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Research paper

Effects of Aggregate Abrasrion Values to Marshall Properties of Asphalt Concrete AC- WC

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Abstract

Asphalt Concrete AC-WC is one of the most common pavement types used in Indonesia, consisting of a mixture of hard asphalt, filler and a continuous graded aggregate, which is mixed, pave and compacted at a certain temperature. The mixture of ashpalt concrete requires a mixing process that uses materials as the specifications. Aggregate abrasion becomes an important part that will be examined based on aggregate hardness each of quarry. Source of material are from Selayang, Sibiru-biru and Armed. Reference for properties value that use in this study is specification from Public Works Department in 2005. From the Experimental, abrasion of material from Selayang 13.51%, Sibiru-biru 17.08% and Armed 35.64%. Optimum Asphalt content was 5.2%, 5.7% and 6.2%. From the research, the results of abrasion testing in this study, the coarse aggregate derived from the three quarry can be used as an aggregate mixture on (AC-WC), with abrasion value < 40%, and mixed properties (stability, flow, VMA , VIM, VFA, MQ) meet the standard specifications of the Department of Public Works April 2005. Increase value of abrasion will decrease performance of asphalt concrete. One of indicator is stability value, in this study the maximum stability value is 1005.31 kg at abrasion value of 13.51%. Increase value of abrasion also decrease the durability, maximum residual stability is 915.73 kg and durability is 91.09%.

Keywords: *Abrasion, Aggregate, Marshall Properties*

1. Introduction

There are several types of flexible pavement. One of which has a high durability is asphalt concrete (AC), with the main component is aggregate, because aggregate determine bearing capacity, durability, and quality of asphalt concrete[1]. One of the aggregate properties that determines the quality of pavement is its hardness. These properties are closely related to the aggregate resistance to the load. The aggregate resistance to mechanical loads, that indicated by the abrasion value, is obtained from the abrasion results using a Los Angeles abrasion device[2][3].

2. Objective Research

This study aims to determine the effect of aggregate abrasion value on the characteristic of AC-WC concrete asphalt mixture.[4], [5]. The sample of material came from Selayang, Sibiru-biru and Armed quarry as a asphalt onsrete mixture. The reason for using the these three aggregate as sample because Stone Crusher Plant of PT. Adhi Karya has used these materials and it has different hardness[3], [6].

3. Research and Methodology

This research was conducted at Highway Laboratory, Islamic University of North Sumatera on the basis of Asphalt Concrete - Wearing Course (AC - WC) system with guidance specification of Department of Public Works, April 2005 which is the basis of highway development of Hot Sealed Mixed Section. While the testing standards used mostly adopted from the methods approved or in standard by the Department of Public Works in the form of SK-SK SNI.[7]–[9].

Provision of Asphalt AC-WC Properties

AC-WC is a type of pavement consisting of aggregate and asphalt mixtures, with or without additives. Asphalt concrete-forming materials are mixed at the mixer installation at a certain temperature, then transported locally, overlaid and compacted. The mixing temperature is determined by the type of bitumen to be used. The mixing temperature is generally between 145-155^{0}C, so called hot mixed asphalt concrete. This mixture is known as hotmix.[2]

The main material of the composition of an asphalt mixture is actually only two kinds, namely aggregates and asphalt. However, in the use of asphalt and aggregate can be various, depending on the method and the intended interest in the preparation of a pavement.[10] The use of AC-WC is for the surface layer (topmost) in the pavement and has the most delicate texture compared to other types of laston.[11] In a continuous graded mixture of laston, it has slightly cavities in its aggregate structure compared with a graded mixture of gaps. This causes the AC-WC

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mixture to be more sensitive to the variation in the proportion of the mixture.[12]–[15]

According to the hot asphalt specification of the Department of Public Works April 2005, Asphalt Concrete (AC) consists of three mixtures, Asphalt Concrete Wearing Course (AC-WC), Asphalt Concrete Binder Course (AC-BC), and Asphalt Concrete Base (AC-Base) and the maximum aggregate size of each mixture is 19 mm, 25.4 mm, 37.5 mm. The provisions on the properties of the mixture of AC with Asphalt Pen 60/70 can be seen in table 1.[2].

Table 1. Standard for AC-WC mixture

Mixture Properties		AC		
		WC	BC	Base
Asphalt Absorption (%)	Max	1.2		
Number of punch		75		112
Void In Mix (VIM) (%)	Min	3.5		
	Max	5.5		
Void In Mineral Aggregate (VMA) (%)	Min	15	14	13
Void Filled With Asphalt (VFA) (%)	Min	65	63	60
Marshall Stability (kg)	Min	800		1500
	Max	-		-
Flow (mm)	Min	3		5
Marshall Quotient (MQ) (kg/mm)	Min	250		300
Residual Marshall Stability (%) after 24 hours immersion, 60ºC	Min	75		
Mixture cavity (%) refusal	Min	2,5		

4. Presentation and Data Analysis

The result of material examination and mixed AC-WC experiment can be seen in Table 2.

