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CHARACTERISTICS OF ASBUTON'S COLD PAVING HOT MIX (CPHMA) BASED ON MARSHALL TEST

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Abstract

The purpose of this study was to obtain the characteristics of the Cold Paving Hot Mix Asbuton (CPHMA) mixture based on the Marshall test. The presentation of data analysis is presented after all research processes in the form of testing the mixed Marshall characteristics have been achieved or have been completed. The results of the examination of the physical properties of the material show results that meet the general specifications of 2018 revision 2. Based on the characteristics of the asphalt mixture with two types of mixtures, the values of the properties of the mixture based on the Marshall test, the characteristic values of the CPHMA mixture are 6.1% asphalt content, 6.6% VIM, VMA 29.6%, VFB 78.0%, stability 619 kg, melt (flow) 5.0 mm, and 73.2%. While the characteristics of the HRS-WC mixture are asphalt content 6.9%, VIM 5.0%, VMA 19.1%, VFB 73.6%, stability 1159 kg, MQ 288kg/mm, and residual stability 91.7%. The quality of the CPHMA mixture from the results of the characteristic test based on the Marshall test meets the required specifications and the CPHMA mixture can encourage the independence of the National asphalt based on Buton asphalt.

Keywords: Characteristics, CPHMA

Abstrak

Tujuan dari penelitian ini adalah untuk mendapatkan karakteristik campuran Cold Paving Hot Mix Asbuton (CPHMA) berdasarkan uji Marshall. Penyajian analisis data disajikan setelah semua proses penelitian berupa pengujian karakteristik campuran Marshall telah tercapai atau telah selesai. Hasil pemeriksaan sifat fisis material menunjukkan hasil yang memenuhi spesifikasi umum tahun 2018 revisi 2. Berdasarkan karakteristik campuran aspal dengan dua jenis campuran, maka nilai sifat campuran berdasarkan Marshall pengujian, nilai karakteristik campuran CPHMA adalah kadar aspal 6,1%, VIM 6,6%, VMA 29,6%, VFB 78,0%, stabilitas 619 kg, leleh (flow) 5,0 mm, dan 73,2%. Sedangkan karakteristik campuran HRS-WC adalah kadar aspal 6,9%, VIM 5,0%, VMA 19,1%, VFB 73,6%, stabilitas 1159 kg, MQ 288kg/mm, dan stabilitas residu 91,7%. Mutu campuran CPHMA dari hasil uji karakteristik berdasarkan uji Marshall memenuhi spesifikasi yang dipersyaratkan dan campuran CPHMA dapat mendorong kemandirian aspal Nasional berbasis aspal Buton.

Kata kunci: Karakteristik, *CPHMA*

INTRODUCTION

Improvement and development of road transportation accessibility is very important to support regional social and economic activities of a country. Therefore, the development of a road network is something that is deemed necessary to be able to serve the development of traffic flows safely and comfortably. One of the supporting factors for the accessibility of a road network to be safe and comfortable for road users is by designing a surface layer of road pavement that will remain satisfactory throughout its service life (Djakfar et al, 2017), (Djakfar et al, 2018) and (Affandi, 2008).

The surface layer of the road pavement is a layer that is in direct contact with the surface of the vehicle's wheels. The distribution of wheel load received by the surface layer is much greater than the layer below it. This reason causes the surface coating to be designed with better quality materials with higher technical requirements. If the asphalt pavement construction used is oriented towards strength (high stability) it is possible to use a *dense-graded gradation*, for flexibility and durability use *a gap-graded gradation*, while for the purpose of *permeability, an* open/uniform gradation can be used (*open-graded*) (Thanaya, 2016). This demands the need for a road pavement design that is able to overcome the impacts that are often caused by the current road pavement structure such as high accident rates, noise and others, in other words requiring pavement construction that meets the requirements so that road service services be maximized. One alternative to reduce the impact is by optimizing the use of asbuton as road pavement work. One of the developing technologies for using asbuton is *Cold paving hot mix asbuton*. Djakfar et al (2020), PUPR (2018) and (Akbariawan et al, 2015) stated that in General Specifications 2018 Revision 2 CPHMA is a mixture of asbuton consisting of aggregate, granular asbuton, rejuvenator and other added materials mixed with hot and cold.

