Asphalt 60/70 Penetration Analysis of AC/BC Mixture With the Addition of Ethylene Vinyl Acetate (EVA) As Asphalt Raw Material

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ABSTRACT

This study was conducted to determine how much influence EVA (Ethylene Vinyl Acetate) added to Laston AC-BC has on Marshall characteristic values. The Marshall test carried out will produce stability values at the optimum asphalt conditions that meet the 2018 Highways specifications. The stability value will be used to analyze changes in the characteristics of the Laston AC-BC (Asphalt Concrate – Binder Course) mixture after adding a mixture of EVA (Ethylene Vinyl Acetate) . To determine an aggregate gradation in the AC-BC mixed layer, coarse aggregate is used in the form of crushed stone with a maximum size of ” while for fine aggregate it is a mixture of crushed stone, stone ash and sand. The additive or modifier used is EVA (Ethylene Vinyl Acetate) polymer. Next, to obtain good asphalt concrete, the gradation of the aggregate must meet the general specifications of Bina Marga 2018 which have been determined through SNI-ASTM-C136-2012. In making the test object, ± 1200 gram of aggregate and asphalt are needed so that the specified height of the test object will be produced. Through the analysis of the aggregate sieve, the weight of the aggregate required for the test object can be calculated. Modification of asphalt with EVA aims to determine the stiffness and properties of asphalt in resisting loading with a certain penetration value so as to produce a Penetration Index value which will affect the characteristics of asphalt against weather changes. Research and knowledge related to the addition of a mixture of EVA (Ethylene Vinyl Acetate) to asphalt can be further developed so that it can be implemented on types of road pavements with higher traffic density conditions

Key word: ethylene vinyl acetate (EVA); test marshall; campuran AC/BC.

INTRODUCTION

Flexible pavement with asphalt binder is a type of pavement that is more often used in highway construction. Flexible pavement generally uses a mixture of asphalt and aggregate as a surface layer. Asphalt is a structural and non-structural layer used in the process of carrying out road construction work. In the asphalt mixture there are several types of aggregate consisting of fine aggregate, coarse aggregate, mineral filler and bitumen binder. Polymer is a component that can be used as an additive in road pavements and can increase pavement resistance to various damages, such as permanent deformation, cracking due to temperature changes, fatigue damage, and material separation/release (Industry et al. 1991, Waste, Beverages, and From 2021).

Asphalt as one of the constituent materials of the pavement structure which functions as a binder has not been able to overcome the problems caused by high temperatures, traffic volume and over loading. One method that can be done to improve the performance of asphalt is by modifying asphalt with the addition of polymeric materials. One of the polymeric materials that can overcome this problem is plastomer type EVA (Ethylene Vinyl Acetate) polymer. This type of polymer is easy to use and has good ability to unite with asphalt, the temperature is stable in normal mixing and the temperature is easy to control (Sistra et al., 2016). EVA (Ethylene Vinyl Acetate) is a thermoplastic material composed by the copolymerization of ethylene and vinyl acetate. EVA is a transparent semi-rigid product and is a transparent elastic material similar to PVC plastic mixed with rubber. According to (Waste, Beverage, and Dari 2021, (Suparma et al., 2015) In the stages of making EVA modified asphalt, it is known that the materials used cannot be mixed homogeneously if using a manual mix.

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EVA material will float on the asphalt surface in a thin layer, so a Mechanical Stirrer is needed (Handayasari et al., 2020). Mixture testing is generally not only carried out on asphalt or aggregate, but must also be carried out on asphalt and aggregate mixtures to obtain the desired ratio and characteristics for the mixture (Iqbal et al., 2010); (Saleh et al., 2016).

Asphalt modification with EVA is expected to increase the stiffness index of asphalt, due to its rigidity in resisting loading and penetration, with this mixture it is hoped that asphalt will become harder and can increase the softening point value in order to produce a good Penetration Index value so that asphalt is more resistant to changes in weather (Dwi et al., 2015).

In the construction of road pavement layers, there are rigid pavements and flexible pavements. Discussion of ordinary rigid pavement on concrete with the concept of rigid pavement. The rigid pavement concept is adapted to the pavement layer conditions that have been planned (Syaiful S, 2021, Syaiful S, Rusfana H, 2022). Flexible pavements have been prepared with standard asphalt content so that it is possible to survive in any weather. Extreme weather in the study area is prepared with a clear concept so that it is expected to be optimal in determining flexible pavement calculations using Asphalt (Syaiful S, Lasmana L, 2020; Shofia MH et al, 2012).

