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The Influence of Short-Term Aging on Bitumen Properties

[1] Suleiman ArafatYero, [2] Mohd Rosli Hainin
[1, 2] Department ofGeotechnics/Transportation,
Fakulti Civil Enginnering, UniversitiTeknologi Malaysia,
81310 skudai, Johor Bahru, Malaysia.
[1] arafatyero@yahoo.com

ABSTRACT

The short-term aging properties of neat bitumen were investigated using the rolling thin film oven test (RTFOT) to simulate aging during mixing, compaction and laying of asphalt mixtures, though the actual time of short-term aging in the field varies depending on haulage distances or paving times. The empirical tests, which include penetration and softening points, were conducted to ascertain the binder consistency. The RTFOT was conducted at 163^{0}C for 70min, 85min, and 100min for bitumen 80/100-penetration grade. Results from the study indicated that aging resulted in oxidation of the bitumen with increase in the stiffness of the binder. It was observed that aging increased the viscosity, decreased the binder penetration and increased the softening point of the neat bitumen. The results from the study also indicated that the magnitude of the short-term aging depends on the binder source, and aging time, as with longer aging time, the binder hardness and viscosity increases, thereby decreasing the penetration and increasing the binder softening point.

Keywords: *Bitumen, aging, oxidation, penetration and softening point*

1. INTRODUCTION

The aging of bitumen is one of the principal factors causing the deterioration of asphalt concrete pavements. The aging modes of failures includes fatigue, thermal induce cracks, and raveling. In practice the actual time for short-term aging in construction sites varies and depends on hauling distances or paving delays [1]. There are two basic mechanisms involved in binder aging; these include an irreversible process like chemical changes of the bitumen, consisting of oxidation of bitumen molecules, and loss of volatile components which subsequently has an impact on the rheological properties of the binders. The reversible process is the second mechanism termed as physical hardening; this involves the reorganization of the binder molecular structure, under specific conditions [2].

Bitumen aging can be attributed to some factors these include the binder characteristics and it content in the mix, nature of aggregates and particle size distribution, air void content in the mix. Other factors include production related parameters such as temperature and time [3]. In this study the rolling thin film oven test (RTFOT) was used to simulate short-term aging during asphalt mix production at the plant. The RTFOT measures the effect of heat and air on a moving film of semi-solid asphaltic binder. The test temperature of 163^{0}C and time for the RTFO test is 85 min expected to produce aging effects comparable to average site conditions [4]

Also, aging in general increase the size distribution of the large binder molecules that results in the increase in viscosity and stiffness of the binder [5] . However, previous researches dealt with aging in neat binder and polymer modified binders, not much study has been conducted on the effect of short-term aging on bitumen 80/100 penetration grade, commonly used for Malaysian asphaltic pavements.

2. EXPERIMENTAL METHOD

2.1 Material

For this study, two different neat bitumens 80/100 penetration grades from unknown sources labeled as A and B were used for the study. Some physical-chemical characteristics of the bitumen used in this study is shown in Table 1 below:

Table 1: Bitumen characteristics

Test	ASTM	A	B
Penetration (dmm)	D5-97	85	93
Softening point (C)	D36-95	46	46.5

2.2 Short-Term Binder Aging

The different binder samples A and B were simulated and artificially aged at 163^{0}C for 85 mins using the rolling thin film oven test (RTFOT) in accordance with ASTM D 2872 (2006). For variability test, the same standard temperature for RTFOT was conducted at different additional time lags of 70 min and 100 min.

2.3 Penetration Test

The penetration grade of the neat bitumen samples were investigated before and after the simulation of short-term aging in the laboratory, in accordance with ASTMD5-97 specification,

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2.4 Softening Point Test

The softening point of the various test samples was determined using the ring and ball test in accordance to ASTM D36-95 specification, before and after the short-term aging of the binders.

2.5 Viscosity Test

The viscosity of bitumens A and B were measured before and after the simulation of the short-term aging, using the Brooks field viscometer; the equipment was used to measure the viscosity characteristics of the neat binders. The viscosities of each bitumen sample were tested at the standard temperature of 135°C and a shear rate of 6.8/s. This shear rate was selected because it conforms to the rotational speed of 20rpm with the Brookfield Spindle 27 recommended for Super pave (SHRP) (John Read and W. David, 2003).

3. RESULTS

Results from the study indicated a reduction in binder penetration for bitumen B as compared to A at low test temperatures; this could be attributed to different binder sources as could be seen in Table 2 below:

Table 2: Un aged bitumen penetration and softhening points

Binder type	Specific gravity	Penetration (dmm) @ 25°C	@ 10°C	Softening Point (°C)
A	1.030	85	46	46
B	1.030	93	49	46.5

Note: A and B are bitumen 80/100

From the study, the results indicated a decrease in penetration with aged binders as they become stiffer than unaged binders which results in increase in softening point of the binders as could be seen in Table 3 below:

Table 3: Aged bitumen penetration and softhening points

Binder type	Specific gravity	Penetration(dmm) @25°C	@10°C	Softening Point (°C)
A	1.030	73	38	49
B	1.030	75	39	49

The results obtained after investigating the RTFOT samples indicated that long aging time increases both viscosity and softening points, while the penetration for both binder A and B decreases, this could be attributed to the effect of longer aging time and oxidation of the binder molecules which hardens the binder as could be seen in Table 4 below:

Table 4: Aged bitumen penetration and softhening points at different time lag

Time (min)	Penetration @ 25°C (dmm)		Softening point (°C)	
	A	B	A	B
70	76	77	48	48
85	73	75	48.5	48
100	71	72	49	49

From the results the penetration of binder B is higher than binder A irrespective of the aging time; this indicates that binder penetration depends on its source as presented in Figure 1.

Fig 1: Binders penetration and time

The softening points (SP) for the aged binders increased, with the longer aging time producing higher softening point for both binder A and B as illustrated in Figure 2.

Fig 2: Softening point and time

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4. CONCLUSSION

The short-term aging of the bitumen used in asphalt concrete mixtures is said to take place during production of the mixtures at the plant. This study has indicated physical hardness of the binder after simulating the base bitumen to aging using RTFOT, reducing binder penetration and increasing softening points, the same trend was found for longer aging time. This indicates that aging depends on time and binder source as there was some slight difference in values for binder A and B. Aging increases the binder hardness, this could be attributed to the increase stiffness of the binder after the RTFOT.

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