Modulus resilientanalysis of flexible pavement AC–WC and AC–BC using asphalt penetration 60/70 from Marshall testing results

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Abstract

The quality of asphalt concrete that meets the technical specifications as asphalt pavement construction materials become key considerations in the design life of the road can be achieved. Mix asphalt used for road pavement is generally of asphalt concrete with penetration 60/70. Asphalt concrete is a construction material that has a flexural behavior for receiving the traffic load. One of the behavior in question is modulus resilient (Mr), the selection of aggregate gradation and type of asphalt that meet certain requirements greatly affect the quality of asphalt concrete. The test method uses static loading by means of Marshall Test. Modulus of elasticities can be measured by the Marshall parameters. The maximum value of modulus resilient for asphalt mixture AC–WC = 37845 MPa and AC–BC = 31626 MPa. Implementation Marshall Test still fit for use in determining the modulus resilient although there are other ways more detail in the search for the value of modulus resilient of a material. Analysis modulus resilient on the author aims to know the value of modulus resilient (Mr) on the pavement AC–BC and AC–WC as an evaluation the results of the planning detail engineering design (DED) pavement.

Key words; AC–WC and AC–BC pavement,Asphalt pen 60/70, Loading Static, Modulus Resilient.

Introduction

Handling the increase in the road structure intended for vehicular traffic convenience. Directly visible damage occurs on the surface layer, among the causes is the durability and rigidity of asphalt pavement that do not meet the design life. Another problem is the use of asphalt mix material and mixing process and implementation of the work in the field. Technology asphalt concrete until now highly developed continues to prove a lot of studies and research conducted to answer the question above.

Analysis of the behavior of asphalt pavement layer is an important part of the study has been conducted in recent years. Here are a few studies on the behavior of asphalt pavement under different loading conditions through experimental and computational techniques focused on stiffness modulus. To evaluation of resilient behavior of flexible pavement asphalt layers using bitumen pen 60/70. Testing method using a single loading pulse shape known as have sine is representing a given loading form to the binder layer and indirect tensile test to determine modulus resilient using universal testing mechanism.

Di–Benedettto, et al. (2013) introduced the indirect tensile test method a modulus of rigidity as the main property of asphalt is closely related to permanent deformation. In a summary of the findings by RILEM Technical Committee 206 Advanced Testing and Characterization of Materials Asphalt, the bonds between the layers on the pavement too well considered. The influence from diameter of the sample, temperature test, speed, voltages that arise, and the aging of shear bond strength was valuated through shear test (Partl, et al., 2011). Chailleux, et al. (2011) investigation modulus press of high modulus asphalt mixtures using the indirect tensile test and compared with the complex modulus. In addition, the e of wave loading on the test results is explored. Indirect tensile test conducted in accordance with EN 12697–26 standard procedure.

Carbonneau, et al.(2003) evaluation of the implementation of the indirect tensile stiffness modulus test as an alternative to direct tension modulus test. The results showed a good correlation between the two test methods. Based on the limit of the measuring instrument, achieving the target strain is difficult, especially for a mix of high modulus. Alternative test was used to mix the cold with some damage to the sample during the test. In another study, (Carbonneau, et al.,2009) compared to indirect tension modulus test performed on two different mixtures using six engines with direct tensile testing. Mr measured in accordance with EN 12697–26 annex C (IT–CY) standard procedure, compared with estimates of the complex modulus and tensile modulus directly. Indirect tensile test is a method that is reliable, fast and low cost and is recommended for semi–coarse asphalt mix design. However, for a mix of high modulus, the test procedure requires some adjustments.

Currently planning method with mechanical and empirical pavement, flexible pavement is designed based on the effect of temperature and loading conditions are different. One of the characteristic properties of bitumen of the most important in the design procedure is the modulus of asphalt pavement. This parameter is the elasticity behavior of bituminous materials in a variety of loading conditions and traffic. In addition, the elastic multilayer theory and finite element model for asphalt pavement thickness determination and analysis of pavement structure is already highly developed.

