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Influencing Factors on Shear Strength of Asphalt Mortar with High Viscosity

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Abstract. In orderto study the influencing factors on the shear strength of asphalt mortar with high viscosity, many different compositions are considered to analyse theshear strength of asphalt mortar, such as asphalt from different resource, mineral powder, wimble weight, temperature and ratio of filler to bitumen. The results indicate that among these factors, the influence of wimble strength is the smallest, which can be ignored. The shear strength of asphalt mortar decreases with increasing temperature from 25℃~50℃.Meanwhile it changes with the ratio of filler to bitumen by 1.2 under the temperature changing from 25℃~35℃.Also with the rising ratio between filler and bitumen, the shear strength of mortar increases. However, the temperature sensitivity changes differently with its peak. Compared to the type of mineral powder, the influence of asphalt resource on shear strength and temperature sensitivity are more significant.

1. Introduction

Since performance of drainage requires large air void in the mixture of pavement, asphalt and mortar play the important roles in the mixture. Asphalt mortar combined with asphalt and mineral powder plays an important role in asphalt mixture. In dense-graded asphalt mixture, asphalt mortar can fulfil the interspace among the aggregates. And it also forms glue sand with fine aggregate which can coheres with coarse aggregate particles and ensures the overall strength of the mixture[1].Porous asphalt pavement is known as its good performance, such as drainage quickly, good performance in skid resistance. Since porous asphalt mixture is composed with large amount of coarse aggregate, less fine aggregate and high void ratio,it has the frame structure on stone-stone. Asphalt and mortar play the important roles in the mixture. And asphalt mortar is the most important factor in maintaining the stability of the structure [2, 3]. Since porous asphalt mixture lays on the surface of pavement structure, it is affected by the traffic directly. Therefor the shear resistance becomes the most important performance [4-9]. As so far, many studies have done on shear behaviour of mixture, but few on asphalt mortar.

In this paper, influences of asphalt, mineral powder and ratio of filler to bitumen to shear performance are studied by testing the feature of whole performance. And the influences of asphalt, mineral powder, and asphalt mortar are analysed basing on the testing results.

2. Experimental

2.1. Bitumen
Two kinds of modified bitumen are made from matrix bitumen,ESSO70#. One(named B1) is modifiedwith TPSbeing 12% of bitumen in weight, and the other(named B2) is 5%SBS.

2.2. Mineral powder
Two types of limestone powder from different resourceare used in the study. And their specific surface areas and particle sizes are tested by different methods. The table 2 shows the results.

2.3.Asphalt mortar
Asphalt mortar is the mixture of bitumen and mineral powder. Firstly, mineral powder is heated and dried to a constant weight at 105±5℃. Then, a certain quality mineral powder is added into modified asphalt under 160℃. And the mixture is stirred until it isup to the best. So three kinds of asphalt mortar are chosen for studied from 2 types of bitumen and 2 kinds of mineral powder.

Table 1. Indexes of bitumen.

Properties	Test values		
	ESSO70#	B1	B2
Softening point (℃)	49.9	90.2	79.2
Penetration(25℃,0.1mm)	64.1	50.3	56.4
Ductility(cm)	>150(15℃)	44.1(5℃)	37.9(5℃)
Toughness（N·m）	/	29.6	30.2
Tenacity（N·m）	/	16.9	20.9
Dynamic viscosity(60℃,Pa.s)	/	41743	16713

Table 2. Indexes of mineral powder.

Properties		1#	2#
Apparent density（t/m3）		2.64	2.68
Size range	<0.6mm（%）	100	100
	<0.15mm（%）	99.4	98.4
	<0.075mm（%）	86.4	79.4
Specific surface area（<0.075mm）（m^2/kg）		2392.5	3224.6
Average particle size（<0.075mm）（μm）		5.476	4.879

Table 3. Asphalt mortar.

Asphalt mortar	Modified asphalt	Mineral powder	Ratio of filler to bitumen
B1-1	B1	1#	
B1-2	B1	2#	0.4,0.6,0.8,1.0,1.2,1.4,1.6
B2-1	B2	1#	

2.4. Shear strength
The shear strength is calculated by measuring the cone depth of a certain mass at fixed time which is similar to Soil Test. And the shear strength can be calculated by Equation(1).

$$\tau = \frac{981M\cos^2(\frac{\alpha}{2})}{\pi h^2 \tan(\frac{\alpha}{2})} \tag{1}$$

where, τ is shear strength (kPa), M stands for total weight (g), h is cone depth(0.1mm), and α is the angel between tips.

