ISSN: 2414-1895 DOI: 10.6919/ICJE.202406_10(6).0014

Study on the Application and Performance of a New Domestic Waterborne Inorganic Permeable Waterproofing Agent

Xing Chen*, Pengfei Lu, and Kunhao Liu

China Railway Tunnel Bureau Group Special High and New Technology Co., Ltd, Shanghai, China

*1809175902@qq.com

Abstract

Through the field test of a new type of waterborne inorganic permeable waterproof agent made in China at two leakage points in a subway station of Guangfo Ring Line, the test results show that adding this type of waterproofing agent to the cement-based filling material has a good effect on repairing the leakage of the structure. the white crystal produced by it can improve the strength and self-repair of seepage cracks in the repair area. At the same time, through the indoor control test, it shows that it can effectively improve the anti-permeability, anti-carbonation, anti-chloride penetration and early crack resistance of concrete. The comprehensive performance of the new waterproofing agent is ahead of the same type of products at home and abroad, and has high engineering application value.

Keywords

Concrete; Waterproofing Agent; Crack.

1. Introduction

Concrete, as the most common and widely used building material in construction, will inevitably produce cracks due to plastic shrinkage, external load, uneven settlement and temperature [1]. When the crack is exposed in the erosive environment, the external water and erosive ions will enter the concrete and cause the deterioration of the concrete, induce the concrete carbonization, steel bar corrosion and other problems, reduce the service life of the building, and even cause serious safety accidents.

At present, the repair of concrete cracks can be divided into grouting method, surface treatment method, filling method, structural reinforcement method, concrete replacement method and electrochemical protection method, among which the first three are the most commonly used treatment methods [2]. The grouting method can deal with fine fissures to large fissures and has a wide range of applications, but excessive pressure in the grouting process may cause the secondary expansion of cracks, and the commonly used water-soluble polyurethane chemical slurry is toxic [3]; the surface treatment method is suitable for shallow fissures where it is difficult to fill, and is suitable for large area water leakage, but it has the disadvantages of narrow application range and poor durability [4]. The filling method can directly repair wide cracks, shallow cracks or fillers can be filled by slotting, and the filling materials are generally cement-based materials, so it has the characteristics of wide application, low repair cost and permanent [5].

In this field test, the filling method is used to repair concrete cracks, and the water plugging effect and strength change of the repaired area are observed by adding the new waterborne inorganic permeable waterproofing agent to the filler. And through the indoor control test, the improvement of the material on the performance of concrete is further analyzed.

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2. Brief Introduction of Materials

The new type of water-based permeable inorganic waterproofing agent is a kind of inorganic protective material, which is made of alkali metal silicate solution as the main raw material, catalyst and auxiliary agent, mixed reaction, and can penetrate into the concrete to carry out osmotic crystallization reaction. fill internal pores and repair microcracks.

The new waterborne inorganic permeable waterproofing agent is a colorless, transparent and odorless liquid material with a density of 1.17g/m^3, a pH value of 11.86 at room temperature (with strong alkalinity), a viscosity of 10.4Pa ·s, a surface tension of 16.2mN/m, a gelation time of 64min and a depth resistance of 13mm. It has good storage stability (10 cycles). In line with the latest issued "JC/T1018-2020 water-based permeable inorganic waterproofing agent" standard.

The limit of ammonia release is 0.035%, which is in line with the GB18588 "limit of ammonia release from concrete admixtures".

3. Selection of the Test Site

Affected by the surrounding hydrogeology, a subway station on the Guangfo Ring Line has clear water seeping out from the walls of some structures, resulting in a small area of wetting, as shown in figure 1; there are even large-scale obvious cracks at the junction of some structures, where the leaking water is linear dripping, resulting in a large area of wetting, as shown in figure 3. The wall seepage position in figure 1 is treated by injection grouting (grouting) before the test, but the water stopping effect is not ideal. The water seeps out along the periphery of the water stop needle (as shown in figure 2), and the wet problem still exists, which confirms the limitations of the grouting method.

The two seepage points are two different types of water leakage, namely, small area wetting caused by small cracks invisible to the naked eye, and linear dripping caused by larger cracks, which represent two typical types of water leakage in the structure. Therefore, these two places are selected as the experimental sites.

