Research on Impregnation Coatings for Protecting Concrete

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Abstract. The protecting of concrete, which consists of coating a chemical substance onto concrete's surface, has been applied to architectural conservation. There is increasing interest in studying materials for concrete which can reduce the infiltration of water and salt solutions and rehabilitate and extend its service life. Silicon compounds are frequently used as a base for commercial protecting paint due to their hydrophobicity and penetrability. In this study, concrete was coated with composite of impregnation type consisted of two different silanes and auxiliary enetrant to resist the diffusion of water. The properties of concrete coated with impregnation coatings composed of silanes and auxiliary were researched. And the penetrating performance of the composite was also investigated. The coating of composite silane improved the property of concrete.

Introduction

Various environment conditions (water dew, carbon dioxide, chloride ion, etc.) cause the corrosion and deterioration of the concrete structure. With concrete deterioration and/or steel corrosion, the long-term safety of structures would be greatly compromised [1]. The effect of the ingress of above mention matters drew attention to the need to prevent of delay the ingress of deleterious substance, which led to a dominating research focus on the protecting coating [2,3].

Though surface treatment and coatings to concrete are available in many types and qualities, among which invisible hydrophobic silane impregnations are the kind of the most popular [4-6]. The research and application of silane impregnations vary from country to country. In some countries such treatment is even compulsory for bridges exposed to de-icing salts. Among copious silanes, octyltriethoxysilane is most widely used due to its appropriate volatile and hydrolysis & condensation rate [7,8].

However, the penetration of octyltriethoxysilane on the concrete surface is limited because of the large molecular structure and high viscosity. In this research, silane of small structure methylethoxysilane and auxiliary enetrant JFC (fatty alcohol polyoxyethylene ether) was mixed with base octyltriethoxysilane. The properties of concrete coated with composite coatings were researched. And the penetrating performance of the composite protecting material was also investigated.

Experimental Program

Material Methyltriethoxysilane and octyltriethoxysilane (WD13, noted as Component A) were supplied by Wuhan University Silicone New Material Co., Ltd., Wuhan, China. JFC (fatty alcohol polyoxyethylene ether, noted as Component B) was obtained from Shanghai Reagent Plant, China. Each index of cement chosen in this research was abide by GB175—1999. Coarse used here was calcified macadam according GB/T 14685-2001. And the Lightweight material was middle sand selected by GB/T14684-2001. The components weight ratio of these three components and water was 25:50:80:12. The average 28th-day compressive strength of the concrete was 46.8 MPa.

Sample preparation and testing program Cube concrete specimens (50mm×50mm×50mm) were obtained from an on-site concrete batch plant used for constructing a building behind seawater. The concrete used was classified as class C45 concrete. Concrete specimens (cubic) had an average unit weight of (on the basis of 20 specimens)≥400 kg/m^3. In order to determine the protecting performances of the impregnation composite the concrete specimens were coated and immersed in water followed by drying at room condition. And concrete specimens should be cured for more than 28 days before cleaning and drying prior to be coated. Water blaster was used to clean the concrete surface. The specimens were dried at room condition for one day before coating the impregnation and they were accurately weighed during the coating cycle. The coated specimens were placed at room condition for 21 days before being immersed in water.

Component of the impregnation The experiments were set to examine the effect of active component proportion (Series A1,2,3,4) and the content of auxiliary enetrant (Series B1,2,3,4 and C1,2,3). The concrete components were shown in Tab. 1.

Tab. 1 Component of the impregnation composite

Serial Number	A (%)	B (%)	JFC
A1	100	0	0
A2	80	20	0
A3	60	40	0
A4	40	60	0
B1	95	0	5
B2	75	20	5
B3	55	40	5
B4	35	60	5
C1	60%	37%	3
C2	60%	36%	4
C3	60%	35%	5

Test Results and Discussion

Effect of formula on the viscosity The viscosity of the composite was expressed by the time during which the material flowed 100mm capillary tube. The higher the viscosity, the slower would the liquid flow speed. The result was shown in Fig. 1. The low viscosity and high valid element were most desired. From Fig. 1, it could be seen that the time increased with the increasing of component A. Hence, the change of viscosity was in the same way. With the proportion change of component A, the viscosity changed a little below 40% and increased sharply above 80%. So, we inferred from the results that 40～80% would be the appropriate range for component A.

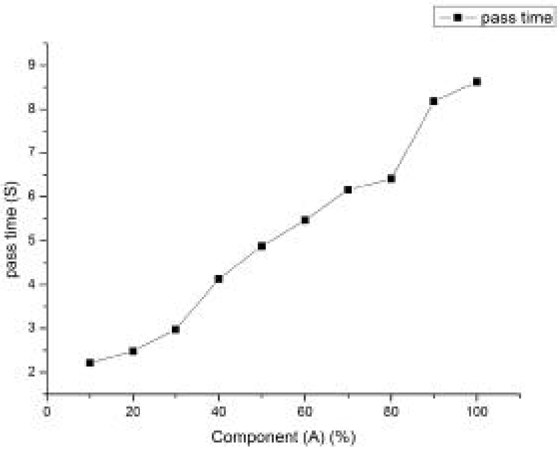

Fig. 1 Effect of formula on the flow length

Effect of auxiliary on the surface tension The auxiliary enetrant was added into the impregnation to lower the surface tension of the composite, so that the composite could penetrate deeper into the concrete. According to the report of Reyleigh, the surface tension equals approximately $\rho ghr(h+h/3)/2$, so the tension surface increased with the increasing of the capillary height. The results were shown in Fig. 2. The surface tension decreased a lot with the increasing of the auxiliary enetrant JFC. However the trend to descend smoothed down a bit when the JFC content was higher than 6%. Hence, the operative content of JFC would be 3%~5%.

