

Experimental Research on Fuel Oil Corrosion Resistance of Asphalt Mixtures

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Abstract. Asphalt mixtures were immersed in the fuel oil to study the oil corrosion resistance. The mechanical performance of asphalt mixtures in the oil was evaluated by the observation, mass loss measurement, Marshall stability test and splitting strength test. Effects of immersion time, binder types, and anti-oil corrosion additive content were analyzed. It is found that there is the evident stripping after immersing the mixture in the oil. The stability test and strength significantly decrease. Using the anti-oil corrosion additive can effectively improve the mechanical performance of asphalt mixtures in the oil. It still can satisfy the criteria after immersing for 7 days. Finally, the optimum anti-oil corrosion additive content of 0.4% is recommended.

0 Introduction

In recent years, the traffic volume of road has increased greatly, and some overload vehicle run in poor condition, which is easy to cause oil leakage^[1-2]. Asphalt is mainly composed of alkanes, cycloparaffins, aromatic hydrocarbons and their derivatives, which are easily soluble in organic solvents such as diesel and gasoline^[3]. When the oil is in contact with the asphalt pavement, it is easy to dissolve the asphalt, causing the asphalt film to peel off from the surface of the aggregate^[4-5]. Therefore, oil corrosion resistance is an important road performance of asphalt mixture.

The anti-oil corrosion property of asphalt mixture was studied by different scholars. Zhang rui and Huang xiaoming^[6] analyzed various occasions where fuel oil could leak, and respectively tested the mass loss, high-temperature performance (rutting test) and splitting strength of matrix asphalt mixture and SBS modified asphalt mixture after immersion in oil. Li pei et al^[7] improved the oil corrosion resistance of asphalt mixture by adding modifier, and verified the pavement performance of modified asphalt mixture. Li shanqiang and Li hao^[8] proposed the test method of fuel oil

corrosion, and evaluated the oil corrosion resistance of different types of asphalt mixtures through Marshall stability test under oil corrosion conditions, immersion Marshall stability test, Kentaberg dispersion test and wheel rutting test. In this paper, the oil corrosion resistance of two different types of asphalt mixtures was evaluated by the apparent change, mass loss, Marshall stability test and splitting strength test under the condition of oil immersion.

1 Test program

1.1 Raw material and mix proportion design

Two kinds of asphalt mixtures were selected for oil corrosion resistance test. Among them, AC-13C mixture is AC-13 grade + basalt aggregate +70# matrix asphalt, and AC-13M mixture is AC-13 grade + basalt aggregate +SBS modified asphalt. The main technical properties of asphalt are shown in table 1, the main technical properties of aggregate are shown in table 2, and the aggregate gradation is shown in figure 1.

Table 1. Asphalt binder properties.

Test programs	70#Matrix asphalt		SBS modified asphalt	
	Measured	Required	Measured	Required
Density (15°C) / (g/cm ³)	1.022	Measured	1.026	Measured
needle penetration (25°C)/0.1mm	69	60-80	53	40-60
softening point /°C	52	≥46	78	≥60
ductility (matrix asphalt 15°C/ modified asphalt 5°C) /cm	>100	≥100	32.5	≥20
dynamic viscosity (60°C) / (Pa·s)	1551	≥180	24000	

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RTFOT	quality loss /%	-0.14	-0.8~+0.8	-0.05	-1.0~+1.0
	Residual injection ratio /%	68.1	≥61	77.0	≥65
	Residual ductility (matrix asphalt 15 °C / modified asphalt 5 °C) /cm	9.0	≥6	25	≥15

Table 2. Coarse aggregate properties.

Test programs	4.75~13.2 mm particle size	2.36~4.75 mm particle size	Technical standard
Soft grain in aggregate/%	0.4	/	≤3
Apparent relative density / (g/cm ³)	2.730	2.778	≥2.60
Bulk volume relative density / (g/cm ³)	2.707	2.740	/
Crushing value/%	18.9	/	≤26
Sediment percentage/%	0.3	0.5	≤1.0
Needle like content/%	4.7	/	≤15

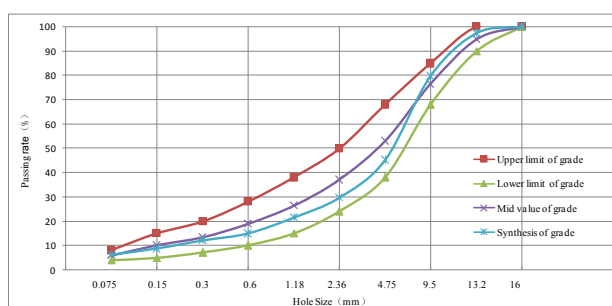


Fig. 1. Aggregate gradation curve.

