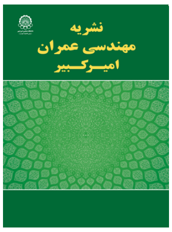

Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 53(10) (2022) 969-972
DOI: 10.22060/ceej.2020.18351.6842

Study on the effect of reclaimed asphalt pavement and rejuvenator on fracture behavior of WMA

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ABSTRACT: Recycling or, in other words, reuse of pavement is one of the latest technologies in the field of road construction that is now more accepted than other pavement construction methods. In addition to better environmental protection, this technology results in significant cost savings. Still, one of the major concerns of its use is the creation of undesirable properties in asphalt mix, such as bitumen aging and reduced cracking resistance. The use of rejuvenation agent and WMA (warm mix asphalt) additive are the solutions to improve the performance of asphalt mixers containing RAP (reclaimed asphalt pavement) materials. Hence, in this research, in order to evaluate the effect of using RAP on the fracture resistance of WMA mixtures, the RAP materials with two dosages of 25% and 50%, one type of rejuvenation agent and Sasobit, as a WMA additive, were employed. To study the fracture resistance of the mixtures at the temperatures of -15 ºC and 25 ºC under mode I loading, semi-circular bending test was selected, and different fracture parameters including critical fracture load, fracture energy, flexibility index, cracking resistance index and fracture toughness were calculated. The results exhibited that the addition of RAP material to the mixture had a negative effect on the fracture parameters at different temperatures and resulted in the reduction of these parameters. While the mixtures containing rejuvenator showed more elastic behavior than those without rejuvenator. Therefore, the use of a rejuvenator led to the improvement of the fracture parameters.

Review History:

Received: May, 02, 2020
Revised: Jun. 21, 2020
Accepted: Jul. 15, 2020
Available Online: Aug. 18, 2020

Keywords:

Semi-circular bending test
Warm Mix Asphalt (WMA)
Reclaimed Asphalt Pavement (RAP)
Rejuvenator
Resistance to cracking

1. INTRODUCTION

Nowadays, an increase in the costs of fuel and materials has led to the use of reclaimed asphalt pavements (RAP) in the preparation of asphalt mixtures. Based on the previous studies, each year, 100 million tons of asphalt concretes are obtained from the damaged pavements and are then discarded. The reuse of these waste materials known as RAP can significantly reduce the production costs of asphalt mixtures [1]. There are limitations in the use of RAP materials in asphalt mixtures, and an amount between 15% and 40% is recommended. Higher usage of RAP materials causes the asphalt mixture more brittle, which reduces its resistance against cracking [2].

Many investigations in recent years have been performed to explore the fracture behavior of asphalt mixtures (see, e.g. [3-8]). This paper investigates the fracture behavior of warm mix asphalt (WMA) mixtures containing RAP and a rejuvenation agent.

2. METHODOLOGY

In this research, the fracture behavior of five different mixtures described in Table 1 is investigated. A binder with a penetration grade of 60/70 and siliceous aggregates with the nominal maximum aggregate size (NMAS) of 19 mm is used. In addition, all the mixtures contain an air void of 4%. After preparation of the mixtures according to the Superpave mix design, the semi-circular bend (SCB) specimens are produced using the gyratory compactor machine. Figure 1 shows the

Table 1. Asphalt mixtures investigated in this research

Mixture	Sasobit (%)	RAP (%)	Rejuvenator (%)
CW	3	0	0
25RW	3	25	0
50RW	3	50	0
25RRW	3	25	10.5
50RRW	3	50	10.5

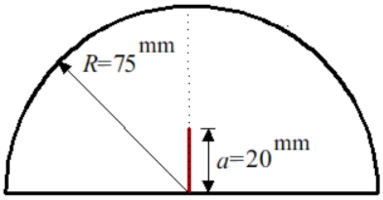

Fig. 1. Geometry of the SCB specimen

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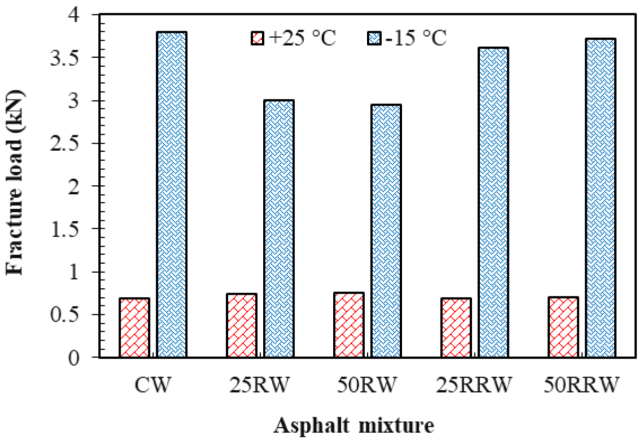