RESEARCH METHODS

The method used in this study is the experimental method, namely the method carried out by conducting experimental activities to obtain data. The initial stages of research conducted at UPT. Construction Materials Laboratory of the Department of Highways and Construction of North Sumatra Province is collecting secondary data on the quality of asphalt materials and checking the quality of the aggregates to be used in the mixed trials. Data collection techniques were carried out by experimental methods on several test objects from various treatment conditions tested in the laboratory. For some things in material testing, secondary data is used. Secondary data is data used from material test objects that have been carried out by the company and tested at the Material Testing Center

Material

The materials used in this study include:

1. Asphalt Hard.
   This study used Pertamina's hard asphalt obtained from the Asphalt Mixing Plant (AMP) of PT. Mighty Pure Works, Deli Serdang.
2. Coarse and Fine Aggregates.
   The coarse and fine aggregates used were obtained from the Asphalt Mixing Plant (AMP) of PT. Mighty Pure Works, Deli Serdang.
3. EVA Polymer (Ethylene Vinyl Acetate).
   This study used EVA Polymer (Ethylene Vinyl Acetate) as a material for the Laston AC-BC mixture obtained from a chemical shop located on Jl. West Irian No. 29, Gg. Buntu Kec. Medan, North Sumatra

Aggregate Wear Check

Los Angeles machine was used to obtain data on the resistance of the coarse aggregate to wear. The wear value was expressed by the ratio between the weight of the wear material passing through the No. sieve. 12 of the initial weight using units of % (percent) according to SNI 2417:2008. The aggregate wear data collection stage uses the following tools (Kurniawan & Setyawan, 2016) (Saleh et al., 2019)

1. Los Angeles Abrasion Machine (steel cylinder closed on both sides) diameter 711 mm (28 inches) long 508 mm (20 inches) deep.
2. The cylinder rests on two short shafts that are continuous and rotate on a horizontal axis.
3. No.12 filter (1.70 mm) and other filters.
4. Scales with an accuracy level of 0.1%

5. Steel balls with an average diameter of 4.68 cm (1 27/32 inches) and weighing between 390 grams to. 445 grams.
6. Oven with temperature control as a heating device with a temperature of 110°C ± 5°C.

Mixed Planning (Mix Design).

Asphalt concrete planning includes gradation planning and aggregate composition for the asphalt mixture and the number of test objects. The aggregate gradation used in this study is the combined aggregate gradation of Laston AC-BC layers. The ideal aggregate gradation size must comply with the 2018 General Highways Specifications. The mixing process is carried out after first sieving each fraction. The composition of the mixed material is adjusted to the number of coarse aggregate fractions CA (Course Aggregate), MA (Medium Aggregate), and fine aggregate FA (Fine Aggregate).

Test Methods

The analysis was carried out through a testing process using the Marshall test method according to RSNI M-01-2003. Testing of the test object (sample) carried out in this process is divided into two parts, which consist of:

a. Testing bulk specific gravity (specific gravity).
b. Stability and flow test

To find out a good asphalt mixture requires examining the properties (asphalt properties) of the mixture through several types of tests as follows:

1. Penetration Test
   This test is carried out to determine whether the asphalt is hard or soft (solid or semi-solid) by inserting a penetration needle through the size, load and time that is set into the asphalt at a certain temperature. This test was carried out by loading the asphalt surface weighing 100 grams on a 1 mm diameter needle support for 5 seconds at a temperature of 250°C. The higher the penetration value indicates that the asphalt is more elastic and makes the pavement more resistant to melting/fatigue.
2. Softening Point Test
   This inspection is intended to determine the softening point of asphalt which ranges from 30°C to 200°C. The softening point is the temperature when a steel ball with a certain weight pushes down an asphalt layer which is retained in a certain sized ring, so that the asphalt touches the base plate which is located under the certain sized ring until the asphalt touches the base plate which is located under the ring at a certain height due to heating speed.
3. Ductility Test
   This experiment is to determine the cohesive properties of asphalt by measuring the longest distance that can be pulled between two molds containing hard asphalt before breaking, at a certain temperature and tensile speed. Cohesion is the ability of asphalt particles to stick to each other. Asphalt with low ductility is asphalt that has poor cohesion compared to asphalt with high ductility.
4. Flash Point Test and Fire Point
   This test is carried out to determine the flash point and firing point of all types of petroleum products except fuel oil and other materials which have an open cup flash point of less than 70°C. Through this test it will be known at what temperature the asphalt will be damaged due to heat, namely when the first flame occurs for the flash point, and the flame is evenly distributed for at least 5 (five) seconds for the burn point.
5. Asphalt Adhesion Test on Aggregate
   This attachment test is carried out to determine the adhesion of asphalt to certain rocks in water. Asphalt adhesion test to aggregate is a quantitative test used to determine the adhesion (adhesion) of asphalt to aggregate. Adhesion is the ability of asphalt to adhere and bind aggregates. Observation of the results of the attachment test was carried out visually.

