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Experimental Study on Splitting Strength of AC-25 Emulsified Asphalt Cold Recycled Mixture

Zhaohui Sun¹, Zhiqi Song¹, Hanyag Cheng¹ and Weidong Sun²

1.The Transportation Engineering School of Shenyang Jianzhu University, Shenyang, China

2.Liaoning Provincial Communications College Quality Supervision Guidance Evaluation Center, Shenyang, China
Happhforevernicety@126.com

Abstract. In the asphalt pavement design, determining reasonable structural parameters plays an important role in reducing early damage to the pavement and increasing use time of the pavement. Based on the optimized design, the dry-wet splitting strength and freeze-thaw splitting strength of AC-25 cold recycled emulsified asphalt mixture were studied. The results indicate that the dry-wet splitting strength of AC-25 cold recycled emulsified asphalt mixture is much higher than the technical requirements of the specification. The ratio of dry-wet splitting strength and the ratio of freezing-thawing cycle strength meet the indicators of the specification. Engineering application can refer to grading results of design.

1. Introduction

Generally speaking, the cold recycled asphalt mixture of emulsified asphalt has low tensile strength, and the asphalt pavement of the structure layer of cold recycled asphalt mixture is more likely to cause crack deformation and damage. Based on the preliminary work, this paper further develops the splitting strength test of AC-25 emulsified asphalt cold recycled mixture, which lays a foundation for the application of AC-25 emulsified asphalt cold recycled mixture in pavement.

2. Raw Material Testing

The asphalt mixture base of this testing road that is cold mixing and cold paving emulsified employs small crushed stone and stone chips in the stone pit with Fuxin clay. Xinmin Highway Asphalt Mixing Station manufactures the emulsified asphalt. Normal Portland cement is produced by Shenyang Hongxiang Cement Co., Ltd. Grade 32.5. The results of raw-material testing are shown in the Table 1 to Table 5. The properties of the raw materials tested accords with the requirements of specifications.

Table 1. Results of mineral screening tests

Mineral specifications name	Percentage of passing the following grid (mm) (%)											
	26.5	19	16	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
Milling planer 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
Splinter	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



Table 2. Test results of recovery asphalt pavement materials (RAP)

Material specifications name	Water content (%)	Asphalt content(%)	Sand equivalent (%)
RAP	0.55	4.3	75.6

Table 3. Various indexes of emulsified asphalt

Test projects		Unit	Quality indicators	Test results
Demulsification speed			Slow split	Slow split
Particle charge			Cation(+)	Cation(+)
Residue on screen (1.18mm screen)		No higher than	%	0.1
Viscosity	Engela viscosity E25			2~30
	25°C Saybolt viscosity Va		s	7~100
evaporati on the remains	Residue content	No less than	%	62
	Solubility	No less than	%	97.5
	Penetration(25°C)		0.1mm	50~300
	Ductility(15°C)	No less than	cm	40
Adhesion with coarse aggregate, wrapping area		No less than		2/3
Mixing test with coarse and fine aggregate			Uniform	Uniform
Ordinary temperature storage stability	1d	No higher than	%	1
	5d	No higher than		5
				4.2

Table 4. The technical index of coarse aggregate

Test projects	Technical indicators	Test results
The crushing value of the stone (%)	≤ 30	19.5
Los Angeles wear value	≤ 35	17.0
Apparent relative density	≥ 2.45	2.743
Hydroscopicity (%)	≤ 3.0	0.69
Needle flake particle content(%)	≤ 20	6.2
Water washing method <0.075mm particle content(%)	≤ 1	0.1
Content of soft rock(%)	≤ 5	2.6

Table 5. The technical index of fine aggregate

Test projects	Technical indicators	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. AC-25 Emulsified Asphalt Cold Recycled Mixture Design Scheme

As AC-25 emulsified asphalt cold recycled mixture is used for pavement base, according to the aggregate gradation design scope stipulated in the current "Highway asphalt pavement recovery technical code"[2], combined with the screening results of cold recycled material, The synthesis

classification is shown in Table 6 , and the mineral materials composition is shown in Table 7. The optimal moisture content is 5.836%, the best ratio of emulsified asphalt to stone content is 3.8%.

Table 6. Target mix ratio design

Mesh 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
Level 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 type(mm)	Milling planer material	10~25mm Crushed stone	Splinter	Mineral powder	Cement
Composition ratio(%)	65	25	10	/	1.5

4. Dry-Wet Splitting Strength Test of AC-25 Emulsified Asphalt Cold Recycled Mixture

The recommended AC-25 cold recycled emulsified asphalt mixture was tested in accordance with the modified Marshall test method. Cylindrical specimens of diameter \times height = 101.6mm \times 63.5mm were prepared by secondary compaction method, and the two sides were compacted 50 times, placed in a 60 ° C ventilated oven for 40 hours, and the two sides were compacted. 25 times after being cured , demoulding after it was at indoor temperature for 12 hours, according to the “Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering” (JTG E20-2011) T0716, the experiment temperature is 15 °C \pm 0.5 °C, and the loading rate is 50 mm/min. . When the diameter of the test piece is 100 mm \pm 2.0 mm and the width of the bead is 12.7 mm, calculating the tensile strength of the split as shown in Equation (1).

$$R_T = 0.006287 P_T / h \quad (1)$$

Where: R_T - splitting tensile strength, MPa;

P_T - the maximum value of the test load, N;

h - test piece height, mm.

