ISSN 2278-3091
Volume 13, No.2, March - April 2024
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCS1E/static/pdf/file/ijatcse081322024.pdf
https://doi.org/10.30534/ijatcse/2024/081322024

Comparison of Marshall Quotient Value on Laston Ac-Wc with Additional Pecan Shell Charcoal Waste

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Received Date : February 28, 2024 Accepted Date: March 27, 2024 Published Date: April 06, 2024

ABSTRACT

Some factors that affect the durability of asphalt include the type of asphalt concrete mixture used, Mixed materials must have good mechanical properties and be able to support high traffic loads. This study aims to determine the characteristics of marshalls in the addition of asphalt coated concrete wear (laston AC-WC with a percentage of hazelnut shell charcoal mixture of 0%, 2%, 3%, and 5%, and determine the effect of the quality of stiffness of the hazelnut shell charcoal waste mixture. This study used the marshall test method. The results showed that wear-coated concrete asphalt (AC-WC) with the addition of 5% hazelnut shell charcoal met the specifications, as well as a mixture of asphalt concrete with a charcoal content of 0% hazelnut shells or pure test objects. The value of VIM, and VFA is not a percentage of 0%, 2%, 3%, and 5% that meet the predetermined specification so that the difference in pure Ac-Wc laston and Ac-Wc laston with coconut shell charcoal additives, can be proven by the Marshall quotient value in the absence of a mixture with an average Marshall Quotient value of 590.13 Kg, in a mixture of 2% with an average Marshall Quotient value of 1004.91 Kg, on a mixture of 3% with an average value of 1024.99 Kg, and on a mixture of 4% with an average value of Marshall Quotient of 681.93 Kg. Thus, it can contribute to the development of road construction technology and become a reference in the use of hazelnut shell charcoal in wear-coated concrete asphalt mixture (AC-WC) as an alternative to environmentally friendly and sustainable mixed materials

Key words : Asphalt, Pecan Shell, Marshall Test Characteristics.

1. INTRODUCTION

The increasing need for road infrastructure that is able to withstand high traffic loads, triggers the emergence of alternative material innovations as one of the uses of hazelnut shell charcoal waste [15]. The utilization of this waste pays attention to several factors that affect the durability of asphalt, the asphalt concrete mixture used must have good mechanical properties and be able to cope with high traffic loads [11][12][3].

Pecan shells are not optimally utilized, usually only used as fuel, but this study aims to determine the characteristic value of Marsall on asphalt coated concrete (laston AC-WC) at the percentage of hazelnut shell charcoal mixture 0%.2%, 3% and 5%, can find out the quality of asphalt concrete coated wear (laston AC-WC) with the addition of hazelnut shell charcoal and without the addition of hazelnut shell charcoal, and knowing the difference in the value of the marshall quotient. The hazelnut shell charcoal material used in this study was obtained at the disposal waste of the pecan sales place in Rau Market, Serang City. Thus, it is expected to contribute to the use of hazelnut shells in the development of technology to make alternative materials of mixed materials that are environmentally friendly and sustainable.

1.1 Characteristics of Asphalt Concrete

In order to achieve high quality, the asphalt mixture must meet seven special characteristics [2][5][6]. However, in its implementation in the field, it is not always possible to achieve all seven of these characteristics in one asphalt mixture. This is due to the need to adjust the dominant properties of the asphalt mixture to specific needs in the field, which will ultimately determine the type of asphalt concrete to be used [13]. The seven characteristics include stability, durability, flexibility, fatigue resistance, roughness or shear resistance, waterproof, Easy to implement (Workability).

1.2 Asphalt Concrete Material

Asphalt

Asphalt is a natural material commonly found in solid or liquid form, depending on the source. Asphalt has thermoplastic properties, which are properties where a material will change shape due to being influenced by certain temperatures, which is where materials with this property are very familiar in bending pavement construction [14].

The constituent elements of asphalt consist of asphaltene in solid form dominated by hydrocarbons. The asphaltene content in asphalt ranges from 30-40%, which will affect the soft point, penetration value and hard and soft shape of asphalt. In addition to asphaltene, there are other elements that make up asphalt, namely malten. Malten is a liquid with a high resin content that functions so that the asphaltene kandugan that forms colloids with malten becomes balanced [7].