Table 2. The results of abrasive abrasion aggregate from Selayang Quarry

Sieve Size				Gradation B (500 rounds)		
Pass		Restrained		Sample I	Sample II	Sample III
Sieve Num	(mm)	Sieve Num	(mm)	(gram)	(gram)	(gram)
¾	19.00	½	12.50	2500±10	2500±10	2500±10
½	12.50	3/8	9.50	2500±10	2500±10	2500±10
Aggregate total weight (a)				5000±10	5000±10	5000±10
Number of Ball				11	11	11
Ball Weight				4584±25	4584±25	4584±25
Restrained weight at number. 12 (b)				4347.50	4298.82	4326.99
Abrasion				13.05	14.02%	13.46%
Abrasion Rate				13.51%		

Table 3. The results of abrasive abrasion aggregate from Sibiru-biru Quarry

Sieve Size				Gradation B (500 rounds)		
Pass		Restrained		Sample I	Sample II	Sample III
Sieve Num	(mm)	Sieve Num	(mm)	(gram)	(gram)	(gram)
¾	19.00	1/2	12.50	2500±10	2500±10	2500±10
½	12.50	3/8	9.50	2500±10	2500±10	2500±10
Aggregate total weight (a)				5000±10	5000±10	5000±10
Number of Ball				11	11	11
Ball Weight				4584±25	4584±25	4584±25
Restrained weight at number. 12 (b)				4154.81	4129.08	4154.81
Abrasion				16.90 %	17.42 %	16.90 %
Abrasion Rate				17.08 %		

Table 4. The results of abrasive abrasion aggregate from Armed Quarry

Sieve Size				Gradation B (500 rounds)	
Pass		Restrained		Pass	Restrained
Sieve Num	(mm)	Sieve Num	(mm)	Sieve Num	(mm)
¾	19.00	1/2	12.50	2500±10	2500±10
½	12.50	3/8	9.50	2500±10	2500±10
Aggregate total weight (a)				5000±10	5000±10
Number of Ball				11	11
Ball Weight				4584±25	4584±25
Restrained weight at number. 12 (b)				3205.41	3230.06
Abrasion				35.89%	35.39%
Abrasion Rate				35.64%	

Table 5. Test Result of Coarse Aggregate

No	Test	Material Source		
		I	II	III
1	Abrasion (%)	13.51	17.08	35.64
2	Absorbsion (%)	0.436	0.941	3.059
	a. Bulk Density	2.689	2.633	2.439
	b. SSD Density	2.701	2.658	2.514
	c. Apparent Density	2.721	2.701	2.636
3	Flat Index (%)	10.17	8.79	5.23
	Elongation Index (%)	2.55	2.52	1.82

Table 6. Test Result of Fine Aggregate

No	Test	Material Source		
		I	II	III
1	Abrasion (%)	-	-	-
2	Absorbsion (%)	1.168	1.732	2.018
	a. Bulk Density	2.777	2.844	2.815
	b. SSD Density	2.810	2.893	2.872
	c. Apparent Density	2.870	2.991	2.985
3	Flat Index (%)	-	-	-
	Elongation Index (%)	-	-	-

Table 7. Test Result of Filler

No	Test	Material Source		
		I	II	III
1	Abrasion (%)	-	-	-
2	Absorbsion (%)	-	-	-
	a. Bulk Density	2.028	2.054	2.029
	b. SSD Density			
	c. Apparent Density			
3	Flat Index (%)	-	-	-
	Elongation Index (%)	-	-	-

Table 8. Marshall Test Data of Selayang Quarry

Mixture Proprties	Bitumen Content					Spec	
	4.5%	5.0%	5.5%	6.0%	6.5%	Min	Max
Bulk Density (gr/cc)	2.313	2.349	2.375	2.387	2.386	2	-
Stability (kg)	863.15	979.20	1037.23	1018.37	938.22	800	-
Yield (mm)	2.87	3.25	3.47	3.40	3.12	3	-
VMA (%)	16.914	16.060	15.603	15.621	16.115	15	-
VIM (%)	7.491	5.340	3.604	2.390	1.723	3.5	5.5
VFA (%)	55.713	66.761	77.128	84.789	89.683	65	-
MQ (kg/mm)	301.10	301.29	299.20	299.52	301.03	250	-

