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Research on the Preparation of High Permeability Emulsified Asphalt and Its Properties

Lili Cheng[1], Xin Sun[1], Huadong Sun[2], Yongling Ding[2]

[1]Suzhou Hongyi Technology Co., LTD., Suzhou, Jiangsu, 215000, China
[2]School of Traffic and Civil Engineering, Shandong Jiaotong University, Jinan, Shandong 250357, China

Abstract: *This paper selects AH-90 # asphalt as matrix asphalt, uses different emulsifiers to emulsify it, and selects out emulsifiers 1 # and 2 # that meet the quality requirements of translayer emulsified asphalt. By examining the influence of emulsifier dosage, kerosene content and asphalt temperature on the performance of emulsified asphalt, the formulation conditions of emulsifying asphalt are 0.7%~1.3%, kerosene content 0~2%, asphalt temperature 130~140℃; the formulation conditions of emulsified asphalt produced by 2 # emulsifier are 1.4%~1.8%, kerosene content 2%, and asphalt temperature 130℃.*

Keywords: *high permeability; emulsified asphalt; performance; influencing factors*

1. Introduction

China's highway mostly with semi-rigid materials as the base, due to the different polarity of the binding material, the semi-rigid base and asphalt surface layer is not easy to form a stable overall structure. The combination quality of semi-rigid base layer and asphalt surface layer with asphalt concrete layers is one of the important factors affecting the durability of asphalt pavement. If the problem between the layers is not handled properly, the road surface is prone to disease, shorten the service life, affect the traffic safety, and cause adverse effects. In order to ensure the good combination between the semi-rigid base and the asphalt pavement, the method of spraying the oil permeable layer on the semi-rigid base has been adopted, which is an important technical means to solve the problem of loose between layers. Whether the oil permeable layer can go deep into a certain depth of the base layer has a great impact on enhancing the integrity of the base layer and forming a good combination between the base layer and the asphalt structure layer. The transversine is located on the surface of the base layer, and the penetration depth is greater than 5mm, so that the semi-rigid base of inorganic binding material can gradually transition to the asphalt surface layer of organic binding material[1-4].

The permeable layer of asphalt pavement is the treatment layer at the interface between the main structures of asphalt pavement. China's Technical Code for Construction of Highway Asphalt Pavement (JTG F40-2004)[5]There is a clear definition in it. As a kind of interlayer functional layer, the permeable layer located on the surface of the base layer can protect the base layer, strengthen the combination of the base layer and the asphalt surface layer, and play the role of consolidation, stability, waterproof and connection, which is very important to the quality and life of the road surface. After the construction, the transversine oil will have a certain depth of penetration on the semi-rigid base and reduce the modulus of the base material, which will play a good transition coupling role between the structural layers from organic combination to inorganic binding material. In the penetration depth, the organic material (asphalt) fills the surface gap of the semi-rigid base, forming a special structural layer, called the coupling layer. Due to the intervention of organic material (asphalt), the bonding effect of the flexible pavement (asphalt concrete surface layer) is very good, and the coupling layer itself is also a part of the semi-rigid base, so it can effectively solve the bonding problem of the flexible pavement and the semi-rigid pavement of the base[6-10].

Improper selection or construction of transbed asphalt will have great influence on the quality of asphalt pavement. In recent years, our country many engineering of the layer of oil cannot penetrate into a rigid base depth, consolidation, stable base and enhance the effect of interlayers, the layer of asphalt is only attached to the basic surface of a thin layer, easily wheels stick, roll or wear, and even become a weak layer between base, surface, asphalt surface damage. Some projects have cancelled the transbed, and the bottom oil of the following sealing layer replaces the transbed oil, which causes the

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asphalt pavement after a period of traffic. It can be said that the problem of transbed oil of semi-rigid base asphalt pavement is still a technical problem in road construction in China[11].

