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UTILIZATION OF MADURA COARSE AND FINE AGGREGATES IN LOW-TRAFFIC ROAD PAVEMENTS

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ABSTRACT
Aggregates from Sampang are still rarely used in flexible pavement. Therefore, this research is to identify the effects of coarse aggregate and soft aggregate from Sampang – Madura, to recognize their performance in the HRS – WC mixture. It adopted Bina Marga General Standards 2010, Division 6 (Revision 3) for HRS – WC mixture, by testing the physical characteristic of coarse aggregate and soft aggregate from Sampang (in terms of specific gravity and absorption, coarse aggregate wear and tear, and sieve passing Nr. 200) and Marshall Characteristic Testing with asphalt content variables of 6%, 6,5%, 7%, 7,5%, and 8% of the total mixture, each with 3 tested objects. With reference to the physical aggregate characteristic, it was found that the coarse aggregate satisfied the specification standard. On the other hand, the value of the specific gravity of the soft aggregate was still lower than the specification standard, i.e., 2,25 gram/cm^2, while the minimum standard was 2,5 gram/cm^3. It definitely affected the performance of the HRS – WC mixture. As the volume of the mixture was larger and left a larger cavity in the mixture, it required larger content of asphalt in order to generate a mixture qualifying the Bina Marga General Standards 2010, Division 6 (Revision 3). Based on the results of Marshall Test Characteristic Testing, it was found that the optimum content of asphalt was 8% of the total mixture.

Keywords: *Sampang; Coarse aggregate and soft aggregate; HRS WC; Aggregates physical characteristic, Marshall Testing*

1. Introduction

Infrastructure development, especially road pavement on Madura Island, still uses aggregate from Java Island which, shipping costs, requires quite large expenditures. This requires an alternative use of aggregates to reduce shipping costs, namely by utilizing local aggregates. Regions that produce aggregate materials on Madura Island include Bangkalan, Pamekasan, and Sampang Regencies [1]. Aggregate is the main component of the dominant road pavement, so the quality of the aggregate properties affects the performance of the pavement mixture [2]. Madura aggregates, especially from the Sampang area, are rarely used for flexible pavements. Utilization of Sampang aggregates for road flexible pavement also still needs further research so that its quality can be determined.

According to Sukirman [3], one type of flexible pavement mixture that is often used in Indonesia is Lastaton, which can also be called a thin layer of asphalt concrete. Lataston is a gap-graded surface layer mixture where some aggregate fractions are not used in the mix composition planning. Lataston is usually used for planning roads with light to moderate traffic volumes.

It is hoped that from this research, using Sampang coarse and fine aggregates can be an alternative pavement material in Madura. Therefore, research was conducted on the use of coarse and fine aggregates of Sampang on the performance of the Lataston mixture.

Vol. 4, No. 1, pp. 86-92, March 2023
e-ISSN: 2775-5592

2. Literature Review

Aggregates

Coarse aggregate shall consist of crushed stone or crushed gravel clean, dry, strong, and free from other materials that are not needed. For gravel, it must be tested with a Los Angeles machine for a maximum of 40% using SNI 1737-1989-F. According to ASTM 1974, aggregate is a rock that functions as a construction material consisting of solid minerals, in the form of large masses or in the form of fragments.

Aggregate properties that affect the quality of the pavement mix are strength and durability, ability to be coated properly, ease of implementation and produce a safe pavement layer [4].

Following are the parameters in testing the characteristics of coarse aggregate according to the general specifications of Division-6 asphalt pavement, Directorate General of Highways, Bina Marga 2010 [5]:

Table 1. Coarse Aggregate Requirements

Testing	Standard	Value
Specific gravity and absorption of coarse aggregate • Bulk specific gravity • Apparent specific gravity • Absorption	SNI 1969:2008 [6]	≥2.5 - ≤3 %
Abrasion with a 500 rpm Los Angeles engine	SNI 2417:2008 [7]	Max. 30%
The material passes through the sieve No.200	SNI 03-4142-1996 [8]	Max. 2%

Source: General specification of Division-6 asphalt pavement, Directorate General of Highways 2010 [5].