Figure 1. Water seepage on the wall

Figure 2. Water seepage at the water stop needle

Figure 3. Water seepage in the joint of the structure

4. Experimental Analysis

Similar test steps are adopted at the two leakage points in the field test, as shown in figure 4..

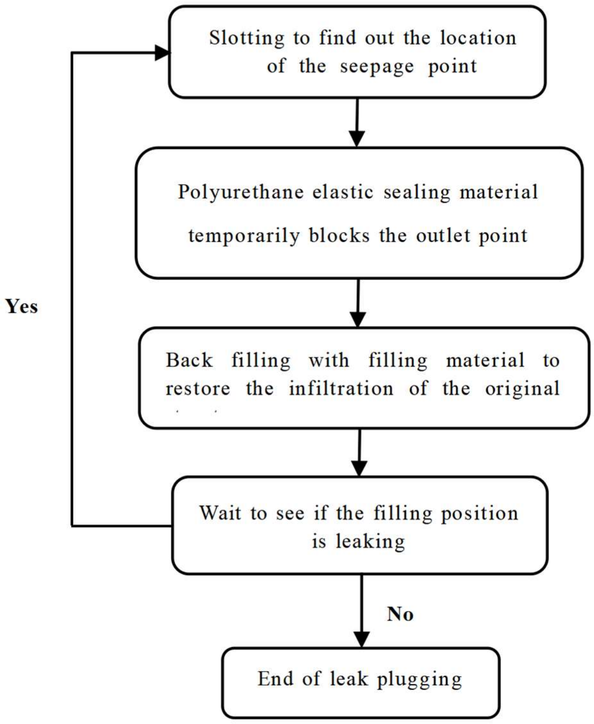

Figure 4. Test flow chart

4.1 Treatment of Wall Leakage

First, a "U-shaped" groove is opened along the 5cm around the needle leakage, the depth of the groove is about 5cm, and the depth of the groove cannot exceed the buried depth of the steel bar (as shown in figure 5a-b). Then, the polyurethane elastic sealing material is applied to the outlet point until there is no water seepage on the surface. Finally, the fillers mixed with cement, water, drying sand, new waterborne inorganic permeable waterproofing agent, glass fiber (mass ratio of glass fiber to cement 1: 1000), polyvinyl alcohol and superplasticizer (polycarboxylic acid) are filled in the slot and flattened with a spatula (as shown in figures 6a and 7a).

After 24 hours (1 day), white crystals began to precipitate at the two slotting points, and the amount of white crystals precipitated at the slotting point 1 was obviously more than that at the slotting point

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2 (as shown in figure 6b and 7b), except that there was a small amount of water seepage at the top crack at the slotting point 1. the surface of the filling material at the two slotting points is dry and there is no obvious water stain.

After 96h (4d), the precipitation amount of white crystal at the slotting point 1 further increased, and the top seepage crack was also filled with the precipitated white crystal, showing a good self-repairing function, but there was no obvious change at the slotting point 2.

After 288h (12d), the surface of the filler at the two slotting points was completely dry, and the wet area disappeared completely.

a slotting point 1 b slotting point 2

Figure 5. slotting at the location of water seepage on the wall

a 0 hours later b 24 hours later c 96 hours later d 288 hours later

Figure 6. Treatment effect at slotting point 1

a 0 hours later b 24 hours later c 96 hours later d 288 hours later

Figure 7. Treatment effect at slotting point 2

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The electronic rebound instrument is used to test the strength of the two slotting points, and the change diagram of the strength with time in the 7d-12d time period is drawn, as shown in figure 8. It can be seen from the figure that the strength of the filler at the slotting point 1 is always greater than that at the slotting point 2, which is positively correlated with the precipitation amount of white crystals on the surface. The analysis may be that the active ions in the "deep crystal" waterborne inorganic permeable waterproofing agent promote the drastic hydration of calcium silicate (dicalcium silicate, tricalcium silicate) in the filler, resulting in a large amount of C-S-H gel and ettringite. And the filler contains carboxylate, which can combine with free calcium ions to form metastable calcium ion complexes, which can react with $CO_3{}^{2}$- and HCO^{3}- in structural cracks to form calcium carbonate crystals. Calcium carbonate crystal is compounded with C-S-H gel and ettringite to effectively bridge the original cracks in the structure, so as to improve the compactness of concrete and achieve the effect of self-repairing water plugging and improving strength.

