or raw materials and other aspects are demanding.

2.2 Swimming pool waterproof construction

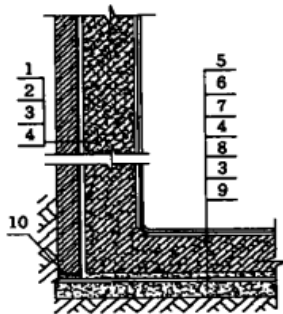


Figure 1: Waterproof structure of swimming pool.

The size of a class of buildings is large, and it is susceptible to crack due to structural deformation, temperature difference deformation, expansion and contraction deformation. Thus the waterproof construction process would rather use the extension of good, long-term change in the water, than use rigid waterproof layer, besides the use of the process should not produce any toxic and harmful substances to infiltrate into EPDM coil and other waterproofing membrane. As shown in the figure 1, it indicates waterproof structures of swimming pool which involve 10 parts. The first part is 120 mm thick brick mold (or point polystyrene board) thick cement mortar. The second part is 20mm thick cement mortar. The third part is 2mm thick polyurethane waterproof coating. The fourth part is waterproof concrete slab. The fifth part is swimming pool special tile.

2.3 Swimming pool waterproof to be resolved

Polymer coating applied to the outdoor swimming pool environment will be affected by the water treatment agent and the impact of sunlight, but also may be affected by the water temperature, water pressure, and other media, such as microorganisms, urea and other effects. At present, the degree of research is relatively simple about the coating of polymer coating, so the next step should expand the preferred type of topcoat to extend the aging time. In addition, in order to obtain a more self-healing cement-based protective coating that is more suitable for the outdoor swimming pool environment, the corresponding performance of the polymer

cement-based coating formulation should be carried out in the next application to improve the material properties.

3. Simulation experiment

TG7683 is selected as the polymer emulsion in this subject because it can meet the requirements of high flexibility and high strength cement-based waterproof material, and it has advantages of excellent low temperature, flexibility and adhesion to all kinds of substrates. The choice of ordinary Portland cement is because it has the advantages of high strength, good frost resistance, dry shrinkage, good wear resistance and good carbon resistance. It can be used as the base material of polymer cement waterproof coating. Calcium carbonate can improve the denaturation of polymer cement waterproof coating, the adhesion of the material, scrub resistance, and stain resistance, while it can be considered as the base material of polymer cement waterproof coating. Quartz powder is a hard, wear-resistant, chemically stable silicate mineral, which is used as a filler to improve weather resistance in this subject.

This experiment is tested in accordance with GB18445-2012 "cement-based infiltration crystalline waterproof material". The base specimen is selected by the swimming pool used in the building materials as a test object. We prepare the waterproof coating according to the design ratio and apply it to the base surface. After the substrate has been painted twice, it is moved to the standard curing box for 28 days to test the impervious pressure. The tensile bond strength of the waterproof coating is measured by 8-character scale. In order to further study the mechanism of the permeation of cementitious permeable crystalline waterproof coating, we select the samples with better physical properties, which are analyzed and characterized by XRD, FT-IR.

3.1 The preparation of materials and equipment

Table 1. The main chemical reagents

Material	Function
TG7683	Polymer cement-based waterproof material for the emulsion
Silok-7679	Dispersant
THIX-318	Defoamer
White cement	Concrete
CACO ₃	To improve the adhesion of paint
Quartz powder	To improve weather resistance
Active masterbatch	To increase anti-cracking ability and thickening
Surfactant	To slow down the curing speed

3.2 Experiment process

The first step is the preparation of liquid material. We the right amount of water, wetting agent, defoamer and plasticizer and other additives with high-speed stirring in the middle of the container and then it is mixed for 15 min, then we add polytetrafluoroethylene emulsion, and it is stirred for 20 min.

The second step is the preparation of powder. An amount of cement, calcium carbonate and quartz powder are ground, crushed, and then they are fully mixed with the active masterbatch. Finally it is made of powder.

