Construction and Building Materials 177 (2018) 43–50

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Influence of base asphalt aging levels on the foaming characteristics and rheological properties of foamed asphalt

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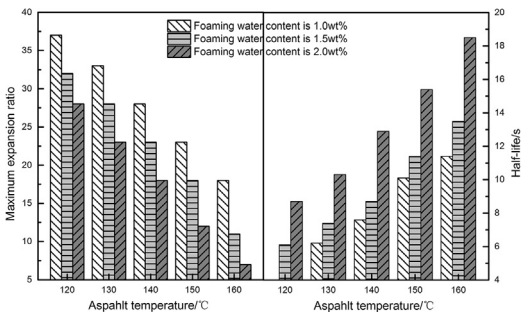
HIGHLIGHTS

- Deeper aging degree needs higher temperature and foaming water content.
- Aging process has better for high-temperature property and temperature sensitivity.
- Aging process has adverse for fatigue resistance property.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 21 July 2017
Received in revised form 24 March 2018
Accepted 10 May 2018

Keywords:
Foamed asphalt
Different aging levels
Foaming characteristic
Rheological properties
Foaming water

ABSTRACT

Foamed asphalt technique is widely used in road construction due to its environmental and economic effects. The various characteristics of foamed asphalt and mixtures have already been investigated; however, few studies focused on what happened on the properties of foamed asphalt when the base asphalt was aged at different degree. In this study, the foaming characteristics and rheological performance of foamed asphalt prepared by different aging levels for base asphalt and foaming water content were determined. The rheological properties such as failure temperature, Zero shear viscosity @60 °C, temperature sensitivity, and fatigue resistance were evaluated by DSR tests. The results show that the deeper aging degree of asphalt for foaming process needs higher temperature and more foaming water content. And aging process of asphalt has better for high-temperature performance and temperature sensitivity, and adverse for fatigue resistance performance.

1. Introduction

Hot mix asphalt (HMA) is a main technology for the asphalt pavement construction, which needs higher temperature to mix the aggregates and asphalt binders. As we all known, the higher temperature leads more energy consumption and greenhouse gas emissions to pollute the environment [1].

Because of decreasing greenhouse gas emissions and energy consumption, and prolonging construction season [2], warm mix asphalt (WMA) has been utilized in road construction for many years [3]. There are three main WMA technologies [4] such as organic additives group [5], chemical additives group [6] and foaming technology group [7]. In the past many years, over 30 different WMA technologies were used in the United States, while almost 60% of the technologies are based on the foaming methods [8]. According to the foamed asphalt, the viscosity and phase state have been determined. The viscosity of foamed asphalt was evaluated by Brookfield viscometer and the authors suggested that it is could

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https://doi.org/10.1016/j.conbuildmat.2018.05.100
0950-0618/

Table 1
Properties of asphalts at different aging degree.

Property	Test Standards	Base asphalt	RTFOT	PAV
Penetration (25 °C, 100 g, 5 s)/0.1 mm	ASTM D 5	68	57	41
Ductility (15 °C, 5 cm/min)/cm	ASTM D 113	>100	91	54
Softening point/°C	ASTM D 36	49.3	53.9	60.1
Density (15 °C)/g/cm^3	ASTM D 70	1.032	1.102	1.134
Solubility(trichloroethylene)/%	ASTM D 2042	99.8	99.8	99.8

be measured the foaming quality by the viscosity at the first 60 s [9–11]. The neutron scattering was used to detect phase state of residual foaming water in the system, and it could be found that size of bubble is less than 0.1 μm [12].

Besides, many researches focused on the properties of modified asphalt by foaming process. The performance of binder with different foaming water content has been investigated [13], and the results showed that with the increase of foaming water content, the sensitivities of the storage modulus and loss modulus for the foamed CRMA binder decrease gradually. Others studied the effects of asphalt binder and recycled crumb rubber on the properties of foamed CRMA asphalt binder [14].

