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Study Of Asphalt Characteristics Using Fly Ash as a Substitute For Sand In Concrete Asphalt (AC – WC) Using The Marshall Test (RSNI M-01-2003) and Test Standards Specifications For Bina Marga Specifications 2018 Revision 2

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Abstract *Utilization of fly ash which is part of the residue from burning coal for power plants (PLTU), where the combustion products have the same size as sand. Asphalt concrete is a type of construction pavement consisting of a mixture of asphalt and aggregate, either with or without added materials. This research aims to determine the characteristic values of asphalt using fly ash as a substitute for sand in AC – WC asphalt concrete with mixed variations of 25%, 50% and 75%. From the research results, the AC-WC mixture used according to the standard, namely the condition of 5.5% asphalt content, obtained a stability value of 1580kg, a VFB value of 79.00%, a VMA value of 15.50%, a VIM value of 3.40%, a MQ value of 550kg/mm , flow value 2.90mm and density value 2.35. Tests with mixture variations of 25%, 50% and 75% obtained a maximum stability value of 1706.5kg at a variation of 25%, a maximum flow value of 3.54mm at a variation of 75%, a maximum VIM value of 6.90% at a variation of 75%, a maximum VMA value 17.68% at 75% variation, maximum VFB value 84.89% at 25% variation, maximum density value 2.38 at 25% variation and MQ value 605.33kg/mm at 25% variation. From the results of a study of the characteristics of asphalt using fly ash as a substitute for sand in AC-WC concrete asphalt with a variation of 50% which meets the requirements of the 2018 General Specifications Revision 2.*

Keywords: *Fly Ash, Sand and AC – WC*

BACKGROUND

Road pavement is a layer of pavement that is located between the subgrade layer and vehicle wheels and functions as a means of transportation to make it easier for vehicles to pass safely and comfortably. In road pavement construction there is a covering layer which is commonly known as laston or asphalt concrete layer. In Indonesia, road construction often experiences damage quickly, therefore new innovations are needed in mixing road construction which can make the road construction durable and not quickly damaged.

Current technological developments and scientific developments encourage people to be creative and innovate in the development of road construction by adding alternative materials which are considered to have potential as additional ingredients in mixtures that are able to overcome the weaknesses of asphalt. Coal is the main fuel for steam power plants, according to Wardani (2008) from burning coal, 5% of pollutants are

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produced in the form of ash (fly ash and bottom ash), around 10-20% is bottom ash and around 80-90% fly ash from the total ash produced.

With the existence of Government Regulation (PP) Number 22 of 2021 concerning the Implementation of Environmental Protection and Management which states that fly ash and bottom ash (FABA) as the end result of coal burning activities, is no longer listed in the hazardous and toxic waste category, due to coal burning. In PLTU activities are carried out at high temperatures, so that the unburnt carbon content in FABA is minimum and more stable when stored.). The use of fly ash pads in asphalt concrete mixtures is to fill voids in the mixture, to increase the binding capacity of asphalt concrete and is also expected to increase the stability of the asphalt concrete mixture.

Based on this background, this research aims to try to determine the value of Marshall characteristics when using fly ash as a substitute sand with several variations of the mixture, and wanted to know the effects that occur on the asphalt concrete (AC – WC) mixture so that it is hoped that this fly ash can improve the characteristics of an asphalt concrete (AC – WC) mixture.

THEORETICAL STUDY

Asphalt Concrete (AC) or commonly known as laston (Asphalt Concrete Layer) is a surface layer consisting of laston as a wear layer (AC – WC) with a thickness of 4 cm. Laston is made from graded aggregate with a predominance of sand and hard asphalt which is mixed, spread and compacted hot at a certain temperature. Provisions for the properties of hot asphalt mixtures according to the 2018 Bina Marga Specifications Revision 2.

Asphalt is defined as a black or dark brown material, at low temperatures it is dense to slightly dense. If heated to a certain temperature, asphalt can change shape to become soft/liquid so that it can wrap aggregate particles when making asphalt concrete or can enter the pores that exist when spraying/watering macadam pavement or melting. If the temperature begins to drop, the asphalt will harden and bind the aggregate in place. Asphalt used in road pavement construction functions as a binding material which provides a strong bond between the asphalt and the aggregate and between the asphalt itself as a cavity filler between the aggregate grains and the pores in the aggregate itself. The general requirements for asphalt that must be maintained during work are durability due to weather influences during its service life, asphalt hardness, adhesion and cohesion and sensitivity to temperature.

