

THE EFFECT OF USING RED BRICK WASTE MIXED WITH ASPHALT CONCRETE WEARING COURSE

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ABSTRACT

Flexible pavement is a road construction that uses aggregate and asphalt as a binder to create a strong road layer. This pavement is able to withstand and distribute vehicle loads to the underlying soil layer and is often used on roads with reduced loads and traffic. This study used AC 60/70 penetration asphalt, which is suitable for hot climates and high traffic. With the large amount of red brick waste in Indonesia, this study utilizes the waste as a partial substitute for fine aggregate in the laston mixture. The title of this study is "The Effect of Using Brick Waste on Asphalt Concrete Wearing Course Mixture". The Marshall test characteristics on the AC-WC mixture using red brick powder as a filler substitute with a variation of 40% 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 already meeting the specifications. For the VFB test value of 28.27%, it does not meet the 2018 Bina Marga specifications. Meanwhile, red brick powder with a variation of 80% 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 already meets the specifications.

Keywords: Asphalt, Asphalt Concrete Wearing Course, Powder, Red Brick.

INTRODUCTION

Flexible pavement is a road construction that uses aggregate and asphalt as a binder to create a strong road layer. This pavement is able to withstand and distribute vehicle loads to the underlying soil layer and is often used on roads with reduced loads and traffic. This study used AC 60/70 penetration asphalt, which is suitable for hot climates and high traffic.

With the large amount of red brick waste in Indonesia, this study utilizes this waste as a partial replacement for fine aggregate in the laston mixture. The title of this study is "The Effect of Using Brick Waste on Asphalt Concrete Wearing Course Mixture".

METHODS

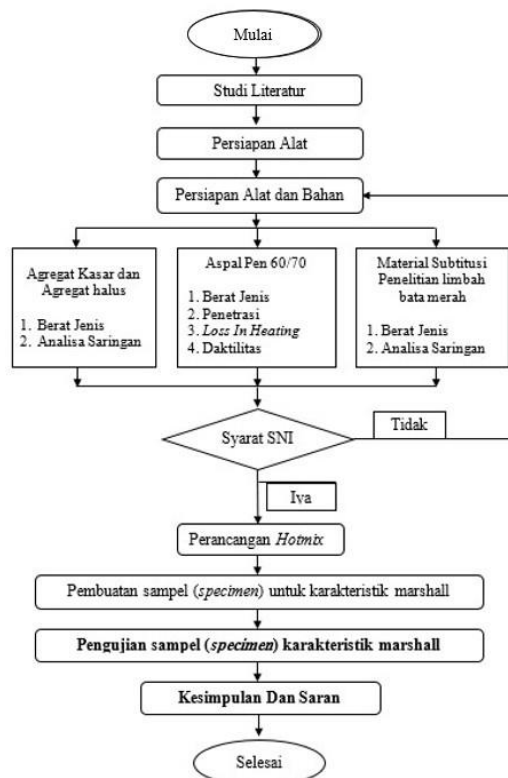


Figure 2. Research Flowchart

This research was conducted from May to June 2024 at the Asphalt Laboratory, Civil Engineering Study Program, Faculty of Engineering, Krisnadwipayana University, Jakarta. In this study, asphalt concrete wearing course samples were tested with various proportions of red brick dust waste as filler.

The filler used must be free from unwanted components and able to pass through sieve No. 200. Additional filler must also be free from lumps and in dry condition. The red brick dust waste used in this study successfully passed through sieve No. 200. The specifications for this filler are in accordance with those described in SNI 1994, which are described in Table 4.

Table 4. Filler Aggregate Requirements

No.	Karakteristik	Standar Pengujian	Satuan	Spesifikasi	
	Filler			Min.	Maks.
1	Material yang lolos saringan No. 200	SK SNIM-02-1994-03	%	70	-
2	Berat Jenis	AASHTO T-85 -81		-	-

In this study, the equipment used included digital scales, digital sieves, ovens with a temperature of $(110 \pm 5)^{\circ}\text{C}$, manual sieves, asphalt ductility measuring instruments, pycnometers, thermometers, stopwatches, soaking tubs, electric stoves, molds, extruders, Marshall testers, compaction hammers, and instruments for measuring specific gravity and coarse aggregate absorption.



Figure 3. Digital Sieve Equipment

RESULTS AND DISCUSSION

Penetration test was conducted to assess the hardness of asphalt by inserting a needle into a standardized sample at a temperature of 25°C, using a load of 50 grams for 5 seconds. The test results showed a penetration value of 64.75, which corresponds to the asphalt penetration level in the range 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	

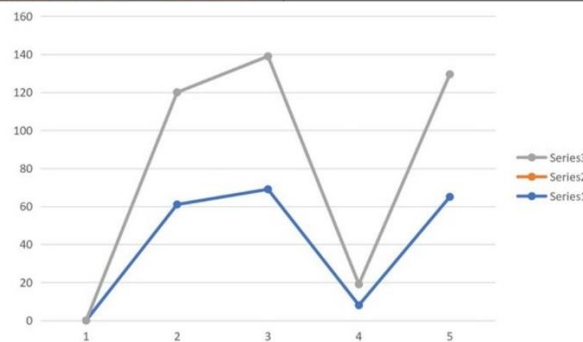


Figure 3. Asphalt Penetration Test Graph

A sieve analysis test is run to measure the percentage of material that successfully passes through sieves of various sizes.

