

THE EFFECT OF GRANITE WASTE AS A FINE AGGREGATE SUBSTITUTION IN ASPHALT CONCRETE BINDER COURSE

Niko Fitriandana Rinjoko¹, Yonas Prima Arga Rumbyarso², Lydia Darmiyanti³

^{1,2,3}Department of Civil Engineering, Krisnadwipayana University
Email : Okiokiniko@gmail.com

ABSTRACT

Roads play a crucial role in local economies, supporting the distribution of goods and the mobility of citizens, but are often damaged by heavy traffic loads, poor drainage and inadequate infrastructure. Asphalt pavement is a popular choice due to its durability and affordable construction costs. Building waste includes construction and demolition waste, containing recyclable to toxic materials. Management of this waste is effective to reduce costs and support industry sustainability, in Indonesia, granite stone waste is widely generated. Analysis of Marshall characteristics in AC-WC mixtures using granite stone powder as a substitute for filler with a variation of 30% resulted in a stability value of 2487 kg, a VMA value of 36.51%, a flow value of 3.35 mm, a VIM value of 26.19% and an MQ value of 742 kg/mm that meets specifications. The VFB test value of 28.27% does not meet the 2018 Bina Marga specifications. While the granite stone powder with a variation of 60% produces a stability value of 2568 kg, a VMA value of 37.31%, a flow value of 3.4 mm, a VIM value of 27.12% and an MQ value of 756 kg/mm that meets the specifications. Meanwhile, the VFB test value of 27.31% does not meet the 2018 Bina Marga specifications. The presentation results of the mix design on cement filler are hot bin I by 17%, hot bin II by 45%, hot bin III by 32%, cement filler 6%, asphalt 6%.

Keywords: Asphalt, Asphalt Concrete Binder Course, Granite Stone.

INTRODUCTION

Roads play a crucial role in local economies, supporting the distribution of goods and mobility of residents, but are often damaged by heavy traffic loads, poor drainage, and inadequate infrastructure. Asphalt pavements are a popular choice due to their durability and affordable construction costs. Construction waste, including construction and demolition waste, contains materials ranging from recyclable to toxic. Managing this waste is effective in reducing costs and supporting the sustainability of the industry. In Indonesia, granite waste is widely generated, and a study is scheduled to explore its use as a fine aggregate in the Asphalt Concrete Binder Course entitled “The Effect of Granite Waste as a Substitute for Fine Aggregate in Asphalt Concrete Binder Course Pavements”.

