The Durability of Asphalt Concrete with Dammar Resin Binder

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Abstract: The aging process of daspal on paved concrete pavement layers occurs during mixing in the Asphalt Mixing plant and the time of service life. The process of aging of the daspal when mixing is called short-term aging and aging of the daspal during the lifetime of the road service is called long-term aging. The study was conducted in a laboratory with an oven method for simulating aging. The short-term aging method (Short Term Oven Aging, STOA) is the testing of the specimens at 135 ^{0}C before compacting for 4 hours representing aging of the daspal mixture at the time of production of the asphalt mixture from on-site carriage to sealing. The long-term aging testing methods (Long Term Oven Aging, LTOA) was performed 85 ^{0}C after the condensation for 48 hours representing a service period of 5 years. The aim of this research is to know the effect of the process of daspal aging with respect to concrete asphalt. The research covers the value of Stability, Flow, Marshall Quotient, VIM, VFB, Density, and Indirect Tensile Stiffness Modulus. This research uses the optimum modification of the basic composition of resin (100 gr of pure resin or chunks + 350 gr of dammar powder), fly ash powder (150 gr) and cooking oil (205 gr) and 4 % latex mixed by way of cooking at temperatures below 150 ^{o}C. The composition scored a ductility of 115.5 cm, flash point 260 ^{o}C, penetration 43 dmm and specific gravity 0.99 gr/cm3. Results indicated stability (1906.48 kg), Flow (4.6 mm), VIM (3.79%), VFB (74.2 %), Marshall Quotient (421,45 kg/mm), Density (2,36g /cm^3). Therefore, it can be said that the daspal test object satisfies the requirements as a mixture of AC - WC of coarse gradation. Result of ITSM test at temperature 20 ^{0}C is equal to 11156 MPa, at 30 ^{0}C equal to 6930 MPa and at 40 ^{0}C equal to 5127 MPa. For flexible pavement layer thickness analysis with SPDM Software Bisar 3.0 at all temperature variation, results showed that Thickness value that is 24 cm at temperature of 20 ^{0}C, 30,6 cm at 30 ^{0}C and 35,3 cm at 40 ^{0}C.

1 INTRODUCTION

The development of highway construction is very rapidly developed, where all human activities are using land transportation, so the construction and maintenance of the highway is the main concern of the government, to get a sense of security, comfortable for the users of the highway. One of the causes of a decrease in the strength of the mixture on the flexible pavement is the aging process. According to Huber and Decker (1995) in his research entitled Engineering Properties of Asphalt Mixtures and the Relationtiship to Their Performance which refers to the ASTM method says that the short term ovulation process (Short Term Oven Anging, STOA), oven done at 135˚C for 4 hours before compacting. The STOA simulation was carried out to determine the aging of the asphalt mixture during the process of preparing the dosage mixture of the dioxide mixing base (AMP), during the transporting and spreading of the field, while the Long Term Oven Anging (LTOA) testing procedure was carried out at 85^{0}C for 48 hours after compaction. LTOA simulation is done to find out aging of asphalt mixer during service period. In the study stated that the test at 85˚C for 48 hours represents mixed ages for 5 years in the field. Therefore, this research is done by making specimens of STOA and LTOA by testing using Marshall Test method so that the aging daspal mixture can be known the level of air (porosity), stability and flow.

In this research will be aging process on aggregate mixture with Asphalt Concrete Wearing Course (AC-WC) coating, by making specimens STOA and LTOA using Marshall Test. The AC-WC mixture is used because it is a wear-resistant coated top surface that has direct contact with the vehicle load on it, which is affected by temperature so that it undergoes aging.

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Figure 1: Process of the specimens production.

One of the mixed performance parameters in the flexible pavement is the durability of the pavement due to weather and water effects. Road conditions that are always submerged by water will decrease the durability of the pavement layer of the pavement. This becomes even worse when at the time of the process of preparing a mixture of batches, during transport, on-site deployment, and during the service period aging on the dacal mixture, thereby reducing the performance of asphalt pavement such as low stability values, intercellular cavities or less dense mixtures and bad durability. The parameters used to see the durability level of the asphalt mixture are the parameters used in comparing the stability test value with the standard stability.

2 EXPERIMENTAL

2.1 Specimens Preparation

This research uses the composition of resin (100 gr of pure resin or chunks blend to 350 gr of damar powder), fly ash powder (150 gr) and cooking oil (205 gr) and 4% latex mixed by way of cooking at temperatures below 150 ºC (Haryanto, 2012). The details of specimens production process is shown in Figure 1.

