World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:7, No:2, 2013

Evaluate Aging Effect of SBS Modified Bitumen

Seyed Abbas Tabatabaei

***Abstract*—**One of the important factors of cracks on the asphalt pavements is bitumen aging that associated with the loss of volatile components and oxidation of asphalt binder. This paper is about effect of Styrene-Butadiene-Styrene (SBS) polymer on asphalt aging In order to decrease asphalt aging effects. For this purpose samples of base bitumen and SBS modified bitumen aged according to the rolling thin film oven test (RTFOT) and pressure aging vessel (PAV), respectively. Properties of each sample were evaluated using Fourier Transform Infrared (FTIR) spectroscopy, n-heptane precipitation, viscosity test, softening point test and penetration test. FT-IR Analysis, showed lower oxidation of SBS modified bitumen than base bitumen, after aging.

***Keywords*—**SBS, Asphalt aging, modified bitumen.

I. Introduction

TODAY the application of modified polymer bitumen has been expanded in road construction industry. This is due to the considerable effect of polymer in optimizing the application of bitumen and increased durability of pavements.

Limited numbers of polymers are used as bitumen modifiers such as Ethylene-vinyl-acetate (EUA) poly-ethylene (PE) Styrene Butadiene (SPE) and Styrene-Butadiene-Styrene (SBS) which can be considered among the types of most applicable polymers bitumen modifiers is the SBS polymer which due to the following characteristics is considered as the most applicable polymers [1].

1- Increased elasticity
2- Decreased heat sensitivity
3- Increased viscosity
4- Increased adhesion

II. Expression of Research

Cracks in asphalt pavements are generally classified into two groups

1- Cracks in low heats
2- Cracks resulting from fatigue

One of factors which have an important role in both kinds of cracks in paving surfaces is the aging of bitumen [2].Aging causes the cracks in low heats. Laboratorial results show that aging will cause increased aging resulting from fatigue [3].

Based on studies carried out one method of decreasing aging effects is to modify bitumen by means of polymer [4].

III. History

In year 1990 laboratorial studies have showed that elastic return in modified polymer bitumen SBS in comparison with bitumen is very high [5]. In year 1997 Australian road construction society reported that even small amount of SBS in bitumen will cause increased elastic return, softening point, viscosity and adhesion of bitumen [1]. In year 2001, 3 kinds of bitumen, modified with polymer SBS and modified with SBS polymer have been compared. Although all 3 kinds have the same applicability, the modified bitumen in comparison to bitumen shows more strength against fatigue and rutting [6].In 2007 a research around the effect of SBS polymer in hot mix asphalt on the amount of cracks has been studied [7].In 2002 the effect of different amounts of SBS morphology of bitumen has been considered and come to this conclusion that rheology characters of bitumen by increasing SBS range will be improved. Also the improvement of geologic characters of bitumen is not suitable to the increased range of SBS polymer [8]. In 1998 the aging effects in modified bitumen by SBS polymer have been studied. The results of DMA test have showed that a viscoelastic characteristic of polymer bitumen after aging is better than bitumen after aging. Also on the basis of FT-IR test, the oxidized range after aging in modified bitumen by SBS polymer is less than bitumen.

IV. Laboratory Studies

A. Degree of Penetration

Test results of penetration degree based on standard ASTM D55 for pure modified bitumen by SBS polymer before and after aging by methods RTFOT and PAV in Tables I and II have been demonstrated.

TABLE I
Results of Penetration Degree for Bitumen before and after Aging

	penetration degree (dmm) of 1st Sample	penetration degree (dmm) of 2nd sample	penetration degree (dmm) of 3rd sample	Average of penetration degree (dmm)
Before aging	67	65	68	66
After RTFOT	43	43	41	42
After PAV	15	17	16	16

TABLE II
Results of Penetration Degree for Modified Bitumen by SBS before and after Aging

	penetration degree (dmm) of 1st Sample	penetration degree (dmm) of 2nd sample	penetration degree (dmm) of 3rd sample	Average of penetration degree (dmm)
Before aging	34	33	32	33
After RTFOT	28	26	27	27
After PAV	15	15	16	15

Seyed Abbas Tabatabaei, Associate Professor, Shahid Chamran University of Ahvaz - (phone: +98-611-3330011~17 (ext. 5652); fax: +98-611-3336642; e-mail: tabatabaei-s@scu.ac.ir).

