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Cite as: AIP Conference Proceedings **2391**, 070012 (2022); https://doi.org/10.1063/5.0073735
Published Online: 24 March 2022

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Marshall Characteristics of Asphalt Concrete Binder Course (AC-BC) Mixture Containing Modificated Asbuton (Retona Blend 55) Type

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Abstract. The distribution of asphalt mixing plant (AMP) has not been evenly distributed in Indonesia, making it difficult to process road procurement and development in areas without AMP. It is currently available on the market of cold paving hot mix Asbuton products, comprising aggregates, grain Asbutons, perennials and other additives when necessary in accordance with the requirements of the specifications, which are spread and compressed at air temperature. The hot mixing is done by fabrication then marketed in packaged form. While the spraying and compaction is done cold (air temperature), so this product can also be an alternative choice especially for road construction in areas that have limitations of asphalt mixing units such as in remote areas and small islands. This study aims to determine the effect of modified Asbuton contents on the characteristics of Marshall AC-BC (Asphalt Concrete Binder Course). The results showed that the value of Marshall stability obtained on the content of modified Asbuton content of 4.5%, 5.0%, 5.5%, 6.0%, and 6.5% of 1218.57 kg, 1415.22 kg, 2251.01 kg, 1548.67 kg, and 1243.15 kg. From this result the most optimal is the content of modified Asbuton content 5.5% and the smallest content of modified Asbuton content 4.5%. Based on the relationship between the content of modified Asbuton content and stability, it was found that the content of optimum asphalt content was at 5.5%. The value of the test results is in accordance with the specification of effective asphalt level determination by the Bina Marga Indonesia requirement.

INTRODUCTION

The development of road construction in Indonesia has recently increased. This has resulted in the increasing need for asphalt, which is one of the materials used in the pavement mixture. Asphalt concrete (AC) or concrete asphalt layer (Laston) is one type of flexible pavement that is widely applied in Indonesia. Laston which is known in Indonesia consists of asphalt concrete wearing course, asphalt concrete binder course (AC-BC), and asphalt concrete base (AC base). AC-BC asphalt mixture is a binder layer with a coarser gradation than AC-WC but smoother than AC base. Laston is usually used in areas that experience high deformation such as mountainous areas, toll gates or in areas near traffic lights and areas with heavy traffic.

Indonesia has natural asphalt known as Asbuton, it is name that way because the asphalt location is on the island of Buton, Southeast Sulawesi. Bitumen content in Asbuton varies from 10-40%, even in some locations it is found with bitumen content of 90% which can be found in Kabungka and Lawele areas. Asbuton has quite a large deposit of around 600 million tons [1,2]. Asbuton deposits are estimated to be equivalent to 24 millions oil asphalt [3,4].

The need for oil asphalt in Indonesia is greater than the existing oil asphalt production. Importing oil asphalt from abroad is one way to anticipate this so that this does not continue to happen. The use of Indonesian natural asphalt, namely Asbuton, can be an alternative in dealing with this. For this reason, various Asbuton research and development continue to this day.

Several road pavement experts have conducted research on the use of Asbuton as a substitute for 60/70 penetration asphalt. The types of Asbuton generally used are Lawele, Buton rock aslphalt (BRA) and BGA with type 20/25 [5-8].

International Conference on Science and Applied Science (ICSAS) 2021
AIP Conf. Proc. 2391, 070012-1–070012-10; https://doi.org/10.1063/5.0073735
Published by AIP Publishing. 978-0-7354-4185-9/$30.00

Asphalt technology development continues to this day. Modified Asbuton (retona) is a mixture of natural Buton asphalt and oil asphalt which is processed into one using a tool with specifications in the form of 90% bitumen minimum and 10% maximum mineral. Modified Asbuton has better stability, durability, workability, stability and service life compared to other types of asphalt [9-10].

