EVALUATION OF BITUMEN PROPERTIES MODIFIED WITH ADDITIVE

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ABSTRACT
The study investigated the characteristics of bitumen 60/70 and 80/100 penetration grade modified with a commercial additive Sasobit wax, a long chain aliphatic hydrocarbon (LCAH). This additive is obtained from coal gasification using the Fischer-Tropsch process. Bitumen is thermo-visco-elastic material where temperature and rate of load application have a great influence on their performance. The neat binders lack the proper viscous-elastic balance required in asphalt mixture. Tn the study an additive Sasobit wax with high molecular weight was used to enhance the bitumen performance. In this the fundamental rheological and mechanical tests were conducted, which include penetration test, softening point, viscosity test, the rolling thin film oven test (RTFOT), and pressure age vessel (PAV). The trend is with an increase in additive the binder viscosity decreases at high temperature as it stiffens and becomes hard at low temperature, thereby increasing the softening point and reducing the penetration of the binder.

Keywords: *Rheology, viscocity, Sasobit wax, penetration and softening point.*

1. INTRODUCTION
Bitumen is a black sticky material natural derived from the fractional distillation of crude oil, and is particularly suitable as a binder for road construction. Normally, at room temperature bitumen is soft with a density of 1 g/cm3, but at low temperature it becomes brittle and at high temperature it flows like a viscous liquid [1]]. Rheology simply means the flow of fluids and deformation of solids under stress and strain.The study of the rheological properties enables the propare understanding of the performance of bitumen with or without the additive. The mechanical test normally conducted on bitumen is to ascertain the consistency of the binder, as it’s been used in highway construction.

The road system of transportation constitutes the main means of moving goods and services in a developing nation such as Malaysia. Most of these roads are build using the conventional hot mix asphalt (HMA) technology. The process of producing the HMA involves heating the asphalt binder to a high temperature of 160/170^{o}C before mixing with the aggregate, hot mix asphalt concrete is composed of two components, bitumen (binder) and aggregate.

The binder constitutes about 4 – 6% by weight of the mix, while the aggregate constitutes between 94 – 96% by weight of the asphalt concrete mix, bitumen been used as the binder, has a visco -elastic characteristics and it is thermoplastic, it’s soft when heated and hard on cooling Brian [2]. Although the percentage of the binder is relatively small, the binder influences pavement performance more than the aggregate as environmental factors, such as high temperature due to solar radiation, and freeze at low temperature affects the binder more than the aggregate [3]. The performance of asphalt pavement is mainly governed by the properties of the binder, and it exhibit’s a visco elastic behaviour hence in pavement when exposed to high temperature permanenet deformation (Rutting) takes place along the wheel path of the pavement. On the other hand, bitumen in pavement at low temperature exhibits brittleness and pavement cracking occurs.

According to Hurley et al. the process of producing HMA consumes energy, and generates emissions [4]. The modification of bitumen with Sasobit wax (additive) has enable the reduction of the emission of green house gases and energy now called the green asphalt technology in pavement termed warm mix asphalt, this involves mixing the asphalt binder at a relatively lower temperature, typically the mixing temperatures of warm mix asphalt ranges from 110 to 130^{o}C compared to the conventional mixing temperatures for hot mix asphalt and a compaction temperature of 30-40^{o}C less than the production temperature for both [5]. This process reduces the high rate of emission generated and also the fuel consumption as compared with the conventional HMA. Warm mix asphalt (WMA) technology has the potential to significantly reduce mixing temperatures, improve compaction, extend the paving season, reduce fuel consumption, and reduce emissions [6]. Its benefits are reduction in energy consumption during production and reduced emissions during production and placement this is achieved with the lowering of viscosity and increase mobility of the binder with the addition of the additive.

