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Effect of Aeolian Sand on Skid Resistance of Asphalt Pavements with Different Gradations

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Abstract—Effect of aeolian sand on the skid resistance of AC-13 and SMA-13 asphalt pavements was investigated by characterization of skid resistance value and structural depth of the asphalt mixture before and after accelerated wearing. The results indicate that when the aeolian sand cover is less than 1.0 kg/m^2, the aeolian sand affects the skid resistance of AC-13 and SMA-13 asphalt pavements similarly. However, when the aeolian sand cover exceeds 1.0 kg/m^2, the aeolian sand affects the skid resistance of AC-13 asphalt pavement more significantly than that of SMA-13 asphalt pavement. With the aeolian sand cover increasing from 1.0 kg/m^2 to 1.5 kg/m^2, the skid resistance value declines from 53 to 40 and the declining rate is up to 30%. The polished stone value testing of coarse aggregate before and after accelerated wearing shows that the asphalt mixture with the gradation of AC-13 exhibits a bigger polished stone value changing of coarse aggregate, which confirms that the aeolian sand affects the skid resistance of AC-13 asphalt mixture more significantly.

Keywords-asphalt pavement; skid resistance; aeolian sand; accelerated wearing; polished stone value

I. INTRODUCTION

Aeolian sand, which can be accumulated on the surface of asphalt pavement blew by the wind, is mainly distributed in the desert and Gobi areas of China[1]. The content of the Aeolian sand, of which the particle size ranging from 0.074 to 0.25mm is more than 90%. The aeolian sand, which is of low surface activity[2], is easy to become loose due to its less cohesive[3], and exhibits strong non-plastic characteristic[4]. In most desert regions of our nation, the amount of aeolian sand is abundant and widely distributed[5]. Under the role of the gradient wind, the aeolian sand is easy to be accumulated in road surface of asphalt pavement, and forms a covering layer with considerable thickness[6-8], which has significant influence on the friction properties between road surface and the wheels of vehicles[9], so as to result in a negative impact on driving safety significantly.

In recent years, lots of researches referring to the skid resistance of asphalt pavements under the influence of aeolian sand have been carried out[10]. Meanwhile, different kinds of measures have been taken to investigate impact of aeolian sand on the traffic safety, Also, various methods have been adopted to enhance the skid resistance of asphalt pavements which are covered by aeolian sand, such as using reeds and straws son as well as grid black geotextile to build friction system, or removing the aeolian sand covering on the surface of asphalt pavements built in the areas of serious accumulated sand areas[11]. Although the methods mentioned above can refrain aeolian sand cover on asphalt road surface at a large area, there is still a small amount of aeolian sand left in the road surface texture depth space of the top layer of asphalt pavement, it will also lead to the decrement of skid resistance and structure depth of the asphalt pavement, and cause danger to driving safety of asphalt pavement[12]. However, research concerning on the effect of aeolian sand on skid resistant of asphalt pavements in desert areas of Xinjiang Province has rarely been reported.

Based on the research work mentioned above, in this article, two types of asphalt mixture AC-13 and SMA-13 specimens were prepared. Effect of aeolian sand on the skid resistance of AC-13 and SMA-13 asphalt pavements was investigated by characterization of skid resistance value and structural depth of the asphalt mixture before and after accelerated wearing.

II. EXPERIMENT

A. *Materials*

The asphalt used in this paper was SK-90 heavy traffic asphalt, its performance was shown in Table 1. The performance of coarse aggregate and limestone was shown in Table 2. The performance of fine aggregate and limestone was shown in Table 3. The performance of ore, limestone finely ground ore was shown in Table 4. The performance of fiber and wood cellulose was shown in Table 5. The particle size distribution, water content as well as clay content of aeolian sand was shown in Table 6.

TABLE I. PHYSICAL PROPERTIES OF SK-90 ASPHALT

Properties	Technical index
Softening point （℃）	46.7
Ductility （15℃, cm）	>150
Penetration（25℃, 0.1mm）	93
Viscosity （60℃, Pa·s）	223
Saturation （%）	11.3
Aromatics （%）	57.4
resins （%）	19.5
Asphaltenes （%）	11.8

TABLE II PERFORMANCE OF COARSE AGGREGATE

Performance index	Results
The apparent density of coarse aggregate	2.71
The rate of water absorption /%	0.3
Crushing value /%	18.2
Adhesion	5
Polished value	46.0
The content of soft rock /%	2.1
Mud content /%	0.4

TABLE III THE PERFORMANCE OF FINE AGGREGATE

Performance index	Test results
The apparent density of fine aggregate	2.707
Consistency （>0.3mm）/%	1.9
Sand equivalent /%	76

TABLE IV PERFORMANCE OF LIMESTONE FINELY GROUND ORE

Performance index		Test results
Apparent density，g/cm^3		2.712
Water content，%		0.3
Granularity Scope，%	<0.6mm	100
	<0.15mm	94.3
	<0.075mm	87.4
Surface		Non-caking
Coefficient of hydrophilic		0.6

TABLE V. PERFORMANCE OF LIGNOCELLULOSE

Performance index	Test results
Ash content，%	17.64
Water content，%	4.62
Heating loss	5.37
pH	6.9
Oil absorption	5.22
Length	2.77

TABLE VI PERFORMANCE OF AEOLIAN SAND

Experimental value		Test results
Distribution/%	＞0.5	0
	0.5~0.25	1.3
	0.25~0.074	96.5
	＜0.074	2.2
Water content/%		0.7
Clay content/%		1.3

B. Preparation of different Asphalt Mixture

The of AC-13 and SMA-13 asphalt mixtures were designed and prepared according to requirements of the "Specifications for design of highway asphalt pavement"(JTGD50-2006).

