Planning analysis of asphalt porous mixture based on fly ash waste as filler substitution

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ABSTRACT

In relation to the development of the quality of the transportation system, road pavement technology will gradually develop and be updated in terms of the quality of the transportation infrastructure currently being developed by porous asphalt. Porous asphalt is an asphalt mixture that is designed to have a higher porosity than other types of pavement. it is obtained because the porous asphalt mixture uses a smaller proportion of fine aggregate than other mixtures. In addition to asphalt, there are aggregates both coarse and fine and filler is one of the components in a road pavement construction that has a big role. In order to increase its stability, the use of fine fractions including filler in the mixture proportion should be more. Class C coal fly ash is one of the non-organic and non-plastic materials that can be used as a filler in porous asphalt mixtures and is expected to increase its strength. The purpose of this study was to analyze the effect of using flyash on a porous asphalt mixture on the value of the marshall characteristics and the value of weight loss. The results of this study discuss the marshall test on variations in coal flyash waste 0%, 2%, 3%, 4%, 5%, and 6% using the REAM specification, for the VMA value the percentage of coal flyash waste all meets the specifications specified. has been required, for the VIM value only the percentage of 4% that meet the specifications and 0%, 2%, 3%, 5%, and 6% do not meet the required specifications. For the stability value, the percentage of coal flyash waste 2%,3%,4% met the specifications, while 0%,5%, and 6% did not meet the specifications. For the flow value, the percentage of coal flyash waste 5% did not meet the specifications, while 0%,2%,3%,4%, and 6% had met the required specifications. And for the value of VFB and MQ the percentage of coal flyash waste does not meet the required specifications. Based on the results of the REAM cantabro test, the percentage of coal flyash waste 0% and 2% did not meet the specifications, while 3%,4%,5%, and 6% met the predetermined specifications, namely the maximum weight loss value of 20%.

Keywords: porous asphalt; coal fly ash; ream; pavement; specification.

INTRODUCTION

Road pavement is a layer located above the compacted subgrade, whose function is to withstand traffic loads then continue the load horizontally and vertically and finally so that the load on the lower layer does not exceed the allowable load capacity of the soil. The main difference between a flexible surface and a rigid pavement is the way the structure affects the traffic load to the subgrade. Rigid pavement is able to distribute the load on the subgrade with a large area, so that the pressure received by the subgrade per unit area due to traffic loads is very small. Increasing the hardness of a hard surface can be increased by increasing the quality of the material it contains, which means improving the quality of the asphalt.

Asphalt is a dark brown or dark black hydrocarbon compound formed from the elements asphalthenes, resins, and oils. Asphalt in the pavement layer functions as a binding material between aggregates to form a compact mixture, so that it will provide strength for each aggregate (Kerbs and Walker, 1971) and contains the main parts, namely hydrocarbons produced from petroleum or natural occurrences (asphalt). nature) and dissolved in carbon disulfide. (Wignal, et. al., 1999). Oil asphalt can be divided into 3, namely hard/hot asphalt, cold/liquid asphalt, and emulsified asphalt (Atkins, 2003) which can be used as binders in hollow asphalt mixtures.

Hollow asphalt is an asphalt mixture being developed for wearing course construction. This layer uses an open graded layer that is spread over a waterproof asphalt layer. The mixture is dominated

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by coarse aggregate, to obtain pores high enough to obtain high permeability of hollow asphalt, where permeability is used for subsurface drain. (Tjaronge, 2013). Hollow asphalt is an asphalt mixture that is designed to have a higher porosity than other types of pavement. According to the Road Engineering Association of Malaysia (2008), hollow asphalt has a porosity value of 18-25%. Besides that, hollow asphalt uses mostly coarse aggregate material, which is about 85%, which causes the surface to be rough and has a high skid resistance so that the vehicle does not slip easily and the large cavity in it causes the hollow asphalt to absorb the noise that exists by friction between the tires of the vehicle and the road surface. (Ali, et. al., 2011)

RESEARCH METHODS

Tool

The tools used in this research are asbuton testing tools, aggregate testing tools, test object testing tools, Marshall method mixture testing tools, cantabro testing tools.

Ingredient

Coarse aggregate, fine aggregate, filler, flyash waste as a mixture of hollow asphalt, and oil asphalt.