The development of the amount of traffic load that will be received by the road results in a reduced service life of the pavement layer. Compressive load and tensile load are the two loads experienced by a pavement layer. For compressive load, the value can be obtained by direct Marshall test. A number of regulations have been issued by Bina Marga to determine the characteristics of hot asphalt mixtures and cold mix asphalt, especially emulsion asphalt mixtures. This study aims to determine the effect of modified Asbuton levels on the Marshall characteristics of the AC-BC Asphalt Concrete Binder Course.

LITERATURE REVIEW

General

Pavement is a system consisting of several layers of material that is placed on the subgrade. The main purpose of pavement construction is to provide a flat surface with certain toughness, with a sufficiently long service life and minimum maintenance.

Pavement functions to protect the subgrade and the layers that form the pavement so as not to experience excessive stress and strain due to traffic loads.

Flexible pavement, which is pavement-using asphalt as a binder. The pavement layers carry and spread the traffic load to the subgrade.

Surface layers are usually divided into separate wear layers and binder layers. The foundation layer and the sub-base layer can also be placed in a composite form consisting of different materials, namely the upper base and lower base, or the upper sub base and lower foundation (lower sub base).

According to Bina Marga (2007), concrete asphalt is a homogeneous mixture of aggregate (coarse aggregate, fine aggregate and filler) and asphalt as a binder which has a certain gradation, is mixed, spread and compacted at a certain temperature to accept traffic loads tall one.

Asphalt Concrete (AC) is a mixture for pavement consisting of coarse aggregate, fine aggregate, filler material and asphalt with a certain proportion. This layer must be waterproof, have structural value and be durable. Asphalt Concrete layers can be divided into 3 types of mixtures according to their function, namely (Sukirman, 2003):

1. Laston Layer wear (Asphalt Concrete-Wearing Course, AC-WC)
2. Laston Layer Intermediate Surface (Asphalt Concrete-Binder Course, AC-BC)
3. Laston Layer Foundation (Asphalt Concrete-Base, AC-Base)

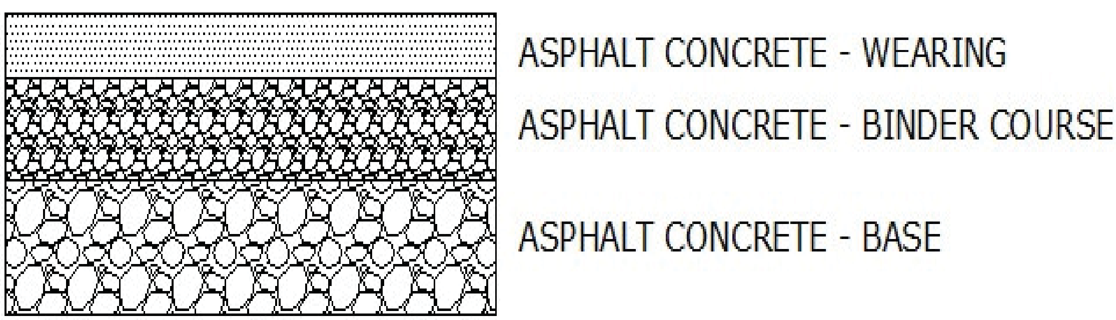

FIGURE 1. Construction of the base layer (base), binder course (binder course) and surface layer (wearing course)

The combined aggregate gradation for the asphalt mixture, expressed in percent by weight of aggregate and filler, must meet the limits given in Table 1.

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TABLE 1. Combined Aggregate Gradients For Asphalt Mixtures