C. Accelerated Wearing Test

In order to evaluate the influence of aeolian sand on skid resistance of asphalt pavements under the repeated wheel rolling, accelerated wearing (AW) instrument, which was developed by Chang'an University, was employed to investigate the influence of aeolian sand on skid resistance of asphalt pavements.

D. Skid Resistance Test

The skid resistance value and structural depth of AC-13 and SMA-13 asphalt mixtures before and after the accelerated wearing test were respectively determined according to the Test method for determining the depth pavement structure by hand sanding law and Test method for tilting pavement skid measured.

E. Polished Value Testing of Coarse Aggregate

Polished stone value of coarse aggregate in asphalt mixture was an important index to evaluate the skid performance of asphalt pavement. In this paper, the polished value of coarse aggregate contained in AC-13 and SMA-13 asphalt mixtures was tested according to the specified method of coarse aggregate polish stone value test.

III. RESULTS AND DISCUSSION

A. Effect of Aeolian Sand on Skid Resistance Value

Fig. 1 shows the effects of aeolian sand on skid resistance of AC-13 and SMA-13 asphalt mixture after the accelerated wearing.

As can be seen from Fig.1, with the coverage increasing of aeolian sand covered on the surface of asphalt mixture, the skid resistance value of AC-13 and SMA-13 asphalt mixture showed a decreasing trends, which indicates that the skid resistance of AC-13 and SMA-13 asphalt mixture was reduced by the aeolian sand covered on asphalt pavement surface. When the coverage of aeolian sand is lower than 1.0 kg/m^2, the skid resistance value of AC-13 and SMA-13 asphalt both shows a slow declining trend. However, when the coverage of aeolian sand exceeds 1.0 kg/m^2, the skid resistance of AC-13 and SMA-13 asphalt mixture began to decline quickly.

It can be also observed from Figure 2 that the skid resistance variation of AC-13 asphalt mixture with the increasing of aeolian sand covering on the surface of asphalt mixture declined more quickly than the skid resistance variation of SMA-13 asphalt mixture with the increasing of aeolian sand. For instance, when the coverage of aeolian sand covering on the surface of asphalt mixture increasing from 0 kg/m^2 to 2.0 kg/m^2, the skid resistance of AC-13 asphalt mixture covered by the aeolian sand changed from 63 to 22, the declining ratio was up to 65.1%, the skid resistance of covered by aeolian sand under a coverage of 2.0 kg/m^2 can not satisfy the skid resistance requirement for asphalt pavement. However, compared with the skid resistance variation of AC-13 mixture, as the coverage of aeolian sand covering on the surface of asphalt mixture increasing from 0 kg/m^2 to 2.0 kg/m^2, the skid resistance of SMA-13 asphalt mixture covered by the aeolian sand changed from 97 to 58, the declining ratio was 40.2%, the skid resistance of SMA-13 covered by aeolian sand under a coverage of 2.0 kg/m^2 can still satisfy the skid resistance requirement for asphalt pavement, which indicates that the aeolian sand covering on the surface of asphalt mixture influences the skid resistance of AC-13 more significantly.

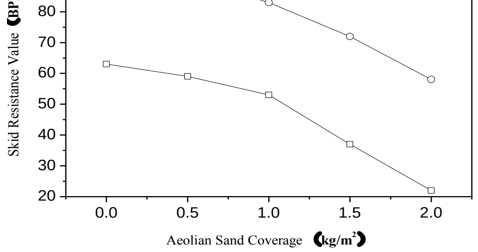

Figure 1. Effect of Aeolian Sand Coverage on Skid Resistance Value

B. Effect of Aeolian Sand on Structure Depth

The change of structure depth of AC-13 and SMA-13 asphalt mixture before and after accelerated wearing is shown in Fig. 2.

As can be seen from Fig. 2, with the increase of aeolian sand coverage, the texture depth of two types of asphalt mixture decrease gradually, indicating that the aeolian sand has a negative impact on the skid resistance of the two types of asphalt pavement. When the coverage of aeolian sand is lower than 1.0 kg/m^2, the structure depth of AC-13 and SMA-13 asphalt mixture declines slowly, however, with the continuous increasing of aeolian sand covered on the surface of asphalt mixtures, when the coverage of aeolian sand on the surface of asphalt mixtures surpassed 1.0 kg/m^{2}both of the AC-13 and SMA-13 asphalt mixture covered by aeolian sand began to decline quickly, compared with the structure depth of AC-13 asphalt mixture covered by aeolian sand under a coverage of 1.0 kg/m^2, the structure depth of AC-13 asphalt mixture covered by aeolian sand under a coverage of 2.0 kg/m^2 declined from 0.76 to 0.42, the declining ratio was up to 44.8%.