Mix Making

Mixing procedure

1. The aggregate is heated to a temperature of 160 C, then oil asphalt is added
2. Coal flyash waste is added to the aggregate mixture and stirred evenly.
3. After that the mixture is stored at a temperature of 90○C for further compaction.
4. After that, a collision is carried out with a variation of 2x50

Manufacture of test objects

The next step is making samples (briquettes) to get the Optimum Asphalt Content (KAO). Samples of asphalt pavement were made with oil asphalt as a binder. Furthermore, testing was carried out with Marshall and Cantabro, after getting the KAO value, the next step was making samples with coal flyash waste material.

Shows the number of test objects

Table 1. Preparation of KAO test objects

Variation of oil asphalt (%)	Marshall testing
4	3
5	3
6	3
7	3
Total	12

Table 2. Preparation of Marshall and Cantabro Test Objects

Variation of Fly Ash with KAO	Marshall Test	Cantabro testing
0%	3	3
2%	3	3
3%	3	3
4%	3	3
5%	3	3
6%	3	3
Sub Total	18	18
Total	36 + 12(KAO)= 48	

RESULTS AND DISCUSSION

Aggregate inspection

Coarse aggregate characteristic testing

The test results of the physical properties of coarse aggregate are carried out in accordance with the testing method of the Indonesian National Standard (SNI). The results of the recapitulation of the coarse aggregate test can be seen in Table 3 below.

Table 3. Characteristics of the physical properties of coarse aggregate

No.	Testing	Interval Value	Results
1	Absorption (%)	Maximum 3	1,58
2	Specific Specific Gravity (%)		
	a. Bulk Specific Gravity	Maximum 3	2,58
	b. SSD Specific Gravity	Maximum 3	2,62
	c. Apparent Specific Gravity	Maximum 3	2,69
3	wear (%)	Maximum 40	31,6
4	Thinness Index	Maximum 25	24,8

Source: Civil Engineering laboratory test results, UNIFA, Irmawan 2022

Testing of Fine Aggregate Characteristics

The test results of the physical properties of fine aggregate are carried out according to the testing method of the Indonesian National Standard (SNI). The results of the recapitulation of the coarse aggregate test can be seen in Table 4. which shows the characteristics of the physical properties of the fine aggregate used in this study.

Table 4. Physical Properties of Fine Aggregate

No.	Testing	Interval Value	Results
1	Absorption (%)	Maximum 3	2,46
2	Specific Gravity (%)		
	a. Bulk Specific Gravity	Maximum 3	2,70
	b. SSD Specific Gravity	Maximum 3	2,76
	c. Apparent Specific Gravity	Maximum 3	2,89
3	Sludge levels (%)	Maximum 3	4,73

Source: Civil engineering laboratory test results, UNIFA, Irmawan 2022

Mix Gradation Determination

In this study, the determination of the mixed gradation and mix design was carried out using a trial gradation system which refers to the open gradation standard required at REAM (Road Engineering Association Of Malaysia).

Determination of the proportion of aggregates is not grouped according to the aggregate fraction (coarse, fine and filler aggregates), but the determination of aggregate composition in this study is carried out by weighing based on the size of each sieve. The composition of aggregates using the sieve gradation method is shown in Table 5 below.

Table 5. Aggregate Aggregation

Sieve Nomor		3/4	1/2	3/8	No. 4	No. 8	No. 200
Crushed Stone	% PASS	100,00	85,33	56,67	0,00	0,00	0,00
85	% BATCH	85	72,53	48,17	0,00	0	0,00
Sand	% PASS	100	100,00	100,00	100,00	78,00	16,00
5	% BATCH	5	5	5	5	3,9	0,8
Fillers	% PASS	100,00	100,00	100,00	100,00	58,00	21,50
10	% BATCH	10,00	10	10,00	10	5,80	2,15
Combined Aggregate		100,00	87,53	63,17	15,00	9,70	2,95

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Specification	100	85-100	55-75	10-25	5-10	2-4

