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The Effect of the Use of Local Papua Coard Aggregate on AC-WC Laston Stability Value

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Abstract **Original Research Article**

Coarse aggregates derived from rock are commonly used as road pavement materials that meet the applicable specifications. This study uses rock aggregates originating from the polymeric area of Jayapura City, and this type is widely found in various areas of northern Papua. The study was conducted to determine the effect of local Papuan coral aggregates on the AC-WC Laston value. According to the 2018 General Specifications of Highways; namely, the added filler material must be dry and free from clumps and when tested by sieving according to SNI ASTM C136: 2012. The test results obtained characteristic values on the use of coral as follows: The highest density value at 4.5% asphalt content and the lowest 5.5% and 6.5%. The VMA value obtained is unstable, but all asphalt content meets Bina Marga Specifications 2010 Revision III, namely with a minimum VMA value of 15%, the highest VIM value of 3-5%, VFA values tend to increase but experience a decrease in asphalt content of 5.5% and 6.5%. The results of the Marshall test on coral material in the AC-WC layer are the high strength value 5495.89 kg, density: 1.74 gr/cm3, VMA: 24.42%, VIM: 15.83 %, VFA: 0.01%, flow: 10.00 mm, and MQ of 348.03 mm/kg. The value of Optimum Asphalt Content (KAO) used as AC-WC layer is 5.5%.

Keywords: Aggregate, Coral, Jayapura, Pavement, Marshal, Stability.

A. INTRODUCTION

1. BACKGROUND

Along with the growth of Indonesian society, which is increasing daily, land transportation services are also getting higher. Regarding this matter, it is necessary to improve the quality of service from road conditions, which is quality road performance in terms of construction, pavement structure, safety, and comfort of the user community (Karlaftis & Kepaptsoglou, 2012). Good planning, sometimes not appropriate in its implementation, will consequently impact road construction (B.P Sunjka and U. Jacob, 2013). One of them is that the flexible pavement gradation composition often does not follow the planning design and designation (Said *et al*., 2011). Aggregate plays an essential role in forming the pavement layer, where the interlocking of the aggregates affects the stability of the pavement layer formed by the aggregate (Fan & Li, 2019; Guo, *et al*., 2020). Each type of asphalt mixture for road pavement layers has a specific aggregate gradation (Ahmed & Attia, 2013). Aggregate grading is expressed as a pass percentage or retained percentage, which is calculated by the weight of the aggregate using a set of sieved aggregates (Lindquist, *et al*., 2015; Fang *et al*., 2019).

Gradation or distribution of particles based on aggregate size is essential in determining pavement stability (Lira, *et al*., 2013). Aggregate gradation affects the size of the voids between grains, determining the stability and ease of implementation in the process (Xiao & Tutumlue, 2017). Each type of asphalt mixture for road pavement has a specific aggregate gradation, and the aggregate has the limits of these gradations, giving different effects on the characteristics of Laston (Golalipour, *et al*., 2012; Sarang *et al*., 2015). Coarse aggregate (mountain stone) can be used as a road pavement material if it meets the applicable specifications. This study uses mountain rock aggregates originating from the Polimak area of Jayapura City, Papua Province.

2. Research Purpose(s)

This study was conducted to determine the effect of using a coarse aggregate of local Papuan corals on the stability value of Laston AC-WC.

B. LITERATURE REVIEW

1. Flexible Pavement

Flexible pavement is a road pavement system where the construction consists of several layers

(Mohod & Kadam, 2016). Each layer of pavement generally uses different materials and requirements according to its function, namely, to spread the vehicle's wheel load so that the subgrade can support it within the limits of its carrying capacity (Papagiannakis & Masad, 2017). The surface layer is the topmost part of the pavement with asphalt adhesive. This surface layer functions, like part of the pavement, to withstand a load of vehicle wheels (Lesueur & Youtcheff, 2014). Then a waterproof layer protects the road body from weather damage and a wear layer (wearing course) (Kokkalis *et al.*, 2017).

