ARPN Journal of Science and Technology

http://www.ejournalofscience.org

The Effect of Aging on Bitumen Properties Modified With Styrene-Butadiene-Styrene (SBS) Polymer

[1] Suleiman Arafat Yero, [2] Mohd. RosliHainin
[1, 2] Department of Geotechnics /Transportation,
Fakulti Civil, University Teknology Malaysia, 81310 skudai, Johor Malaysia.
[1] arafatyero@yahoo.com

ABSTRACT

The study investigated the aging properties of modified bitumen penetration grade PG 76-22 (binder). The aging was simulated using the rolling film oven (RTFOT) and pressure aging vessel (PAV) for short-term and long-term aging during production and lying of asphalt mixtures, though the actual time of long-term aging in the field varies depending on paving times and usage. The empirical tests, which include penetration and softening points, were conducted to ascertain the binder consistency and also the viscosity of the binder was investigated before and after aging. The RTFOT was conducted at 163^{0}C for 85min, and PAV for 20hrs. 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 modified bitumen. It could be concluded that aging increases hardness, thereby decreasing the penetration and increasing the binder softening point and viscosity.

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

1. INTRODUCTION

Aging in bitumen normally resulted from the weathering of the binder due to oxidation. 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 and long-term aging in construction sites varies and depends on hauling distances and period of pavement usage John, R., and W. David (2003). 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 .Xiaohu, L. and U. Issacsson (2002).

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 Edwards, Y. and U. Issacsson (2005). In this study the rolling thin film oven test (RTFOT) was used to simulate short-term aging and the pressure aging vessel (PAV). 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 Annual Book of ASTM Standards (2006)

The PAV was used to simulate long-term aging of bitumen binder that occurs during 5 – 10 years of in-service bituminous pavements Binard, C., Anderson, D., Lapalu, and L.,Planche, (2007). The PAV was used to age RTFOT residue. The PAV test provides an aged bitumen.PAV device consists of a cylinder of clean, dry compressed air with a pressure regulator, release valve, and a slow-release bleed valve was used to supply and regulate air pressure. The PAV is composed of stainless steel, which is able to operate under the pressure 2070 kPa and temperature conditions (90°, 100°, or 110°C) of the test. The vessel accommodates a sample rack on which ten sample pans can be placed for aging.

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 Arafat, S. Y., and M. Rosli, (2011) However, previous researches dealt with aging in neat binder and polymer modified binders, not much study has been conducted on the effect of long-term aging on bitumen 80/100 penetration grade, commonly used for Malaysian asphaltic pavements.

2. EXPERIMENTAL METHOD

a. Material

For this study, two different modified bitumen PG 76-22 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 are shown in Table 1 below:

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Table 1: Bitumen characteristics

Test	ASTM	A	B
Penetration (dmm)	D5-97	42	40.5
Softening point (^{o}C)	D36-95	61	63

b. 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.

c. Long-Term Aging Using Pave

The RTFOT residue were collected and placed in the PAV sample rack in accordance with ASTM D 6521 (2000). The PAV is preheated to the 100°C test temperature. When the PAV reaches within 2°C of the desired temperature, a pressure of 2070 kPa is applied using the valve on the air cylinder. After 20 hours, the air pressure is released slowly (over a period 8 – 10 min) using the bleed valve.

d. Penetration Test

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

e. 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 aging of the binders.

f. Viscosity Test

The viscosity of bitumen A and B were measured before and after the simulation of the short-term and long term-aging, using the Brookfield viscometer; the equipment was used to measure the viscosity characteristics of the binders. The viscosities of each bitumen sample were tested at the standard temperature of 135^{o}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 and increase in softening point after aging of both bitumen A and B after aging, as presented in Table 2 below:

Table 2: Aged bitumen penetration and softhening points

Binder type	Specific gravity	Penetration (dmm) @ 25^{o}C @ 10^{o}C		Softening Point (^{o}C)
A	1.030	43.5	22	62.5
B	1.030	41.5	19.5	64

Note: A and B are bitumen PG 76-22

The results obtained after investigating the RTFOT and PAV 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 3 below:

Table 3: Aged bitumen penetration and softhening points at different time lag

Time (min)	Penetration @ 25^{o}C (dmm)		Softening point (^{o}C)	
	A	B	A	B
70	43	41	60	61.5
85	42	40.5	61	63
100	41	40	63.5	64.5

The results from the penetration tests indicated decrease in penetration for both bitumen A and B as with increase in aging time period as illustrated in Figure 1.

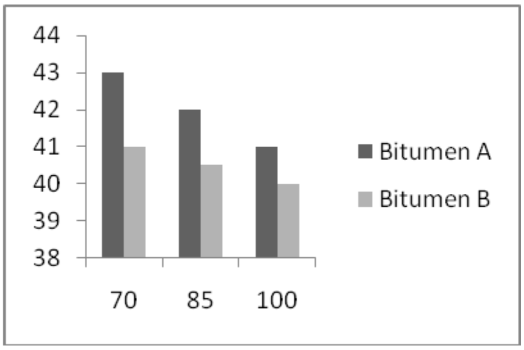

Fig 1: Binders penetration and time

Also there was an increase in softening points of both binders with time indicating aging influences softening point as presented in Figure 2.