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Data Analysis

The coarse aggregate used in the AC-BC mixture in this study was crushed stone with a maximum size of ¾" while the fine aggregate consisted of a mixture of crushed stone, stone ash and sand as an additional material used in the form of EVA polymer (Ethylene Vinyl Acetate). Meanwhile, the fine aggregate gradation used for asphalt concrete follows the general specifications of Bina Marga 2018 according to SNI-ASTM-C136-2012. Based on the results of the sieving test analysis, the data on the percentage combination of aggregate gradations that are in accordance with the 2018 General Highways Specifications in normal conditions are as follows:

1. Coarse aggregate CA ¾ inch = 29 %
2. Aggregate medium MA 3/8 inch = 28%
3. Fine aggregate of rock ash (Cr) = 28%
4. Fine aggregate (sand) = 13%
5. Cement = 2 %

For each test object, ± 1200 grams of aggregate and asphalt composition is required so that the height of the test object is approximately 63.5 mm ± 1.27 mm. For the results of the aggregate sieve analysis for standard specimens, it is known that the weight of the required aggregate is calculated, as can be seen in Table 1.

Table 1. Calculation results of the required aggregate weight for standard test objects.

Rate asphalt (%)	Asphalt (gram)	CA¾ inch (gram)	MA 3/8 inch (gram)	Stone ash (gram)	Sand (gram)	Cement (gram)
5	60	330,6	319,2	320,3	148,2	21,7
5,5	66	328,9	317,5	318,7	147,4	21,5
6	72	327,1	315,8	316,9	146,6	21,4
6,5	78	325,4	314,2	315,3	145,9	21,3
7	84	323,6	312,5	313,6	145,1	21,2

RESULT AND DISCUSSION (10pt Bold)

Next, for the results of the aggregate sieving analysis for the test specimens using EVA (Ethylene Vinyl Acetate) 2%, 3%, 4%, it is known that the weight calculation of the required aggregate is known, as can be seen in table 2.

Table 2. The results of calculating the required aggregate weight for test objects using EVA (Ethylene Vinyl Acetate) 2%, 3%, 4% with 5.5% KAO.

Material	% Agregate	Agregate weight (gram)	Comulative (gram)
Broken stone ¾	27,4	328,7	328,7
Medium	26,4	317,4	646,1
Stone ash	26,5	318,6	964,7
Sand	12,4	147,4	1112,03
Cement	1,8	21,5	1133,6
Asphalt	5,5	66,4	1200
2% EVA	2	1,3	1201,3

% EVA	**2%**	**3%**	**4%**
EVA (gram)	1.3	1,9	2,7

Furthermore, the Marshall test results data with normal asphalt mixture and with the addition of EVA (Ethylene Vinyl Acetate) 2%, 3% and 4%. can be seen in table 3 and table 4

Table 3. Marshall test results with normal mixtures

Asphalt character type	**Asphalt content %**				
	5%	**5,5%**	**6%**	**6,5%**	**7%**
Bulk Density (gr/cc)	2,29	2,32	2,34	2,34	2,33
Stabilty (kg)	1163.60	1280,19	1335.29	1180.19	1048,74
VIM (%)	5,83	4,02	2,62	1,74	1,36
VMA(%)	16,74	16,19	16,03	16,32	17,03
VFB (%)	65,19	75,20	83,65	89,34	92,02
Flow (mm)	3,30	3,65	3,85	3,65	3,25

Table 4. Marshall test results with the addition of a mixture of EVA (Ethylene Vinyl Acetate) 2%, 3% and 4%

Asphalt character type	**Asphalt content EVA %**		
	2%	3%	4%
Bulk Density (gr/cc)	2,39	2,37	2,34
Stabilty (kg)	1530,37	1446,80	1346,88
VIM (%)	1,32	2,11	3,11
VMA (%)	13,90	14,58	15,45
VFB (%)	90,50	85,53	79,88
Flow (mm)	3.33	3,50	3,68

The results of the values for bulk density, stability, percentage of voids in the mixture (VIM), percentage of voids in aggregate (VMA), melting (Flow) in normal asphalt mixtures and asphalt with the addition of EVA (Ethylene Vinyl Acetate) 2 %, 3% and 4% can be seen through the following graph

Weight of contents (Bulk Density)

Density (bulk density) for normal asphalt mixture with the addition of 5% asphalt content produces a density value of 2.29 gr/cc, whereas with the addition of 5.5% the asphalt density value increases to 2.32 gr/cc, then with the addition of 6%, the density value increases to 2.34 gr/cc, as well as with the addition of 6.5% the density value reaches 2.34 gr/cc. However, at 7% content, the density value decreased to 2.33 gr/cc. Based on this, it can be concluded that the addition of excessive bitumen content to a certain limit can reduce the density of a mixture. The bulk density value of normal asphalt before the addition of 2%, 3% and 4% EVA (Ethylene Vinyl Acetate) can be seen in Figure 1.