2. Hot Rolled Sheet Base (HRS Base)

Hot Rolled Sheet Base is a mixture of hot asphalt, known as a thin layer of Asphalt Concrete (Lataston), consisting of coarse aggregate, fine aggregate, filler, and asphalt binder, mixed with specific heat or temperature conditions (Wang, 2016; Kamba & Rachman, 2018). The hot-rolled sheet is divided into two, namely hot-rolled sheet wearing course (HRS WC) and hot-rolled sheet base (HRS Base) (Rahmawati, *et al.*, 2021). HRS WC functions as a wear layer located above the HRS Baselayer (Widyaningsih & Sutanto, 2018).

Hot Rolled Sheet Base (HRS Base) is a mixture of forming materials in coarse aggregate, fine aggregate, filler, and bitumen, which are generally mixed and compacted in a hot state (hot mix) (Nikolaides, 2014). With different percentage comparisons. Hot Rolled Sheet (HRS) functions as a cover layer to prevent the entry of water from the surface into the pavement construction to maintain the strength of the construction underneath (Allen & Rand, 2016; Ching, 2020).

3. Aggregate

Aggregate is a collection of grains of crushed stone, gravel, sand, or other mineral compositions, both natural products and the result of processing (filtering or breaking) which are the primary materials for constructing road complex layers to support strength (McNally, 2016). In general, aggregates can be divided into general terms, namely coarse and fine aggregates (Bogas *et al.*, 2016). Each type of aggregate has a gradation specification or filter analysis set for hot asphalt mixtures in Indonesia, the aggregates used in this study come from the area around Sentani - Jayapura, which is processed or broken down in a stone crusher.

The factors that influence the selection of aggregates for the Hot Rolled Sheet Base (HRS Base) pavement are Size and arrangement of material grains (gradation); Cleanliness of aggregates against other unfavorable materials; hardness of aggregates; durability of the aggregate; particle shape, surface texture, and porosity; adhesion to asphalt (Papagiannakis & Masad, 2017; Nikolaides, 2014; Zollinger *et al.*, 2014).

According to Sukirman Silvia, 2003 "Hot Mixed Asphalt Concrete," in general, the properties of the mixture are primarily determined by the relative amounts of the aggregate components as follows:

1. Coarse aggregate fraction. Namely the size of the aggregate retained by the Number 8 sieves (2.36 mm)
2. Fine fraction, namely the aggregate size that passes the No. 8 sieve and the % retained by the No. sieve. 200 (0.075 mm)
3. Fraction of filler, the aggregate size that passes the number 200 sieves (0.075 mm).

4. Coral Aggregate

Coral aggregate is a natural mineral composition that has been processed (Wang *et al.*, 2019) or through combustion and filtering which functions as a void in mix which has fine grains that pass filter no. 30 where the percentage of weight that passes the sieve Number 200 is a minimum of 65% (SKBI-2.4.26.1987) when viewed from its chemical nature, there are 3 types of lime, namely:

1. Lime stone contains elements of Ca CO3,
2. Live lime (Quick lime contains elements of CaO,
3. Lime / slaked lime / Slake lime contains elements of Ca (OH)2, while the function of lime powder (filler) in the pavement is to increase stability and reduce air voids in the mixture.

The filler must be dry and free from clumps. The coral powder used in this study is dead coral / Slake lime originating from the Polimak - Jayapura area. The gradation meets the requirements according to the General Specifications of Bina Marga 2018 that is, the added filler material must be dry and free from lumps and when tested by sieving according to SNI ASTM C136: 2012 must contain material that passes the No. 200 sieve (75 micron) not less than 75% by weight.

Aggregate Abrasion Examination (SNI 03-2417-1991)

Determine the resistance of a coarse aggregate to wear using a “Los Angeles” machine. The wear is expressed by the ratio of the weight of the material worn through the number sieve 12 (1.7 mm) to the original weight in percentage.

a) Number of iron balls: 8 pieces and 11 pieces
b) Weight of the ball: for 8 iron balls (3200 grams)
c) For 11 iron balls (4400 grams)
d) Number of rounds: 500 times

Analysis of Fine and Coarse Aggregate Sieve (SNI 03-1968-1990)

Sieve analysis is carried out to determine the distribution of grains, calculated from the percentage of the weight of the test object that is retained on each sieve to the weight of the test object.

