Anti-freeze and Anti- corrosion Performance of Road Fiber Reinforced Concrete

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Abstract. To research the anti-freeze performance of road fiber concrete in erosion solution, trabecular specimens that contained three kinds of water-cement ratio (0.44, 0.42 and 0.40) was formed. Half of it were treated with protective agent and then placed in distilled water and 10% Na_2SO_4 solution. The mass, relative dynamic elastic modulus and flexural strength of it were determined by freeze-thaw cycle test. The results showed that: the mass loss rate of concrete decreased with water-cement ratio increased, while the elastic modulus and flexural strength loss rate increased with it, and Na_2SO_4 solution exacerbated this trend. The surface protective agent had improvement for the three indicators of anti-freeze. In addition, the effect of water-cement ratio and erosion solutions was mutually reinforcing.

Introduction

Fiber Reinforced Concrete in road engineering not only enhances the toughness, resistance of shock, cracking capacity, but also improves the durability of the road pavement, extending the life [1]. The study of its mechanical properties and road performance has become a hot topic of concrete science.

Sun Jia-ying [2] studied the strength, shock resistance, flexural properties, brittleness coefficient, wear resistance and other road performance of polypropylene fiber reinforced concrete, then reviewed the effect of film-broken fiber on concrete. Yu Jun-chao [3] using ordinary polypropylene fibers and steel fibers as a reference, studied the effects of crude polypropylene fiber on creep properties of concrete loading a year later. Du Cheng [4] studied the effect of polypropylene fiber on plastic shrinkage and impermeability of concrete, and he believed the application of polypropylene fiber concrete had a good prospect in canal seepage project. For anti-corrosion properties of fiber reinforced concrete, Kong Lin-jie [5] studied the effect of polypropylene fibers types on the ability of sulfate-resistant of concrete by the corrosion factor of mass, compressive strength and tensile strength. Xie Xiao-peng [6] studied the effect of fiber volume fraction, freeze-thaw cycles and concrete strength grade on the basic mechanical properties of concrete by freeze-thaw cycle test.

To research the anti-freeze performance of road fiber concrete in erosion solution, trabecular specimens that contained three kinds of water-cement ratio (0.44, 0.42 and 0.40) was formed. Half of it were treated with protective agent and then placed in distilled water and 10% Na2SO4 solution. The mass, relative dynamic elastic modulus and flexural strength of it were determined by freeze-thaw cycle test.

Raw material and test methods

Raw material

Cement. The cement in this test was P.O 42.5 made in Yuncheng City. The physical-mechanical properties were shown in Table 1. It meets the requirements in the specification that GB175-2007 "Common Portland Cement".

Fine aggregate. The fineness of fine aggregate was 2.8 and density was 2.70 g/cm^3.

Coarse aggregate. The density of coarse aggregate was 2.77 g/cm^3, with well graded.

Water. The water in this test was Ordinary tap water.

Fiber. The polyethylene film-split fibers in this test were made in Zhejiang. The apparent density was 0.97g/cm^3, the tensile strength was 680MPa, the elasticity modulus was 1.1×104 MPa, and the elongation was 3.6%.

Protective agent. The protective agent in this test was made in BASF. The density was 1.0 g/cm^3.

Table 1 Physical-mechanical properties of cement

fineness (m^2/kg)	Setting time /min		Compressive strength /MPa		Flexural strength/MPa		Stability
	Initial setting	Final setting	3d	28d	3d	28d	
350	180	275	30.6	52.8	6.1	9.0	Qualified

Test Methods

In order to accurately measure the effect of water-cement ratio, solution, and protective agent on the performance of cement concrete, the test used univariate analysis method to avoid mutual interference between multiple factors.

First, prepare 48 groups concrete specimen （40cm×10cm×10cm）using three kinds of water-cement ratio. After mold released, half of it were treated with protective agent. This group of specimens was marked as group B. Meanwhile, the other not treated with protective agent was marked as group A. In order to make the workability of concrete similar, water reducer was added into it to guarantee all the slump of fresh concrete was between 30 and 50mm and air content was between 1.3%~1.6%.

Table 2 Mix proportion of concrete

No.	cement/kg	water/kg	fiber/kg	Water reduce/%	Fine aggregate /kg	Corase aggregate /kg
C1	350	154	1.8	0.3	738.8	1205.4
C2	350	147	1.8	0.5	741.5	1209.8
C3	350	140	1.8	1.0	744.5	1214.1

After curing period, the A, B groups of specimen was divided into two groups. One was placed into distilled water, and the other was placed into 10% Na_2SO_4 solution. Then, the freeze-thaw cycle test was carried out in accordance with JTG E30-2005 "Highway Engineering Cement and Cement Concrete testing procedures".

