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Research on Drain and Counter-Clogging Ability of Porous Asphalt Mixture

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Abstract: Porous asphalt pavement arouses the attentions of the world by its good performance such as reduce the potential for hydroplaning, reduce splash and spray, improve visibility, decline traffic noise, and improve driving safety. But the void clogging lessens its durable function. So in this paper appropriate clogging agent was choose, and seepage coefficients were tested by using asphalt mixture pavement surface permeameter to simulation multi-cycle drainage clogging test. The influence of asphalt mixture design parameter such as the porosity, the maximum sizes of the aggregate, gradation and asphalt on the drainage and counter-clogging ability of porous asphalt was researched. The tests indicated that the porosity has an obvious influence on both porous asphalt's permeable ability and counter-clogging ability. Comparing the specimen of 21% void to the ones of 16% void, the drain ability is improved 49.8%, the counter-clogging ability is improved 55.0%. The maximum sizes of the aggregate has an obvious influence on porous asphalt's counter-clogging ability, but no an obvious influence on the drain ability. Comparing the specimen of 16mm to the 13mm, the counter-clogging ability is proved 48%. PAC with the coarser gradation has a better performance on drain and counter-clogging ability. TPS modifier changes PAC little on drain and counter-clogging ability.

Keywords: Clogging, maximum size of the aggregate, porous asphalt, road engineering, seepage coefficient, void.

1. INTRODUCTION

Drainage asphalt pavement, that is porous asphalt course (PAC), is refers to the asphalt pavement which surface of a layer or two layer has the function of drainage. Compared with the traditional dense gradation asphalt pavement, 15% ~ 25% of void structure in porous asphalt pavement can effectively not only prevent road to form water membrane in the rain, improve the road surface roughness, and reduce vehicle slip, but also reduce tyre raise spray, provide visibility for the driver behind, obviously improve the driving safety. Moreover it can reduce noise of the tyre - pavement reflected from the source [1-3]. Porous asphalt pavement in western countries such as Japan has a history of successful and widely used but has not been popularized in our country. This is because there is a worried about void blocking affecting the functions durability of porous asphalt pavement [4]. And there are many scholars at home and abroad to research on the void and drain ability and counter-clogging ability of porous asphalt, such as Chang'an University studied internal void information of the porous asphalt mixture [5-7]; Southeast University mainly studied the penetration performance of drainage asphalt mixture and deduced infiltration model [8-10]. Hamazah studied counter-clogging performance of single and double PAC by loading congestion solution [11-13]. Kurihara studied the effect of jam dosage on the clogging performance of PAC [14]. But the evaluation on drainage and clogging performance of asphalt mixture should include two stages: the first phase is initial drainage

ability of porous asphalt mixture; the second phase is counter-clogging ability of porous asphalt mixture. From the related research, it can be seen that that the study on drainage and anti-clogging ability of PAC is not systematic integrity, the effect of structure parameters and material parameters on the drainage and clogging properties of mixture is not clear, so in this paper the influence law of structure parameter such as void and the maximum nominal size on drainage and anti-clogging ability of PAC will be systematic studied by PAC multi-cycle drainage clogging experiment.

2. EXPERIMENT METHODS

2.1. Specimen preparation

Five types gradation of porous asphalt mixture were designed, by the two types of nominal maximum size of aggregate (13 mm and 16 mm) and two kinds of target void (21% and 16%). Each type of porous asphalt mixture gradation is shown in Table 1.

2.2. Clogging Agent

Effective clogging test needs appropriate clogging material. In order to simulate the clogging effects better, uniform composition gradation was choose [7]. Finally grain composition of two clogging agent is shown in Table 2. The concentration of clogging agent is quality of blockage fines to water as 1:50. Clogging effect of changes in particle size of clogging agent was studied by choose different type clogging agent.

Table 1. Porous asphalts' gradation.

