Optimization Design and Performance Evaluation of Cold-mixed AC-25 Emulsified Asphalt Mixturee

Zhaohui Sun*, Huaizhi Wang, Hanyang Cheng and Shuai Liu

The TransportationEngineering School of Shenyang Jianzhu University, Shenyang, China

*Email: happyforevernicety@126.com

Abstract. Due to the uneven gradation of asphalt mixture recovered by milling, in order to make the pavement performance of cold-mixed emulsified asphalt mixture approach or reach the standard of hot asphalt mixture, on the basis of previous experimental research, the hot-mixed AC-25 mixture was optimized and the performance of the cold-mixed emulsified asphalt mixture was optimized with the objective of the road performance achieved by the hot-mixed AC-25 mixture optimization scheme. The results of the study show that the performance of the cold-mixed cold-laid asphalt mixture after optimization can meet the road performance requirements and provide reference for engineering applications.

1. Introduction

Due to the uneven gradation of the recycled asphalt mixture, in order to make the road performance of the cold-mixed emulsified asphalt mixture approach or meet the standard of the hot-mixed asphalt mixture, on the basis of the hot-mixed AC-25 mixture road performance prediction model[4]established in the early stage of the research group, the optimization design of hot-mixed AC-25 mixture was carried out, and the optimal scheme of cold-mixed emulsified asphalt mixture is further performed and evaluated.

2. Raw material testing

Fuxin clay quarry gravel and stone chips are used in cold-mixed cold -laid emulsified asphalt mixture base layer of this test road, emulsified asphalt is produced by Xinmin Highway Asphalt Mixing Plant and 32.5 grade ordinary silicate cement is produced by Shenyang Hongxiang Cement Co., Ltd. The results of raw material testing are shown in Table 1 to Table 5. The properties of the tested raw materials meet the specifications.

Table 1. Mineral screening test results

Mineral specifications name	Percentage of through the following mesh (mm) (%)											
	26.5	19	16	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
Milling material	100	97.3	94.9	89.4	74.7	39.9	24.3	13.2	8.1	3.4	0.5	0.1
gravel	100	72.8	39.2	12.6	2	0	0	0	0	0	0	0
Chips	100	100	100	100	100	98.2	57.5	35	24.2	16.6	13.4	6.5
Cement	100	100	100	100	100	100	100	100	100	100	100	99.8

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Table 2. Test Results of Recovered Asphalt Pavement Materials (RAP)

Material specification name	Moisture content (%)	Asphalt content (%)	Sand equivalent (%)
RAP	0.55	4.3	75.6

Table 3. Asphalt test results

Test item			Unit	Quality Requirements	Test result
Demulsification speed				Slow split or split	Slow split
Particle charge				Cation(+)	Cation
Sieve residue (1.18mm sieve)		No greater than	%	0.1	0.1
Viscosity	Engela viscosityE25			2~30	18
	25°C Saybolt viscosityVa		s	7~100	/
evaporation the remains	Residue content	No less than	%	62	63
	Solubility	No less than	%	97.5	98
	Penetration(25°C)		0.1mm	50~300	69
	Ductility(15°C)	No less than	cm	40	51
Adhesion with coarse aggregate, wrapping area		No less than		2/3	>2/3
Coarse and fine-grained aggregate mixing test				Uniform	Uniform
Normal temperature storage stability	1d	No greater than	%	1	/
	5d	No greater than		5	4.2

Table 4. Coarse aggregate test results

Test items	Technical requirements	Test results
Stone crush value (%) Loss of wear in Los Angeles Apparent relative density	≤30	19.5
Los Angeles wear loss	≤35	17.0
Apparent relative density	≥2.45	2.743
Water absorption (%)	≤3.0	0.69
Needle particle content (%)	≤20	6.2
Washing method < 0.075mm particle content (%)	≤1	0.1
Soft stone content (%)	≤5	2.6

Table 5. Fine aggregate test results

Test items	Technical requirements	Test results
Apparent relative density	≥2.45	2.743
Mud content (content less than 0.075mm) (%)	≤5	13.9
Sand equivalent (%)	≥50	75.6

3. Aggregate gradation optimization design

As the cold-mixed cold-laid asphalt mixture is used in the base layer, according to the aggregate gradation design scope stipulated in the current" Ttechnical specifications for Highway asphalt pavement recycling [2], combined with the screening results of the rrecycled material, it is determined to use the coarse-grained gradation todo the ccombination design of milling material and new aggregate,grade 32.5 cement content is 1.5% of the quality of cold-mixed cold-laid asphalt mixture. Based on the foregoing research results, the optimal design of the target mix ratio was performed. The design results are shown in Table 6. The composition ratio of the mineral materials is shown in Table 7.

Table 6. Target mix ratio design

Screen size (mm)	37.5	26.5	19	16	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
Level limit	100	100	-	-	80	-	60	45	-	-	20	-	7
Grading lower limit	100	80	-	-	60	-	25	15	-	-	3	-	1
Synthetic grading	100	100	91.4	81.5	71.3	59.1	35.8	21.5	12.1	7.7	3.9	1.7	0.7
Target mix ratio	100	99.6	90.8	81.6	72.5	55.1	32.9	21.6	14.1	8.9	5.6	4.2	2.1

Table 7. Mineral Composition (Mass fraction)

Material specification (mm)	Milling material	10~25mm Crushed stone	Chips	Mineral powder	Cement
Composition ratio (%)	65	25	10	/	1.5

From Table 6, it can be seen that except for 0.075mm sieve pore passing percentage exceeding the gradation range specified in the specification, the other sieve pore passing percentage meet the requirements of the standard gradation range. The particle content below 0.075mm mesh can be supplemented by cement with 1.5% of a total mass of the mineral materials.