After completion daspal modification, will make the specimen samples.

- Mix the aggregate and the asphalt according to the result of the mix design of the optimum dosage content.
- Mix the mixture evenly in the presence of heating to 150 ° C, then mix it in the mold.
- The mixture is compacted with the compactor 75 times on both sides.
- Provide code on each specimen.
- The test object is silenced at room temperature, then remove from the mold with the help of the jack.

2.2 Test Procedure

The design of the baseball mixture begins by testing the quality of the base material consisting of aggregates and some materials, among the resin gum, goring oil, latex, used oil, fly ash, which is presented as a binder layer of dspal. The test standard used is for job design mix testing based on SNI 03-1737-1989 (BSN, 1989). Preparation of test specimens with optimum dosage content of resin (100 gr of pure resin or chunks + 350 gr resin pack or powder), fly ash (150 g), cooking oil (205 g) and 4% latex mixed by cooking at below temperature 150 ºC. With this optimum level, the test object will be tested for resistance to short-term aging (STOA) and long-term (LTOA).

The short-term aging method (Short Term Oven Aging, STOA) is the testing of the specimens at 135^0C before compacting for 4 hours representing aging of the daspal mixture at the time of production of the asphalt mixture from on-site carriage to sealing. The long-term aging testing methods (Long Term Oven Aging, LTOA) was performed 85^0C after the condensation for 48 hours representing a service period of 5 years. Furthermore, to measure the effect of weathering is done by measuring the stability and melting with the Marshall testing apparatus complying with AASHTO T245-74 (Braceras, 2015). The research covers the value of Stability, Flow, Marshall Quotient, VIM, VFB, Density, and Indirect Tensile Stiffness Modulus with standard test temperatures of 20 ºC, 30 ºC and 40 ºC.

Table 1: Determining Characteristics of AC-WC mixture.

Mixture Characteristics	Spec.	AC-WC Corse Gradation
Effective daspal content (%)	Min.	4.3
Void in aggregate (VMA) (%)	Min.	14
Void in mixture (VIM)(%)	Min.	3
	Maks.	5
Void in asphalt (VFB) (%)	Min.	65
Marshall stability (kg)	Min.	800
Flow (mm)	Min.	3
Marshall Quotient (kg/mm)	Min.	250

In this study, the analysis used the comparison method with characteristic properties of the daspal mixture with the characteristics of the mixed layer AC-WC on the Bina Marga (2010) specification. Later, the Inderect Tensile Stiffness Modulus test to find the modulus of rigidity in purpose of designing the thickness of daspal in the field.The AC-WC mixture characteristics are shown in Table 1.

Indirect Tensile Stiffness Modulus is the most conventional laboratory testing method to calculate the asphalt stiffness modulus mixture. This method became the UK Standard Draft for the Development of BS DD 213 (BSI1998) and is similar to the resilient modulus test described by ASTM D-4132 (ASTM 1996). According to standard, Indirect Tensile Stiffness Modulus this test is a non-destructive test and has been identified as a method for calculating the average stiffness of the modulus of the material. The ITSM Test Specimens are shown in Table 2.

Table 2: ITSM Test Specimen

Sample Code	Target Temperature			Number of Specimens
	20˚C	30˚C	40˚C	
DP	3	3	3	9
STOA	3	3	3	9
LTOA	3	3	3	9

(Note: DP: sample daspal murni, STOA: sample daspal after short term oven aging process, LTOA: sample daspal after long term oven aging process).

With uniaxial sinusoidal loading, the modulus stiffness is generally defined as the ratio of maximum stress to maximum strain. Indirect Tensile Stiffness Modulus in MPa is calculated sing equation (1).

$$\text{ITSM} = \frac{L(v + 27)}{(D \times t)} \tag{1}$$

Where, L is the highest value of vertical load applied (N), D is the average amplitude from horizontal deformation obtained from 2 or more applied loads (mm), T is an average thickness of specimen (mm) and V is Poisson's ratio (0.35).

3. RESULTS AND DISCUSSION

3.1. Characteristics of Daspal

Volumetric testing was performed prior to Marshall testing. After the specimen is compacted using a manual compactor, the test object is silenced for approximately 2 hours or the specimen is in a state of room temperature.