Using PR AK[®] modifier to improve the oil corrosion resistance of asphalt mixture, the product is black powder, the particle diameter is between 0 ~ 1200 microns, which can be stored for a long time under room temperature, and suitable for all kinds of asphalt and aggregate type. It is easy to add which adopted direct investment production technology. Anti-oil corrosion additive was only added to the AC-13C mixture, and the dosage was respectively 0% (no mixing), 0.2%, 0.4% and 0.6% of the total mass of the mixture, and a comparative study was conducted with the AC-13M mixture without addition of anti-oil corrosion additive. The best asphalt-aggregate ratio of both asphalt mixtures was 5.0% with Marshall design method.

1.2 Oil-impregnated treatment

The oil immersion vessel is a translucent plastic container which is quadrangular shape. After the standard Marshall test piece was putted into the container, add 500ml No. 0 fuel oil. First, the oil corrosion resistance of the asphalt mixture was evaluated from the aspect of appearance. Taking out the immersion test piece every day to observe the apparent change, and measuring the quality change of the test piece after being dried to constant weight by the blower. The total immersion time was 7 days. The calculation formula of mass loss rate is shown in formula (1).

$$l = (M_0 - M_1) * 100 / M_0 \quad (1)$$

Where, l is mass loss rate /%, M_0 is the mass of specimens before oil immersion /g, M_1 is the mass of specimens after oil immersion /g.

1.3 Oil immersion Marshall stability test

Compared the Marshall stability of asphalt mixture specimens with immersion oil before and after 60 °C. r_{ms} of residual stability ratio after oil immersion is defined as the evaluation index, the calculation formula is shown in formula (2).

$$r_{ms} = ms_1 / ms_0 \quad (2)$$

Where, r_{ms} is the residual stability ratio after oil immersion. ms_0 is the Marshall stability of the specimens before oil immersion /KN; ms_1 is the Marshall stability of the specimens after oil immersion /KN.

1.4 Oil immersion test for splitting strength

The splitting strength of the asphalt mixture Marshall specimens before and after oil immersion was tested under the temperature of 20 °C and the loading rate level of 50 mm/min. Define the residual strength ratio after oil immersion as an evaluation index, The calculation formula is shown in formula (3).

$$r_{ss} = ss_1 / ss_0 \quad (3)$$

Where, r_{ss} is the residual strength ratio after oil immersion, ss_0 is the splitting strength of the specimens before oil immersion /MPa, ss_1 is the splitting strength of the specimens after oil immersion /MPa.

2 Analysis of test results

2.1 Loss of appearance and quality

The apparent change of various types of asphalt mixtures under different oil immersion time is shown in figure 2. It can be seen from the figure that the matrix asphalt mixture (AC-13C-0%) without the addition of anti-oil corrosion additive soaked in the diesel for 1 day, the surface and corner of the test piece began to lose grain. With the time of oil immersion increases, the bitumen dissolves rapidly, and the phenomenon of dropping granules becomes more and more serious. When the oil immersion time reaches 7 days, the surface of the test piece will appear empty, leaving only the skeleton of coarse aggregate, a lot of flaking of asphalt mortar (the adhesive composed of asphalt, mineral powder and part of fine aggregate), and even white material will appear on the surface after the test piece is blown dry. The SBS modified asphalt mixture (AC-13M-0%) without the addition of anti-corrosion additive also showed obvious peeling on its surface after 7 days of immersion, but the severity was less than that of matrix asphalt mixture.

However, the surface spalled phenomenon of matrix asphalt mixtures (AC-13C-0.2%, AC-13C-0.4% and AC-13C-0.6%) mixed with anti-oil corrosion additive was significantly relieved after oil immersion, and the adhesion between asphalt and aggregate remained good. Moreover, with the increase of the content of oil corrosion additive, the surface integrity of the specimen gradually increased.