4. Determination of the optimum moisture content

According to "Technical Specifications for Highway Asphalt Pavement Recycling" (JTG F41-2008), refer to the "Test Methods of Soils for Highway Engineering"JTG E40-2007" T0131 method, the old asphalt pavements materials milled and dried , crushed stone, chips and cement were mixed according to the design ratio, and the amount of emulsified asphalt in the grading is set at 4%. The soil compaction test is carried out by changing five different water consumptions to determine the maximum dry density of the sample, and the maximum dry density and the corresponding optimal water consumption are obtained. As shown in Table 8 and Figure 1, it is used as an indicator of controlling the amount of added water in the later stage.

Table 8. Measured water content and dry density

Water content	0.054	0.055	0.062	0.063	0.064
Dry density (g/cm^3)	2.050	2.065	2.056	2.046	2.042

From the test results, it can be seen that when the amount of emulsified asphalt is 4%, the optimum moisture content is 5.836%, and the maximum dry density of the cold-mixed cold-laid mixture is 2.076g/cm^3.

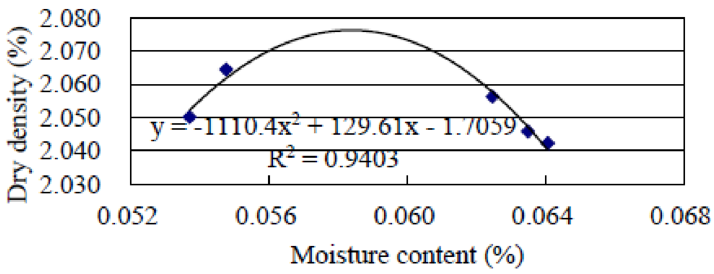

Figure 1. Curve of the relationship between moisture content and dry density

5. Determination of the optimum dosage of emulsified asphalt

With reference to previous engineering experience, wheel rolling specimens with bitumen aggregate ratio3.5%, 3.8% and 4.0% respectively were molded according to the method of "Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering" (JTG E20-2011) T0703. The specimens were cured for 48 hours under the condition of room temperature, rutting test was done at a test temperature of 60°C and a tire contact pressure of 0.7 MPa. The test results are shown in Table 9. The statistical analysis of the dynamic stability test results of different bitumen aggregate ratios is shown in Table 10. 15 °C dry and wet splitting strength test was done according to the current "Technical Specifications for Highway Asphalt Pavement Recycling"[2]. By analysis and comparison, the recommended best ratio of bitumen aggregate ratio is 3.8%.

Table 9. Dynamic stability test results for different bitumen aggregate ratio Unit: times/mm

Asphalt content (%)	Specimen number	45min Deformation (mm)	60min Deformation (mm)	Dynamic stability (times/mm)
3.50	1	3.04	3.46	1427
	2	2.45	2.85	1597
	3	3.24	3.72	1306
3.80	1	2.80	3.50	1904
	2	2.03	2.27	2549
	3	3.03	3.35	1980
4.00	1	4.94	5.16	771
	2	5.82	6.21	1582
	3	5.16	6.16	626

Table 10. Analysis of dynamic stability test results for different bitumen aggregate ratio Unit: times/mm

Bitumen aggregate ratio (%)	3.5	3.8	4.0
Dynamic stability Average value (times/mm)	1443	2144	699
Coefficient of variation	10.1	16.4	14.6

From Table 10, it can be seen that the dynamic stability meets the specification requirements when the bitumen aggregate ratio is 3.5% and 3.8%.

Each group of specimens was subjected to a splitting test at 15°C and a water soaking test for 24 hours. The test results are shown in Table 11.

Table 11. Splitting test results

Emulsified asphalt aggregateratio (%)	15°C Splitting strength (MPa)	Splitting strength for soaking 24h (MPa)	Dry and wet splitting strength ratio (%)	
			Measured value	Technical requirement
3.5	0.45	0.33	75.6	≥75
3.8	1.04	0.79	75.9	≥75
4.0	0.58	0.49	84.5	≥75

From Table 11, it can be seen that the splitting strength at 15°C and the dry and wet splitting strength ratio meet the specifications when the bitumen aggregate ratio is respectively3.5%, 3.8%, and 4.0%.

From Table10 and Table 11, it can be seen that the dynamic stability and splitting strength are higher when the bitumen aggregate ratio is 3.8%. Considering the low temperature and fatigue properties, the amount of emulsified asphalt should not be too low. Therefore, it is recommended that the optimum bitumen aggregate ratio is 3.8%.

6. Road performance evaluation

High-temperature and water-stability tests were carried out under optimum emulsified asphalt content and optimum moisture content, and the dynamic stability was 2150/mm. The dynamic stability ratio was 0.85, and the 15 C splitting strength was 1.2 MPa. The performance of the cold- mixed asphalt mixture after optimization can meet the road performance requirements.

7. Conclusion

The road performance prediction model is applied to optimize the mix proportion of cold-mixed cold laid AC-25 asphalt mixture and the road performance is evaluated, it can provide reference for engineering applications.

8. References

[1] Occupation Standard of the People’s Republic of China., JTG E20-2011 “Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering” [S]
[2] Highway Science Research Institute, Ministry of Communications JTG F40-2004“Technical Specifications for Construction of Highway Asphalt Pavements” [S]
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