According to the place where it was obtained, asphalt is divided into two, namely natural asphalt and oil asphalt [13].

a. Natural Asphalt
Natural asphalt is natural asphalt obtained from nature in the form of chunks or in other forms after undergoing a little processing process.
b. Oil Asphalt
Oil asphalt is the result of residues (deposits) from the process of distillation (refining) of petroleum.
c. Liquid Asphalt
Liquid asphalt is the result of a mixture of hard asphalt (Cement Asphalt) with liquefaction materials (gasoline, kerosene and diesel). This asphalt is liquid at room temperature (25°- 30°C).
d. Asphalt Emulsion
Emulsified asphalt is asphalt that mixes with water and emulsifiers that are given an electric charge with the aim that the grains dissolved in form larger grains.

Aggregate

Aggregate is a solid mineral in the form of fragments or even in large forms that become the arrangement of hard and dense earth skin formations [13]. Aggregates can be grouped into three groups, namely coarse, fine aggregates and rock ash/filler as in table 1[1].

Table 1: Aggregate Garage Specification for Laston

% Qualifying Weight to Aggregate Total				
Sieve Size	**Laston AC**			
ASTM	**(mm)**	**WC**	**BC**	**Base**
1$^{1/2}$’	37,5			100
1’	25		100	90-100
¾”	19	100	90-100	76-90
½”	12,5	90-100	75-90	60-78
3/8’	9,5	77-90	66-82	52-71
No 4	4,75	53-69	46-64	35-54
No 8	2,36	33-53	30-49	23-41
No 16	1,18	21-40	18-38	13-30
No 30	0,600	14-30	12-28	10-22
No 50	0,300	9-22	7-20	6-15
No100	0,150	6-15	5-13	4-10
No 200	0,0755	4-9	4-8	3-7

(Source: Highways, 2018)

Filler

Filler or filling material is a type of aggregate that passes through sieve number 200 (with a size of 0.075 mm) and has a content of more than 75% by weight of the total mixture [4].

Pecan Skin
Pecan skin is one type of agricultural waste that comes from the processing of hazelnut fruit (Aleurites moluccana) to produce hazelnut oil or other products. Pecan peel contains organic compounds that can be converted into charcoal through the carbonization process. Pecan peel charcoal has unique properties, such as high porosity, rough surface, and low hardness. Due to these properties, hazelnut husk charcoal can be used as an additive in asphalt concrete mix to improve the mechanical properties of the mixture.

1.3 Marshall Test

The Marshall test aims to identify the performance of asphalt concrete in solid form. In addition, to review the characteristics of asphalt concrete and ensure the quality of the asphalt concrete mixture [8].

Basically, the Marshall test can only produce two test values for solid asphalt concrete mixtures, namely stability and melt (flow) values. However, other test values can be obtained by weighing test specimens and calculations

Specific Gravity of Solid Asphalt Concrete Bulk

The type of solid asphalt bulk concrete or density is a value to show the density of the asphalt concrete mixture [10]

$$G_{mb} = \frac{B_k}{B_{ssd} - B_a} \quad (1)$$

Where: G_{mb} = Specific gravity of solid asphalt concrete bulk; B_k = Dry weight (gram); B_{ssd} = Surface dry weight of asphalt concrete (gram); B_a = Weight of solid asphalt concrete in water (gram)
$B_{ssd} - B_a$ = Volume of concrete bulk

a. Maximum Sp
b. Ecific Gravity of Paved Mixture

$$G_{mm} = A/(A-C) \quad (2)$$

Where : G_{mm} = Maximum Specific Gravity; A = Weight Dry condition concrete mixture (gram) ; C= Weight Asphalt concrete mixture in water (gram)
c. Effective Specific gravity aggregate
Berat jenis efektif merupakan nilai tengah dari berat jenis curah dan semu yangmenyerap aspal
d. Maximum Specific Gravity of Theoretical Mixtures
The maximum specific gravity of the theoretical mixture can be obtained by the calculation of asphalt concrete mixture as much as 100 grams Berat Jenis Agregat Curah
e. The specific gravity of bulk
aggregate is the specific gravity of each aggregate fraction used in an asphalt concrete mixture Void Mineral Agregat (VMA). Cavities in mineral aggregate or commonly abbreviated as VMA are many cavities between aggregate grains which are expressed in percentage of bulk volume of solid asphalt concrete [9].
When viewed from the weight of solid asphalt concrete

$$VMA = (100 - \frac{Gmb \times Ps}{Gsb}) \quad (3)$$

Where : VMA = Volume of aggregate cavity inside solid asphalt concrete; G_{mb} = Specific gravity of bulk of asphalt concrete; Ps = Aggregate content (%) ; G_{sb} = Specific gravity of bulk of solid asphalt concrete forming aggregate. Jika ditinjau dari berat agregat

