LABORATORIUM STUDY OF ASPHALT STARBIT E-55 POLYMER MODIFIED APPLICATION ON ASPHALT CONCRETE WEARING COURSE (AC-WC)

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ABSTRACT

The conventional asphalt road has almost been considered fail for serving the transportation needs. It is indicated by the occurrence of premature damage which is caused by vehicle load and climate. Starbit E-55, the polymer modified bitumen, is formulated to meet the requirement of highway development. Considering those needs, it is important to investigate the feasibility level of that modified bitumen as alternate asphalt instead of the conventional one. This research began with the measurement of the properties of hard layered AC-WC Starbit E-55, then comparing the result to 60/70 penetration of Pertamina asphalt. The next step is then, to determine the converted value so as to be close to that of Pertamina (60/70 penetration). This step is conducted by applying durability and ITS tests on the mixture. Results of the tests showed that hard layered AC-WC Starbit E-55 has better characteristic at 5.7% optimum level asphalt and 6.4% of Pertamina asphalt (60/70 penetration). Starbit E-55 converted level within hard-layered ACWC is 5.6%. The performance test result on immersion with variance of 1, 3, 5, 7 and 14 days shows that durability value of Starbit E-55 AC-WC has better performance. Moreover, during the process, Starbit E-55 required 15.38% higher energy consumption.

Keywords: Starbit E-55, AC-WC, converted level, Pertamina penetration 60/70, durability, ITS.

1 INTRODUCTION

The resistances to load repetition, rainfall and high temperatures are important factors in determining the design of pavement in Indonesia.

Early damage due to water and poor pavement affected by high temperature are largely found in some cases of pavement failures since the asphalt as a binder layer is very sensitive to both factors. Some materials, especially asphalt formulations have been developed. However, it still needs testing. Each material in a pavement mixture has various characteristics and performances. Therefore diversion of materials is necessary to study in order to find the proper utilization. The intention of this study is expected to contribute valuable information regarding utilization of materials which can be used as tools in determining substantial materials.

2 ASPHALT CONCRETE PAVEMENT (LASTON)

Asphalt Institute (1993; 2001) revealed that asphalt concrete pavement (Laston) is a type of flexible pavements consisting of a mixture of aggregates and asphalt, with or without the added material. Mixing temperature is determined based on the type of bitumen. Mixing temperature is generally between 145^{o}C - 155^{o}C, so-called hot mix asphalt concrete.

The Laston is a combination of well graded aggregate and Asphalt Cement (AC) which are mixed, spread, and compacted in certain temperature. The aggregate is composed of fine aggregate, coarse aggregate, and filler (Bina Marga, 1983). The Laston mix design comprises specified materials and its proportion that will be used to achieve final properties of the desired asphalt mixture (Asphalt Institute, 1993).

2.1 Durability

Durability is the ability of surface layer to withstand repetition of traffic load, such as vehicle weight, friction between vehicle wheel and road surface, and also able to withstand wear from the weather and climate condition as in air, water, or temperature shift (Arifin, et al., 2008).

2.2 Indirect Tensile Strength (ITS)

Administrating continuous (repeating) load could resulted in increasing stress followed with increasing strain, up to a certain strain when the sample started to collapse (fractured) which means that the occurring stress is maximum stress. On this state of the maximum stress and certain stress, the sample is considered going through indirect tensile strength (Totomiharja, 2004).

3 RESEARCH METHOD

3.1 Design Material Preparation

Classification of aggregate particle according to the size of sieve that is used for the concrete mix – fine grade wearing course (AC-WC), and material value terms according to general specification plan of Bina Marga (1983), Asphalt Pavement Division VI, 2010 edition.

3.2 Mixture Design

According to the grading requirement for AC-WC pavement, as shown in Table 1, the grading target that was used is the middle value of fine grade AC-WC. For the calculation, the research used equations based on AASHTO T-209 procedure.

