Functional Study of Anticoagulant Ice Asphalt Mixture with Slow-release Agent

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Abstract. Based on the difference in freezing points of various chlorides, a multi-component synthesis method is employed to produce mixed chlorides with desired freezing points. To address the issue of chloride dissolution time, a sustained-release agent is used to encapsulate the mixed chlorides, creating an anti-coagulant ice modifier that controls release time. Indoor testing is conducted to verify its functionality and durability.

Keywords: Anti-coagulant ice modifier; Asphalt mixture; Sustained-release agent.

1. Introduction

China has a vast territory, with freezing rain in the south and snowfall in the north occurring from time to time. In late January 2016, a nationwide ice and snow disaster broke out, causing immeasurable losses to the people's property and incalculable damage to the roads. The existing methods of spreading deicing agents and artificial deicing are not only inefficient but also have poor timeliness, failing to effectively solve the problem of road snow and ice in a timely manner. Moreover, the difficulty in controlling the amount of spread leads to environmental pollution, seriously violating the "2016 National Transportation Work Conference" green and coordinated development concept. This article is based on a variety of chloride salts with different freezing points, combined with slow-release agents to control the rate of chloride salt precipitation. Its environmental friendliness is verified through metal immersion testing; its functionality is validated by combining it with asphalt mixtures under freezing conditions.

2. Freezing point test of various chlorine salts

The freezing point that the anticoagulant modifier can reduce is the key to its function, so the performance of the anticoagulant ice modifier is tested by different chlorine salt content. According to the measured freezing points of various chlorine salts at different concentrations, and compared with the actual minimum temperature in winter in the implementation area, KY631 portable freezing point tester (FIG. 1) was used.

At room temperature of 20.9℃, the freezing point test results of each chlorine salt are shown in Table 1 and Figure 2.

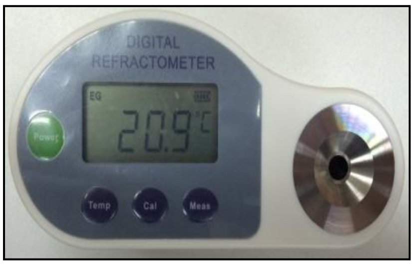

Figure 1: Portable freezing point tester

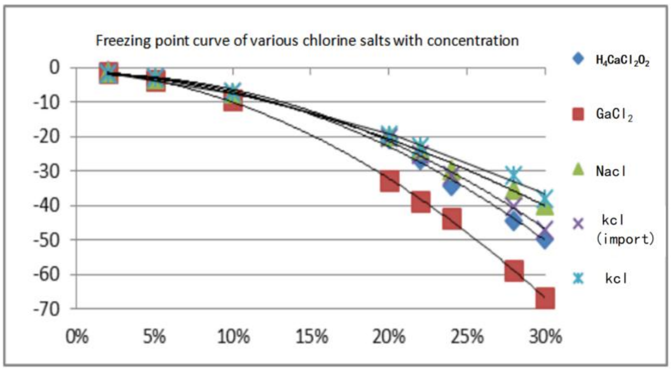

Figure2. Intensity comparison of asphalt mixture with different dosage of anticoagulant ice modifier

Through the above experimental data, it can be seen that when the concentration is less than 5%, the effect of reducing the freezing point is similar. Starting at a concentration of 10%, CaCl2 appearsWith slight differences, its freezing point value is slightly higher than that of the other chlorine salts. When the concentration rises to 20%, CaCl2 is significantly better than other chlorine salts, and the freezing point has exceeded -30℃, and finally reaches the lowest freezing point value of several chlorine salts at 30% concentration. This is contrary to the conventional theory that the freezing point of KCl is lower than CaCl2. It may be because CaCl2 used in this paper and KCl are produced and processed by different manufacturers, resulting in different content of active ingredients, which may result in a conflict with the conventional theory, but it does not affect the multiple combination of anticoagulant ice modifiers. Therefore, the impact of the product batch is ignored.

Table 1: Test values of the relationship between chloride concentration and freezing point

concentration		2%	5%	10 %	20%	22%	24%	28%	30%	Remark
freezing point（℃）	$Cacl_2$	-1.1	-3.7	-8.2	-20.5	-26.8	-34.1	-44.3	-49.6	exothermic
	$Cacl_2$	-1.5	-3.7	-9.4	-32.6	-38.6	-43.7	-58.5	-66.7	exothermic
	$Nacl_2$	-1.3	-3.2	-7.5	-19.7	-23.6	-29.5	-35.4	-39.8	calorieless
	Kcl(import)	-1.3	-2.9	-7.2	-20.3	-25.0	-31.2	-40.3	-47.1	exothermic
	Kcl	-1.6	-3.0	-7.1	-19.3	-22.7	-29.0	-31.1	-37.9	calorieless

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Table 2. Soaking results of anticoagulant asphalt mixture specimen

number	Chloride ion concentration（10^{-2}mol/L）									
	1	2	3	4	5	6	7	8	9	10
A	0.0541	0.1529	0.2823	0.2911	0.2988	0.3013	0.3023	0.3033	0.3038	0.3036
B	0.0467	0.1364	0.2661	0.2716	0.2822	0.28642	0.2934	0.2934	0.2962	0.2966
	11	12	13	14	15	16	17	18	19	20
A	0.3041	0.3042	0.3045	0.3045	0.3048	0.3046	0.3046	0.3046	0.3051	0.3051
B	0.2971	0.2979	0.2980	0.2980	0.2991	0.3001	0.3002	0.3002	0.3003	0.3003

In addition to NaCl dissolution does not release heat, the rest of the chlorine salts dissolve and release heat. Therefore, in the actual use of the road surface, the heat energy generated by the dissolution of chlorine salts can have an effect when the initial freezing point of snow or frozen ice does not drop below 0℃, which also provides a guarantee for the timeliness of anti-freezing ice on the road surface.