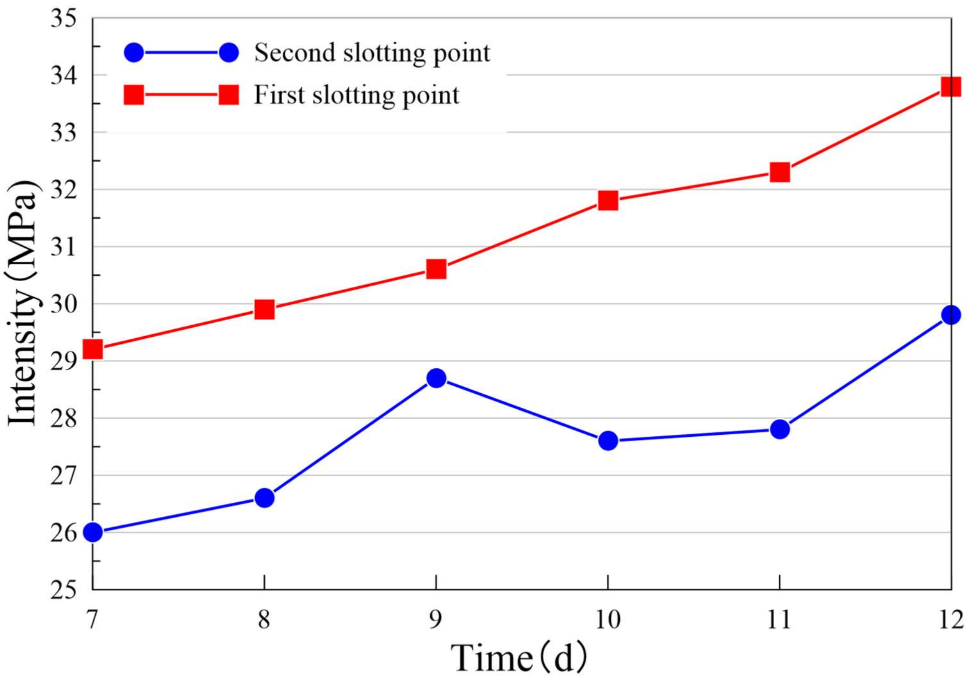

Figure 8. The strength of wall seepage point filler varies with time

4.2 4Treatment of Seepage and Leakage of Structure Joint

There is a large range of water leakage at the junction of the structure, which can be divided into four areas: roof crack, crossbeam and roof joint, left side wall and roof joint and right side wall and roof joint. The four areas are slotted for water plugging and filling restoration in a manner similar to that of wall seepage (as shown in figure 9a).

After 24 hours (1D), white crystals began to precipitate in the fillers at the cracks in the roof, but no crystals were precipitated in the other three areas (as shown in figure 9b). It can be seen from figure 4.7 that the strength of the filler at the crack in the roof is obviously higher than that in the other three areas, which further proves that the precipitation amount of white crystal can improve the strength of this area.

After 120h (5d), white crystals were precipitated in all four areas, and the amount of white crystals increased obviously, and the average intensity was not less than 34MPa.

After 240 hours (10 days), the precipitation amount of white crystals of the fillers in the four areas did not increase, and the surface of the backfilling area was dry and there was no wet seepage.

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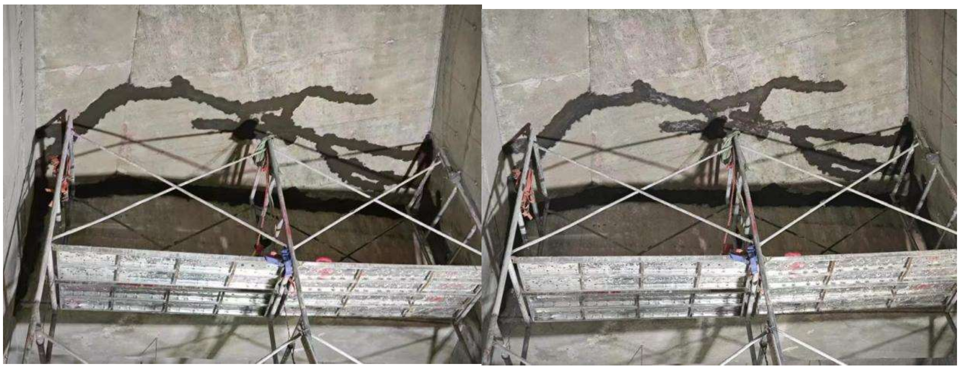

