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The Effects of Sasobit® Modifier on Binder at High and Intermediate Temperatures

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ABSTRACT- Research in the laboratory was carried out to determine if the addition of warm mix asphalt additive (sasobit®) has effects on the stiffness of the virgin bitumen and if the modified bitumen has the potential to increase the amount of Reclaimed Asphalt Pavement (RAP) used in warm mix asphalt. To fulfil this purpose, two types of samples have been prepared.The first was identified as control samples (virgin bitumen 80/100 penetration grade). The other was modifed using the same bitumen penetration grade with sasobit-additive in concentrations from 1% to 3 % by weight of binder at intervals of 0.5%, identified as saso mixes. Both groups were subjected to viscosity test at high service temperatures (115, 125, 135 °C) and intermediate service temperatures (70, 80, 95°C) as well as penetration test to all samples at 25°C to determine the effect of sasobit additive on binder at ambient temperature. The results showed significant reduction in penetration value to all samples in all concentrations of the modifier on the bitumen. The results also showed decrease in viscosity values at high service temperatures to all modified samples compared to that of control samples. However, these values increased at intermediate temperatures to confirm the similar trend in penetration values, which indicated that the addition of sasobit on virgin binder increase the stiffness at low and intermediate temperatures. With regard to incorporating the recovered binder from RAP, the same trend was observed at high service temperature of 135°C to modified samples at sasobit concentration of 1.5% . This may assist in increasing the amount of RAP materials used with this modifier in the mix compared to the amount allowed in conventional mix.

Keywords: Warm Mix Asphalt, Sasobit additive, viscosity, high service temperature, intermediate service temperature, Reclaimed Asphalt Pavement.

I. INTRODUCTION

The most important advantage of producing warm mix asphalt (WMA) is the reduction of energy requirements which consumed a lot of energy to heat the materials during the mixing stage. Therefore, reduction in the energy consumption aid in the reduction of project cost as a direct consequence of reduction of WMA production temperature.

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There are other benefits such as reduction of asphalt fumes during production and lay down, decreased in the associated emissions and odors, reduction of total emissions from asphalt plants, which include the greenhouse gases, compared to the normal HMA [9], [1], [13], [8], [11], [12], [4], [2], [15], [6], [10]. Reductions in energy consumption have been reported to be on average in the range of 10% to 30% when the heating temperature was lowered from 150°C to around 125°C [9],[13]. Thus, a thorough understanding of the properties and performance of WMA is necessary in order to implement it successfully. WMA has the potential to be a viable option for pavements application along with conventional HMA without losing any of the benefits that have been attained by conventional HMA.

The addition of Sasobit on virgin bitumen not only significantly decreased the mix and compaction temperatures; it can also result in the recovered asphalt bitumen to become as soft as or even softer than virgin bitumen, in addition to decreasing the amount of heat energy required (the energy which consumed to heat the materials during mixing) and significantly decrease the emitted CO_2 when incorporated with the recovered bitumen from RAP [10].

The purpose of this research is to determine the effects of incorporating sasobit-additive on the virgin bitumen at high and intermediate temperatures. In addition, this research is also to determine whether warm mix asphalt using sasobit technology has the potential to incorporate high percentages of RAP. Recently, Frag et al. 2010 [5] have conducted research using virgin bitumen 80/100 penetration grade (which is used in this research) to determine the most suitable mixing temperature among various selected temperatures and various concentrations of sasobit additive to comply with the requirements set in Section 4, Standard Specification for Road Works published by the Public Works Department of Malaysia [7]. They found that the temperature at 135°C and 1.5% sasobit by weight of bitumen as the most suitable mixing temperature and percentage of sasobit for WMA using AC14 gradation that complied with all PWD Malaysia's requirements. Therefore, these findings will be considered in this research.

II. RESEARCH SCOPE

The scope of this research was confined to the investigation and comparison of bitumen behaviour in terms of viscosity and penetration values for virgin bitumen 80/100 penetration grade and modified bitumen added with various concentrations of sasobit-additive, as well as modified and unmodified virgin bitumen incorporating different percentages of recovered bitumen extracted from Reclaimed Asphalt Pavement (RAP).

The sasobit-additive was mixed with virgin bitumen 80/100 penetration grade which is commonly used in Malaysia in concentration percentages of 1% to 3% at interval of 0.5% by weight of bitumen using laboratory overhead stirrer at blending temperature of 125°C for one hour to ensure that the sasobit-additive has been fully dissolved and dispersed well within the bitumen.

The main purpose and the objective of this research is to determine whether the sasobit-additive has different effect on the virgin bitumen at high and intermediate service temperatures. Another objective is to know whether this modifier has the potential to assist the WMA to incorporate higher percentages of RAP compared to the regular HMA which generally use around 10% to 20% of RAP.