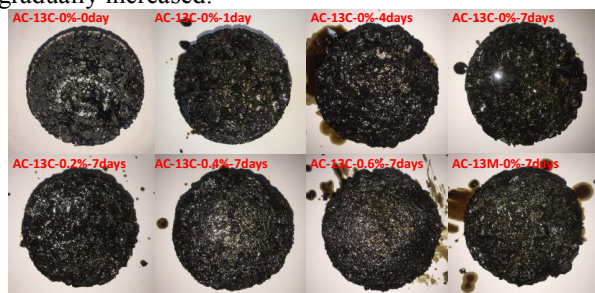


Fig. 2. Appearance change of specimens before and after fuel oil immersion.

The law of the mass loss rate of specimens after oil immersion with the oil immersion time is shown in table 3. It can be seen from the table that the mass loss rate of different asphalt mixtures increases linearly with the increase of immersion time. The mass loss range of common asphalt mixture without anti-oil corrosion additive is the largest, and the average daily mass loss rate is 0.64%/ day. Second, SBS modified asphalt mixture without oil corrosion additive was added, and its average daily mass loss rate was 0.44%/ day. The mass loss of specimens was significantly reduced after the addition of anti-oil corrosion additive. When the dosage was 0.2%, 0.4% and 0.6%, the daily average mass loss rate was 0.36%/ day, 0.18%/ day and 0.14%/ day respectively. Compared with those without anti-oil corrosion additive, the decrease was 43.3% ,72.3% and77.8% respectively.

Table 3. Mass loss ratio of asphalt mixtures under different fuel oil immersion days.

Mass loss ratio in different days	AC-13C-0%	AC-13C-0.2%	AC-13C-0.4%	AC-13C-0.6%	AC-13M-0%
0	0	0	0	0	0
1	1.11	0.19	0.26	0.05	0.03
4	3.04	1.32	0.77	0.27	1.31
7	4.49	2.55	1.24	1.00	3.05
Average	0.64	0.36	0.18	0.14	0.44

2.2 Immersion Marshall stability

The results of various types of 60 °C Marshall stability of asphalt mixture under the condition of different immersion time was shown in figure 3. It can be found that the Marshall stability of various asphalt mixtures before oil immersion all met the specification requirements (not less than 8kN). However, after oil immersion, the stability of both matrix and SBS modified asphalt mixtures was significantly reduced without the addition of anti-oil corrosion additive. The stability of common asphalt mixtures was lower than 8kN after 1 day of oil immersion, while that of SBS modified asphalt mixtures was lower than 8kN after 7

days of oil immersion. The addition of modifier can effectively inhibit the damage of oil corrosion behavior to the high-temperature mechanical properties of asphalt mixture, especially when the content of modifier is not less than 0.4%, its stability is always greater than 8kN under the condition of oil immersion, and even higher than that of SBS modified asphalt mixture.

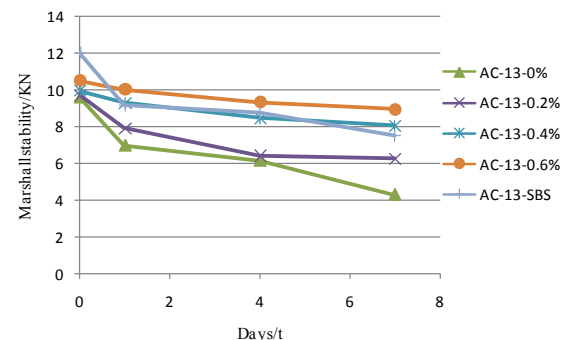


Fig. 3. Marshall stability of asphalt mixtures under different fuel oil immersion days.

It can be seen from figure 4 that although the residual stability ratio of various asphalt mixtures decreases with the extension of oil immersion time, the residual stability ratio of the mixture after the addition of anti-oil corrosion additive is significantly higher than that without anti-oil corrosion additive under the same oil immersion condition. Analysis began after 1 day of oil immersion. With the increase of oil immersion time, the decreasing rate of residual stability ratio of mixture without addition of anti-oil corrosion additive gradually increased, while the performance of mixture with anti-oil corrosion additive was reversed, indicating that addition of modifier could not only weaken but also delay the oil corrosion damage of asphalt mixture. In addition, when the mixing amount is more than 0.4%, the improvement effect of increasing the dosage of modifier is not obvious on the high-temperature mechanical strength of asphalt mixture after oil immersion.

