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Research on Water Absorption and Frost Resistance of Concrete Coated with Different Impregnating Agents for Ballastless Track Structure

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ABSTRACT

In consideration of performance requirement of ballastless track concrete in cold regions of China, 3 types of commercially available impregnating agents were employed to research their effect on water absorption and frozen resistance of concrete, containing silanes, potassium silicate and osmotic curing agent. The results presented that coating silanes was the most effective on the reduction of water absorption among all employed impregnating agents, because of the most significant character change of concrete surface from hydrophilicity to hydrophobicity which could be proved by the contact angle test of concrete. The promotion on frozen resistance of concrete was not as significant as that for water absorption by coating 3 commercially available types of impregnant agents, because of the spalling damage on concrete surface during the freezing-thawing cycles.
Key words：concrete; water absorption; frozen resistance; contact angle

1.INTRODUCTION

As the major corrosion medium concern in freezing-thawing environment, water could gradually penetrate into internal of concrete due to hydrophilicity of concrete, and then accelerated the freezing-thawing damage of concrete. Waterproof treatment on concrete surface was an effective way to inhibit the water from permeating into concrete, which had been researched widely these years based the engineering requirements [1,2].
Water could penetrate into concrete easily because ballastless track bed slab was typical plate structure. Therefore, the characteristic change of concrete surface by coating hydrophobic agents become a potential method to promote the frost resistance of concrete for ballastless track [3]. In this study, 3 types of impregnating agents were employed to research their effect on the water absorption and frozen resistance of concrete by coating on concrete surface.

2. MATERIALS AND METHODOLOGY

2.1 Raw materials and Mix proportion

P·O 42.5 Ordinary Portland Cement confirming to Chinese Standard GB 175-2007 was used as binder in this study. The river sand with a fineness modulus of 2.8 and crushed stone with a maximum size of 20 mm was used as fine and coarse aggregate, respectively. The superplasticizer was used to adjust workability of fresh concrete. The slope and air content was controlled to be 200±10 mm and 2±0.5 %, respectively. The mix proportion was listed in table 1.

Table 1. Mix proportion of concrete （kg/m^3）

Cement	Fly ash	River sand	Crushed stone	Water	Superplasticizer
298	93	698	1163	149	3.4

2.2 Coating methods

In this study, 3 types of impregnating agents were employed including 6 commercially available products listed in table 2. The coating methods of impregnating agents on specimen surface were listed below. The coating dosage was controlled to be 200 ± 10 ml/m^2 every time.

2.3 Test methods

2.3.1 Water absorption

For every impregnating agent, three specimens with size of 100 mm ×100 mm ×100 mm were prepared to test the water absorption. The concrete specimens were coated with different impregnating agents at the age of 14 days, and then cured in the lab (temperature 20 ℃, relative humidity 60%) till 28 days. The water absorption was tested at 28 days by referencing the method of code《Test methods of autoclaved aerated concrete》(GB/T 11969-2008).

2.3.2 Frost resistance

For every impregnating agent, three specimens with size of 100 mm×100 mm×400 mm were prepared to test the frost resistance. The concrete specimens were coated with impregnating agents at

Table 2. Coating method of different impregnating agents

Coating method	Silanes		Potassium silicate	Osmotic curing agent		
	$1^{\#}$—Wacker-liquid	$2^{\#}$—Wacker-paste	$3^{\#}$—Potassium silicate solution	$4^{\#}$—Kaiboda	$5^{\#}$—Longhu	$6^{\#}$—Litoke
Step 1	Keep the surface of concrete specimens clean and dry					
Step 2	Dilution by mass ratio 1:9	No dilution	Dilution by mass ratio 1:2	Dilution by mass ratio 1:4 for component A and B	No dilution for component A and B	Dilution by mass ratio 1:8
Step 3	Coating twice	Coating twice	Coating twice	Coating component A twice	Coating component A twice	Coating twice
Step 4	/	/	/	After 6 h coating component B twice	After 1 h coating component B twice	/

the age of 14 days, and then cured in the lab (temperature 20 ℃, relative humidity 60%) till 24 days, and then immerged in water until 28 days. The frost resistance of concrete was tested according to 《Standard for test methods of long-term performance and durability of ordinary concrete》(GB/T 50082-2009).