In this study the additive was used to lower viscosity of the binder at high temperature, making it less susceptible to high temperature damage, and low temperature damage. The additive is a synthetic long-chain aliphatic hydrocarbon (CH 60-110) Fischer-Tropsch process wax produced from coal gasification [7]. It is introduced to HMA by blending with the binder at the terminal or contractor's tank. The recommended addition rate is 0.8% to 3% by mass of the binder accordingly [8]. The additive (LCAH) that enables the lowering the viscosity of the binder such that working temperatures decrease by 45ºC. It also has a congealing temperature of about 100ºC and is completely soluble in binders at temperatures lower than 110ºC, at temperatures below its melting point, it forms a crystalline network structure in the binder that is reported to provide added stability [9].

Investigating the mechanical and rheological properties of bitumen is of paramount importance as compaction, which is the most crucial stage in the construction of bituminous road pavements depends on fluidity of the binder, viscosity also provides, improve resistance to cracking and deformation of the pavement [10]. It should be noted that both temperature and pressure exert an important influence on bitumen viscocity and consequently, on its workability and road performance. The penetration and softening point test predicates the consistency of the binder, and its classification.

In this study the compatibility of bitumen and the additive was investigated based on the shell bitumen handbook specification [11]. The results from the study indicated that the difference between the top and bottom softening point is less than 5^{o}C, using the ring and ball test indicating that they are compatible even in storage ASTM Standards (2005) [12].

OBJECTIVE

The main objective of the study is to investigate the characteristics of bitumen modified with a LCAH additive, which include viscosity, the bitumen consistency and also its compatibility with the binder.

EXPERIMENT

Material

For this study neat bitumen PEN 60/70 and PEN 80/100 from unknown source and pellets of Sasobit wax supplied by Sasol international was used for the study. Some physical-chemical characteristics of the bitumen used in this study can be seen in Tables 1 below;

Table 1; bitumen consistency test

	ASTMMM test	Bitumen 60/70	Bitumen 80/100
Penetration(dmm)	D5-97	60/70	80/100
Softening point R&B(^{o}C)	D36-95	49	47

Viscocity

The viscocity of the binder was measured using the Brookfield viscometer; the equipment was used to measure the viscosity characteristics of the neat and modified binder PEN 60/70 and PEN80/100.According to the manufacturer the additive reduces both mixing and compaction temperatures. This test determined whether the additive decreases the viscosity of the binders used in the study, which consequently depends on the test temperatures (in the range 100-135 ^{o}C). The viscosity of each bitumen sample with and without LCAH was measured at various test temperatures and at 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 Superpave (SHRP).

Penetration and softening point

The penetration grade of the neat bitumen with and without LCAH was investigated using the penetrometer in accordance with ASTMD5-97 specification, while the softening point of the various test samples was determined using the ring and ball test in accordance to ASTM D36-95.

.RESULTS and DISCUSSION

The effect of LCAH is very obvious when it was added to the binder at the mixing temperature of 135^{o}C and a compaction temperature of 100^{o}C for WMA, considered for this study. The viscosity of the binder PEN 60/70 and PEN 80/100 with and without the additive at the production temperature, a minimal change was observed as compared to the viscosity at lower temperature as could be seen in Table 2 and Figure 1 below. At a low working temperature of 100°C the additive showed a minimal change in temperature decrease with less than 3% LCAH as recommended by manufacturer. There tends to be an increase in viscosity at low temperature in binder with more than 3% LCAH. The trend is at the lowest test temperature the binder with more than 3% sasobit indicates an increase in viscosity, while at the highest temperature the viscosity decreases with an increase in the additive as shown in Table 2 and 3 below;

Table 2: Viscocity of PEN 60/70

Bitumen	rotation speed (rmp)	Shear rate (s)	Viscocity (centipoise) at 100 °C	Viscocity (centipoise) at 120 °C	Viscocity (centipoise) at 135 °C
Neat PEN 60/70	20	6.8	3800	1400	400
PEN 60/70 +1%S	20	6.8	3800	1300	400
PEN60/70+2%S	20	6.8	3700	1300	300
PEN60/70+3%S	20	6.8	3700	1100	300
PEN60/70 +4%S	20	6.8	5100	1100	300
PEN60/70 +5%S	20	6.8	6000	800	200

S=Sasobit

The Figure 1 below indicates that the viscosity of the binder decreases with the addition of the additive and also it increases with a decrease in temperature.