CPHMA has the advantage that in the use of CPHMA it can be cold compacted so it is very suitable for use in areas that are far from the location of the asphalt mixing plant or commonly called the *Asphalt Mixing Plant* (AMP). But in its application in the CPHMA field, it also has a weakness in *workability* because the cooled mixture is stiffer so it is more difficult to compact and therefore affects the performance of the mixture Firstyan et al (2015), (Tjaronge et al, 2016) and Thanaya et al (2017). Several regions in Indonesia have applied the use of CPHMA, in its application in Palu City the compaction of CPHMA does not wait at cold temperatures (30°C) to accelerate the spreading. The temperature used during solidification is at a temperature of 50 to 60°C this is due to the influence of the hot ambient temperature so that the temperature decrease is slow. The purpose of this study was to obtain the characteristics of the *cold paving hot mix asbuton* (CPHMA) mixture. based on the Marshall test (Budiamin et al, 2015)

RESULTS AND DISCUSSION

Data Presentation

1. Results of Examination of Aggregate Characteristics

Aggregate material used in this study, which consists of course and fine aggregates derived from from the Labuan River, Donggala Regency, Central Sulawesi Province. The results of the examination of the characteristics of the aggregates are in accordance with the test method used and the required specifications and are presented in Table 1.

Table 1. The results of the examination of the characteristics of the aggregate material

No.	Test Type	Test result		Testing Method	Requirements
		Chips 3/8"	Chips 3/4"		
Coarse aggregate					
1	Filter analysis	See attachment		SNI ASTM C 136:2012	
2	Aggregate Wear (%)	30		SNI 2417: 2008	max. 40
3	Specific gravity and water absorption				
	- Bulk density	2.76	2.76		
	-SSD specific gravity	2.78	2.79		
	-Apparent specific gravity	2.82	2.83		
	-Water absorption	0.81	0.81	SNI 1969: 2008	max. 3.0
4	Angularity (%)	98/97	97/92	PTM No. 621	min. 95/90
5	Flat and oval particles (%)	5.3	1.0	ASTM D-4791-95	max. 10
6	Aggregate adhesiveness to bitumen (%)	> 95		SNI 2439:2011	min. 95
Fine aggregate					
1	Filter analysis	See attachment		SNI ASTM C 136:2012	
2	Specific gravity and water absorption	Ash Rock	Sand		
	- Bulk density	2.66	2.61		
	-SSD specific gravity	2.69	2.67		
	-Apparent specific gravity	2.74	2.76		
	-Water absorption	1.06	2.01	SNI 1969: 2008	max. 3.0
4	Angularity (%)	-	45.4	SNI 03 - 6877 - 2002	min. 45
5	Sand Equivalent (%)	-	97.8	SNI 03 - 4428 - 1997	min. 60

Source: Central Sulawesi BPJN Laboratory Test Results

2. CPHMA Mixture Characteristics Examination Results

The type of mixture used in this study is a mixture of CPHMA obtained from PT Asbuton Jaya Abadi. The results of the examination of the characteristics of CPHMA are presented in the following table:

Table 2. Examination of Asphalt Content of Extraction Results

No	Inspection	Results	Requirements
1	Asphalt Content (%)	6.13	6 - 8

Source: Central Sulawesi BPJN Laboratory Test Results

Table 3. Examination of CPHMA Aggregate Gradation Results of Extraction

No.	Sieve Size		Test results	Specification	Information
	ASTM	(mm)			
1	"	19.0	100	100	Fulfill
2	”	12.5	93	90 – 100	Fulfill
3	No. 4	4.75	64	45 – 70	Fulfill
4	No. 8	2.36	39	30 – 55	Fulfill
5	No. 50	0.300	19	12 – 25	Fulfill
6	No. 200	0.075	8	6 - 15	Fulfill

Source: Central Sulawesi BPJN Laboratory Test Results

From the results of the asphalt content test and the gradation of the extracted aggregate, it is presented in a comparison graph between the size of the sieve and the percent pass.

