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Influence Of The Powder/Asphalt Ratio On The High Stress Responses Of Crumb Rubber Modified Asphalt Mortars

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ABSTRACT
In order to study different powder/asphalt ratios effect on nonlinear viscoelastic responses of mortar, this paper choose limestone as the filler, and powder/asphalt ratio is 0.2,0.4,0.6,and 0.8.The tests were conducted using a Dynamic Shear Rheometer to perform multiple stress creep recovery (MSCR) tests.The test results show that，with the increase of powder/asphalt ratio，irrecoverable creep compliance(Jnr) value of the mortar decrease gradually, and the amplitude is larger.High temperature performance of the mortar are improve obviously.Using environmental scanning electron microscopy to scan those mortars,it analyzed the improvement of mortar from the microcosmic mechanism.
***Keywords*:** powder/asphalt ratio, crumb rubber modified asphalt mortar, MSCR, High stress responses

I. INTRODUCTION

Thigh temperature stability of asphalt mixture depends not only on mineral aggregate skeleton, but also on the hamper role asphalt binder's to hinder the shear deformation of asphalt mixture. Usually, the contribution of asphalt binder to the ability of mixture's rutting resistance up to 40%[1]. Especially for dense type of dense graded asphalt concrete. Structure of coarse aggregate is in suspension status. The effect of mutual wedging is quite limited. High temperature stiffness of asphalt binder has a more important role. Therefore, the high temperature rheological properties of asphalt mortar which consisting of mineral filler and asphalt become the important factor determining the high temperature performance of asphalt concrete.

Foreign practice experience have show that the application of rubber asphalt mixture which made of waste tire power in pavement engineering can effectively improve the road usage conditions of pavement; improve the flatness of the road; extend pavement life; reduce the noise of pavement; increase the aesthetics of the road. But, it has gradually emerged that high temperature performance improvement is not obvious or water damage and other problems during the application of rubber asphalt.Some pavement even arise serious rutting[2-3]. According to the theory of asphalt mortar, asphalt mastic was the main constituent elements of the asphalt mixture to determine the various pavement performance[4]. Mineral filler is one of the most important factor affecting rubber asphalt mastic and rubber asphalt concrete.

The characterisation of crumb rubber modified asphalt with mineral filler has focused on determining the Superpave parameters that are based on linear viscoelastic response. However, in the past few years, the Multiple Stress Creep Recovery (MSCR) test was introduced to assess the nonlinear viscoelastic response of asphalt binders. The test was performed for better evaluation of rutting resistance[5-9].

This article will research the impact of mineral filler on nonlinear viscoelastic responses of crumb rubber modified asphalt mortars.

II. MATERIALS

2.1 Asphalt

Korean Ssangyong 70# road petroleum asphalt was used. According to Chinese standard test methods of bitumen and bituminous mixtures for highway engineering(JTG E20-2011) and SHRP specifications and test methods to perform some relevant performance test. Test results are shown in Table 1.

Table 1 Performance test results of 70# road asphalt

Test items		Requirements of Chinese specification	Test results
Penetration(25℃、100g、5s)/0.1mm		60～80	67.8
ductility(15℃、5cm/min)/cm		≥ 40	69
soft point/℃		≥ 46	49.0
flash point/℃		≥ 230	262
wax content/%		≤ 3	1.83
Density(15℃)/g/cm^3		measured records	1.031
Solubility/%		≥ 99.5	99.8
RTFOT 163℃;75min	mass loss/%	≤ 0.8	0.3
	penetration ratio/%	≥ 58	79
	ductili	≥ 15	45

	ty15 ℃/cm		
Performance Grading		64-22	

2.2 Crumb Rubber Powder

Crumb rubber powder whose mesh 20, is used in the production of truck tires powder in Changzhou,Jiangsu province. With discarded tires as raw material, at room temperature after a series of treatment processes such as activation of crushing, separation, removal of metal, screening etc. and desulfurization to make black powder-like substance[10].

