Experimental Study on Properties of Modified Asphalt Mortar with Different Flame Retardants

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Abstract: Different inorganic flame retardants or organc flame retardants are added to the matrix asphalt, and the flame retardant modified asphalt is formed through a certain technical process. The experimental study on the rheological properties of the flame-retardant modified asphalt mortar shows that the addition of the flame retardant makes the softening point of the asphalt mortar increase, the penetration degree decreases, the ductility decreases, the viscosity of the asphalt mortar also increased correspondingly, and the viscosity of the flame-retardant asphalt mortar containing decabromodiphenyl ether was proportional to the added amount within a certain range. The short-term aging has a certain degree of influence on the penetration and softening point of the flame-retardant asphalt mortars of each component, but from the analysis of the results of the residual penetration, it can be concluded that the components of the flame-retardant asphalt mortar can meet the requirements of anti-aging performance.

1 INTRODUCTION

In recent years, with the appearance of excellent properties of asphalt pavement, the flame-retardant modified asphalt has received more attention. From the research progress of China's flame-retardant asphalt, the research methods of flame-retardant bitumen are mostly based on the flame-retardant basic research of polymer materials, and the mechanism research and application research are similar, but they are different in examining the combustion characteristics of asphalt.

2 TEST SCHEME

In this paper, different flame retardant materials were selected and mixed into asphalt to prepare flame-retardant modified asphalt, and its related properties were tested, analyzed and evaluated.

2.1 The Technical Nature of Raw Materials

Select Caltex AH-70 asphalt, the main technical performance as shown in Table 1.

The materials used as flame retardant are shown in Table 2.

Table 1 The main performance of asphalt mortar.

AH-70 asphalt	25℃Penetration (0.1mm)	15℃Ductility (cm)	Softening Point (℃)	135℃Viscosity (Pa•s)
	69	200	44.8	0.45

2.2 Experiment Method

The asphalt is heated to 170±5°C to make it flow dynamic. After that, a certain amount of flame retardant of each component is added into the asphalt mortar, and then sheared with a high-speed shearing instrument for 30-45 minutes so that the flame retardant particles can be fully dispersed in asphalt mortar, which is prepared by flame retardant modified asphalt mortar. After that, according to JTG E20-2011, related asphalt mortar performance indicators were tested, including softening point, penetration, ductility and viscosity. The TFOT test of each component flame retardant asphalt mortar was carried out to simulate the aging process of asphalt in the construction process of the hot mix asphalt, and the residual penetration ratio, mass loss, softening point increment and aging index of each component were tested after aging.

Table 2 Related properties of the required test materials.

Flame retardants	density（/cm³）	Maximum particle size（μm）	PH value	Loss of ignition（%）	melting point（℃）
Aluminum hydroxide（ATH）	2.42	10	<8.5	—	—
Zinc borate（ZB）	2.67	5	—	15.5	—
Antimony trioxide	—	1.6	—	—	656
decabromo diphenyl ether（DBDPE）	3.25	5	—	—	300～310

3 ANALYSIS OF TEST RESULTS

3.1 Effect of Addition of Flame Retardants in Each Component on Softening Point of Asphalt Mortar

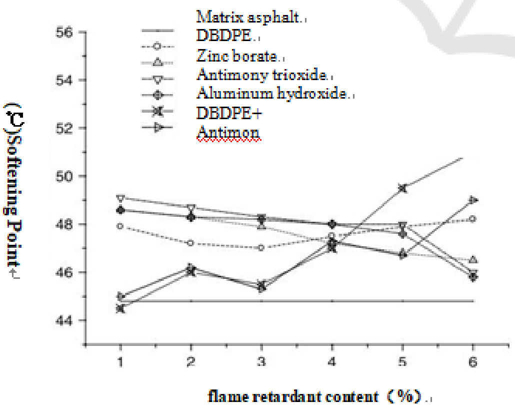

Figure 1 Effect of flame retardant content on softening point.

As shown in Figure 1, with the increase of the amount of flame retardant, the softening point of asphalt mortar has changed greatly, which indicates that the high temperature performance of asphalt has been improved by adding flame retardants. When the content of DBDPE + antimony trioxide reaches 6, the modified asphalt mortar shows a high softening point compared with the matrix asphalt and other flame retardant asphalt mortar. For other flame retardants, ZB, antimony trioxide, and alumina all have the same effect on the softening point of the asphalt mortar, which increases with the increase in the content of flame retardant. However, However, the softening point of DBDPE modified bituminous mortar tends to relax, and the increase its contents but softening point does not increase significantly. The test results show that the effect of DBDPE on the softening point of bituminous mortar is different from that of antimony trioxide and ZB.

