

ZAGING OF BITUMEN PAVEMENT A REVIEW

Md Jamshed Ali, Shashikant B. Dhobale

PG Scholar, Jawaharlal Institute of Technology, Borawan, Khargone, Madhya Pradesh, India

Professor, Jawaharlal Institute of Technology, Borawan, Khargone, Madhya Pradesh, India

Abstract--Age hardening of bitumen has long been professed as one of the main factors that can significantly affect the durability of bituminous paving materials. When the bitumen is age hardened, the asphalt mixture will become brittle and its ability to support traffic-induced stresses and strains may significantly decrease. Deterioration of the pavement by readily-induced cracking may follow. In addition, excessive hardening can also weaken the adhesion between the bitumen and aggregate, resulting in loss of materials at the surface layer and generate weakening of the asphalt mixture. It is generally agreed that ageing is primarily associated with bitumen oxidation and the loss of volatile/oily components from the bitumen to the air and/or aggregates during asphalt mixture production (short-term ageing) and in-place service period (long-term ageing). Both factors cause an increase in viscosity (or stiffness) of the bitumen and consequential stiffening of the asphalt mixture.

In the present research work, study on different research papers is carried out to examine the effect of aging on bitumen binder using different filler materials. In terms of effect of filler materials on bitumen aging, studies have shown that the modified bitumen binder has less effect of aging than the neat bitumen.

INTRODUCTION

Bitumen is manufactured from crude oil. Bitumen is extractive as the last residue from fractional distillation of crude petroleum. Crude petroleum is different molecular weights. In the petroleum refineries the individual components like LPG, naphtha, Kerosene, Diesel etc. are separated through the process of fractional distillation. The heaviest material Obtained from the fractional distillation process is further treated and blended to make different grades of paving grade bitumen. The selection of the appropriate crude is cannot control actual bitumen output it also required adopting varying processes in the refinery. The choice of process would depend on the availability of suitable crude, demand of the end products and total commercial viability of the complete refining process (H.P. Bitumen Handbook).

The function of asphalt pavements (Bjorn Ove Lerfald, 2000) on any given road can be defined as:

1. The roof of the road construction, preventing moisture from penetrating into the construction.
2. A riding surface for the traffic and the users of the road.
3. A structural layer in the construction.

The functional quality of an asphalt pavement will vary, depending on traffic volume. For high volume roads, rutting resistance will be most important, especially to withstand wear from studded tires. These roads have to be resurfaced after few years due to rutting. Pavements on low volume roads will serve for many years before resurfacing, and important properties for these pavements are flexibility and low temperature capacity. The overall long term pavement performance is important for low volume roads.

In spite of the fact that binder content in asphalt pavement is about 5-7 percent by weight, the binder has a great influence on pavement performance. There are arguments for and against using hard or soft binders, and modified or unmodified binders. The choice is complicated due to the fact that binder properties are altered during production and with time in the pavement. This change is called ageing.

To be able to choose the right binder and asphalt mix, it is necessary to know how binder properties change under production and over time under real condition (traffic load, climate, temperatures, etc.) and over time under real condition (traffic load, climate, temperatures, etc.).

II.

Following are the objectives of study:-

1. To workout effect of aging on softening point of neat bitumen and modified bitumen samples.
2. To workout effect of aging on viscosity of neat bitumen and modified bitumen samples.
3. To workout effect of aging on Penetration value of neat bitumen and modified bitumen samples.
4. To workout effect of aging on Rheological properties of neat bitumen and modified bitumen samples.
5. To workout effect of aging on neat bitumen and modified bitumen samples.

III. BASIC ASPECTS.

Some basic aspects of bitumen and filler are following:

Bitumen

1.1 Bitumen is defined as "A viscous liquid, or a solid consisting essentially of hydrocarbons and their derivatives, which is soluble in tri-chloro-ethylene and is substantially non-volatile and softens gradually when heated. It is black or brown in colour & possesses waterproofing and adhesive properties. It is obtained by refinery processes from petroleum, and is also found as a natural deposit or as a component of naturally occurring asphalt, in which it is associated with mineral matter (H.P. Bitumen Handbook).

1.1.1 Types of Bitumen

Bitumen or bituminous binder available in India is mainly of the following types:

- a) Penetration grade
- b) Industrial Grade Bitumen
- c) Cutback
- d) Bitumen Emulsion
- e) Modified Bitumen
- f) Viscosity Grade Bitumen

1.1.2 Tests on Bitumen

The tests carried out on Bitumen are following:

- 1) Penetration test (IS: 1203-1978)
- 2) Softening point test (IS: 1205-1978)
- 3) Viscosity test (IS: 1206-1978)

1.2 Filler

Filler is a fine material which passes a 0.063mm sieve derived from aggregate or other similar granular material (Recasens, 2005). Filler is an important part of the asphalt mixture and historically many early investigations on filler materials have been conducted.