The third step is preparation of self healing composite waterproof coating of JS. The quality of the powder and liquid material are mixed evenly, and then it is scratched and coated into a round or other shapes.

The fourth step is the curing of the sample. According to GB/T 23445-2009 standard, maintenance samples are placed at room temperature 168 h and 50°C after 24h. We cut out about 0.5 mm wide and 10~15mm long incision on the surface of the specimen, then we soaking it for several times at different water temperatures, and it can be used for the determination of related properties.

Under the action of water, the active material of waterproof coating penetrates into the coating film by water. The active chemical reacts with the calcium and aluminum ions in the cement to produce water-insoluble crystals. Crystalline swells water in the cracks from sparse to dense. In the depth of the cracks gradually form a dense crystalline filling area, so as to achieve the purpose of self-healing cracks. As the active material can be re-activated by the water, so the secondary cracks can grow new crystals, which indicates that penetration of crystalline JS composite waterproof coating will go through a repeated self-healing repair, impermeability and waterproof long lasting effect (the crack self-healing mechanism shown in Figure 2).

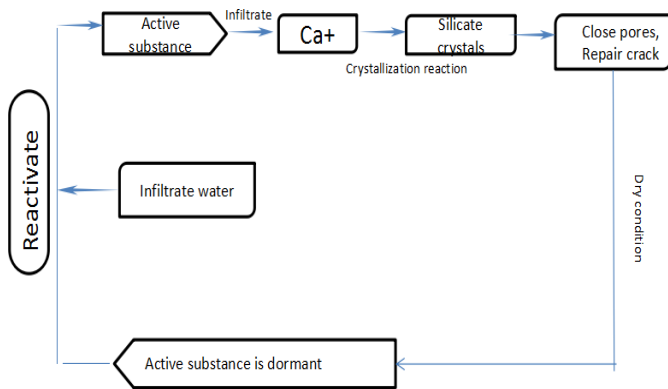


Figure 2: Self-healing mechanism of crack

3.3 Self-healing performance test method

We use the test method of self-healing performance of waterproof coating to prepare standard sample according to GB/T23445-2009 "polymer cement waterproof coating". The test object is selected by the size of the pool of cement matrix, the sample is cut into a size of 1cm×1cm×1cm.

The experiment is followed by cutting the cracks of 0.5 mm in length on the surface of the coated sample. The sample is bonded to the glass wall of the funnel with silicone gel, meanwhile the transparent rubber hose is connected to the glass tube below the funnel with the rubber hose face down. Self-healing properties are tested by continuously dropping water into pipe standard funnel. Water leaks out of the sample and flows along the transparent rubber tube to maintain the height of the water level in the cup and counting until the sample cracks. There is no water seepage and transparent rubber hose without water out, record this time is self-healing performance. We begin to record the time until crack of the sample and the transparent rubber hose do not flow out of water, especially, the record time is self-healing. As shown in figure 3, the recorder is used to record the process from the beginning of the leak to stop the leakage, which can reduce the error of human operation.

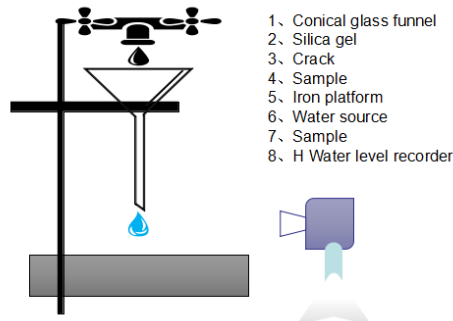


Figure 3: Self-healing polymer cement waterproof coating self-healing performance test method

4. Results and Discussions

This chapter mainly focuses on polytetrafluoroethylene emulsion. We explore the factors that influence the waterproofing effect of cement-based crystalline waterproof material. Firstly, we study the factors that are additives, surfactants and calcium and ion additives which can improve the performance of the waterproof material. Next we consider the external factors that are additives, surfactants, and calcium ion additives on the improvement of the performance of waterproof materials, as well as cement-based material defects in the study of compensation. Finally, the adaptability of the properties of cement-based materials to waterproof materials are studied.