3.2 Effect of Addition of Flame Retardants in Each Component on Softening Point of Asphalt Mortar

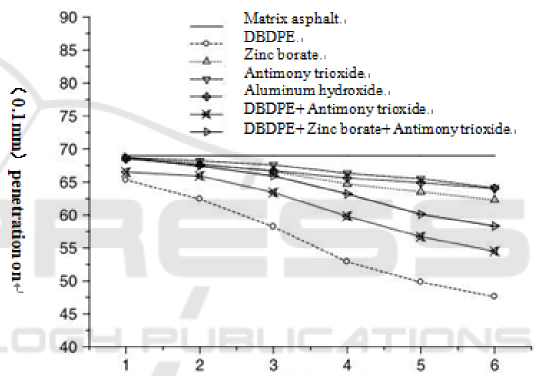

Figure 2 Effect of flame retardant content on penetration.

As shown in figure 2 , with the increase of the content of the flame retardant, the penetration of the flame-retardant asphalt mortar shows a significant decrease. As the flame retardant powder absorbs the oil in the bitumen, the bitumen cement hardens and the penetration is greatly reduced. The comparative test results show that the effect of DBPE on penetration is much greater than that of other single flame retardants. When the DBDPE content is between 1 and 6%, the penetration value is reduced from 65.1mm to 47.6mm.For other single-modified asphalt binders, the reduction tendency of penetration is relatively flat, and the variation of penetration is less than 10 mm within the same flame retardant content range. For the single-component antimony trioxide, the penetration degree of the composite modified flame-retardant bitumen is significantly reduced compared with that of the modified antimony trioxide only by adding DBDPE. However, the composite flame-retardant modified asphalt containing DBDPE has a certain relationship with the number of components and the degree of penetration, which again shows that DBDPE has a great influence on the penetration.

3.3 Effect of Addition of Flame Retardants in Each Component on Ductility of Asphalt Mortar

From figure 3, it can be seen that the low temperature ductility of the modified flame-retardant asphalt gradually decreases with the increase of the content of the flame retardant. The reduction effect exhibited by aluminum hydroxide is more pronounced than other groups of flame retardants. One-component inorganic flame retardants have a great influence on the ductility, but the effect on the ductility tends to be stable with the increase of the content of the flame retardant. When the content of the flame retardant is less than 3%, the ductility is reduced significantly due to the addition of the inorganic flame retardant, and when the content exceeds 3%, the effect of lowering the ductility tends to be slow.

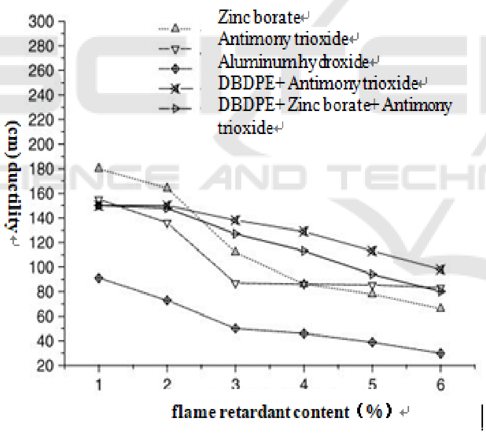

Figure 3 Effect of flame retardant content on ductility.

3.4 Effect of Addition of Flame Retardants in Each Component on Viscosity of Asphalt Mortar

Figure 4 shows that the increase in aspalt viscosity is not directly proportional to the flame retardant content. Of all the flame retardants, DBDPE has the least influence on the asphalt viscosity, while the antimony trioxide has the greatest effect on the asphalt viscosity. When the flame retardant content exceeds 2%, the viscosity of the asphalt martor mutates, due to the fact that some molecules in the flame retardant absorb light oil in the asphalt. The viscosity of DBDPE modified asphalt is basically in direct proportion to its content, which indicates that some molecular interactions.