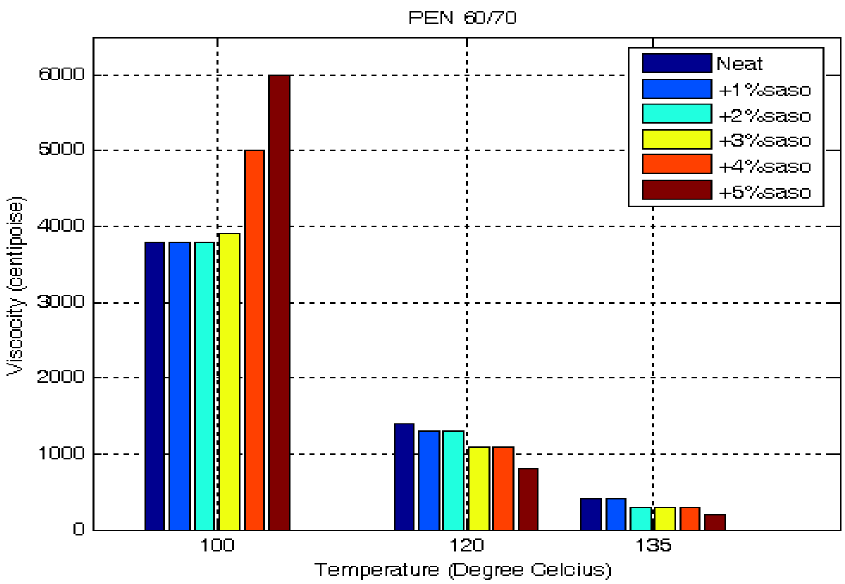

Figure 1: PEN 60/70 Viscosity measured at a shear rate of 6.8/s

Table 3: Viscocity of PEN 80/100

Bitumen	Rotation speed (rmp)	Shear rate (s)	Viscocity (centipoise) at 100 °C	Viscocity (centipoise) at 120 °C	Viscocity (centipoise) at 135 °C
Neat PEN 80/100	20	6.8	3700	1300	300
PEN 80/100 +1%S	20	6.8	3700	1200	300
PEN80/100+2% S	20	6.8	3700	1200	300
PEN80/100+3% S	20	6.8	3900	900	200
PEN80/100+4% S	20	6.8	5000	800	200
PEN80/100+5% S	20	6.8	6000	800	100

S=Sasobit

From the study, there is a relative decrease in the viscosity of the test binder, which depends on the quantity of additive used and the test temperature as shown in Figure.2 below;

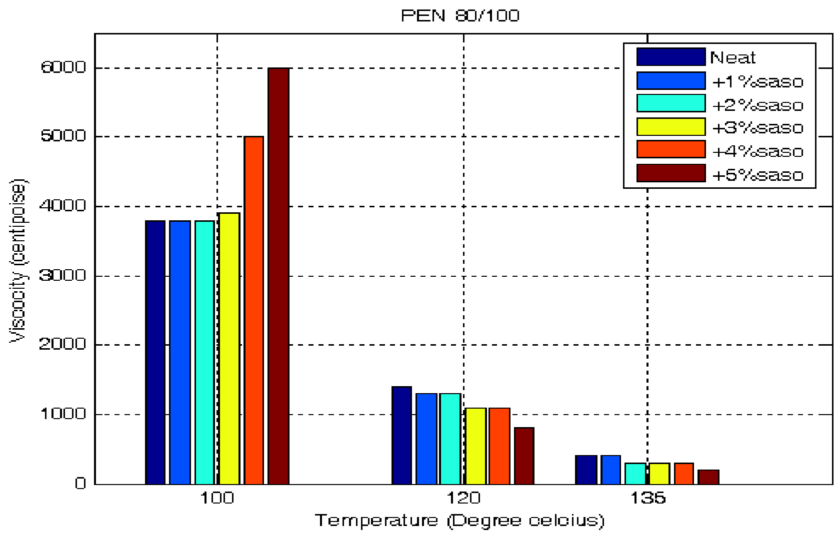

Figure 2: PEN 80/100 Viscosity measured at a shear rate of 6.8/s

The study investigated neat binder with Sasobit wax and the results for the penetration and softening points tests are presented in Table 4 below;