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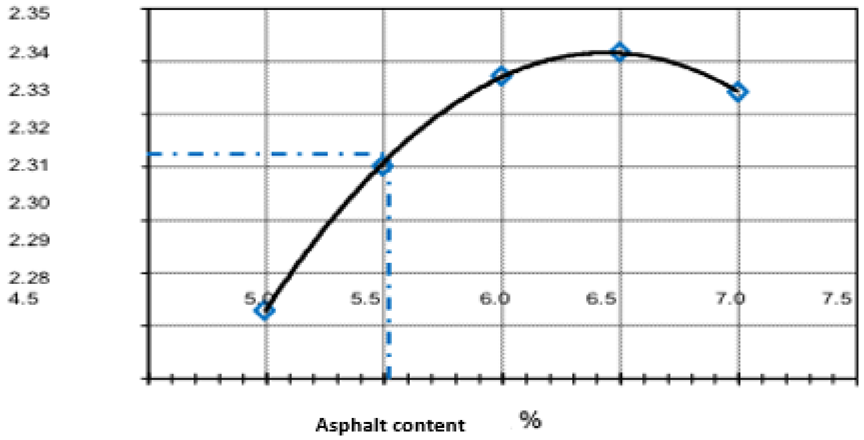

Figure 1. Graph of the relationship between asphalt content (%) and bulk density (gr/cc) in normal mix

For the density value with the addition of 2% EVA, the asphalt density value reaches 2.39 gr/cc, while with the addition of 3% EVA, the density value decreases to 2.37 gr/cc, then after the addition of 4% EVA, the density value drops to 2. .34 gr/cc. Based on the data generated, it can be concluded that the greater the percentage (%) of EVA added, the density value of an asphalt mixture will also decrease, as can be seen in Figure 2.

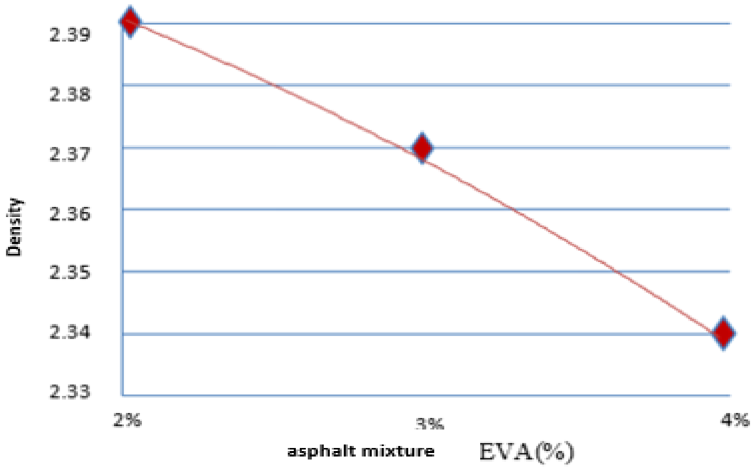

Figure 2. Graph of the relationship between Bulk Density (gr/cc) with the addition of EVA

Stability

The stability value of normal asphalt and the addition of EVA (Ethylene Vinyl Acetate) 2%, 3% and 4% from laboratory test results can be seen in Figure 3.

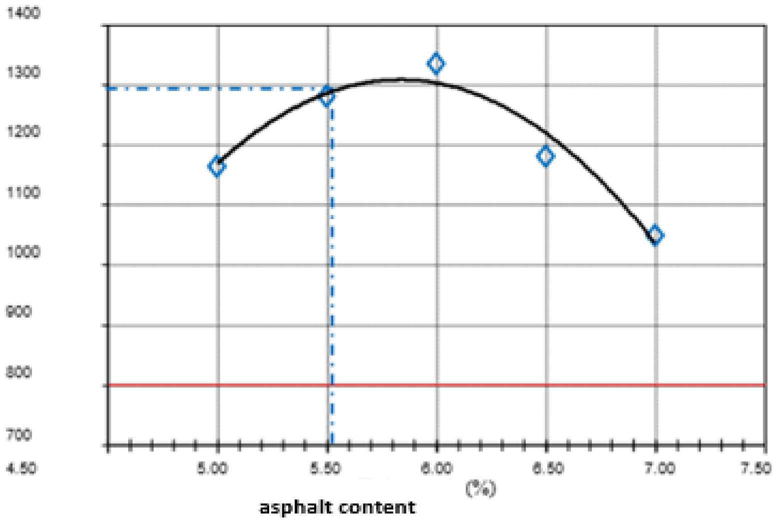

Figure 3. Graph of the relationship between bitumen content and normal mix stability