Volumetric testing was performed prior to Marshall testing. After the specimen is compacted using a manual compactor, the test object is silenced for approximately 2 hours or the specimen is in a state of room temperature. Results of daspal volumetric and Marshall test are shown in Table 3 and 4 respectively.

Table 3: Results of Daspal Volumetric Test

Sample Code	VIM (%)	VMA (%)	VFB (%)	Density (t/m3)
DP	3.79	14.6	74.2	2.36
STOA	4.42	15.16	70.83	2.34
LTOA	3.19	14.06	77.29	2.37
Spec.	3.5-5	Min 14	Min 65	--

Table 4: Results of Daspal Marshall Test

Sample code	Daspal Contain (%)	Flow (mm)	Stability (kg)	*MQ* (kg/m)
DP	5.5	4.6	1906.48	421.45
STOA	5.5	4.8	2290.61	479.45
LTOA	5.5	3.8	2812.88	741.42
Spec	-	min 3	min 800	min 250

The result shows that in DP condition, STOA condition, LTOA condition the VIM, VMA and VFB is good value, with the minimum specification requirement, it can be said that the condition of the

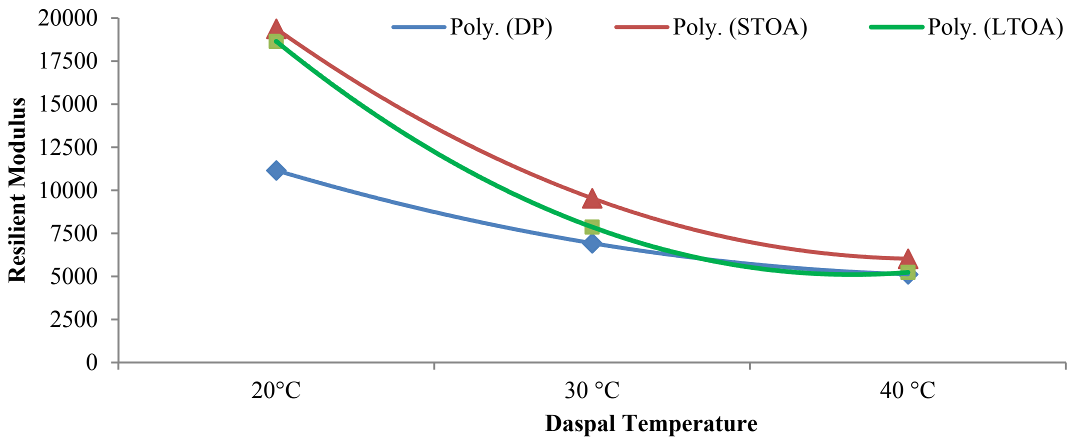

Figure 2: Resilient modulus of daspal against varying daspal temperature.

specimen above meets the requirements as a mixture of coarse gradation AC-WC.

The value of stability has increased, this can be seen with the result of 1906.48 kg in normal conditions, 2290,61 kg at 5 years condition STOA, and 2812,88 kg at 15 years condition LTOA. This suggests that with added time of heating causes locking between the aggregate particles and the binding capacity of the aggregate becoming stronger, as well as better cohesion and adhesion of the carbons. However, the higher the stability the more likely it can cause the pavement to crack and if too low causing deformation. With a minimum specification requirement of 800 kg, it can be concluded that the condition of the specimen above meets the requirements as a coarse-gradation AC-WC mixture.

In the STOA condition, the MQ value has increased from normal condition. In STOA condition MQ value of 479.45 kg/mm while in normal condition has a value of 421.45 kg/mm. This is due to the aging process which causes evaporation/oxidation to the daspal mixture so that the interlocking bond between the aggregates and daspal increases, resulting in the mixture having proven increased flexibility. With the minimum specification requirement of 250 kg/mm, it can be judged that the condition of the specimen above meets the requirements as a coarse-grained AC-WC mixture.

3.2 Indirect Tensile Stiffness Modulus

Indirect Tensile Stiffness Modulus is performed to calculate the dispersion resistance capability of a mixture on the pavement and back to its original shape. After the manufacture of specimens with optimum asphalt content (KAO), the ITSM tests of each of the 9 test specimens were tested at 20^{o}C, 30^{o}C and 40^{o}C temperature using Material Testing Apparatus (MATTA). Test Results Indirect Tensile Stiffness Modulus is presented in Table 5.