a 0 hours later b 24 hours later

c 96 hours later d 288 hours later

Figure 9. effect of water leakage treatment at the junction of structures

During the 1d-6d period, the strength of the four areas at the junction of the structure is tested, and the change of strength with time is plotted, as shown in figure 10. It can be seen from the figure that the strength of the back filler in the roof crack area is obviously higher than that in the other three places. at the same time, it can also be seen from the figure 9b-c that the amount of white crystal precipitation in the roof crack region is always the most, which once again confirms that there is a significant positive correlation between the white crystal precipitation and the strength.

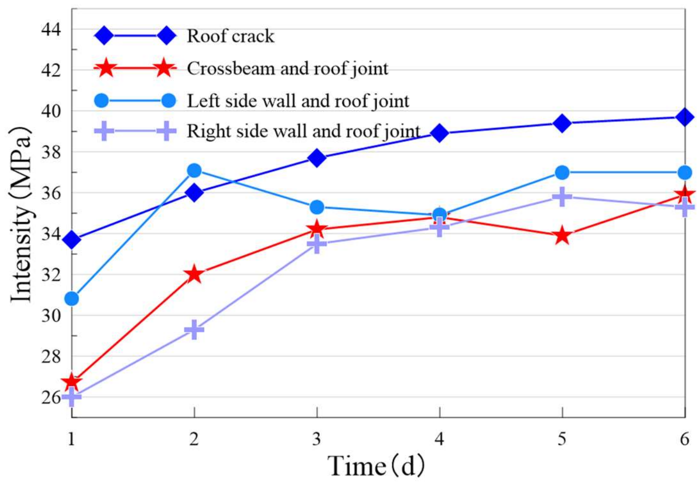

Figure 10. Strength of water seepage point fillers in different areas of the structure varies with time

4.3 Indoor Controlled Test

In order to further test the impact of this water-based penetrating inorganic waterproofing agent on the anti-penetration, anti-carbonation, anti-chloride ion penetration and early crack resistance properties of concrete, J01 (C50 benchmark), J02 (C35 benchmark) and D01 (C50 comparison), Indoor control test of four groups of D02 (C35 comparison), in which D01 and D02 are the ratios of adding the water-based penetrating inorganic waterproofing agent, to test the performance changes of the concrete after adding the water-based penetrating inorganic waterproofing agent.

4.3.1 Result of Impermeability Test

Through controlled tests, this water-based penetrating inorganic waterproofing agent can effectively improve the capillary structure of concrete, block the capillary channels inside the concrete, improve the strength, and greatly improve the impermeability of concrete (the water seepage height of D01 is 86% lower than that of J01) , the water seepage height of D02 is 80% lower than that of J0), achieving permanent waterproof effect. Under 2.5MPa water pressure, the comparison of the strength and water seepage height of the four groups of concrete specimens is shown in Figure 11.

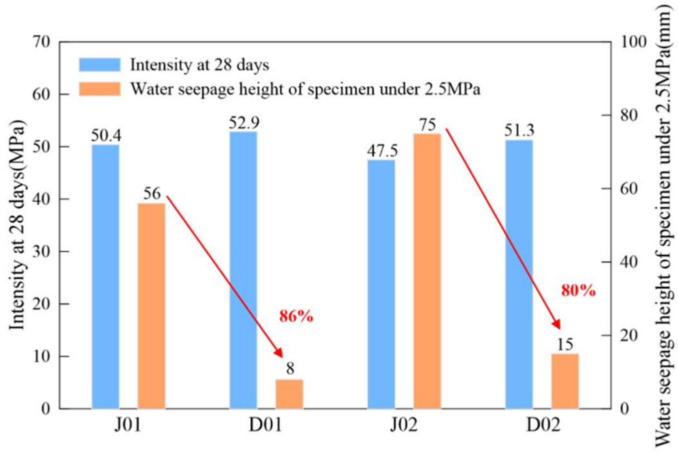

Figure 11. Result of permeability test

The 28-day carbonization test shows that adding this water-based penetrating inorganic waterproofing agent to concrete can effectively reduce the carbonation depth (the carbonation depth of D01 is reduced by 43% compared with J01, and the carbonation depth of D02 is reduced by 50% compared with J02), as shown in Figure 12 Show. The addition of this water-based penetrating inorganic waterproofing agent improves the compactness of concrete, reduces porosity, blocks the entry channels of carbon dioxide, thereby effectively reducing the degree of deterioration of concrete.