Table 1. Grading target on the research

ASTM	Size (mm)	Specification	Target (%)	
			Pass	Restrained
1,5"	37.5			
1"	25			
3/4"	19	100	100	0
1/2"	12.5	90-100	95	5
3/8"	9.5	72-90	81	14
No. 4	4.75	54-69	61.5	19.5
No. 8	2.36	39.1-53	46.05	15.45
No. 16	1.18	31.6-40	35.8	10.25
No. 30	0.600	23.1-30	26.55	9.25
No. 50	0.300	15.5-22	18.75	7.8
No. 100	0.150	9-15	12	6.75
No. 200	0.075	4-10	7	5
Pan	0	0	0	7

The content estimation was according to the percentage of the applied grading target. The formula is shown at Equation (1):

$$Pb = 0.035CA+0.045FA+0.18F+K \quad (1)$$

Where Pb is estimation of asphalt content on the mix, and K is constant in pavement AC-WC mix, from 0.5 to 1.

The amount of required sample to find the optimum asphalt content is shown in Table 2.

The determination of mixture temperature and solidification follows the Heukelom method with Bitumen Test Data Chart (BTDC), as can be seen in Figure 1. Next, Design of Pertamina and Starbit asphalt mixture can be obtained as shown in Table 3 and Table 4.

Table 2. Sample amount in process of finding KAO

Stage	Item	Total
1	Mixed Gmm with Pertamina 60-70 Testing	2
	Mixed Gmm with Starbit E-55 Testing	2
	Sub Total	4
2	From Pb to find KAO with Marshall Method Pertamina Pen. 60/70	
	a) Content -1	3
	b) Content -0.5	3
	c) Content 1	3
	d) Content +0.5	3
	e) Content +1	3
	Starbit E-55	
	a) Content -1	3
	b) Content -0.5	3
	c) Content 1	3
	d) Content +0.5	3
	e) Content +1	3
	Sub Total	30
3	KAO Starbit E-55 asphalt content varied to KAP Starbit E-55	
	a) Content 1	3
	b) Content 2	3
	c) Content 3	3
	Content Total	9
	TOTAL	43

Table 3. Design of Pertamina asphalt mixture

Parameter Input	Value	Unit
Penetration Value(25 °C)	63	dmm.
Softening Point Value	48.5	°C
Parameter I Value	-	
Centistokes (135 °C)	-	Pa.s
Parameter II Value	-	
Centistokes (60 °C)	-	Pa.s
Output Parameter	**Value**	**Unit**
Mixing Temperature (Chart reading)	143	°C
Solidification Temperature (Chart reading)	130	°C

Table 4. Design of Starbit asphalt mixture.

Input Parameter	Value	Unit
Penetration Value(25 °C)	57	dmm.
Softening Point Value	54	°C
Parameter I Value	816	
Centistokes (135 °C)	0.838	Pa.s
Parameter II Value	-	
Centistokes (60 °C)	-	Pa.s
Output Parameter	**Value**	**Unit**
Mixing Temperature (Chart reading)	165	°C
Solidification Temperature (Chart reading)	150	°C

