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THE USAGE OF NATURAL ZEOLITE AS FILLER ON ASPHALT CONCRETE-BINDER COURSE (AC-BC) MIXTURE AND ASPHALT PEN.60/70 MATERIALS OBSERVED FROM CANTABRO TEST RESULT

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ABSTRACT

The use of natural resource to paving process is still less and needs to be expanded particularly related to its function in overcoming the early defects on pavement. Asphalt pen.60/70 and natural zeolite are the parts of those assets, yet, the lack of study regarding these materials is a challenge to foster this study. The specific objective of this study was to examine the use of natural zeolite as filler on Asphalt Concrete-Binder Course (AC-BC) mixture and asphalt Pen.60/70 materials observed from Cantabro test result. Furthermore, the mixture of materials, Pen.60/70 and natural zeolite were done in material planning test, which used 5 filler variation including variation 1 (100% stone dust: 0% natural zeolite), variation 2 (75% stone dust: 25% natural zeolite), variation 3 (50% stone dust: 50% natural zeolite), variation 4 (25% stone dust: 75% natural zeolite), and variation 5 (0% stone dust: 100% natural zeolite). After obtaining the optimum asphalt content of each variation, Marshall Test was done within 0.5 hour and 24 hour submersion and later tested by Cantabro Test. The results showed that the number of optimum asphalt content for variation 1, variation 2, variation 3, variation 4, and variation 5 were at 5,8%, 6,0%, 6,1%, 6,4%, and 6,5% respectively. Meanwhile, the result of Cantabro test showed that there was mass decrease percentage less than 20% on each variation and the lowest decrease number was in variation 2. In other words, the mixture of Asphalt Concrete-Binder Course (AC-BC) which used natural zeolite on variation 2 (75% stone dust: 25% natural zeolite) was an optimum composition in using natural zeolite as a filler in terms of weathering endurance compared to the variation 1 (100% stone dust: 0% natural zeolite), variation 3 (50% stone dust:50% natural zeolite), variation 4 (25% stone dust: 75% natural zeolite), and variation 5 (0% stone dust: 100% natural zeolite).

Keywords: Asphalt Pen.60/70; Cantabro Test; Marshall Test; Natural Zeolite

1. INTRODUCTION

The availability of filler stone dust is currently difficult to obtain in relation with it is necessary an alternative filler. Hence, the writer was encouraged to use the zeolite as filler in the mixture of roadway pavement - particularly a composition of Asphalt Concrete-Binder Course (AC-BC) with regard to the availability of abundant zeolite in Indonesia and also is cheaper than stone dust. As stated by Furqon (2011), the usage of zeolite as a material has an effective and efficient ability in decreasing the mixture temperature to get the warm mix asphalt. In connection with the previous statement, the writer attempted to examine the use of natural zeolite as filler on Asphalt Concrete-Binder Course (AC-BC) mixture and asphalt Pen. 60/70 materials observed from

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cantabro test result. On the other hand, the mixture of Asphalt Concrete-Binder Course (AC-BC) is the layer of asphalt pavement, which is often used and the characteristic of natural zeolite is almost the same with stone dust that can pass the 200 filter. So, the specific objective of this study was to examine the use of natural zeolite as filler on Asphalt Concrete-Binder Course (AC-BC) mixture and asphalt Pen.60/70 materials observed from Cantabro test result.

