Materials and Design 66 (2015) 51–59

Contents lists available at ScienceDirect

Materials and Design

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

Laboratory evaluation on performance of diatomite and glass fiber compound modified asphalt mixture

Qinglin Guo [a], Lili Li [b,*], Yongchun Cheng [c], Yubo Jiao [c], Chun Xu [c]

[a] School of Civil Engineering, Hebei University of Engineering, Handan, Hebei 056038, China
[b] Department of Student's Affairs, Hebei University of Engineering, Handan, Hebei 056038, China
[c] College of Transportation, Jilin University, Changchun, Jilin 130025, China

ARTICLE INFO

Article history:
Received 3 August 2014
Accepted 14 October 2014
Available online 23 October 2014

Keywords:
Diatomite
Glass fiber
Statistical regression analysis
Asphalt mixture

ABSTRACT

The purpose of this paper is to investigate the compound effects of diatomite and glass fiber on asphalt mixture. The diatomite and glass fiber compound modified asphalt mixture (DGFMAM) was prepared in laboratory. Performances of DGFMAM were investigated by experimental method. Wheel tracking test, low temperature indirect tensile test, indirect tensile fatigue test (ITFT) and indirect tensile stiffness modulus test (ITSM) were carried out. The statistical analysis of variance (ANOVA) method and statistical regression method were used to evaluate the effects of diatomite and glass fiber on properties of asphalt mixture. Results indicate that diatomite and glass fiber improve the rutting resistance and fatigue properties of control asphalt mixture. Diatomite has a significant effect on the stiffness modulus of asphalt mixture. Disadvantage of diatomite on low temperature deformation property of asphalt mixture is solved by glass fiber. DGFMAM has better travelling performances than the control mixture. It will provide a reference for the design of compound modified asphalt mixture.

1. Introduction

Asphalt pavement has been widely used in the world due to its good performance. It is constructed using hot asphalt mixture. Hot asphalt mixture is a typical viscoelastic material. This will result in rutting deformation at high temperature in summer and pavement cracking at low temperature in winter. And then the rutting deformation and cracks in pavement will affect the travelling performance of vehicles seriously [1,2]. Thereby, researchers in many countries have been trying to modify the asphalt mixture in order to solve these problems as much as possible.

Diatomite is a material which has light weight, high porosity and good insulation property, its reserve is huge and the cost is low. It has been used to modify asphalt mixture as a result of these characteristics in recent years. And the properties of asphalt binder and mixture modified by diatomite were studied. Bao [3] and Xu [4] investigated the basic properties of diatomite modified asphalt binder. The results suggest that the penetration and ductility decrease with the increase of diatomite, and the softening temperature of asphalt binder is increased by diatomite. Cong et al. [5] evaluated the effect of diatomite on the viscosity of asphalt, the results indicate that the viscosity of modified binder increases with the increase of diatomite, the diatomite modified asphalt mixture is susceptible to low temperature cracking. Zhu et al. [6] evaluated the insulation property and pavement performances of diatomite modified asphalt mixture in laboratory. The results show that diatomite not only improves the rutting resistance significantly but also reduces the thermal conductivity coefficient of asphalt mixture. And the bending stiffness modulus of diatomite modified asphalt binder is less than that of the control binder at low temperature. Tan et al. [7] studied the interaction between diatomite and asphalt, the fracture property of modified asphalt mixture at low temperature. The results indicate that there is no chemical reaction occurred between diatomite and asphalt, the fracture temperature of modified mixture is lower than that of the control mixture. Chen et al. [8] also studied the insulation performance of asphalt mixture modified by diatomite, the results suggest that the thermal conductivity of mixture is reduced by diatomite. Diatomite is helpful for the surface temperature reducing of roadbed in permafrost region. Li et al. [9] also suggested that the bending strength and bending tensile strain of diatomite modified asphalt mixture are less than that of the control mixture at low temperature. Therefore, it can be seen that the high temperature stability and thermal physical property of asphalt mixture are improved by diatomite, but the low temperature deformation ability of diatomite modified asphalt mixture is declined. The pavement which is constructed

* Corresponding author at: No. 199, South Guangming Street, City of Handan, Hebei Province, China. Tel.: +86 15383202570.

E-mail addresses: hbuegql@gmail.com, guoql@hebeu.edu.cn (L. Li).

http://dx.doi.org/10.1016/j.matdes.2014.10.033
0261-3069/

using asphalt mixture modified by diatomite is more susceptible to low temperature cracking than the common pavement. However, the asphalt pavement in seasonal frozen regions such as Jilin province of China has a severe need on low temperature property of asphalt mixture. The asphalt pavement in these regions must have good high temperature stability and anti-crack performance at low temperature simultaneously. Therefore, it is needed to improve the low temperature deformation property of diatomite modified asphalt mixture.