Asphalt Mixture Testing
Optimum asphalt content testing

Optimum asphalt content testing is carried out with the aim of providing the best optimum asphalt content for use and meeting the specifications of the overall characteristic values. And is the asphalt content that provides the highest stability in the pavement layer.
For the manufacture of test objects where each asphalt content has 3 samples. In order to obtain a stable asphalt content graph value, the determination of KAO is carried out by taking two upper asphalt content and two lower asphalt content by calculating the design asphalt content (Pb) with the following formula:
$P = 0.035\ \mathrm{a} + 0.045\ b + \mathrm{K}\ (\mathrm{c}) + F$
Where:
P = Mixed asphalt content approach
a = percentage of aggregate retained in sieve No. 8
b = Percentage of aggregate passing No. sieve. 8 stuck in sieve No.200
c = Percentage of passing sieve No. 200.
K = 0.15 for 11 – 15 % passes sieve No.200 0.20 for ≤ 5% passes sieve No.200
0.18 for 6 – 10% passes the No.200 sieve
F = 0 – 2% depending on aggregate standards if data is not available then 0.7 is taken – 1.
so:

$$p = 0.035\ (a) + 0.045\ (\mathrm{b}) + \mathrm{K}\ (\mathrm{c}) + \mathrm{F}$$
$$= 0.035\ (85) + 0.045\ (5) + 0{,}18\ (10) + 0{,}5$$
$$= 5{,}5\%$$

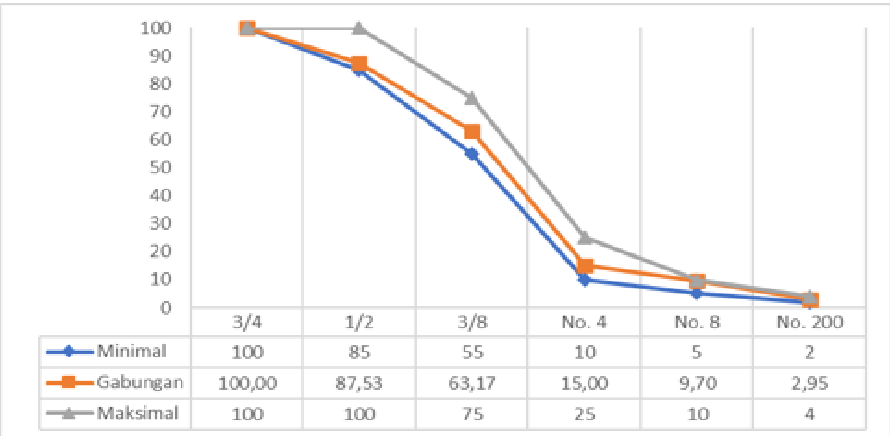

Figure 1. Aggregate Gradation of Asphalt Mix Testing

From the calculation of the design asphalt content (Pb), the asphalt content value is 5.5%. After that, two asphalt levels were taken below and two asphalt content values above 5.5% using 0.5% intervals so that the optimum asphalt content variation values used were 4%, 5%, 6%, and 7%. As for planning the composition of each variation of optimum asphalt content can be seen in the table below:

Table 6. Optimum Asphalt Content 4%

Filter	Aperture	Chipping	Sand	Stone dust	Total
No.	(mm)	(gr)	(gr)	(gr)	(gr)
3/4"	19,00	0,00	0	0	0
1/2"	12,50	143,65	0	0	143,65

3/8"	9,50	280,64	0	0	280,64
4	4,75	554,91	0	0	554,91
8	2,36	0,00	12,67	48,38	61,05
200	0,075	0,00	35,71	42,05	77,79
PAN	Filler	0,00	9,22	24,77	33,99
Aggregate Total Weight					1152
ASPHALT Weight (4%)					48,00
Total					1200,00

Source: Civil engineering laboratory test results, UNIFA, Irmawan 2022

Table 7. Optimum Asphalt Content 5%

Filter	Aperture	Chipping	Sand	Stone dust	Total
No.	(mm)	(gr)	(gr)	(gr)	(gr)
3/4"	19,00	0,00	0	0	0
1/2"	12,50	142,15	0	0	142,15
3/8"	9,50	277,72	0	0	277,72
4	4,75	549,13	0	0	549,13
8	2,36	0,00	12,54	47,88	60,42
200	0,075	0,00	35, 34	41,61	76,95
PAN	Filler	0,00	9,12	24,51	33,63
Aggregate Total Weight					1140
ASPHALT Weight (5%)					60,00
Total					1200,00