Inspection of Specific Gravity and Absorption of Coarse Aggregate (SNI 03-1969-1990)

This inspection is intended to determine the specific gravity (bulk), saturated surface dry density (saturated surface dry), apparent density (apparent), and absorption (absorption) of coarse aggregate. Bulk specific gravity (bulk specific gravity) Specific gravity dry - saturated surface (saturated surface dry), apparent density (apparent specific gravity. Examination of Density and Absorption of Fine Aggregate (SNI 03-1970-1990), This inspection is intended to determine the weight-specific gravity (bulk), saturated surface dry density (saturated surface dry), apparent density (apparent), and absorption (absorption) of fine aggregate.

C. METHODOLOGY

1. Material Preparation

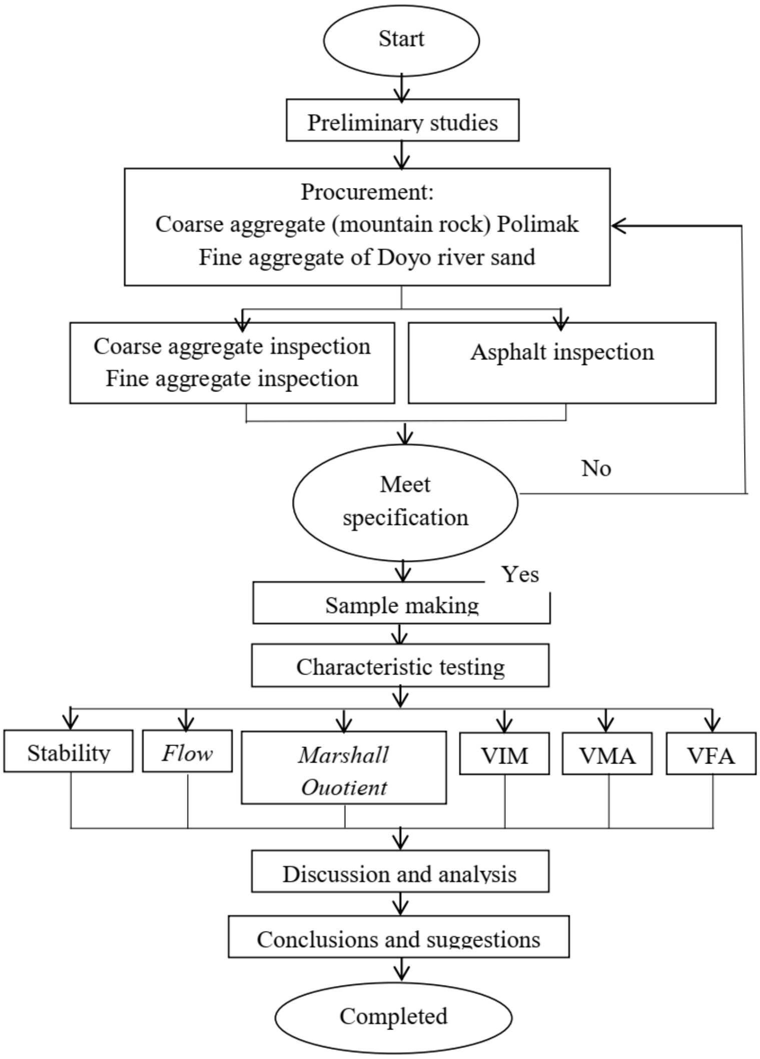
This stage is an activity before starting data collection and processing. This preparatory stage includes the following activities:

1. Determine the need for primary data and secondary data.
2. Literature study with Laston AC-WC as a reference and additional knowledge.
3. Final Project Proposal Making.
4. The research method is arranged in stages of testing in the following order:

a. Mountain coral rock collection at Polimak.
b. Inspection of the material to be used.
c. Planning the AC-WC asphalt concrete layer.
d. Doing testing with Mashall test.
e. Analyze the test results so that the results of the test are obtained.

2. Flowchart

This flow chart is a chart that describes in detail the steps of the research process:



D. RESULT AND DISCUSSIONS

1. Laston Compounding Material Inspection

Before being used as a mixture of Laston, all materials or materials that make up Laston must be tested for their characteristics first. This test aims to see whether the material used is suitable for a mixture of concrete and whether it has complied with the 2010 Revision III General Specification for Highways. This research was conducted at the Highway Laboratory, Faculty of Engineering, Civil Engineering Department, Cenderawasih University.

