STUDY OF THE EFFECT OF INTERFACIAL CONTAMINATION ON FATIGUE PERFORMANCE OF COMPOSITE BEAMS

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Abstract: *The composite asphalt beams with interlayer interface were used to carry out the shear strength test and four-point bending fatigue test. Pollution sources (like oil pollution and loess pollution) were used to simulate the possible conditions in the construction process through adjusting the amount of pollution. The results show that: (1) The effects of oil pollution on the composite beam shear strength is greater than that of loess pollution; (2) Under the same test conditions, the fatigue life of composite beams decreased significantly with the increase of the amount of pollution, and gradually stabilized; (3) Under the same amount of pollution, the effect of oil on interlayer bonding performance is greater than that of loess pollution; (4) According to the loss of bending stiffness modulus, when the amount of pollution reaches a certain level, the interlayer adhesion of asphalt beams will be lost.*

Keywords: *road engineering, composite beam, pollution source, four point bending fatigue test, the bending stiffness modulus loss*

I. INTRODUCTION

As the increasing available of asphalt pavement, fatigue break-down phenomenon of asphalt mixture has been widely concerned as one of the main ways of asphalt pavement damage [1, 2]. In terms of the various types of asphalt pavement fatigue damage, researches focus on the subgrade, pavement materials and their combination of structures, and it is optimized and improved, according to the use of pavement and local temperature changes [3]; however, ignoring interlayer adhesion, waterproofing, stress absorption, and durability issues, the destruction of asphalt pavement would not be fundamentally resolved even if the strength of the surface layer and grassroots is higher. The reason is that the insufficient adhesion between the asphalt pavement layers leads to the inter-layer slippage. It is generally considered that there are mainly two reasons causing the inter-layer slippage: the action of the greater horizontal force and the inter-layer bonding Insufficient [4]. What's more, studies have shown that the existence of horizontal load further weaken the interlayer structure, resulting in inter-layer slippage, and the horizontal load distribution of the stress field of the pavement is greatly affected by the formation of the upper layer will be larger Tensile stress [5,6]. However, this is the conclusion

Data：
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of two extreme cases that the state of contact between layers is completely continuous or completely smooth, which is not in accordance with the reality. The interlayer contact of pavement structure in China is between these two extremes [7], in other words, different contact conditions between layers have a great influence on the mechanical response of pavement structure [8-11]. Based on the finite element theory, this paper analyzes the mechanical response of the contact between different layers under the combined action of horizontal and vertical loads, and the characteristics of each response index changing with the contact state between layers under the coupling of load and temperature [12 , 13, 14]. On the other hand, it illustrates that spraying sticky layer oil between layers can effectively improve the adhesion and shear resistance between layers [15], but it is neglected the influence of interfacial pollution factors. As the pavement structure is completely in the natural environment, the external pollution causes the change of the contact conditions between asphalt pavement layers. Therefore, based on the shear strength test, the fatigue life of the composite asphalt mixture beam and the decay trend of bending stiffness modulus are analyzed in order to analyze the interface pollution mechanism.

II. TEST MATERIALS AND TEST PROGRAM

2.1. Test Materials

In this study, a new type of skeleton compact waterproofing compound SMAP-5 and a skeleton suspension compacting compound SMA-13 were used to prepare the composite trabecular to simulate the asphalt pavement structure of the steel bridge deck. SBS modified emulsified asphalt. Aggregate using basalt crushed stone, mineral powder selected limestone ore, fiber using lignin fiber, asphalt using self-developed high viscoelastic modified asphalt. The composition of the two mixture gradation is shown in table 1, and the corresponding volume parameters are shown in table 2. Composite trabecular longitudinal section shown in figure 1.

Table 1. *The compound gradation of mixture*

Aperture Size /mm		16	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
Passing Rate/%	SMAP-5	100	100	100	97	46	38	30	22	17	12
	SMA-13	10.5	13	14	16.5	17.5	19	26.5	64	95	100

Table 2. *The trabecular combination and Volume of composite beams*

The type of mixture		Mixture volume parameters	
		Thick Aggregate Content Above 2.36mm（%）	Porosity（%）
Upper Layer	SMA-13	80	3.57
Bottom Layer	SMAP-5	54	0.73