The term aggregate includes cobblestone, crushed stone, stone ash and sand, among others. Aggregate has a very important role in road pavement, because aggregate is the main component of the road pavement layer. The bearing capacity of a road pavement is determined largely by the characteristics of the aggregate used. Selecting the right aggregate that meets the requirements will be crucial in the success of road construction or maintenance. According to the General Specifications for Bina Marga 2018 Revision 2, coarse aggregate can be defined as a mixed design retained on sieve No. (4.75 mm) which is carried out wet or must be clean, hard, durable and free from clay or other undesirable materials and meet the provisions given in Table 2.2 having an aggregate weight greater than 4.75 mm with a broken surface one or more and consisting of crushed stone or crushed gravel; and shall be supplied in single nominal sizes, each of which, when tested, shall conform to specification.

Fly ash itself does not have the binding ability like cement. However, with the presence of water and its fine particle size, the silica oxide contained in fly ash will react chemically with the calcium hydroside formed from the cement hydration process and produce a substance that has binding ability. According to ACI Committee 226, it is explained that fly ash has quite fine grains, namely passing sieve No. 325 (45 milli microns) 5 – 27%, with a specific gravity between 2.15 – 2.8 and a blackish gray color.

Stability is the ability of a road pavement structure without experiencing permanent changes in shape such as waves, grooves and bleeding. The need for stability is proportional to the amount of traffic and vehicle load that will pass through the road. Roads with high traffic volumes and frequently used by heavy vehicles require greater stability compared to roads with small traffic volumes and small vehicle loads passing through them. However, a stability value that is too high can cause the pavement layer to become stiff and crack quickly. The stability value is obtained from friction between grains, locking between particles and good binding power of the asphalt layer.

Thus, high stability can be obtained by seeking to use: - Densely graded aggregate - Aggregate with a rough surface - Cube shaped aggregate - Asphalt with a low penetration value - Asphalt with an optimum amount for bonding between grains. Well-graded or tightly graded aggregate will provide small voids in mineral aggregate to produce high stability, but requires a low asphalt content to bind the aggregate. The small

Void In Mineral Aggregate (VMA) results in limited asphalt being able to cover the aggregate, resulting in a thin asphalt film. The thin asphalt film is easily separated so that the pavement layer is no longer watertight, oxidation easily occurs, and the pavement layer becomes damaged. Meanwhile, using a lot of asphalt results in the asphalt no longer being able to cover the aggregate properly (because the VMA is small) and also produces small voids in mix (VIM). The presence of traffic loads which increase the compaction of the layer causes the asphalt layer to melt out which is called bleeding.

PMarshall testing aims to measure the durability (stability) of aggregate and asphalt mixtures against plastic fatigue (flow). Flow is defined as the change in deformation or strain of a mixture from no load to maximum load. The Marshall tool is a press tool equipped with a Proving Ring (testing ring) with a capacity of 22.2 KN (5000 lbs) and a flowmeter. Proving rings are used to measure stability values and flowmeters to measure plastic melting or flow. From the results of the Marshall test, the properties of the mixture were obtained, including: Volume Weight, Optimum Asphalt Content, VIM, VMA, VFB, Asphalt Absorption, Marshall quotient (Marshall coefficient) and must meet the requirements for the properties of the Laston mixture.

RESEARCH METHODS

The steps taken in analyzing the data obtained are as follows: Preparation of tools and materials, material testing, mixture planning, making asphalt test objects without Fly Ash, making Fly Ash asphalt test objects as a substitute for sand, marshall testing asphalt test objects with Fly Ash and finally the processing and discussion of the results. This research uses primary data, namely data obtained directly from research conducted in the laboratory and secondary data, namely literature.

RESULTS AND DISCUSSION

1. AGGREGATE TEST RESULTS

The test results on physical properties include coarse aggregate and fine aggregate, from the aggregate test results the data obtained meets the permitted requirements (General Specifications 2018 revision 2).