2. METHODOLOGY/EXPERIMENT

To examine the use of natural zeolite as filler on Asphalt Concrete-Binder Course (AC-BC) mixture and asphalt Pen.60/70 materials observed from Cantabro test result. This study was conducted in several stages including to examining the aggregate, asphalt, the appropriateness of filler, Marshall Test and Cantabro Test. Moreover, the stages of the research will be discussed in detail as follows.

a. The input stage

   The first stage was conducted by collecting the secondary data;

b. The process stage

   There were some activities carried out in the process stage. The first one was to design the planning mixture with a variety of filler contents such as variation 1 (100% rock dust + 0% natural zeolite), variation 2 (75% of rock dust + 25% zeolite nature), variation 3 (50% of rock dust + 50% natural zeolite), variation 4 (25% of rock dust + 75% zeolite) and variation 5 (0% of rock dust + 100% natural zeolite). Furthermore, testing was conducted by following the standard and the analysis was by comparing the test data with the standardise specification.

c. The output stage

   As conducted the study, in this stages, the conclusion and suggestion of the research and recommendation were given on the usage of zeolite as filler.

In addition, the research of natural zeolite as filler is required by some initial studies to achieve the intended goal. The initial studies will be discussed as follows.

a. Normative overview is related to the standard test and specification. The standard used come from the norms, guidelines, and manual from the Ministry of Public Works, Indonesian National Standard (RSNI and SNI), standard of foreign include AASHTO, ASTM and BS /EN.
b. Scientific study is conducted through a library activity derived from a book about pavement design, zeolite, scientific journal and scientific research.
c. Identifying the pavement’s problem is related to the characteristics of pavement in general and the pavement in Indonesia located at high temperature and high rainfall intensity so, it needed a pavement that does not decline easily towards high temperature and water resistant. Also, it is not worn-out easily caused by wheels friction of the vehicle.
d. Research methodology of this research is related to the research methods such as laboratory testing steps.

2.1 Preparation of Research Materials

The materials employed in this research are discussed as follows.

2.1.1. Asphalt

Asphalt is a colloidal complex system of hydrocarbon material made by asphalthene, resin and oil. Asphalt material is dark brown up to black, sticky, solid-shaped or semi-solid obtained from natural refining oil (Kreb & Walker, 1971).

2.1.2. Aggregate

Aggregate is the mineral granular particle used with the combination of various types of adhesives materials in the shape of the concrete or as a base road material, *backfill*, and others (Atkins, 1997).

Coarse aggregate

According to Bina Marga coarse aggregate is the aggregate with a larger particle size compared to the sieve no. 4 (4.75 mm). Meanwhile, AASHTO stated coarse aggregate is the particle left on the sieve No. 10 or aggregate diameter> 2 mm.

Delicate aggregate

As mentioned by Bina Marga, delicate aggregate is aggregate which consists of softer particle size compared to the sieve no. 4(4.75 mm). Meanwhile, according to AASHTO it is particle which lies between the sieve No. 10 - No.200 or between the diameters of 2.0 mm to 0.075 mm.

2.1.3. Filler padding (Filler)

According to Bina Marga, padding is a part of the delicate aggregate minimum 75% which can pass the sieve no. 200 (0.075 mm).

2.2. Designing the Mixturing Asphalt Concrete (AC)

The general purpose of designing the mixtured asphalt concrete was to determine a combination of asphalt and aggregate that could provide a pavement performance in the long term from every part of the pavement structure. The design of the asphalt aggregate mixture is the procedure of laboratory that must be done to prepare an aggregate structure to be used in asphalt concrete mixture (Asphalt Institute, 1997).

The design of asphalt concrete mixture for layer pavement must fulfil the properties of Stability, Preservation or durability, Flexibility, Skid resistance, fatigue resistance, work ability, and impermeability.

2.5. Testing Object test

2.5.1 Test volumetric

Volumetric test was used to obtain volumetric parameters such as VITM, VMA and VFWA by using the equations calculation of the density.

2.5.2 Marshall Test

Marshall Test was used to evaluate the characteristics of two mixtures VFWA, VITM, VMA, stability, *flow* and *Marshall Quotient* to determine the optimum bitumen content (OBC).

2.5.3 Test Cantabro

Cantabro test as a test used to determine the resistance of object test endurance towards the specimen wears by using *Los Angeles* machine. Cantabro test illustrated the further asphalt resistance to restrain the friction between the wheels of the vehicle and the road surface.

