The Use of Red Brick Powder and Fly Ash As Filler On Asphalt Concrete - Binder Course

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Abstract. Road pavement planning is one of the determining factors in creating safe road infrastructure. One type of asphalt that is commonly used is flexible pavement with a surface layer of asphalt concrete (Laston). To increase the durability of road pavement, this can be done by making changes to the physical and chemical properties of the road pavement, by replacing the building of materials pavement. This research uses a comparison of red brick powder and fly ash as filler asphalt. The chemical structure of red brick powder and fly ash has similarities to pozzolan cement compounds, with silica content which is expected to reduce asphalt content and increase mixture stability. This research was carried out with variations in asphalt content of 5%, 5.5%, and 6% with an Optimum Asphalt Content (KAO) of 5.89%. The filler material used is Red Brick Powder (SBM) and Fly Ash (FA), with the filler structure used being 100% cement, 25% SBM : 75% FA, 50% SBM : 50% FA, and 75% SBM : 25% FA. The results of data analysis show that the comparison that has the most optimum value is the ratio of 25% SBM : 75% FA with a Stability value of 1509.018 kg, a Flow value of 3.070 mm, a VIM value of 3.658%, a VFA value of 75.351%, a VMA value of 14.770%, and a Marshall Quotient value of 491.563 kg/mm.

Keywords: Asphalt Concrete, Red Brick Powder, Fly Ash, Marshall, AC – BC

1 Introduction

1.1 Background

The durability of pavement construction is determined based on the type of pavement used and the quality of the material. Flexible pavement with a surface layer of asphalt concrete (Laston) is a type of road pavement that is generally used. One of them is Layers Asphalt Concrete Binder Course (AC-BC), which functions to withstand the traffic load received and then transmit it to the upper foundation asphalt layer.

Many studies focus on increasing the durability of road pavement, one of which is changing the physical and chemical properties of road pavement by replacing one of the building materials with another material, such as replacing the asphalt materials filler. The replacement of this material is expected to reduce pavement costs with

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better quality asphalt concrete, extend road service time, and meet technical requirements for use as road pavement material.

Filler has a functions as a complement to the aggregate gradation line so that the asphalt's resistance to high temperatures will increase, and can prevent deformation of the pavement. Filler commonly used is Portland cement because the content in it can increase binding power and stability. Other alternative materials that can be used as fillers are red brick powder and fly ash.

1.2 Research Objectives

The aim of this research is to determine the effect of red brick powder and fly ash as filler on the layer Asphalt Concrete Binder Course (AC-BC) to the Marshall Characteristic Value.

2 Literature Review

2.1 Road Paving

Pavement, or hard layer, is an additional layer between the ground and the wheels that is composed of the best-choice materials made with the aim of reducing deformation of the ground, which is usually not strong enough and resistant to a load. Road pavement is a layer of pavement located between the subgrade layer and vehicle wheels, which functions to provide transportation services, and during the service period, it is hoped that no significant damage will occur [6].

2.2 Filler Material

Filler is the finest mineral of asphalt concrete aggregate with a size of less than sieve number 200 and must not contain moisture. The ideal material that is commonly used as filler is cement portland, which is packed in bags until it is free from moisture. Being moisture-free is very important because filler doesn't go through the heating machine but goes straight into the pumpmill through screw intrusion.