2.3.3 Contact angle

The contact angle of concrete surface with coating impregnant agents was tested according to 《Standard Test Method for Surface Wettability and Absorbency of Sheeted Materials Using an Automated Contact Angle Tester》(ASTM D 5725-99-2008).

3. TEST RESULTS

3.1 Water absorption of concrete coated with different impregnant agents

The initial time for testing the water absorption of concrete coated with different impregnant agents was 28-day age. Test results of water absorption for 14 days immersion in water were present in figure 1. It could be found that potassium silicate($3^{\#}$),osmotic curing agents($4^{\#}$,$5^{\#}$,$6^{\#}$) and control group had the similar water absorption after immersed 14 days, around 2.5%. The water absorption of concrete coated with silanes (containing $1^{\#}$ and $2^{\#}$) was lower than that coated with potassium silicate or osmotic curing agents. The water absorption coated with Wacker-paste($2^{\#}$) was lowest, about 0.89% after immersed 14 days. Overall, water absorption of concrete by coated with silanes could be decreased significantly, while the potassium silicate and osmotic curing agents did not present obvious inhibition for water absorption of concrete.

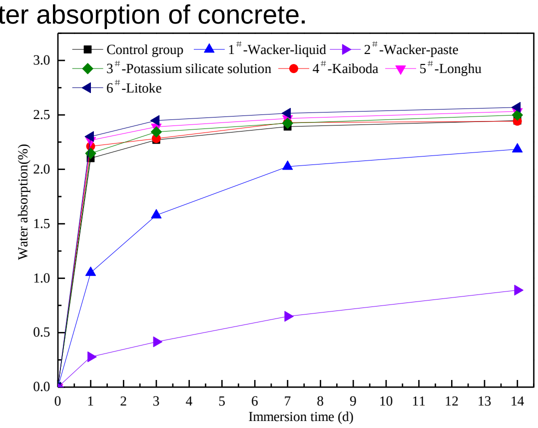
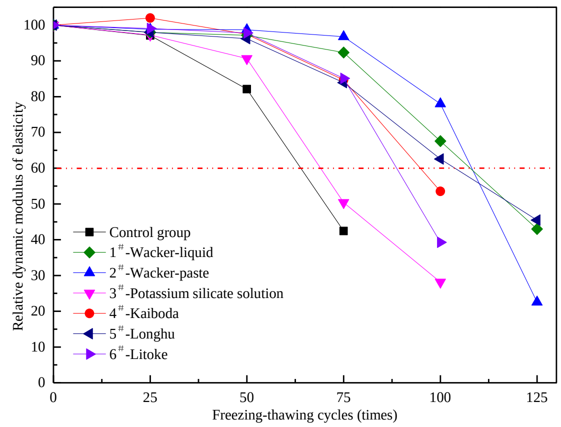


Figure 1. Water absorption of concrete coated with different impregnate agents

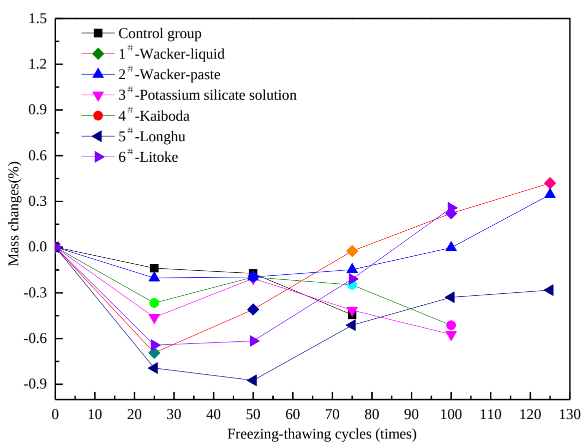
3.2 Frost resistance of concrete coated with different impregnant agents

The measurement results for frost resistance of concrete coated with different impregnant agents at the age of 28 days was shown in Figure 2, including relative dynamic modulus of elasticity and mass changes. It could be found that coating impregnant agents could cause varying degrees of promotion for frost resistance of concrete. The freezing-thawing cycles could achieve to be 125 times for 1#, 2#and 5#, while freezing-thawing cycles could achieve to be 100 times for 3#, 4#and 6#, compared to the controlled group with only 75 freezing-thawing cycles. Compared with the other 2 types of impregnant agent, coating silanes was the most effective way to enhance the frost resistance of concrete in this study.