Sieve size (mm)	% of weight passed to total aggregate in the mix								
	Latasir (SS)		Lataston (HRS)				Laston (AC)		
			Gaps gradation		Semi gap gradattion				
	Kelas A	Kelas B	WC	Base	WC	Base	WC	BC	Base
37.50									100
25.00								100	90 - 100
19.00	100	100	100	100	100	100	100	90 - 100	76 - 90
12.50			90 - 100	90 - 100	87 - 100	90 - 100	90 - 100	75 - 90	60 - 78
9.50	90 - 100		75 - 85	65 - 90	55 - 88	55 - 70	77 - 90	66 - 82	52 - 71
4.75							53 - 69	46 - 64	35 - 54
2.36		75 - 100	50 – 72[3]	35 - 55[3]	50 – 62	32 - 44	33 - 53	30 - 49	23 - 41
1.18							21 - 40	18 - 38	13 - 30
0.60			35 - 60	15 - 35	20 – 45	15 - 35	14 - 30	12 - 28	10 - 22
0.30					15 – 35	5 - 35	9 - 22	7 - 20	6 - 15
0.15							6 - 15	5 -13	4 - 10
0.075	10 - 15	8 – 13	6 - 10	2 - 9	6 – 10	4 - 8	4 - 9	4 - 8	3 - 7

According to Sukirman (2003), he explains that asphalt concrete (Laston) is used for roads with heavy traffic loads, Laston is also known as AC (Asphalt Concrete). There are seven characteristics of the mixture that asphalt concrete must have as follows:

1. Resistant to pressure (stability)

Resistance to pressure is the ability of a road pavement to accept traffic loads without permanent changes such as waves, grooves and bleeding. Roads serving high traffic volume and predominantly consist of heavy vehicles, require a pavement with high stability. Factors that can affect the stability value of asphalt concrete are internal friction and cohesion.

2. Durability

Durability is the ability of asphalt concrete to accept repetitive traffic loads such as vehicle weight and friction between vehicle wheels and road surfaces, as well as withstand wear and tear due to weather and climate effects, such as air, water or changes in temperature. The durability of asphalt concrete is influenced by the thickness of the film or asphalt blanket, the number of pores in the mixture, the density and water resistance of the mixture. The thicker the asphalt film will result in easy bleeding which will make the road more slippery.

3. Flexibility

Flexibility is the ability of asphalt concrete to adjust due to settlement (consolidation / settlement) and movement of the foundation or subgrade, without cracking. The decrease occurs as a result of repetition of traffic loads, or a decrease due to the weight of the landfill made on the original soil. Flexibility can be improved by using open grade aggregate with high bitumen content.

4. Resistance to melting (fatigue resistance)

Melt resistance is the ability of asphalt concrete to accept repeated deflection due to load repetition, without melting in the form of grooves and cracks.

5. Skid Resistance

Toughness or shear resistance is the ability of the asphalt concrete surface, especially in wet conditions, to provide friction to the wheels of the vehicle so that the wheels of the vehicle do not slip or slip. In addition, the aggregate that is used must not only have a rough surface, but also must have the resistance to make the surface not easy to become slippery due to vehicle repetitions.

6. Waterproof (impermeable)

Water tightness is the ability of asphalt concrete not to be entered by water or air into the asphalt concrete layer. Water and air can cause the acceleration of the asphalt aging process, and the peeling of the asphalt film / blanket from the aggregate surface. The level of immunity of asphalt concrete is inversely related to its durability.

7. Easy to implement (workability)

Workability is the ability of the asphalt concrete mixture to be easily spread and compressed. Factors that affect the level of ease in the spread and compaction process are the viscosity of the asphalt, the sensitivity of the bitumen to changes in gradation temperature and aggregate conditions.

Aggregate

Aggregate, which is the main material for road structure, is a collection of crushed stone and sand, or other minerals, both natural and artificial. The pavement contains 90-95% aggregate by weight percent, or 75-85% aggregate by volume percent. The aggregate used must be clean from dirt, organic materials or other unwanted materials, because it will reduce the performance of the mixture (Hary C., 2015)

Aggregate or rock, or granular material is a hard, compact grained material. Aggregates have a very important role in transportation infrastructure, especially in this case on road pavements. The pavement bearing capacity is determined in large part by the characteristics of the aggregates used. The selection of the right aggregate that meets the requirements will determine the success of road construction or maintenance (Hot Asphalt Mixed Work Manual, Ministry of Public Works).