VMA = (100 – Gmb/Gsb) × 100/((100+$Pa1$)100) (4)

f. Void In Mix (VIM)

VIM is the cavity between the grains of aggregate covered with asphalt or the volume of cavities in solid asphalt concrete. VIM functions as a cavity where aggregate shifts due to compaction carried out by traffic activities.

VIM = (100 x $\frac{Gmm - Gmb}{G_{mm}}$) (5)

g. Void Fild Asphalt (VFA**)**

VFA = 100 ($VMA - VIM$)/ (VMA) (6)

h. stability

The stability value obtained from the test aims to determine the shear compressive strength. The higher the indigo i stabilitas The better the asphalt concrete mixture in withstanding the load of traffic vehicles.

i. Fatigue

Fatigue or flow can indicate the level of flexibility or brittleness of asphalt concrete. The fatigue value of asphalt depends on the asphalt content in the asphalt concrete mixture. The higher the asphalt content in the mixture, it will cause a large flow value because the mixture is plastic

1.4 Marshall Quotient

The marshall quotient value is intended to determine the stiffness value of the asphalt concrete mixture [8]. The marshall quotient value is derived from the quotient of stability with flow MQ = M_s / M_f

Where: MQ = Marshall Quotient (Kg/mm) ; Ms = Marshall Stabilitas (Kg) dan MF = Marshall Flow (mm).

2. RESEARCH METHOD

2.1 Data Requirements

The data needed in this study are:

Primary Data

- Rated thickness of asphalt
- Rated asphalt density
- Marshall Quotient Value

Secondary Data

- Characteristics of laston (AMP) PT. Claten Bersinar Sejahtera
- Pecan shell waste is obtained from UMKM, Village Own Mr.Jumadi. Rau Market, Serang Banten.

2.2 Research Materials

The materials to be used in this study are as follows:

a. Laston AC-WC obtained from PT. Claten Bersinar Sejahtera

b. This hazelnut shell waste is obtained from production waste in Serang City**.**

2.3 Research Equipment

This research uses equipment from the UPTD Laboratory of the Provincial PUPR Office. Banten, as for some of the equipment that will be used as follows:

The research tool used in this research is the Laboratory of the PUPR Office of Banten Province. The equipment used includes:

a. A set of Marshall test equipment
Pressure head, Electrically driven loader jack with vertical movement speed 50,8 mm/menit, The Testing Ring with a capacity of 22.2 KN (5000 lbs) with a precision of 25 lbs is equipped with a press watch reader with a precision of 0.025 cm.Arloji untuk pembacaan nilai kelehan/*flow* dengan ketelitian 0,0025 cm.

b. Compressive strength testing machine

c. Mold specimen (Mould) with diameter 10.2 cm and height 7.5 cm Oven with temperature control that can heat up to 200°C

d. *Waterbath*

e. Cylindrical compactor weighing 4.536 kg and having a free fall height of 45.7 cm.

f. Wooden compactor foundation

g. Scales with an accuracy of 0.1 grams

h. Temperature gauge with a temperature capacity of 250°C with a precision of 1%

i. Caliper to measure the thickness of the specimen

j. Jack to remove the specimen from the mold.