Source: Civil engineering laboratory test results, UNIFA, Irmawan 2022

Table 8. Optimum Asphalt Content 6%

Filter	Aperture	Chipping	Sand	Stone dust	Total
No.	(mm)	(gr)	(gr)	(gr)	(gr)
3/4"	19,00	0,00	0	0	0
1/2"	12,50	141,40	0	0	141,40
3/8"	9,50	276,25	0	0	276,25
4	4,75	546,24	0	0	546,24
8	2,36	0,00	12,47	47,63	60,1
200	0,075	0,00	35, 15	41,39	76,54
PAN	Filler	0,00	9,07	24,38	33,45
Aggregate Total Weight					1134
ASPHALT Weight (6%)					72,00
Total					1200,00

Source: Civil engineering laboratory test results, UNIFA, Irmawan 2022

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Table 9. Optimum Asphalt Content 7%

Filter	Aperture	Chipping	Sand	Stone dust	Total
No.	(mm)	(gr)	(gr)	(gr)	(gr)
3/4"	19,00	0,00	0	0	0
1/2"	12,50	139,16	0	0	139,16
3/8"	9,50	271,87	0	0	271,87
4	4,75	537,57	0	0	537,57
8	2,36	0,00	12,28	46,87	59,15
200	0,075	0,00	34,60	40,73	75,33
PAN	Filler	0,00	8,93	23,99	32,92
Aggregate Total Weight					1116
ASPHALT Weight (7%)					84,00
Total					1200,00

Source: Civil engineering laboratory test results, UNIFA, Irmawan 2022

Table 10. Optimum Asphalt Content Test Results

Asphalt content	Content weight	VIM	VMA	VFB	Stability (Kg)	Flow (mm)	Marshall coefficient (Kg/mm)
4,00	2,010	27,010	34,550	21,840	156,38	3,02	51,781
5,00	2,010	26,920	34,470	21,900	364,08	3,42	106,46
6,00	2,060	23,490	34,330	33,760	429,73	3,48	123,49
7,00	2,040	24,300	35,710	37,470	1605,54	3,26	492,50

Source: Civil engineering laboratory test results, UNIFA, Irmawan 2022

Marshall Test

The Marshall test aims to measure the durability (stability) of a mixture of aggregate, asphalt against plastic melting (flow) and Marshall Quotient, which is a value of pseudo stiffness. Another important parameter is void analysis consisting of Void In the Mix (VIM).),

It can be seen in table 9. the results of the Marshall Test of the Road Engineering Association of Malaysia (REAM.) specifications.

Table 11. Marshall Parameters Specifications Road Engineering Association of Malaysia (REAM)

No	Test parameters		Varia	tion	of	coal fly	ash	Specification
		0%	2%	3%	4%	5%	6%	
1	VMA	37,12	35,41	39,59	34,86	28,85	36,89	Min 16%
2	VFB	27,29	29,37	24,57	30,08	39,70	27,53	70-80 (%)
3	VIM	27.00	25,02	29,99	24,51	17,54	26,87	18 -25 (%)
4	Stability	183,77	362,89	421,38	408,25	244,71	286,49	Min 350
5	Flow	3,02	3,42	3,48	3,26	1,76	2,58	2’-4’
6	Marshall quitient	46,35	106,94	121,20	125,36	139,04	111,19	Min 200

Source: Civil engineering laboratory test results, Irmawan, 2022

VMA (Voids in Mineral Aggregate)

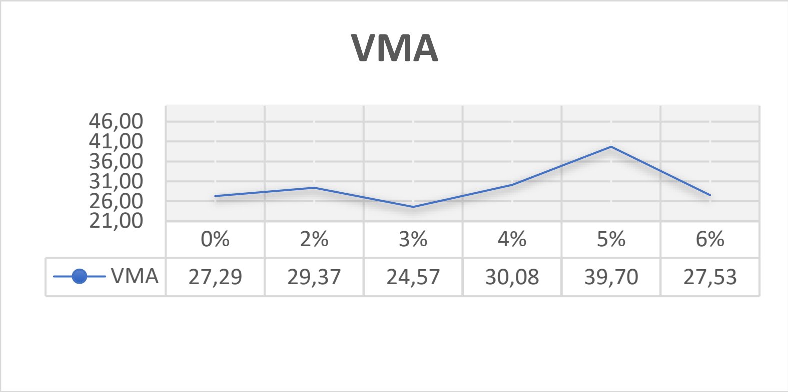

Figure 2. The results of the VMA Road Engineering Association of Malaysia (REAM) scores