To facilitate comparison of the test results, number the specimen as shown in table 3. A-C2-1 represented the specimen with water-cement ratio 0.42, not treated with protective agent and the erosion solution was 10% Na_2SO_4.

Table 3 List of specimen No.

Water-cement ratio	Specimen No. in different solution	
	Distilled water	10%Na_2SO_4
0.44	A-C1-1	A-C1-2
0.42	A-C2-1	A-C2-2
0.40	A-C3-1	A-C3-2

Mass loss rate of fiber concrete.

In two kinds of erosion solution, the mass loss rate of concrete specimen was shown in Figure 1. The set of concrete without treated with protective agent was more sensitive to freezing and thawing cycles test. Whether the solution was distilled water or 10% Na_2SO_4 after freeze-thaw cycles, the mass loss rate of concrete increases with water-cement ratio decreasing. When freeze-thaw cycles were 150, the mass loss rate of concrete that water-cement ratio was 0.40 was about 23% higher than concrete that the water-cement ratio was 0.42 in distilled water. Meanwhile, for specimen in 10% Na_2SO_4, this value was 13%.

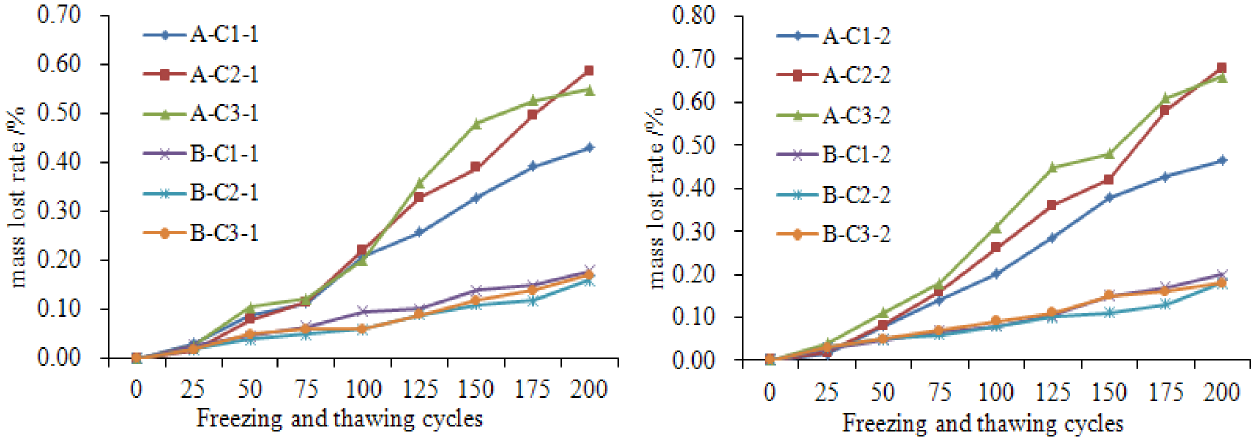

Fig.1 Mass loss rate of concrete specimen

After treated with protective agent, mass loss rate of concrete specimen decreased. The average decline in distilled water was bigger, can be reached 74%. In other words, protective agent was very effective in improving the frost ability of concrete.

Relative dynamic modulus of fiber concrete

In two kinds of erosion solution, the relative dynamic modulus of concrete specimen was shown in Figure 2. When the freeze-thaw cycles were little than 100, the effect of water-cement ratio was not obvious, when the cycles were bigger than 100, relative dynamic modulus of concrete decreased with water-cement ratio increasing, and this effect was gradually increased with the cycles of freeze-thaw increasingly significant. Take the specimen in 10% Na_2SO_4 solution for example; when the cycles were 75, the relatively elastic modulus of concrete specimen with two kinds of water-cement ratio was approximately equal. But, when the cycles were 150, the relatively elastic modulus of specimen that water-cement ratio was 0.40 was 4% higher than specimen that water-cement ratio was 0.42. For specimen that the water-cement ratio was 0.44, the value was 9%.