2.3 Mineral Filler

Mineral filler used is limestone filler which is used in practical engineering. According to aggregate testing procedures of highway engineering(JTG E42-2005) to perform relevant tests.The basically technical performance measurement results are as shown in Table 2.

Table 2 Determination results of basic technical performance of limestone filler

filler kinds	apparent density	Hydrophilic coefficient	＜ 0.075mm percentage
limestone filler	2.71	0.89 （＜1）	90.4

The outward appearance of limestone filler used there is no big power or caking. The mineral filler used to make the mastic is passing from 0.075mm screen.

2.4 Preparation of Rubber Asphalt Mortar

Select Mixed with 18% of rubber powder as a modifier and add the 20 mesh rubber powder to 70# road asphalt slowly in 3 times to prepare rubber asphalt,in which the blend temperature is 175±5□, the stirring rate is controlled at 1000r/min and the stirring time is about 45min[11].Add mineral powder to the prepared rubber asphalt artificial and stir constantly to rubber asphalt mortar mixed evenly. Due to the different content of mineral powder have different effects on high temperature properties of rubber asphalt mortar.The rubber asphalt mortar whose ratios of filler to bitumen (the weight of mineral powder/ the weight of rubber asphalt)are 0.2,0.4,0.6,0.8 is selected in this paper.

III. HIGH STRESS RESPONSES

New binder samples were also tested following the MSCR test protocol (AASHTO–TP 70-2009). The DSR was set to perform ten cycles of loading and unloading at two different stress levels, 100Pa and 3200Pa. In this test, the stress was applied on the sample for 1 second and then released for 9 seconds for relaxation.

The MSCR test results were used to calculate the average irrecoverable creep compliance (Jnr) as follows:

$$J_{nr}^{n}\left(kPa^{-1}\right)=\frac{\varepsilon_r^n-\varepsilon_0^n}{Stress\ Level} \qquad (1)$$

where ε_R^n is the initial stain at the beginning of loading at ‘n’ cycle while ε_r^n

is the strain value at the end of the unloading at ‘n’ cycle. Values of ‘n’ are from 1 to 10 for each stress level. Dividing the amount of irrecoverable strains over the stress level was meant to normalize the irrecoverable creep compliance value.

The normalization was presented by D’Angelo et al.[7] to eliminate the effect of different stress levels in one test for better comparison between binders. Similarly, percentage of recovery (R) is the average of measured recovery for ‘n’number of cycles by using equation (2):

$$R_n(\%)=\frac{\varepsilon_c^n-\varepsilon_r^n}{\varepsilon_c^n-\varepsilon_0^n} \qquad (2)$$

Where, ε_r^n is the value of strain at the end of loading at ‘n’ cycle. Values of irrecoverable creep compliance (Jnr) and percentage of recovery was calculated for each cycle separately and then averaged at each stress level.

IV. RESULTS AND DISCUSSION

The irrecoverable creep compliance and percentage of recovery were calculated using the MSCR test results. Results in Figure 1 and Figure 2 were averaged for all cycles at each stress level.Data indicated that with the increase of filler-bitumen ratio, decrease the irrecoverable creep compliance, so improve the the rutting resistance ability. For 0% filler-bitumen ratio, when increase the stress, decrease the Jnr.But, as the increase of filler-bitumen ratio, Jnr increase with the addition of filler-bitumen ratio and when filler-bitumen ratio is 0.6, the increase of stress made the Jnr increase rate reach the peak. Irrecoverable creep compliance(Jnr) has the same change trend under 0.1kPa and 3.2kPa. What’s more, with the increase of filler-bitumen ratio, percentage of recovery increase, indicating that the stress range of line viscoelastic behavior of asphalt expanded.

