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The Effect of Using Low Density Polyethylene (LDPE) and High Density Polyethylene (HDPE) Plastic Waste in the Asphalt Concrete Wearing Course (AC-WC) Comparsion of Marshall Characteristics

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Abstract:- Increasing the quality of hot asphalt mixtures is continuously carried out with various kinds of experiments, one of which is by mixing additives in the form of polymers. LDPE (Low Density Polyethylene) and HDPE (High Density Polyethylene) are polyethylene chain structures that can be found in daily life, such as the form of plastic food wrappers, plastic bags and shopping bags. This study aims to compare the effect of using LDPE and HDPE plastic waste without the use of plastic waste on the characteristics of the hot asphalt mixture Marshall Asphalt Concrete Wearing Course (AC-WC). After obtaining the optimum asphalt content at 5.6%, the optimum plastic content for LDPE is 2.1% and HDPE is 2.4%. The results of the Marshall characteristic test showed that the stability value of the AC-WC hot asphalt mixture with the addition of HDPE plastic waste was higher, that was 1216 kg, compared to the addition of LDPE plastic which was 1130 kg and without the addition of 1211 kg plastic. The value of flow in the addition of LDPE plastic had the highest value, 3.53 mm compared to the addition of HDPE plastic, 3.27 mm and without the addition of plastic which had the lowest value, 3.20 mm. From the results of residual stability testing with IKS (Residual Strength Index), the addition of LDPE plastic was 95.6% and HDPE 93.7%, while without the addition of plastic it was 90.3%.

Keyword *: Asphalt Mixtures, LDPE, HDPE, Plastic Waste, Marshall Characteristic.*

I. INTRODUCTION

At this time transportation is very important for society. It can be found at this time that almost all of them have vehicles, even though each of them has the least two-wheeled vehicle. Transportation is absolutely necessary for everyone. However, the excessive use of transportation will have an impact on the arrangement of the pavement itself.

According to Tjitjik WS (2008), the growth of traffic into heavy and dense traffic is due to the rapid population growth followed by an increase in the need for food, shelter and clothing which causes the pavement to be damaged before the service life is passed where currently there are several sections of road pavement that have no longer able to accommodate the capacity / load of passing vehicles. Apart from that, the weather factor also affects the asphalt immediately due to the weather being oxidized by the sun.

The quality improvement of the asphalt mixture is often carried out by experts using asphalt modified with polymeric materials. Apart from pure additives, polymer materials can also be obtained through the extraction process from plastic waste. There are 2 types of plastics that are often used in previous studies, namely LDPE and HDPE. Each type of plastic waste produces different asphalt characteristics depending on the percentage of the mixture of asphalt and the plastic waste used.

This study aims to compare the effect of using plastic and without the use of plastic on laston WC, to compare the effect of using low density polyethylene (LDPE) and high density polyethylene (hdpe) plastic waste on laston WC, and to determine the percentage of mixtures of asphalt and plastic waste. the most optimum for testing the characteristics of Marshall.

II. RESEARCH METHODS

To complete the research, several stages are required as follows:

A. Preparation Of Tools And Materials

Materials and testing equipment for aggregate characteristics are test equipment owned by the Asphalt Mixing Plant Laboratory of PT. Kadi International unit Karangjati while testing the characteristics of asphalt using equipment at the Semarang State Polytechnic Laboratory.

B. Make Test Object

Starting with making a test object to get an estimate of the optimum asphalt content (OAC) with the following conditions:

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Table 1. Number of Marshall Test Objects to Get Optimum Asphalt Content

Asphalt Content	Number of Test Objects	Description
(Pb) + 1,5%	2	A mixture of aggregate to the specifications asphalt concrete wearing course + (Asphalt Content(Pb) + 1,5%).
(Pb) + 1,0%	2	A mixture of aggregate to the specifications asphalt concrete wearing course + (Asphalt Content(Pb) + 1,0%).
(Pb) + 0,5%	2	A mixture of aggregate to the specifications asphalt concrete wearing course + (Asphalt Content(Pb) + 0,5%).
(Pb)	2	A mixture of aggregate to the specifications asphalt concrete wearing course + (Asphalt Content(Pb)).
(Pb) - 0,5%	2	A mixture of aggregate to the specifications asphalt concrete wearing course + (Asphalt Content(Pb) - 0,5%).
(Pb) - 1,0%	2	A mixture of aggregate to the specifications asphalt concrete wearing course + (Asphalt Content(Pb) - 1,0%).
Total	12	

Source: Analysis Results (2020)

After obtaining the OAC value, it is continued by making the test object for testing the Marshall parameter according to table 2.