Supporting equipment which includes heating stoves, stirring spoons, heat-resistant gloves, material mixing cups, washcloths, spatulas, scales, stationery for marking test objects

2.4 Test Specimen Manufacturing

This study used a type of testing on the Marshall Test (Table 2). The number of test specimens made is as follows

Table 2: Marshall Test Specimens

Material	Amount of Material			
Pecan shell waste	0%	2%	3%	5%
Number of Test specimen Samples	3	3	3	3

There are several stages of making test specimens for the Marshall test.

a. The weight for each specimen is ± 1200 grams which will later produce a specimen with a height of approximately 63.5 mm ± 1.27 mm

b. Heat the material for the specimen to a minimum mixing temperature of 158°C

c. After reaching the minimum mixing temperature, mix the additive material at a temperature of approximately not less than 130°C, after mixing evenly, put the test specimen into the heated mold

d. The specimen mold and the face of the collider are preheated at a temperature of not less than 90°C, this has the intention that the test specimen material is not attached to the mold wall when it will be removed.

e. Placing the mold on top of the compactor with an anchor for stability

f. Putting sheets of paper as a base with a size that is adjusted to the size of the mold, this is so that the test specimen is not attached to the base of the mold or to the collider at the top.

g. Inserting all mixed materials into the mold (mold) accompanied by compaction using a heated spatula 15 times on the circumference of the mold and 10 times in the middle.
h. Prepare the collider rod and the surface of the pressing head, so that the pressing head can slide freely,
i. Compaction with a collider 75times 2x reps (two sides), compaction must be carried out at a temperature of not less than 130°C so that the specimen has maximum density
j. Remove the base piece and attach it to the test specimen dispense, then remove the specimen with the help of a jack
k. After the specimen is removed, let it sit at room temperature for ± 24 hours..
l. Heating asphalt to the required viscosity level for both mixing and compaction work.

2.5 Marshall Test

It takes a maximum of 30 seconds from the soaking bath.

a. Soak the test specimen in the waterbath for 30-40 minutes with a temperature of 60 ^{0}C ± 1 ^{0}C .
b. Remove the specimen from the bath and place it into the bottom segment of the pressing head.
c. Attach the top segment above the specimen and place the entire specimen.
d. Set the flow meter (Flow) so that the number is really at the zero value position.
e. Raising the specimen and head until they touch the base of the reinforcing ring before loading.
f. Provide loading at a fixed speed of approximately 50 mm/min until maximum loading is reached.
g. Note the value indicated on the watch.

3. RESULTS AND DISCUSSION

3.1 Aggregate Examination Results

Aggregate is the main material with the amount of the mixture reaching 90-95% (depending on the amount of asphalt in the mixture). Below are the results of abrasion testing

Table 3: Abrasion Test Results

Gradation Inspection		Crushed Stone
Sieve		Test Results
Skip	Stuck	Weight Before (a)(gram)
9.57 mm	4,75 mm(#4)	2500
4,75 mm	2,38 mm(#8)	2500
Amount of Weight		5000
Weight After (b)		4050
Worn weight (a-b)		950

Based on the data above, the wear value is obtained 19% with a test specimen weight of 5000 grams. With these results, the gradation can be used for asphalt concrete material, because it meets the specification value of Bina Marga 2018, which has a maximum wear value of 40%.

3.2 Asphalt Inspection Results

Asphalt is a material that functions as an aggregate binder in asphalt concrete mixture. The amount of asphalt content in the asphalt concrete mixture greatly determines the quality of concrete asphalt. If it is too much, asphalt concrete will have a dense mixture texture, but it is feared that bleeding can easily occur. The results of the examination can be seen in the table below.

Table 4: Asphalt Pen 60/70 Inspection Results

Types of Testing	unit	Spesifikasi*	Result
Penetration on 25^{0}C(0,1)	0,1 mm	60-70	66,6
Flash Point	^{0}C	≥232	343
Flabby Point	^{0}C	≥48	50,5
Specific Gravity of Asphalt	Kg/m’	≥1,0	1,037
Daktilitas	cm	≥100	≥ 100 cm
Solubility in TCE	%Berat	≥99	99,7
Viskositas Kinomatik pada 135^{0}C	Cst	≥300	302,3
Mixing Temperature	^{0}C	-	150
Compaction Temperature	^{0}C	-	139
Paraffin Levels	%	≤ 2	0,1178

* General Specifications of Highways 2018

Table 4 shows that the asphalt used as an adhesive in asphalt concrete has met the specifications of Bina Marga 2018. Therefore, asphalt can be used as an adhesive in research concrete asphalt materials.

3.3 Test Specimen Weighing Results

Test objects that have been made, let stand first for approximately 24 hours. After going through the planting process, the specimen is measured in thickness and diameter using a caliper to get more precise results. Before weighing, each specimen is assigned a code or mark with the intention that the weighing results are not confused with each other.