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

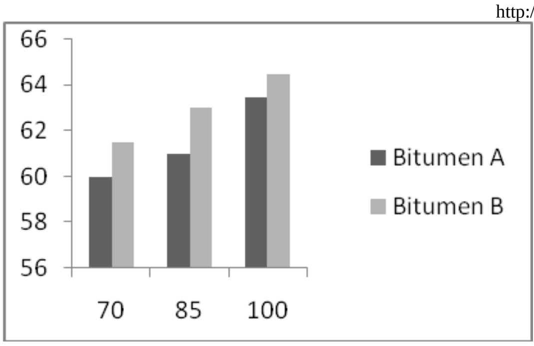

Fig 2: Binders softening point and time

Results from the study indicated that long-term aging increases the binder viscosity and this could be attributed to the increase hardness of the bitumen after RTFO and PAV test conducted on binders A and B, as presented in Table 4.

Table 4: Bitumen Viscosity at 135^{o}C

Des	Binder A		Binder B	
	Before PAV	After PAV	Before PAV	After PAV
Cp	2355	2750	2400	2650
SS	160.2	187.0	163.3	180.2
SR	6.8	6.8	6.8	6.8
T %	2.3	2.7	2.4	2.6

The viscosity trend for bitumen A indicated increase in kinematic viscosity due to aging as illustrated in Figure 3.

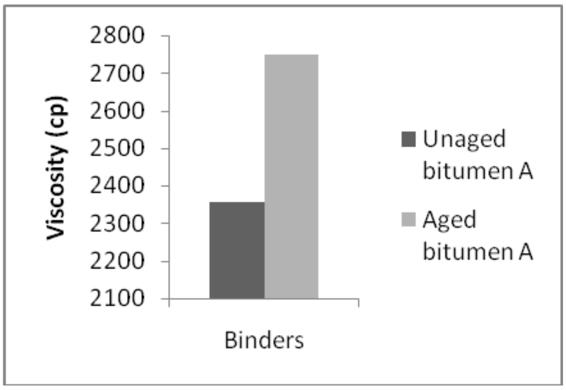

Fig 3: Viscosity trend of bitumen A

There is an increase in viscosity after aging of bitumen B as presented in Figure 4.

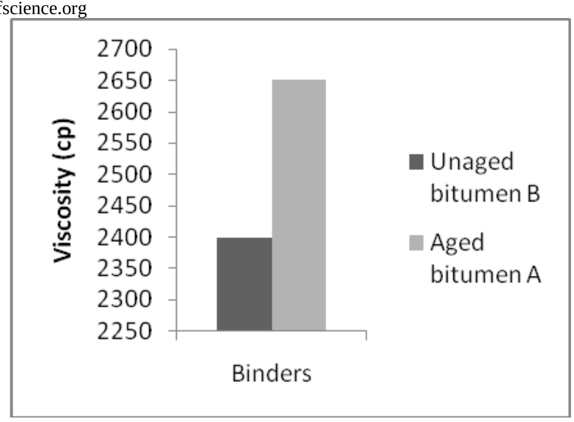

Fig 4: Viscosity trend of bitumen B

4. CONCLUSSION

The study indicated physical hardness of the binder after simulating the base bitumen to aging using RTFOT and PAV, reduces binder penetration and increases softening points. This indicates that aging depends on time and binder source as there was some slight difference in values for binder P and Q. The increase in RTFO test time indicated hardening of the binder. The long term aging increases the binder high temperature viscosity; this could be attributed to the increase stiffness due to binder oxidation. It can be concluded that aging affects the bitumen properties.

ACKNOWLEDGEMENT

The study was carried out in the of Highway and Transportation laboratory, Faculty of Civil Engineering, UniversitiTeknologi Malaysia (UTM), and all involved in the study are acknowledged.

REFERENCES

[1] John, R., and W. David (2003). The Shell Bitumen Handbook, ISBN 0- 7277-3220-X, Pp47-156.

[2] Xiaohu, L. and U. Issacsson (2002). Effect of aging on bitumen chemistry and rheology. J. const. And building Mat., 16:15-22.

[3] Edwards, Y. and U. Issacsson (2005). Influence of commercial waxes on bitumen aging properties. J. Energy and fuel. 19: 2519-2525.

[4] Annual Book of ASTM Standards: Road and Paving Materials, Traveled Surface Characteristics, American Society for Testing and Materials (2006), Vol. 04.03.

[5] Suleiman A. and Mohd R. H 2012, Bitumen characterization and warm stone mastic asphalt, PhD Thesis, UTM.

ARPN Journal of Science and Technology

http://www.ejournalofscience.org

[6] Binard, C., Anderson, D., Lapalu, L. Planche, and J., P."Zero Shea Viscosity of Modified and Unmodified Binders"3rdEurasphalt & Eurobitume Congress Vienna (2004) – Paper 236, 1721-1733.