Effect of Inorganic Super Fine Powder on the Property of SBS-Modified Asphalt

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Abstract: SBS-modified asphalt (SMA) processes fine performance at high or low temperature, but it shows poor stability at high temperature, which leads to segregation. Addition of inorganic super fine powder can expect to further enhance the elasticity at high temperature. These improved parameters can lead to an improvement on anti-oxidation and anti-rutting. In this work, different inorganic super fine powders such as nano-montmorillonite, nano-$CaCO_3$, and microscale flyash were utilized to improve the performance of SBS modified asphalt, and their reinforced machnisms were investigated.

Keywords: SBS-modified asphalt; norganic super fine powder; nano-montmorillonite; nano-$CaCO_3$; microscale flash

1. Introduction

Asphalt has been utilized in various areas such as pavement construction and waterproofing membrane. Asphalt is usually modified by variable quantities of thermoplastic polymeric materials that significantly change the overall viscoelastic properties. Styrene-butadiene-styrene (SBS), as one of good asphalt modifiers, is suitable for blending with a fairy large number of asphalt types without serious problems of solubility and phase segregation. However, like all unsaturated rubbers, SBS is prone to aging, and this limits the possibility of recycling the end of life road pavement [1].

The addition of inorganic super fine powders to polymers can form hybrid organic-inorganic networks, provided the particle loading exceeds the critical volume fraction. The resulting composite materials can exhibit enhancements in thermal, mechanical, and functional properties [2,3]. To increase the pavement performance and anti-aging property of SBS modified asphalt, Three kinds of inorganic super fine powders including nano-montmorillonite, nano-$CaCO_3$, and microscale flyash were respectively utilized to prepare composite modified asphalts by melt blending, and their physical performance and anti-aging properties were investigated.

2. Experimental

2.1. Preparation of SBS Modified Asphalts

5% (mass ratio) of SBS was added to base asphalt by melt blending under 175-180 ℃, then the mixture was stirred by high-speed shearing for 1 h.

2.2. Preparation of Composite Modified Asphalts

4% (mass ratio) of nano-montmorillonite, nano-$CaCO_3$ (40-60 nm size) and microscale flyash (2-6 um size) were respectively added to SBS modified asphalt by melt blending respectively, then the mixture was stirred by high-speed shearing for 1 h. Three kinds of composite modified asphalts were obtained.

2.3. Measurements

The penetration, softening point, and ductility of the resulting composite modified asphlts were measured following national standards China, respectively. Rolling thin film oven test (RTFOT) was carried out following GB/T 5304-2001. The samples rolled at the speed of 15±0.2 r/min under 163±0.5 ℃ for at least 75 min. The mass loss, penetration, softening point, and ductility before or after aging were measured.

3. Results and Discussion

3.1. Influence of Super Fine Powders on the Physical Properties of SBS Modified Asphalt

Influence of different inorganic super fine powders with the same mass ratio (4 %) to SBS modified asphalt was shown in Table 1. With the addition of super fine powders, the penetrations of the composite modified asphalts derease, which indicates the enhanced viscosity appears. Moreover, the effect of three powders on penetration is similar.

However, the effect of these powders on the softening point is so different. Nano-MMT has an excellent performance prior to the other two powders, which is attributed to its special lamellar structure, by which intercalation nano-composite networks formed between MMT, SBS, and asphalt. $CaCO_3$ and flyash, with spherical and hollow structure, play an important role in sur-

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face and interface modification. The effect of different sizes (nanoscale and microscale) on the softing point is limited.

With the addition of powders, significant effect appears on the ductility of the composite modified asphalts. The ductility appears decreasing. Among of them, nano $CaCO_3$ shows special performance, perhaps derives from the surface effect of nano materials.

Table 1. Influence of Different Powder on the Physical Property of SBS Modified Asphalt

Parameter	SBS Modified Asphalt with Different Powder			
	SBS modified asphalt	*4% MMT addition*	*4% $CaCO_3$ addition*	*4% Flyash addition*
Penetration(25 ℃)/0.1mm	31	29	29	28
Softening point/℃	63.5	88.6	74.4	73
Ductility (5 ℃)/cm	22.2	13.4	17.3	9.9

3.2. Influence of Super Fine Powders on the Aging Properties of SBS Modified Asphalt

Property comparison of base asphalt, SBS modified asphalt and $CaCO_3$/SBS modified asphalt before and after aging was shown in Table 2. The base asphalt after aging appears as aromatic components decreasing, resins and asphaltenes increasing, and saturated components keeping relatively stable. As a result, the base asphalt after aging becomes harden and its ductility deceases [4]. However, the parameter changes and their tendency of $CaCO_3$/SBS modified asphalts are different from that of the base asphalt.

Generally, the penetrtion of asphalt decreases after aging. The residue penetration reflects the change before and after aging. The more residue penetration, the better anti-aging performance. The penetrations of the composite modified asphalts decrease.

After aging, asphalt becomes viscous and harden, and its softening point increases. As shown in Table 2, after aging, the softening point of SBS modified asphalt deceases slightly. However, the softening point of the composite modified asphalts decreases significantly after aging, which demonstrates that the effect of aging on the rheological properties of SBS modified asphalt is different from that of the composite modified asphalt.

The ductility of asphalt decreases after aging. To some extent, the change of residue ductility reflects aging degree, further reflects anti-aging ability and the performance under low temperature. The ductility decreases significantly even after a short-term aging process, as shown in Table 2. These results demonstrates that the anti-aging properties of SBS modified asphalt get worse, as a result of combination of asphalt and SBS aging. In contrast, The residue ductility ratio of the nano-MMT/SBS modified asphalts is the highest value to 48.5%, which derive from the intercalation structure which can effectively slow down the aging.

Table 2. Effect of Different Powder on Composite Modified Asphalts Before and After Aging

Parameter	Before/After Aging			
	SBS modified asphalt	*4% MMT addition*	*4% $CaCO_3$ addition*	*4% Flyash addition*
Penetration(25 ℃)/0.1mm	31/30	29/27	29/26	28/24
Softening point/℃	63.5/63.1	88.6/64.7	74.4/64	73/63
Ductility (5 ℃)/cm	22.2/3.5	13.4/6.5	17.3/3.5	9.9/1.5
Residue ductility ratio (%)	15.8	48.5	20	15.2

3.3. Anti-aging Mechanism of the Composite Modified Asphalt

The oxygen in the air can penetrate into asphalt, and result in asphalt oxidative dimerization, larger molucular sizes, and an increasing viscosity. Nano-MMT/SBS composite modified asphalt pocesses good anti-aging properties due to the nanoscale dispersion of MMT lamellae in asphalt [5,6], and nano $CaCO_3$ due to its good surface effect of nano particles, which can effectively inhibit the penetration of oxygen, lighten asphalt and SBS oxidative dimerization, and reduce composite asphalts aging degree.

4. Conclusions

Three kinds of composite modified asphalts were prepared by melt blending with inorganic super fine powders with SBS modified asphalt. The influence of powders on the properties of SBS modified asphalt appears as a decreasing penetration, an increasing softening point, and a decreasing ductility. The difference of the softening point of composite modified asphalt and SBS modified asphalt is perhaps attributed to the different rheological properties between them. The improvement of anti-aging properties of composite modified asphalt is mainly due to the formation of nano-composite structures and the good surface effect between powder, SBS, and asphalt, which can effectively inhibit the penetration of oxygen and ease asphalt and SBS oxidative aging.

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