METHODS

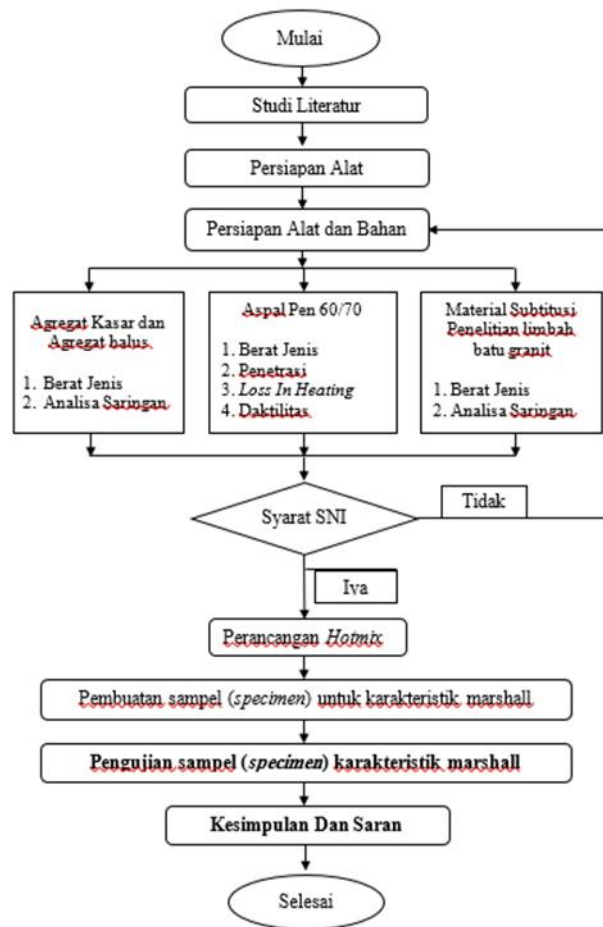


Figure 1. Research Flowchart

The research was conducted from May to June 2024 at the Asphalt Laboratory of the Civil Engineering Study Program, Faculty of Engineering, Krisnadwipayana University, Jakarta. This study used asphalt concrete binder course samples with varying percentages of granite waste as filler.

Each percentage was made into 6 samples, each consisting of 2 test objects. The total number of samples needed is listed in Table 4.

Table 4. Number of AC-WC Test Specimens for Marshall Standard Test

Kadar Aspal (%)	Jumlah		
	Aspal Normal (%)	Limbah Batu Granit (30%)	Limbah Batu Granit (60%)
5	3	3	3
6	3	3	3
7	3	3	3
Total		27	

The instruments used in this study were digital scales, digital sieves, ovens with a temperature of $(110 \pm 5)^{\circ}\text{C}$, sieves, asphalt ductility tools, pycnometers, thermometers, stopwatches, soaking tubs, electric stoves, molding, extruders, marshall testers, compactor hammers, specific gravity and absorption of coarse aggregate.



Figure 2. Asphalt Ductility Tool

RESULTS AND DISCUSSION

Penetration testing measures the hardness level of asphalt by inserting a needle into a standard sample at a temperature of 25°C, a load of 50 grams, for 5 seconds. The test results showed a penetration value of 64.75, corresponding to an asphalt penetration level of 80 within the limits of 60/70.

Table 5. Asphalt Penetration Test

Room Temperature : 31 °C		Water Temperature : 25 °C	Dampness : 55 °C
Pouring Temperature : °C		Duration Penetration : (5 ± 0,5) Sec	
Conditions Test	Ballast Use : 50 Grams	Temperatur Test : 25 °C	
Number Test		I	II
1. Penetration Measurement I (0,1 mm)		61	59
2. Penetration Measurement II (0,1 mm)		69	70
3. Deviation test I & II (0,1 mm)		8	11
4. Average Result I & II (0,1 mm)		65	64.5
5. Max Deviation From Measurement (0,1 mm)		11	
6. Average Measurement 1,2,3 (0,1 mm)		64,75	
7. Measurement Result level Penetration		B	

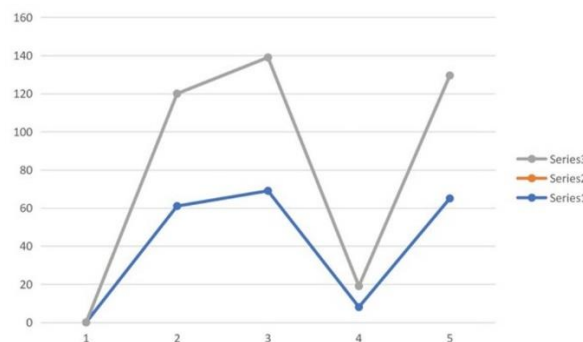


Figure 3. Asphalt Penetration Testing Graph

Sieve analysis testing to determine how many percentages of several materials pass through several sieve numbers.

Table 6. Cement Filler Sieve Analysis

No. Saringan	Berat Tertahan (gram)				Jumlah Berat Tertahan (gram)	Jumlah Tertahan (%)	Jumlah Lolos (%)
	I	II	III	Rata- Rata			
1"	-	-	-	-	-	-	-
3/4"	0	0	0	0	0	0	100
1/2"	0	0	0	0	0	0	100
3/8"	0	0	0	0	0	0	100
No. 4	0	0	0	0	0	0	100
No. 8	0	0	0	0	0	0	100
No. 16	0	0	0	0	0	0	100
No. 30	0	0	0	0	0	0	100
No. 50	1,2	2,3	2,1	1,87	1,87	0,09	99,91
No. 100	15	18	15	16	17,87	0,83	99,17
No. 200	23	25,2	28,4	25,5	27,4	1,63	98,37