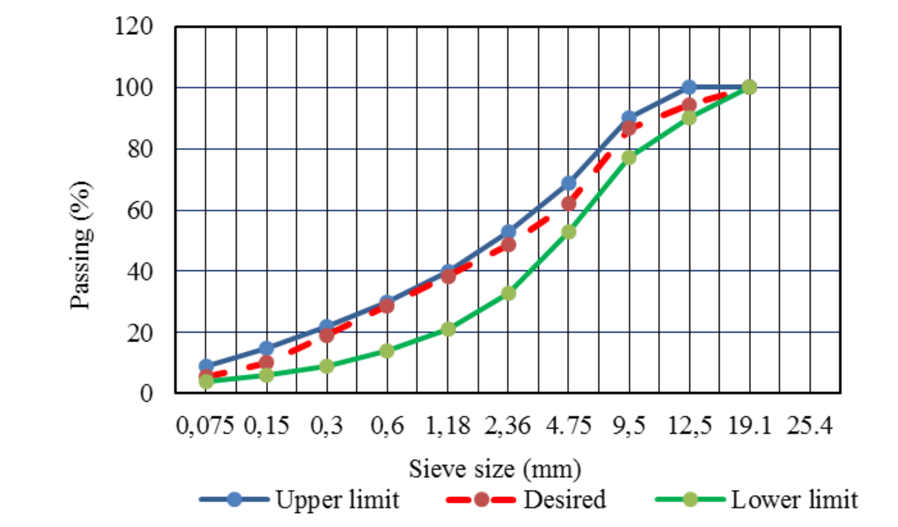
Package contract Preservation Rehabilitation Major Krueng Raya Banda Aceh–Lambaro–BlangBintang (SKPD–03) of fiscal year 2016 to be used as an example of calculation analysis on the pavement modulus resilient AC–BC and AC–WC based on test results marshall. Previous research has shown that the determination of the modulus in the asphalt layer using dynamic modulus and not modulus resilient (Mr) which makes some of the responses in the pavement ignored, which can be effective on pavement performance prediction (Ameri, et al., 2014 and Zhou, et al., 2010). Based on the above reasons, the authors use analysis Mr on the design of flexible pavements.

Experimental/Methods

Material

Aggregates

Directorat Jenderal Bina Marga (2010) Aggregates are used in the preparation of test samples must satisfy the physical properties in accordance with the technical specifications (Ameri, et al., 2014). The maximum nominal aggregate size of the mixture is 19 mm for asphalt concrete surface layer (AC–WC), whereas for the binder layer (AC–BC) is 25 mm. Source of aggregate material from AMP PT. Ayu Lestari Indah, Aceh Besar (2016). As the material of asphalt concrete aggregate required that can be divided into two (2) types of aggregates are coarse aggregates with with provisions retained on a sieve no. 8 or sieve size 2.36 mm and fine aggregate with a sieve size no. 8 (2.36 mm) and retained on sieve no. 200 (0.075 mm). Before to the first gradation test material abrasion test is conducted using a Los Angeles with SNI 06–2417–2008 method with the results of 16.486%. Further test to determine composition graded aggregate mixture used. Theaggregate gradation test results are shown in Figure 1 and 2.



TFigure. 1. Asphalt concrete/AC–WC aggregate gradation of the Bina Marga (2014)

Table 1.Physical properties of aggregate

Test	Method	Value	Standar requirement
Abrasi test	SNI 06-2417-2008	16,486	Min 40 (%)

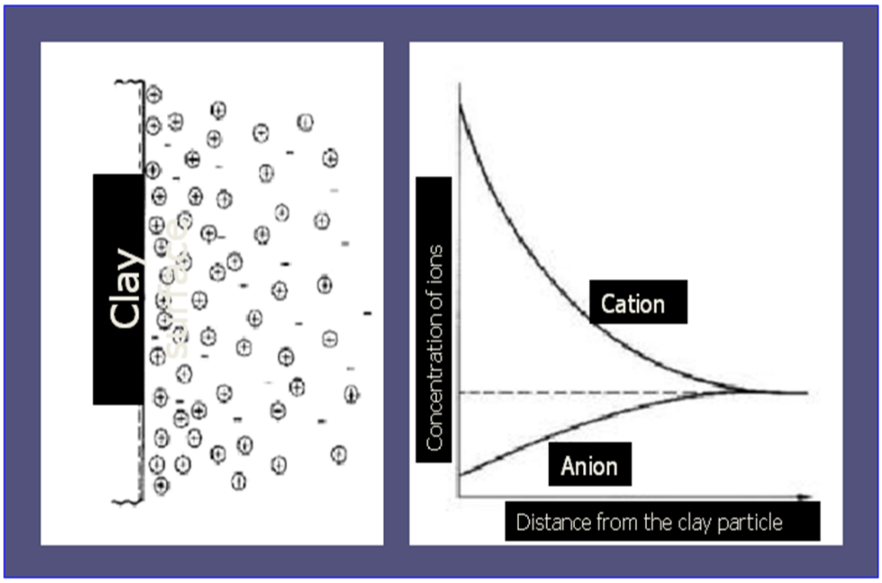


Figure. 2. Asphalt concrete/AC–BC aggregate gradation based on the Bina Marga (2014)

Bitumen

Samples were prepared using the mix asphalt bitumen pen 60/70 is in the technical specifications of Highways called bitumen of type I (Ameri, et al., 2014). Before the asphalt is used as asphalt concrete pavement asphalt test is carried out in the National Road Implementation I Medan Office (2016) which aims to determine the physical properties of the asphalt corresponding technical requirements specified. Here are the results of test of asphalt as in Table2 below.