In order to solve the permeability problem, many units prepare high permeability emulsified asphalt by adding permeability agent to asphalt first and then emulsification, and then develop high permeability emulsified asphalt[12]. As a translayer oil, high permeability emulsified asphalt has been widely used in some projects[13]. Chen Li[14]The emulsified asphalt with slow crack cation emulsifier. Bai Guotao et al[15]Different kinds of kerosene are used as permeability to emulsified asphalt, which shows that 20% content of aviation kerosene has the most obvious permeability gain to emulsified asphalt. But this material is expensive, and it does not meet the actual demand. And the amount of kerosene is 20%, which is not far from the conventional kerosene diluted asphalt content, so the pollution problem caused by kerosene dilution asphalt is not solved. Gao Yumei et al[16]By comparing the results of the penetration depth of emulsion asphalt under different kerosene blending capacity, the permeability of emulsion asphalt increased significantly at 8% to 12%. When the blending capacity exceeds 12%, the permeability increases slowly. Combined with the solid engineering, the optimal mixing amount of kerosene permeability agent is determined to be 12%. However, it does not consider the influence of emulsified asphalt with kerosene permeable agent on its own properties.Zhang X[17]Using aromatic hydrocarbon oil as a penetrant to add to the emulsified asphalt, the test shows that compared with the traditional products, the storage stability is better, and the permeability and depth are greatly improved.Shi S[18]Biomass oil was selected as penetrant, and the test structure showed that biomass oil emulsified asphalt has the best permeability performance when the ratio of biomass oil / asphalt is 1:3. Zhang X And ShiS et al. chose new materials as permeable agents. The main effect of the new permeable agent is to dilute the asphalt content and reduce the viscosity, but its cost is high and not in practical application, so it is difficult to popularize.

In view of the above situation, this paper selects a low cost kerosene dilent and develops a low content and high permeability emulsified asphalt to minimize the pollution of kerosene to the environment.

2. Experimental content and method

2.1 Experimental raw materials

AH-90 # asphalt, Property determination: needle entry degree (25℃, 100g, 5S)/0.1mm is 85. Softening point: 44.8℃, 15℃ extension (5cm / min) / cm> 150; Emulsifier: Special slow cracking emulsifier for transbed emulsified asphalt, Emulsifiers 1 #, 2 #, 3 # and 4 # are cationic emulsifiers of quaternary ammonium salt, 5 # is an alkyaryl sulfonate anion emulsifier; Water selection of laboratory tap water; Diluent mainly uses kerosene as a diluent. First use them to dilute the asphalt in proportion, the diluted asphalt is then emulsified in a certain proportion. The property density of the kerosene used in this study was 0.801 g · cm-3(25℃), a viscosity of 1.6034 mm2·s-1(25℃)

2.2 Experimental instruments

AF-90H colloidal grinding (Rink Electronics Company, Germany), LYY-7C intelligent asphalt extension instrument, SYD-2806E softening point tester, WNE-1C asphalt Engra viscometer, SYD-0653 emulsified asphalt microparticle ion charge tester, HWY-10 multi-function circulating constant temperature water bath (Shanghai Changji Geological Instrument Co., LTD.); SYD-2801E automatic asphalt needle entry meter (Wuxi South China Experimental Instrument Co., LTD.); 101A-1E electric drum air drying box (Shanghai Experimental Instrument Factory).

2.3 Experimental Methods

The emulsified bitumen in this study was prepared from colloidal mill production.

2.4 Quality detection method of permeable layer emulsified asphalt

Technical requirements of cationic emulsified asphalt refer to the industry standard for PC-2 construction specification (JTG F40-2004), anionic emulsified asphalt should meet the requirements of PA-2 specification, the standard of the permeable emulsified asphalt penetration depth is not less than 5 (inorganic stable aggregate base) ~10mm (no binding base). The measurement method of each

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emulsion index refers to the industry standard "Highway Engineering Asphalt and Asphalt Mixture Test Regulations" (JTG E20-2011) issued by the Ministry of Communications.

3. Formulation study

At present, it is generally believed that the emulsification of the low grade asphalt with diluent is stronger than the bonding performance and shear resistance of the emulsion for permeable layer oil. Therefore, AH-90 # asphalt is used as matrix asphalt, dilution is added to dilute it, and then colloidal grinding and emulsifying is added according to a certain oil-water ratio to prepare emulsified asphalt.