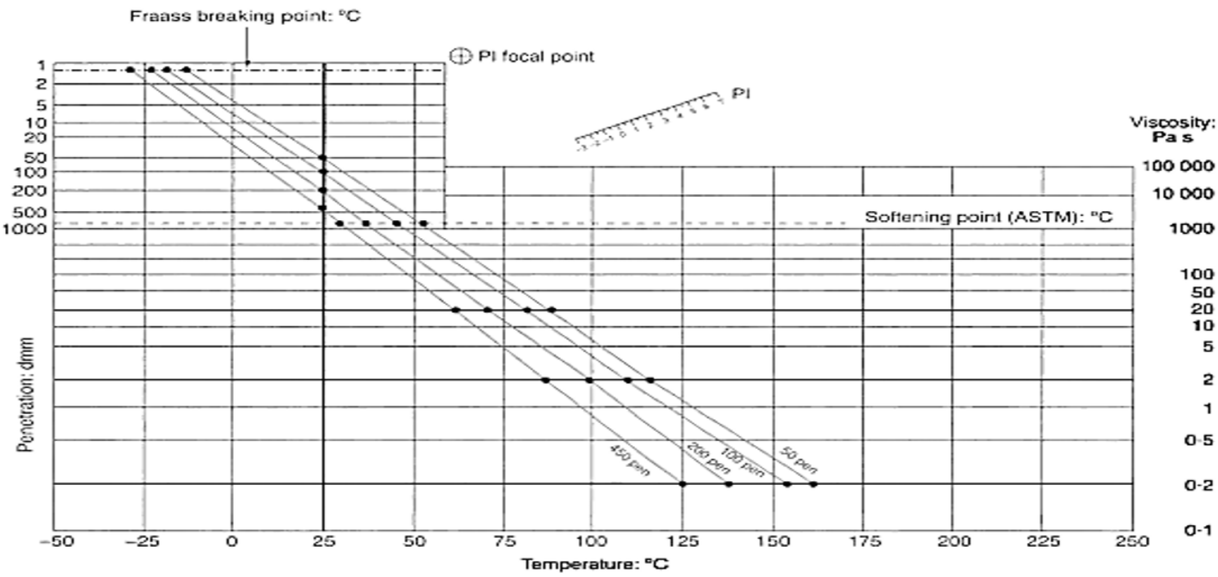


Figure 1. Bitumen Test Data Chart.

The determination of asphalt content with Marshall Method could be divided into 5 (five) steps (Washington Asphalt Pavement Association, 2002). Determination of asphalt content mixture adaptation applied Starbit E-55 asphalt as depicted in Figure 2, was performed by find the KAO upper and lower limit characteristic value. Content value was estimated such that generated after same characteristics with Pertamina asphalt mixture on KAO state condition.

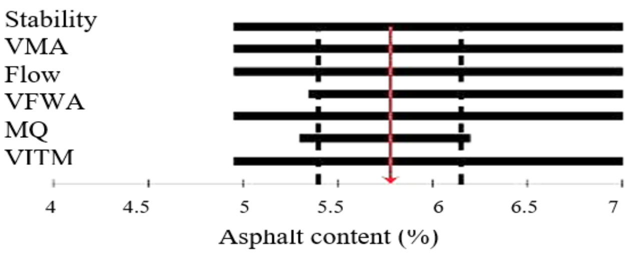


Figure 2. Asphalt Content Determination according to terms value.

Amount of sample that was required in order to test preservation performance and indirect tensile strength is shown in Table 5.

Table 5. Estimation of research sample amount

Stage	Item	Total
3	Durability Test	
	Pertamina Pen. 60/70	3
	Starbit E-55	
	Sub Total	39
4	ITS Test	
	Pertamina Pen. 60/70	3
	Starbit E-55	
	Sub Total	39
	TOTAL	78
	Total sample from all activities	121

4 TESTING

4.1 Durability Test

The equation for standard soaking depicted index of retained strength is shown in Equation (2):

$$IRS = \frac{M_{Si}}{M_{Ss}} 100 \tag{2}$$

Where *IRS* is Index of Retained Stability (%), M_{Si} = Marshall Soak Stability, and M_{Ss} is Marshall Standard Stability.

Next the modified soaking was conducted by using the Equation (3):

$$r = \sum_{i-0}^{n-1} \frac{S_{i+1}}{t_{i+1} - t_i} \tag{3}$$

Where S_i is strength remained on time t_i, S_{i+1} is strength remained on time t_{i+1}, t_i is time on step *i* soaking.

4.2 Indirect Tensile Strength (ITS) Test

The calculation of indirect tensile strength with strain strength value parameter that was generated from maximum loading was using the Equation (4) as follows:

$$ITS = \frac{2P}{\pi \times d \times h} \tag{4}$$

Where *ITS* is Indirect tensile strength (kPa), *P* is maximum load (N), *h* is sample thickness (mm), and *d* is diameter (mm).

Furthermore, the calculation was continued to find the index of retained strength. It was a ratio of early indirect tensile strength of un-soaked and soaked sample, by using the Equation (5):

$$ITSIndex = \frac{ITS_0}{ITS_n}100 \qquad (5)$$

Where ITS_o is early indirect tensile strength (kPa) and ITS_n is indirect tensile strength n (variation).