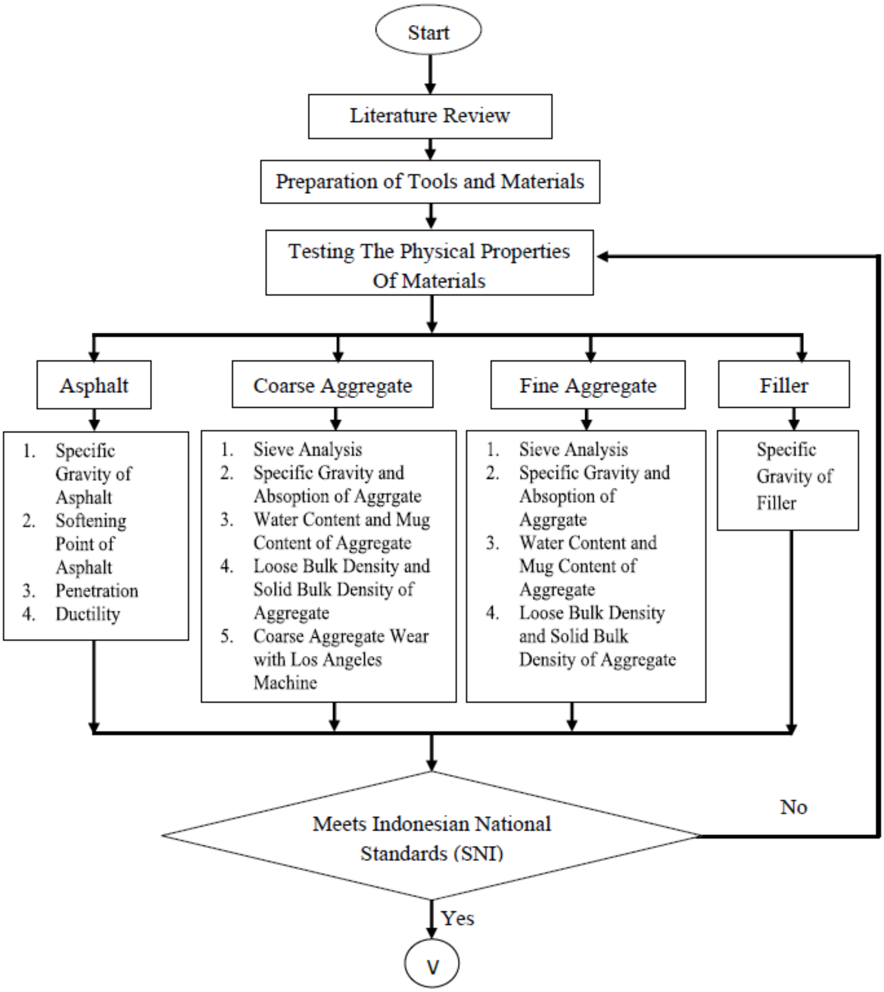
2.3 Red Brick

Bricks are stones made for construction purposes, such as making walls. The basic material for making red bricks is plastic properties. Clay, as the basic material for making red bricks is burned at a high temperature above 800°C until it hardens like stone. According to Lasmini & Arifin (2009), the use of silica in asphalt mixtures can increase the potential stability and durability of an asphalt mixture. The chemical structure of red brick powder and fly ash has similarities to pozzolan cement compounds, with silica content, which is expected to reduce asphalt content and increase mixture stability.

3 Research Methodology

This research was carried out at the Material Testing Laboratory of the Civil Engineering Department, State Polytechnic of Sriwijaya. The testing standards refer to the general specifications for Bina Marga 2018 Revision 2. The research stages carried out are the preparation stage, material testing stage, manufacturing test object stage, and object testing stage.

The material used in this research is solid asphalt with a penetration of 60/70 from PT. Hakaaston, coarse aggregate sizes 2/3, 1/2, and 1/1 from Lahat, fine aggregate from Tanjung Raja, filler is cement type 1 from PT. Semen Baturaja, red brick powder from Sukarami, Palembang, and fly ash which comes from PT. Bukit Asam Tbk, Tanjung Enim. This research methodology is shown in the research flow diagram as follows:



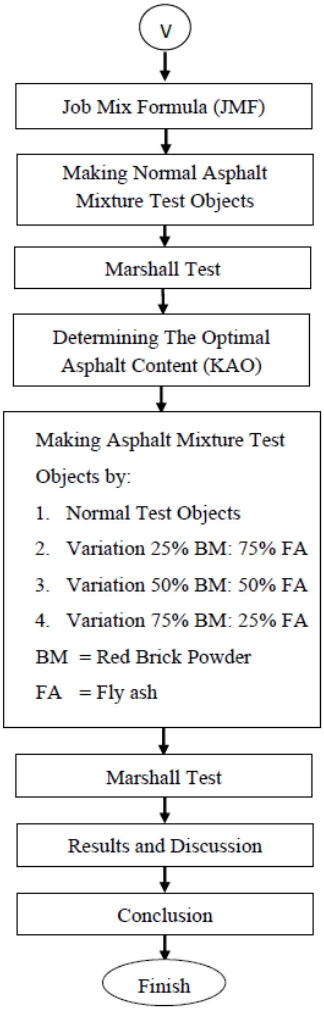


Fig. 1. Research Flow Diagram

4 Results and Discussion

4.1 Aggregate Physical Properties Test Results

In this research, the coarse aggregate used from Lahat, and fine aggregate comes from Tanjung Raja. Recapitulation testing results from the physical properties of coarse aggregate that carried out on coarse aggregate 2/3, coarse aggregate 1/2, and coarse aggregate 1/1 are shown in Table 1. And the recapitulation testing results from the physical properties of fine aggregate, which is sand, is shown in Table 2. as follows:

Table 1. Recapitulation Testing Results From The Physical Properties Of Coarse Aggregate

Test Type	Results Coarse Aggregate			Unit
	2/3	1/2	1/1	
Sieve Analysis	9,064	8,042	6,504	-
Bulk Specific Gravity	2,575	2,570	2,543	-
SSD Specific Gravity	2,612	2,602	2,581	-
Apparent Specific Gravity	2,672	2,655	2,644	-
Effective Specific Gravity	2,624	2,613	2,593	-
Absorption	1,407	1,244	1,492	%
Water Content	2,412	0,888	0,273	%
Mud Content	0,174	0,197	0,453	%
Loose Bulk Density	1,373	1,225	1,214	gr/cm^3
Solid Bulk Density	1,534	1,442	1,416	gr/cm^3
Test objects that penetrate a 2.36 mm sieve (impact value)	20,273			%
Test objects that penetrate a 2.36 mm sieve (Los Angeles Abrasion)	29,346			%

Table 2. Recapitulation Testing Results From The Physical Properties Of Fine Aggregate

Test Type	Results	Unit
Sieve Analysis	3,364	-
Bulk Specific Gravity	2,505	-
SSD Specific Gravity	2,521	-
Apparent Specific Gravity	2,547	-
Effective Specific Gravity	2,526	-
Absorption	0,664	%
Water Content	4,286	%
Mud Content	0,928	%
Loose Bulk Density	1,209	gr/cm^3
Solid Bulk Density	1,361	gr/cm^3

4.2 Filler Test Results

This research uses filler, which is Portland cement Type 1, red brick powder, and fly ash. Test recapitulation results are shown in Table 3 as follows:

Table 3. Recapitulation Testing Results From The Physical Properties Of Filler

Test Type	Results	Unit
Specific Gravity of Portland Cement	3,019	gr/cm^3
Specific Gravity of Red Brick Powder	3,048	gr/cm^3
Specific Gravity of Fly Ash	3,033	gr/cm^3

4.3 Asphalt Test Results

This research uses solid asphalt with penetrations of 60/70. Test recapitulation results are shown in Table 4 as follows:

Table 4. Recapitulation Testing Results From The Physical Properties Of Asphalt

Test Type	Results	Unit
Specific Gravity of Asphalt	1,045	-
Softening Point of Asphalt	49,7	°C
Penetration	60/70	mm
Ductility	135,125	cm

4.4 The Test Result of Marshall Test Object

Marshall Test Results to Obtain Optimum Asphalt Content (KAO). The composition of the mixture used to make the test specimens is the result of an aggregate mixture design obtained from test results with asphalt variations of 5%, 5.5%, and 6% as shown in Table 5 as follows:

Table 5. Recapitulation Marshall Testing Results To Obtain Optimum Asphalt Content (KAO)

Mixture Characteristics	Unit	Asphalt Content (%)			Specs
		5	5,5	6	
Stability	kg	1501,58	1404,47	1512,02	Min 800
Flow	mm	3,13	3,21	3,57	2-4
VIM	%	6,69	5,79	4,23	3-5

VFA	%	57,78	63,70	72,72	Min 65
VMA	%	15,83	15,95	15,47	Min 14
Marshall Quotient	kg/mm	479,51	437,94	423,87	-