The weighing of the specimen is carried out in three stages, the first, the specimen is weighed in air dry conditions. Second, the specimen is weighed in water. Third, the specimen is weighed in a surface dry state (SSD). These three processes are carried out right before the marshall test, or rather before the specimen is immersed in the waterbath. The results of weighing test specimens can be used to obtain the value of the weight of the contents as well as the density of asphalt concrete.

The number of specimens made in the study amounted to 12 specimens with charcoal content of 0% (pure), 2%, 3% and 5% hazelnut shells. The following are the test specimen weighing results presented in Table 5.

Table 5: Test Specimen Weighing Results

Mixture	Sample	thick	In Air	SSD	In Water	Fill Weight
		cm	gram	gram	gram	ml
0%	A	6,50	1220,86	1221,86	667,16	554,700
	B	6,67	1195,06	1197,24	640,32	556,920
	C	6,62	1153,69	1155,46	627,16	528,300
	Rata-rata	6,60	1189,87	1191,52	644,88	546,64
2%	A	7,08	1209,59	1216,94	663,16	553,780
	B	7,06	1183,45	1197,44	656,42	541,020
	C	7,90	1162,886	1171,68	635,45	536,2300
	Average	7,34	1185,30	1195,35	651,68	543,68
3%	A	7,50	1180,40	1187,19	644,51	542,680
	B	7,40	1234,11	1239,20	674,15	565,050
	C	7,90	1244,32	1251,25	680,47	570,780
	Average	7,60	1219,61	1225,88	666,38	559,50
5%	A	7,50	1240,88	671,17	572,610	572,610
	B	7,30	1216,31	652,64	652,6440	652,640
	C	7,80	1245,90	678,83	577,930	577,930
		7,53	1234,36	667,55	573,040	5730,040

From the weighing results contained in Table 5, it can be seen that the sample weight tends to increase with the increase in the pecan shell charcoal mixture used, this can be seen in the ratio of dry weight of air (in air) at 0% pecan shell charcoal content or pure test specimens have an average weight of 1189.87 grams, 2% hazelnut shell charcoal content has an average weight of 1185.30 grams, The charcoal content of 3% hazelnut shells has an average weight of 1219.61 grams and the charcoal content of 5% pecan shells has an average weight of 1234.36 grams.Adapun nilai berat isi pada hasil penimbangan benda uji, pada kadar arang cangkang kemiri 2% memiliki nilai rata-rata paling rendah, yaitu sebesar 543,68ml berbeda dengan arang cangkang kemiri 0% atau murni memiliki nilai sebesar 546,64 ml, kadar arang cangkang kemiri 3% sebesar 565,51 ml, dan arang cangkang kemiri 5% sebesar 573,040 ml.

3.4 Marshall Test Results

The marshall test is a test to measure the performance of solid asphalt concrete mixture. The marshall test is performed to obtain stability and flow values. Here is one example of the calculation of the marshall test on the test specimen with the addition of 2% hazelnut shell charcoal content, as follows

Specific Gravity of Asphalt (Gb)= 1,037 kg/m^3
Tool Calibration = 23,98
Sample Height = 6,4 cm
Sample Diameter = 10,2 cm
Pecan shell charcoal content (a)= 2%
Asphalt against Mixture (b) = 6%
Air Dry Weight (c) = 1183,45 gram
Saturated Weight *SSD* (d) = 1197,44 gram
Weight in Water (e) = 656,42 gram
Fill Weight (f) = 541,02 ml
Fill Weight / *Density* (g) = 1,803 gram/ml
Specific Gravity Maks. Teoritis (h)= 2,389
Vol. Asphalt against Mixture (I)= 10,43%
Vol. Bulk Agregat (j) = 66,59%
Amount of Air Content (k) = 22,98 %
Void Mineral Agregat (VMA) (l)= 10,43 %
Void in Mix (VIM) (m) = 24,53 %
Void Filled Asphalt (VFA) (n) = 26,57%
Press Watch Reading (o) = 109
Stabilitas (p) = Press Watch Reading × Tool calibration = 109 × 23,98 = 261 3,8 kg
Corrected Stability (q) = Stabilitas (p) × Correlation rate
= 2613,8 × 0,83 = 2613,8 kg
Flow (r) = 2,60 mm
Marshall Quotient (s) = 864,57 kg/mm

