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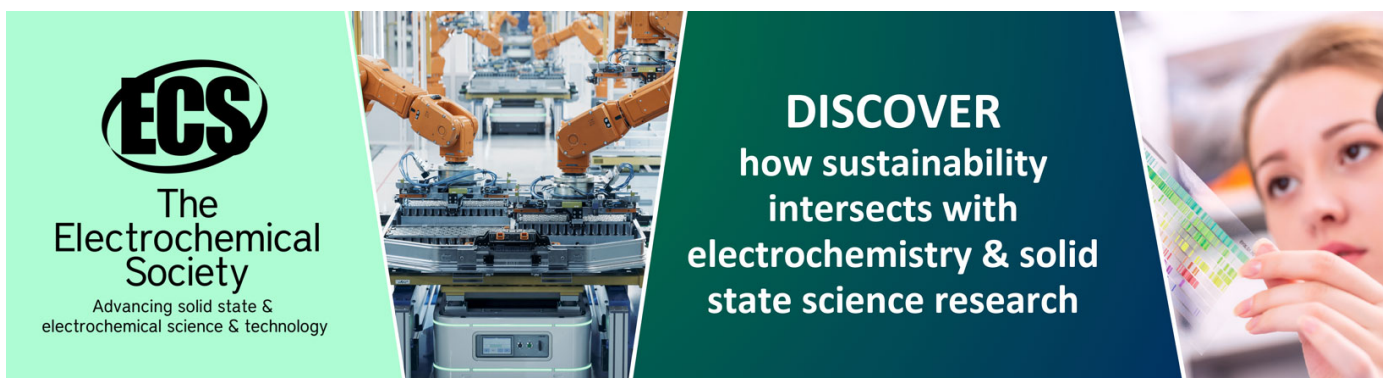
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The Effect of Coal Powder Addition to Asphalt Concrete - Wearing Course (AC-WC) Mixture to Increase Road Surface Hardness Quality

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Abstract. The most common type of structural asphalt pavement in Indonesia is asphalt concrete-wearing course (AC-WC). This type of layer is the most vulnerable type, with damages mostly caused by weather and tire pressure of heavy vehicles. In this study, the test object was produced based on standardized general specification called '*Spesifikasi Umum Bina Marga*' 2010 (Division VI). The mixture of the test object contained varied amount of charcoal powder: 10%, 20%, and 30%. From Marshal Test data obtained in the study, the mixture which met the qualification of '*Spesifikasi Umum Bina Marga*' 2010 was the one containing 30% charcoal powder. The mixture had 1183 kg stability value, 3.73 mm flow value, 316.9 kg/mm Marshal quotient, 4.47 % VIM, 17.08% VMA, and 73.82% void filled. Therefore, it was concluded that 30% charcoal powder content met the Marshal test standard, and more addition of charcoal powder resulted in more void filled to cover the aggregate, and less void left in the mixture (VIM).

1. Introduction

Wood Charcoal is residue containing carbon produced from burning wood in high temperature. Charcoal is black-colored, light, and made up of 80% carbon. The charcoal used in this study contained 85% to 98% carbon, and other components such as ash or other chemical substances. Due to the active carbon content in the wood charcoal, mixing charcoals into asphalt was expected to increase ductility, the ability to hold vapor pressure under high temperature (flash point), and other physical properties of the asphalt. Road, where the asphalt is applied, is one of land transportation infrastructures with crucial role for the growth of economy, social, culture, tourism development, and defense and security; all of which are important for national development [1].

The method used in this study was Marshall method. The sequences performed in Marshall method were: testing specific gravity, designing aggregate gradation, designing aggregate composite materials, measuring bulk specific gravity of aggregate, measuring maximum specific gravity of the mix, and measuring Marshall parameter values.

Therefore, this study on the use of charcoal powder and stone dust as filler in asphalt mixture was conducted. The ratio of charcoal powder in the mixture were 0%, 10%, 20%, and 30% of the weight of the stone dust used.