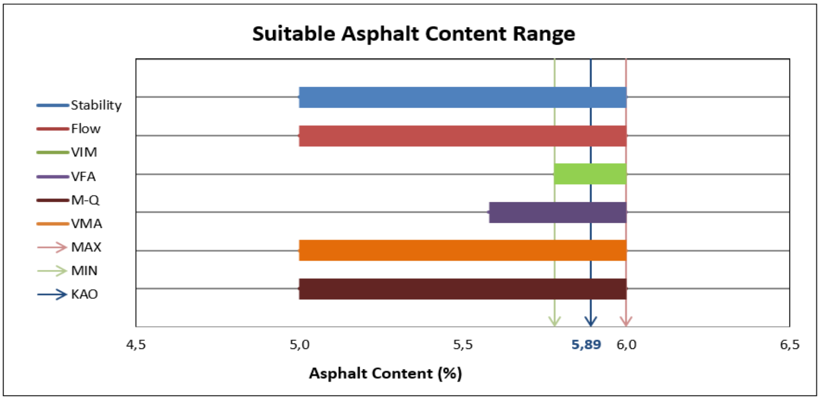


Fig. 2. Graph Of Recapitulation Marshall Testing Results To Obtain Optimum Asphalt Content (KAO)

The graph above shows that the variation in asphalt content that meets the General Specifications for Bina Marga 2018 Revision 2 is a variation in asphalt content of 5.78% to 6.0%. So it can be concluded that the Optimum Asphalt Content (KAO) for this research is 5.89%.

Marshall Test Results with Red Brick Powder and Fly Ash as Asphalt Mixture Filler. The proportion of red brick powder and fly ash as a asphalt mixture filler at an asphalt content of 5.89% obtained from Marshall test results, shown in Table 6 as follows:

Table 6. Recapitulation Of Marshall Test Results With Red Brick Powder And Fly Ash As Filler Material

Proportion of Red Brick Powder (SBM) and Fly Ash (FA)	Mixture Characteristics					
	Stability	Flow	VIM	VFB	VMA	MQ
25% SBM : 75% FA	1509,01	3,07	3,65	75,35	14,77	491,56
50% SBM : 50% FA	1493,67	3,23	3,55	75,86	14,67	462,20
75% SBM : 25% FA	1304,52	3,44	3,39	76,80	14,53	379,12
Specification	Min. 800 Kg	2-4 mm	3-5 mm	Min. 65%	Min. 14%	- Kg/mm

Analysis of Stability. Figure 3 shows that the proportion with the greatest stability value is 25% SBM: 75% FA, while the other two proportions produced lower stability values. Based on the General Specifications for Bina Marga 2018 Revision 2, the standard Marshall stability value for modified asphalt is a minimum of 1000 kg, so it can be concluded that the stability value for all variations meets the standard.

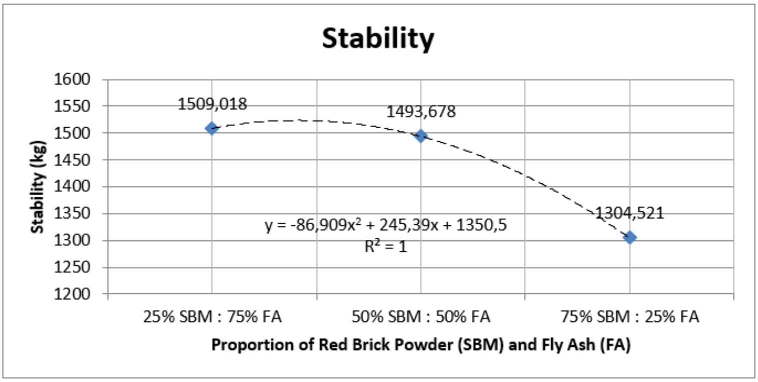


Fig. 3. Graph Of Analysis Marshall Test Results For Modified Asphalt To Stability Value

Analysis of Flow. Figure 4 shows that the flow value increased. An increase in flow value causes the potential for asphalt concrete to cracking became smaller, while the potential for asphalt concrete to bleeding increases. Based on the General Specifications for Bina Marga 2018 Revision 2, the standard values of the value flow for modified asphalt are a minimum of 2 mm and a maximum of 4 mm, so it can be concluded that the value flow in all variations meets the standards.