4.1 Effect of Temperature on Self-healing Property of Self-healing Polymer Cement Waterproof

The self-healing properties of cracks are measured at different temperatures when the mass ratio of active masterbatch powder is 5%

Table 2. Self-healing time of crack at different temperatures

Temperature/	Self-healing time/h
20	27
25	25
30	20
35	15

It can be seen from Table 2 that when the content of active masterbatch is constant, the self-healing time of the crack is gradually shortened and the self-healing effect is gradually improved as the temperature increases.

4.2 Effect of active masterbatch on self - healing properties of fractures

When the temperature is 25°C, the effect of the active masterbatch content on the self-healing time of the fracture is shown in figure 4.

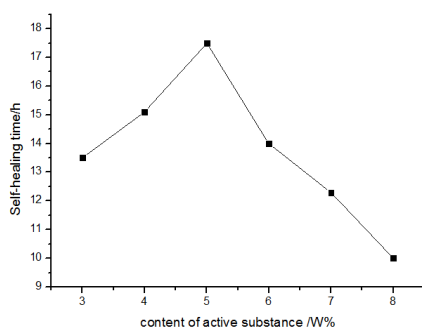


Figure 4: Effect of active master batch contents on self-healing time of crack

It can be seen from Fig. 5 that when the temperature is constant, the self-healing time of the crack is gradually shortened and the self-healing effect is gradually improved with the increase of the content of the active masterbatch

4.3 Effects of Cement Types on Coatings

Cement is a more active filler, which has the most significant effect on the mechanical properties of the coating. Usually the preparation of self-healing waterproof coating can choose white cement, ordinary portland cement or sulphoaluminate cement.

Table 3. Effect of Different Kinds of Cement on the Performance of Waterproof Coating

Project	Cement varieties	
	White cement	Portland cement
Tensile strength / MPa	6.88	5.11
Elongation at break /%	10.22	6.93
Self-healing time	8.23	5.01

It can be seen from Table 3 that the tensile strength of the coating prepared by white cement is slightly higher than that of the coating prepared by ordinary portland cement, but the elongation at break is slightly lower and the auto stability is much worse. This may be due to the infiltration of crystalline active components, the affinity of between calcium ions and active components is strong, which can not only enhance the cement hydrate and the interaction between the polymer, but also promote the repair capacity.of calcium ion crack Therefore, it is appropriate to use ordinary portland cement to prepare autogenous waterproof coating.

4.4 Effect of Cement Content on the Performance of Waterproof Coating

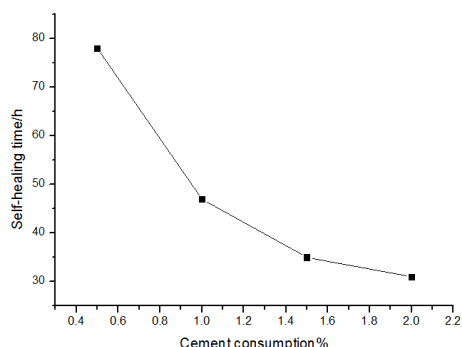


Figure 5: Effect of Different Cement Dosages on Self-healing of Coatings

It can be seen from figure 5 that with the increase of the amount of cement, the cracking time of JS coating film is getting shorter and shorter, but the decrease is gradually reduced. This is because the cement hydrate is easy to crack, excessive use of cement will lead to increased possibility of cracking of the coating. Therefore, powder mixture ratio of cement and calcium carbonate powder should be 2:1.

5. Conclusion

To sum up, with the economic development and improvement of people's living standards, swimming has gradually become a mass recreational activity. So the design and construction of swimming pool is also particularly important and waterproof measure is essential. In this paper, the cement-based permeable crystalline waterproof coating has the ability of infiltration and crystallization, and its performance is superior to the ordinary inorganic rigid plugging waterproof material. But it is not omnipotent, only it is used in the correct application field and with the construction method, so as to play a cement-based penetration of crystalline waterproof coating good waterproof effect.

Acknowledgments

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