Put the tested piece into the water of 15 \pm 0.5 ° C for 24 hours to carry out a wet splitting strength test. The test results of dry-wet splitting strength are shown in Table 8 and Table 9. When the difference between a certain set of measured values and the average value is greater than k times the standard deviation, the measured value shall be discarded, and the average of the remaining measured values shall be used as the test result. When the number n of tests is 4, the k value is 1.46, and the tested data are valid. The effective test value of the measured splitting strength is directly taken as the splitting strength value for pavement design.

Table 8. Test results of dry splitting strength (15 °C) of AC-25 emulsified asphalt cold recycled mixture

Test piece number	Test piece height /mm	Test load maximum /N	Dry splitting strength/MPa	Average /MPa	Standard deviation	Coefficient of variation	Representative value/MPa	Splitting strength specification value (hot mix)/MPa
1	63.5	11.92	1.18	1.04	0.12	11.10	1.04	0.6~1.0
2	62.9	9.03	0.90					
3	63.4	10.69	1.06					
4	62.7	10.2	1.02					

Table 9. Test results of wet splitting strength (15 °C) of AC-25 emulsified asphalt cold recycled mixture

Test piece number	Test piece height /mm	Test load maximum /N	Wet splitting strength /MPa	Average /MPa	Standard deviation	Coefficient of variation	Dry and wet splitting strength ratio/%	Dry and wet splitting strength ratio specification value
1	63.2	8.96	0.89	0.79	0.08	10.50	75.9	75
2	63.7	6.99	0.69					
3	63.1	8.23	0.82					
4	63.5	7.9	0.78					

It can be seen from the test results in Table 8 and Table 9 that the dry crack strength of AC-25 cold recycled emulsified asphalt mixture is 1.04MPa, which conforms to the standard of hot mix asphalt and the dry-wet splitting strength ratio conforms to the requirements of the specification.

5. Freeze-Thaw Splitting Strength Test of AC-25 Emulsified Asphalt Cold Recycled Mixture

The freeze-thaw splitting strength test specimens were also molded into cylindrical specimens by Marshall compaction method, and the recommended AC-25 emulsified asphalt cold recycled mixture was tested according to the modified Marshall test method. The cylindrical test piece with the diameter *high=101.6mm*63.5mm was prepared by the second compaction method, and the two sides were compacted 50 times, placed in a 60 °C ventilated oven for 40 hours and the two sides were compacted 25 times after being cured, the mold was released after being placed at indoor temperature for 12 hours, and tested according to the “Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering” (JTG E20-2011) T0729. During the experiment, the tested pieces were divided into two groups, four test pieces in each group, one set was immersed in 25 °C water for 2 hours, and the other test process was as follows: hold under vacuum conditions of 98.3 kPa to 98.7 kPa for 15 min, then open Valve, return to normal pressure, the test piece is placed in water for 0.5h; take out the test piece into a plastic bag, add about 10ml of water, tie the bag, and put the test piece into the -18 °C refrigerator for 16 hours; Immediately after removal, the device was placed in a constant temperature water bath at 60 °C, the plastic bag was removed, and kept for 24 hours; then, it was immersed in water at 25 °C for 2 hours. Firstly, the pressure value at the time of fracturing is measured, and the tensile strength of the splitting is calculated according to the formula (1). Finally, the tensile strength of freeze-thaw splitting TSR is calculated by the formula (2). The tested consequence are shown in Table 10 and Table 11.

$$TSR = \left(\frac{R_{T2}}{R_{T1}} \right) \times 100 \quad (2)$$

Where: TSR - freeze-thaw splitting tensile strength ratio, %;

R_{T1} - splitting tensile strength of the first set of specimens without freeze-thaw cycles, MPa;

R_{T2} - splitting tensile strength of the second set of specimens after freeze-thaw cycles, MPa;
h- the height of the tested piece, mm.

Table 10. Test results of splitting strength (25 °C) of AC-25 emulsified asphalt cold recycled mixture

Test piece number	Test piece height/mm	Test load maximum /N	Splitting strength /MPa	Average/MPa	Standard deviation	Coefficient of variation	Representative value /MPa	Freeze-thaw splitting strength ratio specification value/%
1	63.2	6.84	0.68	0.67	0.03	4.4	0.67	70
2	63.5	6.36	0.63					
3	62.8	6.69	0.67					
4	63.0	7.01	0.70					

Table 11. Test results of splitting strength (25 °C) after freeze-thaw

Test piece number	Test piece height/mm	Test load maximum /N	Splitting strength /MPa	Average/MPa	Standard deviation	Coefficient of variation	Representative value /MPa	Freeze-thaw splitting strength ratio TSR/%
1	63.0	5.31	0.53	0.518	0.03	5.8	0.52	78
2	63.2	4.83	0.48					
3	63.5	5.15	0.51					
4	62.9	5.5	0.55					

It can be seen from the test results in Table 10 and Table 11 that the freeze-thaw splitting strength ratio of AC-25 emulsion asphalt mixture meets the requirements of the specification.

6. Conclusion

Based on our country's current recycling technical rules for the road asphalt pavement. At the basis of pre-optimized design, the strength of dry-wet splitting and freeze thawing for AC-25 emulsified asphalt cold recycled mixtures were tested. The results show that the designed AC -25 emulsified asphalt cold recycled blending has a dry splitting strength of 1.04 MPa and a wet splitting strength of 0.79 MPa, which is much larger than the specification of 0.40 (base layer, subbase layer) and 0.50 (lower layer). Both the splitting strength and the freeze-thaw cycle strength meet the specification and requirement, and the designed gradation can make a reference for the engineering applications.

7. References

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