Judging from the Stability chart for normal asphalt mixtures, it can be seen that with the addition of 5% asphalt content, the stability reached 1,163.60 kg, at 5.5% it increased to 1,280.19 kg, at 6% it increased to 1,335.29, at 6 .5% decreased to 1,180.19 kg and at 7% also decreased by 1,048.74 so that it can be concluded that the addition of excessive bitumen content to a certain extent can reduce the stability of a mixture. While the tests were carried out with the addition of 2% EVA, the stability value was 1,530.37 kg, while with the addition of 3% EVA, the stability value decreased to 1,446.80 kg and the addition of 4% EVA, the stability value decreased to 1,346.88 kg. Thus it can be concluded that the greater the percentage (%) of EVA added, the stability value of a mixture decreases, as can be seen in Figure 4.

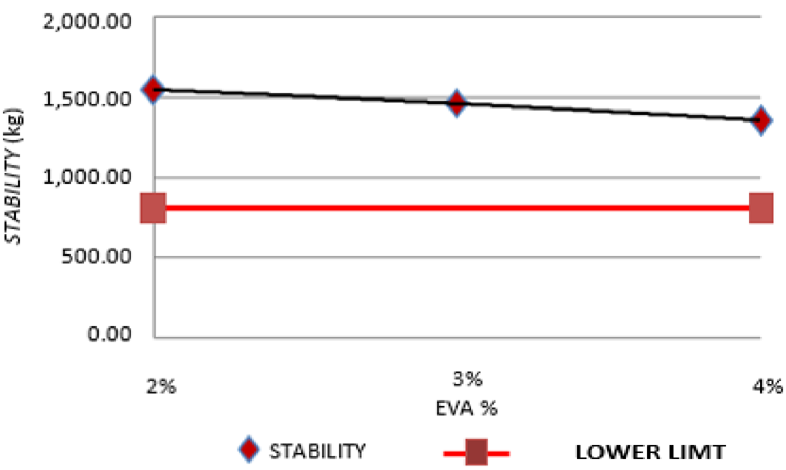

Figure 4. Graph of the relationship between stability and EVA

Void in Mix Marshall (VIM)

In normal asphalt mixtures it is known that with the addition of 5% asphalt content, the VIM Marshall value reaches 5.83%, at 5.5% it decreases by 4.02%, at 6% it decreases by 2.62%, at 6.5% it decreases by 1.74% and at 7% there was a decrease of 1.36%. Likewise with VIM PRD, the addition of 5.5% asphalt content reached 2.79%, at 6% it decreased by 1.69% and at 6.5% it also decreased by 0.91% so it can be concluded that the addition of asphalt content which is excessive to a certain limit causes the VIM Marshall and VIM PRD values with a mixture to decrease, as can be seen in Figure 5.

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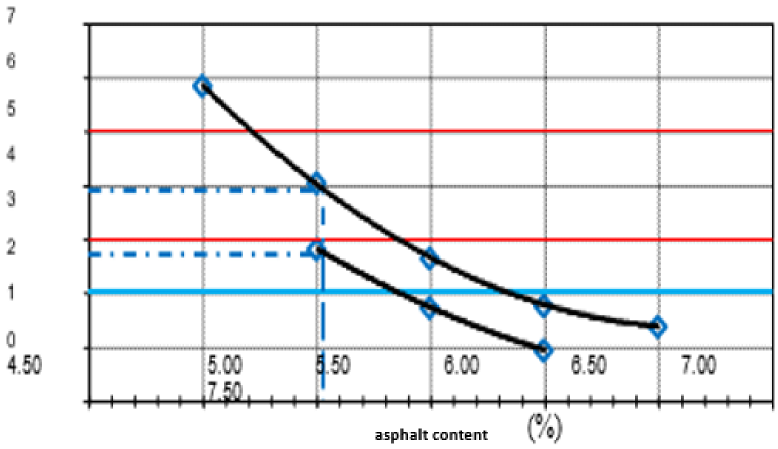

Figure 5. Graph of the relationship between asphalt content and VIM Marshal and VIM PRD in Normal mixtures

While the examination carried out with the addition of 2% EVA resulted in a Marshall VIM value of 1.32%, the addition of 3% EVA Marshall's VIM value rose to 2.11% and at 4% Marshall's VIM value rose to 3.11%. Based on these data it can be concluded that the greater the percentage of EVA added, the VIM Marhall of an asphalt mixture will increase, as can be seen in Figure 6.