		Mixture gradation type				
		1	2	3	4	5
Passing ratio / %	19mm	100	100	100	100	100
	16mm	100	98.0	100	98.0	100
	13.2mm	96.6	84.0	95.0	84.0	90.0
	9.5mm	78.9	50.0	75.0	52.0	60.0
	4.75mm	19.2	18.0	25.0	25.0	23.0
	2.36mm	15.6	15.6	17.5	17.5	15.0
	1.18 mm	11.8	11.8	12.0	12.0	12.7
	0.6mm	10.2	10.2	10.0	10.0	10.8
	0.3mm	7.4	7.4	8.0	8.0	8.3
	0.15mm	5.9	5.9	6.0	6.0	7.0
	0.075mm	4.0	4.0	4.0	4.0	5.0
VV /%		21	21	16	16	21
BC /%		4.32	5.16	4.31	5.13	4.78
NMAS / mm		13	16	13	16	13

Table 2. Clogging agent composition.

Mesh size (mm)	Passing Ratio (by mass)/%	
	Clogging agent a	Clogging agent b
2.36	100	100
1.18	100	83.5
0.6	80	66.8
0.3	60	50.1
0.15	40	33.3
0.075	20	16.7

2.3. Multi-cycle Drain Clogging Test

With the aid of the asphalt mixture water penetration test (T0730-2011) in «Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering» (JTG E20-2011), the specific test steps of multi-cycle drainage clogging test are as follows: (1) firstly mixture penetration test was carried out, and recorded the corresponding time, calculated the initial water penetration coefficient; (2) secondly clogging agent selected concentration was prepared and quantitative (500 ml) joined the pavement seepage instrument to simulate clogging specimen; (3) after clogging test mixture penetration test was carried out again and recorded water penetration time; (4) repeat step (2), (3) until the time of water seepage is more than 3 min. Step (2), (3) is named as one-cycle clogging load.

But the evaluation on drainage and clogging performance of asphalt mixture mainly divided into two parts: one part is asphalt mixture drainage capability before no clogging, char-

acterized by the initial water penetration coefficient before loading clogging agent; the other part is counter-clogging ability of porous asphalt mixture, characterized by the number of clogging load cycle. The corresponding maximum size, void and the category of the clogging agent are shown in Table 3. Specimens 9# adopted the coarse gradation is opposed to specimens 1#, specimens 10# by the application of high viscosity modified asphalt is opposed to a specimens 1# (Fig. 1).

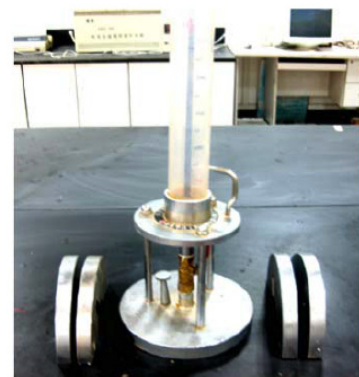


Fig. (1). Pavement surface permeameter.

Penetration coefficient of asphalt mixture is calculated as follow [15]:

$$C_w = \frac{V_2 - V_1}{t_2 - t_1} \times 60 \tag{1}$$

where C_w is pavement penetration coefficient (ml/min); V_1 is the water volume (ml) of the first time, usually for 100 ml; V_2 is The water volume (ml) of the second time, usually for 500 ml; t_1 is the first time (s); t_2 is the second time (s).

The calculation time is the time needed of the water surface from the dial 100 ml to 500 ml. If water penetration time is too long, it also can be calculated by the water volume pass through within the 3 min. So the critical value of water penetration coefficient can be as the 133.3 ml/min (400 ml /3 min). When the measured water penetration coefficient is less than 133.3 ml/min, the specimen will be identified as blocked to termination the block test.

Table 3. Void, the maximum size of the aggregate and category of the clogging agent.