3.5 Density

The calculation of the weight of the contents of the test specimen is contained in the calculation of the Marshall Test. The density value is used as a parameter for the density level of the asphalt mixture after solidification. The following is a comparison of the average density value of each hazelnut shell charcoal content

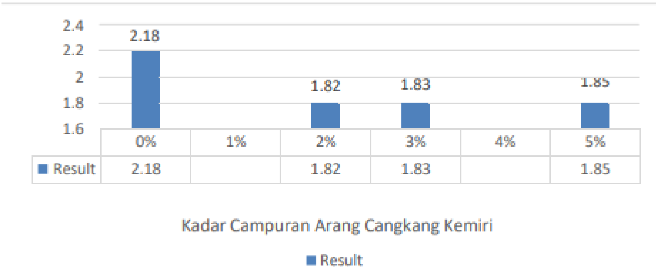

Figure 1: Average Density Value of Pecan Shell Charcoal Mixture

The picture above shows concrete asphalt with 0% hazelnut shell charcoal content has the highest density value compared to others with a value of 2.18 grams / mm. The concrete asphalt with a charcoal content of 5% hazelnut shell has the second highest value with a value of 1.85 grams / mm. While the two asphalt concrete mixtures with pecan shell charcoal content of 2% and 3%, have almost the same value and are the lowest value, which is 1.82 grams / mm.

3.6 Void mineral aggregate (VMA)

Cavities in aggregate minerals or commonly called VMA are the number of cavities contained in the gradation of aggregates in a concrete asphalt mixture. The VMA value is usually influenced by the type of gradation, the temperature at compaction and the number of collisions at compaction. The following is the average VMA value of the research results presented in Figure 2 below.

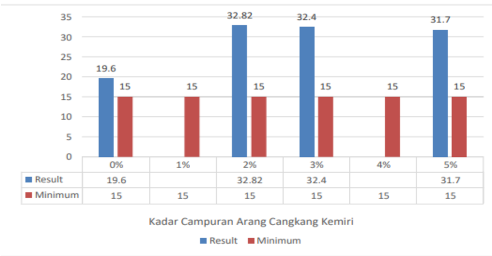

Figure 2: VMA Average Value of Pecan Shell Charcoal Content Mixture.

In Figure 2, the average value of all test objects meets the specifications of Bina Marga 2018, which is 15%. The largest VMA value is found in the 2% hazelnut shell charcoal content which is 32.82% and the 5% hazelnut shell charcoal content has the lowest value, which is 31.7%. A large VMA value will indicate a small density, while a small VMA value will have a large density result.

3.7 Void In Mix (VIM)

Cavities in a mixture, commonly referred to as VIM (Voids in Mix), refer to the empty spaces between aggregate grains that have been coated with a layer of asphalt. If the VIM is too large, it can cause aging or decreased time asphalt concrete service, while if the VIM is too small, it can cause damage in the form of bleeding.

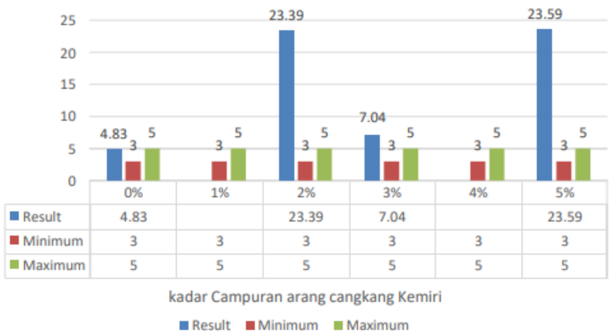

Figure 3: Average value of VIM Pecan Charcoal Mixture

It can be seen in the graph above that only concrete asphalt with a charcoal content of 0% hazelnut shells meets the specifications of Bina Marga 2018, which is 4.83%, while for other hazelnut shell charcoal content, it does not meet the specifications because it has a higher value. High VIM values tend to have a high level of stiffness, and have cavities that are too large, this can result in cavities filled with water or air which causes the durability of asphalt concrete to be disrupted due to the oxidation process. The consequences of this oxidation process can cause the service life of the pavement layer to be reduced.