Table 7. Analysis of Granite Stone Powder Waste Filler Sieve

No. Saringan	Berat Tertahan (gram)			Jumlah Berat Tertahan (gram)	Jumlah Tertahan (%)	Jumlah Lolos (%)
	I	II	Rata- Rata			
1"	-	-	-	-	-	-
3/4"	0	0	0	0	0	100
1/2"	0	0	0	0	0	100
3/8"	0	0	0	0	0	100
No. 4	0	0	0	0	0	100
No. 8	0	0	0	0	0	100
No. 16	0	0	0	0	0	100
No. 30	0	0	0	0	0	100
No. 50	0	0	0	0	0	100
No. 100	0	0	0	0	0	100
No. 200	95,7	36,8	66,3	132,5	22,48	77,52
Jumlah	95,7	36,8	66,25	132,5	100	

According to SNI 0013-81, the filler specific gravity testing standard ranges from 2.25 – 2.7 gr/cm³. The results of the cement filler specific gravity study were 2.36 gr/cm³ and the specific gravity of the granite stone powder waste filler was 2.44 gr/cm³ based on the filler material standards used in the study, it is suitable for use in the AC-BC laston components.

Table 8. Cement and Granite Stone Powder Waste Specific Gravity Test

Tempratur Ruangan : 31 °C	Air : 25 °C	Oven : 105 °C	Kelembaban : 55 °C
Contoh :			
1. Nomor Pemeriksaan	filler semen		kapur tohor
2. Berat Picometer (W1) (CC)	60,1 gr		60,1 Gr
3. Berat Picometer + Contoh (W2) (CC)	147,0 gr		150,7 Gr
4. Berat Pic + Contoh + Air (W3) (CC)	215,0 gr		218,4 Gr
5. Berat Pic + Air (W4) (CC)	164,9 gr		164,9 Gr
6. Berat Jenis	$\frac{2 - 1}{4 - 1 - 3 \rightarrow 2}$		
	$\frac{215,0 - 60,1}{164,9 - 60,1}$		
	2,36 gr		2,44 Gr

Laston Mix Plan

Calculation of the composition of the asphalt mixture plan or solid asphalt concrete in the Laboratory of the Faculty of Civil Engineering, Krisnadwipayana University. With the

experiment of the percentage composition of hot bin I 42%, hot bin II 37%, hot bin III 20%, cement filler 1% and asphalt content 5.7%. Calculation of the composition of the solid concrete layer mixture plan in the Concrete Technology Laboratory, Krisnadwipayana University.

Table 9. Cement Filler Design Results

Material		Kadar	
Kadar Aspal Optimum		6	%
Berat Sampel		1200	Gram
Berat Kadar Aspal Optimum		7,200	Gram
Berat Agregat Kasar (Hot Bin I)	: 17%	204	Gram
Berat Agregat Sedang (Hot Bin II)	: 45%	540	Gram
Berat Agregat Halus (Hot Bin III)	: 32%	384.0	Gram
Filler Semen	: 6%	72	Gram
Filler (Limbah Serbuk Batu Granit)	: 0%	0	Gram
Total :		1,200	Gram

Table 10. Design Results of 30% Granite Stone Powder Waste Filler

Material		Kadar	
Kadar Aspal Optimum		6	%
Berat Sampel		1200	Gram
Berat Kadar Aspal Optimum		7,200	Gram
Berat Agregat Kasar (Hot Bin I)	: 17%	204	Gram
Berat Agregat Sedang (Hot Bin II)	: 45%	540	Gram
Berat Agregat Halus (Hot Bin III)	: 32%	384.0	Gram
Berat Filler Total	: 6%	72.0	Gram
Filler (Semen) dari Berat Total Filler	: 60%	43.20	Gram
Filler (Limbah serbuk batu granit) dari Berat Total Filler	: 30%	28.80	Gram
Total :		1,200	Gram