Table 2.The results oftest on asphaltpen 60/70

Test	Method	Value	Standar requirement
Penetration 25°C (0,1 mm)	SNI 06–2456–1991	62	60–70
Softening point (°C)	SNI 2434:2011	48	≥ 48
Ductility 25°C (cm)	SNI 2432:2011	150	≥ 100
Flash point (°C)	SNI 2433:2011	323	≥ 232
Solubility in Trichloroethylene (%)	AASHTO T44–03	99	≥ 99
Specific gravity	SNI 2441:2011	1,052	≥ 1,0

Mixture design

Asphalt concrete mix design is achieved in accordance with the Marshall method specified in, AASHTO TP31–96 (1996) standard methods. Optimum bitumen content should be based on laboratory and field testing as set out in the work plan of the mixture (JMF). Mixing is done at AMP PT. Ayu Lestari Indah used for preservation work rehabilitation majorKrueng Raya–Banda Aceh–Lambaro–BlangBintang (SKPD–03) of fiscal year 2016. The specimens were made, namely asphalt AC–WC and AC–BC, with the shape of a cylinder diameter of 101, 60 mm (4 in) and thicknes40 mm and 60 mm with the number of each 12 specimen. The temperature of the asphalt mix is set to 160 °C while the temperature of solidification of 140–145 °C. Compaction is done by the number of collisions 2 x 75 times per field. Furthermore the specimen soaked with water for 24 hours. Once it is done indirectly with the tensile test at 60 °C using a Marshall Test to determine the value of stability and flow.

Marshall test

Testing marshall conducted to determine the stability, fatigue plastic (flow), volume weight (density), percent voids in the mixture (VIM), percent void filled with bitumen (VFB), percent voids between the grains of aggregate (VMA) and Marshall Quotient (MQ) which an overview of the size of the resistance to deformation of the test specimen. Methode tests conducted in accordance with SNI 06–2489–1991, whereas in the calculation to determine the value ITS and Mr using ASTM method D4123–04 (Carbonneau, et al., 2009).

Table 3. The results of recapitulation Marshall Test of asphalt concrete AC–WC and AC–BC.

Creteria	Unit	AC–WC		AC–BC	
		Value	Specification	Value	Specification
OBC	%	5.790	–	5.481	–
VIM Marshall	%	4.35	3 – 5	4.57	3 – 5
VIM Refusal	%	2.83	min 2	3.27	min 2
VMA	%	15.47	min 14	15.14	min 14
VFB	%	71.89	min 65	69.78	min 65
Stability	Kg	994.76	min 800	1030.08	min 800
Flow	Mm	3.40	2 – 4	3.31	2 – 4
Density	gr/cm²	2.345	–	2.350	–
Marshall Quotient	kg/mm	277.87		311.36	

Indirect tensile strength (ITS)

Indirect tensile strength is a method to determine the tensile strength of asphalt concrete is happening on the field. Asphalt pavement layers must be having two loading namely compressive load and tensile load. To obtain tensile force loading happens on the ground is very hard, so that the appropriate method to determine the tensile force on the tarmac by using laboratory methods of indirect tensile strength. Indirect tensile strength value using the following Eq. (1):

$$ITS = \frac{2 \times P}{\pi \times d \times h} \quad \text{.......(1)}$$

where ITS, is the value of indirect tensile strength (N/mm²), P value of stability (N), specimen height h (mm), d the diameter of the specimen (mm).

The indirect tensile test a trait test tensile failure of asphalt which is useful to prediction the condition of potential cracks. Good pavement layer is able to withstand the maximum load that the occurrence of cracks can be prevented. The specimen test for tensile test indirect cylindrical is experiencing loading tap with two pressure plate.