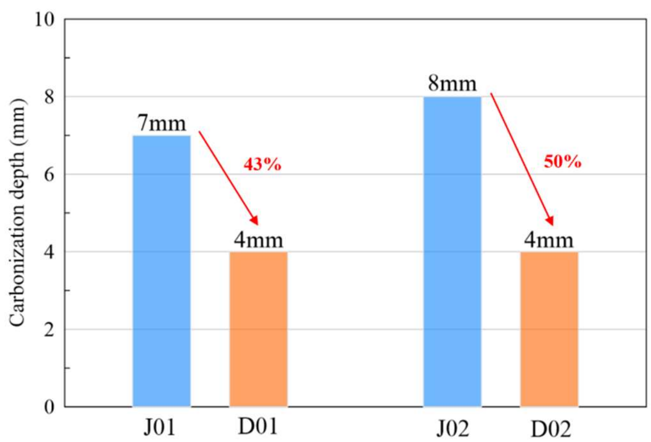

Figure 12. Carbonization depth test results

4.3.2 Chloride Ion Penetration Test Results

Through the analysis of anti-permeability and carbonation test results, after adding this water-based penetrating inorganic waterproofing agent, the density of concrete increased, blocking the passage of chloride ion penetration, and the 56d electric flux and chloride ion diffusion coefficient were reduced. The test results are as follows As shown in Figure 13.

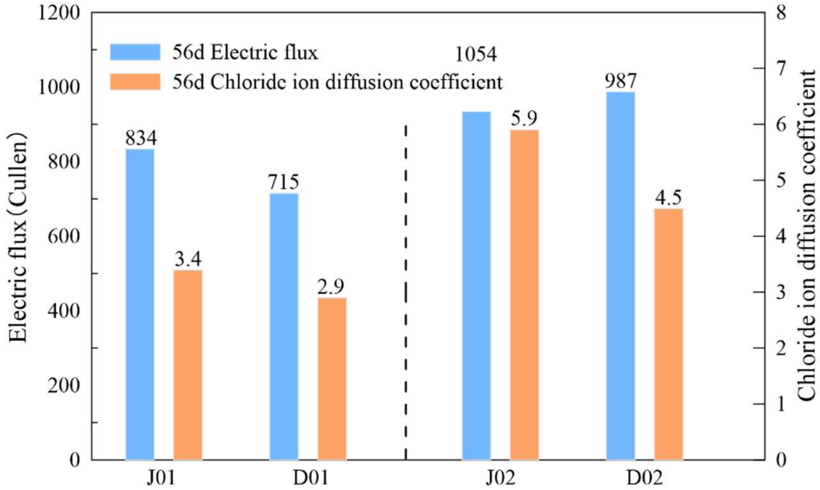

Figure 13. Electric flux and chloride ion diffusion coefficient

4.3.3 Early Crack Resistance Test Results

Through comparative tests, a large area of early cracks appeared on the blank concrete specimen without the water-based penetrating inorganic waterproofing agent, with a maximum width of 0.35mm, and the number of cracks per unit area was 16; the water-based penetrating inorganic waterproofing agent was added Only 3 cracks appeared in the concrete specimen with the agent, and the maximum width of the cracks was 0.08mm, as shown in Figure 4.11. The test results show that the water-based penetrating inorganic waterproofing agent can effectively improve the early crack resistance of concrete.

5. Conclusion

Through on-site tests and indoor control tests to repair two water seepage points, the following conclusions are drawn:

(1) Adding this water-based inorganic penetrating waterproofing agent to the backfill material can effectively control water seepage from micro-cracks and linear dripping caused by larger cracks. The white crystals precipitated through the complex precipitation reaction improve the compactness of the filling area. It plays the role of increasing strength and self-healing of water seepage cracks.

(2) Through the indoor control test, it is shown that the water-based penetrating inorganic waterproofing agent can effectively improve the anti-penetration, anti-carbonation, anti-chloride ion penetration and early crack resistance properties of concrete.

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