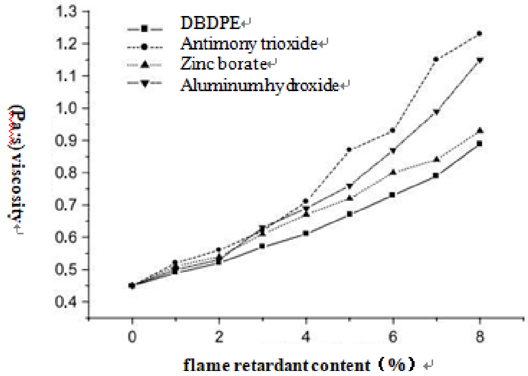

Figure 4 Effect of flame retardant content on viscosity at 135°C.

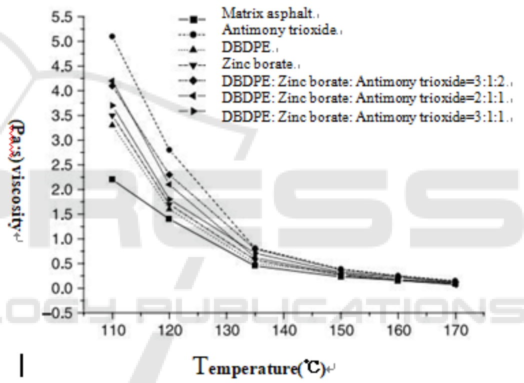

Figure 5 Effect of temperature on the viscosity of the flame retardant asphalt mortar at 135 ° C .

As shown in figure 5, the viscosity of the flame retardant modified pitch is higher than that of the base pitch. Before 135 °C, the impact of various flame retardants on asphalt viscosity varies greatly. At 110°C, the flame-retardant asphalt containing 6% antimony trioxide has a viscosity that is twice that of the base asphalt, which is about twice that at 120°C. The viscosity of the flame-retardant modified bitumen of antimony trioxide and DBDPE is 0.81Pa • s and 0.5Pa•s, which indicates that the viscosity at 135°C can meet the construction requirements.

3.5 Effect of TFOT on Flame Retardant Asphalt Mortar

From Table 3, it can be seen that the mass loss of the flame-retardant modified bituminous mortar TFOT varies from 0.02% to 0.2% compared to the unaged bituminous binder. The flame-retardant bitumen containing 5% DBDPE has the lowest mass loss, but the flame-retardant bitumen containing 2.5% antimony trioxide has the largest mass loss among all the flame-retardant modified asphalt. The residual penetration ratio of all flame-retardant modified asphalt mortars is more than 80%, which means that when the flame retardant is added in the asphalt mortar, the anti-aging properties of the asphalt mortar can be improved. From the point of view of the change of the softening point, it is shown that the short-term aging has different effects on the results of the softening point of the asphalt mortar.

Table 3 Effect of short-term aging on flame retardant modified asphalt mortar.

Flame retardant content	Loss of quality（%）	PRP（%）	ΔT（℃）	AI
5%DBDPE	0.022	83.1	4.8	0.0075
2.5% Zinc borate	0.107	86.1	4.7	0.0179
2.5%Antimony trioxide	0.188	85.9	4.7	0.0086
5%Aluminum hydroxide	0.116	81.7	4.5	0.0057
6%DBDPE: Zinc borate: Antimony trioxide=3:1:1	0.034	83.9	4.9	0.0118

4 CONCLUSIONS

(1) The addition of flame retardants in each component increases the softening point to varying degrees, and the effect of decabromodiphenyl ether tends to ease with increasing flame retardant content；Both penetration and matrix asphalt are reduced, and the influence degree of each component is different. The effect of single component of decabromodiphenyl ether is the most significant, the effect of the mixed flame retardant containing decabromodiphenyl ether on the penetration is relatively significant compared with other flame retardants. The degree of ductility of asphalt mortar has also been reduced to varying degrees. The addition of inorganic flame retardants makes this change relatively significant. When the amount added exceeds 3%, the effect of this reduction tends to be moderated.

(2) The addition of flame retardant will also increase the viscosity of the asphalt mortar. The decabromodiphenyl ether flame etardant asphalt mortar viscosity is basically proportional to the amount of flame retardant added. The effect of temperature on the viscosity of each flame-retardant asphalt mortar shows that the 135°C viscosity of the flame-retardant asphalt mortar can meet the construction requirements.

(3) The effect of short-term aging on the asphalt mortar of each component is different. Decabromodiphenyl ether has the lowes mass loss after aging and the largest mass loss of antimony trioxide. From the analysis of the results of the residual penetration, the flame-retardant asphalt mortars of various components have good anti-aging properties.

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