When carrying out multiple combinations, the proportion of each component can be flexibly mastered according to the freezing point corresponding to different chlorine salts and the actual temperature of the use area, so as to achieve the goal of snowfall and ice melting and economic and environmental protection.

3. Research on the Function of Anticoagulant Ice Asphalt Mixture

The main active component of snow melting ice is chloride ion, so the function of anticoagulant ice modifier can be effectively reflected through the monitoring of chloride ion content. The anticoagulant ice asphalt mixture with sustained release effect was prepared by the mixture of chlorine salt coated with the sustained release agent. Two tests were conducted to verify its functionality, including monitoring of chloride content changes and natural freezing tests.

3.1 Monitoring of chloride ion concentration change

The prepared specimens were soaked for a long time, and the function of the anticoagulant ice modifier was evaluated by measuring the change of chloride ion content in the specimens. The soaking method is shown in Figure 3. The room temperature is 22.9 ℃ , the chloride ion concentration is measured once A day, and the specimens are numbered A and B respectively. The test results are shown in Table 2 and Figure 4.

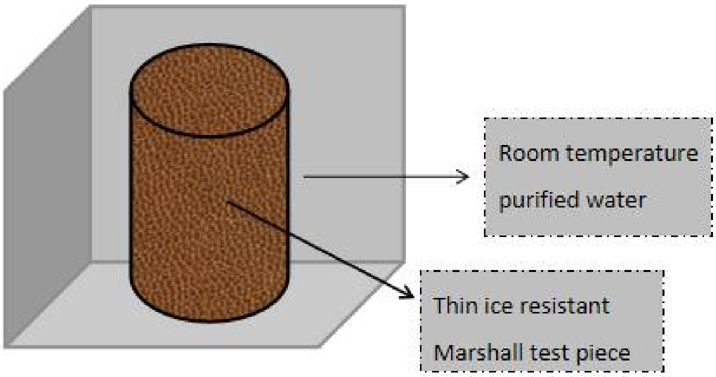

Figure 3: Soaking method of asphalt mixture

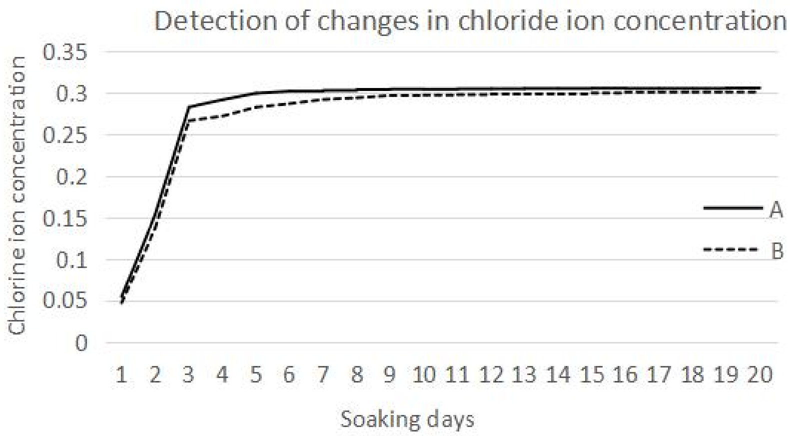

Figure 4: Chlorine ion precipitation situation

By simulating the most unfavorable precipitation conditions on the road surface, chloride ions continuously precipitate during the soaking period of the specimens, and the solution concentration gradually increases, it is considered that the requirements for sustained release have been met; The solution concentration finally reaches a stable peak, indicating that all chloride ions that can be soaked and dissolved have already precipitated. The remaining anti freezing ice modifier in the mixture can still function under the action of vehicle load and internal capillary pressure of the mixture.

3.2 Natural freezing experiment

By preparing two sets of specimens (one with 5% e added anti freezing ice modifier and the other without), they were directly placed in a natural environment at -10 ℃. After 10 hours, the specimens with added anti freezing ice modifier had no snow accumulation, and the ice layer was easily damaged. The surface of the specimens without added anti freezing ice modifier was completely frozen, accompanied by snow accumulation, as shown in Figure 5.

It is obvious that after 10 hours of low-temperature curing, the upper part of the specimen with added anticoagulant ice modifier did not completely freeze, and there was a water film between the ice layer and the specimen, with a freezing time of 6 hours; The unadded specimens have been completely frozen, with an ice layer thickness of approximately lcm~2cm and a freezing time of 3 hours. Therefore, the anti freezing ice modifier asphalt mixture has the effect of reducing the freezing point and inhibiting freezing.

4. Conclusion

（1）Through freezing point testing, the composition ratio of each chloride salt can be controlled by using a multiple combination method to synthesize a mixed chloride salt that produces the maximum benefit.

（2）Using slow-release agents to coat mixed chloride salts can effectively reduce the rate of chloride ion precipitation, reduce losses during rainy summer seasons, and continue to work in winter.

（3）The diffusion of solution ions causes chloride ions to gradually precipitate until their peak. Later, under the action of capillary pressure and vehicle load, chloride ions inside the mixture gradually diffuse towards the road surface, thereby continuously reducing the freezing point on the road surface and inhibiting freezing.

（4）The direct freezing in the natural environment intuitively and effectively reflects the function of anti freezing ice mixture to suppress freezing.

Figure 5: Results of natural freezing test

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