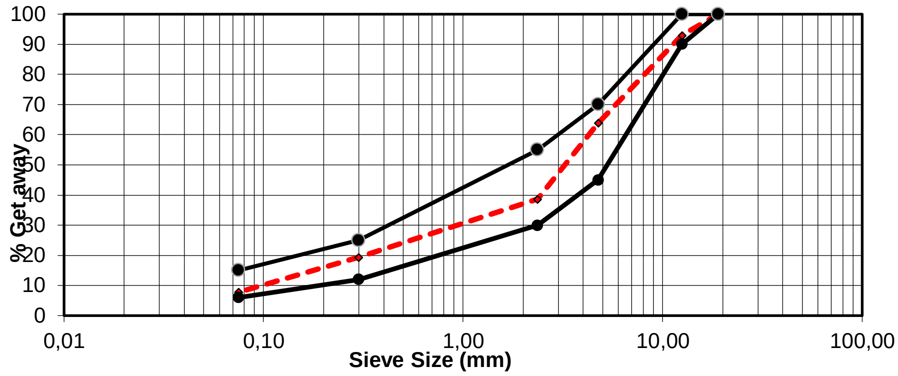

Figure 1. CPHMA Aggregate grading curve

3. CPHMA Mixed Marshall Test Results

This test was conducted to find the value of Stability, Meltability (Flow*)*, *Marshall Quotien* (MQ), voids filled with asphalt (VFB), voids in the mixture (VIM) and voids in aggregate (VMA) on the extracted CPHMA Asphalt Content.

Table 4. Data of Marshall Mixed CPHMA. Test Results

No.	Mixture Properties	Test results	Specification	Information
1	VIM (%)	6.6	4 - 10	Fulfill
2	VMA (%)	29.6	Min. 16	Fulfill
3	VFB (%)	78.0	Min. 60	Fulfill
4	Marshall Stability (kg) Air Temperature	619	Min. 500	Fulfill
5	Flow (mm)	5.0	2 - 5	Fulfill
6	Marshall Stability Residual (%) After Immersion For 24 Hours, Air Temperature	73.2	Min. 70	Fulfill

Source: Central Sulawesi BPJN Laboratory Test Results

4. The results of the examination of the HRS-WC mixture

To obtain the asphalt mix content CPHMA, in this study, is limited in the 2018 General Specification Revision 2 starting from 6.0 % to 8.0 %. From the characteristic value of the mixture produced in the Marshall test, it is above, can be compared with the Lataston Lapis Aus (HRS-WC) mixture. Determination of the amount of aggregate in the Lataston Lapis Aus mixture based on the percentage of use of course, medium and fine aggregates. From the results of the estimated asphalt content, four variations of asphalt content were made, two above and two below the estimated design asphalt content with an increase or decrease of 0.5%. Determination of the optimum asphalt content in the HRS-WC mixture based on the Marshall test can seen in the following pictures.