5 RESULTANDDISCUSSION

5.1 Starbit E-55 Asphalt Mixture Characteristic

The characteristic of mixture used Starbit E-55 asphalt showed a better value on optimum asphalt content which can be seen in Table 6.

Table 6. Mixture properties value on optimum asphalt content

Properties	Pertamina	Starbit	
	6.4%	Specification	5.7%
Stability	1,770	1,000	2,020
Flow	3.3	> 3	3.3
Density	2.36	-	2.34
VMA	17.1	> 15	17.7
VFWA	77.2	> 65	75.5
VITM	3.87	3 - 6	4.3
MQ	534	> 300	612

On 0.7% content,it is lower than that of Pertamina penetration 60-70 asphalt. VITM and VMA value of the mixture that used Starbit E-55 asphalt was higher. Since it has lower content value, the VFWA value or the absorbed asphalt content will be lower as well.

Table 7 indicates that an effort to equate the properties values, particularly the stability and the Marshall Quotient can be achieved.

Table 7. Mixture properties value on adjusted asphalt content

Properties	Pertamina	Starbit	
	6.4%	Spesification	5.6%
Stability	1,770	1,000	1,759
Flow	3.3	> 3	3.3
Density	2.36	-	2.34
VMA	17.1	> 15	18.37
VFWA	77.2	> 65	72.61
VITM	3.87	3 – 6	5.032
MQ	534	> 300	533

The effect of asphalt content reduction in the mixture that used Starbit E-55 can be seen at higher VITM and VMA values.

5.2 Starbit E-55 Asphalt Mixture Performance

The highest amount of preservation reduction on sample used Pertamina 60/70 was found at the time when the soaking was conducted over 5 days which the stability value decreased to 16.9% on the 7th day as shown in Figure 3.

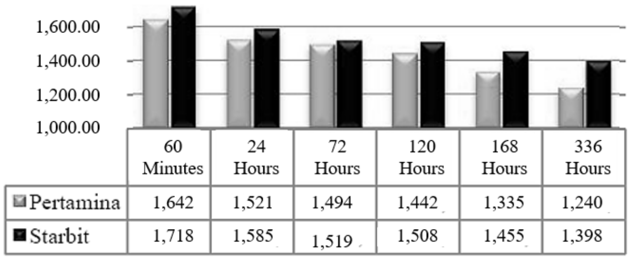


Figure 3. Durability value on soaking time variation.

In the second durability index calculation, it could be noticed that the retained strength index value on sample that used Pertamina 60/70 asphalt was lower than the retained strength index value on the sample that used Starbit E-55 asphalt, whereas the sample that used Starbit E-55 asphalt still has retained strength index 81.37%, compared to sample that used Pertamina 60/70 asphalt that has 75.54%, with 5.83% comparison difference.

Figure 4 is depiction of mixture performance of each asphalt type that have soaking variation, the amount of preservation performance was calculated from remain stability value

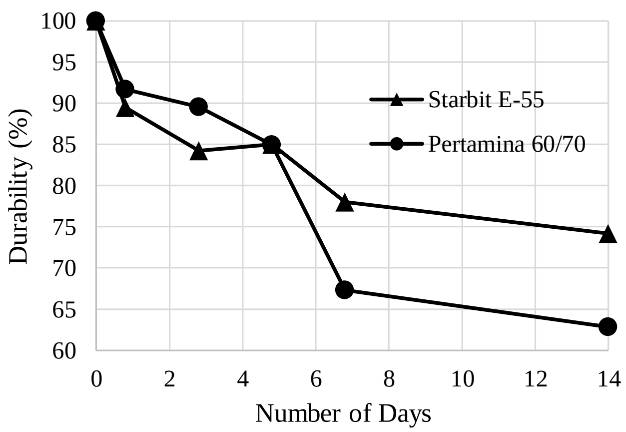


Figure 4. Mixture stability on various soaking.

The values that comparable into Indirect Tensile Strenght graphic result on soaking variation areas can be seen in Figure 5.

