Study on the Performances of an Anticoagulant Ice Coating Material for Asphalt Pavement

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Abstract. In order to improve the anti-icing performance of asphalt pavement and alleviate the effect of pavement freezing, the method of coating anticoagulant ice coating on the surface of asphalt pavement is adopted. In this article, application research is conducted on an anticoagulant ice coating material on asphalt pavement using standard test methods. With different dosages of anticoagulant ice agent, the major performance indexes, including the freezing point and ice adhesion on coating surface, of anticoagulant ice coating material are compared. By comparing and analyzing the results, the transformation rules and optimum dosage of anticoagulant ice agent are achieved. The results of this paper can effectively alleviate the freezing phenomenon of pavement and improve the traffic capacity of pavement.

Keywords. Anticoagulant ice pavement; coating material; water borne epoxy resin; anticoagulant ice agent.

1. Introduction
The excellent pavement application and high driving comfort results in widespread application of asphalt pavement in high-level highways worldwide. According to statistics, about 60% highways in China suffers from snow mantle and ice pavement, which may result in slump in coefficient of road adhesion and thus lead to vehicle slipping, brake failure and steering failure. In this condition, traffic accidents are more likely to happen and traffic safety is badly influenced. It can be told from statistics that the traffic accident rate is increased by 100% and casualty rate by 25% with snow mantle and ice pavement [1]. About 15%-30% of traffic accidents in winter are related to snow and ice on the road area [2]. In the same period, 5.86 times of vehicle accidents like collision and scratch happen every one million vehicles passing one kilometer in snowy day, while in non-snowy days, the rate is 0.41 times. The accident rate in snowy day is as much as 13 times of that in non-snowy day [3]. The solution for snow mantle and ice pavement is in urgent need.

2. State-of-the-Art Chemical Techniques in Pavement Ice Melting
A common method to solve the problem of snow and ice is to spread snow-melting agent on the icing pavement.

However, the frequently-used snow-melting agent, chloride salt, has nonnegligible shortcomings. Once used, the remaining chloride salt on pavement will accelerate the damage of asphalt pavement, and chloride salt will be flushed to river by rainwater, causing severe contamination on surface water
and border trees [4]. Not only will it do harm to soil, water, atmosphere and ecological environment, but also as a passive method, it involves in great amount of work and cost [5]. Another method, snow-melting asphalt pavement, has received increasing attention in recent years. With the additives of snow-melting agent in asphalt mixture, the agent in pavement can be dissolved out under the combined influence of rainwater and vehicle load. In this way, the anticoagulant ice asphalt pavement can melt snow and ice in real time. Meng studied the influence of the content of salt storage anticoagulant on the road performance and ice melting effect of asphalt mixture. On the premise of ensuring that all performance indexes meet the specification requirements, the content of salt storage anticoagulant should be in the range of 4%-6% [6]. Chang combined salt storage materials and high elastic materials in a certain proportion to prepare high elastic salt storage asphalt mixture, and verified its deicing performance through experiments [7]. However, with the dissolution of snow-melting agent, the effectiveness decreased gradually. Beyond that, the dissolved agent cannot be replenished easily. As a result, the snow-melting asphalt pavement with this technique has very limited service-span. Also, this kind of snow-melting asphalt mixture has limited application scenarios as it can only be used for new pavement construction, but not applicable to the built ones [8].

The anticoagulant ice coating material is a technique proposed in recent years for de-icing [9]. The working principle of it is to add environment-friendly material, which can lower the surface freezing point, to the coating carrier material. In this way, an anticoagulant ice material is achieved to lower the freezing point of pavement. If applied on asphalt pavement by man power or machine, it can help with snow melting and de-icing in rainy days or snowy days [10]. Compared with other snow-melting asphalt pavement techniques, the anticoagulant ice coating material can be used in larger scale and different kinds of built roads.