a. Effect of asphalt content on the stability of HRS-WC mixture

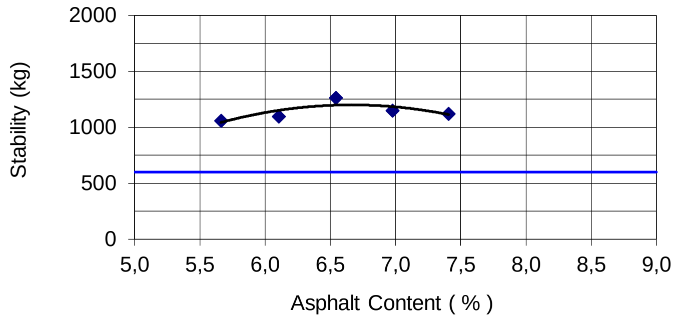

Figure 2. Graph of the relationship between asphalt content and stability

From Figure 2 above, the stability value increases from the asphalt content of 5.7 % to 6.8 %, then the stability decreases with the addition of asphalt content to 6.8 %. Stability value in above meet the specifications required in the general specifications 2018 revision 2 at least 600 kg. The highest mixture stability of 1220 kg occurs when the asphalt content is 6.8%. The addition of bitumen content greater than 6.8% will gradually reduce the stability of the mixture. This happens because the larger asphalt can no longer enter into the pores that are already full, so the asphalt actually damages the interlocking between the aggregates because it will occupy the space between the aggregates, so that if there is a load, the asphalt will become a lubricant, especially when the temperature increases. . This condition will ultimately reduce the ability of the mix collaboratively to carry and transmit the load to each aggregate in the mix. In other words, the stability value is determined mainly by the surface texture of the aggregate. Meanwhile, the optimal asphalt content depends on surface area, surface texture, aggregate porosity, and asphalt stiffness. Where necessary, the design asphalt content is adjusted in such a way as to avoid bleeding or possible loss of stability.

b. Effect of asphalt content on HRS-WC mixture Flow

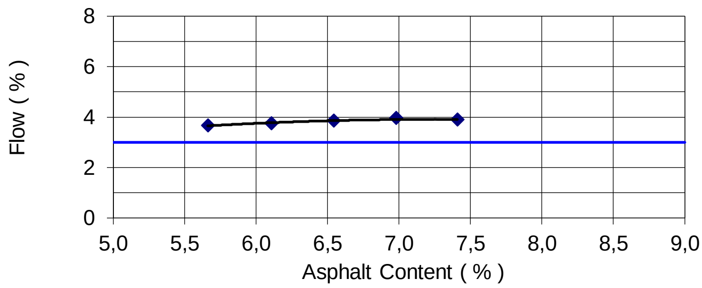

Figure 3. Graph of the relationship between asphalt content and *flow*

From Figure 3 above, the *flow value* meets the specifications required in the general specification 2018 revision 2. It can be seen that the flow of the mixture increases with increasing asphalt content. This means that the ability of the mixture to withstand plastic deformation or rutting will improve with increasing asphalt content in the mixture. If the asphalt content is low, the flow of the asphalt mixture will be small, so if an external load is applied, the mixture will quickly fail because it does not have sufficient elastic ability to change slowly according to the rhythm of the load increase. This condition will be worse if the temperature around the asphalt mixture increases, because the asphalt will quickly change its shape from solid to liquid causing the asphalt to lose its ability to envelop and glue the aggregate. The deformation behavior of the mixture can be divided into three stages, namely the densification stage, the stable stage and the flow stage. In general, the higher the flow rate, the longer it will take until the flow starts and the better the rutting resistance of the asphalt mixture.

c. Effect of asphalt content on VIM of HRS-WC mixture

From Figure 4 above the VIM value at asphalt content of 5.7 % to 7.4 % The smaller the bit, the more asphalt that fills the voids between the aggregate grains, so the volume of the voids in the mixture decreases. VIM states the percentage of air voids in the asphalt mixture. However, the VIM value above is still at an asphalt content of 6.7% to 7.4%, meeting the specifications required in the general specification 2018 revision 2, which is between 3% - 5%. From the data above, it can be seen that the minimum asphalt content that must be applied to the HRS-WC mixture is 6.7%. If it is less than 6.7%, it is feared that the mixture will lose flexibility when external loads act on it. When the temperature on the road surface rises, the number of cavities is not large enough to accommodate the movement of the asphalt that starts to melt, so that bleeding in the mixture has the potential to occur, which in turn will weaken the bond between asphalt and aggregate. Conversely, if the remaining air voids are greater than 7.4%, it allows water infiltration into the road body during rain, where the water will put pressure on the mixture so that it will slowly reduce the ability of the asphalt to bind to the aggregate. If this condition continues, it will lead to disintegration and trigger failure of the asphalt mixture.

