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Proceeding Paper

Innovative Design of Paving Cold Mix and Cohesive Overlays for Sustainable Pavement Maintenance †

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Abstract: A cold mix overlay is a typical preventive maintenance treatment that is applied to an existing pavement surface. However, the service life of cold mix overlay is limited because of its poor skid resistance and high tendency to crack, especially in cold regions. This study presents a new technology of high-performance cold mix overlay materials that slows skid resistance reduction, increases the resistance to thermal cracking, and shows long-lasting anti−icing performance. The sustainable performance of paving cold mix overlays can be assured by adding high-performance anti−icing agents, fiber, and emulsified asphalt to the cold mix. A series of laboratory tests were conducted to evaluate the performance and anti−icing effect of the cold mix. The results showed that the freezing temperature of the cold mix dropped to more than −10 °C. The open-to-traffic time can be shortened to 3.5 h after construction. The anti-wearing ability and cracking resistance were evidently increased in comparison with traditional micro-surfacing techniques by conducting indoor wet-wheel wearing tests and low-temperature bending beam tests. Based on the study, the new-tech cold mix overlay has shown promising applications in North America.

Keywords: cold mix overlay; preventive maintenance; overlay; anti−icing; freezing point; high performance; wet-wheel wearing test

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1. Introduction

Cold mix overlay is a pavement maintenance overlay technology that has the advantages of a short construction period and rapid opening of traffic. To meet the higher performance requirements for heavy traffic volume and complex climate conditions, researchers have carried out investigations on how to improve the performance of cold mix overlays regarding cracking resistance, water damage resistance, etc.

According to literature, the performance of cold mix overlays could be achieved by optimizing the performance of modified asphalt emulsions or by adding additional special fibers. Ji et al. [1] conducted research on using waterborne epoxy resins to improve the performance of micro-surfacing. The waterborne epoxy resin and SBR composite modified emulsified asphalt were used to enhance the performance of micro-surfacing by Zheng et al. [2]. Yao et al. [3] reported that polypropylene fiber micro-surfacing has the best cracking resistance. Luo et al. [4] investigated the influence of fiber type and fiber content on micro-surfacing cracking and rutting resistance. The recommended optimal fiber content is 0.1–0.2% by weight of the asphalt mixture. Yu et al. [5] used high-viscosity and high elasticity modified asphalt emulsions to pre-pared HCUP-8 cold mix overlay.

In summary, the performance of micro-surfacing and cold mix overlays, such as cracking resistance and water damage resistance, could be effectively enhanced by optimizing the performance of modified asphalt emulsions and adding fibers or polymer resins [6]. However, there was a lack of research on the long-lasting anti−icing cold mix overlay. The effect of anti−icing agents on the performance of the cold mix overlay needs to be further investigated. The purpose of this study is to evaluate the effect of an anti−icing agent on the performance of a cold mix overlay and to optimize the performance of the anti−icing cold mix overlay.

2. Materials and Methods

2.1. Materials

The extended-release anti−icing agent obtained by Road Intellitech Co., Ltd., (Nanjing, China) was consistent with Table 1. The emulsified asphalt, trackless tack coat emulsifier asphalt, and polypropylene fiber were also purchased by Road Intellitech Co., Ltd. The coarse aggregates and fine aggregates were obtained from Zhenjiang Maodi Industrial Co., LTD., (Zhenjiang, China) which met the technical specifications for preventive maintenance of highway asphalt pavement (JTGT 5142-01-2021).

Table 1. Physical and mechanical properties of the extended-release anti−icing agent (ERA).

Test Item	Units	Technical Requirement
Freezing Point (20% aqueous solution)	°C	≤−14
Quality Loss (170 °C)	%	≤0.5
Corrosion Rate	mm/a	≤0.15
Water Content	%	≤3

2.2. Gradation

The basalt aggregates were used in the cold mix overlay. Which grading range and com-posite gradation were shown in Table 2.

Table 2. The gradation of cold mix overlay mixture.

Sieve Diameter	Percentage Passing (%)								ERA	PPF	Cement	PREA
	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075 *				
Limits	100	70–90	45–70	28–50	19–34	12–25	7–18	5–15	5%	0.3%	1.5%	11%
Gradation	100	79.0	56.6	35.6	25.2	13.9	8.7	1.8				

* The first gear of 0.075 is replaced by ERA, and the substitution ratio is 9:10.

3. Results and Discussion

The bond property of the ice interface and the cold mix overlay mixture was evaluated by a drawing test of the ice interface, which was used to evaluate the freezing point reduction ability of the anti−icing agent. The test result is shown in Figure 1a. The pulling strength of the binder increased as the test temperature decreased. The pulling strength of ERA increased smoothly as the temperature decreased from −5 °C to −10 °C. However, the pulling strength of ERA significantly increased from −10 °C to −12 °C. This phenomenon occurred because the ice had formed when the temperature reached −12 °C. Thereby, the freezing point of ERA was −10 °C.