Overall, the frost resistance of concrete could be enhanced by coating with impregnant agents, but the degree of improvement was limited. In general, the penetration depth of impregnant agents for concrete was in the range of 3mm to 5mm[4]. When the surface concrete was spalled during the freezing-thawing, the protective effect of impregnant agents for concrete was lost.



a) Relative dynamic modulus of elasticity



b) Mass changes

Figure 2 . Frost resistance of concrete coated with different impregnate agents

3.3 Contact angle of concrete coated with different impregnant agents

The measurement results for contact angle of concrete surface coated with different impregnant agents at 28 days was shown in figure 3 and 4. It could be seen that the contact angle of concrete surface coated with silanes was greatest, more than 110°. The contact angle coated with osmotic curing agent was slightly less, around 90°. The contact angle coated with potassium silicate was slightly more than that of controlled group, only 48.67°. Overall, after coating silanes the concrete surface showed to be hydrophobicity, while concrete surface with coating other 2 types of impregnant agents was presented weak hydrophobicity, including potassium silicate and osmotic curing agent.

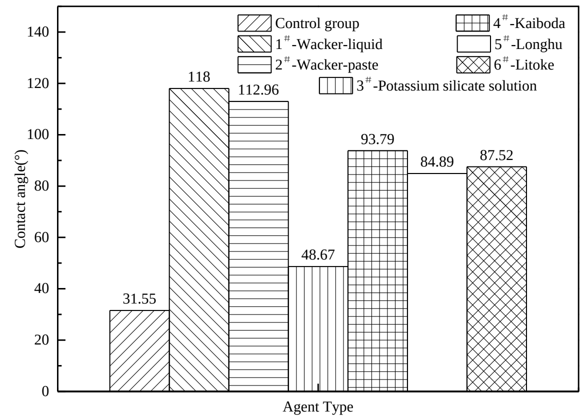


Figure 3. Contact angle of concrete coated with different impregnate agents

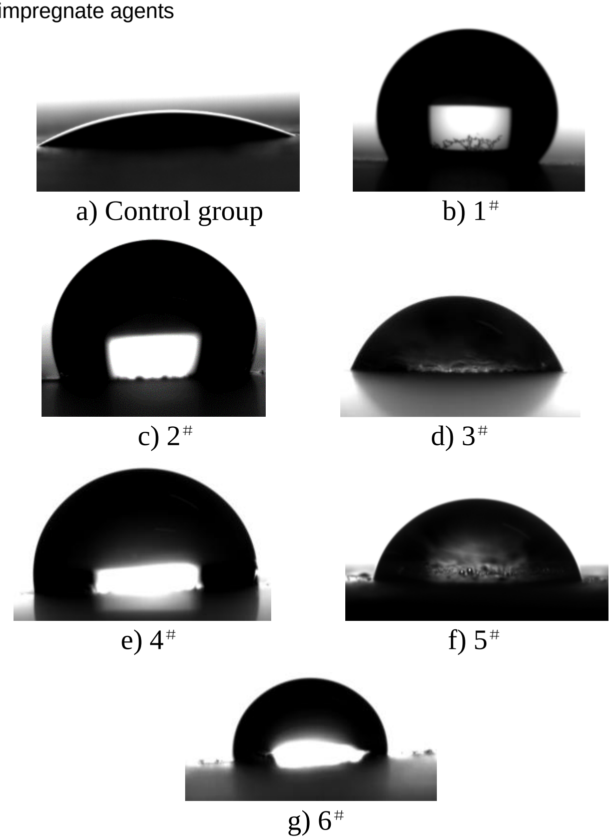


Figure 4. Contact angle of concrete surface coated with different impregnant agents

4. CONCLUSIONS

The water absorption of concrete could be decreased with varying degrees after coating impregnant agents, the reason was that the character change of concrete surface changed from hydrophilicity to hydrophobicity. The frost resistance of concrete was enhanced after coating impregnant agents, but the degree of improvement was limited, because the protective effect of impregnant agents for concrete was lost after surface concrete of specimen was spalled off during the freezing-thawing process. Compared with potassium silicate and osmotic curing agent, coating silanes impregnant agents was the most effective on the promotion of water absorption and frost resistance for ballastless track concrete.

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