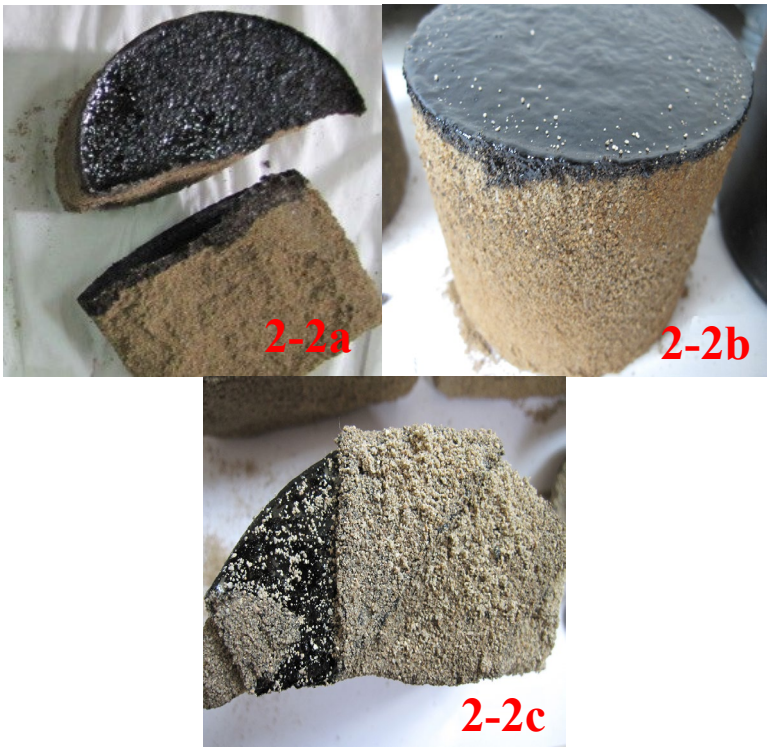
3.1 Study on the influence of emulsifier species on the permeability of emulsified asphalt

Various emulsifiers are used to emulsiAH-90 # asphalt, and a relatively good emulsifier is initially selected by the permeability of the emulsion. The asphalt is then emulsified to obtain the best formulation. The permeability of the emulsion obtained by emulsifying AH-90 # asphalt with various emulsifiers is shown in Table 1and Figure 1.

Table 1. Permeability of the emulsion obtained by emulsifying AH-90 # asphalt with various emulsifiers

Emulsifier	Emulsifier%	Time of penetration	Penetration state	Length of penetration, mm
1#	1.3	3672	V	5.51
2#	1.3	1218	IV	6.00
3#	1.3	600	II	1.77
4#	1.3	1245	III	4.45
5#	1.3	—	Breastbreaking immediately	2.99

Note: Emulsion conditions: the temperature of asphalt is 135℃, and the temperature of emulsifier water solution is 55℃.



Samples of 2-2a and 2-2b emulsion with poor permeability of 2-2c emulsion

Figure 1. Emulsion permeability samples

As can be seen from Table 1, the emulsion prepared by emulsifier 1 # and 2 # has relatively good permeability. The penetration state and penetration depth of 1 # emulsion meet the requirements (see Figure 1); the penetration depth of 2 # emulsion meets the requirements, but there is still a small

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amount of asphalt on the surface of the specimen. As emulsified, these two emulsifying asphalt can meet the requirements; the emulsion prepared by emulsifier 3 # can penetrate a certain depth, but there is more emulsion on the surface of the specimen (as shown in Figure 1); the permeability of the emulsion prepared by emulsifier 4 # and 5 # is not ideal. For 5 # emulsion, the emulsion starts upon contact with the aggregate, most of them are formed on the surface of the specimen (Figure 1).

3.2 Study on the influence of diluent content on the properties of emulsified asphalt

According to the results obtained in the previous experiment, two emulsifiers 1 # and 2 # with relatively good emulsion permeability were selected for the next experiment.