3.8 Void Filled Asphalt (VFA)

Cavities in the asphalt mixture, often referred to as VFA (Voids Filled with Asphalt), are the part of the VMA that is not filled by asphalt. VFA can be thought of as empty space in mineral aggregates that have been filled by asphalt in the mixture. VFA values have an important role in determining the stability of asphalt mixtures. If the VFA value is too small, it indicates that little free space is filled by asphalt in the mixture. However, if the VFA value is too large, this could mean that the asphalt concrete mixture is overfilled by asphalt, which can lead to blending.

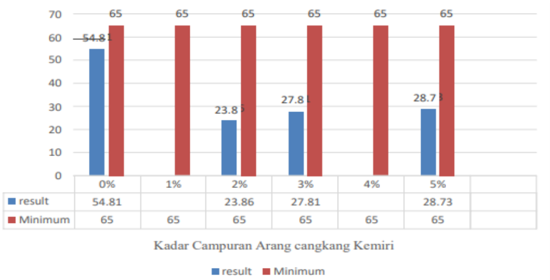

Figure 4: Average VFA Value of Pecan Charcoal Blend

Based on Figure 4, only asphalt concrete with a charcoal content of 0% pecan shells (54.81%) meets the specifications. For VFA values at pecan shell charcoal content of 2%, 3% and 5% only have percentages of 23.86%, 27.81% and 28.73%. This shows that asphalt concrete with charcoal content of 2%, 3% and 5% hazelnut shells has many cavities that are not filled by asphalt. Of course, it will result in the durability of asphalt concrete because unfilled cavities can be oxidized which can cause grain peeling in the asphalt concrete mixture.

3.9 Stability

Stability is one of two values obtained when the marshall test is performed. shows that all asphalt concrete mixtures with hazelnut shell charcoal or pure, have results above the specifications determined by Bina Marga 2018. The highest stability value is found in the mixed content of 2% hazelnut shell charcoal with a value of 2573.85 kg, followed by 3% hazelnut shell charcoal content of 2350.04 kg, 0% hazelnut shell charcoal content of 2294.09 kg and 5% or pure pecan shell charcoal of 2078.27 kg.

3.10 Flow

Based on the value of Flow Flow, it can be seen from the Flow gauge watch showing that all asphalt concrete mixtures with hazelnut shell charcoal content have met the specifications. The flow value in 0% or pure hazelnut shell charcoal has a value of 2.7 mm, at 2% hazelnut shell charcoal content of 2.72 mm, at 3% hazelnut shell charcoal content of 2.6 mm, and 5% at 2.1 mm. If you look closely, the resulting flow value tends to decrease according to the amount of hazelnut shell charcoal used in asphalt concrete mixture.

3.11 Marshall Quotient

The Marshall quotient shows the stiffness of a solid concrete asphalt. The Marshall quotient value depends on stability and flow. If the resulting marshall quotient value is low, then asphalt concrete has flexible properties. Conversely, if the resulting marshall quotient value is high, it will produce rigid asphalt concrete.

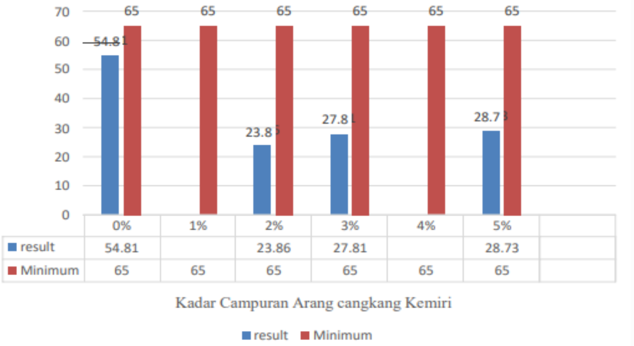

Figure 5: Average Marshall Quotient Value of Pecan Charcoal Mixture

In Figure 5 above shows an increasing trend of the marshall quotient value obtained, as the charcoal content of pecan shells increases in the asphalt concrete mixture, starting from a mixture content of 0% or pure has a value of 590.13 kg / mm, then at a 2% pecan shell charcoal content has a value of 859.35 kg / mm, 5% pecan shell charcoal content of 866.44 kg / mm, and the last and the highest in hazelnut shell charcoal content 3% is 912.48 kg/mm. With these results, all asphalt concrete mixtures with hazelnut shell charcoal have met the specifications of Bina Marga 2018, which has a specification value of 250 kg / mm. This result shows that the more hazelnut shell charcoal content in the asphalt concrete mixture will produce a high stability value with a low divisor (flow) value, it can produce a marshall quotient value.