Glass fiber is a kind of inorganic fiber with high tensile strength. In the previous studies, glass fiber has been used to modify asphalt mixture successfully in order to improve the deformation ability. Aysar et al. [10] investigated the fracture behavior of asphalt concrete with glass fiber. It shows that the glass fiber modified mixture has a potential resistance to against crack initiation. This will be beneficial to preventing pavement cracks at low temperature. Abtahi et al. [11] thought that glass fiber improves the strength, fatigue property and ductility of asphalt mixture. Fu [12] investigated the properties of asphalt mixture modified by glass fiber. The result suggests that glass fiber has no significant influence on the bending strength, but the bending failure strain increases with the increase of glass fiber. Glass fiber improves the property of rutting resistance significantly. Besides, Mahrez et al. [13] indicated that the use of glass fiber in pavement may increase the cost of construction, but this will reduce the cost of maintenance. It can be found that glass fiber not only improves the ductility, anti-cracking property and fatigue property of asphalt mixture but also seems to be economic for the modification of mixture. In summary, some effects of diatomite and glass fiber on asphalt mixture are similar, and the others are different. The downside of one modifier on the mixture can be changed by another modifier. Effects of diatomite and glass fiber on asphalt mixture have been investigated in previous researches separately. The compound modified effects of diatomite and glass fiber are unknown. If diatomite and glass fiber are used to modify asphalt mixture simultaneously, a new kind of asphalt mixture which has good rutting resistance and low temperature performance may be obtained. Furthermore, it will provide a technology reference for the design of mixture.

In this paper, a preparation process of diatomite and glass fiber compound modified asphalt mixture (DGFMAM) was discussed. The control asphalt was modified by diatomite. Then the modified asphalt and glass fiber were used to prepare DGFMAM. The specimens of DGFMAM for experiments were prepared in laboratory. Effects of diatomite and glass fiber on the performances of asphalt mixture were tested and evaluated.

2. Materials and preparation method

2.1. Materials

In this study, the heavy traffic asphalt AH-90 was used for experiments. Its basic properties are listed in Table 1. Diatomite is the calcined product, and its physical properties are presented in Table 2. As shown in Table 3, the particle size distribution of diatomite was investigated according to the Standard ASTM D4464-10. Glass fiber is the short fiber from Taishan Fiberglass Inc., Shandong Province, China. And its properties are presented in Table 4. Silane coupling agent was used to process the glass fiber in order to improve the bonding property of interface. The aggregates are limestone. As presented in Table 5, apparent specific gravities of aggregate were tested according to the Standards **ASTM:C127** and **ASTM:C128**. The selected gradation of asphalt mixture is shown in Fig. 1.

Table 1
Properties of the control asphalt.

Property	Value	Standard
Penetration (25 °C, 0.1 mm)	86	ASTM-D5
Ductility (15 °C, cm)	168.5	ASTM-D113
Softening point (°C)	44.5	ASTM-D36
Penetration index	−1.416	–

Table 2
Properties of diatomite.

Property	Color	PH	Specific gravity (g/cm^3)	Bulk density (g/cm^3)
Value	Orange	7–8	2.1–2.3	0.35–0.42

Table 3
Particles size distribution of diatomite.

Particle size (μm)	<5	10–5	20–10	40–20	>40
Value (%)	62	27	4.4	2.1	1.4

2.2. Preparation method of DGFMAM

The control asphalt was modified by diatomite at first. The processing method has significant impact on the properties of modified asphalt. A low mixing speed is difficult to ensure uniform distribution of diatomite in asphalt. Therefore, the equipment with a speed of 600 r/min was used to blend. The specific processes of asphalt modification are as follows.

First, diatomite and the control asphalt were weighed with the required quality, and they were placed in the oven at 135 °C for 4 h. Second, diatomite and the control asphalt were taken out from the oven. Diatomite was added into the control asphalt. The diatomite and asphalt were mixed by the blending equipment with a speed of 600 r/min.

Based on the results of repeated test, it was found that the blending time should be set for 15 min. Besides, diatomite particles will sink in asphalt as a result of the weight of particle when the modified asphalt is placed for a long time. So a second blending should be conducted when the modified asphalt was used for experiment again.

The preparation procedures of DGFMAM are as follows.

1. Aggregates were mixed in the mixing oven at 170 °C. And then the diatomite modified asphalt was added, they were mixed about 90s in order to make aggregate surface uniformly coated by asphalt mastic, then the diatomite modified asphalt mixture was obtained.
2. Glass fiber was added into the diatomite modified asphalt mixture which had been obtained in previous step. They were mixed about 90s, and then the mineral filler was added. The diatomite and glass fiber compound modified asphalt mixture were obtained after a second mix within 90s. Distribution status of glass fiber in asphalt mixture has a direct impact on properties. So the mixing time should be increased

Table 4
Physical properties of glass fiber.

Property	Value	Standard
Length (mm)	12	GB/T 14336 [14]
Specific gravity (g/cm^3)	2.5	GB/T 14335 [15]
Color	White	–
Melting temperature (°C)	>1500	ASTM-D7138
Tensile strength (MPa)	3100–3400	ASTM-D5035
Ultimate tensile strain (%)	3.3–3.6	ASTM-D5035