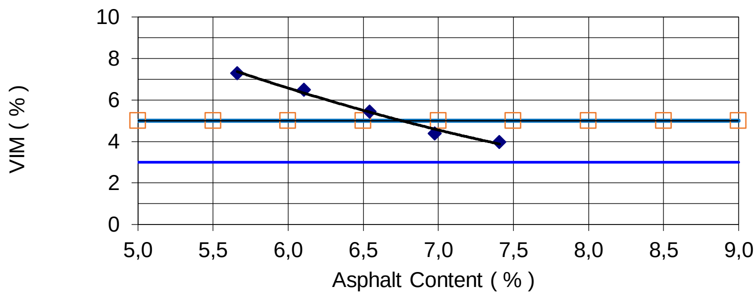

Figure 4. Graph of Relationship between asphalt content and VIM

d. Effect of asphalt content on the VMA of HRS-WC mixture

From Figure 5, the value of VMA increases with the addition of asphalt content. The more asphalt content in the above, the more durable the mixture. However, if the VMA is too large, the mixture may exhibit stability problems and be uneconomical to produce. The VM A value above still meets the specifications required in the general specification 2018 revision 2, namely the minimum 17%.

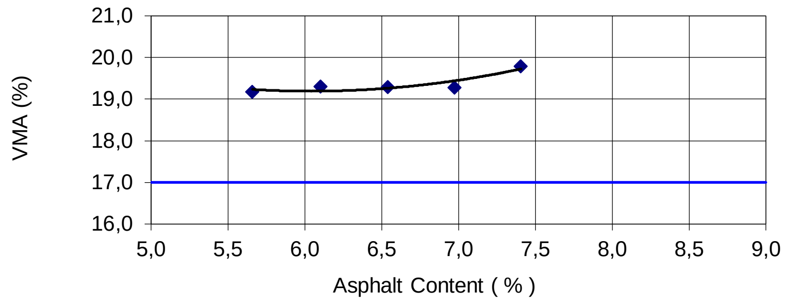

Figure 5. Graph of the relationship between asphalt content and VMA

e. Effect of asphalt content on VFB of HRS-WC mixture

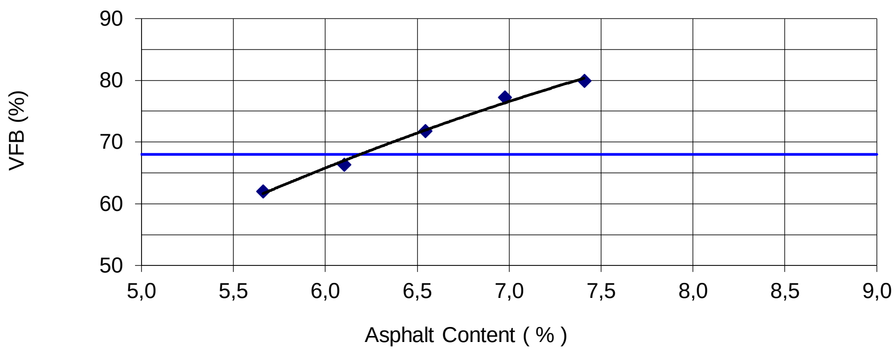

Figure 6. Graph of the relationship between asphalt content and VFB

The VFB value indicates the percentage of voids that can be filled with asphalt. From the table above, the VFB value increases with the addition of asphalt content. The more asphalt content, the more durable the mixture and the less asphalt content, the thinner the asphalt-covered aggregate which causes the mixture to not last. The value of VFB affects the impermeability of the mixture to water and air as well as the elasticity of the mixture. However, the VFB value at the asphalt content of 6.2% to 7.4% meets the required specifications.

f. Effect of asphalt content on the MQ of HRS-WC mixture

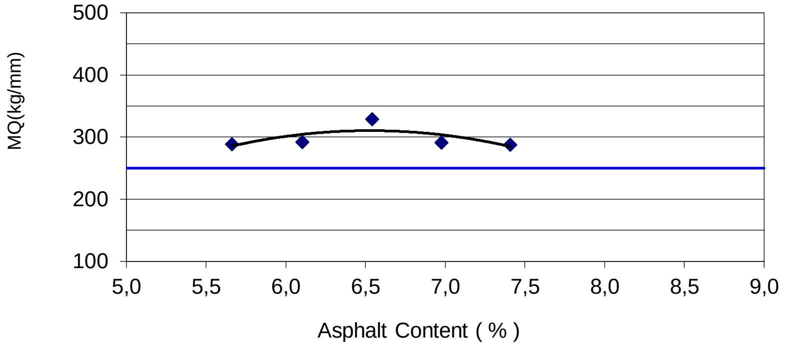

Figure 7. Graph of the relationship between asphalt content and MQ

The MQ value shows the percentage of the stability value divided by the melting value (flow). From the table, the MQ value meets the minimum required specifications of 250 kg/mm. To get the optimum asphalt content in the HRS-WC $_{\text{mixture}}$ with Bar-chart method.