Table 6: Reafitulation of Research Results

Characteristics of Asphalt Laston AC-WC	**Unit**	**Pecan Shell Charcoal Content**			
		0%	**2%**	**3%**	**5%**
Density	gr/ml	2,18	1,82	1,83	1,85
VMA	%	17,46	100,52	10,59	31,70
VIM	%	6,21	23,86	23,39	22,59
VFA	%	64,62	27,30	27,81	28,73
Stability	kg	2158,68	2213,51	2021,03	1787,31
Flow	mm	3,7	2,72	2,60	2,10
Marshall Quoitient	Kg/mm	590,13	859,35	912,48	866,44

Table 6: Mixture of asphalt concrete

Characteristics of Asphalt Laston AC-WC	**Unit**	**Specifications**		**Asphalt Content**
		Min	**Maks**	**%**
Density	gr/ml	-	-	6
VMA	%	15	-	
VIM	%	3	5	
VFA	%	65	-	
Stability	kg	800	-	
Flow	mm	2	4	
Marshall Quoitient	Kg/mm	250	-	

Table 6 above shows that overall, the mixture of asphalt concrete with 2%, 3%, 5% hazelnut shells has met predetermined specifications, such as density, stability, flow, marshall quotient to compressive strength. The use of hazelnut shell charcoal as an additive is proven to increase the stability value, this can be seen in Table where the stability value produced by the asphalt concrete mixture with the addition of pecan shell charcoal as much as 2%, 3%, and 5% has a Table 6 above shows that overall, the mixture of asphalt concrete with 2%, 3%, 5% hazelnut shells has met predetermined specifications, such as density, stability, flow, marshall quotient to compressive strength. The use of hazelnut shell charcoal as an additive is proven to increase the stability value, this can be seen in Table 6 where the stability value produced by the asphalt concrete mixture with the addition of pecan shell charcoal as much as 2%, 3%, and 5% has a value Large than asphalt concrete mixture without added hazelnut shell charcoal (0%).

4. CONCLUSION

Based on the results and discussion of the research, several conclusions can be drawn, including:

1. In this study, the VMA value of all asphalt concrete mixtures with pecan shell charcoal content of 2%, 3% and 5% is only a percentage of 5% mixture that meets the specifications, as well as asphalt concrete mixture with 0% hazelnut shell charcoal content or pure test objects. For VIM and VFA values, none of the percentages of 0%, 2%, 3%, and 5% meet the predetermined specification. For the stability value, all asphalt concrete mixtures that use hazelnut shell charcoal (2%, 3%, and 5%) or not (0% or pure) have met the specifications, as well as the flow value obtained by all asphalt concrete mixtures have met the specifications. Based on the explanation above, it shows that the asphalt concrete mixture with a pecan shell charcoal content of 5% has the best quality when compared to the mixture of asphalt concrete with other hazelnut shell charcoal content. This is because the mixture of asphalt concrete with hazelnut shell charcoal as much as 5% meets all species Predetermined characteristics of Marshall.
2. For asphalt concrete mixture with the addition of hazelnut shell charcoal (2%, 3% and 5%) tends to have a higher marshall quotient value compared to asphalt concrete mixture without additional hazelnut shell charcoal. The marshall quotient values obtained were 859.35 kg / mm, 912.48 kg / mm and 866.44 kg / mm, respectively, and the asphalt concrete mixture without hazelnut shell charcoal had a value of 590.13 kg / mm.
3. Based on the results of Marshall Quotient research, there is a significant difference in pure Ac-Wc laston and Ac-Wc laston with coconut shell charcoal additives, it can be proven by the Marshall quotient value without a mixture with an average Marshall Quotient value of 590.13 Kg, in a mixture of 2% with an average Marshall Quotient value of 1004.91 Kg, in a mixture of 3% with an average value of 1024.99 Kg, and at a mixture of 4% with an average Marshall Quotient value of 681.93 Kg.

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