Aggregate or rock, or granular material is a hard, compact grained material. The term aggregate includes, among other things, cobblestone, crushed stone, rock ash and sand. Aggregates have a very important role in transportation infrastructure, especially in this case on road pavements. The pavement bearing capacity is determined in large part by the characteristics of the aggregates used. The selection of the right aggregate that meets the requirements will determine the success of road construction or maintenance. The quality of an aggregate is greatly influenced by the properties it contains. Among the existing characteristics, namely strength or strength, durability or durability, adhesiveness or adhesion to asphalt and workability or ease of implementation.

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Modified Asbuton (Retona)

Refinery buton asphalt (retona) is Kabungka or Lawele Asbuton which has reduced the amount of minerals in it (by semi-extraction using chemicals) and mixed with oil asphalt. Furthermore, it is ready to be liquefied in the AMP asphalt tank with or without the addition of oil asphalt again to be pumped into the pug mill which contains aggregate. (Soehartono, 2015)

Buton asphalt Type Retona Blend 55 is natural Buton asphalt with oil asphalt which is processed into one using a tool with specifications in the form of 90% bitumen minimum and 10% maximum mineral.

In this study we used high quality natural asphalt (Retona Blend 55) obtained from PT. Olah Bumi Mandiri-Jakarta. Retona is a combination of partially extracted buton grain with hard asphalt pen 60 or pen 80 which is made by fabrication by a process as shown in the flow chart in Figure 2.

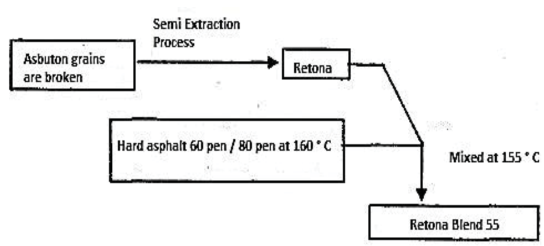

FIGURE 2. The process flow of making Blend 55 modified Asbuton by fabrication

The use of Retona is expected to overcome the weaknesses of the 60/70 penetration asphalt. Asbuton modification is developed through refining and Asbuton extraction processes. The process does not remove all the minerals from the Asbuton, but only maintains the Buton Asphalt Refinery (Retona). The modified Asbuton was explored by PT. Olah Bumi Mandiri produced in Jakarta. This modified Asbuton is an additive (addition) to the mixture of oil asphalt, in order to enhance the quality of the softening point. In this study, the type of Retona used is Retona Blend 55 which can be used directly like ordinary asphalt. Retona Blend 55 is a mixture of penetration oil asphalt 60 or penetration 80 with refinery Buton asphalt.

Asphalt Testing with the Marshall Method

The mixed design based on the Marshall method was invented by Bruce Marshall, and has been standardized by ASTM or AASHTO through several modifications, namely ASTM D 1559-76, or AASHTO T-245-90. The basic principles of the Marshall method are stability and flow checks, as well as density and pore analysis of the formed solid mixture. The Marshall tool is a pressing device equipped with a proving ring with a 22.2 KN (5000 lbs.) capacity and a flow meter. The probing ring is used to measure the stability value, and the flow meter to measure the plastic melt or flow. The Marshall specimen is a cylinder with a diameter of 4 inches (10.2 cm) and a height of 2.5 inches (6.35 cm). Marshall testing procedure follows SNI 06-2489-1991, AASHTO T 245-90 or ASTM D 1559-76. Broadly speaking, Marshall testing includes: preparation of specimens, determination of bulk density of specimens, checking of stability and flow values, and calculation of volumetric properties of specimens. In the preparation of test objects, there are several things that need to be considered, including:

1. The number of specimens prepared.
2. Preparation of aggregates to be used.
3. Determination of mixing and compaction temperature.
4. Preparation of asphalt concrete mixture.
5. Compaction of the test object.
6. Prepare for Marshall testing.