Based on Figure 2. Shows the results of testing the VMA value without the addition of a mixture of coal flyash waste 0% = 37.12, at a mixture of 2% coal flyash waste shows a decrease in the volume yield of the number of voids between mineral aggregates, namely 35.41. The mixture in the percentage of coal flyash waste 3% = 39.59 and 6% = 36.89 there was an increase, while the mixture of coal flyash waste 4% = 34.86 and 5% = 28.85 there was a decrease in the volume of the number of voids between minerals aggregate. The VMA test results meet the Road Engineering Association of Malaysia (REAM) specifications that have been required, which is 16%.

VIM (Void In Mix).

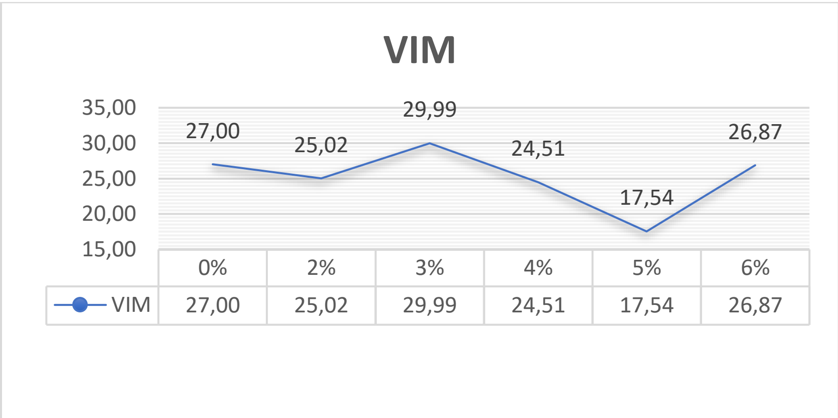

Figure 3. The results of the VIM Road Engineering Association Of Malaysia (REAM) scores

Based on Figure 3. Showing the results of testing the VIM value without the addition of a mixture of coal flyash waste 0% = 27.00, at a mixture of 2% = 25.02, 4% = 24.51, and 5% = 17.54 coal flyash waste showed a decrease in cavity yield. air in the mixture. The mixture at the percentage of coal flyash waste 3% = 29.99 and 6% = 26.87 there was an increase. From the VIM test results that do not meet the specifications, the percentage of coal flyash waste is 0%, 2%, 3%, 5%, and 6%. Meanwhile, the percentage of coal flyash waste that meets the specifications is 4%. The Road Engineering Association of Malaysia (REAM) specifications that have been required are 18%-25%.

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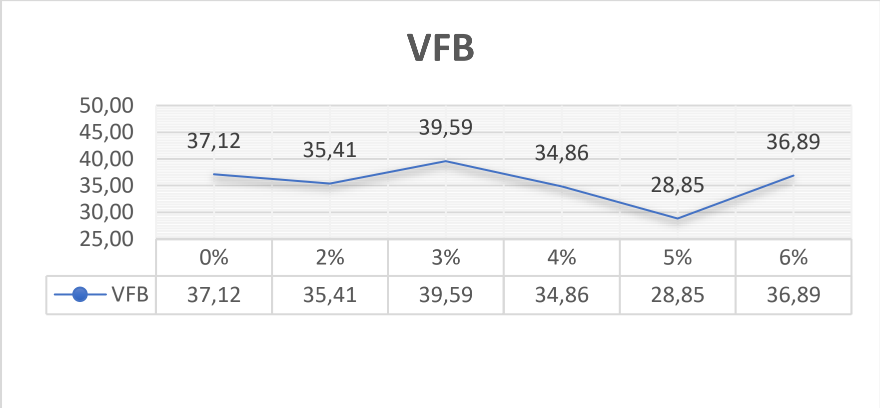
VFB (Voids Filler in Bitumen)