III. RESEARCH MATERIALS

The modifier used in this research is sasobit, derived from coal gasification process. It is produced by Sasol Wax Company, South Africa. The chemical composition of sasobit is fine crystalline materials in long-chain hydrocarbons, produced by means of Fischer-tropsch (F-T) synthesis. It's long chain is composed from 40 to 115 carbon atoms. As mentioned from producer [14], the melting point of sasobit additive is about 100 °C and it's completely dissolved in bitumen at temperatures above 115°C.

The bitumen used in this research is 80/100 penetration, having a specific gravity of 1.03 gm/cm^3 and it's basic properties as shown in Table1.

Table 1. The basic properties of virgin bitumen 80/100 penetration.

Type of test	Test result	Test Designation
Viscosity at 135 °C (cP)	425	ASTM D 4402-02
Penetration at 25°C, 100g (0.1mm)	91	ASTM D 5
Softening point (°C)	47.5	ASTM D 36
Ductility at 25°C (cm)	111	ASTM D 113

RAP materials used were milled from surface layer from the Grand Saga Highway (Kuala Lumpur-Kajang Highway). The extraction method was used to extract the aged bitumen from aggregate using the Rotary Evaporator (ASTM D5404-03).

IV. EXPERIMENTAL SCHEME

The virgin bitumen was blended with sasobit-additive in five concentrations (from 1% to 3% by weight of the bitumen at intervals of 0.5 %). Two groups of samples were prepared using the bitumen 80/100 penetration grade. The first group include two batches of virgin and modified bitumen 80/100 penetration without the addition of recovered binder (modified with five different sasobit concentrations of 1% to 3% at intervals of 0.5 %, identified as Control sample and saso samples 1 to 5 respectively). The other group of samples consist of two batches of samples. The first group have used same bitumen grade with three different concentrations of recovered binder at 30%, 40% and 50 % while the second group have the same recovered binder percentages with modified binder in concentrations of 1.5 % sasobit by weight of binder. In order to accomplish the research objectives, all samples were subjected to two type of testing, the first was viscosity test at a range of high temperatures of 115,125,135 °C, and the same test at a range of intermediate service temperatures of 95, 80, 70°C. According to ASTM D 4402-02 (Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer), the No. 27 spindle was used at rotational speed 20 RPM for high temperatures (above 100°C), while at the lowest test temperatures (intermediate temperatures) the speed of rotation was decreased. Three readings were recorded at 1-minute intervals for each sample while the mean value was recorded as the final result. The second type of testing carried out was the penetration test at 25°C, 100g (0.1mm) according to ASTM D 5.

V. EXPERIMENTAL RESULTS

A. *Effect of Sasobit on Penetration Value at 25°C*

The data in Table 2 (a) presents the test results for both the viscosity and penetration tests. With regard to the penetration test, it is could be seen that the addition of sasobit-additive on the virgin bitumen has increased the hardening of the virgin bitumen in ambient temperature and the rate of hardening increased with higher concentrations of the modifier added to the bitumen. From the observation, the different percentages of modifier added on virgin bitumen, the stiffness increased with increase the amount of sasobit, this means that the sasobit-additive cause the hardening the virgin binder in the low service temperatures.

Table 2(a). Viscosity and Penetration Values for Group 1 samples.

Mix Type	Penetration Value 100g (0.1mm) at 25° C	Viscosity at 135°C(cP)
Control Mix	91	425
1 % Sasobit Mix	86	350
1.5 % Sasobit Mix	81	337
2 % Sasobit Mix	73	325
2.5 % Sasobit Mix	68	300
3 % Sasobit Mix	62	287.5

B. *Effect of Sasobit on bitumen with Inclusion Recovery Binder*

Similar trend was found with the addition of this modifier on all mixes with virgin bitumen and modified bitumen as shown in Table 2(b). The samples included various percentages of recovered bitumen from RAP (30%, 40% and 50%) with and without sasobit modifier in concentrations of 1.5% by weight of binder. The viscosity values for all percentages of recovered binder incorporated with sasobit samples was found to have lower viscosity than that of unmodified reclaimed samples at high service temperature (135°C). These results confirm the findings from samples without the inclusion of recovered binder. This also means that the addition of this modifier has the potential to allow the asphalt mix to incorporate more percentage of RAP compared to the conventional HMA.