It can be also observed from Figure 2 that the structure depth variation of AC-13 asphalt mixture with the increasing of aeolian sand covering on the surface of asphalt mixture declined more quickly than the structure depth variation of SMA-13 asphalt mixture with the increasing of aeolian sand. For instance, when the coverage of aeolian sand covering on the surface of asphalt mixture increasing from 0 kg/m^2 to 2.0 kg/m^2, the structure depth of AC-13 asphalt mixture covered by the aeolian sand changed from 0.88 to 0.42, the declining ratio was up to 52.3%, the structure depth of covered by aeolian sand under a coverage of 2.0 kg/m^2 can not satisfy the skid resistance requirement for asphalt pavement. However, compared with the structure depth variation of AC-13 mixture, as the coverage of aeolian sand covering on the surface of asphalt mixture increasing from 0 kg/m^2 to 2.0 kg/m^2, the structure depth of SMA-13 asphalt mixture covered by the aeolian sand changed from 1.35 to 1.03, the declining ratio was 23.7%, the structure depth of SMA-13 covered by aeolian sand under a coverage of 2.0 kg/m^2 can still satisfy the skid resistance requirement for asphalt pavement, which indicates that the aeolian sand covering on the surface of asphalt mixture influences the skid resistance of AC-13 more significantly.

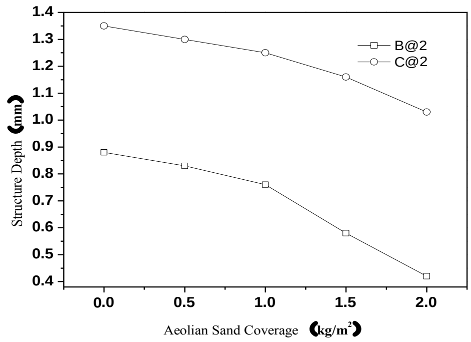

Figure 2. Effect of Aeolian Sand Coverage on Structure Depth

C. Polished Stone Value Characterization of Coarse Aggregate

The polishing value of coarse aggregate of AC-13 and SMA-13 asphalt mixture before and after accelerated wearing (AW) is listed in Table 7. It can be seen from Table 7 that for with different coverage of aeolian sand, the polished value in coarse aggregate after accelerated wearing all shows a declining trend. It can also be seen from the data in Table 7 that under the same amount of coverage of aeolian sand, the polished value of the coarse aggregate contained in AC-13 asphalt mixture changed more significantly than that of SMA-13 after accelerated wearing test carried out under the same circumstances. When the coverage of aeolian sand was 2.0kg/m^2, the polished value of coarse aggregate contained in AC-13 asphalt mixture varied from 46 to 33, the decreasing extent was 28.7%. However, when the coverage of aeolian sand was 2.0kg/m^2, the polished value of coarse aggregate contained in SMA-13 asphalt mixture varied from 46 to 38, the decreasing extent was 17.4%, which also indicates that he aeolian sand covering on the surface of asphalt mixture influences the skid resistance of AC-13 more significantly.

TABLE VII. POLISHED STONE VALUE OF COARSE AGGREGATE

Aeolian sand coverage	Condition	Coarse aggregate of AC13	Coarse aggregate of SMA13
0.5	Before AW	46	46
	After AW	43	44
1.0	Before AW	46	46
	After AW	41	42
1.5	Before AW	46	46
	After AW	38	40
2.0	Before AW	46	46
	After AW	33	38

IV. CONCLUSION

Two types of asphalt mixture, AC-13 and SMA-13 asphalt mixture were prepared in laboratory. Effect of aeolian sand on the skid resistance of AC-13 and SMA-13 asphalt pavements was investigated by characterization of skid resistance value and structural depth of the asphalt mixture before and after accelerated wearing.

(1) The aeolian sand exhibit strong influence on the skid resistance of AC-13 and SMA-13 asphalt, with the coverage increasing of aeolian sand covered on the surface of asphalt mixture, the skid resistance value and structure depth declined quickly.

(2) The aeolian sand influences the skid resistance of AC-13 asphalt pavement more significantly than that of SMA-13 asphalt pavement. With the aeolian sand coverage increasing from 0 kg/m^2 to 2.5 kg/m^2, the skid resistance value declines from 63 to 22, the declining rate is up to 30%.

(3) The polished stone value testing of coarse aggregate contained in asphalt mixture before and after accelerated wearing shows that the asphalt mixture with the gradation of AC-13 exhibits a bigger polished stone value changing of coarse aggregate, which confirms that the aeolian sand affects the skid resistance of AC-13 asphalt mixture more significantly.

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