The emulsion with relatively good permeability, by adding kerosene and other diluents into the asphalt, can further increase the depth of penetration, easier to penetrate. However, the amount of kerosene is not easy to be too much, otherwise the evaporation residue injection degree and extension of the emulsion is easy to exceed the standard, and the amount of kerosene mixed is too much, the surface color of the specimen is light, the asphalt is too little, it is difficult to play a bonding role. Kerosene is volatile due to heat, so when kerosene is added to the asphalt, the asphalt temperature should be reduced. For different contents of kerosene, it is preliminarily determined that the content of kerosene in kerosene diluted asphalt does not exceed 6%, and the temperature of asphalt is 110℃ -130℃. The properties of the emulsion prepared with the above two preferred emulsifiers are shown in Table 2 and Table 3.

Table 2. Measurement results of emulsified asphalt properties prepared by 1 # emulsifier

Project		Unit	The standard requires that the PC-2	Experimental result			
emulsifier		—	—	1 # emulsifier			
The emulsifier solution pH		—	—	8.0	8.0	8.0	8.0
Kerosene content (accounting for diluted bitumen)		%	—	0	2	4	6
Lactobacillus content		%	—	1.3	1.3	1.3	1.3
Asphalt temperature		℃	—	140	130	120	110
Emulsifier aqueous solution temperature		℃	—	55	55	55	55
degree Engler			1~6	6	5	4	4
Remamount on screen (1.18mm)		%	≤0.1	0	0	0	0
Breastbreaking speed experiment		—	Slow crack	Slow crack	Slow crack	Slow crack	Slow crack
electric charge		—	(+)	+	+	+	+
evaporated residue	content	%	≥50	64	57	56	58
	solubility	%	≥97.5	99.9	99.8	99.9	99.9
	Needle entry degree (100g, 25℃, 5s)	0.1mm	50~300	95	128	162	340
	15℃ tensivity	cm	≥40	> 150	102	91	79
Adhesion to the coarse aggregate, and the binding area		—	≥2/3	>2/3	>2/3	>2/3	<2/3
Storage stability	1d	%	≤1	0.7	1.6	2.8	3.2
	5d	%	≤5	3.5	6.2	8.7	10.5
The penetration of the experiment	time of penetration	s	—	3672	2439	142	moment
	length of penetration	mm	>5	5.51	5.42	6.03	8.07
	Penetration state	—	—	V	V	V	V

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Table 3. Measurement results of emulsified asphalt properties prepared from 2 # emulsifier

Project		Unit	The standard requires that the PC-2	Experimental result			
emulsifier		—	—	2 # The emulsifier			
The emulsifier solution pH		—	—	2.0～3.0			
Kerosene content (accounting for diluted bitumen)		%	—	0	2	4	6
Lactobacillus content		%	—	1.4	1.4	1.4	1.4
Asphalt temperature		℃	—	140	130	120	110
Emulsifier aqueous solution temperature		℃	—	55	55	55	55
degree Engler			1~6	10	6	5	4
Remamount on screen (1.18mm)		%	≤0.1	0.02	0	0	0
Breastbreaking speed experiment		—	Slow crack	Slow crack	Slow crack	Slow crack	Slow crack
electric charge		—	(+)	+	+	+	+
evaporated residue	content	%	≥50	66	60	56	57
	solubility	%	≥97.5	99.2	99.4	99.5	99.5
	Needle entry degree (100g, 25℃, 5s)	0.1mm	50~300	89	114	134	325
	15℃ tensivity	cm	≥40	>150	98	91	88
Adhesion to the coarse aggregate, and the binding area		—	≥2/3	>2/3	>2/3	>2/3	<2/3
Storage stability	1d	%	≤1	0.8	2.6	1.5	3.9
	5d	%	≤5	0.4	9.6	12.54	18.6
The penetration of the experiment	time of penetration	s	—	moment	352	254	moment
	length of penetration	mm	>5	6.00	5.31	6.08	8.28
	Penetration state	—	—	IV	V	V	V