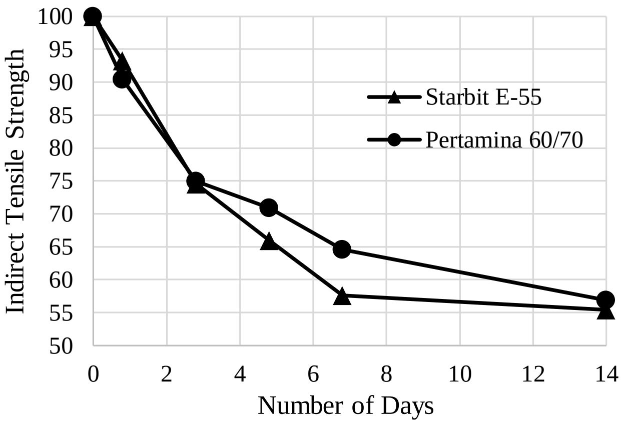
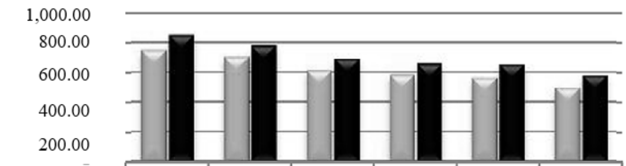


Figure 5. ITS value on soaking variation.

According to the result of indirect tensile strength test of the sample as shown inFigure 6, that used Starbit E-55 and sample that used Pertamina 60/70, the indirect tensile strength value each sample up to 5th days soaking tends to have different reduction level. Starbit mixture has lower reduction value which is 0.82%, while that of Pertamina mixture decreased 0.86%.

The result from soaking above 5 to 14 days did not show any difference between the sample that used Starbit E-55 asphalt and the sample that used Pertamina 60/70 asphalt. Each sample reduction was 0.18%. On the second soaking index calculation showed that each sample loss strength index result, which were 30.93% on sample that used Starbit E-55 asphalt and 34% on sample that used Pertamina 60/70, with 3.07% difference. The result showed that indirect tensile strength of the mixture that used Starbit E-55 asphalt was still better when compared with mixture that used Pertamina 60/70 asphalt.



	60 Minutes	24 Hours	72 Hours	120 Hours	168 Hours	336 Hours
Pertamina	747.5	702.0	612.7	582.5	562.0	493.4
Starbit	846.9	776.3	689.3	656.4	651.6	578.4

Figure 6. ITS mixture on soaking time variation.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the research result, the following conclusion can be given:

a) Conversion content value of the Starbit E-55 asphalt on fine grade AC-WC pavement layer was 5.6%, with 0.8% difference to the asphalt content of Pertamina penetration 60/70.
b) Characteristic value of the fine grade AC-WC pavement layer that used Starbit E-55 asphalt was higher with 2,020 kg stability value and 612 kg/mm MQ, compared to the AC-WC pavement layer with fine grading that use Pertamina penetration 60/70 asphalt with 1,770 kg stability value and 534 kg/mm MQ.
c) Starbit E-55 asphalt mixture created fine grade AC-WC pavement layer that has more pores.
d) Preservation level of Asphalt Concrete Wearing Course that used Starbit E-55 was better than the ones that used Pertamina 60/70 as can be seen from the endurance at laboratory soaking for 14 days.
e) The indirect tensile strength of varied mixture that has 14 days soaking time showed that Asphalt Concrete Wearing Course that used Starbit E-55 was more durable with 30.93% loss strength index, and 34% in Asphalt Concrete Wearing Course that used Pertamina 60/70 asphalt.
f) The fine grade AC-WC pavement layer that used Starbit E-55 asphalt needed higher heat energy, approximately 15.385% in mixing process, compared to energy needed by the fine grade AC-WC pavement layer that used Pertamina 60/70 asphalt.

6.2 Recommendations

The following recommendations are deemed useful for next researches:

a) Further research on testing the performance of Starbit E-55 asphalt in fine grade AC-WC pavement layer is needed, particularly on skid resistance test and wearing test.
b) Temperature decreasing time on every processing of fine grade AC-WC pavement layer that used Starbit E-55 asphalt is necessary to study.
c) Adjusted asphalt content that implemented in fine grade Asphalt Concrete Wearing Course work still need to be reconsidered, in terms of the comparing values that are not so significant.

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