Mixture	VV (%)	Valid VV (%)	Gradation	NMAS (mm)	Clogging agent
1	21.2	16.6	1	13	a
2	21.1	16.8	1	13	b
3	20.8	16.2	2	16	a
4	21.3	15.9	2	16	b
5	16.6	11.8	3	13	a
6	15.2	11.2	3	13	b
7	15.4	11.1	4	16	a
8	16.0	11.9	4	16	b
9	21.0	16.2	5	13	a
10	20.7	15.8	1	13	a

3. RESULTS AND ANALYSIS

3.1. Effect of Clogging Agent Particle Size on PAC's Counter-clogging Ability

First the blocking rule of clogging material particle size on PAC is studied. The clogging test was carried out on the same gradation and void of specimen respectively choose clogging agent type a, type b. Test results showed that the cycle number of clogging agent loading with the larger particle size is generally small (only specimen 7# and 8# has a contrary). That is said that clogging agent with the maximum nominal size of 1.18 mm is more easier to block the PAC specimen than clogging agent with the maximum nominal size of 0.6 mm. It can be found the void of 7# and 8# drainage asphalt mixture is in the lower limit of the required porosity range, and void of specimens 8# is greater than specimens 7#, therefore this contrast is also acceptable (Fig. 2).

3.2. Effect of Porosity on PAC's Drain and Counter-clogging Ability

Loading times of 0 is characterized initial drainage capacity of the porous asphalt mixture. From Figs. (3 and 4) it is obvious that the more void of PAC is, the greater initial drainage ability is. The average initial water penetration coefficient of the mixture specimens (1# ~ 4#, VV is about 21%) is 6361.5 ml/min, and the average initial water penetration coefficient of the mixture specimens (5# ~ 8#, VV is about 16%) is 3129.3 ml/min. The initial water penetration coefficient of mixture specimens (1# ~ 4#) is significantly

greater than that of mixture specimens (5# ~ 8#). The average initial water penetration coefficient of the specimens for void of 21% compared to void of 16% is increased by 49.8%. That is say the greater PAC void is, the stronger drainage ability is.

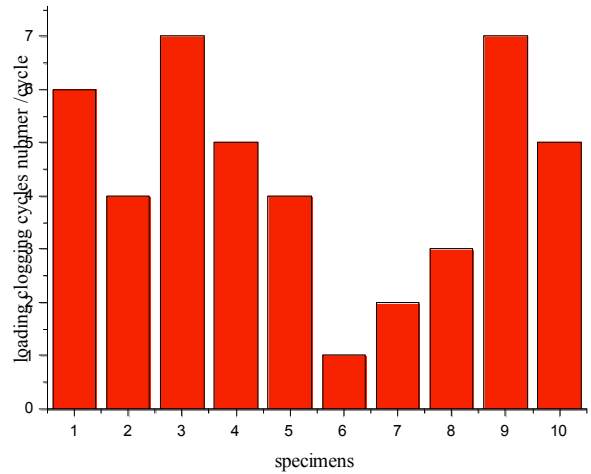


Fig. (2). Porous asphalts' clogging times.

