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Review

A review on low temperature performances of rubberized asphalt materials

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HIGHLIGHTS

- Rubber particles can block crack initiation and propagation and improve cracking resistance.
- The low temperature properties of rubber modified binder are associated with many factors.
- Micro cracks could not be induced destructive cracks due to effects of rubber particles.
- Anti-cracking properties of CRMB can be improved by chemical modifications and physical treatments.
- The low temperature properties of CRM mixtures can be evaluated by IDT, SCB, and ACCD tests.

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ABSTRACT

The benefits of applying the crumb rubber modified binders have been widely recognized. The improvements on low temperature properties of asphalt binders have been proven by adding crumb rubber. The article reviews the crack resistance mechanism of crumb rubber modified asphalt. Rubber particles can block the generation of cracks, leading to the improvement of low-temperature properties of the binder. The review finds that the low temperature properties of crumb rubber modified binder (CRMB) are govern by the factors such as asphalt properties, crumb rubber properties, mixing temperature, mixing time, mixing type and admixture. These factors have effects on the interaction between crumb rubber and binder that affect the low temperature performance of CRMB. The bending beam rheometer (BBR) test is the most frequently used method to evaluate the low-temperature properties of CRMB. Meanwhile, the low temperature properties of crumb rubber modified asphalt mixtures are commendably evaluated by the indirect tensile test (IDT), the semi-circular bending (SCB) test and the asphalt concrete cracking device (ACCD). Furthermore, the low temperature anti-cracking properties of CRMB can be improved by the chemical modification and physical treatment methods.

Contents

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1. Introduction

Low-temperature cracking is one of the main damage forms of asphalt pavements in cold weather. The thermal tensile stress in asphalt pavements exceeded its resistance strength with the decrease of temperature, leading to the occurrence of the thermal cracking in asphalt pavements. Crack in asphalt pavements affected and shorten the service life of asphalt pavement. The cracking resistance performances of pavements were closely connected with the properties of binder and mixture [1,2]. The addition of crumb rubber had been recommended to resist and reduce the thermal cracking of pavement. Meanwhile, the crumb rubber as a modifier was used in the pavement in the United States in the early 1960s [3]. At present, the use of crumb rubber produced from waste tire rubbers to modify the binder could not only enhance the properties of binder, but also embody the economical and environmental advantages by reducing waste tires in landfills. Due to low susceptibility to temperature variances, the crumb rubber has low stiffness and maintains elastically at low temperature conditions [4,5]. It was reported that crumb rubber modified binders (CRMB) improved low temperature cracking performance of asphalt pavements through improving fracture toughness [6,7] and increasing tensile strength [8].

The addition of crumb rubber to asphalt could be achieved in variety of ways. At present, these methods were classified as the wet approach and the dry approach [9]. Crumb rubber modification by wet method had been proved to contribute to the improvement of low-temperature anti-cracking resistance of asphaltic mixes. The swelling process of the interaction between crumb rubber and binder had a direct effect on the performance improvement. Though the absorption of light components in binder, the crumb rubber could swell up to three to five times its original volume [10]. Many factors had an effect on the properties of CRMB. These factors included type of binder, crumb rubber content, crumb rubber type, particle size, production parameters such as mixing time, mixing temperature, mixing type and so on [11,12]. The correct selection of the production variables was of remarkable influence on the properties of CRMB. In addition, many new additives had been introduced into the CRMB. In general, these additives such as advera, LEADCAP and epoxidized soybean oil and so on promoted CRMB to have better low temperature performances.

There were many different methods to evaluate the low temperature properties of CRMB and its mixture. The Fraass brittle point test was one of the earliest methods to measure the low temperature performance of asphalt. It was not currently widely used [13]. Since the traditional test methods did not accurately predict

Table 1
Performance grade, source, type of modifications and average properties of binders.

	PG64-22 Neat Binder	PG64-22 + GRT	PG58-22 + GTR	PG64-22 + GRT	PG64-22 + GTR	PG64-22 + GTR
Source	Aggregate industries	–	Iranian asphalt	Detroit asphalt	Middle Eastern	Gorman
Modification	None	12% Ground tire rubber (GTR)	10% Waste tire rubber (WTR)	15% Ground tire rubber (GTR)	15% Ground tire rubber (GTR)	12% Ground tire rubber (GTR)
PG grade	PG64-28	–	–	–	–	PG88-16
Continuous grade	67.9–29.2	–	–	–	–	88.7–19.8
AASHTO T313 BBR creep stiffness (60 s) S(MPa)	263 (−18 °C)	66.1 (−12 °C)	157 (−18 °C)	193 (−18 °C)	108 (−12 °C)	43.6 (−6 °C)
AASHTO T313 BBR slope (60 s) m value	0.316 (−18 °C) [18]	0.355 (−12 °C) [85]	0.364 (−18 °C) [86]	– [5]	0.325 (−12 °C) [87]	0.318 (−6 °C) [88]