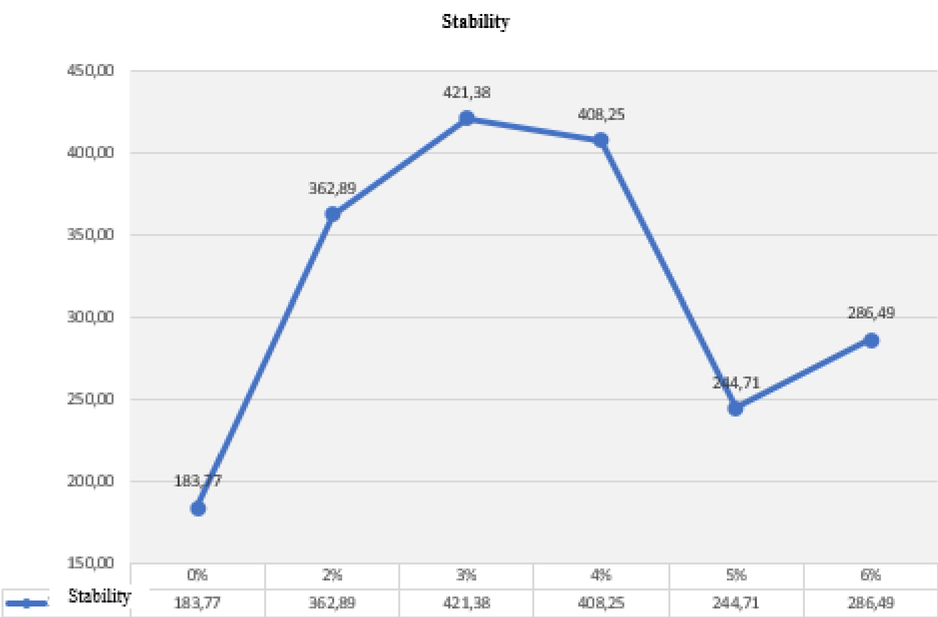


	0%	2%	3%	4%	5%	6%
VFB	37,12	35,41	39,59	34,86	28,85	36,89

Figure 4. Results of VFB Road Engineering Association of Malaysia (REAM) scores

Based on Figure 4 Shows the results of testing the VFB value without the addition of a mixture of coal flyash waste 0% = 27.29, in a mixture of coal flyash waste percentage 2% = 29.37, 3% = 24.57, 4% = 30.08, 5% = 39.70, and 6% = 27.53. From the percentage above, the results of testing the VFB value of all coal flyash waste mixtures do not meet the required specifications, namely 70%-80%.

Stability



	0%	2%	3%	4%	5%	6%
Stability	183,77	362,89	421,38	408,25	244,71	286,49

Figure 5. Results of Road Engineering Association Of Malaysia (REAM) Stability scores.

Based on Figure 5. Shows the results of stability testing without the addition of a mixture of coal flyash waste 0% = 183.77, in a mixture of coal flyash waste percentage 2% = 362.89, 3% = 421.38, 4% = 408.25, increased, while at 5% = 244.71 , and 6% = 286.49, the percentage of coal flyash waste decreased. It can be said that the lower the value on the percentage of use of coal flyash waste, the higher the value obtained, on the contrary, the lower the value on the percentage of use of coal flyash waste, the smaller the value obtained. From the percentage above, the results of testing the Stability value on a mixture of coal flyash waste at 2%,3%, and 4% meet the specifications, while at 5% and 6% do not meet the required specifications, namely Min 350kg.

Flow

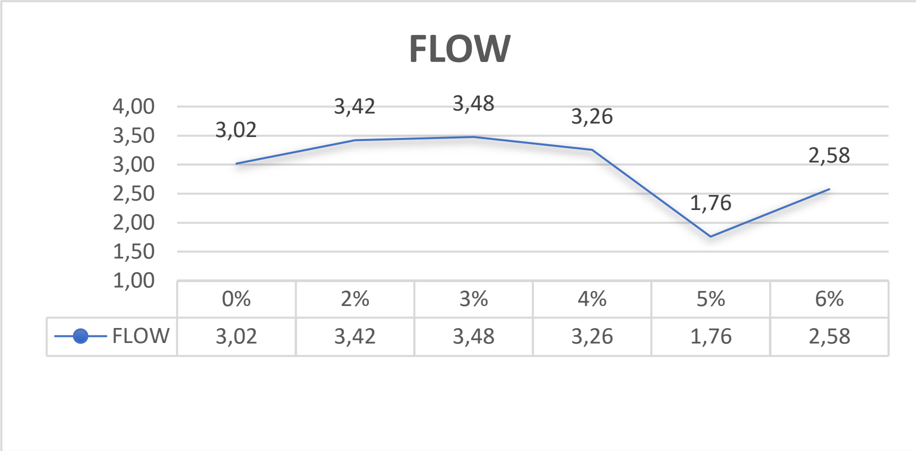


Figure 6. The results of the Flow Road Engineering Association of Malaysia (REAM) scores.