3. RESULTS

3.1 The results of aggregate and asphalt investigation Pen.60 / 70

The procedures of aggregate and asphalt inspection denote the first stage should be done. The complete inspection result can be seen in Table 1 and Table 2.

Table1. The result of Aggregate and Filler inspection

No.	Types of test	Unit	Specification*)	Result
	Coarse Aggregate			
1	Used on the machine *Los Angeles*	%	< 40	26,9
2	Water absorbent	gr/cm^3	< 3	1,055
3	Density Apparent	gr/cm^3	> 2,50	2,653
4	Dry Density (*Bulk*)	%	> 2,50	2,581
5	*Soundness Test*	%	< 12	0,082
6	Flat and Oval Particle	%	> 10	2,14
7	Passed sieves Material No. 200	%	< 1	0,33
	Delicate Aggregates			
1	*Sand Equivalent*	%	> 60	75,00
2	Water absorption	%		1,087
3	Apparent Specific Weight	gr/cm^3	> 2,50	2,623
4	Dry specific Weight (*Bulk*)	gr/cm^3	> 2,50	2,550
5	Passed sieves Material No. 200	%	< 8	0,48
	Filler			
1	apparent density of dust rock	gr/cm^3	> 2,50	2,61
2	apparent density of natural zeolite	gr/cm^3	-	2,19

**) Source: General Specification 2010 Revise II (2012)*

Table2. Pertamina Asphalt Test Results 60/70

No.	Types of test	Unit	Specification *)	Result
1	Penetration of 25 °C	0,1 mm	60-70	64,60
2	Flabby centre	^oC	> 48	48,50
3	Flash centre	^oC	≥ 232	331
4	Ductility	Cm	≥100	>100
5	Weight loss	%	≤ 0,8	0,048
6	Solubility In CCl4	%	≥99	99,661
7	Penetration After weight loss	% real	≥ 54	95,49
8	Type of Weight Asphalt	gr/cm^3	≥ 1,0	1,039

**) Source: General Specification 2010 Revise II (2012)*

3.2 The test results determining Optimum Asphalt Content (KAO)

The test results determined the optimum bitumen content obtained from the Marshall test. It can be seen in Table 3 to Table 7.

Table 3.The Results of Determination Test Variation 1 (100% stone dust: 0% natural zeolite)

No.	Marshall Characteristics	Specification 2010 *)	Asphalt content (%)				
			5,0	5,5	6,0	6,5	7,0
1	*Density*	-	2,295	2,327	2,337	2,310	2,358
2	VMA (%)	Min.14	15,3	14,6	15,1	16,1	14,8
3	VITM (%)	3,0 – 5,0	7	5	4	4	2
4	VFWA (%)	Min.63	52,3	64,2	70,7	73,6	90,8
5	*Stability* (kg)	Min.800	1024	1033	1140	1051	1198
6	*Flow* (mm)	Min.3	4	4	4	5	5
7	MQ (kg/mm)	Min.250	265	254	253	229	229

**) Source: General Specification 2010 Revise II (2012)*

Table 4. Test Result of Determination Test Variation 2 (75% stone dust: 25% of natural zeolite)

No.	Marshall Characteristics	Specification 2010 *)	Asphalt content (%)				
			5,0	5,5	6,0	6,5	7,0
1	*Density*	-	2,287	2,333	2,376	2,353	2,367
2	VMA (%)	Min.14	15,4	14,3	14,4	14,4	14,3
3	VITM (%)	3,0 – 5,0	9	7	4	5	3
4	VFWA (%)	Min.63	37,2	50,3	68,1	68,2	78,3
5	*Stability* (kg)	Min.800	1200	1278	1311	1131	1221
6	*Flow* (mm)	Min.3	4	5	5	5	6
7	MQ (kg/mm)	Min.250	271	284	273	207	213