The results gained from Tables I and II show that before aging, the penetration degree of modified bitumen by polymer SBS is less than bitumen. In all samples of bitumen and modified bitumen by SBS polymer, the penetration degree after aging will be decreased. The decrease of penetration degree after aging either in method RTFOT or in PAV for bitumen is more in than modified bitumen by SBS polymer

B. Softening Point

Test results of softening point on ASTM D3678 standard for two kinds of bitumen and modified bitumen by SBS before and after aging has been presented in Table III.

TABLE III
RESULTS OF SOFTENING POINT FOR BITUMEN AND MODIFIED BITUMEN BY SBS BEFORE AND AFTER AGING

	Softening Point (°C) of bitumen	Softening Point (°C) of modified bitumen by SBS
Before Aging	49	64
After RTFOT	53	65
After PAV	59	70

C. Study of Thermal Sensitivity, the Index of Penetration, Viscosity, Sediment Survey of Bitumen by Normal Hptal and Absorbing the Infrared Spectrum (FT-IR)

Test and studies on the initial bitumen and modified one by polymer have been carried out and test results in have been presented in Tables IV - XII. The study of all Tables IV - XII show that polymer bitumen has the following advantages toward the initial bitumen. Thermal sensitivity: the thermal sensitivity of bitumen is more than the modified bitumen by polymer SBS. The thermal sensitivity will be increased after aging in polymer bitumen.

D. Penetration Index

This index will be decreased after aging. The penetration index in modified bitumen by SBS polymer is greater than bitumen.

E. Viscosity

Viscosity after aging is increased. Initial viscosity in modified bitumen by SBS polymer is greater than bitumen. A viscosity change in logarithmic scale for bitumen is more than modified bitumen by SBS polymer.

F. Bitumen Sediment Test by Normal

The percentage of asphalt after aging is increased. The percentage of asphalt in modified bitumen for bitumen after short period aging by method RTFOT and after long time aging by method PAV is more than the modified bitumen by SBS polymer.

G. Absorption of Infrared Spectrum (FT-IR)

After aging carbonyl and Oxide Sulphate has been increased. Increase of carbonyl index and Oxide Sulphate range after RTFOT and PAV in bitumen is more than modified bitumen or SBS. The range of Styrene index before and after aging has been without any change. We can conclude that destruction of SBS polymer construction has not been considerable after aging. Results of experiments are shown in Fig. 1 to 6 and Table XI and XII.

TABLE IV
AMOUNT OF THERMAL SENSITIVITY FOR BITUMEN BEFORE AND AFTER AGING

	Softening Point (°C)	penetration degree (dmm)	thermal sensitivity (A) × 1000
Before Aging	49	66	45.1
After RTFOT	53	42	45.7
After PAV	59	16	50.0

TABLE V
AMOUNT OF THERMAL SENSITIVITY OF MODIFIED BITUMEN BY SBS BEFORE AND AFTER AGING

	Softening Point (°C)	penetration degree (dmm)	thermal sensitivity (A) × 1000
Before Aging	64	33	35.5
After RTFOT	65	27	36.8
After PAV	70	15	38.4

TABLE VI
PENETRATION INDEX OF BITUMEN BEFORE AND AFTER AGING

	thermal sensitivity (A) × 1000	Penetration index (PI)
Before Aging	45.1	-0.78
After RTFOT	45.7	-0.87
After PAV	50.0	-1.43

TABLE VII
PENETRATION INDEX OF MODIFIED BITUMEN BY SBS POLYMER BEFORE AND AFTER AGING

	thermal sensitivity (A) × 1000	Penetration index (PI)
Before Aging	35.5	0.81
After RTFOT	36.8	0.57
After PAV	38.4	0.27

TABLE VIII
VISCOSITY (PA.S) FORBITUMEN AND MODIFIED ONE BY SBS POLYMER BEFORE AND AFTER AGING

	Bitumen	modified bitumen by SBS
Before Aging	0.37	1.39
After RTFOT	0.60	1.92
After PAV	1.22	3.25

TABLE IX
PERCENTAGE OF ASPHALTENE OF BITUMEN BEFORE AND AFTER AGING

	Amount of Bitumen (mgr.)	Amount of Alluvium (mgr.)	Percentage of Asphaltene	Percentage of Maltn
Before Aging	125	19	15.2	84.8
After RTFOT	107	20	18.7	81.3
After PAV	117	31	2635	73.5