Table 6. Cement Filler Sieve Test

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. Fish Bone Powder Waste Filler Sieve Test

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 specific gravity of filler should be in the range of 2.25-2.7 gr/cm³. In this study, it was found that the specific gravity of filler from cement is 2.36 gr/cm³, while the specific gravity of filler from red brick powder waste is 2.44 gr/cm³. Based on this standard, both types of fillers meet the requirements for use as components in the manufacture of laston asphalt concrete wearing course.

Table 8. Specific Gravity Analysis Test of Cement and Red Brick Powder Waste

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	$\frac{2-1}{4-\frac{1-3}{2}}$		
	2,36	gr	2,44 Gr

The composition design for asphalt mixture or dense asphalt concrete was carried out in the Concrete Laboratory of the Faculty of Civil Engineering, Krisnadwipayana University. In the experiment, the composition was determined with a proportion of hot bin I of 42%, hot bin II 37%, and hot bin III 20%, plus 1% cement filler and 5.7% asphalt.

Table 9. Cement Filler Planning Output

Material		Kadar	
Kadar Aspal Optimum		6	%
Berat Sampel		1200	Gram
Berat Kadar Aspal Optimum		7,2	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	Gram
Filler Semen	: 6%	72	Gram
Filler Limbah Serbuk Tulang Ikan	: 0%	1,2	Gram

In the test, the stability value obtained using cement filler was 2266 kg, while the use of red brick powder filler resulted in a stability of 2487 kg with a fluctuation of 40% and 2568 kg with a fluctuation of 80%. This shows that red brick powder filler provides higher stability than cement filler. Stability, which refers to the capacity of the pavement mixture to support the load until melting occurs, is influenced by internal friction determined by the thickness of the asphalt layer.

The stability value of red brick powder, both in variations of 40% and 80%, has met the Bina Marga standard which sets a minimum weight of 2200 kg. Therefore, red brick powder

can be considered an effective substitute for cement filler by maintaining stability in accordance with the requirements.

From the tests conducted, the value of voids in aggregate (VMA) differs depending on the type of filler used. With cement filler, the VMA value is 27.90%. The use of red brick powder filler at a variation of 40% increased the VMA to 36.51%, and at a variation of 80%, the VMA value increased even higher to 37.31%. These results indicate that the use of red brick powder filler produces a larger volume of empty space in the aggregate compared to cement filler. In addition, red brick powder also meets the minimum VMA requirement of 18% set by Bina Marga 2018. The test showed that the use of cement filler produced a flow value of 3.35 mm, while red brick powder filler produced the same value at a variation of 40% and slightly higher at 3.40 mm for a variation of 80%. The mixture with cement filler showed a lower flow value compared to that using red brick powder filler. The flow value measures the change in shape of the asphalt mixture due to the load given during the test, indicating a greater need for asphalt in the combination with red brick powder filler. The use of more asphalt reduces air gaps and can reduce the binding capacity of asphalt to aggregate, increasing the potential for plastic deformation under load. However, the flow value of the mixture using red brick powder filler is still within the Bina Marga criteria which require a range of 2 to 4 mm.

The remaining pore volume in the asphalt mixture after compaction is known as the pore volume of dense asphalt concrete (VIM). The test using cement filler produced a VIM value of 16.17%. Meanwhile, the use of red brick powder filler gave a higher VIM value, with a variation of 40% reaching 26.19% and a variation of 80% of 27.12%.

This increase in the VIM value indicates that the use of red brick powder filler results in more grains and cavities in the laston mixture, compared to the smaller volume of cement filler. However, the VIM value for cement and lime fillers still meets the 2018 Bina Marga specifications which set a minimum range of 3.5 - 5.5%.

The Marshall Quotient value represents the ratio of flow to stability and provides an estimate of the level of stiffness and flexibility of the mixture. The combination becomes harder as the MQ value increases, while the pavement becomes more flexible as the MQ value decreases. The Marshall Quotient Test Value with cement filler is 676 kg/mm, compared to the test with filler producing a value of 676 kg/mm, red brick powder variation of 40% is 742 kg/mm and the use of red brick powder filler variation of 80% is 756 kg/mm. This shows that the marshall quotient value in the red brick powder filler test is greater than the cement filler. However, the marshall quotient value of the cement filler and lime material mixture has met the 2018 Bina Marga specifications of a minimum of 250 kg/mm.

CONCLUSIONS

Marshall test characteristics on AC-WC mixture using red brick powder as filler substitute with variation of 40% 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 specifications. For VFB test value of 28.27% did not meet Bina Marga 2018 specifications. While red brick powder with variation of 80% 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 specifications.

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