2. Asphalt Test Results

The asphalt used is asphalt with penetration of 60/70 Pertamina, which several asphalts have tested. The test results can be seen in table 4.1, and complete data on asphalt test results can be seen in the appendix.

Table-2: Asphalt Pen Test Results 60/70

No	Checking Type	Test Standart	Unit	General Specifications of Bina Marga 2010 Revision III		Test Result
				Min	Max	
1	Penetration	SNI 2456:1991	mm	60	70	61,40
2	Softening Point	SNI 2434:1991	°C	48	58	53,5
3	Flash point	SNI 2433:2011	°C	232	-	260
4	Burn Point	SNI 2433:2011	°C	232	-	275
5	Asphalt Specific Gravity	SNI 06-2441-1991		1	-	1

Source: Laboratory Test Results, 2021.

The test results of asphalt Pertamina Penetration 60/70 can be seen in the table above shows that the characteristics of the asphalt have met the General Specifications of Bina Marga 2010 Revision III. Then the asphalt can be used as a constituent of Laston.

2. Aggregate Test Results

The aggregates tested in this study were coarse aggregate and fine aggregate. The aggregate test results can be seen in table 4.2, and for complete data on the results of testing for coarse and fine aggregates, it can also be seen in the appendix.

Table 3: Aggregate Test Results

No	Checking Type	Test Standart	Unit	General Specifications of Bina Marga 2010 Revision 3		Test Results
				Min	Max	
	Coarse Aggregate					
1	Specific Gravity (Bulk)	SNI 1969:1990				2,775
2	SSD Density					2,819
3	Apparent Density					2,904
4	Absorption		%		3	1,600
5	Abrasion Test	SNI 2417:2008	%		40	24,03
	Fine Aggregate					
1	Specific Gravity (Bulk)	SNI 1970:1990				2,647
2	SSD Density					2,667
3	Apparent Density					2,700
4	Absorption		%		3	0,746

Source: Laboratory Test Results, 2021

The test results of coarse aggregate and fine aggregate, which can be seen in the table above, show that they met the 2010 Revision III Bina Marga Specifications. Then the coarse aggregate and fine aggregate can be used as a mixture of asphalt.

3. Perencanaan Campuran

The design asphalt content can be seen in table 4.3, which is obtained with variations in asphalt content in the test are 4%, 4.5%, 5%, 5.5%, 6%, and 6.5%. The proportion of each aggregate for each test object is 62.73% coarse aggregate, 30.89% fine aggregate, and a 6.4% filler. The filler used in this test is three-wheel brand Portland cement. A complete calculation of the proportion can be seen in the appendix.

Table 0: Mixed Composition

Design asphalt content (Pb)	4%	4.5%	5%	5.5%	6%	6.5%
Total mix (gr)	1200	1200	1200	1200	1200	1200
Asphalt Weight (gr)	48	54	60	66	72	78
Aggregate Weight (gr)	1152	1146	1140	1134	1128	1122
Coarse Aggregate 62.73%	722.66	718.90	715.13	711.37	707.60	703.84
Fine Aggregate 30.89%	355.85	353.99	352.14	350.29	348.43	346.58
Filler (cement) 6.4% (gr)	73.61	73.23	72.85	72.46	72.08	71.70

Source: Laboratory Test Results, 2021

4. Marshall Test for Optimum Asphalt Content

The characteristics of the asphalt-concrete mixture can be determined by analyzing the values of density, stability, flow, VIM, VMA, VFA, and MQ through the Marshall Test. The data can be seen in Table 4.4 below

Table 5: Aggregate Data Used in Mix

Description	**Specific gravity**		**Proportion In Mixture (%)**
	Dry (Bulk)	**Pseudo (Apparent)**	
Coarse Aggregate (19,0 mm s.d 2,36 mm)	2,775	2,904	62,73
Fine Aggregate (1,18 mm s.d 0,075 mm)	2,647	2,700	30,89
Cement Filler	3,15		6,4
Asphalt Pen 60/70	1,0		

Source: Laboratory Test Results, 2021

5. Data Analysis of Marshall Test Results

In determining the optimum asphalt content (KAO) using the method used based on RSNI M-06-2004 with marshall characteristics, including density, stability, flow, VIM, VMA, VFA, and MQ. The properties of the Lastton mixture that lead to the 2010 Revision III Bina Marga Specifications can be seen in Table 4.5 as follows:

Table 6: Conditions for the Properties of Laston's Mixtures

Mixed properties		Laston		
		Asphalt concrete layer	Layer Between	Foundation
Number of collisions per plane		75		112
Cavity in mix (VIM) (%)	Min	3,0		
	Max	5,0		
Cavity in aggregate (VMA) (%)	Min	15	14	13
Asphalt filled cavity (VFA) (%)	Min	65	65	65
Marshall Stability (kg)	Min	800		1800
Melting (Flow) (mm)	Min	2		3
	Max	4		6

Source: Highways Specification 2010 Revision III

From the results of data analysis and the results of the Marshall test, it is possible to determine the optimum asphalt content, and each value obtained is regulated according to the 2010 Revision III Bina Marga Specification.

Table 7: Marshall Test Results Determination of KAO with Coral Materials

% Asphalt Level	**Density (gr/ml)**	**VMA (%)**	**VIM (%)**	**VFA (%)**	**Stability (kg)**	**Flow (mm)**	**MQ (kg/mm)**
4	1,80	20,77	14,61	34,93	3171,60	6,00	594,27
4,5	1,82	19,80	12,61	39,43	3624,75	8,33	432,85
5	1,79	21,79	13,85	39,14	4198,78	9,00	464,80
5,5	1,74	24,42	15,83	37,01	5495,89	10,00	348,03
6	1,81	21,68	11,82	45,49	5009,59	9,00	548,72
6,5	1,69	27,48	17,45	38,40	2689,90	6,33	307,91

Source: Laboratory Test Results, 2021

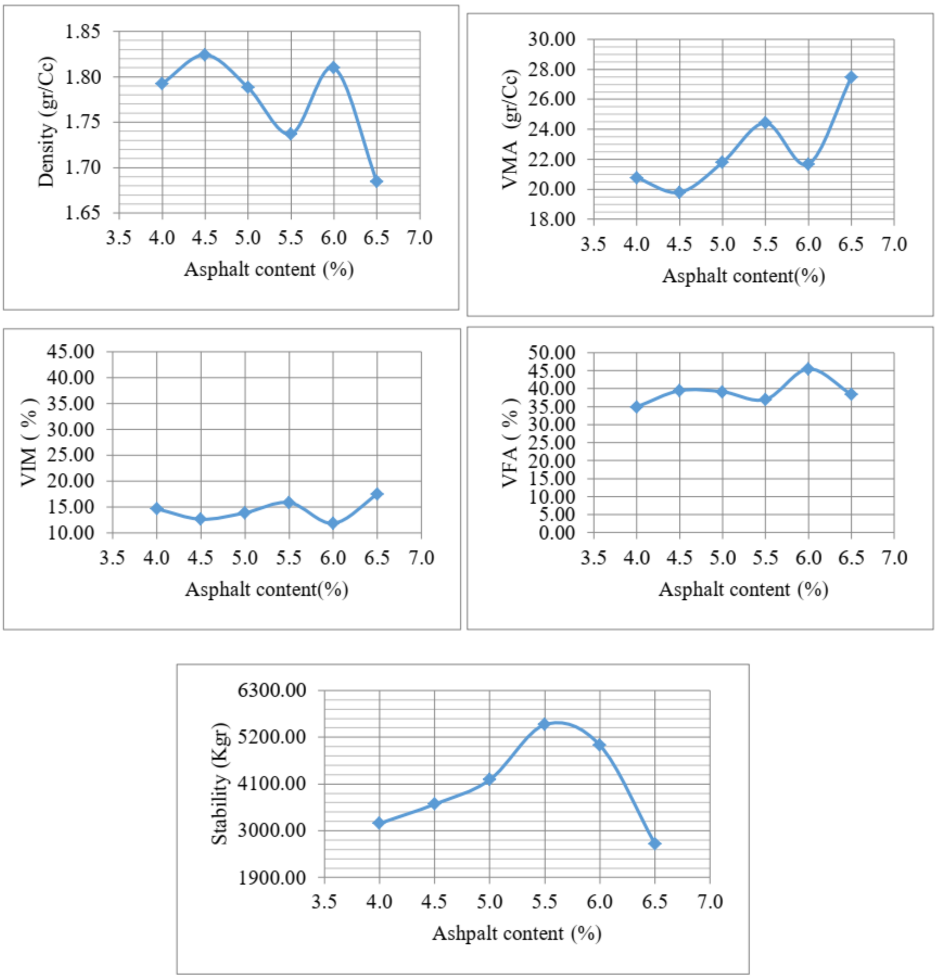
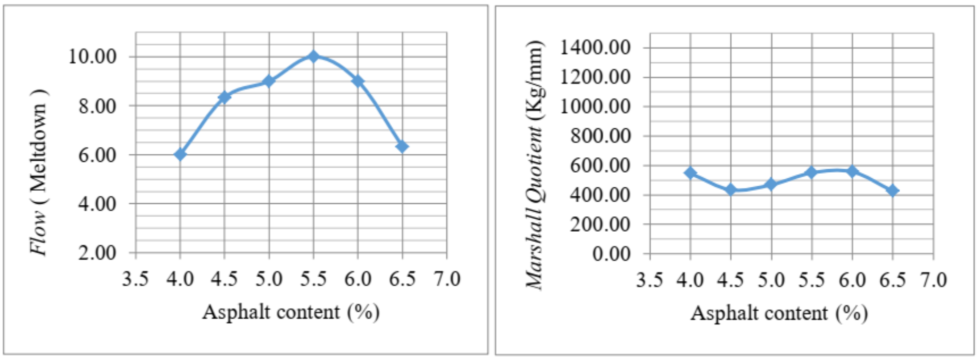