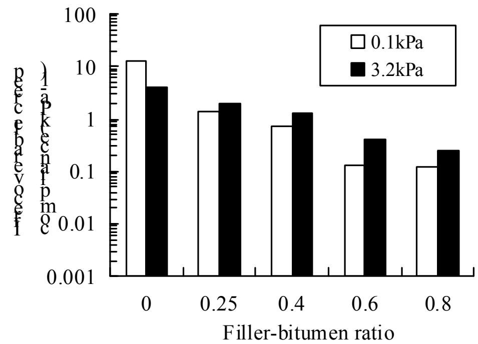


Figure 1. Irrecoverable creep compliance (Jnr) of both stress levels with different filler-bitumen ratio

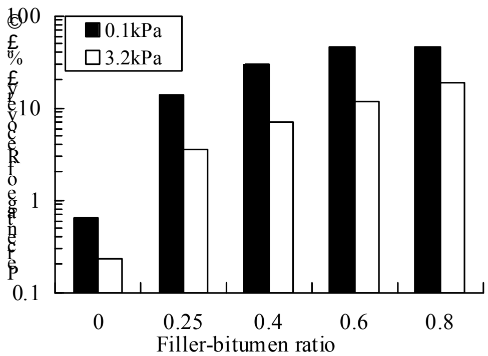
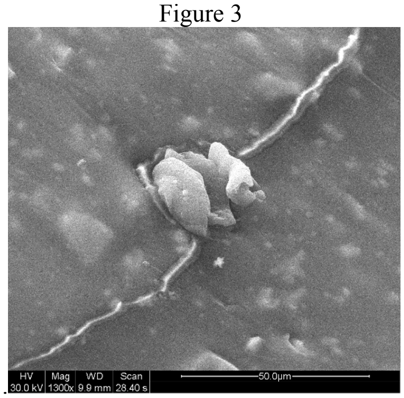


Figure 2. Percentage of recovery of both stress levels with different filler-bitumen ratio

The following content will perform environmental scanning test(ESEM) to different rubber-asphalt mastic.From the microscopic point of view to explain the reasons for above conclusions obtained. Test scanning photographs shown in

Figure 3



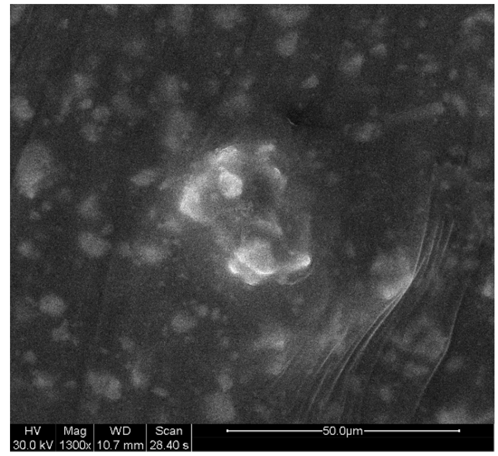


Figure 3 the ESEM of rubber asphalt mortar under different Filler-bitumen ratio (left 0.4, right, 0.4)

It can be seen from the Figure 3, the rubber asphalt added mineral powder have smooth delicate mortar, rubber asphalt coat mineral powder evenly it is because of volume-filling reinforcement and physical reaction between mineral powder and asphalt. And with the increase of filler-bitumen ratio, the number of "structure of asphalt"generated from asphalt and mineral powder increasing, the formed phase structure is more stable. adhesion effect is more stronger, so the rubber asphalt mortar can get a better high temperature performance.

V. CONCLUSION

(1) With the increase of filler-bitumen ratio, the irrecoverable creep compliance (Jnr) decrease gradually and the increase amplitude is larger indicating that the high temperature performance of crumb rubber modified asphalt mortars improved obviously.

(2) With the increase of filler-bitumen ratio, percentage of recovery(R) is increasing gradually and indicating the elastic recovery ability is better.

(3) rubber asphalt added mineral powder have smooth delicate mortar, rubber asphalt coat mineral powder evenly it is because of volume-filling reinforcement and physical reaction between mineral powder and asphalt.

(4) With the increase of filler-bitumen ratio, the number of "structure of asphalt"generated from asphalt and mineral powder increasing, the formed phase structure is more stable. adhesion effect is more stronger, so the rubber asphalt mortar can get a better high temperature performance.

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