Table 11. Design Results of 60% Granite Stone Powder Waste Filler

Material		Kadar	
Kadar Aspal Optimum		66	%
Berat Sampel		1200	Gram
Berat Kadar Aspal Optimum		79,200	Gram
Berat Agregat Kasar (Hot Bin I)	: 17%	204	Gram
Berat Agregat Sedang (Hot Bin II)	: 45%	540	Gram
Berat Agregat Halus (Hot Bin III)	: 32%	384.0	Gram
Berat Filler Total	: 6%	72.0	Gram
Filler (Semen) dari Berat Total Filler	: 20%	14.4	Gram
Filler (Limbah Serbuk Batu Granit) dari Berat Total Filler	: 60%	57.6	Gram
Total :		1,200	Gram

Evaluation of the use of granite stone powder waste on AC-BC laston

The use of granite stone powder waste as a substitute for cement filler increases the stability of the asphalt mixture, with a stability value for cement filler of 2266 kg, 30% granite stone powder waste of 2487 kg, and 60% of 2568 kg. These results indicate that granite stone powder waste provides higher stability than cement filler. Stability refers to the ability of the asphalt mixture to withstand loads without yielding, influenced by factors such as asphalt layer thickness. All stability values for variations of granite stone powder waste meet the minimum Bina Marga specifications of 2200 lbs.

The use of granite stone powder waste as a substitute for cement filler increases the void content in the aggregate (VMA), with a VMA value using cement filler of 27.90%, while

the use of 30% and 60% granite waste produces VMA values of 36.51% and 37.31% respectively. These results indicate that granite stone powder waste provides a higher VMA value than cement filler and meets the 2018 Bina Marga specifications which set a minimum of 18%.

The use of granite stone powder waste as a substitute for cement filler increases the flow value of the asphalt mixture. The flow value for the mixture with cement filler is 3.35 mm, the same as the mixture using 30% granite waste, but increases slightly to 3.40 mm for the 60% variation. Flow indicates the change in shape of the asphalt mixture under load, and the higher flow value in the mixture with granite waste indicates that this mixture requires more asphalt, reduces air space in the mixture, and results in lower adhesion between asphalt and aggregate. Although the flow value is higher, this mixture still meets the Bina Marga specifications which set a flow limit between 2 mm and 4 mm.

The use of granite stone powder waste as a substitute for cement filler increases the pore volume in dense asphalt concrete (VIM). The VIM value for the mixture with cement filler is 16.17%, while for the variation of 30% granite waste it is 26.19% and for 60% it is 27.12%. The addition of granite stone powder waste causes an increase in pore volume, indicating the presence of more grains and cavities in the laston mixture. However, the VIM value for all variations still meets the minimum specifications of Bina Marga 2018 which is 3.5 - 5.5%. The use of granite stone powder as a substitute for cement filler increases the Marshall Quotient (MQ) value, which measures the stiffness and flexibility of the asphalt mixture. The MQ value for the mixture with cement filler is 676 kg / mm, while with 30% granite stone powder filler it is 742 kg / mm and for the variation of 60% it is 756 kg / mm. This shows that the mixture with granite stone powder has a higher stiffness compared to cement. All MQ values of this mixture have met the minimum specifications of Bina Marga 2018 of 250 kg / mm.

CONCLUSIONS

Marshall characteristic analysis on AC-WC mixture using granite stone powder as filler substitute with variation of 30% resulted in stability value of 2487 kg, VMA value of 36.51%, flow value of 3.35 mm, VIM value of 26.19% and MQ value of 742 kg/mm already met the specification. For VFB test value of 28.27% did not meet Bina Marga 2018 specification. While granite stone powder with variation of 60% resulted in stability value of 2568 kg, VMA value of 37.31%, flow value of 3.4 mm, VIM value of 27.12% and MQ value of 756 kg/mm already met the specification. Meanwhile, the VFB test value of 27.31% does not meet the 2018 Bina Marga specifications. The presentation results of the mix design on the cement filler are hot bin I of 17%, hot bin II of 45%, hot bin III of 32%, cement filler 6%, asphalt 6%.

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