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The Pavement Performance Research on the Powder Colored Asphalt Mixture

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Abstract. The high-strength powder colored asphalt was studied by sieve analysis, density and cone penetration test in order to study technical performance. Secondly, the mixing process of colored asphalt mixture was put forward through the Marshall Compaction test. The best whetstone of the colored asphalt mixture was determined by Marshall Test design method. Finally, the variation of pavement performance for colored asphalt was analyzed by the rutting test, immersion Marshall Test split and freeze-thaw test and low-temperature bending test. The results showed: the high temperature performance of colored asphalt mixture was outstanding, but the low temperature performance was lower. Therefore the high-strength powder colored asphalt mixture is suitable to be used in high temperature areas.

1 Introduction

The colored asphalt concrete pavement is studied in Europe and other developed countries from the 1950s, and the application is gradually expanded [1], [2]. The colored asphalt paving technology begins with the early 1980s, and the efficiency is rarely, especially the road engineering applications. At present, the colored asphalt concrete pavement is used widely in China, involving more than 20 provinces, and the kind of the colored pavement is also very much, but relatively few high viscosity colored asphalt.

Most southern coastal areas have relatively developed economy, big volume of transportation, more traffic accidents, coupled with sustained high temperatures all year round; above all, the desired material requirements is relatively high, tending to high hardness, high viscosity, which is conducive to resolving early disease pavement occurred. The high-viscosity, high-strength colored asphalt is rarely used in road construction, belonging to the new material; there are no uniform technical indicators. The technical performance of high viscosity color binders will be analyzed by the laboratory tests in this paper based on the colored asphalt from Shenzhen Co., Ltd.

This kind of colored asphalt performance would be studied from high temperature stability, water stability and low temperature crack resistance, comparing with SBS I-C modified asphalt mixture performance.

2 Raw material

2.1 SBS I-C

The modified asphalt—SBS I-C is a superior technical performance of heavy traffic asphalt; the common technical indicators were seen in Table 1.

2.2 The colored asphalt

(1) Sieving. The colored asphalt is a high-strength powder colored asphalt, both having plastic powder particles; it was sieved; the sieving results were shown in Table 2.

Table 2 showed: the particle size distribution range of colored asphalt is more than 2.36mm, most concentrating between 2.36mm ~ 4.75mm and under 0.075mm; the part above 0.075mm accounted for about 70%, and the other under 0.075mm is about 30%. The portions of above 0.075mm were heated, and could be bonded together; this part was the colored asphalt binder. The other did not occur under heating conditions; it would be as filler in the mix, acting as part of slag.

(2) Density. The colored asphalt contains lighter quality plastic particles and powdered substances; the density of the plastic particles is less, floating on the water; the density of the powdered substance is relatively large, sinking to the bottom; therefore, the density of colored asphalt cannot be measured with the ordinary asphalt density method. In addition, it cannot be tested the conventional indicators like ordinary asphalt when the heating temperature of the colored asphalt exceeds 200°C, still in a viscous state. So the colored of asphalt is regarded as cementitious paste for research. It was made possible firstly melted in an oven at 135°C ~ 163°C about to exclude air bubbles, and then re-measured the density of water for measuring the density. The results were shown in Table 3.

Table 1. The common experimental value of SBS I-C.

Number	Test items	Specification Value	Measured value	Test Standard
1	Penetration (25°C, 100g, 5s, 0.1mm)	60～75	63.27	T0604-2011
2	Penetration index PI	≮-0.1	0.87	
3	Ductility (5cm/min, 5°C, cm)	≮35	52.4	T0605-2011
4	Softening Point (°C)	≮80	>90	T0606-2011
5	Kinematic viscosity 135°C (Pa·s)	2~3	2.2	T0625-2011
6	Elastic recovery (25°C, %)	≮80	85.17	T0662-2011
7	Storage stability	≯2.5	0.25	T0661-2011
8	Density(15°C, g/cm3)	The measured records	1.26	T0603-2011
Rolling Thin Film Heating Test (163°C,85min)				T0610-2011
9	Mass loss (%)	≯1.0	0.36	T0609-2011
10	Penetration ratio (25°C, %)	≮65	71.34	T0604-2011
11	Ductility (5°C, cm)	≮25	25.3	T0605-2011

Table 2. The sieving results.