RESEARCH METHODOLOGY

Research Materials

The materials/materials used in this study are as follows:

- Coarse aggregate, fine aggregate and rock ash are taken from a rock crusher around Abepura, Jayapura.
- The modified Retona Blend 55 type of Asbuton was obtained from one of the emulsion asphalt producers in Indonesia.

Making Test Objects

The making of the test object refers to SNI 03-6758-2002 which adopts ASTM D 1074-02, begins with weighing the components of the mixture, namely the modified aggregate and Asbuton according to the mix design.

The combined aggregate is heated at a temperature of 124-1270C, and asphalt is heated separately at a temperature of 1100C. After reaching this temperature, the aggregate and modified Asbuton are mixed while stirring wet for at least 90 seconds or a maximum of 120 seconds.

Next, the mixture is put into a mold cylinder which has been coated with filter paper on both sides. This process is carried out by pouring a mixture of 3 layers, where each layer is pierced 25 times (15 times on the edge and 10 times in the middle). Then the process of compaction of the mixture at a temperature of 1100C is carried out using a pulverizer (weight 4.5 kg and falling height 45.7 cm) with the number of collisions 75 times for each plane. After cold conditions, the compacted specimen is removed from the mold using an ejector. After being removed from the mold, the specimen is ready to be treated in accordance with the regulations of Bina Marga for determining KAO.

Aggregate Characteristics Testing

Types of testing and testing methods for coarse aggregate (chipping), rock ash, and fillers are shown in Table 2 and Table 3.

TABLE 2. Coarse Aggregate Characteristics Testing

Testing	Testing Method
Water Absorption	SNI 03-1969-1990
Specific gravity	SNI 03-1969-1990
Flake Index	RSNI T-01-2005
Aggregate Wear	SNI 2417-2008

TABLE 3. Testing Methods of Rock Ash and Filler Characteristics

Testing	Testing Method
Water Absorption	SNI 03-1970-1990
Specific gravity	SNI 03-1970-1990
Sand Equivalent	SNI 03-4428-1997

RESULTS AND DISCUSSION

Results of Examination of Aggregate Characteristics

An examination of the aggregate characteristics is carried out to determine the suitability of the aggregate to be used. Tables 4 to 6 show the results of the aggregate characteristics testing that has been carried out. Based on the results of testing the characteristics of coarse and fine aggregates, it can be seen that the aggregates used meet the DGH specifications for the required road materials.

TABLE 4. Results of Coarse Aggregate Examination

Examination	(Crushed stone)	
	0,5 - 1 (cm)	1 - 2 (cm)
Water absorption,%	2.071	2.08
Bulk density	2.622	2.627
Saturated Surface Dry (SSD) Specific Gravity	2.677	2.682
Artificial density	2.773	2.779
Flakiness index,%	20.1	9.38
Aggregate wear,%	25.72	24.36

TABLE 5. Rock Ash Inspection Results

Water Absorbtion, %	2.792
Sand Equivalent, %	89.66

Bulk density	Specific Grafity Saturated Surface Dry (SSD)	Artificial density
2.449	2.518	2.629

TABLE 6. Filler Inspection Results

Water absorption,%	2.283
Sand Equivalent,%	69.57

Bulk density	Specific Grafity Saturated surface dry (SSD)	Artificial density
2.595	2.654	2.758

Results of Examination of the Characteristics of the Retona Blend Modified Asbuton 55

Modified Asbuton is the binder used in this research. Inspection of the asphalt characteristics is carried out to determine the physical properties of the asphalt in relation to the performance of the asphalt itself. The following Table 7 will display the results of the tests that have been carried out:

TABLE 7. Characteristics of Modified Asbuton (Retona Blend 55)

No	Testing	Result	Specification	
			Min	Max
1	Penetration Before Losing Weight (mm)	78.6	60	79
2	Softening Point (ºC)	52	48	58
3	Ductility at 25º C, 5cm/minute (cm)	114	100	-
4	Flash Point (ºC)	280	200	-
5	Specific Gravity	1.12	1	-
6	Weight Loss (%)	0.3	-	0.8
7	Penetration After Weight Loss (mm)	86	54	-

