

Pavement performance research on asphalt mixture of AC-13C with Lucobit

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Abstract. To study the gradation applicability of Lucobit modifier and make it adapt to China's basic national conditions well, the gradation of AC-13C was selected to research pavement performance in this text. The mix design of AC-13C without Lucobit is researched first. And then the performance of AC-13C is verified. In the end, the performance comparisons between AC-13C with 7% Lucobit and without are carried out. Results show that the performance of AC-13C asphalt mixture with 7% Lucobit and without can all meet the requirement. Compared with the performance of AC-13C without Lucobit, the low temperature and water stability performance with Lucobit improve a little and the high temperature performance improves a lot. So Lucobit modifier can greatly improve the high temperature performance of AC-13C asphalt mixture.

Introduction

The application of Lucobit in abroad has a history of 40 years[1][2]. Lucobit project used at abroad follows below. In 1969, Austrian Silvretta mountain road; In 1969, German Hamburg Harbour bridge deck surfacing, yet no overhaul[3-6]; In 1970, German Berlin loop and bam berg, street; In 1970, Thomas Unger street in Munich; In 1971, German Half ALD highway A8; In 2007 ~ 2009, city road of Dusseldorf. In Germany Lucobit was usually used for gradation of SMA asphalt pavement through the survey on application of Lucobit in abroad[7][8]. To research the grading applicability of Lucobit modifier and make it adapt to the basic national conditions well, the gradation of AC-13C was chosen to research mix design and pavement performance in this text.

Materials and methods

Asphalt is 70 # produced by Nanjing Refinery Limited Liability Company; technical indicators are shown in Table 1.

Table 1 Technical indicators of A grade 70 #asphalt

Test items	Technical requirements	Actually measured values	Conclusions
Softening Point($T_{R\&B}$)(°C)	46	48.5	Qualified
Ductility(5cm/min, 15°C)(cm)	100	>100	Qualified
Penetration(25°C, 100g, 5s)(0.1mm)	60~80	64	Qualified
Penetration index PI	-1.5~+1.0	-0.99	Qualified
Dynamic viscosity(60°C)(Pa·s)	180	362	Qualified
The relative density(25°C/25°C)	/	1.032	/
The solubility (%)	99.5	99.62	Qualified

Test items		Technical requirements	Actually measured values	Conclusions
Flash point(COC)(°C)		260	298	Qualified
Wax content		2.2	2.0	Qualified
RTFOT	Quality changes(%)	±0.8	-0.08	Qualified
	Penetration ratio(%)	61	65.6	Qualified
	Ductility(5cm/min,15°C)(cm)	15	20	Qualified

The technical performance of modifier are shown in Table 2.

Table 2 Technical performance of modifier

Types	The colors of appearance	The size of diameter(mm)	Melting point(°C)	Density(g·cm ⁻³)
Lucobit	granular,black	4	80-100	0.97

The aggregate of above layer is basalt produced by Liyang Company, The aggregate size of 1 # is 10-15mm; 2 # is 5-10 mm; 3 # is 3-5mm; 4 # is 0-3mm. The mineral powder is made up of limestone aggregate. Test results of basalt are shown in Table 3 and Table 4.

Table 3 Test results of limestone mineral aggregates

Name of mineral aggregates	Apparent Relative Density	Bulk relative density	Water absorption(%)	Sand equivalent	particle content of Needles and flakes(%)	clay content of aggregates(%)
1#	2.961	2.882	0.93	/	5.8	0.9
2#	2.980	2.893	1.02	/	4.8	1.0
3#	2.977	2.851	1.49	/	/	1.0
4#	2.925	2.765	1.99	74	/	/
Mineral powder	2.695	/	/	/	/	/

Table 4 Screening results of limestone mineral aggregates

The diameter of the sieve Aggregates	The pass rate(%)									
	16	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
1#	100	86.1	29.7	1.3	1.0	1.0	1.0	1.0	1.0	1.0
2#	100	100	100	22.7	3.4	2.0	2.0	2.0	2.0	1.0
3#	100	100	100	99.4	5.4	3.0	1.8	1.4	1.3	1.1
4#	100	100	100	100	85.4	56.9	34.6	16.9	12.2	10.0
Mineral powder	100	100	100	100	100	100	100	97.5	93.1	72.3

The upper and lower limit of mineral aggregate gradation is shown in Table 5.

Table 5 Gradation of AC-13C asphalt mixture

Types of gradation	Passing rate(%)									
	16	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
AC-13C	84.3	73.2	58.3	41.4	25.6	19.2	12.8	7.2	5.9	5.1

Results and discussions

The grading limit of AC-13C Lucobit asphalt mixture is shown in Table8. The design grading curve of AC-13C is shown in Figure 1.