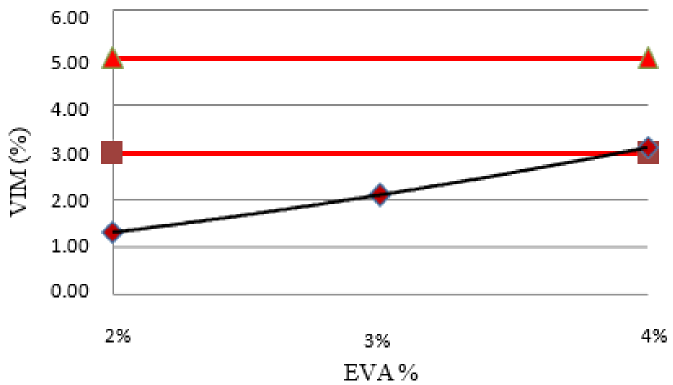

Figure 6. Graph g relationship between Voids in Mix (VIM) and EVA a void In Mineral Aggregate (VMA)

In normal asphalt mixtures it can be seen that with the addition of 5% asphalt content it produces a VMA value of 16.74%, at 5.5% it decreases by 16.19%, at 6% there is a decrease of 16.03%, but at the addition of asphalt content 6.5% again experienced an increase reaching 16.32% and at the addition of 7% it also increased by 17.03%. Based on these data it can be concluded that with the addition of bitumen content between the range of 5% - 6%, the VMA value has decreased, which means there are fewer voids in the aggregate, while in the range of 6% - 7% VMA has increased, which means the voids in the aggregate are increasing. The Void In Mineral Agreggate (VMA) value on normal asphalt with the addition of EVA (Ethylene Vinyl Acetate) of 2%, 3% and 4% can be seen in Figure 7.

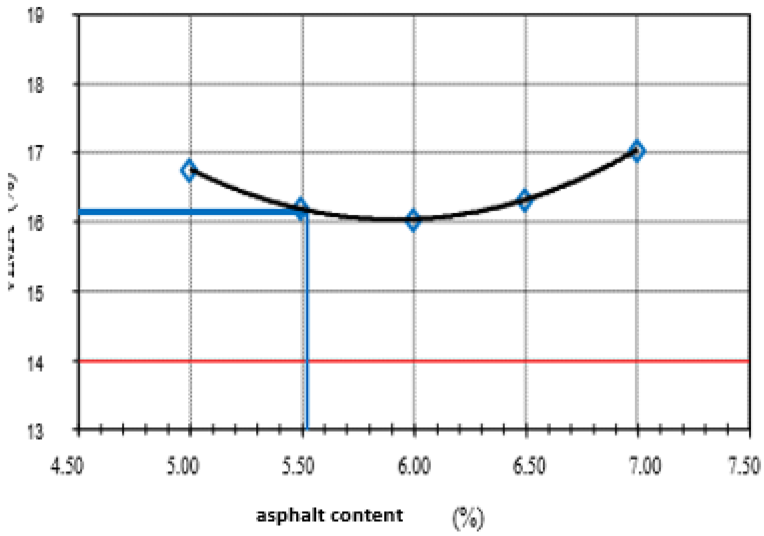

Figure 7. Graph of the relationship between asphalt content and VMA in normal mixtures.

From laboratory tests with the addition of 2% EVA, it produced a VMA value of 13.90%, whereas with the addition of 3%, the increase in VMA reached 14.58% and at 4% there was also an increase in VMA to 15.45%. From these data it can be concluded that the greater the the addition of the percentage of EVA causes the VMA value of a mixture to also increase, as shown in figure 8.

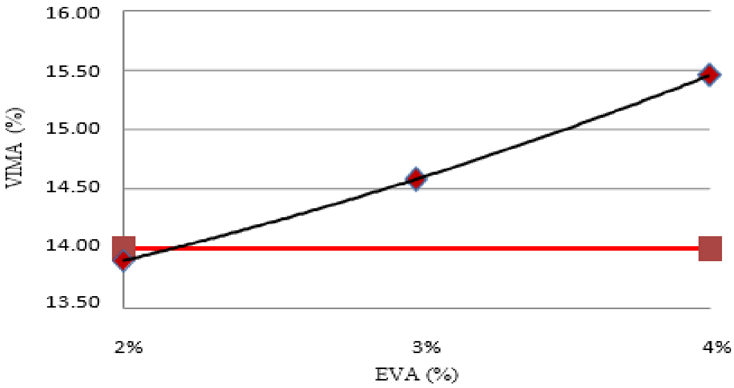

Figure 8. Graph of the relationship between VMA and EVA

Void Filled with Bitumen (VFB)