From the research conducted, Figure 6. Shows the results of testing the Flow value without the addition of a mixture of coal flyash waste 0% = 3.02, in a mixture of coal flyash waste percentage 2% = 3.42 3% = 3.48, 4% = 3.26, 5% = 1.76, and 6% = 2.58. From the percentages above, the results of testing the Flow values that meet the required specifications are 0%,2%,3%,4%, and 6%, while the 5% percentage does not meet the Road Engineering Association Of Malaysia (REAM) specifications, namely 2 -4 mm.

Marshall Quitient

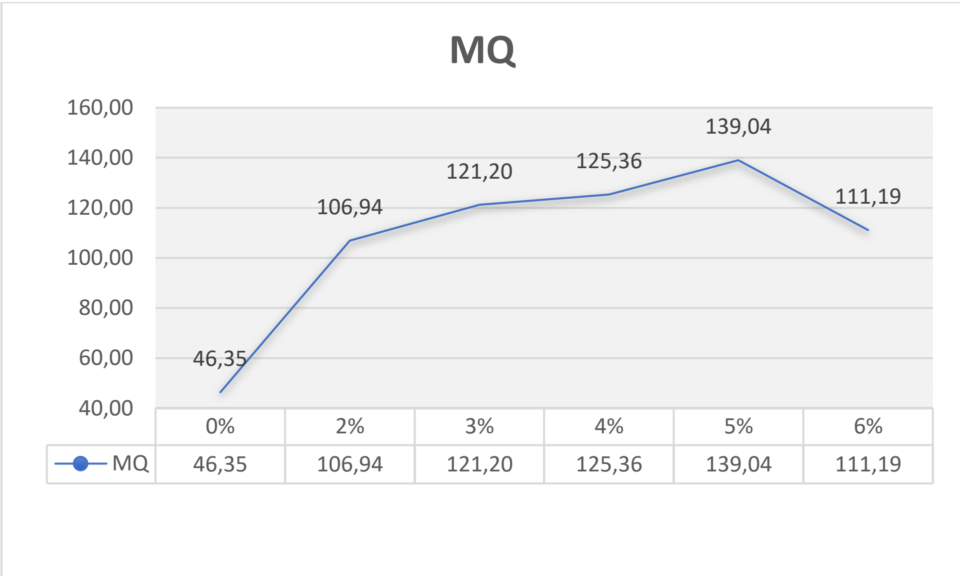


Figure 7. The results of the Road Engineering Association of Malaysia (REAM) MQ scores.

Based on Figure 7. Shows the results of testing the MQ value without the addition of a mixture of coal flyash waste 0% = 46.35, in a mixture of coal flyash waste percentage 2% = 106.94, 3% = 121.20, 4% = 125.36 , 5% = 139.04, and 6% = 111.19. From the percentage above, the results of testing the MQ value of all coal flyash waste mixtures do not meet the required specifications, namely Min 200 kg.

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Cantabro Test

Cantabro testing is carried out to evaluate the resistance of the asphalt mixture to grain release, an abrasion test can be carried out (Cantabrian Test). The compacted test object (briquette) is inserted into the Los Angeles machine drum to determine the wear of the test object.

After completion of the test object is removed and weighed to determine the weight after abrasion (Mi). Based on the specifications of the Road Engineering Association of Malaysia (REAM,) which requires the maximum weight loss value of porous asphalt is not more than 20%,