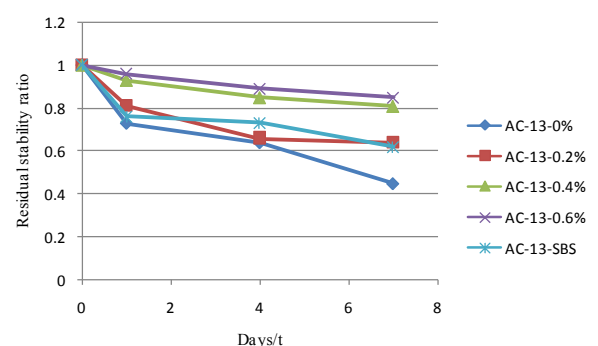


Fig 4. Residual stability ratio of asphalt mixtures under different fuel oil immersion days.

2.3 The splitting strength of oil immersion

Various types of asphalt mixture of 20 °C split strength results under different immersion time was shown in figure 5. It can be found that, similar to the results of Marshall stability test, different types of asphalt mixtures show a declining trend in their splitting strength after oil

immersion. The reduction in strength of the mixture without oil corrosion inhibitor is significantly greater than that of the mixture with oil corrosion inhibitor. The influence law of oil immersion time on residual strength ratio of asphalt mixture is shown in figure 6. With the increase of oil immersion time, the residual strength ratio of mixture without addition of anti-oil corrosion additive increased constantly, and the intensity drop of matrix and SBS modified asphalt mixture after 7 days of oil immersion reached 31.2% and 24.0% respectively. With the addition of 0.2%, 0.4% and 0.6% of anti-oil corrosion additive, the splitting strength of matrix asphalt mixture decreased only by 18.6%, 12.4% and 11.8% respectively, and the decreasing rate decreased. Similarly, increasing the content of modifier from 0.4% to 0.6% has no significant effect on further improving the normal temperature mechanical strength of asphalt mixture after immersion in oil.

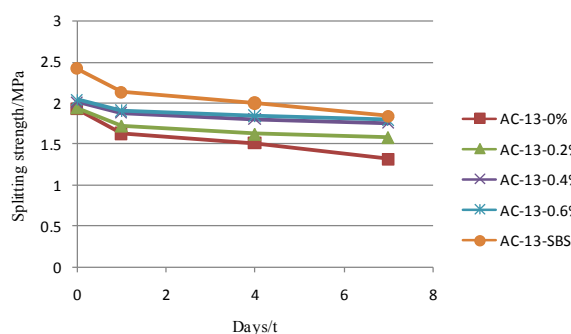


Fig 5. Splitting strength of asphalt mixtures under different fuel oil immersion days/MPa.

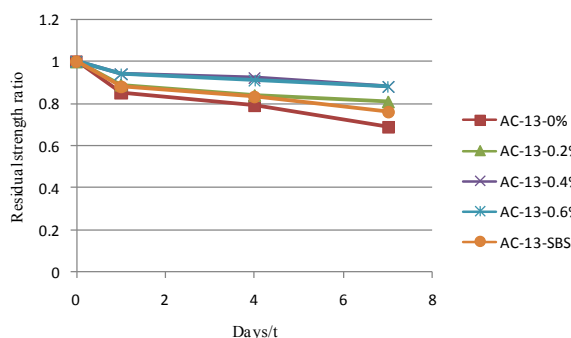


Fig 6. Residual strength ratio of asphalt mixtures under different fuel oil immersion days.

3 Conclusions

- No matter matrix asphalt mixture or SBS modified asphalt mixture, the degranulation and surface spalling will occur after oil immersion. With the increase of oil immersion time, the mass loss rate of the mixture increased linearly, and the residual Marshall stability and residual splitting strength continued to decline and the decline rate gradually increased.
- The addition of anti-oil corrosion additive can significantly inhibit and delay the effect of oil

corrosion, improve the adhesion between asphalt and aggregate, reduce the mass loss rate of asphalt mixture after oil immersion, improve the residual Marshall stability and residual splitting strength after oil immersion, and reduce the rate of decline of mechanical strength with oil immersion time. After 7 days of immersion, the mechanical properties of matrix asphalt mixture with anti-oil corrosion additive still meet the requirements of the specification.

- The oil corrosion resistance of asphalt mixture was improved with the increase of the content of modifier, but when the content was greater than 0.4%, it had no significant effect to continue to increase the content. Therefore, the optimal amount of anti-oil corrosion additive is 0.4% after considering the effect and economy.

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