Table 9. Marshall Test Data of Sibiru-biru Quarry

Mixture Properties	Bitumen Content					Spec	
	4.5%	5.0%	5.5%	6.0%	6.5%	Min	Max
Bulk Density (gr/cc)	2.294	2.325	2.348	2.362	2.363	2	-
Stability (kg)	826.88	938.40	988.99	993.34	942.93	800	-
Yield (mm)	2.75	3.13	3.30	3.32	3.18	3	-
VMA (%)	17.347	16.683	16.284	16.250	16.651	15	-
VIM (%)	8.583	6.660	5.007	3.747	2.981	3.5	5.5
VFA (%)	50.534	60.342	69.296	76.962	82.175	65	-
MQ (kg/mm)	300.68	299.49	299.69	299.50	296.21	250	-

Table 10. Marshall Test Data of Armed Quarry

Mixture Properties	Bitumen Content					Spec	
	4.5%	5.0%	5.5%	6.0%	6.5%	Min	Max
Bulk Density (gr/cc)	2.186	2.207	2.231	2.256	2.279	2	-
Stability (kg)	781.55	816.00	848.64	881.64	919.36	800	-
Yield (mm)	2.80	2.90	3.05	3.15	3.30	3	-
VMA (%)	17.330	16.948	16.486	16.008	15.620	15	-
VIM (%)	10.386	8.843	7.189	5.493	3.872	3.5	5.5
VFA (%)	40.098	48.247	56.711	65.729	75.320	65	-
MQ (kg/mm)	279.12	281.38	278.24	279.89	278.59	250	-

Table 11. Optimum Bitumen Content for Every Aggregate Abrrasion

Material Source	Abrrasion Value (%)	Optimum Bitumen Content (%)
Selayang	13.51	5.2
Sibiru-biru	17.08	5.7
Armed	35.64	6.2

Table 12. Characteristics of mixture (AC-WC) withe variation of abrassion value

Mixture Properties (AC-WC)	Abrasion Coarse Aggregate variation (%)			Mixture Specification	
	13.51	17.08	35.64	Min	Max
Density (gr/cc)	2.365	2.331	2.287	2	-
Stability (kg)	1005.31	931.33	913.92	800	-
Yield (mm)	3.35	3.12	3.05	3	-
VMA (%)	15.682	17.069	15.036	15	-
VIM (%)	4.427	5.415	3.924	3.5	5.5
VFA (%)	71.800	68.296	74.008	65	-
MQ (kg/mm)	300.09	298.82	299.65	250	-
Optimum Bitumen Content (%)	5.2	5.7	6.2	4	7

Table 13. Stabitilty after and before immersion at temprature 60^0C for 24 hours

Abrasion (%)	Optimum Bitumen Content (%)	30 minutes Immersion Stability, 60ºC (a)	24 hours Immersion, 60ºC (b)	Durability (Residual Marshall) (%) (b/a)
13.51	5.2	1005.31 kg	915.73 kg	91.09
17.08	5.7	931.33 kg	811.47 kg	87.13
35.64	6.2	913.92 kg	748.00 kg	81.84

5. Conclusion

From the research conducted can be drawn a number of conclusions:

1. From the results of abrasion testing in this study, the coarse aggregate derived from the three quarry can be used as an aggregate mixture on (AC-WC), with abrasion value < 40%, and mixed properties (stability, flow, VMA, VIM, VFA, MQ) meet the standard specifications of the Department of Public Works April 2005.
2. The greater the value of aggregate abrasion, the performance of the concrete asphalt mix will decrease further. One indicator is the value of stability, where the value of stability tends to decrease with the greater abrasion value. In this study the maximum stability value of 1005.31 kg occurred at abrasion value of 13.51%.
3. The results of this study indicate that the greater the aggregate abrasion value, the optimum bitumen content (KAO) also tends to increase due to the large abrasion value indicates the cavity in the aggregate is sufficient so that the absorption is also higher. The higher aggregate absorption causes the required asphalt level is also greater. Thus the asphalt function in the mix as a glue or aggregate sheath can be met. Asphalt in sufficient quantities for the bonding between the grains will produce a mixture with characteristics (stability, durability, flexibility, skid resistance, waterproof and fatigue resistance) is good.
4. Aggregate with low abrasion value (13.51%) tends to have high susceptibility index that is equal to 10.17%. Flat-shaped aggregate particles may be the result of a stone breaking machine or indeed the nature of the aggregate which, if solved, tends to be flat-shaped. The flat-shaped aggregate breaks easily during mixing, compacting, or due to traffic loads, therefore the amount of flat aggregate is limited by the value of the index of required by the Department of Public Works April 2005 which is max 25%.
5. The greater the aggregate abrasion value, the durability of the asphalt concrete mixture will decrease further. One indicator is the value of residual stability, where the value of residual stability tends to decrease with increasing abrasion value. In this study, the maximum residual stability value of 915.73 kg occurred at a 13.51% abrasion value which yielded a durability value of 91.09%.

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