**) Source: General Specification 2010 Revise II (2012)*

Table 5. The Result of Determination Test Variation 3 (50% of stone dust: 50% of natural zeolite)

No.	Marshall Characteristics	Specification 2010 *)	Asphalt content (%)				
			5,0	5,5	6,0	6,5	7,0
1	*Density*	-	2,266	2,296	2,325	2,335	2,354
2	VMA (%)	Min.14	16,0	15,3	14,7	14,8	14,5
3	VITM (%)	3,0 – 5,0	9	7	5	4	2
4	VFWA (%)	Min.63	43,2	53,8	65,4	74,1	85,2
5	*Stability* (kg)	Min.800	1131	1104	1217	1229	1386
6	*Flow* (mm)	Min.3	5	4	5	6	6
7	MQ (kg/mm)	Min.250	248	260	259	221	238

**) Source: General Specification 2010 Revise II (2012)*

Table 6. The Results of Determination Test Variation 4 (25% of rock dust: 75% of natural zeolite)

No.	Marshall Characteristics	Specification 2010*)	Asphalt content (%)				
			5,0	5,5	6,0	6,5	7,0
1	*Density*	-	2,257	2,263	2,277	2,329	2,343
2	VMA (%)	Min.14	16,1	16,3	16,2	14,7	14,7
3	VITM (%)	3,0 – 5,0	9	8	7	4	2
4	VFWA (%)	Min.63	44,4	51,4	59,8	75,9	85,7
5	*Stability* (kg)	Min.800	1471	1531	1486	1539	1217
6	*Flow* (mm)	Min.3	5	4	4	5	6
7	MQ (kg/mm)	Min.250	265	322	309	249	204

**) Source: General Specification 2010 Revise II (2012)*

Table 7.The results of Determination test Variation 5 (0% of rock dust: 100% natural zeolite)

No.	Marshall Characteristics	Specification 2010*)	Asphalt content (%)				
			5,0	5,5	6,0	6,5	7,0
1	*Density*	-	2,249	2,260	2,294	2,308	2,347
2	VMA (%)	Min.14	16,1	16,1	15,3	15,3	14,3
3	VITM (%)	3,0 – 5,0	10	9	7	5	3
4	VFWA (%)	Min.63	37,3	45,1	56,5	65,5	80,7
5	*Stability* (kg)	Min.800	1102	1149	1281	1141	1330
6	*Flow* (mm)	Min.3	4	5	5	5	7
7	MQ (kg/mm)	Min.250	249	255	272	254	202

**) Source: General Specification 2010 Revise II (2012)*

3.3. The result of Marshall Immersion test

The stability standard testing to baths are 0.5 hours and 24 hours immersion and it was performed at the optimum bitumen content, as seen in Table 8.

Table. 8 The results of stability test mix AC-BC (Stability left)

Variation	Stability Percentage		Submersion Index
	0,5 hours	24 hours	(%)
1	1229	1161	94,46
2	1348	1241	92,06
3	1365	1223	89,64
4	1304	1148	88,04
5	1249	1084	86,78

3.4 The Result of Cantabro test

Cantabro Test was conducted at the optimum bitumen content which was each variation of 300 rounds of Los Angeles machine. Each result could be seen in Table 9.

Table 9. The result of Cantabro test in every variation

Variation	Basic weight (gram)	Final Weight (gram)	Weight Loss (%)
	Regulation		≤ 20%
Variation 1 (5,8%)	1245,59	1210,57	2,81
Variation 2 (6,0%)	1263,12	1238,10	1,98
Variation 3 (6,1%)	1263,28	1226,78	2,89
Variation 4 (6,4%)	1271,45	1227,99	3,42
Variation 5 (6,5%)	1256,39	1212,96	3,46

**) Source: General Specification 2010 Revise II (2012)*

4. DISCUSSION

The basic materials used in this research included aggregate and asphalt. Aggregates used consisted of coarse and delicate aggregate. Dust stone used as filler was from Clereng, Kulon Progo District, Yogyakarta and filler of natural zeolite is from Trucuk, Klaten District, Central Java. Further, asphalt used in this study was derived from asphalt belonged to Pertamina of Pen. 60/70 coming from Cilacap. Based on the testing result, aggregates and asphalt used in this study have fulfilled the requirements of aggregates and asphalts for the material in mixture of AC-BC in accordance with the general specifications of public work ministry in 2010 second revision (2012).