3. Results and discussion

3.1. Weight of cone

Two cones with different weight are used to investigate their influence on shear strength. And the results in Figure.1 for B1-1 show there is no remarkable influence of cone weight on it.

3.2Temperature

The cone penetration tests forthree kinds of asphalt mortar are carried out under different temperatureranging from25℃~50℃. Then the shear strength is calculated by equation (1) under each condition.

As can be seen in Fig.1, the shear strength increases with the increasing proportion of mineral powder in bitumen. Since the increasing number of filler can raise the viscosity of asphalt mortar which is beneficial to shear behaviour. And this result indicates that ratio of filler to bitumen in mixture should be added to improve shear behaviour as well as to road performance in some circumstances.

Fig.1 shows that the shear strength drops down quickly with increasing of temperature. And it drops obviously with temperature changing from 25℃~35℃. But the drop rate is differ from types of mortar.As to mortar of B2-1, the reduction of shear strength is up to 80% with temperature changing from 25℃~35℃. By contract, the shear strength of mortar B1-1and B1-2 reduces separately around 75% and 60%. When temperature changes from 35℃~50℃, the drop rate of shear strength becomes considerable slow down with range of 14%~20%. Therefore, the whole range of testing temperature can be divided into two parts with 35℃. And 35℃ can be suggested to distinguish the temperature of different asphalt mortar.

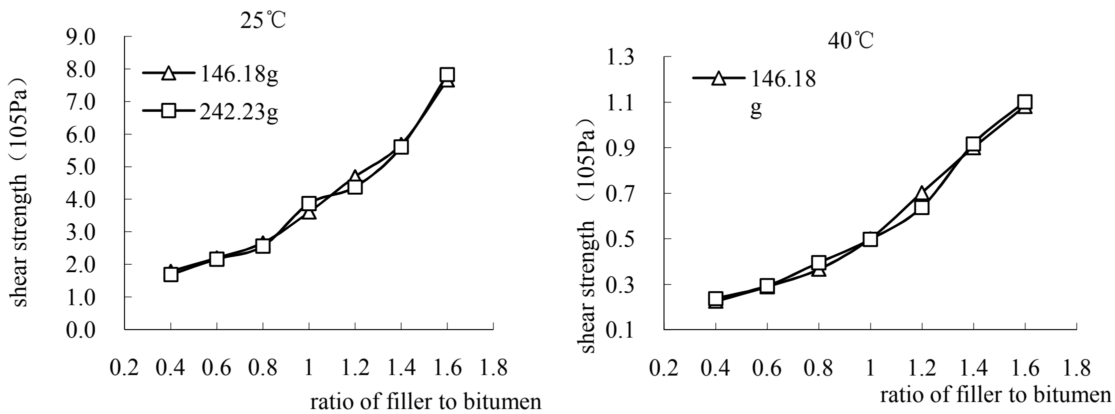

Fig.1. Influence of cone weight (A1-1)