Sieve size	The total amount of the first group (161.55g)				The total amount of the second group(128.89g)				
	Each mesh quality (g)	Single sieve (%)	Accumulated sieve (%)	Passing rate (%)	The mesh quality (%)	Single sieve (%)	Accumulated sieve (%)	Passing rate (%)	Average (%)
4.75	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00	100.00
2.36	48.44	30.21	30.21	69.79	40.51	31.53	31.53	68.47	69.13
1.18	0.08	0.05	30.26	69.74	0.06	0.05	31.58	68.42	69.08
0.6	0.08	0.05	30.31	69.69	0.05	0.04	31.62	68.38	69.04
0.3	3.68	2.29	32.60	67.40	2.92	2.27	33.89	66.11	66.75
0.15	22.81	14.23	46.83	53.17	18.22	14.18	48.07	51.93	52.55
0.075	22.54	14.06	60.89	39.11	16.67	12.98	61.05	38.95	39.03
Sieve bottom	62.72	39.11	100.00	0.00	50.04	38.95	100.00	0.00	0
Sum	160.35	-	-	-	128.47	-	-	-	-
Differ.	1.20	-	-	-	0.42	-	-	-	-

Table 3. The determination value of the colored asphalt density.

m_1 (g)	m_2 (g)	m_3 (g)	m_4 (g)	m_5 (g)	Density g/cm^3
47.08	41.27	102.66	147.82	61.06	1.2676
47.71	41.77	105.33	151.98	59.72	1.2202

The equation is:

$$\rho = m_3/[(m_4-m_5)-(m_2-m_1)] \qquad (1.1)$$

where: m_1- Cylinder mass; m_2- Cylinder mass in water; m_3- Asphalt mass; m_4-Asphalt mass+ Cylinder mass; m_5-Asphalt mass+ Cylinder mass in water after heating

The density is 1.244g/cm^3 by calculation.

(3) Cone Penetration

a. The test results of cone penetration. The penetration test was made at 25°C, 30°C, 40°C, 50°C, 60°C, 70°C and 5s. Penetration weight in six temperature conditions was uniform. The cone penetration value was made a linear correlation fitting analysis with the temperature, and the cone penetration value took logarithmic; if $y=\lg P$, $x=T$, $y=ax+b$ was made a linear regression, namely the regression equation. Only 25°C, 50°C, 70°C three temperatures were made a linear regression corresponding cone penetration value; the regression results were shown in Table 4. And the penetration test results were shown in Table 5.

Table 4. The regression result.

Number	The regression equation	R^2
1	$y=0.489x-4.677$	*0.996*
2	$y=0.509x-5.051$	*0.997*
3	$y=0.528x-5.527$	*0.995*

Table 5. The test results of cone penetration.

Test temperature	Cone Penetration 25°C			Cone Penetration 40°C			Cone Penetration 50°C			Cone Penetration 60°C			Cone Penetration 70°C		
Number	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Measured value	7.9	8.1	8.0	12.3	12.4	12.6	19	20	20	24	23	24	30	32	32
Average value	8			12.4			19.7			23.7			31		

As can be seen from Table 4 and Table 5: the cone penetration value of colored asphalt is relatively small, indicating that the large hardness. The value of penetration increases with temperature increasing, and the cone penetration value trends to be evident. The correlation coefficient R^2 for the fitting regression equations were above 0.99, indicating that the cone penetration value and temperature changes conform to the form $lgP=AT+K$.

b. Shear Strength τ. Shear strength τ can be measured in terms of cone penetration value according to formula (1.2):

$$\tau = [981Q\cos2(\alpha/2)]/[\pi h2\tan(\alpha/2)] \qquad (1.2)$$

where: τ—Shear strength, KPa; Q—Penetration Weight [3], [4], g; h—cone penetration，0.1mm; α—Cone angle needle number.