Figure 2: Graph of Marshall Characteristics of Coral

Source: Laboratory Test Results, 2021



Source: Laboratory test results, 2021

From graphs in Figures 2 and 3, the values of marshall characteristics on the use of coral can be seen in Table 4.9 as follows:

1. The highest density value is at 4.5% asphalt content, and the lowest is 5.5% and 6.5%. So from the graph, the density value has gone up and down.
2. The VMA value obtained from the graph shows that the VMA value is unstable, but all asphalt content meets the 2010 Revision III Bina Marga Specification, with a minimum VMA value of 15%.
3. The highest VIM value obtained from the graph is found in the asphalt content of 6.5%. From the graph, the VIM value obtained from all asphalt content does not meet the requirements of Bina Marga 2010 Revision III, which is 3-5%.
4. The VFA value tends to increase but decreases at 5.5% and 6.5% at the asphalt content. The requirement for VFA value according to Bina Marga 2010 Revision III is at least 65%, so that the VFA value of all asphalt content does not meet the requirements.

5. The highest stability value obtained from the graph results is in the asphalt content of 5.5%. According to Bina Marga 2010 Revision III, the requirement for stability value is at least 800 kg so that the stability value of all asphalt content meets the specified requirements.
6. The flow value tends to be unstable so that the highest asphalt content is 5.5%, and all asphalt content does not meet the flow requirements of Bina Marga 2010 Revision III.
7. The highest MQ value obtained from the graph is at 6% asphalt content and the lowest at 6.5% asphalt content.

Table 8: Determining KAO on Coral Use

No.	Criterias	Spesification	Asphalt Content					
1	Stability (kg)	Min 800						
2	*Flow* (mm)	2-4						
3	VIM (%)	3-5						
4	VFA (%)	Min 65						
5	VMA (%)	Min 15						
KAO = (5+5,5+6+6,5)/4=5,75~ 5,5%			4	4,5	5	5,5	6	6,5

Information:
Colored = fulfill
Colorless = does not meet
Source: test results, 2021.

E. CLOSING

1. CONCLUSION

The results of the Marshall test on the use of coral material in the AC-WC layer, the stability value of 5495.89 kg was obtained with the other marshall characteristic values: density: 1.74 gr/cm3, VMA: 24.42%, VIM: 15, 83%, VFA: 37.01%, stability of 5495.89 kg, flow: 10.00 mm and MQ of 348.03 mm/kg. The i value of Optimum Asphalt Content (KAO) used as AC-WC layer is 5.5%.

1.1 SUGGESTION

It is necessary to vary the levels of the coral mixture on the test object, including the use of fine aggregates with different composition variations to obtain a specific stability value.

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