Mixed Gradation Determination

The proportion of the combined aggregate is obtained by the comparison value of the planned aggregate composition multiplied by the percentage value passed in the filter analysis. From the results obtained for all components, namely 1-2 cm crushed stone, 0.5-1 cm crushed stone and rock ash then added and sieve analysis is carried out to get the expected combined percentage. The combined aggregate gradation is shown in Figure 3. Comparison of the composition of the aggregate between the coarse aggregate of crushed stone 1-2 cm, the coarse aggregate of crushed stone from 0.5 to 1 cm and the ash of the rock is 19%: 54%: 27% of the aggregate composition. the value of the 2010 Directorate of Highways specification interval. The combined aggregate design is between the upper and lower thresholds in the specification intervals of the Directorate of Highways for road materials to obtain an optimal mixture.

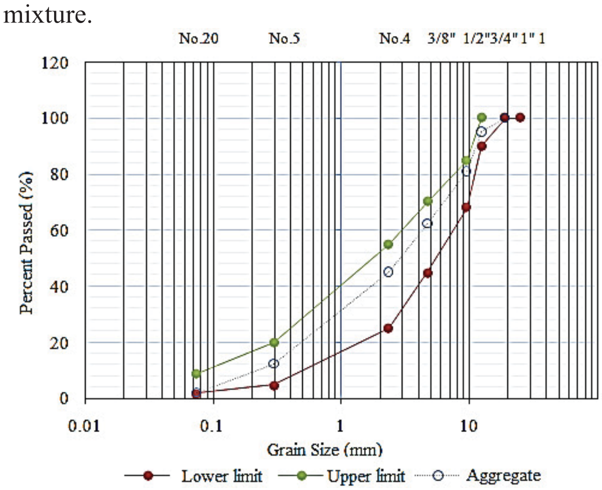

FIGURE 3. Compound aggregate gradation

Test Results of AC-BC Mixture Using Asbuton Modified Retoan Blend 55 Type As Binder With Marshall Method

Tests with each variation of the modified Asbuton content using Marshall compactor with 75 times the number of collisions for each plane. The parameters obtained are stability and flexibility (flow) which indicates the measure of the resistance of a test object in receiving a load obtained from the analysis of the Marshall test. In addition, the volumetric value consisting of the cavity between the aggregate (VMA), the asphalt filled cavity (VFB), and the cavity in the mixture (VIM) is also characteristic of Marshall.

Table 8 shows that not all test results are included in the characteristics specification of the AC-WC mixture in accordance with the General Specifications for Road Works by Bina Marga in 2010. From Table 8 a graph of the characteristics of the AC-WC mixture was made for all Marshall parameters, both stability parameters and volumetric parameters without the addition of fly ash as a filler to the predetermined variations in asphalt content to obtain the optimum asphalt content.

TABLE 8. Marshall characteristics test results for all parameters

No	Modified Asbuton content (%)	VMA (%)	VIM (%)	VFB (%)	Stability (kg)	Flow (mm)	MQ (kg/mm)
1	4.50	16.57	7.98	56.72	1218.57	3.83	318.61
2	5.00	16.61	6.84	59.87	1415.22	3.02	469.62
3	5.50	16.62	5.65	66.05	2251.01	2.73	826.48
4	6.00	16.73	4.56	73.67	1548.67	2.80	596.04
5	6.50	17.05	3.71	79.77	1243.15	3.67	340.27
6	Specification	15%<	3-5%	65%<	800 kg<	2-4 mm	Min 250