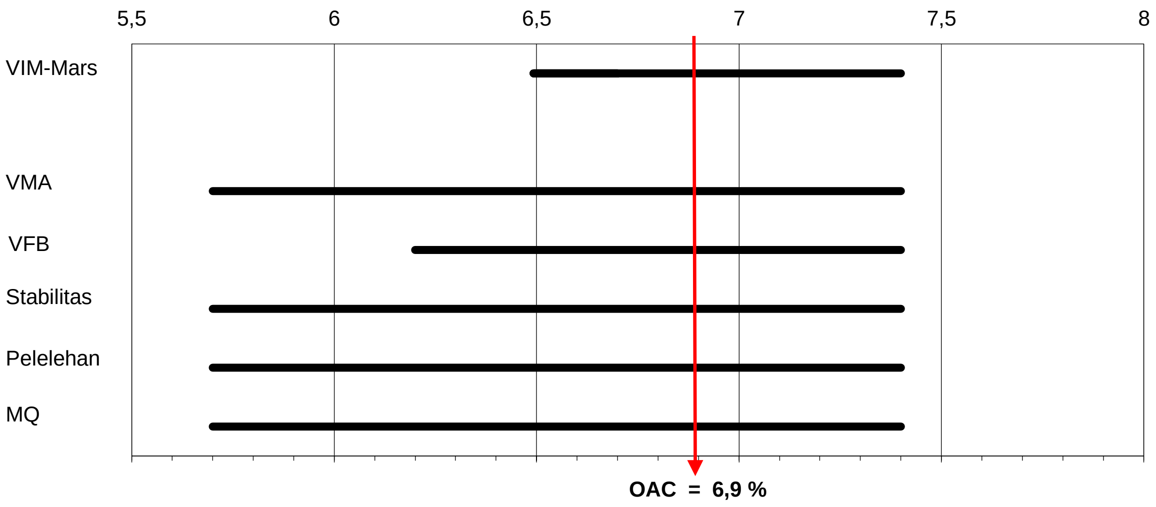

Figure 8. Determination of Asphalt Content by Bar-chart Method

5. Marshall Test Results of HRS-WC Mixture on OAC

From the results of determining the optimum asphalt content using the Bar-chart method, a test object for the HRS-WC asphalt mixture was made at the optimum asphalt content.

Table 5. Marshall Test Results Data on Mixed OAC HRS-WC

No.	Mixture Properties	Test results	Specification	Information
1	Optimum Asphalt Level	6.9	-	KAO

No.	Mixture Properties	Test results	Specification	Information
2	VIM (%)	5.0	3 - 5	Fulfill
3	VMA (%)	19.1	Min. 17	Fulfill
4	VFB (%)	73.6	Min. 68	Fulfill
5	Marshall Stability (kg)	1159	Min. 600	Fulfill
6	Marshall Quotient (kg/mm)	288	Min. 250	Fulfill
7	Marshall Stability Residual (%) After Immersion For 24 Hours, 60 ^{0} c	91.7	Min. 90	Fulfill

Source: Central Sulawesi BPJN Laboratory Test Results

6. Comparison of CPHMA Mixture Characteristics Value with HRS-WC Layer Mixture

From the results of the Marshall test on a mixture of CPHMA and a mixture of HRS-WC, the characteristics of the mixture are obtained as shown in Table 6 below.