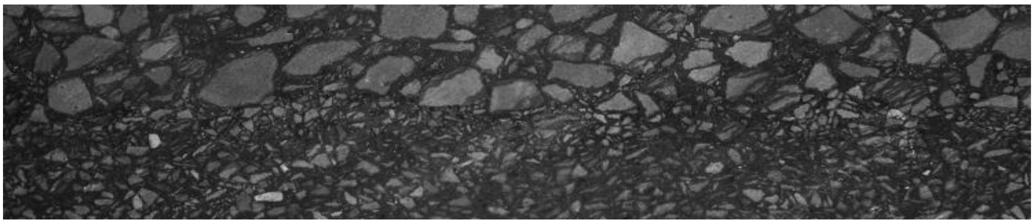


Figure 1. *SMA-13+SMAP-5 asphalt mixture composite beam specimen*

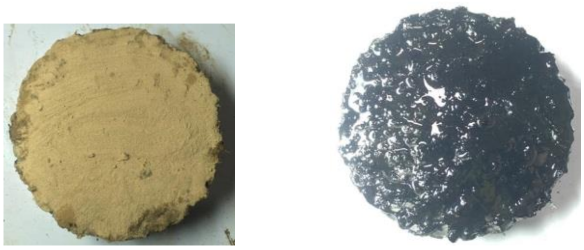
2.2. Test Methods

The four point bending fatigue test is the main test method. Considering the fatigue failure of asphalt mixture, the temperature of the asphalt mixture mainly concentrates between 13℃ and 15℃, which is the temperature of the spring melting in the north and the rainy season in the south. Therefore, the test temperature is 15℃. Due to improving the test efficiency and reducing the experimental period, the strain level is 1250με, and the interval time is not set for load loading.

Actually, in road construction project, the sand in the environment and the mechanical oil pollution during construction are the inter layer pollution sources, so the two pollution sources of wind sand and oil pollution are considered as the objects of study that is about the influence of asphalt mixture pavement fatigue performance.

Using loess simulates environmental sand, and mechanical oil pollution during oil simulation construction. Different levels of pollution are represented by 0 kg/m2, 0.1kg/m2, 0.2kg/m2 and 0.3kg/m2 pollution respectively. And the test loading frequency choose 10Hz

Taking the Marshall specimen as an example, the sketch of interlayer pollution is shown in figure 2.



a) Sand Pollution b) Oil Pollution

Figure 2. *The Sketch Of Interlayer Pollution*

III. TEST RESULTS ANALYSIS

3.1. Interface Pollution On The Shear Strength Between Layers

According to the above test scheme, the test of the shear strength of the Marshall specimen under different conditions is carried out. The table below shows the test results.

Table 3. *The Shear Strength Test Results*

Interlayer Contact Conditions		Amount	Shear Stress（kN）	Shear Strength（MPa）
Clean		——	12.64	1.56
Pollution	Sand	0.1kg/㎡	11.02	1.36
		0.2kg/㎡	10.13	1.25
		0.3kg/㎡	9.16	1.13
	Oil	0.1kg/㎡	10.37	1.28
		0.2kg/㎡	9.48	1.17
		0.3kg/㎡	3.89	0.48

From the test results in table 3, it can be seen that the shear strength decreases to some extent with respect to the cleanliness of the Marshall specimen. The shear strength of the mixture with powdery loess as interlayer contamination decreased by 12.82%, 19.87% and 27.56% respectively, by compare, the figure for the clean layer. The shear strength of the mixture with oil as interlayer was Shear strength of the mixture between the layers decreased by 17.95%, 25.00% and 32.05% respectively.

From the above data analysis, it can be concluded that both soil pollution and oil pollution reduce the shear strength between layers and under the same pollution load, the impact of oil pollution is greater than that of soil pollution.

The main reason is that the soil particles hinder the bond between the upper and lower mixture, and in the cutting process, the static friction force between upper and lower layers is converted into sliding friction force, resulting in a mixture of interlayer shear strength decreased, however, the chemical composition of oil, whether it is sticky oil or asphalt mixture, has a high solubility and permeability. Oil can make viscous layer of asphalt material oil content increased, leading to weaken the interlayer adhesion. Meanwhile, the oil on the upper and lower layer of the bond between the material not only played a role in impeding but also have some lubrication, as result of there is decrease trend for the shear strength of asphalt mixture that is under a variety of factors.

3.2. Interface Pollution On The Fatigue Life Of Composite Trabecular

According to the experimental plan, the inter-layer pollution takes into account the common pollution in pavement, namely sand pollution and oil pollution. The composite beams fatigue test results shown in figure 3.