The test results show that when the asphalt content increases, the stability value also increases until it reaches an optimum value when the asphalt content is at the optimum asphalt content, the highest stability value occurs in the mixture, and when the asphalt content content passes the optimum asphalt content the stability value also decreased. The stability value obtained meets all the specifications stipulated by the 2010 Revision 3 Specification, Bina Marga division 6 asphalt mixture, which is ≥ 800 kg. The stability value is one of the parameters that can be used to determine the optimum asphalt content value in an asphalt mixture. The lowest stability value is the mixture with a modified Asbuton content of 4.5%, with a stability value of 1218.57 kg and the highest stability value in a mixture with a modified Asbuton content of 5.5% with a stability value of 2251.01 kg. The mixture containing modified Asbuton content of 5.0% has a stability value of 1415.22 kg which is almost the same as the modified Asbuton content of 6.0% with a stability value of 1548.67 kg and a mixture containing a modified Asbuton content of 6.5% with a stability value of 1243 , 15 kg. Thus, it can be seen that the optimum modified Asbuton content is between 5.0% and 6.0% modified Asbuton content. Apart from stability parameters, other parameters are also such as flow, Marshall quotient (MQ), VIM, VMA and VFB which are known volumetric parameters to obtain the Optimum Asphalt Content (KAO) in this study.

Flow is the amount of vertical deformation expressed in millimeters (mm) that occurs in solid specimens from the asphalt mixture until it reaches the maximum load point at the time of Marshall stability testing. This shows the amount of deformation that occurs in the asphalt pavement layer due to holding the load above it. The flow values obtained did not meet all the specifications set by Bina Marga, namely 2 mm to 4 mm. The lowest flow value is in the mixture with a modified Asbuton content of 5.5%, with a flow value of 2.73 mm and the highest flow value in a mixture with a modified Asbuton level of 4.5% and 6.5% with a flow value of 3 respectively 83 mm and 3.67 mm. The mixture containing the modified Asbuton content of 5.0% had a flow value of 3.02 mm which was relatively greater than the mixture containing the modified Asbuton content of 6.0% with a flow value of 2.80 mm. Increasing the cavity between the mixture and the use of high modified Asbuton content can cause the plastic melt value (flow) to increase.

The Marshall quotient value obtained is in accordance with the specifications set by Bina Marga, which is a minimum of 250 kg/mm. The lowest Marshall quotient value was in the mixture with a modified Asbuton content of 4.5% of 318.61 kg/mm, and the highest Marshall quotient value was in a mixture with a modified Asbuton content of 5.5% of 826.48 kg/mm. The mixture containing the modified Asbuton content of 6.5% had a Marshall quotient value of 340.27 kg/mm while the modified Asbuton content was 6.0% with a Marshall quotient value of 596.04 kg/mm and a mixture containing a modified Asbuton content of 5.0% with Marshall quotient value 469.02 kg/mm. The high values of modified Marshall quotient mixtures of Asbuton is due to the large stability and small flow and the thickened aggregate and changes that are not easy to occur. In the end, it will increase the binding capacity between aggregates in the mixture when loaded. Increasing the bond between the aggregates will increase the value of the stability of the mixture which leads to a smaller flow value.

The low value of the modified Marshall quotient mixture of Asbuton is due to the small stability and large flow and the thickened aggregate and easy changes that will eventually reduce the binding power between aggregates in the mixture when loaded. The reduced bond between the aggregates will reduce the stability of the mixture which leads to an increased flow value.

VIM is the intergranular space occupied by asphalt and air in the compacted asphalt mixture. A high VIM value indicates that the asphalt mixture is more porous so that the asphalt is less durable and has low stability. The relationship between modified Asbuton contents and VIM values. The VIM value required by the General Specification 2010, revision 3 is 3% to 5%. It can be seen that the levels of modified Asbuton are 4.5%, 5.0%, 5.5%, 6.0%, and 6.5%, the VIM (Void in Mix) values respectively are 7.98%, 6.84 %, 5.65%, 4.56%, and 3.71%. Based on the VIM value obtained, it can be seen that the VIM value that meets the 2010 specifications, Revision 3 is the modified Asbuton level, namely 5.5%, 6.0% and 6.5%, while the modified Asbuton content is 4.5% and 5.0%. does not meet specifications 2010, Revision 3.