3. Preparation of Anticoagulant Ice Coating Material

3.1. Anticoagulant Ice Agent

The proposed anticoagulant ice agent is a kind of solid powder that can lower surface freezing point and disperse homogeneously in carrier material. Environment-friendly composite materials are commonly used as anticoagulant ice agent because they do not cause chloride pollution to environment. In this article, the adopted anticoagulant ice agent is IM2 type, and its major performance indexes are shown in table 1.

| No. | Item                        | Unit   | Performance               |
|-----|-----------------------------|--------|---------------------------|
| 1   | Smell                       | -      | No obvious pungent smell  |
| 2   | Fineness (0.075mm sieve)    | %      | 78                        |
| 3   | Freezing point              | °C     | -10                       |
| 4   | Carbon steel corrosion rate | mm/a   | 0.12                      |

3.2. Coating Carrier

The most commonly used carriers for anticoagulant ice coating material are emulsified asphalt and silicone solution. The carrier adopted in this article is emulsified asphalt, and the major performance indexes are shown in table 2.
Table 2. Major performance indexes of emulsified asphalt.

| No. | Item                  | Unit | Performance |
|-----|-----------------------|------|-------------|
| 1   | Evaporation residue   | %    | 50          |
| 2   | Softening point       | ℃    | 55          |
| 3   | Ductility (5℃)        | cm   | 23          |
| 4   | Storage stability     | %    | 2           |
| 5   | Adhesive strength     | %    | 3           |
| 6   | Adhesive strength     | MPa  | 0.41        |

3.3. Mixture of Two Components
Stir the mixture while adding certain dosage of anticoagulant ice agent to emulsified asphalt, making anticoagulant ice agent disperse homogeneously, to achieve anticoagulant ice coating material. The performance of mixture is shown in table 3.

Table 3. Performance of mixture.

| No. | Item                  | Performance                     |
|-----|-----------------------|---------------------------------|
| 1   | Status of mixture     | No aggregation                  |
| 2   | Demulsification rate  | No demulsification in 3h-5h     |

4. Experiment

4.1. Specimen Preparation
A Marshall specimen of φ101.6mm×63.5mm is made according to T0702 asphalt mixture preparation method in JTGE20 standard (Marshall compaction method). The specimen grading is AC-13. Take the median value of recommended standard grading range. Apply anticoagulant ice coating material of 400g/m² on prepared Marshall specimen, and wait for demulsification and film-forming of emulsified asphalt.

Immerse the prepared specimen in pure water. The specimen surface is 2cm below the water surface. Wipe the specimen after 24 or 48 hours with wet cloth and the immersed specimen is achieved.

4.2. Anticoagulant Ice Performance Test
Prepare non-immersed specimens and immersed specimens with additive of anticoagulant ice agent of 2%, 4%, 6% and 8% respectively. Take emulsified asphalt without additive as control group. Conduct performance tests of freezing point and ice adhesion on coating surface following JT/T1239-2019 Technical specification of anticoagulant ice coating material for asphalt pavement [11].

5. Experiment Results

5.1. Freezing Point on Coating Surface
The result of freezing point test on coating surface with different dosages of anticoagulant ice agent additive is shown in table 4.

On the whole, the freezing point on surfaces of Marshall specimens decreases noticeably with anticoagulant ice agent additive. The freezing point decreases and the rate of decreasing slows down with the increase of additive dosage. When the specimens are not immersed and dosage is from 2% to 6%, the change of freezing point is significant, with freezing point of -3.5℃ when additive dosage is 2% and freezing point of -5.2℃ when additive dosage is 6%. When the specimens are not immersed and dosage is from 6% to 8%, the surface freezing point decreases unnoticedly by only 0.1℃. For specimens immersed in pure water for 24 hours, the surface freezing point increases to certain degree
and the more dosage of anticoagulant ice agent, the more the freezing point increases. However, the anticoagulant ice performance of specimens with more dosage of anticoagulant ice agent is always better than those with less dosage. The surface freezing point of specimens immersed for 48 hours is higher than those immersed for 24 hours by 0.1°C-0.2°C, proving that after slightly drop of performance at the beginning of immersing, the duration of immersing has insignificant influence on freezing point of coating surface. The results show that the coating has excellent water resisting property.