From laboratory tests on normal asphalt mixtures it can be seen that with the addition of 5% asphalt content it produces a VFB value of 65.19%, at an addition of 5.5% the VFB value increases by 75.20%, at 6% it increases by 83.65 %, at 6.5% it increased by 89.34% and at 7% it also increased by 92.02%. Based on these data it can be concluded that the addition of bitumen content from 5% to 7% resulted in an increase in the VFB value. The value of Void Filled With Bitumen (VFB) on normal asphalt with the addition of 2%, 3% and 4% EVA (Ethylene Vinyl Acetate) can be seen in Figure 9.

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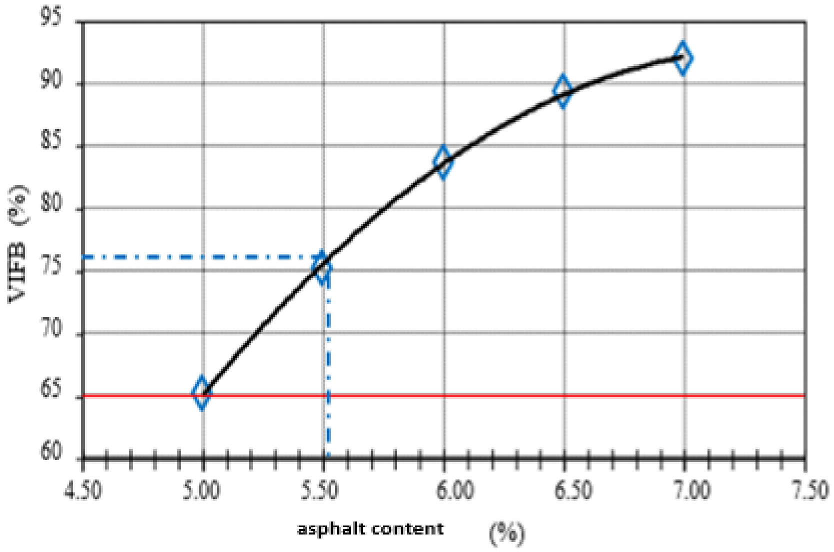

Figure 9. Graph of the relationship between asphalt content and VFB in normal mixtures

From laboratory tests it is known that the addition of 2% EVA produces a Void Filled With Bitumen (VFB) value of 90.50%, while the addition of 3% EVA produces a VFB value of 85.53%, then with the addition of 4% produces a VFB value of 79.98 %. Based on the graphic data above, it can be concluded that the greater the % EVA added to the asphalt mixture, the value of Void Filled With Bitumen (VFB) decreases, as can be seen in Figure 10.

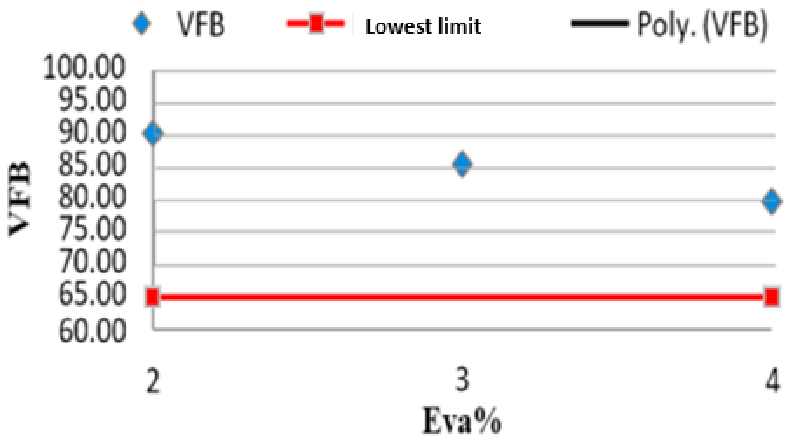

Figure 10. Graph of the relationship between VFB and EVA

Flow

From the results of laboratory tests it is known that the graph for normal asphalt mixture at the addition of 5% asphalt content gives a flow value of 3.30 mm, at 5.5% it increases by 3.65 mm, at 6% it also increases by 3.85 mm, but at 6.5% it again decreased by 3.65 mm and at 7% it also decreased by 3.25 mm. Based on these data it can be concluded that the addition of bitumen content in the range of 5% - 6% resulted in an increase in the flow value while in the range of 6% - 7% the flow value decreased, as can be seen in Figure 11.