2. Literature Review

2.1. Previous Studies

This study was conducted on asphalt concrete - wearing course (AC-WC) using pen 60 asphalt mixed with 2.5% and 5% carbide waste. The objective of this study was to find out the Marshall perimeters of the asphalt concrete physical properties from different types of asphalt. The Marshall perimeters showed that the optimum asphalt content was 6% for 0% asphalt, 6.7% for asphalt mixed with 2.5% carbide waste, and 6.8% for asphalt mixed with 5% carbide waste [2].

2.2 Percentage Refusal Density (PRD)

Percentage refusal density is the condition in which a mixture reaches the point of maximum density and therefore, cannot become any denser even if the mixture is further compacted. Percentage refusal density (PRD) is the ratio of inter densities to refusal density, expressed as a percentage. That density is an approach to the real condition in the field after asphalt containing mixture is secondarily compressed by pressures from vehicles over several years of the planned service life without getting plastic deformation.

2.3 Marshall Method

Marshall method concept was originally developed by Bruce Marshall in Mississippi State Highway Department around 1939. The method was further refined by U.S. Army Corps of Engineering. Currently, it has become a standard test method in American Society for Testing and Materials (ASTM): ASTM D1559 Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus. This method is only used for testing hot asphalt concrete mixture containing hard asphalt with certain penetration grade and 1-inch maximum sized aggregate [3]

Voids in the mixture at percentage refusal density, stability, and flow as well as the result of Marshall / Marshall Quotient (MQ) are the result of dividing stability to flow. The formula is as follows:

$$MQ = \frac{MS}{MF} \quad (1)$$

Explanation:

MQ = Marshall Quotient (kg/mm)

MS = Marshal stability (kg)

MF = Flow Marshall (mm)

3. Research Methodology

3.1 The Testing of Pen 60/70 Asphalt

Testing the physical properties of pen 60/70 asphalt made of AC-WC mixture was performed by testing the following properties:

1. Penetration test
2. Softening point
3. Specific gravity
4. Flash point and Fire point
5. Adhesion to aggregate

3.2 The Testing of Aggregate

Choosing the right and qualified aggregates will affect the supportive hardening ability and the success of both road construction and road maintenance. In asphalt containing mixture, aggregate

gives 90% - 95% contribution to the mixture weight. Therefore, the aggregate physical properties are some of the decisive factors of the mixture quality.

The tested physical properties of the aggregate were:

1. Particle size
2. Gradation
3. Cleanliness
4. Hardness
5. Particle shape
6. Texture of surface
7. Absorption
8. Adhesion to asphalt

3.3 Marshall Testing

This experiment used standard test object that was a mold with 101.6 mm diameter and 75 mm (3 inch) height. The test object was obtained using Marshall compaction hammer with the weight of 4.54 kg (10 lbs), diameter of 3.7/8 inch and free fall of 457 mm (18 inch). The test result showed Marshall properties which were affected by the mixture physical properties such as density, voids in the mineral aggregate (VMA), voids filled with asphalt (VFA), voids in the mixture (VIM), stability value and flow value.

4. Result and Discussion

4.1 The Testing of Asphalt Properties

The asphalt used in this research was Pertamina asphalt with 60/70 penetration grade.

Table 1. Test Result Of Pen 60/70 Asphalt Physical Properties

No	Asphalt Properties	Units	Test methods	Specifications		Results
				Min	Max	
1	Penetration 25°C, 100 gr, 5 seconds	mm	SNI 06-2456-1991	60	70	70
2	Softening point 5°C	°C	SNI 2434-2011	48	-	49
3	Flash point	°C	SNI 2433-2011	232	-	312
4	Mass lost (using TFOT)	%	SNI 06-2441-1991	-	0.8	0.2073
5	Asphalt solubility in C ₂ H ₅ CL ₃	%	AASHTO T44-03	99	-	99.713
6	Specific gravity	g/cc	SNI 2441-2011	1	-	1.032