Following are the parameters in testing the characteristics of fine aggregate according to the general specifications of Division-6 asphalt pavement, Directorate General of Highways, 2010 [5]:

Table 2. Fine Aggregate Requirements

Testing	Standard	Value
Specific gravity and absorption of fine aggregate • Bulk specific gravity • Apparent specific gravity • Absorption	SNI 1970:2008 [9]	≥2.5 - ≤3 %
The material passes through the sieve No.200	SNI ASTM C117:2012 [10]	Maks. 10%

Source: General specification of Division-6 asphalt pavement, Directorate General of Highways 2010 [5].

Lataston

According to Sukirman [3], Lataston is a flexible pavement mixture made of gap-graded aggregate, filler, and asphalt in a certain ratio which is mixed and compacted in hot conditions, and has a fairly dense, dense, and smooth texture.

The HRS mixture requires a large amount of bitumen because it consists of a lot of fines. Usually, the HRS mixture is applied in planning roads with small to medium vehicle volumes.

The advantages of the HRS mixture are flexibility and resistance to melting which is quite high. To determine the performance of the HRS – WC mixture, the Marshall test was carried out.

Vol. 4, No. 1, pp. 86-92, March 2023
e-ISSN: 2775-5592

3. Methods

The data collection technique was carried out with experiments in the laboratory beginning with the asphalt testing and then testing the characteristics of the coarse and fine aggregates of Sampang and then the Marshall test was carried out to find out the effect of using Sampang coarse and fine aggregates on the performance of the HRS - WC mix.

In the Marshall test, asphalt content planning is carried out, after which the test object is made according to the planned asphalt content aiming to find the optimum asphalt measure. For every grade, 3 samples of test objects were made, a total of 15 pieces of test objects for the planned asphalt content. Heating the mixture to a temperature of 155ºC, the temperature of compacting the mixture to 115ºC-140ºC, and the number of collisions was 2x75 times.

The following is a flowchart in this study:

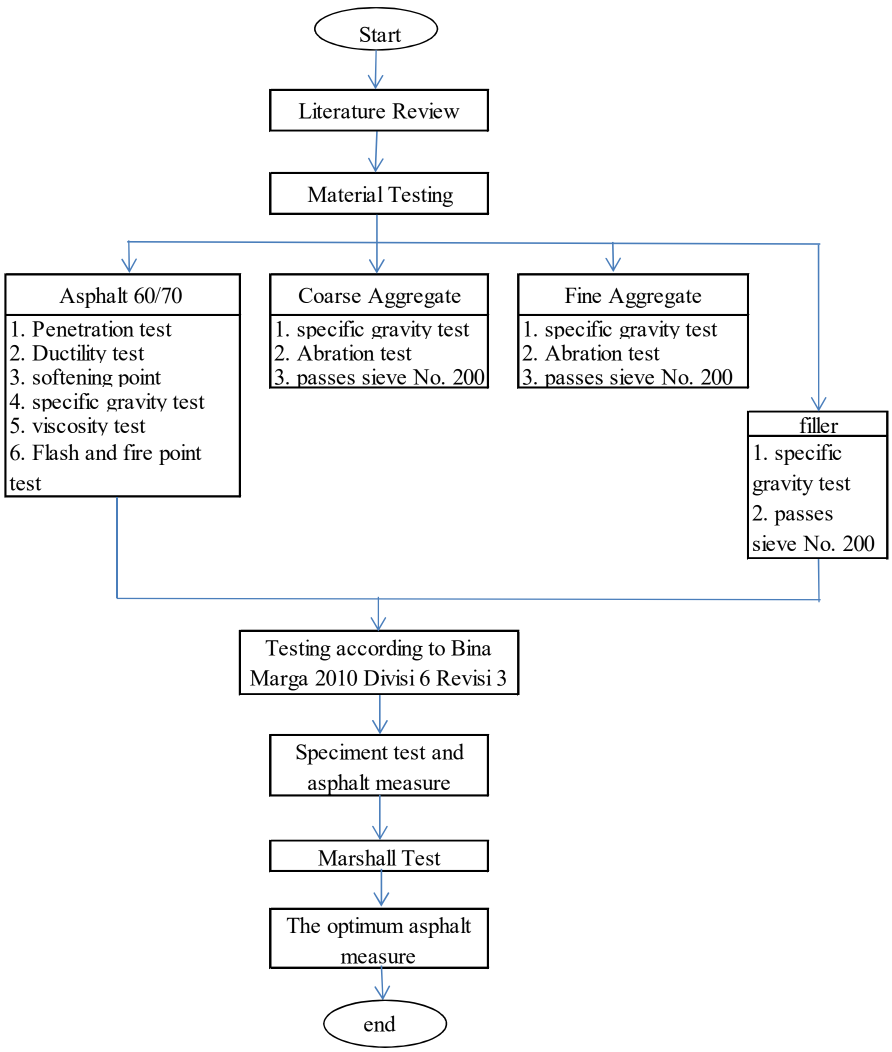

Figure 1. Research Flowchart

Vol. 4, No. 1, pp. 86-92, March 2023
e-ISSN: 2775-5592

4. Result and Discussion

4.1. Asphalt Testing Results

Table 3. Asphalt Pen. 60/70 Result

No.	Testing	Standards	Units	Requirements	Results
1	Penetration	SNI 06-2456-1991 [11]	mm	60-70	62
2	Softening point	SNI 2434:2011 [12]	%	min. 48	52
3	Flash and fire point	SNI 2433:2011 [13]	°C	min. 200	288
4	Weight losing	SNI 06-2441-1991 [14]	%	maks. 0,8	0,196
5	Solubility of Substance CS2/CCL4	AASHTO T44-03 [15]	%	min. 99	99,935
6	Ductility	SNI 2432:2011 [16]	cm	min. 100	> 140
7	Ductility after losing weight	SNI 2432:2011 [16]	cm	min. 100	100
8	Penetration after weight loss	SNI 06-2456-1991 [11]	%	min. 54	96
9	Specific Gravity	SNI 2441:2011 [17]	gr/cm^3	min. 1	1,031

Source: Laboratory Testing Results, 2023

4.2. Coarse Aggregate Testing Results

Table 4. Coarse Aggregate Testing Results

Material Testing	Unit	Result	Standards	Requirements
Bulk Specific Gravity	gram/cm^3	2,65	SNI 1969:2008 [6]	≥2,5
Apparent Specific Gravity	gram/cm^3	2,71	SNI 1969:2008 [6]	-
Absorption	%	0,95	SNI 1969:2008 [6]	≤3 %
Abrasion with Los Angeles Machine 500	%	26,63	SNI 2417:2008 [7]	Maks. 40%
Passing sieve No.200	%	0,3	SNI ASTM C136 : 2012 [8]	Maks.2%

Source: Laboratory Testing Results, 2023

4.3. Fine Aggregate Testing Results

Table 5. Fine Aggregate Testing Results

Material Testing	Unit	Result	Standards	Requirements
Bulk Specific Gravity	gram/cm^3	2,25	SNI 1970:2008 [9]	≥2.5
Apparent Specific Gravity	gram/cm^3	2,36	SNI 1970:2008 [9]	-
Absorption	%	2,15	SNI 1970:2008 [9]	≤3 %
Passing sieve No.200	%	7,1	SNI ASTM C117:2012 [10]	Maks.10%

Source: Laboratory Testing Results, 2023

Vol. 4, No. 1, pp. 86-92, March 2023
e-ISSN: 2775-5592

4.4. Marshall Testing Results [18]

Table 6. Asphalt Measure Testing Results

No	Characteristics	Requirements	Asphalt Measure (%)				
			6	6,5	7	7,5	8
1	Density (gr/cm³)	-	2,04	2,07	2,08	2,09	2,12
2	VMA (%)	≥ 18	21,54	20,58	21,72	20,58	20,06
3	VIM (%)	4−6	10,63	8,46	7,54	6,29	4,56
4	VFA (%)	≥ 68	50,65	58,88	63,59	69,43	77,25
5	Stabilitas (Kg)	≥ 800	794,57	860,36	919,12	1100,88	1133,59
6	Flow (mm)	≥ 3	1,33	2,05	2,47	3,13	3,8
7	MQ (Kg/mm)	≥ 250	603,13	420,9	377,51	353,34	298,63