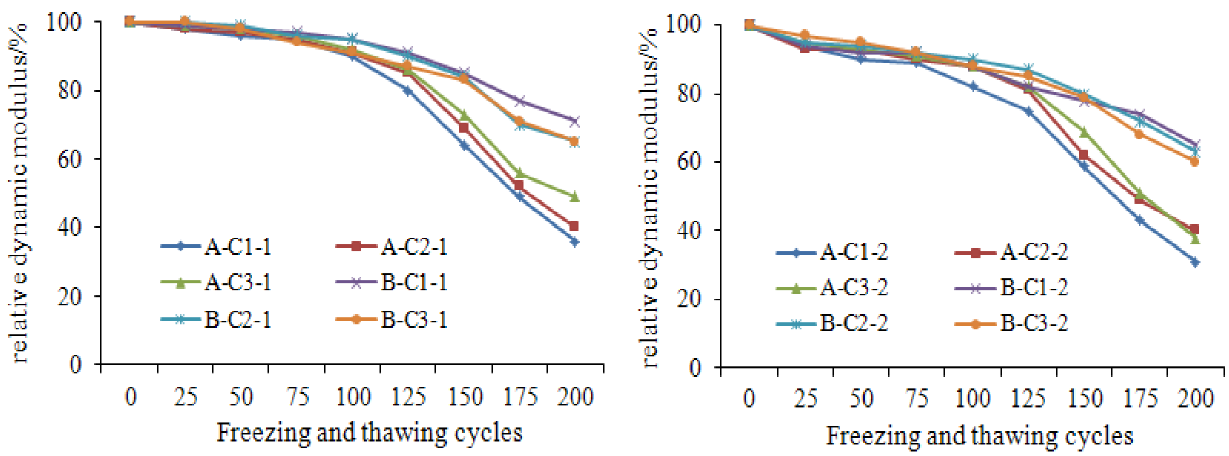

Fig.2 Relative dynamic modules of concrete specimen

Contrast A with B, it can be found that, the relative dynamic modulus of concrete increased after treated with protective agent, and this effect was more intense with freeze-thaw cycles increasing.

Flexural tensile strength loss rate of fiber concrete

Figure 3 showed that flexural tensile strength loss rate of fiber concrete in two kinds of erosion solution. The data point in some curve was missed for that group specimen was completely frozen, and unable to test the flexural strength. In general, the flexural strength loss rate of specimen not treated with protective agent increased with water-cement ratio increasing. After treatment, flexural strength of specimen with three kinds of water-cement ratio all improved. Take specimen in distilled water for example, after treated with protective agent, flexural tensile strength loss rate of concrete that water-cement ratio was 0.40 reduced by 66%. For concrete in 10% Na_2SO_4 solution, this value was 71%.

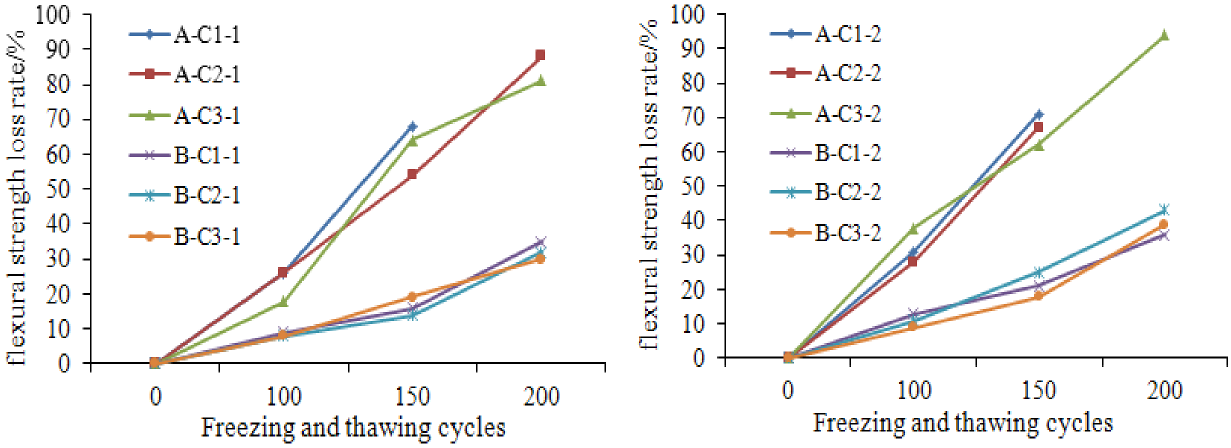

Fig.3 Flexural tensile strength loss rate of concrete specimen

The effect of protective agent on flexural tensile strength was similar with relative elastic module. The sensitivity of flexural tensile strength loss rate on the water-cement ratio was small.

Summary

1.in freeze-thaw cycle test, the mass loss rate of concrete decreased with water-cement ratio increasing. Meanwhile, the dynamic elastic modulus and flexural strength loss rate increased with it. Na_2SO_4 solution promoted mass, elastic modulus and flexural strength loss.

2.the concrete protective agent has a good effect on the mass loss rate, the relative dynamic modulus and flexural strength loss rate. After treated with protective agent, the concrete antifreeze indicators were no longer sensitive for water-cement ratio, especially the flexural strength.

3.the roles of water-cement ratio and erosion solutions were interactional. Especially the freeze-thaw cycles reached 100, Na_2SO_4 solution would further the effect of water-cement ratio. Meanwhile, water-cement ratio also exacerbated the effects of Na_2SO_4 solution.

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