Table 4: bitumen consistency test

Test	Neat Bitumen	Bitumen+ 1% saso	Bitumen+ 2% saso	Bitumen+ 3% saso	Bitumen+ 4% saso	Bitumen + 5% saso
Penetration (dmm)	80/100	60/70	40/50	30/40	20/30	10/20
Softening (^{o}C)	47	49	52	65	71	82

The neat bitumen with penetration grade 60/70 and 80/100 as investigated with the penetrometer at 25 ^{o}C for 5seconds and indicated a softening point using the Ring and Ball test as seen below. The same test was conducted on the binder with various % of the additive; the trend is the binder hardens with an increase in the quantity of the additive. As the binder stiffens the penetration reduces and the softening point increases is illustrated in Figure 3 below;

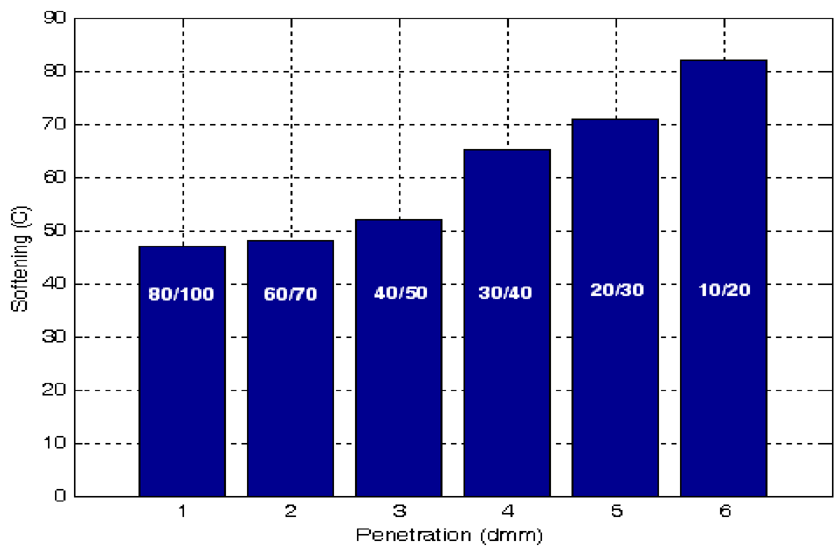

Figure 3 ; The softening point and penetration of bitumen with various additive content

Compatibility test

All the test samples of neat asphalt with the additive where tested for compatibility in accordance with the shell hand book code on compatibility test, the samples were put in the oven at 150^oC and the softening point of the top and bottom tested for 1day, 3days, 5days and 7days with all the samples producing a softening point difference of less than 5^oC between the top and bottom for all the samples indicating that Sasobit is compatibile and storage stable with bitumen.

CONCLUSSION

The additive (LCAH) used in this study was to lower the mixing and compaction temperatures of asphalt. The results indicated that the viscocity of the binders can be reduced through the use of LCAH especially, at high temperature there by increasing the softening point and reducing the penetration of the binders. The study has investigated the viscosity of two classes of bitumen with and without the additive (Sasobit), using the Brookfield viscometer, penetrometer for penetration test and the ring and ball test (R&B) for the softening point. From the study the results for both PEN 60/70 and PEN 80/100 shows that at low temperature the visocosity of bitumen with or without the additive increases, this indicates the temperature influences the viscosity of the binder making it susceptible to temperature change. At high test temperature the binder viscosity with additive decreases with an increase in the LCAH, this shows that the more the additive, at high temperature the lower the viscosity vice-versa. This shows that the additive can reduce viscosity of the binder at high temperature, improving the mobility of the binder and enhancing the coating of the aggregate in mix. While at low test temperature the binder with Sasobit more than 3% indicating an increase in viscosity for both PEN 60/70 and PEN 80/100 this conforms to the Sasol recommendation of adding Sasobit up to 3%. The addition of LCAH increases the softening point and decreases the penetration of both binders.

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