1.2.1 Function of filler

Filler plays a vital role in Bitumen mix. It fills the voids of bituminous mix. It is helpful during compaction. The proper compaction can be achieved. It helps in making the binder stiffer and helpful in moisture resistance.

1.2.2 Characteristics of filler

Characteristics of filler (Bjorn Ove Lerfald, 2000) given by Miller and Traxler are following:

1. Primary feature of elementary significance: particle size, size distribution, shape.
2. Primary mineralogical characteristics of less importance: texture, hardness, strength, specific gravity, wettability.
3. Secondary characteristics dependent on one or more primary characteristics: void content, average void diameter and surface area.

1.2.3 Effects of adding filler to Bitumen

Effects of filler on bitumen (Bjorn Ove Lerfald 2000) given by Anderson are following:

- Makes the binder stiffer.
- Extend the bitumen.
- Improves moisture resistance.
- Reduces bitumen ageing.
- Influence the mix workability and compaction

effort.

1.2 Aging of Bitumen

Bitumen, like any organic matter, is affected by factors like presence of oxygen, ultraviolet rays and changes in temperature. These factors are responsible for hardening of bitumen. Hardening results in decrease in penetration increase in softening point and increase in penetration index (PI). For increased life of bituminous pavement it is essential that excessive hardness does not take place (H.P. Bitumen Handbook).

1.3.1 Factors affecting aging

Traxler (1963) identified 15 different factors which may affect the chemical, rheological and adhesion characteristics of bitumen. Some of these effects were proved by Traxler with experimental data. However it is noted that some of those listed had not been given experimental consideration.

1.3 Aging Tests for Bituminous Materials

The tests carried out on Bitumen for aging are following:

- i) Thin Film Oven Test (TFOT) (ASTM D 1754 -76)
- ii) Rolling Thin Film Oven Test (ASTM D 2872)
- iii) Pressure Aging Vessel Test (AASHTO PP1)

2.0 LITERATURE REVIEW

- In year 1978 **Craus et al.**
- evaluated the influence that the type of filler had on durability of bituminous mixers.