TABLE X
PERCENTAGE OF MODIFIED BITUMEN ASPHALTENE BY SBS POLYMER BEFORE AND AFTER AGING

	Amount of Bitumen (mgr.)	Amount of Alluvium (mgr.)	Percentage of Asphaltene	Percentage of Maltn
Before Aging	104	21	20.2	79.8
After RTFOT	113	25	22.1	77.9
After PAV	98	27	27.5	72.5

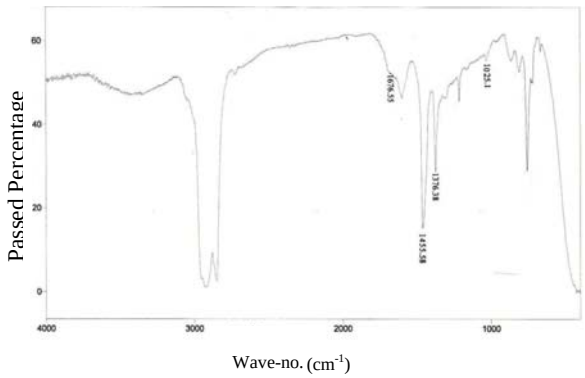

Fig. 1 IR absorption spectra for bitumen before aging

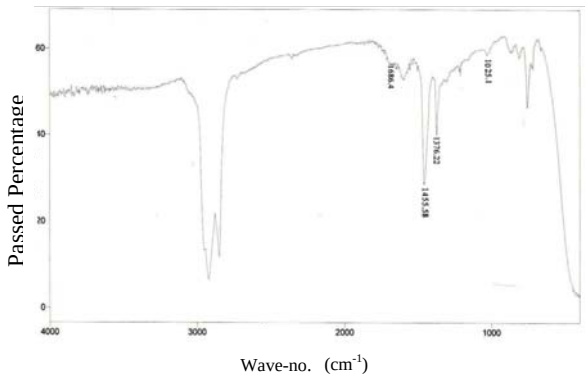

Fig. 2 IR absorption spectra for bitumen after aging according to RTFOT method

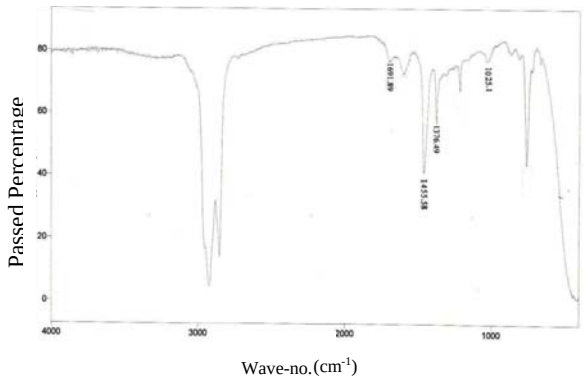

Fig. 3 IR absorption spectra for bitumen after aging according to PAV method

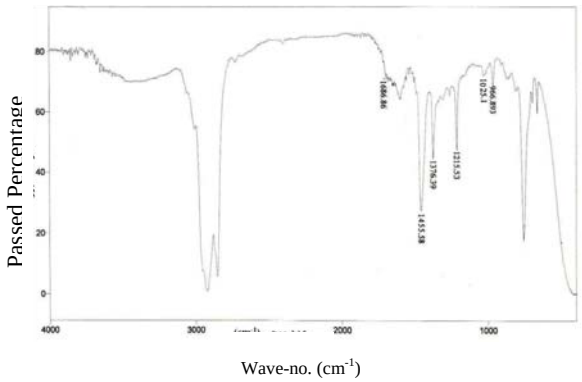

Fig. 4 IR absorption spectra for modified bitumen by SBS before aging

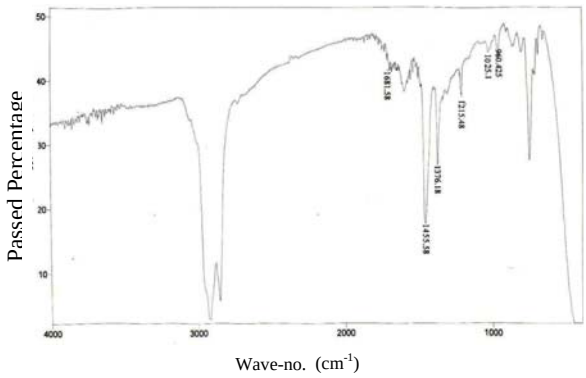

Fig. 5 IR absorption spectra for modified bitumen by SBS after aging according to RTFOT method