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Table 2(b). Viscosity and Penetration Values for group 2 samples

Mix Type	Penetration Value 100g (0.1mm) at 25° C	Viscosity at 135°C (cP)
30 % recovered bitumen + 70 % virgin bitumen	75	537
40 % recovered bitumen + 60 % virgin bitumen	65	600
50 % recovered bitumen + 50 % virgin bitumen	51	850
30 % recovered bitumen + 70 % virgin B +1.5 % Sasobit	53	487
40 % recovered bitumen + 60 % virgin B +1.5 % Sasobit	47.5	512.5
50 % recovered bitumen + 50 % virgin B + 1.5 % Sasobit	40	637

C. Effect of Sasobit on Viscosity Value of Virgin Binder at High and Intermediate Temperature

The addition of sasobit-additive significantly assists in lowering the viscosity value at high service temperatures as shown in Table 3 and Figures 1 (a) and (b). It is clear from the results obtained for samples with sasobit concentration of 1.5% by weight of binder, the viscosity values at high temperatures of 115, 125, 135°C were lower than the values at same temperatures in control samples as shown in Table 3. However, for the viscosity values at intermediate temperatures of 70 and 80°C, the sasobit samples showed higher viscosity values than that of control samples.However, the viscosity at 95°C is similar for both binders, this trend corresponds with the trend obtained from the penetration results at low temperatures, which found that there is an increase of stiffness values of virgin binder with the addition of sasobit-additive. It could be inferred that the turning point between the high and intermediate behaviour falls in range of 85°C to 90°C.

Table 3. The Viscosity Values of Control and Sasobit mix.

Mix Type	Penetration Value at 25° C	Viscosity at 135°C (cP)	Viscosity at 125°C (cP)	Viscosity at 115°C (cP)	Viscosity at 95°C (cP)	Viscosity at 80°C (cP)	Viscosity at 70°C (cP)
Control Mix	91	425	550	1000	3875	13650	34125
1.5 % Sasobit Mix	81	337	487	800	3750	17200	39100

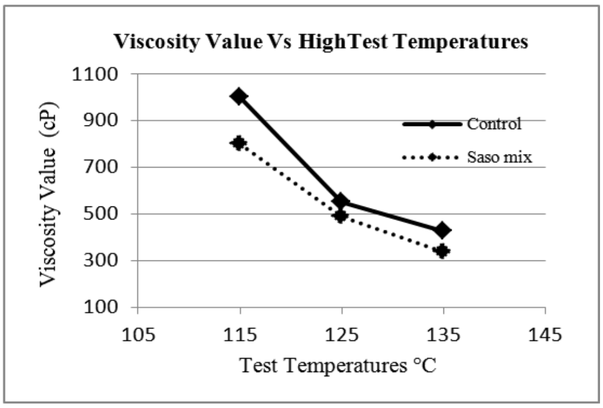

Figure 1(a). Viscosity at High Temperatures

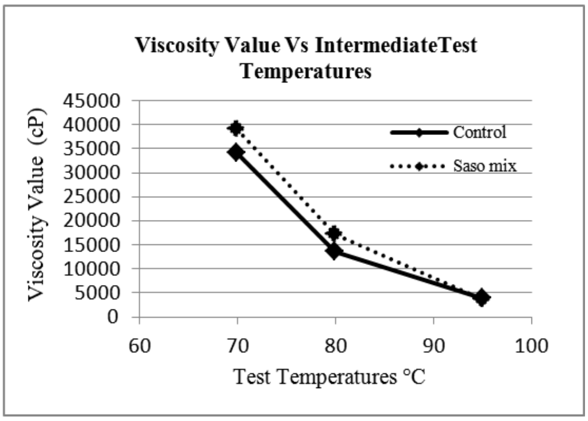

Figure 1(b). Viscosity at intermediate Temperatures

VI.CONCLUSION

From this research the following conclusions can be made:

The addition of sasobit-additive in specific percentages on the virgin bitumen reduces the penetration values at 25°C to the virgin binder for all sasobit modifier concentrations. This indicates that the sasobit modifier increase the binder stiffness value at lower temperatures which could lead to the increase in the resistance of binder against permanent deformation (rutting) . In addition, the rate of reduction in permanent deformation value of binder depends on the amount of the modifier added to the virgin binder.

The binder viscosity values at high service temperatures (115, 125 , 135°C) and the viscosity with addition of sasobit modifier are lower than that without the modifier at all temperatures. For intermediate temperatures (70 and 80°C) the values were higher in the sasobit samples compared to that of control samples. This shows that the stiffness of the virgin binder increased with addition of this modifier at low and intermediate temperatures. It could inferred that the articulator point between the high and intermediate behaviour falls in range of 85°C to 90°C.

With respect to the effect of sasobit additive on the recovered binder, since this modifier decreased the viscosity of binder at high service temperatures, this could indicate the possibility of increasing the percentages of RAP materials for new surface layer mix in presence of the sasobit modifier.

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VII. RECOMMENDATION

To validate this research findings, further research using other types and sources of virgin and recovered bitumen is required. Research is on-going to investigate the incorporation of various RAP contents with the sasobit-additive, as well as conducting performance tests such as rutting, stiffness, moisture sensitivity and fatigue test.

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