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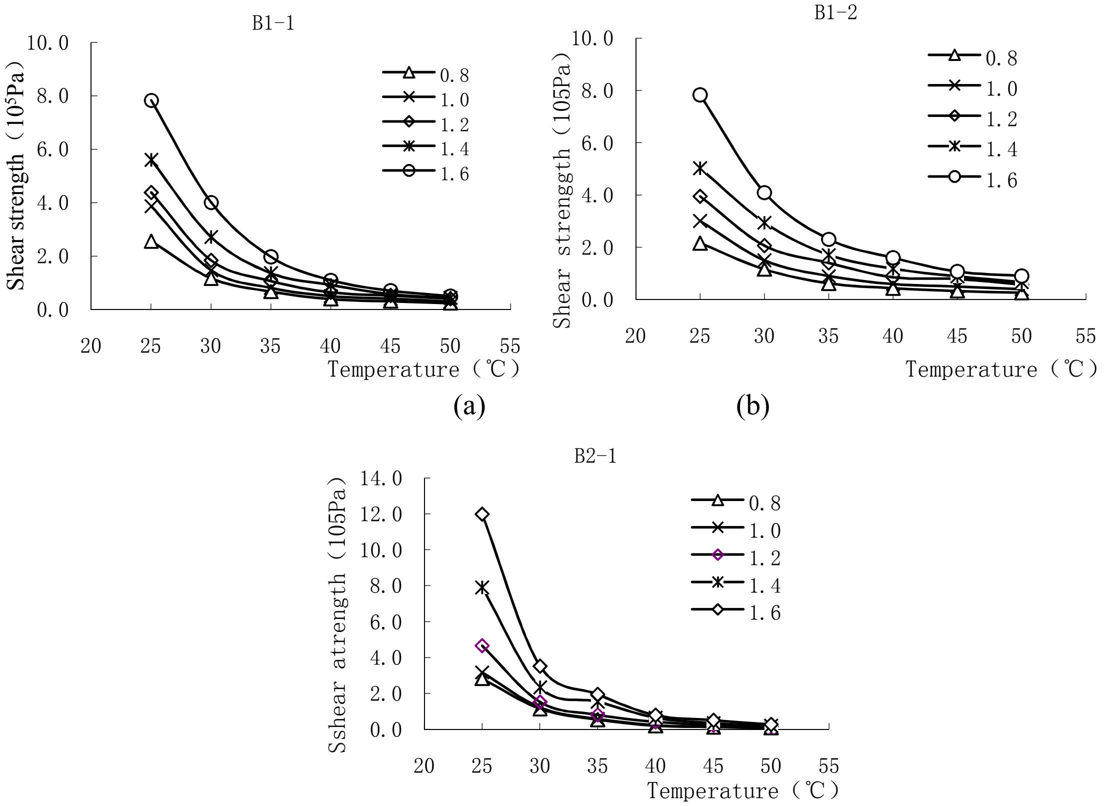

(c)

Fig.2.Curves for effect of temperatuire on asphalt mortar

3.3 Asphalt and mineral powder

From Figure2 (a, b, c),the relationship between shear strength and temperature can be represented by the following formula-equation (2):

$$\tau = Kt^{E} \quad (2)$$

Where,τ is shear strength (10^5Pa), t is temperature (℃), and K and E are regression coefficients. Meanwhile, the shear strength increases with the increasing of K value. And|E|value represents the sensitivity of shear strength to the temperature [10]. The larger the|E| value is, the greater sensitivity the shear strength is.

Table 4.K and E for different asphalt mortar

B1-1			B1-2			B2-1		
Ration of filler to bitumen	K	E	Ration of filler to bitumen	K	E	Ration of filler to bitumen	K	E
0.8	14680	-3.4384	0.8	44326	-3.1056	0.8	6E+07	-5.2154
1.0	36958	-3.6239	1.0	33124	-2.9287	1.0	7E+07	-5.2346
1.2	23471	-3.4317	1.2	22426	-2.7407	1.2	3E+07	-4.9305
1.4	85537	-3.7251	1.4	63375	-2.9408	1.4	1E+08	-5.1860
1.6	4E+06	-4.0737	1.6	21082	-3.188	1.6	3E+08	-5.3525

Table 4 shows that there is a minimumfor |E| value with the ration of filler to bitumen beingat 1.2. So it indicates that the sensitivity of shear strength to the temperature is minimal and the mortar has the best temperature stability. Therefore this ratio of filler to bitumen can be suggested to use in the porous asphalt mixture which can also guarantee its characters. At the same ratio of filler to bitumen, mortar of B2-1 is more sensitive than the other two. And the |E| value of B1-2 is the smallest which reveals that the asphalt mortar of B1-2 has the best temperature stability among the three studied. The results suggest that combining with the same asphalt, the larger specific area of mineral powder is, the smaller sensitivity of asphalt mortar has. Because there are sufficient areas on the surface of mineral powder which can adhere to asphalt. Then the structural asphalt are formed which is very important to characters of mixture. Similarly, an asphalt with higher viscosity is beneficial to form the structural asphalt. However comparing with mineral powder, the type of asphalt is more obviousto the influence of temperature sensitivity. So that bitumen with high viscosity is usually chosen in order to improve the shear resistance of porous asphalt mixture, especially used on the crossing.

3.4. Ratio of filler to bitumen

In order to study the influence of ratio of filler to bitumen, shear strength under different temperature with different ratio are tested. Fig.3.shows the results of different mortar under different temperature and ratio of filler to bitumen.