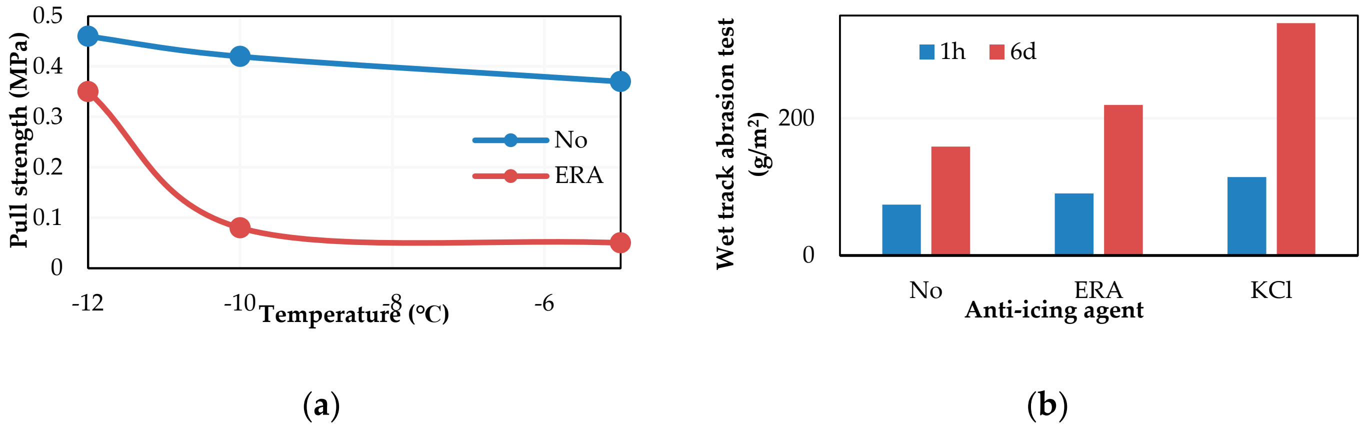

Figure 1. The ice point and wet track abrasion were influenced by anti−icing agents. (**a**) Ice drawing force; (**b**) The wet track abrasion test.

The wet track abrasion test was applied to evaluate the water damage resistance of cold asphalt mixtures. The wet track abrasion times of 1 h and 6 d are shown in Figure 1b. The wet track abrasion of KCl cold mixtures was higher than the other two cold mixtures. The cold mixture of No was smaller than the other two cold mixtures. This was because the release rates of the three cold mixtures were as follows: KCl > ERA > No. The voids formed when the KCl or ERA were released, which could affect the water damage resistance of the mixtures.

The cohesion torque reflects the forming speed and opening traffic time of the cold mix overlay. As shown in Figure 2, the cohesion torque of ERA cold mixtures increased as the anti-emulsification time got longer. When the anti-emulsification time reached 3.5 h, the cohesion torque of ERA cold mixtures was 2.4 N·m.

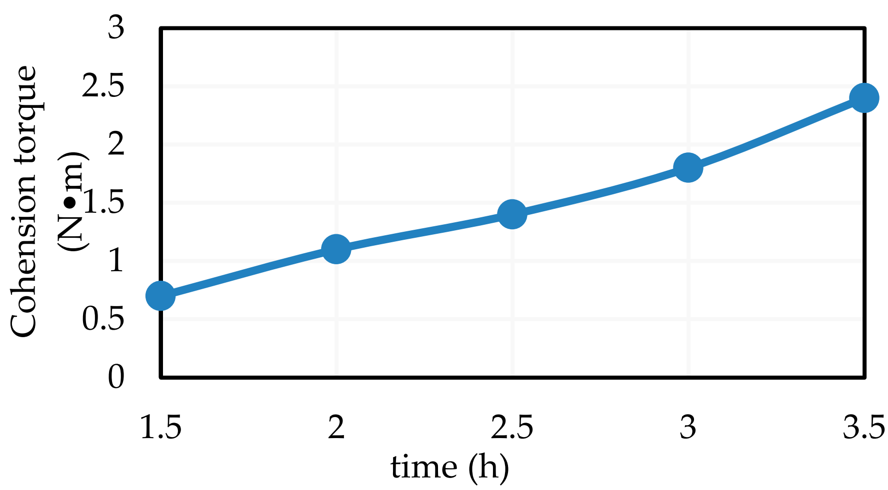

Figure 2. The cohesion torque of the ERA cold mix overlay.

With excellent conditions in hand, the optimal properties of the ERA cold mix overlay mixture were tested, and the results are shown in Table 3 The mixture performance of the ERA cold mix overlay was worse than micro-surfacing.

Table 3. The performance of different asphalt mixtures.

Test Item	ERA	Micro-Surfacing	Units	Technical Requirement
Mixing time/s	180	138	/	≥120
Breaking time/min	20	5	/	/
Cohesion torque /(N·m)	2.40 (3.5 h)	2.15	/	≥2.0
Wet track abrasion test 1 d/(g/m^2)	90.4	74.1	/	≥538
Wet track abrasion test 1 d/(g/m^2)	219.6	158.8	/	≥807
Load wheel test (g/m^2)	198.6	167.3	/	≥538

Flexural tensile strains were used to investigate the low-temperature performance of asphalt mixtures. The results were shown in Figure 3. The ultimate flexural tensile strains of the ERA cold mix overlay could reach 3848.6 με, which was more excellent than the others. This phenomenon was due to the PREA's excellent performance. So, the cracking resistance of the ERA cold mix overlay was the best of all.