**Table 4.** Freezing point on coating surface with different dosages of anticoagulant ice agent additive.

| Dosage of anticoagulant ice agent | Freezing point on coating surface |
|----------------------------------|----------------------------------|
|                                  | Non-immers | Immerse for 24h | Immerse for 48h |
| 0                                | 0          | 0                | 0               |
| 2%                               | -3.5       | -2.7             | -2.6            |
| 4%                               | -4.5       | -3.4             | -3.2            |
| 6%                               | -5.2       | -3.9             | -3.8            |
| 8%                               | -5.3       | -4.0             | -3.8            |

**5.2. The Ice Adhesion Strength of the Coating Surface**

Table 5 showed the test results of the ice adhesion strength of the anticoagulant ice coating surfaces with different contents of anticoagulant ice agents.

**Table 5.** The ice adhesion strength of the coating surface from different contents of anticoagulant ice agents (Unit: N).

| Content of anticoagulant ice agents | Ice adhesion strength of the coating surface |
|-------------------------------------|----------------------------------|
|                                     | Non-immers | Immerse for 24h | Immerse for 48h |
| 0                                   | 150        | 150              | 150             |
| 2%                                  | 36         | 68               | 73              |
| 4%                                  | 34         | 52               | 56              |
| 6%                                  | 30         | 48               | 53              |
| 8%                                  | 27         | 40               | 44              |

In general, after adding anticoagulant ice agent, the ice adhesion strength of the surface of Marshall test piece significantly decreased. With the content of the anticoagulant ice agent increased, the strength got a decreased trend. As to pieces without immersion, under the test temperature of -15°C, the adhesion strength between ice and blank sample (the anticoagulant ice agent content was 0) was 150N. And after adding 2% anticoagulant ice agent content, the strength was 36N, which was highly effective. Within the test range, the content increased by 2%, the strength decreased by 3N. And when the content was higher than 6%, the adhesion strength between coating and ice decreased to 30N or less, the 1/5 of the blank sample, which showed a strong anticoagulant ice effect. After immersed by pure water for 24h, all the specimens’ surface ice adhesion strength increased and with more the content, the increase of the freezing point was small. Specimens immersed for 48h had a good performance on the adhesion strength compared to specimens immersed for 24h and the increase was by 4N-5N. Combining the two immersed curves, anticoagulant ice agents with high contents do have a better water resistance performance among the surface ice adhesion strength indices.

**6. Conclusions**

This paper proposed a research on the composite of anticoagulant ice coating prepared by IM2 anticoagulant ice agent and modified emulsified asphalt and the influence of different contents of anticoagulant ice agents on the freezing point and adhesion strength of the coating surface. The results
showed that

(1) The chosen two-component raw material has a good mixing performance, strong adaptability, which meets the requirements of the preparation of anticoagulant ice coating materials.

(2) Compared to blank sample without anticoagulant ice, the anticoagulant ice coating can decrease the freezing point and adhesion strength of the coating surface, showing an excellent anticoagulant ice performance.

(3) In the test range of the content between 2%-8%, the more the content, the stronger the anticoagulant ice performance (freezing point and ice adhesion strength of the surface) of the coating. The decline range of the freezing point of the coating surface decreases gradually according to the increase of the content. And the ice adhesion strength of the coating surface decreases linearly with the increase of the content.

(4) The anticoagulant ice performance of the coating is weakened after immersion. But after the early performance weakened (immersed for 24h), the performance changes little when immersed further for a long time (48h). The anticoagulant ice performance of the coating still meets the requirements and has good water resistance property after immersion for 48h.

(5) Taking comprehensive consideration of performance and cost, 6% is the best anticoagulant ice agent content. Further content increase has no more impact on freezing point of the coating surface and the ice adhesion strength of the surface decreases to 1/5 of the blank sample. And after immersion by water for 48h, the coating shows a good performance on anticoagulant ice and durability.

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