Modulus resilient (Mr)

Modulus resilient (Mr) is a measure of the stiffness of a material, which is the approximate Modulus of Elasticity (E). Carbonneau, et al. (2009)the modulus of elasticity is stress divided by strain using weights done slowly. While the modulus resilient is voltage divided by the strain to be done quickly load in accordance with that experienced by the pavement. The magnitude of the test load is applied in Mr be selected as part of the indirect tensile strength (ITS) of asphalt mixtures (Al–Qadi, et al., 2087 and Asphalt Institute, 2007).Modulus resilient also called elasticity of a material in tension indirect method can be calculated using Eq. (2):

$$Mr = \frac{P \times (\mu + 0.27)}{\Delta H} \quad \text{.......(2)}$$

where Mr is the modulus resilient (MPa), P repeated load (N), μ is the poison ratio, t is the thickness of the specimen (mm) and ΔH is the horizontal deformation (mm), (ASTM D7369–11, 2011). Poisson's ratio in Eq. (2) is generally set to 0.35.

Results and Discussion

The value Marshall Test specimen results for asphalt concrete AC–WC and AC–BC on each specimen showing different variations. Value indirect tensile strength (ITS) and the modulus resilient (Mr) is calculated by equation (1) and (2). Table 3 is the average value marshall test on each of the asphalt mix. From the analysis of the known value of the indirect tensile test (ITS) and modulus resilient (Mr) for the asphalt concrete (AC–WC) is a maximum of 1,283 kPa and 37,845 MPa, while for AC–BC is 878 kPa and 31,626 MPa. Table 4 show the value of ITS and Mr varied, the average value of ITS and Mr for asphalt concrete mix AC–WC and AC–BC is the value of ITS 1.168 Kpa, Mr 33.481 MPa and ITS 820 Kpa, Mr 24.285 MPa. On the asphalt mixture AC–WC are shared values ITS but Mr different, these conditions occur in the test specimen number 4 = 12, number 6 = 11, number 5 = 10 and number 3 = 9. While the AC–BC only specimen number 1 = 3. Factors affecting these similarities are the value of stability experienced the same.

ITS value relationship and Mr indicate that the value of tensile force that occurs then the modulus resilient is also a great value. The test object number 1 value ITS are tends to be low, namely 1117 Kpa with modulus resilient 31.962 MPa compared with the specimen number 6 of 31.087 MPa, it is influenced by the amount of deformation experienced. The reability value R = 0.6337 at AC–WC, R = 0.5279 for the AC–BC as in figure 3 and 4. The results for subsequent analysis known the value of Mris design for AC–WC and AC–BC amounted to 3.144 MPa and 21.432 MPa, and shows that the second pavement layersmodulus resilient is in accordance with Mrcontained in the initial design, so its performance is expected to correspond service life.

Table 4. The results of indirect tensile strength (ITS) and modulus of resilience (Mr) test.

No.	AC–WC asphalt content 5,790 %		AC–BC asphalt content 5,481 %	
	ITS (Kpa)	Mr (Mpa)	ITS (Kpa)	Mr (Mpa)
1	1,117	31,962	878	26,684
2	1,283	37,845	889	25,432
3	1,217	33,829	878	31,626
4	1,133	30,637	778	22,253
5	1,167	33,393	811	25,453
6	1,150	31,087	733	20,382
7	1,100	32,439	844	22,818
8	1,183	35,987	800	22,889
9	1,217	34,824	855	23,779
10	1,167	32,439	766	22,600
11	1,150	33,913	789	23,982
12	1,133	33,422	822	23,525

Conslusions

1. The modulus resilient is a parameter that determines the strength of the asphalt mix, that influenced by static loading and plastic deformation.
2. The high value of indirect tensile strength generally indicates the magnitude of the modulus resilient, so it can be called that the asphalt mixture has a high strength.
3. The similarity in the value of the indirect tensile strength (ITS)of the asphalt mixture AC–WC and AC–BC but modulus resilient values there is a difference, this is due to the static loading (stability marshall) experienced by each specimen is the same but different deformation values.
4. In the process of mixing asphalt concrete AC–WC uses an effective asphalt content 5.790% for all specimens, while AC–BC amounted to 5.481%.
5. The modulus resilient maximum value for the asphalt mixture AC–WC = 37845 MPa and AC–BC = 31.626 MPa.
6. The modulus resilient analysis results prove that the modulus resilient of asphalt mixture AC–WC is greater than the AC–BC, so the mix in the laboratory trial results can be used as a reference implementation in the field.
7. The test results on the stability and flow test marshall greatly affect the value of modulus resilient
8. Implementation Marshall Test still fit for use in determining the modulus resilient although there are other ways more detail in the search for the value of modulus resilient of a material.

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