Fig. 2. Fracture load of mixtures at -15 °C and 25 °C

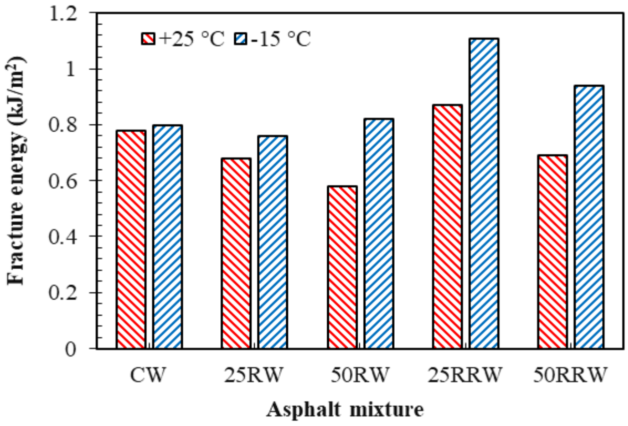

Fig. 3. Fracture energy of mixtures at -15°C and 25 °C

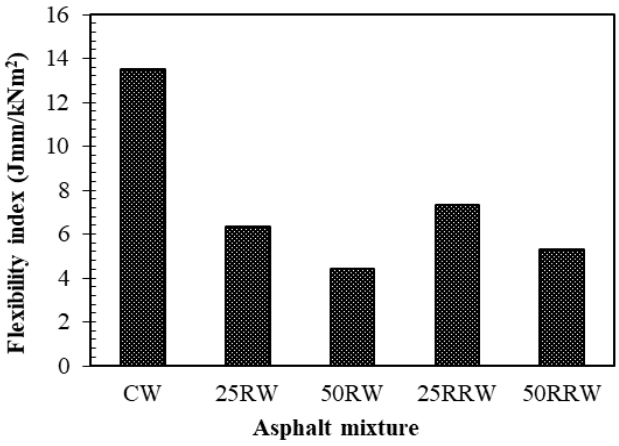

Fig. 4. Flexibility index of mixtures at 25 °C

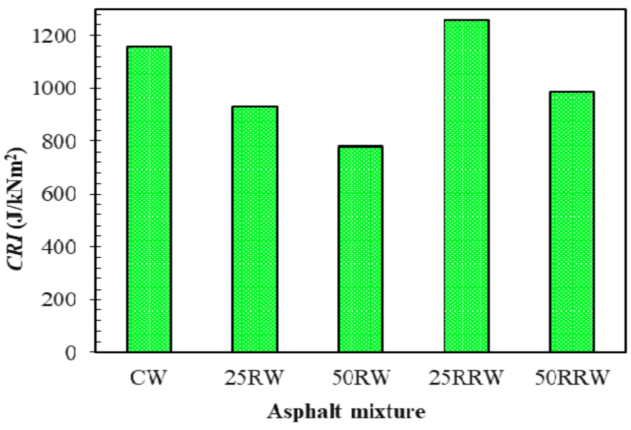

Fig. 5. Cracking resistance index of mixtures at 25 °C

geometry of the SCB specimen. In this research, the thickness *t* of the SCB is considered as 30 mm. Since the fracture tests are performed at two different temperatures of -15 °C and 25 °C, the SCB specimens are conditioned at the mentioned temperatures for 4 hours to have a uniform temperature within the specimens. The fracture tests are then conducted using the three-point bending fixture with a span of 100 mm. During the tests, the cross-head fixture has a displacement rate of 1 mm/min. The load-displacement curves are finally recorded from the tests. Five different fracture parameters described below are then calculated.

a) *Fracture Load* (P_{cr})

This parameter is the maximum load available in the load-displacement curve.

b) *Fracture Energy* (G_f)

This parameter is calculated as the area under the load-displacement curve.

c) *Flexibility Index (FI)*

This parameter is calculated using the following formula.

$$FI = 0.01 \times \frac{G_f}{|m|} \tag{1}$$

where, $|m|$ is the slope of the post-peak curve at the inflection point.

d) *Crack Resistance Index (CRI)*

This parameter is defined as follows:

$$CRI = \frac{G_f}{P_{cr}} \tag{2}$$

e) *Fracture Toughness* (K_{Ic})

This parameter is another index for determining the resistance of a cracked body against the fracture and is written as follows:

$$K_{Ic} = \frac{P_{cr}}{2Rt}(\sqrt{\pi a} Y_I) \tag{3}$$

where, *R*, *t* and *a* are the radius, thickness and crack length in the SCB specimen shown in Figure 1. In addition, Y_I is the geometry factor and its value is taken 4.8 herein [9].

3. RESULTS AND DISCUSSION

The results of fracture parameters described above are shown in Figures 2-6. According to Figure 2, the addition of RAP results in increasing the fracture load at 25 °C. At the same time, its addition leads to a reduction of the fracture

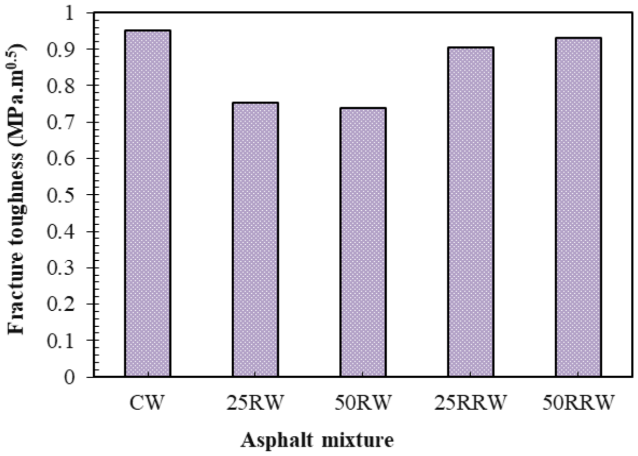

Fig. 6. Fracture toughness of mixtures at -15°C

load at -15 °C. Meanwhile, the rejuvenator causes the mixtures to be weakened against cracking. Based on Figure 3, the addition of RAP leads to reduction of the fracture energy at both temperatures; while, the addition of rejuvenator has a positive effect on this parameter. According to Figures 4-6, the addition of RAP leads to a decrease of the parameters of the flexibility index, *CRI* and fracture toughness; while, the addition of rejuvenator results in the improvement of these parameters.

4. CONCLUSIONS

The results show that the use of RAP together with a rejuvenator is able to improve the fracture parameters.

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HOW TO CITE THIS ARTICLE

S. Pirmohammad, S. Sobhi, A. Yousefi, Study on the effect of reclaimed asphalt pavement and rejuvenator on fracture behavior of WMA, Amirkabir J. Civil Eng., 53(10) (2022) 969-972.

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