Table. Aggregate Test Results

No	Characteristics	Standard	Unit	Results	Specification
		Testing			
		CA (Course Aggregate)			
1	Heavy Bulk Type	SNI 1969 2008	g/cm3	2,731	Min 2.5
2	Heavy SSD Type	SNI 1969 2008	g/cm3	2,750	Min 2.5
3	Heavy Pseudo Type	SNI 1969 2008	g/cm3	2,785	Min 2.5
4	Absorption	SNI 1969 2008	%	0.712	Max.3
5	Abrasion	SNI 1969 2008	%	26,24	Max.40
		MA (Medium Aggregate)			
1	Heavy Bulk Type	SNI 1969 2008	g/cm3	2,590	Min 2.5
2	Heavy SSD Type	SNI 1969 2008	g/cm3	2,627	Min 2.5
3	Heavy Pseudo Type	SNI 1969 2008	g/cm3	2,690	Min 2.5
4	Absorption	SNI 1969 2008	%	1,436	Max.3
		FA (Fine Aggregate)			
1	Heavy Bulk Type	SNI 1970 2008	g/cm3	2,527	Min 2.5
2	Heavy SSD Type	SNI 1970 2008	g/cm3	2,546	Min 2.5
3	Heavy Pseudo Type	SNI 1970 2008	g/cm3	2,578	Min 2.5
4	Absorption	SNI 1970 2008	%	0.786	Max.3
		Sand (Barito River)			
1	Heavy Bulk Type	SNI 1970 2008	g/cm3	2,633	Min 2.5
2	Heavy SSD Type	SNI 1970 2008	g/cm3	2,662	Min 2.5
3	Heavy Pseudo Type	SNI 1970 2008	g/cm3	2,711	Min 2.5
4	Absorption	SNI 1970 2008	%	1,092	Max.3

Source: 2023 MAB Kalimantan Islamic University Laboratory Test Results

2. Asphalt Test Results

The hard asphalt tested at the Kalimantan Islamic University MAB Laboratory obtained asphalt penetration of 60/70 which can be seen in the following table.

Table. Asphalt Test Results

No	Characteristi	Standard	Unit	Resu	Specificati
1	Penetration 25℃	SNI 06 2456:2011	0.1mm	65.56	60 – 70
2	Point Soft (℃)	SNI 06 2434:2011	℃	48.50	≥ 48
3	Heavy Asphalt Type	SNI 06 2441:2011	-	1.10	≥ 1.0

Source: 2023 MAB Kalimantan Islamic University Laboratory Test Results

From the asphalt test results tested at the Kalimantan Islamic University MAB Laboratory, it was found that the tested asphalt met the specifications required in the 2018 Bina Marga Specifications Revision 2.

3. Aggregate Sieve Analysis Results

In the aggregate gradation tests that have been carried out on Course Aggregate, Medium Aggregate, Fine Aggregate, Sand and Filler, the results obtained are the percent passing the filter which can be seen in the following table.

Table. Aggregate Sieve Analysis Results

Number Filter		Pass Percent (%)				
Mm	Inch	C.A	M.A	F.A	S	FILER
19.1	¾”	100.00	100.00	100.00	100.00	100.00
12.7	½”	49.36	100.00	100.00	100.00	100
9.52	3/8”	49.36	96.85	100.00	100.00	100
4.76	No.4	49.36	21.65	99.36	100.00	100
2.38	No.8	0.38	1.30	76.66	98.82	100
1.19	No.16	0.38	1.08	53.67	95.59	100
0.59	No. 30	0.35	0.93	29.89	85.23	100
0.279	No. 50	0.35	0.79	18.41	66.65	100
0.149	No. 100	0.29	0.58	10.69	5.75	100
0.075	No. 200	0.17	0.37	5.03	0.71	100

he combination of aggregates for making test specimens is carried out using the diagonal method and the trial and error method which is based on the middle value of the specifications. The combined gradation mean value is obtained from the upper and lower limits of the aggregate gradation specifications. After obtaining the middle value of the aggregate gradation for the Asphalt Concrete (AC-WC) mixture, the next step is to determine the mixture proportion that is closest to the middle value of the specifications.

There are two (2) methods used to determine the mixture proportions in this test, namely the diagonal method and the trial and error method.

4. Determine the initial estimate of planned asphalt content (Pb)

Determine the initial estimate of the planned asphalt content using the following calculation method:

Pb = 0.035(%CA) + 0.045(%FA) + 0.18(%Fi) + Constant

Where,

%CA = Coarse Aggregate (100 - %pass # no.8) = 100% - 46.40% = 53.60%

%FA = Fine Aggregate (%pass # no.8 - %pass # no.200)

= 46.40% - 4.15% = 42.25%

%Fi = Filler Material (%pass # no.200) = 4.15%Laston's constant = 0.5 to 1

PB = 0.035(53.60) + 0.045(42.25) + 0.18(4.15) + 1

= 1.88 + 1.90 + 0.75+ 1

= 5.53% ≈ 5.50%

In calculating the initial estimate of the planned asphalt content (Pb), the result was 5.5%. Thus, the composition of the Asphalt Concrete (AC-WC) asphalt mixture for making marshall test specimens has variations in asphalt content of 4.0%; 4.5%; 5.0%; 5.5%; 6.0%;

5. Mixed Aggregate Fraction Proportions

For weighing aggregate and asphalt according to the cumulative weight calculation which has been calculated based on the mixture as calculated in the following table.