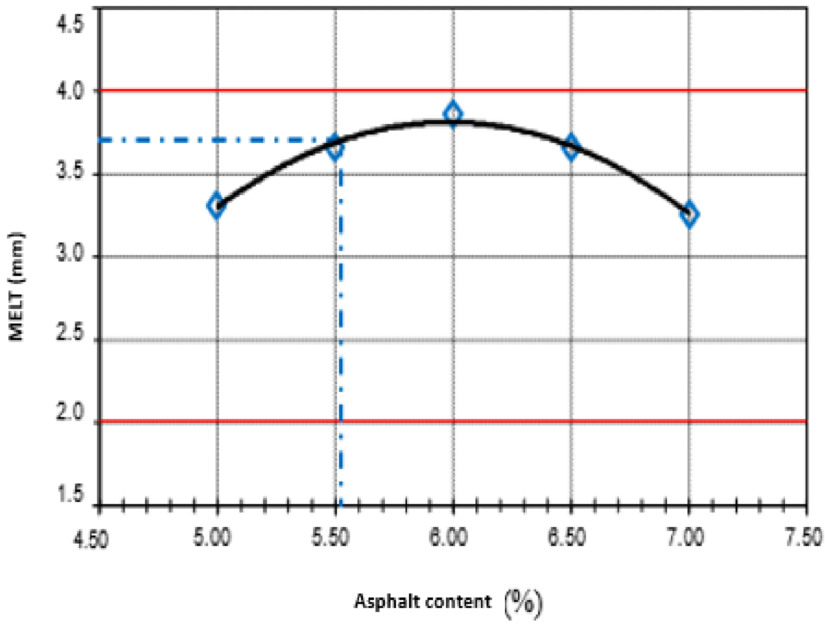

Figure 11. Graph of the relationship between bitumen content (%) and Flow (mm) of normal mix.

Furthermore, based on laboratory testing, the addition of 2% EVA resulted in a flow value of 3.33 mm, while at 3% the flow value increased to 3.50 mm and at 4% the flow value also increased by 3.68 mm. Thus it can be concluded that the greater the percentage of EVA added, the flow value of the asphalt mixture will also increase, as shown in Figure 8.

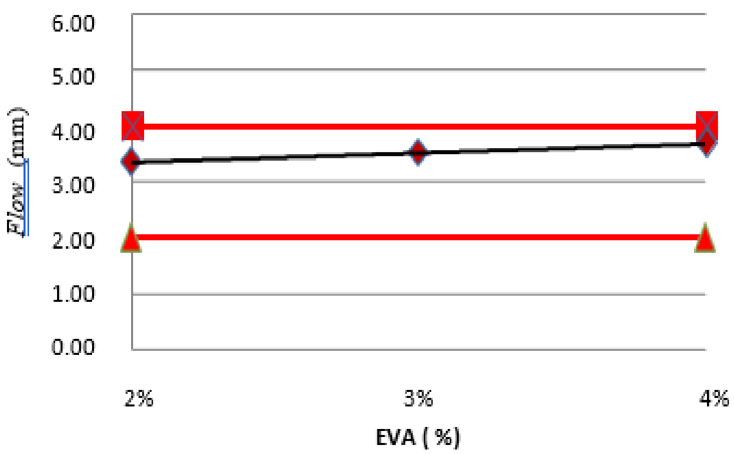

Figure 12. Graph of the relationship between flow and EVA

CONCLUSION

The method used to determine the aggregate gradation in the AC-BC mixed layer consists of coarse aggregate in the form of crushed stone with a maximum size of ¾" while for fine aggregate in the form of a mixture of crushed stone, stone ash and sand. The additional material or modifier used in this test is EVA polymer (Ethylene Vinyl Acetate). Next, to obtain good asphalt concrete, the selected aggregate gradation must meet the general specifications of Bina Marga 2018 which have been established through SNI-ASTM-C136-2012. In making the test object, ± 1200 grams of aggregate and asphalt are required so that the height of the test object will be produced according to applicable regulations. The next stage is the process of analyzing the aggregate sieve which aims to obtain the calculation of the weight of the aggregate needed to make the test object. Furthermore, to

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determine the effect of adding EVA (Ethylene Vinyl Acetate) to the Laston AC-BC mixture with levels of 2%, 3% and 4%, an analysis is needed related to the Marshall characteristic value of the asphalt mixture in accordance with the general specifications of Bina Marga 2018.

Asphalt modification testing using EVA (Ethylene Vinyl Acetate) is expected to increase the stiffness index on asphalt, due to its properties and stiffness which are able to withstand loading and penetration, with this mixture it is hoped that asphalt will become harder and can increase the softening point value in order to produce a penetration value. Good index so that asphalt is more resistant to weather changes.

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