As can be seen from Table 2 and Table 3: both emulsifiers are optional slafine emulsifiers. Without adding kerosene, the basic properties and permeability of the emulsion prepared by 1 # emulsion can meet the requirements of PC-2 in Technical Code for Construction of Highway Asphalt Pavement (JTG F40-2004); the permeability of the emulsion, the viscosity of the emulsion is slightly larger, and other indexes meet the requirements; add asphalt with a certain amount of kerosene, and then emulsified. The residue of the 2 # emulsified asphalt sieve decreases after adding kerosene, indicating that the particles of the 2 # emulsified asphalt are uniform and small, which increases the penetration effect of the 2 # emulsified asphalt[19]. After the addition of two kinds of diluent kerosene, the permeability performance of emulsified asphalt is enhanced. This is because the solid content of emulsified asphalt decreases, and the viscosity of emulsified asphalt is reduced, and it is easier to penetrate into the aggregate[20]. When the content of kerosene (accounting for diluted asphalt) is 2~4%, the emulsion prepared by the two emulsifiers is better, and the permeability state of 2 # emulsified asphalt becomes V, indicating that the permeability of kerosene to 2 # emulsified asphalt is greatly improved. The emulsion prepared by emulsifier 1 # and 2 # meets the requirements except stability and can be prepared for use or used after mixing for short time. When the kerosene content reaches 6%, the penetration depth of the emulsion prepared by the two emulsifier is less than the kerosene content, but the surface of the specimen is light and brown (as shown in Figure 2), the asphalt of the specimen surface is too little and the bonding strength is not enough, the bonding can be increased by increasing the spraying amount of the emulsion, but the amount of kerosene will increase and the economic cost will be increased. Moreover, when the kerosene content is 6%, the emulsion stability, adhesion and the needle penetration degree of the evaporation residue also exceed the standard. Therefore, when all the indicators can meet the requirements, the smaller the kerosene consumption, the better, and the kerosene content of 2% is more appropriate. As is shown in Figure 2.

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Figure 2. Lighter-colored samples after emulsion penetration

3.3 Study on the influence of emulsifier dosage on the permeability performance of emulsified asphalt

For the above two emulsifiers, the amount of emulsifier is investigated under the best formulation. The determination results of emulsified asphalt are shown in Table 4.

Table 4. Property termination results of emulsified asphalt by changing the dosage of emulsifier

Emulsifier	Emulsifier content /%	Time of penetration	Length of penetration /mm				Penetration state
			1	2	3	mean	
1#	0.7	moment	9.31	8.43	8.90	8.88	V
	1.3	moment	8.92	8.28	8.58	8.59	V
2#	1.0	3600	Only one layer of oil film				I
	1.8	128	8.67	9.30	8.00	8.66	V

According to Table 2-3, the penetration depth and penetration grade of emulsion are within the range of 0.7~1.3%; the permeability of 2 # emulsifier is good at 1.8% and the dosage is 1.0%. Based on the above experiments, the optimal dosage of 1 # emulsifier is 0.7~1.3%, and the optimal dosage of 2 # emulsifier is 1.4~1.8%.

4. Conclusion

(1) 1 # emulsifier is an optional permeable emulsifier with good compatibility with AH-90 # asphalt. The basic performance of the prepared emulsion meets the requirements of PC-2 in the Technical Code for Construction of Highway Asphalt Pavement (JTG F40-2004). After the evaporation residue content of the emulsion is diluted to 40% and sprayed on the standard sand test, the emulsion is rapidly infiltrated, and the permeability meets the standard of more than 5mm. And 1 # emulsifier added to the water does not need to add acid to adjust the pH value, easy to use.

(2) 2 # emulsifier is an optional transbed emulsifier. After adding 2% kerosene to the asphalt, the emulsion prepared by these two emulsifiers meets the requirements of PC-2 in the Technical Code for Construction of Highway Asphalt Pavement (JTG F40-2004), and the permeability is also qualified.

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