4.2 The Testing of Aggregate Properties

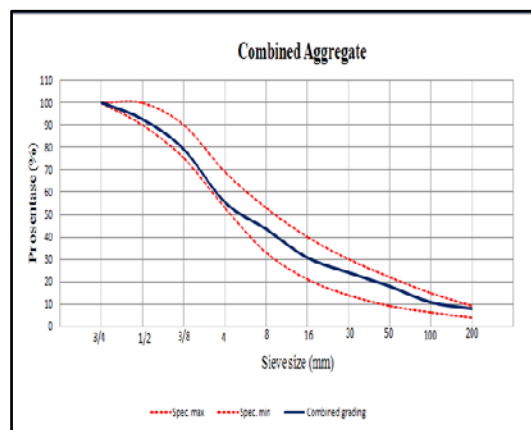
The testing was conducted to determine properties of coarse aggregate, medium aggregate, fine aggregate and stone dust. The test was conducted under Indonesian National Standardization (*Standard Nasional Indonesia*, SNI). Gradation observation was based on AC-WC gradation of Department of Public Works Specification (*Spesifikasi Departemen PU*) 2010.

Table 2. Specific Gravity Testing

NO.	AGGREGATE	BULK	S.S.D	APPARENT	ABSORSED
1	Fine Aggregate	2.565	2.611	2.691	1.829
2	Medium Aggregate	2.575	2.625	2.711	1.943
3	Coarse Aggregate	2.694	0.915	2.823	1.002
4	Filler	3.150		3.150	

4.3 Composition and Proportion of Marshall Test Object

Composition and proportion of aggregate were determined using particle analysis result of every aggregate caught in the strainer. Mixture type used was coarse grade suitable for AC-WC mixture according to Department of Public Works Specification (*Spesifikasi Departemen Pekerjaan Umum*) 2010.

**Figure 1.** Combination of Aggregate Grade

4.4 Test Result of Marshall Test Object with Charcoal Powder Filler and Test Object without Charcoal Powder

Table 3. Marshall Test

MARSHALL TEST									
Char-coal powder	No	Bulk Sp. Gr	V.I.M	V.M.A	Void Filled	Stability	Flow		Marshall Quotient
		Combine mix	%	%	%	Meas	Adjust	Mm	Kg/mm
0%	1	2.312				80	953	3.2	
	2	2.321				95	1131	3	
	3	2.331				100	1191	3.1	
Average		2.321	4.34	16.97	74.42		1092	3.1	352.2
10%	1	2.269				125	1489	2.9	
	2	2.302				116	1382	3.4	
	3	2.312				100	1191	3.2	
Average		2.298	5.32	17.81	70.18		1354	3.17	427.5

20%	1	2.248				135	1608	4	
	2	2.321				117	1393	3.6	
	3	2.331				110	1310	3.6	
Average		2.3	5.22	17.73	70.54		1437	3.73	384.9
30%	1	2.269				83	989	3.9	
	2	2.344				110	1310	3.8	
	3	2.341				105	1251	3.5	
Average		2.318	4.47	17.08	73.82		1183	3.73	316.9
Spec			3.0-5.0	>15	>65		>1000	>3.0	>300

5. Conclusion

The study concluded that adding charcoal powder to AC-WC mixture give substantial result. The more charcoal powder added to the mixture, the more voids filled to surface aggregate, and less void in the mixture (VIM). In addition, Marshall test data showed that filler containing 30% charcoal powder met every requirement of Department of Public Works Specification (*Spesifikasi Departemen Pekerjaan Umum*) 2010. Filler containing 30% charcoal powder had 1,183 kg stability value, 3.73 mm flow value, 316.9 kg/mm Marshal Quotient, 4.47% VIM, 17.08 % VMA, and 73.82 % void filled.

6. References

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