Gradation	BGA Level	Sample	Asphalt content	Weight before testing (Mo)	Weight after testing (Mi)	Lose weight	Average weight loss			Specification
						Mo-Mi	(Mo-Mi) / Mo	x	100	
Tipe	%	No.	%	Kg	Kg	Kg	%			%
Ream 0%	5,5	1	5,5	1200	466	734	61,17			Max. 20
		2		1215	989	226	18.60			
		3		1210	1008	202	16.69			
			Average				32.15			
Ream 2%	5,5	1	5,5	1206	462	744	61.69			Max. 20
		2		1220	1165	55	4,51			
		3		1225	1156	69	5.63			
			Average				23,94			
Ream 3%	5,5	1	5,5	1204	1121	83	6.89			Max. 20
		2		1210	1115	95	7.85			
		3		1200	1070	130	10.83			
			Average				8.53			
Ream 4%	5,5	1	5,5	1210	1105	105	8.68			Max. 20
		2		1200	775	425	35.42			
		3		1211	1106	105	8.67			
			Average				17.59			
Ream 5%	5,5	1	5,5	1200	1159	41	3.42			Max. 20
		2		1210	1195	15	1.24			
		3		1215	1163	52	4,28			
			Average				2,98			
Ream 6%	5,5	1	5,5	1215	1170	45	3.70			Max. 20
		2		1245	1190	55	4,42			
		3		1200	1165	35	2.92			
			Average				3.68			

Figure 8. Cantabro Test Results

Source: Civil engineering laboratory test results, Irmawan, 2022

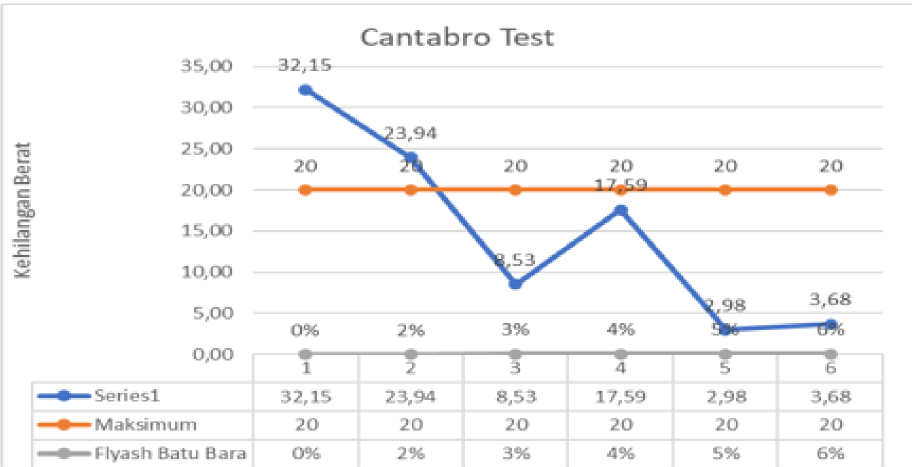

Figure 9. Graph of Weight Loss Value

In Figure 9, it can be seen the relationship between the value of weight loss and the variation of coal flyash waste. And the required weight loss value is based on the Road Engineering Association Of Malaysia (REAM) specification, which should not be more than 20%. And from the variations of the coal flyash waste used that meet the specifications only the percentage of coal flyash waste is 3%, 4%, 5%, and 6%.

CONCLUSION

Based on the results of the analysis of data testing and discussions that have been carried out, it can be concluded as follows, the results of testing the optimum asphalt content that have been carried out in the laboratory on test objects with variations in asphalt content of 4%, 5.%, 6%, and 7%, produce a grade value The best optimum asphalt to use is the optimum asphalt content of 5.5%. Based on the results of the Marshall Test with variations of coal flyash waste in the Road Engineering Association Of Malaysia (REAM) Specifications for the VMA value all meet the specifications, for the VFB and MQ values for the variation of coal flyash waste all do not meet the specifications, so it can be said that the VMA value inversely proportional to the value of VFB and MQ. The VIM value for the percentage of coal flyash waste variation of 0%,2%,3%,5%, and 6% did not meet the specifications, while 4% had met the specifications. For the results of the Stability values for variations in coal flyash waste 0%, 5%, and 6% did not meet the specifications, while the percentage of coal flyash waste at 2%, 3%, and 4%, had met the specifications. For the results of the Flow values for variations in coal flyash waste 0%, 2%, 3%, 4%, and 6% have met the specifications, and for variations of coal flyash waste at 5% did not meet the specifications. Based on the results of the Cantabro Test, the Road Engineering Association Of Malaysia (REAM) specification on coal flyash waste 0% and 2% did not meet the specifications, while the variations in coal flyash waste 3%,4%,5%, and 6% had met the specifications. . The higher the percentage of coal flyah waste, the smaller the loss value in the hollow asphalt mixture.

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