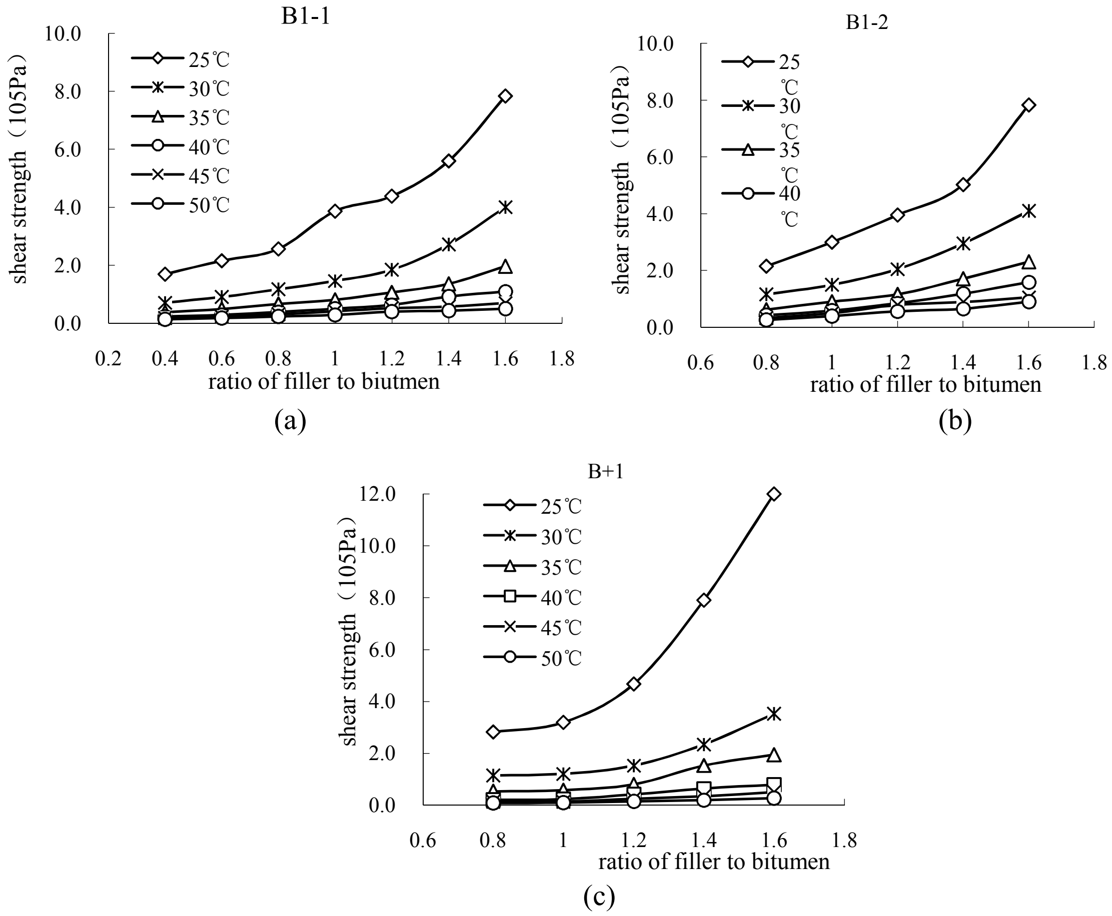

Fig.3. Curves for shear strength with ratio of filler to bitumen

The curves in Fig.3 show that the shear strength rise with the increasing of ratio of filler to bitumen and reduce with the temperature rising. And it is obviously influenced by the ratio of filler to bitumen. With the larger amount of mineral powder in asphalt mortar, the shear strength is higher. Because large amount of filler can provide more surface area for asphalt to adhere, the more structural asphalt can be formed in the mortar which is beneficial for the character in its asphalt mixture. With the same ratio of filler to bitumen, the shear strength of B1-2 is the highest because of the asphalt with high viscosity which can strengthen the adhesion between asphalt andmineral powder. Then the performance of asphalt can be improved effectively.

4. Conclusions

This study investigated the influencing factors of asphalt mortar on shear strength. The influence of cone weight is so small that it can be ignored. The ratio of filler to bitumen influenced the temperature sensitivity and shear strength. When it is at 1.2, the temperature sensitivity of asphalt mortar is the smallest, and it has the best performance at high temperature. Also the shear strength can be improved by adding the asphalt with higher viscosity or finer mineral powder. The drop rate declined with the increasing of temperature. Therefore, 35℃ can be suggested as the division temperature for asphalt mortar.

Acknowledgments

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