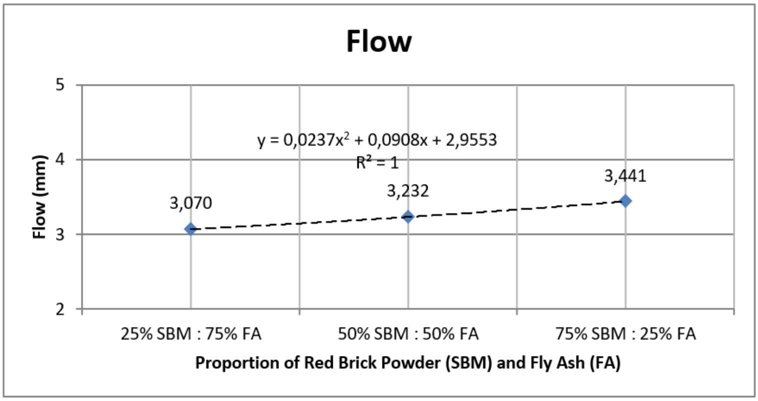


Fig. 4. Graph Of Analysis Marshall Test Results For Modified Asphalt To Flow Value

Analysis of VIM. Figure 5 shows that the VIM value has decreased. A decrease in the VIM value can cause the water tightness of asphalt concrete to increase, causing a decrease in the asphalt concrete oxidation process, which can slow down asphalt aging. This means that the potential for asphalt concrete to be stiffer is smaller, which increases the durability properties of asphalt concrete. Based on the 2018 General Bina Marga Specifications Revision 2, Marshall's standard VIM value for modified asphalt is a minimum of 3% and a maximum of 5%, so it can be concluded that the VIM value of all variations meets the standard.

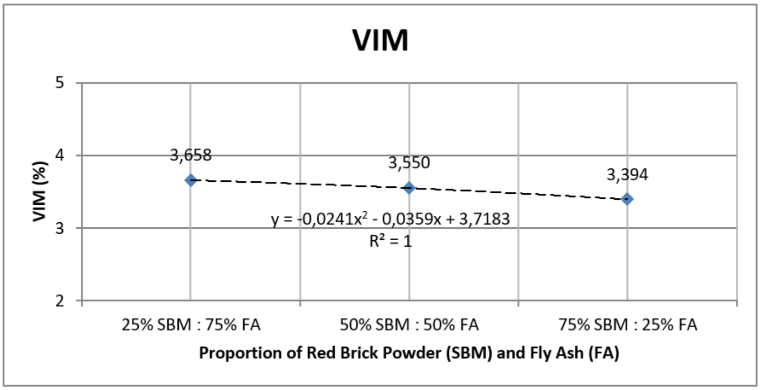


Fig. 5. Graph Of Analysis Marshall Test Results For Modified Asphalt To VIM Value

Analysis of VFA. Figure 6 shows that the VFA value has increased. The larger voids in the aggregate can cause voids filled with asphalt is larger too. Based on the 2018 General Bina Marga Specifications Revision 2, the Standard Marshall VFA value for modified asphalt is a minimum of 65%, so it can be concluded that the VFA value of all variations meets the standard.

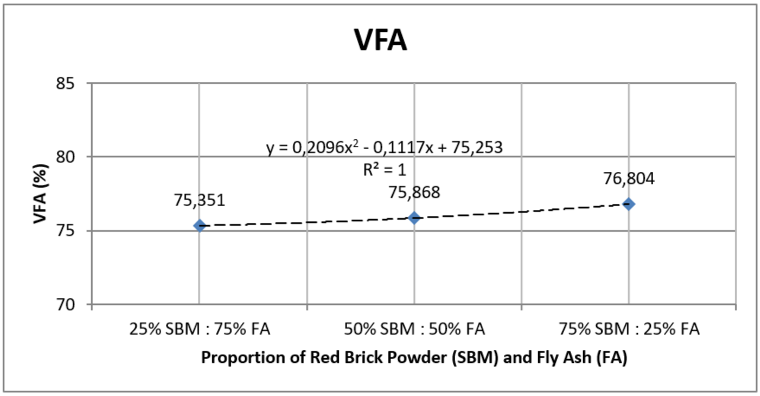


Fig. 6. Graph Of Analysis Marshall Test Results For Modified Asphalt To VFA Value

Analysis of VMA. Figure 7 shows that the VMA value has decreased. As the VMA value decreases, the asphalt film will become thinner, which will affect the bleeding potensial of asphalt concrete gets smaller. Based on the 2018 General Bina Marga

Specifications Revision 2, the Standard Marshall VMA value for modified asphalt is a minimum of 14%, so it can be concluded that the VMA value for all variations meets the standard.