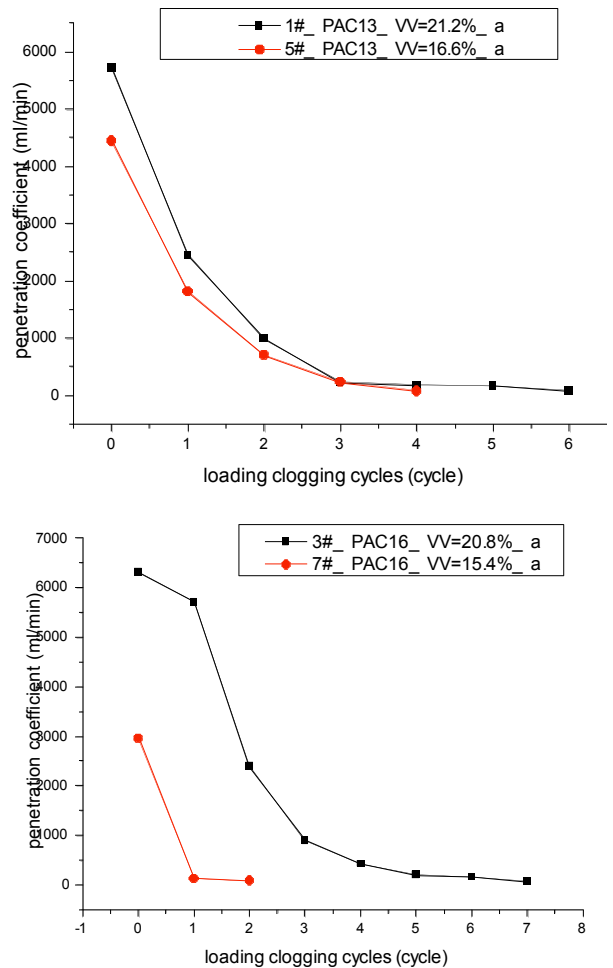


Fig. (3). Clogging times and penetration coefficients in different void by agent a.

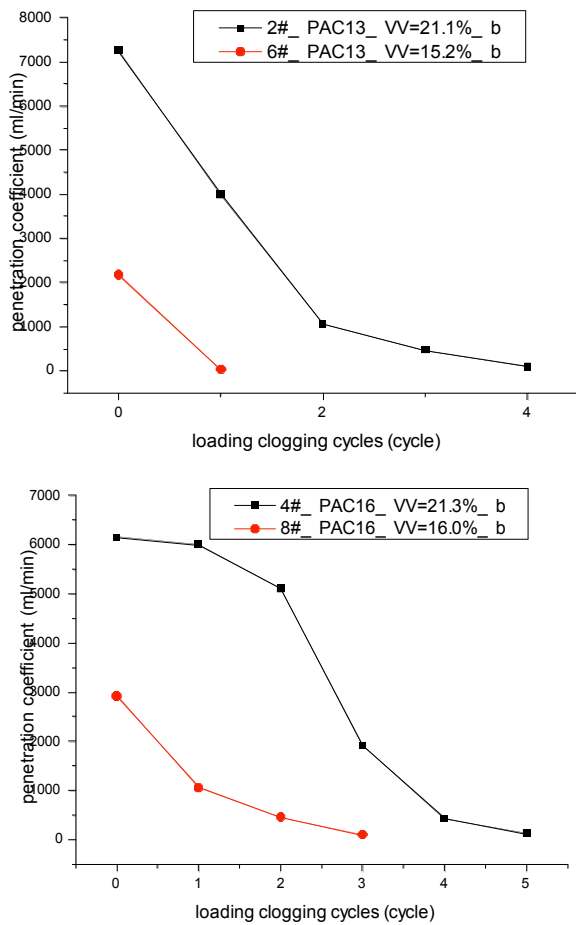


Fig. (4). Clogging times and penetration coefficients in different void by agent b.

Compared by clogging loading cycle number of 1# to 5#, 2# to 6#, 3# to 7#, 4# to 8#, it is known that the clogging loading cycle number of larger void mixture specimen is higher than that of small voids mixture specimen, the clogging loading cycle number of specimens with VV of 21% is more 3 cycles than that of specimens with VV of 16%. The counter-clogging ability of porous asphalt mixture with more voids is stronger than that of mixture with fewer voids. That is to say, the greater the void ratio of asphalt mixture is, the stronger counter-clogging ability is.

As medium of water seepage, PAC drainage ability is based on several continuous channels from one specimen's side to the other [16]. The greater void of asphalt mixture is, the greater the channel number is, and so the stronger the PAC drainage ability is. And that the number of channels no blocking is more in loading the same clogging agent shows the good drainage performance. This also indicates that the water penetration coefficient can reflect the presence of PAC internal aperture channels.