Source: Laboratory Testing Results, 2023

4.5. Determine The Optimum Asphalts Measure

Table 7. The Optimum Asphalt Measure

No	Characteristics	Requirements	Asphalt Measure (%)				
			6	6,5	7	7,5	8
1	Density (gr/cm	-					
2	VMA (%)	≥ 18					
3	VIM (%)	4-6					
4	VFA (%)	≥ 68					
5	Stability (kg)	≥ 800					
6	Flow (mm)	≥ 3					
7	MQ (kg/mm)	≥ 250					

8%

4.6. The Effect of Sampling Coarse and Fine Aggregate Characteristics on the Performance of the HRS – WC Mixture

From the results of testing the characteristics of the coarse aggregate according to Table 4, the bulk specific gravity value was 2.65 gram/cm^3, the abrasion was 26.63%, and it passed the No. sieve. 200 of 0.3% have met the special specifications of Highways 2010 Division 6 (Revision 3). Meanwhile, in testing the characteristics of the fine aggregate in Table 5, the water absorption value was 2.15% and it passed the No. sieve. 200 of 7.1% have met the special specifications of Highways 2010 Division 6 (Revision 3). However, the bulk-specific gravity value of fine aggregate, which is 2.25 gram/cm^3, is below the minimum standard, which is 2.5 gram/cm^3.

This low bulk specific gravity value causes the volume of the mixture to be larger so that the voids in the mixture obtained are very large. As a result, according to the analysis in Figure 2, the optimum asphalt content of the mixture obtained is 8% of the total mixture. With the Marshall characteristic results according to Table 6, among others, the density value is 2.12 gram/cm3, the VMA value is 20.06%, the VIM value is 4.56%, the VFA value is 77.25%, the stability value is 1133.59 kg, the flow value is 3.80 mm, the MQ value is 298.63 kg/mm. From testing with the Marshall method, it can be concluded that to obtain a mixture that meets the special specifications of Highways 2010 Division 6 (Revision 3) a high asphalt content is required.

Vol. 4, No. 1, pp. 86-92, March 2023
e-ISSN: 2775-5592

5. Conclusions

Based on data from the results of testing the HRS –WC mixture using coarse and fine aggregates from Sampang, the following conclusions were drawn:

1. Testing the characteristics of the coarse aggregate from Sampang completely meets the special specifications of the 2010 Bina Marga Division 6 (Revision 3). However, for testing the characteristics of fine aggregate from Sampang with bulk specific gravity values, it does not meet the special specifications of Bina Marga 2010 Division 6 (Revision 3), while for testing the value of water absorption and passing sieve tests No. 200 in fine aggregate can meet the special specifications of Highways 2010 Division 6 (Revision 3).
2. The use of coarse and fine aggregates in Sampang causes the mixture to have large internal voids, thus requiring a large asphalt content to meet the specific specifications of Bina Marga 2010 Division 6 (Revision 3). From the Marshall test results, the optimum asphalt content of the mixture was 8% from a total mixture of 1200 grams.

Based on the results of this study, several suggestions are proposed by the author so that further research goes well, including:

1. Mix composition planning for additional non-cement filler should use the same filler as the fine aggregate used.
2. Fine aggregate from Sampang is mixed with fine aggregate which is commonly used for flexible pavement work in order to obtain efficient asphalt content results.
3. HRS – WC mixture is planned to have a higher optimum asphalt content.
4. The need for further research by:
   - Testing the chemical properties of coarse and fine aggregates.
   - Using additives.
   - Using different aggregate gradation variations.
   - Mixing Sampang fine aggregate with fine aggregate which is commonly used in flexible pavement planning to determine the proper and efficient mix ratio.

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Vol. 4, No. 1, pp. 86-92, March 2023
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