- In year 1990, **C. P. Valkering et al.** have showed that elastic return in modified polymer bitumen using SBS has high than neat bitumen.
- In year 1998 **Petersen et al.** had carried out research work, using RTFOT named thin film accelerated aging test, Strained to enumerate how the addition of filler might benefit the reduction of hardening by age and improve the properties of flow at low temperatures.
- In year 2002, **Chen et al.** the effect of different quantity of SBS of bitumen has been considered and come to this result those rheology characters of bitumen by increasing SBS range will be improved.
- In year 2003, **Mehraz et al.** carried out experiments to study the effects of three different rubber concentrations (3%, 9%, and 15%). According to this study after a rolling thin film oven test, the unmodified bitumen showed an improvements of about 1.5 times in G^* value, and in rubberized, the samples with 3% and 9% rubber showed an increase of about 2.5 times, the sample with 15% rubber showed an increase of about 1.5 times compared to their original unaged values. Further research works are also carried out using different filler materials are following.
- **Mahrez, Karim (2003)** Carried out research work on "Rheological evaluation of aging properties of rubber crumb modified bitumen." Used 80/100 penetration grade bitumen and CR as filler. Carried out DSR method for properties of aged and unaged bitumen binder. Carried out TFOT, RTFOT and PAV tests for aging.
- **Recasens Martinez, Jimenez, Bianchetto (2005)** Carried out research work on "Effect of filler on aging potential of asphalt mixtures." Used 80/100 penetration grade bitumen and hydrated lime and calcium carbonate as filler. Carried out Viscosity test, Penetration test and Softening Point test method for properties of aged and unaged bitumen binder. Carried out the Universal de Caracterización de Ligantes method for aging and a new direct tensile test was used to determine the toughness of the aged mixture and, thus, to assess the effect the filler has. In this research work it is shown that effect that filler has on the aging of bitumen was analysed but with the filler being integrated by volume, not by weight. The direct tensile test developed by the Road Research Laboratory of the Technical University of Catalonia permits observation of how an increase in filler produces an increase in the breaking load and a decrease in the maximum deformation.
- **Bianchetto, Miro, Perez-jimenez, Martinez (2007)** Presented a paper on "Effect of calcareous fillers on bituminous mix aging." Used 70/100 penetration grade bitumen and hydrated lime and calcium carbonate as filler. Carried out DSR method for properties of aged and unaged bitumen binder. Carried out the Universal de Caracterización de Ligantes tests for aging.
- **Pilat, Krol (2008)** Presented a paper on "The evaluation of aging process of the polymer modified bitumen by image analysis." Used 50/70 penetration grade bitumen and SBS elastomers as filler. Carried out Softening point, Penetration, Elastic Recovery test and Dynamic Viscosity test method for properties of aged and unaged bitumen binder. Carried out TFOT and PAV tests for aging. Microstructural changes of polymer dispersion were tested using fluorescent microscopy.
- **A. A. Mohamed, Husaini Omar, M.O.Hamraz, H. ismail (2009)** Presented a paper on "Rheological Properties of crumb rubber modified bitumen containing antioxidant." Used 80/100 penetration grade bitumen and CR30 as filler. Carried out DSR method for properties of aged and unaged bitumen binder. Carried out TFOT tests for aging.
- **Yero, RosliHainin (2012)** Presented paper on "Effect of aging on bitumen properties modified with SBS polymer." Used 76-22 penetration grade bitumen and SBS as filler. Carried out Viscosity test, Penetration test and Softening Point test methods method for properties of aged and unaged bitumen binder.
- **Seyed Abbas Tabatabaei (2012)** presented a paper on "Evaluate aging effect of SBS modified bitumen." Used 70/100 penetration grade bitumen and SBS as filler. Carried out FTIR, Viscosity test, Penetration test and Softening Point test methods for properties of aged and unaged bitumen binder. Carried out RTFOT and PAV tests for aging.
- **Manindersingh, Praveenkumar (2012)** Carried out research work on "Laboratory study on bitumen modification for improved physical, rheological properties and the effect of short term aging." Used 60/70 penetration grade bitumen and EVA, SBS and CR as filler. Carried out DSR method for properties of aged and unaged bitumen binder penetration test and softening point for physical properties. Carried out TFOT tests for aging.
- **AsimHassain Ali, Nuha S. Mashaan, Mohammed Rehan Karim (2012)** Presented a paper on "Investigation on aging resistance of rubberized bitumen binder." Used 80/100 penetration grade bitumen and CR as filler. Carried out DSR method for properties of aged and unaged bitumen binder. Carried out RTFOT and PAV tests for aging.

- **In year 2003, Mahrez and Rehan** evaluated the effects of three different rubber concentrations (3%, 9%, and 15%). According to this research work the unmodified bitumen showed an improvement of about 1.5 times in G^* value after a rolling thin film oven test (RTFOT). This study has shown that G^* value an increase of about 2.5 times in the rubberized sample with 3% and 9% rubber, and the sample of 15% rubber showed an increase of about 1.5 times compared to their original unaged values.
- **In year 2007, Bianchetto, Miro, Perez-jimenez, Martinez** carried out research work on "Effect of calcareous filler on bituminous mix aging." In this study hydrate lime and calcium carbonate used as a filler material and 70/100 penetration grade bitumen as a binder. DSR method carried out for properties of aged and unaged bitumen binder and also carried out the Universal de Caracterización de Ligantes tests (UCL) for aging.
- **Yero et al. Presented paper in year 2012** on "Effect of aging on bitumen properties modified with SBS polymer." In this study used 76-22 penetration grade bitumen and SBS as filler. Viscosity test, Penetration test and Softening Point test method for properties of aged and unaged bitumen binder is carried out. The aging was simulated using the rolling film oven (RTFOT) and pressure aging vessel (PAV) for short-term and long-term aging.
- **In year 2012, Seyed Abbas Tabatabaei** presented a paper on "Evaluate aging effect of SBS modified bitumen." In this study used 70-100 penetration grade bitumen and SBS as filler. Carried out Fourier Transform Infrared (FTIR) spectroscopy, Viscosity test, Penetration test and Softening Point test methods for properties of aged and unaged bitumen binder. Bitumen and SBS modified bitumen aged according to the rolling thin film oven test (RTFOT) and pressure aging vessel (PAV), respectively.
- **In year 2012, Maninder Singh et al.** presented paper on "Evaluating the Effect of Polymer Modification on Physical and Rheological Properties of Conventional Bitumen" In this paper VG30 bitumen and two polymers: Styrene Butadiene Styrene (SBS) block copolymer and Ethylene Vinyl Acetate (EVA) polymers were used as modifiers. Carried out DSR method, Viscosity test, Penetration test for physical properties of aged and unaged bitumen binder. Also carried out thin film oven test (TFOT) for short term aging.
- **Pada Sabtu, (2010)** compared properties of the modified bitumen were compared with ordinary bitumen. It was observed that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic

additive, up to 12 % by weight. The softening point of the modified bitumen increased with the addition of plastic additive, up to 8.0 % by weight. Studies were carried out on Bituminous mixes using 60/70 grade bitumen having average Marshall Stability Value (MSV) of 1300 kg at optimum bitumen content of 5.0 % by weight of the mix.