3.3. Effect of Maximum Nominal Size on PAC's Drain and Counter-clogging Ability

As you can see from Figs. (5 and 6), the effect of the maximum nominal size on the initial drainage capacity of PAC specimens is not obvious. The average initial water penetration coefficient of the specimen with maximum

nominal size of 16 mm compared to that of 13 mm increased by only 2.3%. This is further illustrated the main factor to affect the initial drainage capacity of PAC is void.

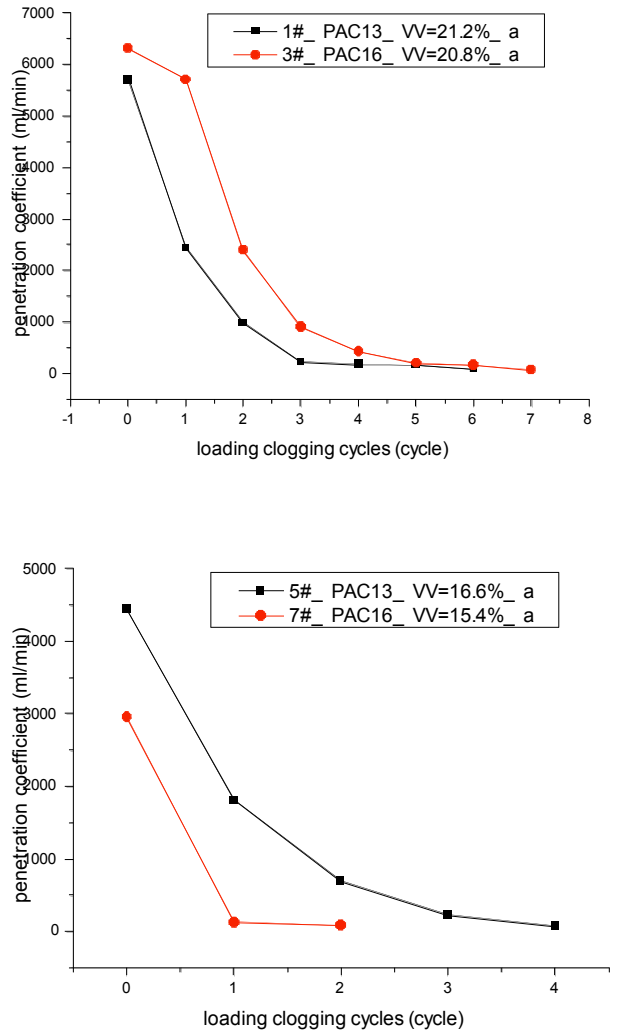


Fig. (5). clogging times and penetration coefficients in different aggregate maximum size by agent a.

Compared to 1# and 3#, 2# and 4#, 6# and 8#, it can be found that the clogging loading cycle number with the maximum nominal size of 16 mm is increased 48% on average than that of 13mm. The results shows that PAC specimen with a larger the maximum nominal size has the better counter-clogging effect. There is abnormal at loading number of specimens 5# and 7#. That is because the smaller void of specimen 7# reduces the counter-clogging ability.

3.4. Effect of Coarse, Fine Gradation and Asphalt Type on PAC's Drain and Counter-clogging Ability

Compared by the specimens of 1# and 9# in Fig. (7), it can be seen that gradation has significantly influence on PAC drainage ability. At the same void, the initial drainage and counter-clogging ability of the coarse gradation is both better than that of fine gradation.