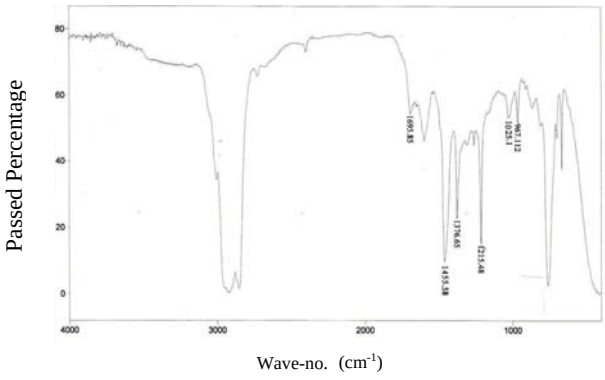

Fig. 6 IR absorption spectra for modified bitumen by SBS after aging according to PAV method

TABLE XI
AMOUNTS OF STRUCTURES INDEX FOR BITUMEN BEFORE AND AFTER AGING

	Carbonyl Index	Oxide Sulphate Index	Sum of Carbonyl and Oxide Sulphate Indexes
Before Aging	0.000	0.033	0.033
After RTFOT	0.051	0.056	0.107
After PAV	0.085	0.121	0.206

TABLE XII
AMOUNTS OF STRUCTURES INDEX FOR MODIFIED BITUMEN BY SBS POLYMER BEFORE AND AFTER AGING

	Carbonyl Index	Oxide Sulphate Index	Styrene Index	Sum of Carbonyl and Oxide Sulphate Indexes
Before Aging	0.000	0.039	0.079	0.039
After RTFOT	0.032	0.051	0.080	0.083
After PAV	0.065	0.094	0.077	0.159

V. CONCLUSION

Studies in these researches show the following results;

Survey of laboratory tests of softening point, penetration degree and viscosity show that the increase of SBS polymer to bitumen will cause improvement of geologic characters of bitumen including decrease of bitumen thermal sensitivity, softening point and penetration index and decrease of penetration degree.

Comparison before and after aging in each kind of two bitumen and modified one by SBS show that aging will cause increased softening point and viscosity as well as decrease of penetration degree.

After aging the range of structure of Asphaltene in bitumen will be increased and range of this increase after a long time aging will be higher.

Aging causes oxidation of bitumen and forms the carbonyl and Oxide Sulphate structures in bitumen.

Aging in modified bitumen by SBS has been less than bitumen.

REFERENCES

[1] Y. Yildirim, 'Polymer modified asphalt binders', Construction and Building Materials, Vol. 21, pp. 66-72, 2007.
[2] X. Lu, U. Isacsson, 'Effect of aging on bitumen chemistry and rheology', Constructio and Building Materials, Vol. 16, pp. 15-22, 2002.
[3] T.Xiaoge, Z. Jianlong, Z. Qisen, 'Effect of aging on viscoelastic performance of asphalt binder', Proceeding of the 23rd Southern African Transport Conference, Pretoria, South Aferica, 12. 15 July, 2004.
[4] W. J. Woo, E. Ofori-Abebresse, A. Chowdhury, J. Hilbrich, Z. Kraus, A. E. Martin, C. J. Glover, 'Polymer modified asphalt durability in pavement', Project 0-4688, Texas Transportation Institute, Texas 77843-3135, 2006.
[5] C. P. Valkering, W. Vonk, 'Thermoplastic rubbers for the modification of bitumens: Improved elastic recovery for high deformation resistance of asphalt mixes', Proceedings of 15th Australian Road Research Board Conference, Vermont South, Australia, 1990.
[6] S. M. Sargand, S. S. Kim, 'Performance evaluation of polymer modified and unmodified superpave mixes', Second International Symposium on Maintenance and Rehabilitation of Pavements and Technological Control, Auburn, 2001.
[7] S. Tayfur, H. Ozen, A. Aksoy, 'Investigation of rutting performance of asphalt mixtures containing polymer modifiers', Construction and Building Materials, Vol. 21, pp. 328-337, 2007.
[8] J. S. Chen, M. C. Liao, M. S. Shiah, 'Asphalt Modified by Styrene-Butadiene-StyreneTriblock Copolymer: Morphology and Model', Journal of Materials in Civil Engineering, Vol. 14, Mo. 3, pp. 224-229, 2002.