Table 2. Number of Marshall Test Objects to Get Optimum Plastic Content (OPC)

Type of Test Object	Plastic Content	Test Object Code	Number of Test Objects
WITHOUT PLASTIC	0%	A-1, A-2, A-3	3
LDPE	1%	L-1, L-2, L-3	3
	3%	L-4, L-5, L-6	3
	5%	L-7, L-8, L-9	3
	7%	L-10, L-11, L-12	3
HDPE	1%	H-1, H-2, H-3	3
	3%	H-4, H-5, H-6	3
	5%	H-7, H-8, H-9	3
	7%	H-10, H-11, H-12	3
TOTAL			27

Source: Analysis Results (2020)

After the marshall test is carried out, then the test object is made to test the stability of the remaining marshall with the number of test objects as follows:

Table 3. Number of Test Objects for Residual Stability Testing

Type of Test Object	Test Object Code	Number of Test Objects
LDPE	SL-1, SL-2, SL-3	3
HDPE	SH-1, SH-2, SH-3	3
TOTAL		6

Source: Analysis Results (2020)

C. Research Design

The research was carried out by making test objects with optimum asphalt content (OAC) obtained from the test results. Meanwhile, the ratio of adding LDPE and HDPE plastic waste was 1%, 3%, 5%, and 7% of the weight of asphalt.

The test was conducted to determine the comparison of the effect of using plastic waste and without the use of plastic waste on the Laston AC-WC hot mix concrete asphalt.

The test carried out in this study is to test the mixed properties with the Marshall method. The test procedure is based on SNI 06-2489-1991 or ASTM D 1559.

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D. Data Analysis

Make an analysis of the test results which include:

a. Calculating Marshall Quotient (MQ), Void in Mineral Aggregate (VMA), Void in the Mixed (VIM) and Void Filled with Asphalt (VFA).
b. Draw a graph of the relationship between asphalt content and Marshall parameters such as: Density, Marshall Stability, Marshall Flow, VFA, VIM, VMA and MQ.
c. Marshall Quotient (MQ), Void in Mineral Aggregate (VMA), Void in the Mixed (VIM) and Void Filled with Asphalt (VFA) after adding LDPE and HDPE plastics with a predetermined variation on optimum asphalt content.
d. Draw a graph of the relationship between plastic content and Marshall parameters such as: Density, Marshall Stability, Marshall Flow, VFA, VIM, VMA and MQ.
e. Make a comparison chart between test objects without the addition of plastic, test objects with the addition of LDPE plastic and test objects with the addition of HDPE plastic.

III. RESULTS AND DISCUSSION

The research was started by testing the basic characteristics of the materials, namely asphalt and aggregate, both coarse and fine, while the added material in the form of plastic waste was not tested.

A. Basic Characteristic Testing

a. Asphalt

The asphalt used is a pen shell 60/70 asphalt. Following are the results of testing the basic characteristics of asphalt;

Table 4. Summary of Asphalt Properties Testing Results

No.	Properties	Standard of Test Method	Unit	Spesification		Test Results
				Min	Max	
1.	Penetration at 25°C	SNI-06-2456-1991	mm	60	70	66.05
2.	Softening Point	SNI-06-2433-1991	°C	48	58	49
3.	Specific Gravity at 25°C	SNI-06-2441-1991	gr/cc	1.01	1.06	1.034
4.	Ductility at 25°C	SNI-06-2441-1991	Cm	100	-	> 100
5.	Loss on Heating	SNI-06-2440-1991	%	-	0.8	0.015
6.	Saybolt Furol Viscosity					
	Mixture Temperature (at viscosity of 170±20 cSt)	SNI-6721-2011	°C	155 ±1		151.8
	Compaction Temperature (at viscosity of 280±30 cSt)		°C	145 ±1		148.0