3.0 PROPOSED METHODOLOGY

a) Stripping Value Test

The stripping value of aggregates is determined as the ratio of the uncovered area observed visually to the total area of aggregates, expressed as a percentage.

b) Penetration Test

The penetration values of different sample is evaluated at laboratory before and after aging in accordance with IS:1203-1978.

c) Softening Point Test

The softening point of the various test samples is obtained using the ring and ball test in accordance to IS: 1205-1978, before and after aging.

d) Viscosity Test

The viscosity of samples is determined using Cannon-Manning vacuums viscometer before and after aging. The test was conducted at the temperature of 60°C as per IS: 1206(part-2)-1978.

4.0 EXPECTED OUTCOMES

The bitumen modified using different material like SBS, CR, Hydrated lime, Calcium carbonate, EVA etc. resist the effect of aging. Mahrez et al. concluded that the use of CR reduced the aging effect on rheological properties of the bitumen binder. Aging index was taken for evaluating and characterizing the aging properties of rubberised bitumen. It was found that in all binders the aging index is observed to be greater than one, which indicates hardening of these binders. Recasens et al. concluded that the hydrated lime tends to stiffen the mixture less and make it less brittle than does calcium carbonate. The filler content proposed must be 20% or 30% less than the content recommended to minimize the effect of aging on bitumen in conditions where there is no aging. Bianchetto et al. concluded that the use of hydrated lime and calcium carbonate as filler reduced the aging effect on rheological properties of the bitumen binder. Pilat et al. concluded that Viscoelastic properties of road bitumen are improved by means of SBS elastomers modification. It is good to replace a part of the elastomer with a linear particle for modifying road bitumen with a branched particle elastomer. It can be seen that Binders with a branched particle show increased resistance to the ageing processes. They have lower temperature sensitivity and lose the properties slower in

comparison to bitumen modified with a linear particle polymer only.

Mohamed et al. concluded that the use of CR30 reduced the aging effect on rheological properties of the bitumen binder than neat bitumen. Yero et al. Concluded that Modified bitumen with SBS show greater resistance to aging than neat bitumen. Seyed Abbas Tabatabaei concluded that the use of SBS bitumen binder reduced the aging effect on physical properties of the bitumen binder. FTIR result shows 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 base bitumen. Manindarsingh et al. concluded that the use of EVA, SBS and CR binder reduced the aging effect on rheological and physical properties of the bitumen binder.

REFERENCES

[1] Asim Hassan Ali, Nuha S. Mashaan, Mohamed Rehan Karim (2012) "Investigation on aging resistance of rubberized bitumen binder", International Journal of Environment and bioenergy, Florida, USA.

[2] Maninder Singh, Praveen Kumar (2012) "Laboratory study on bitumen modification for improved physical, rheological properties and the effect of short term aging", 25th ARRB Conference, Perth, Australia.

[3] Seyed Abbas Tabatabaei (2012)" Evaluate aging effect of SBS modified bitumen", World academy of science, Engineering and technology 72.

[4] Suleiman Arafat Yero, Mohd. Roslihainin (2012) "The effect of aging on bitumen properties modified with Styrene-Butadiene-Styrene (SBS) Polymer", ARPN journal of science and technology, Vol 2, No 7.

[5] A.A.Mohamed, Husani Omar, M.O.Hamzah, H.Ismail (2008) "Rheological properties of crumb rubber modified bitumen containing antioxidant", the Arabian journal for science and engineering, Volume 34, No 18.

[6] Jerzy Pilat, Jan Krol (2008) "The evaluation of aging process of the polymer modified bitumen by image analysis." Foundation of civil and environmental engineering.No. 11, publishing house of Poznan University of technology, Poznan, 2008.

[7] Bianchetto, Miro, Perez-jimenez, Martinez (2007) "Effect of calcareous fillers on bituminous mix aging." Transportation Research Board.