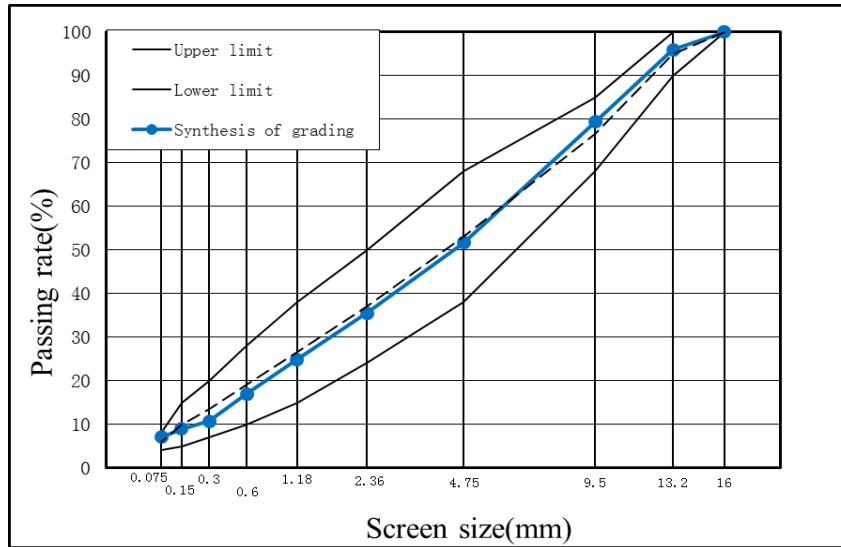


Fig.1. Design grading curve of AC-13C

Tests were carried out over using the materials from the scene. The mix design results of AC-13C asphalt mixture are shown in Table 6 and Table 7.

Table 6 Mineral aggregate proportion and asphalt-aggregate ratio

Mixture type	The proportion of all kinds of following mineral aggregate (%)					Asphalt-aggregate ratio (%)	Effective dosage of asphalt P_{be} (%)
	1#	2#	3#	4#	Mineral powder		
AC-13C	29.5	25.0	6.5	35.0	4.0	5.1	4.1

Table 7 Optimal asphalt-aggregate ratio, density and VV

Mixture type	Asphalt-aggregate ratio (%)	Bulk volume relative density	VV (%)	Theoretical relative density of testing	Effective thickness of asphalt film(μ m)
AC-13C	5.1	2.537	4.5	2.657	6.7

Results show that the asphalt-aggregate ratio of AC-13C asphalt mixture is 5.1% and the VV is 4.5%.The VV can meet the requirement of dense gradation asphalt mixture.

According to the characteristics of Lucobit, the calculation formula of equivalent asphalt-aggregate ratio and equivalent asphalt content are put forward by research group. The computation formulas are as follows.

$$Pa' = [(m_q + m_L) / m_m] \times 100 \quad (1)$$

$$Pb' = [Pa' / (100 + Pa')] \times 100 \quad (2)$$

Pa' —Equivalent asphalt-aggregate ratio,%

m_q —quality of asphalt,g

m_L —quality of Lucobit,g

m_m —quality of asphalt mineral aggregate,g

Pb' —Equivalent asphalt content,%

According to the above two computation formulas,the dosage of Lucobit is 7% and the equivalent asphalt-aggregate ratio is 5.1%.Test results of AC-13C asphalt mixture with Lucobit are shown in Table 8 to Table 11.

Table 8 Test results of Marshall Immersion

Mixture type	Stability(kN)	Immersion Marshall stability(kN)	Residual stability S_0 (%)	Requirement (%)
AC-13C	9.56	7.76	81.2	≥ 80
AC-13C with Lucobit	11.40	9.92	87.0	≥ 85

Table 9 Test results of freeze-thaw splitting

Mixture type	Unconditional splitting strength(MPa)	Condition of splitting strength (MPa)	TSR (%)	Requirement (%)
AC-13C	0.716	0.556	77.7	≥75
AC-13C with Lucobit	0.950	0.794	83.6	≥80

Table 10 Test results of dynamic stability

Mixture type	Equivalent asphalt content (%)	Dynamic stability(times/mm)				Requirement	Coefficient of variation(%)
		1	2	3	Average		
AC-13C	5.1	1886	1914	1774	1858	≥1000	4.0
AC-13C with Lucobit	5.1	7546	7125	7598	7423	≥2800	3.5

Table 11 Test results of -10°C trabecular bending

Mixture type	Largest load /kN	Middle span deflection /mm	Bending tensile strength/MPa	Stiffness modulus/MPa	Failure strain/με	Requirement /με
AC-13C	0.87	0.41	7.10	3299	2152	≥2000
AC-13C with Lucobit	0.98	0.52	8.00	2937	2724	≥2500

Results show that water stability, high temperature and low temperature performance of AC-13C asphalt mixture with Lucobit can all meet the requirements. Equivalent asphalt content is 7%.

Conclusions

(1) The mix design method of AC-13C asphalt mixture with Lucobit is determined. It is that the mix design of asphalt mixture without Lucobit is conducted first and then with it is.

(2) 7% Lucobit modifier can greatly improve the high temperature performance of AC-13C asphalt mixture and a slight increase on other performances.

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