In this case, the mixture of asphalt used was the asphalt concrete-binder course (AC-BC) mixture in accordance with the general specification of Public Work Ministry in 2010 second revision (2012). Furthermore, the mixture of materials, Pen.60/70 and natural zeolite were done in material planning test using 5 filler variations including variation 1 (100% stone dust: 0% natural zeolite), variation 2 (75% stone dust: 25% natural zeolite), variation 3 (50% stone dust: 50% natural zeolite), variation 4 (25% stone dust: 75% natural zeolite), and variation 5 (0% stone dust: 100% natural zeolite). From each variation, the researcher could determine the optimum asphalt content through Marshall test. After obtaining the optimum asphalt content of each variation, cantabro test was conducted to figure out the stability of retained Marshall and the number of mass decrease percentage.

Moreover, to know the optimum asphalt content, it could be seen from the bar chart by using *Narrow Range* method. It was then continued by choosing the range of asphalt content which fulfilled the requirement of mixture characteristic through Marshall test. The test results showed a possibility that the number of optimum asphalt content for each variation increased such as for variation 1(100% stone dust: 0% natural zeolite) at 5,8%, variation 2 (75% stone dust: 25% natural zeolite) at 6,0%, variation 3 (50% stone dust: 50% natural zeolite) at 6,1%, variation 4 (25% stone dust: 75% natural zeolite) at 6,4%, and variation 5 (0% stone dust: 100% natural zeolite) at 6,5%. Further, based on the optimum asphalt content, it was made material testing to obtain the stability of Marshall retained and the percentage of mass decrease through Cantabro test.

Marshall retained residual value was obtained by comparing the value of stability soaking 0,5 hours and 24 hours for each variation. The research findings showed that the index of residual Marshall Stability was on variation 1(100% stone dust: 0% natural zeolite) and variation 2 (75% stone dust: 25% natural zeolite). Both of variation fulfilled the requirement of specification at $\geq$ 90%. For the value of mass the decrease percentage by using Cantabro test was obtained by making a testing object for each variation by calculating the percentage of mass decrease. Based on the test results obtained from Cantabro test, mas decrease percentage value for all variations meet the requirement of specification below 20%. Therefore, it could be found that there is a relationship between asphalt content and the value of Cantabro test. Also, it could be seen from the more percentage in the use of natural zeolite, the more increasing the value of Cantabro but still below the required specification requirements.

5. CONCLUSION

Further, with regard to the findings of research, it could be concluded that

a. Optimum Asphalt Content (KAO) for each variation has increased in which variation 1 (100 rock dust + 0% zeolite) KAO 5.8%; variation 2 (75% of rock dust + 25% zeolite) KAO 6.0%; 3 variations (50% of rock dust + 50% zeolite) KAO 6.1%; variations in 4 (25% of rock dust + 75% zeolite) KAO 6.4% and variations 5 (0% of rock dust + 100% zeolite) KAO 6.5%.

b. Cantabro Test result mixed with AC-BC by using natural zeolite as *filler* had a shortage of weight percentage below 20%; thus, all of these variations meet the requirements.

c. The correlation which can be obtained from bitumen content with Cantabro Test result is, the more of the natural zeolite usage, can increase the Cantabro but still needs the specification of requirements.

d. The use of natural zeolite as *filler* in a pavement mixture can be used to change the substitute for stone dust in maintaining its wear and tear.

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