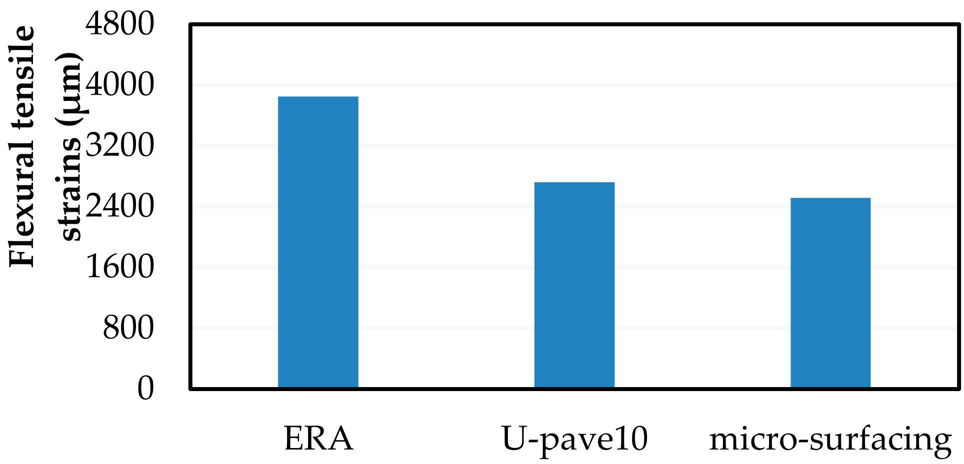

Figure 3. The flexural tensile strains of different asphalt mixtures.

The cumulative release was often used to evaluate the durability of anti−icing. The concentration of chloride ions was detected by a rapid determination instrument of chloride ion content. The results were shown in Figure 4. The chloride release rate of KCl was faster than ERA. The anti−icing function of KCl was finished when the soaking days reached 20 d. However, the anti−icing function of ERA was finished as the soaking days reached 95 d and the single release of chloride ions was 0.00158948 mol/L, which was the critical ice inhibition concentration.

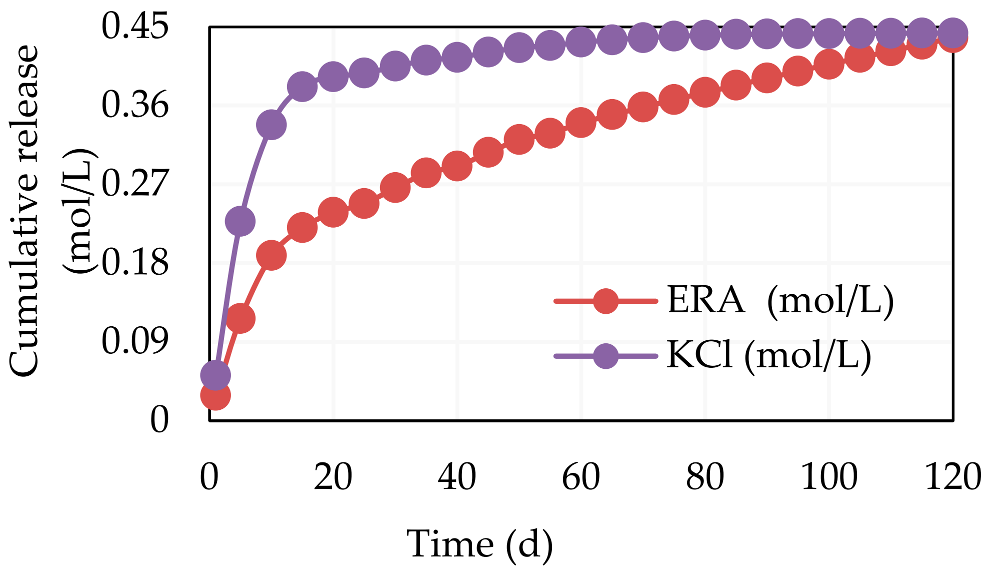

Figure 4. The cumulative release of different anti−icing agents.

4. Conclusions

To obtain an excellent anti−icing cold mix overlay, this paper studied the effects of the ERA anti−icing agent on the freezing point, opening traffic time, wet track abrasion, flexural tensile strains, and mixture performance. The rapid determination instrument for chloride ion content was used to evaluate the durability of anti−icing.

(1) The freezing temperature of cold asphalt mixtures dropped to much lower than −10 °C. This technology shortened the open-to-traffic time to 3.5 h after construction;
(2) The ERA cold mix overlay had excellent water damage and cracking resistance performance. The flexural tensile strains could reach 3848.6 με, which was higher than that of micro-surfacing and U-pave 10 hot asphalt mixtures;
(3) The performance of ERA cold mixtures met the ISSA standards. The durability of anti−icing cold mixtures could reach 95 days when soaked in water. Thereby, the new-tech cold mix overlay had shown promising applications in North America.

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