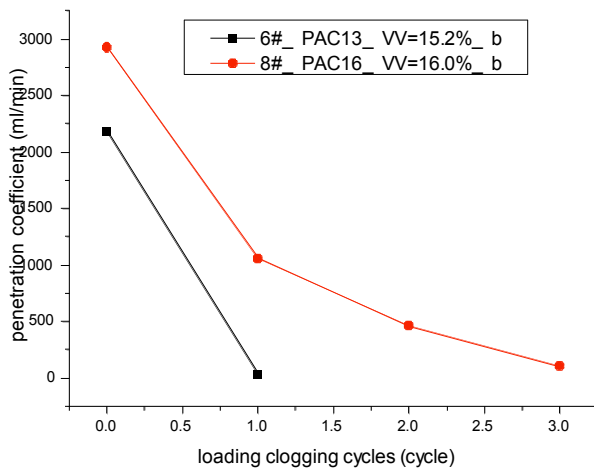
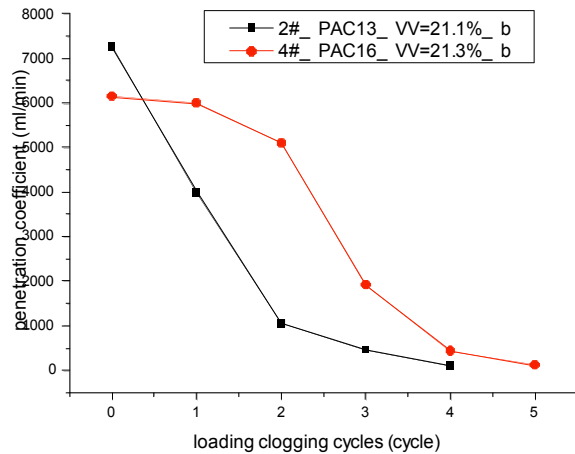


Fig. (6). clogging times and penetration coefficients in different aggregate maximum size by agent b.

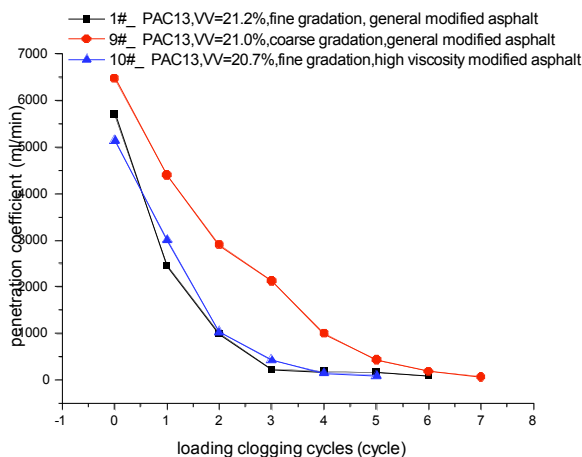


Fig. (7). The clogging times and corresponding water penetration coefficients of porous asphalts in different gradations and asphalts

Special after in the first four cycles of loading clogging agent, drainage ability of coarse gradation specimens is better than that of fine gradation. So at the conditions that other structural parameters are the same, the coarse gradation PAC has the stronger drainage and counter-clogging ability. This is because the large particle size of aggregate contacted to each other sets aside the gap larger than smaller particle size of aggregate, and not easy to be blocked by clogging agent.

Compared by 1# and 10# in Fig. (7), it can be found that drainage and counter-clogging ability of PAC has little impact by the use of high elastic asphalt.

CONCLUSION

- (1) The multi-cycles drainage and clogging test was put forward by using pavement seepage meter. Through the determination of the initial water penetration coefficient and cycle-numbers of loading clogging the drainage and counter-clogging ability of asphalt mixture was evaluated.
- (2) The average initial water penetration coefficient of the specimens (VV=21%) compared to the specimens (VV=16%) is increased by 49.8%. Cycle-numbers of load clogging for the specimens (VV=21%) compared to the specimens (VV=16%) is increased by 55% on average. The greater void of asphalt mixture is, the stronger drainage and counter-clogging ability are.
- (3) The average initial water penetration coefficient of specimens with the diameter of 16 mm compared to that of 13mm increased by only 2.3%, there is no obvious effect of biggest diameter variation on its ability to drainage, but cycle-number of loading clogging of specimens with the size of 16 mm compared to that of 13mm is increased 48% on average, so PAC specimen with larger maximum nominal diameter has better counter-clogging ability.
- (4) The coarse gradation of PAC has stronger ability of drainage and counter-clogging. Asphalt type does not affect the PAC drainage and anti-clogging ability.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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