The cavity between aggregates (VMA) is the vacuum that exists between the aggregate particles in the compacted paving mixture, including the space filled with asphalt. VMA represents the space available to accommodate the asphalt and the volume of air space required in the mixture. The more cavities in the dry aggregate, the more space is available for the asphalt film. The minimum VMA value must be adhered to so that a durable asphalt film thickness can be achieved. The 2010 General Specification, Revision 3, Division 6 on Asphalt Pavement requires that the VMA value in the asphalt mixture is at least 15%. VMA indicates a cavity that occurs between the binding of the aggregate, where this parameter is one of the volumetric parameters. The VMA value at the 5.0% modified Asbuton content was 16.61% which was relatively smaller than the VMA value at the 5.5% modified Asbuton level of 16.62%. Meanwhile, the modified Asbuton levels were 4.5%, 6.0% and 6.5%, respectively; the VMA values were 16.57%, 16.73% and 17.05%. Therefore, all levels of modified Asbuton used in this study meet the specifications required by the General Specifications 2010, Revision 3, Division 6 concerning Asphalt Pavement.

VFB is the percentage of cavity in the mass of solid aggregate filled with asphalt. Asphalt filled cavities are important not only as a measure of relative durability, but also because there is an excellent relationship between relative durability and density. If the VFB is too low, the asphalt is insufficient to provide durability and is too congested under traffic. The relationship between modified Asbutone content and VFB value. Based on the 2010 General Specifications, Revision 3, Division 6 on Asphalt Pavement, the VFB requirement in asphalt mixtures is a minimum of 65%. The results of the volumetric test of asphalt mixture using modified Asbuton as a binder in the form of VFB parameters showed values of 56.72%, 59.87%, 66.05%, 73.67%, and 79.77% for each modified Asbuton content, namely 4.5%, 5.0%, 5.5%, 6.0%, and 6.5%. Therefore, all the modified Asbuton levels used meet the general specifications 2010, Revision 3, except for the modified Asbuton levels of 4.5% and 5.0%.

Analysis of determining the optimum asphalt content using the formula for determining the effective asphalt content, the modified asphalt content of a test object is analyzed as follows.

$$Pb = 0{,}035\ (\%AK) + 0{,}045\ (\%AH) + 0{,}18\ (\%F) + k$$

Where:

Coarse Aggregate = 67,19%
Fine Aggregate = 24,87%
Filler = 7,94%
Constant = 0,6

$$Pb = (0{,}035 \times 67{,}19) + (0{,}045 \times 24{,}87) + (0{,}18 \times 7{,}94) + 0{,}6 = 5{,}5\%$$

The calculation of the 5.5% modified Asbuton content refers to Book III issued by the Ministry of Public Works in 2006.

ACKNOWLEDGMENTS

Conclusion

Based on the research results, it can be concluded that:

1. Marshall Stability Value obtained in the content of modified Asbuton content 4.5%, 5.0%, 5.5%, 6%, and 6.5% of 1218.57 kg, 1415.22 kg, 2251.01 kg, 1548.67 kg, and 1243.15 kg. From these results, the most optimal is the content of modified Asbuton content of 5.5% and the smallest content of modified Asbuton content is 4.5%.
2. Based on the relationship between the modified Asbuton content and compressive strength, the optimum asphalt content was obtained at 5.5%. This test result value is in accordance with the specifications for determining the effective asphalt content by the Ministry of Public Works in 2006.

Suggestion

From the research results obtained, there are several things that are suggested, namely:

1. In the process of planning and implementing modified Asbuton flexible pavement, it is necessary to pay attention to and consider more carefully the effect of the Asbuton content content of modified asphalt concrete mixture which will certainly affect the quality of the mixture.
2. Further research is needed on the use of modified Asbuton (retona) as the main component used in the Asphalt Concrete Binder Course.

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