Table 6. Marshall Test Results Mixed CPHMA and HRS-WC

No.	Mixture Properties	Marshall Test Results	
		CPHMA	HRS-WC
1	Optimum Asphalt Level	6.1	6.9
2	VIM (%)	6.6	5.0
3	VMA (%)	29.6	19.1
4	VFB (%)	78.0	73.6
5	Marshall Stability (kg)	619	1159
6	Marshall Quotient (kg/mm)	-	288
7	Flow (mm)	5.0	-
8	Marshall Stability Residual (%) After Immersion For 24 Hours, 60 ^{0} c	73.2	91.7

Source: Central Sulawesi BPJN Laboratory Test Results

Discussion

The characteristics of the asphalt mixture based on the Marshall test, the researchers describe as follows:

a. Optimum Asphalt Content (OAC)
The optimum asphalt content is the asphalt content where all the characteristics of the asphalt mixture characteristics meet all the provisions in the specifications generally close to the middle of the asphalt content range that meets all the required parameters. The lower optimum asphalt mixture (Table 6) means the mixture is more economical.

b. Density
A mixture with a high-density value will be able to withstand a greater load than a mixture with a low-density value.

c. Void in Mineral Aggregate (VMA)
Table 6 shows that in the CPHMA mixture the VMA value is greater than the HRS-WC mixture. The VMA value is influenced by the distribution of aggregate grains, grain shape, surface texture, water absorption by the aggregate and compaction energy and asphalt content.

d. Void Filled of Bitumen (VFB)
In the CPHMA mixture, the VFB value was greater than the HRS-WC mixture. This VFB value will affect the mixture's impermeability to water and air, the stiffness and

elasticity of the mixture, so that the VFB value determines the value of stability, flexibility and durability.

e. Void in the Mix (VIM)
The higher the VIM value, the larger the voids in the mixture, so the mixture will be porous and, in the mixture, will result in the mixture being easily oxidized and reducing its durability. On the other hand, if the VIM value is too low, it will have problems with plastic deformation.

f. Marshall Stability
Stability value is influenced by grain shape, quality, surface texture and gradation distribution. From table 6, the test results obtained that the stability value for the HRS-WC mixture was higher than the CPHMA mixture. In this case, showing resistance to permanent deformation such as routing, shoving, in supporting traffic loads is important.

g. Flow (Marshall Flow)
Flow is the amount of vertical deformation that occurs from the initial loading until the stability condition decreases. The flow value is influenced by asphalt content, asphalt viscosity, aggregate gradation distribution and compaction temperature. Table 6 shows the flow value for the CPHMA mixture required in the specifications.

h. Marshall Quotient (Marshall Quotient)
The MQ value indicates the flexibility of the mixture, that is, the larger the MQ value, the stiffer the mixture, and vice versa, the smaller the MQ value, the more flexible the mixture. So, the MQ values are the factors that affect the stability and flow values, namely the shape, quality, surface texture, distribution of aggregate gradations, adhesion (cohesion) of mixed asphalt content, viscosity and compaction temperature.

i. Residual Stability
Residual stability value stated at the worst condition. Table 6 shows the residual stability values for both CPHMA and HRS-WC mixtures that meet the required specifications. A mixture that has a residual stability value higher than the minimum limit is the best mixture. Residual stability is influenced by temperature, quality, distribution of aggregate gradations, adhesion, surface texture and asphalt content.

CONCLUSIONS

Based on the data analysis conducted in this study, the following conclusions can be drawn:

1. The results of the examination of the physical properties of the materials show results that meet the general specifications of 2018 revision 2.
2. Based on the characteristics of the asphalt mixture with two types of mixtures, the values for the properties of the mixture based on the Marshall test are as follows:
   a. The characteristic values of the CPHMA mixture are as follows: Asphalt content = 6.1%, VIM = 6.6%; VMA = 29.6%; VFB = 78.0%; Stability = 619 kg; Melting (flow) = 5.0 mm; Residual Stability = 73.2%.
   b. The characteristic values for the HRS-WC mixture are as follows: Asphalt content = 6.9%; VIM = 5.0 %; VMA = 19.1%; VFB = 73.6%; Stability = 1159 kg; MQ = 288kg/mm and Residual Stability = 91.7%.
3. The quality of the CPHMA mixture from the results of the characteristic test based on the Marshall test meets the required specifications and the CPHMA mixture can encourage the independence of the National asphalt based on Buton asphalt.

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