The τ was calculated under different temperature conditions according to the Equation (1.1). The results were shown in Fig. 1.

2.3 Physical indicators test of coarse aggregate

The coarse aggregate selected good texture, color uniformity, good acid and alkali diabase. The indicators met the requirements of the literature [5], specified in Table 6.

2.4 Physical indicators test of fine aggregate

The fine aggregate selected the limestone, the basic performances were shown in Table 7.

2.5 Mineral powder

The mineral powder selected limestone filler or other alkaline rocks finely powder; it should look white, and its indicators were shown in Table 8.

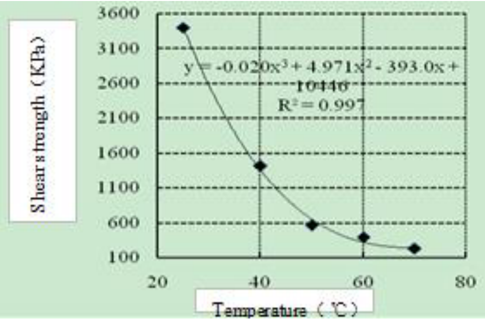

Figure 1. The regression analysis between τ and temperature

Table 6. Technical indicators of the coarse aggregate.

Test item		Unit	Test results	Test standard	Test method
Crushed stone value		%	10.907	≯26	T0316－2005
Los Angeles abrasion loss		%	10.783	≯28	T0317－2005
Gross volume relative density (g/cm³)	13.2～16mm	-	2.833	-	T0304－2005
	9.5～13.2mm	-	2.812		
	4.75～9.5 mm	-	2.784		
Apparent relative density (g/cm³)	13.2～16mm	-	2.898	≮2.60	T0304－2005
	9.5～13.2mm	-	2.890		
	4.75～9.5 mm	-	2.901		
Water absorption	13.2～16mm	%	0.791	≯2.0	T0304－2005
	9.5～13.2mm		0.956		
	4.75～9.5 mm		1.453		
The needle flake content	9.5～13.2mm	%	4.499	≯15	T0312－2005
	4.75～9.5 mm		8.783		

Table 7. Technical specifications of the limestone.

Test item		Unit	Test results	Test method
Density (g/cm³)	2.36～4.75mm	-	2.825	T0304－2005
	1.18～2.36mm	-	2.692	
	0.6～1.18 mm	-	2.746	
	0.3～0.6mm	-	2.740	
	0.15～0.3mm	-	2.771	
	0.075～0.15mm	-	2.703	

Table 8. The indicators of mineral powder.

Test item		Unit	Test results	Test standard	Test method
Apparent relative density(g/cm^3)		-	2.628	≮2.50	T0352-2005
Particle size range	<0.6	%	100	100	T0351-2005
	<0.15	%	98.65	90～100	
	<0.075	%	97.43	75～100	
Hydrophilic coefficient		-	0.794	<1	T0353-2005

3 The mixing process of the colored asphalt

The heating temperature of colored asphalt aggregate was controlled at 220°C ~ 270°C; the colored asphalt mix was added like mineral powder; the mixing temperature is generally between 240°C ~ 270°C; the mixing time was 120s; the compaction temperature was 210°C ~ 230°C. All kinds of mineral aggregate mixture were uniform mixing. If the color material occurred, they would be discarded, the reason why the color material causes: the heating temperature between mineral aggregate and asphalt was insufficient; the material amount of color combination was inadequate; mixing time is too short; he blade was wear due to prolonged use; the fine aggregate amount was the high side; the mix temperature was too high.

4 Pavement performances

Mix Gradation diagram was seen in Fig. 2 accord to [6].