Fig. 1. Foaming machine.

However, there are few research focused on the foaming process and properties for the foamed asphalt different aging stages. In fact, the aging process is a crucial factor for the characteristics of the asphalt, which effects on the properties of binder [15], bringing about the changes of asphalt stiffness [16].

Furthermore, there are two aging stages [17] during the life of asphalt pavement, including short term aging [18] and long term aging [19]. Short term aging for asphalt appears in the process of manufacturing and lying of asphalt mixtures [20]. Long term aging is used to measure the performance of asphalt due to environmental factors during the service life of pavement [21]. In Superpave Specification, the rolling-thin film oven tests (RTFOT) are used to simulate the short term aging and the pressure aging vessel (PAV) is used to stimulate the long term aging that occurs 5–7 years in the field [22].

This study is aims to stimulate the aging process for asphalt by RTFOT tests and PAV tests. And three aging degree asphalt samples including base asphalt, RTFOT samples, and PAV samples were obtained to prepare the foamed asphalt with various foaming water content (0 wt%, 1.0 wt%, 1.5 wt%, and 2.0 wt%), and then the foaming characteristic and rheological properties of foamed asphalt were investigated.

2. Experimental materials and methods

2.1. Asphalt

The 70# base asphalt produced from SsangYong asphalt plant of South Korea was selected. And then the RTFOT tests and PAV tests were conducted. The three different aging degree asphalt including base asphalt samples, RTFOT samples, and PAV samples were obtained, and the basic properties of these samples are listed in Table 1.

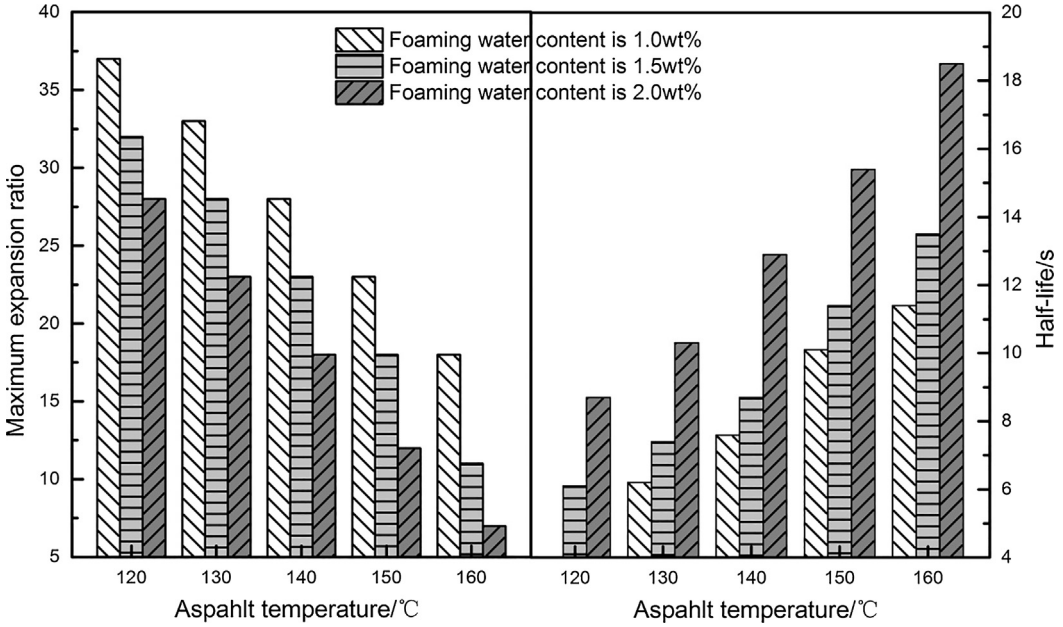

Fig. 2. Maximum expansion ratio and half-life of foamed asphalt with different asphalt temperature and different foaming water content.