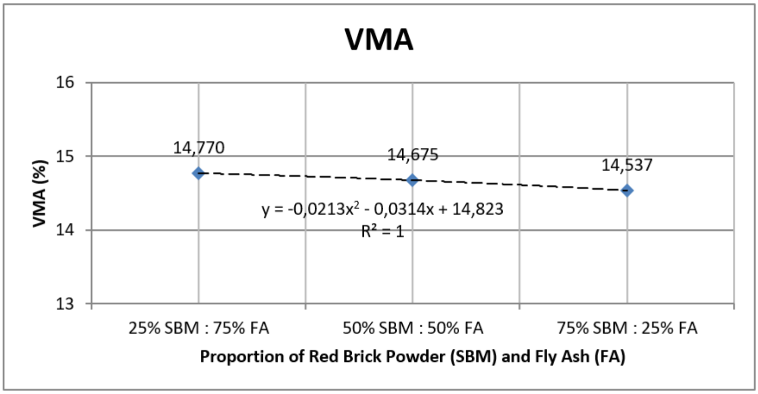


Fig. 7. Graph Of Analysis Marshall Test Results For Modified Asphalt To VMA Value

Analysis of Marshall Quotient. Figure 8 shows that the Marshall Quotient decreases. The decreasing of the Marshall Quotient value for asphalt concrete, which causes the stiffness of asphalt concrete is decrease too.

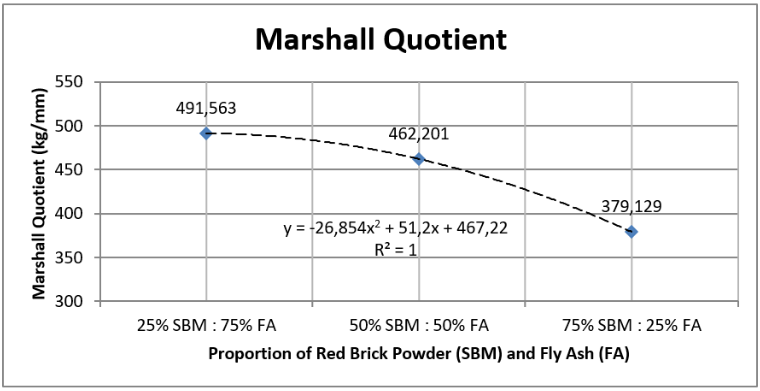


Fig. 8. Graph Of Analysis Marshall Test Results For Modified Asphalt To VMA Value

4.5 Discussion

Based on the analysis test results showed the proportion that has the most optimum value is 25% SBM: 75% FA with a Stability value of 1509.018 kg, a Flow value of 3.070 mm, a VIM value of 3.658%, a VFA value of 75.351%, a VMA value of 14.770%, and a Marshall Quotient value of 491.563 kg/mm. All Marshall characteristic values meet the 2018 General Bina Marga Specifications Revision 2.

5 Conclusion

Based on discussion and analysis of test result data in research on The Use of Red Brick Powder and Fly Ash As Filler On Asphalt Concrete - Binder Course to Marshall Characteristic Values, Researchers draw the following conclusions:

1. Based on Marshall test results with a variation in asphalt content of 5%, 5.5%, and 6%, the Optimum Asphalt Content (KAO) value is 5.89%.
2. Based on Marshall test results using Red Brick Powder and Fly Ash according to the standards of the General Specifications for Bina Marga 2018 Revision 2, it can be concluded that the stability value of all variations meets the specification standards with a minimum of 1000 kg; at a flow value, all variations meet the specification standard of 2–4 mm; at the VIM value, all variations meet the specification standard of 3%–5%; at the VFA value, all variations meet the specification standard, with a minimum of 65%; at the VMA value, all variations meet the specification standard with a minimum of 14%; and the most optimum Marshall Quotient value is on 25% SBM : 75% FA proportion.
3. Based on the results of the Marshall test analysis with a proportion of red brick powder and fly ash as a filler in the asphalt mixture, it can be concluded that the most optimum value and one that meets all standards of the General Specifications for Highways 2018 Revision 2 is an asphalt mixture with a proportion of red brick powder and fly ash is 25% SBM : 75% FA, with a stability value of 1509.018 kg, a flow value of 3.070 mm, a VIM value of 3.658%, a VFA value of 75.351%, a VMA value of 14.770%, and a Marshall Quotient value of 491.563 kg/mm.

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