Table 5: Results of Daspal Marshall Test

Sample Code	Resilient Modulus (MPa)		
	20 ^{0}C	30 ^{0}C	40 ^{0}C
DP	11156	6930	5127
STOA	19378	9540	6029
LTOA	18648	7868	5234

From Table 5 it can be converted into a total graph of the relationship between the Resilient Modulus of the daspal and the varying temperature of the daspal can be presented in Figure 2.

The value of ITSM is greater at lower temperatures. This corresponds to the nature of the asphalt becoming more rigid at lower temperatures. Figure 2 shows that the results of ITSM on daspal under STOA conditions decreased from 19378 MPa values at 20^{0}C to 9540 MPa at 30^{0}C and 6029 MPa at 40^{0}C. As for pure daspal (DP) conditions and daspal of LTOA conditions also decreased in ITSM with temperature rise. Thus, the daspal of STOA condition has better values of ITSM than the pure daspal of LTOA conditions. This suggests that the aging process makes the daspal better than the daspal before aging.

3.3 Daspal Thickness Design According to ITSM Values

The outcome of flexible pavement thickness design with SPDM Bisar 3.0 Software Program is presented in Figure 14 as follows:

The thickness design of daspal pavement layer using Bisar 3.0 software as shown in Figure 3 confirms that the smallest thickness design value (24

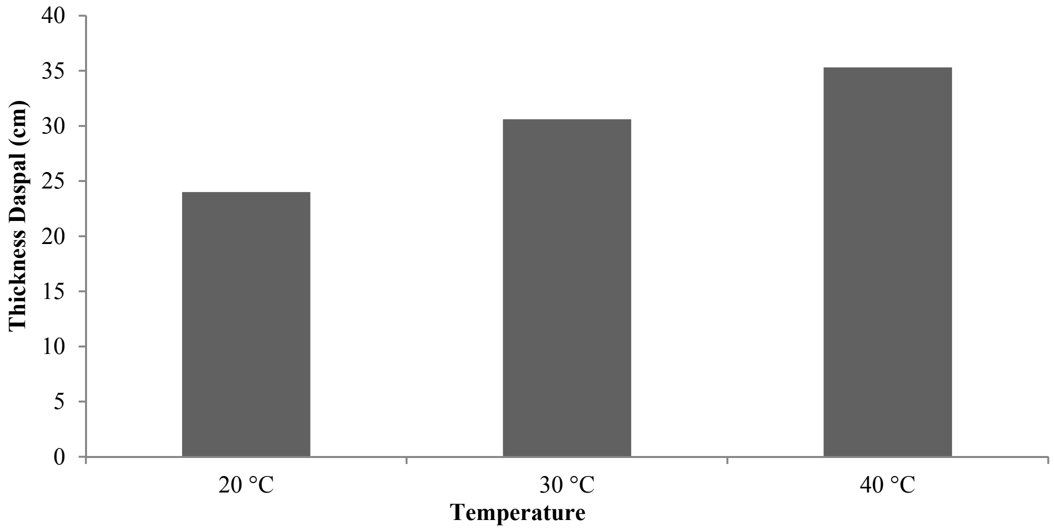

Figure 3: Daspal thickness design with different temperature variations

cm) at 20^0C temperature compared to other temperature conditions. This shows that for effective daspal pavement thickness should be designed at 20^0C as optimal.

4 CONCLUSION

Based on this research with the effect of aging on the characteristics of daspal using Bina Marga 2010 Specification, it can be concluded that the stability value of the concrete mixture of the daspal has increased significantly due to the aging of daspal in the mixture. When value of daspal stability is too high it leads to easy cracking. The flow value of mixture slightly increased in STOA condition and decreased in LTOA condition due to longer oven periods. The void in the mixture (VIM) increased in STOA condition and slightly decreased in LTOA condition due to aging process. The value of void in daspal (VFB) decreased in STOA conditions and increased in LTOA conditions due to the aging process.

Indirect Tensile Stiffness Modulus (ITSM) value under conditions DP, STOA and LTOA test specimens can be concluded that the STOA is the most effective condition because it has the greatest rigidity modulus value.

The result of daspal pavement layer thickness analysis with SPDM Software Bisar 3.0 method concluded that in all temperature variation, it is better to design the thickness of daspal layer based at the temperature 20 ^{0}C because the smallest thickness design value (24 cm).

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