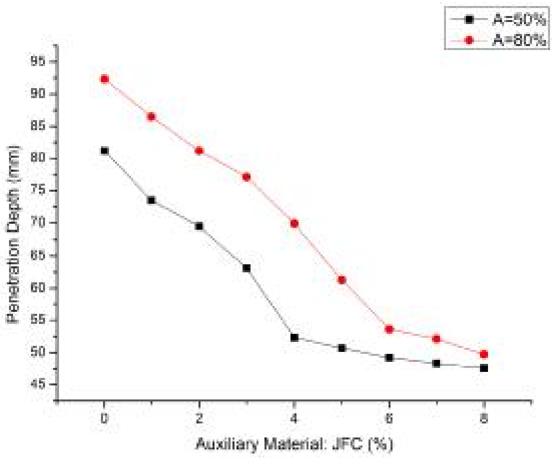

Fig. 2 Effect of auxiliary on the capillary height

Effect of components on the water adsorption rate The water adsorption rates of the concretes was characterized according to JTJ275-2000. The water adsorption rate of the concrete coated with different impregnation composite was shown in Fig. 3. It could be easily seen from the figure that, the water adsorption rate decreased a lot after surface paint. However, when the auxiliary enetrant was too large the water adsorption increased even more than 7 times. What's more, it was apparent that the higher the component A proportion, the lower the water adsorption rate. That is, the fraction A was the most valid component. In order to achieve effective impregnation, the proportion of component A should be controlled between 50%~80%.

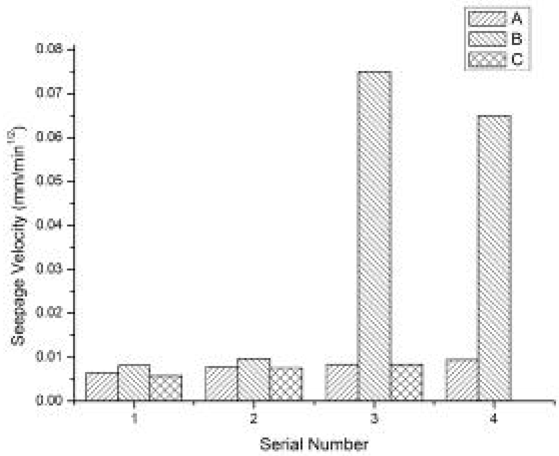

Fig. 3 Effect of components on the water adsorption rate

Properties of the impregnation composites The properties of the above impregnation composite were investigated. And the results were shown in Tab. 2. The pH of the composite was affected by the addition of the auxiliary enetrant JFC, from neutral to acid.

Tab. 2 Properties of the impregnation composite

Serial Number	pH	Contact Angle	Penetration Depth
A1	7	123	0.88
A2	7	117	1.05
A3	7	114	1.60
A4	7	113	1.62
B1	6.8	121	1.65
B2	6.8	120	1.78
B3	6.8	117	2.25
B4	6.8	109	1.94
C1	6.8	113	1.87
C2	6.8	115	2.05
C3	6.8	114	1.98

The contact angles of all the specimen coated with impregnation were above 90° as the alkyl of the silane was hydrophobic. All the samples coated with the impregnation prepared in this research met the requirements of JTJ275-2000.

The penetrate depth was only 0.88mm with pure WD13 (A). The value increased to 1.62 with the addition of Methyltriethoxysilane (B). This phenomenon could be explained that the A penetrated hardy due to its large molecular structure while B of small molecular structure penetrated easily. Hence, active component A was introduced into the concrete structure by inter-molecular forces, increasing the penetrate depth. The penetrate depth was high with the addition of auxiliary entrant which could be explained as follows. For one thing, the penetrate JFC of the low surface tension could promote the penetrate of A and B. For another, volatilization of B was reduced with addition of JFC, which could improve the penetrate depth.

Summary

In this paper, impregnation composite was prepared and researched for protecting concrete. Base components of silane was mixed with auxiliary enetrant to improve the penetrate depth of the impregnation. The research revealed that the properties of impregnation were affected by the components. Both the silane of small molecular structure and the auxiliary entrant could improve the penetrate depth of the impregnation. The optimum content of octyltriethoxysilane was between 50%~80%. Although the auxiliary entrant could improve some performance of the impregnation, the protecting effect would be reduced if added too much. The hydrophobic property in this research met the construction technical requirements. This research is valuable for both material science and construction technology.

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