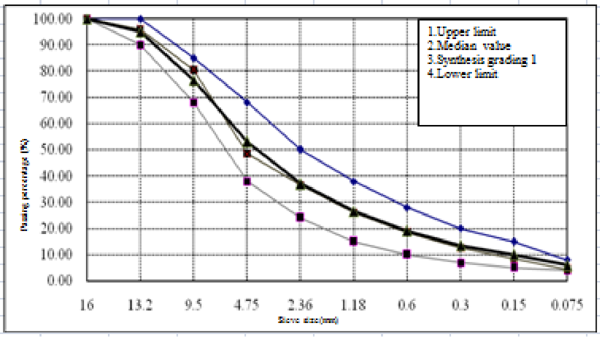

Figure 2. The design grading curve

The Marshall Test of the colored asphalt mixture was made at 8%, 9%, 10%, 11% of asphalt-aggregate ratio to measure the gross volume relative density for *VV, VFA, VMA,* and the *MS, FL* at 60°C after soaking 0.5h. The optimum asphalt-aggregate ratio took 10.4% according to practical experience, and the mixture pavement performance was studied at 10.4% of the asphalt-aggregate ratio.

4.1 High-temperature stability

Table 9 showed: the dynamic stability of the two mixtures was very large. Relative deformation of colored asphalt is 17.8% of the SBS mixture, indicating excellent high temperature performance of colored asphalt.

Table 9. Rutting test results.

Matrix	DS, time/mm	d_{45}, mm	d_{60}, mm	δ (%)
The colored asphalt	14000	0.239	0.284	0.57
SBS I-C	5139	1.481	1.604	3.21

4.2 Water stability

The immersion Marshall Test [7] was made to check the water stability; the method was simple and could better evaluate the water stability of mixture. The test results were shown in Table 10 according to reference [6] about the water stability of ordinary asphalt mixture.

Table 10. Residual stability test results

Matrix	MS(kN)	MS$_1$(kN)	MS$_0$(%)
The colored asphalt	65.02	59.78	91.94
SBS I-C	15.32	13.64	89.03

Table 10 showed: the stability value of the colored asphalt mixture is four times of that of SBS mixture; the MS0 of the colored asphalt was larger than that of SBS, namely: colored asphalt> SBS.

4.3 Low temperature anti-cracking performance

The shear strength and deformation of the mixture will affect the low temperature anti-cracking performance [8]. In general, the mixture has high crack resistance, higher strength and deformability is also better. The -10°C Low temperature bending test results of mixture were shown in Table 11 according to the specification [6] the technical requirements of the low temperature bending testing of ordinary asphalt mixture.

Table 11. Low temperature bending test results.

Binder Category	R_B [MPa]	ε_B	S_B, [MPa]	Bending creep compliance [MPa-1]
The colored asphalt	15.06	3358.5	4791.3	233.515
SBS I-C	7.51	2965.1	2534.8	394.508

Table 11 showed: the RB of the colored asphalt was 2.01 times of SBS, showing that the colored asphalt flexural capacity is strong. The curved tensile strain limits of the two mixtures exceeded the minimum failure strain for cold winter areas, the εB for the colored asphalt is 1.13 times of that of SBS I-C. The SB of the colored asphalt is 1.89 times of that of SBS I-C from the bending stiffness modulus, suggesting that the low temperature resistance of the colored asphalt was poor to deformation.

5 Conclusions

The part above 0.075mm was the binder, and the other 0.075mm below was as part of the filler such as mineral powder for the powder colored asphalt material. It would emit a pungent odor when heated. It is determined by the temperature sensing performance of cone penetration. The powder colored asphalt mixture had good high-temperature stability; the stability value is relatively high in water stability, but the splitting strength is relatively small, indicating that the colored asphalt had poor water stability; the curved tensile strain limits of the mixture exceeded the minimum failure strain for cold winter areas from low temperature crack resistance.

Sources of project funds

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