Table. Composition of AC – WC Asphalt Mixture

Type Aggregate	Code	Proportion Mixture	Heavy Test Object (gr)	Heavy Aggregate (gr)	Cumulative (gr)
Crushed Stone	C.A	15%	1200	180	240
Crushed Stone	M.A	30%	1200	360	540
Batu Ash	F.A	38%	1200	456	996

Sand	S	15%	1200	180	1176
Cement	F	2%	1200	24	1200

Source: 2023 MAB Kalimantan Islamic University Laboratory Test Results

6. Determination of Fly Ash Content

As for the determination of Fly Ash Content, it is carried out based on the results of the properties of the asphalt mixture of fly ash as a substitute for sand, which can be seen in the following table.

Table. The Effect of Fly Ash as a Substitute for Sand on the VFB of Asphalt Mixtures

Characteristic Mixture	Rate *Fly Ash*				Specification	Standard Testing
	0%	25%	50%	75%		
Amount Collision	75	75	75	75	75	
Density	2.33	2.38	2.32	2.27	-	Specification
Stability	1580.00	1706.05	1598.34	1257.99	Min. 800	Build
Flow	2.90	2.88	3.52	3.54	2 – 4	Clan
MQ	550.00	605.33	501.18	356.43	Min. 250	2018
VIM	3.50	2.02	4.25	6.90	3 – 5	Revision 2
VMAs	15.50	13.20	15.31	17.68	Min. 15	
VFB	75.50	84.89	72.34	61.24	Min. 65	

Source: 2023 MAB Kalimantan Islamic University Laboratory Test Results

From the data in the table it can be seen that the variations in the mixture of asphalt specimens with fly ash as a substitute for sand with variations of 25%, 50% and 75% meet the specifications for Asphalt Concrete (AC – WC) for Density, stability, flow, Marshall Quotient values. , VIM, VMA and VFB at 50% variation.

CONCLUSIONS AND RECOMMENDATIONS

In calculating the Optimum Asphalt Content (KAO) for the Asphalt Concrete (AC–WC) mixture using normal materials with an asphalt content value of 5.5%, the Stability value was 1580 kg with a specification of 800kg, VFB 75.00% with a specification of 65%, VMA 15 .50% with specifications of 15.00%, VIM 4.00% with specifications of 3-5%, MQ 550 kg/mm, Flow 2.95 mm with specifications of 2-4 mm, Density 2.33. From the results of this research, marshall characteristics use fly ash as a sand substitute with a composition of 25%, 50% and 75%. Stability 25% = 1706.5 kg, 50% = 1598.34 kg and 75% = 1257.99 kg. All Meet Minimum Stability Specifications of 800 kg.Flow 25% = 2.88 mm, 50% = 3.52 mm and 75% = 3.54 mm. All Meet Flow Specifications 2 – 4mm. VIM (Void In Mix) 25% = 2.02%, 50% = 4.25% and 75% = 6.90%. What meets the VIM specifications of 3% – 5% is a 50% variation. VMA (Void Mineral Aggregate) 25% = 13.20%, 50% = 15.31% and 75% = 17.68%. What Meets the minimum VMA Specification of 15% is the 50% and 75% Variations. VFB (Void Filed Bitumen) 25% = 84.89%, 50% = 72.34% and 75% = 62.24%. What meets the minimum VFB specification of 65% is a variation of 25% and 50%. Density 25% = 2.38, 50% = 2.34 and 75% = 2.27. Marshall Quotient 25% = 605.33 kg/mm, 50% = 501.18 kg/mm, and 75% = 356.43 kg/mm. All Meet the Minimum MQ Specification of 250 kg/mm. From this description it can be seen that variations in the mixture of asphalt test specimens with fly ash as a substitute for sand with variations of 25%, 50% and 75% are the best or meet the specifications for Asphalt Concrete (AC – WC) for Density, stability, flow, Marshall Quotient values. , VIM, VMA and VFB at 50% variation.

The suggestions obtained from the results of the study of the characteristics of asphalt using Fly Ash as a substitute for sand in AC - WC concrete asphalt which have been carried out are: For further research, we hope to try using aggregates from different locations and also different asphalt. Necessity accuracy in weighing, observation temperature when mixing temperature and compaction so that optimal results are obtained. There is a need for further research regarding the selection of coal ash waste types for AC - WC asphalt concrete mixtures.

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