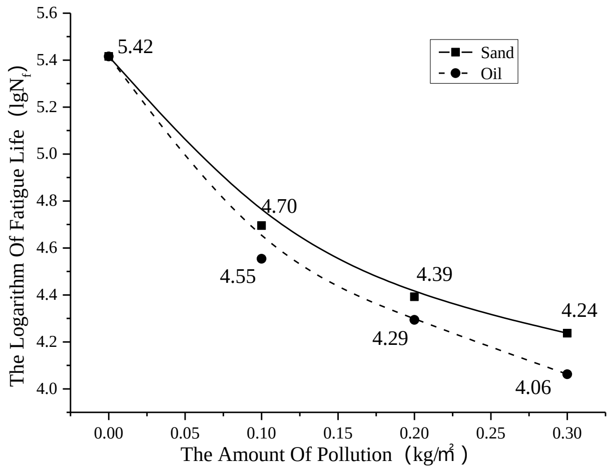


Figure 3. *The Result of Four Point Bending Beams Test*

The figure 3 illustrates that the fatigue life of the mixture will decrease when the contact between the upper and lower layers is polluted. By contrast with the cleanliness of the interlayer, when the loess is used as the interlayer pollution source, the fatigue life of the mixture under different pollution amount is decreased by 13.37%, 18.96% and 21.83% respectively; when the oil is used as an inter-layer pollution source, the figure for asphalt mixture decreased by 15.98%, 20.78% and 25.05% respectively. The results show that the influence of loess pollution source on the fatigue life of the mixture is less than that of the oil source on the fatigue life of the mixture. The reason is that the presence of loess particles and mixed layer interface between the adhesive layer, although hindered the bonding of the upper and lower mixture, under the action of the vehicle load, the friction between the layers of the mixture changed from static friction into sliding friction. However, as for oil pollution, it not only hinders the bonding of the upper and lower mixes, but also lubricates the layers as the vehicle loads.

3.3. Bending Stiffness Modulus Loss Analysis

According to the above test results, it can be found that the interface pollution has a greater impact on the fatigue life of the composite trabecula, and the degree of influence is related to not only the pollution source but also the pollution amount received. The bending stiffness modulus loss of the composite beam specimen is shown in figure. 4.

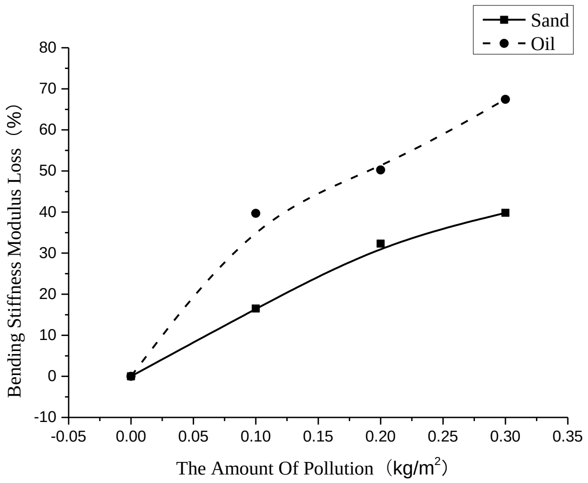


Figure 4. *Bending Stiffness Modulus Loss*

The Figure. 4 shows that the bending stiffness modulus of the interfacial layer of trabecular specimens has different degrees of loss when subjected to two kinds of pollution sources, and the oil contamination has the greatest impact on the loss of bending stiffness modulus. At the same time, as the amount of pollution increases to a certain limit, oil contamination will take the lead in delaying the bond between layers.

IV. CONCLUSIONS

(1) The shear strength of asphalt composite trabecular interface is less affected by loess pollution than that of oil pollution. With the increase of interface pollution sources, the shear strength of composite specimens will be further reduced.

(2) As the amount of pollution increases, the fatigue properties of asphalt mixtures tend to decrease significantly, but with the increase of pollution, the fatigue life of composite trabecula tends to be stable.

(3) Under the same amount of pollution, oil pollution has a greater impact on interlayer adhesion than that of loess.

(4) According to the results of flexural stiffness loss analysis, as the amount of pollution increases, the loss of bending stiffness modulus of the beam specimen will be more and more, indicating that the adhesion between layers is weakened. When the amount of pollution increases To a certain value, the asphalt pavement surface bond performance of the basic loss.

Research and analysis results show that: when adopting layered pavement asphalt pavement, the interface between upper and lower asphalt layers should be kept clean, especially when preventing the construction equipment from polluting the interface, and improving the adhesion of the asphalt pavement and the whole Sex is of great importance.

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