Source: Analysis of Testing Results (2020) and Bina Marga Specification (2018)

b. Aggregate

The aggregate used coarse and fine aggregate from Kandangan, Bawen, Semarang Regency. Following are the results of testing the basic characteristics of coarse and fine aggregates;

Table 5. Summary of Coarse Aggregate Physical Properties Testing Results

No	Properties	Standard of Test Method	Spesification		Unit	Test Result
			Min	Max		
	Coarse Aggregate					
1	Soundness	SNI 3407:2008	-	15	%	6.00
2	Abration with Los Angeles Machine	SNI 2417:2008	-	3	%	26.71
3	Coating and Stripping of Bitumen-Aggregate	SNI 2439:2011	95	-	%	98.00
4	Flat and Elongated Particles	ASTM D4791	-	10	%	4.01
5	Amount of material finer than 0.075 mm	SNI 03-4142-1996	-	2	%	0.44
6	Specific Gravity					
	Bulk Specific Gravity		2.5	-		2.62
	SSD Specific Gravity	SNI 1969:2008	-	-		2.65
	Apparent Specific Gravity		-	-		2.7
	Absorption		-	3	%	1.24

Source: Analysis of Testing Results (2020) and Bina Marga Specification (2018)

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Table 6. Summary of Fine Aggregate Physical Properties Testing Results

No	Properties	Standard of Test Method	Spesification		Unit	Test Result
			Min	Max		
	Fine Aggregate					
1	Amount of material finer than 0.075 mm	SNI 03-4142-1996		10	%	7.47
2	Specific Gravity					
	Bulk Specific Gravity		2.5	-		2.58
	SSD Specific Gravity	SNI 1969:2008	-	-		2.58
	Apparent Specific Gravity		-	-		2.72
	Absorption		-	3	%	1.56

Source: Analysis of Testing Results (2020) and Bina Marga Specification (2018)

From the results of the tests that have been carried out, each material has met the specifications required by Bina Marga.

B. Optimum Asphalt Content (OAC)

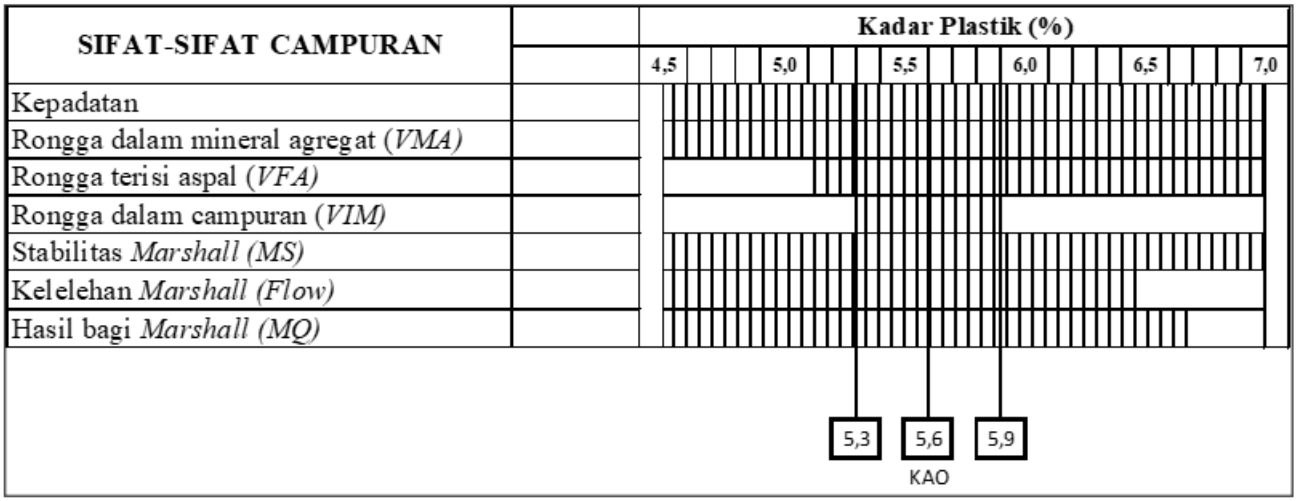
Before the Marshall test with the addition of LDPE and HDPE plastics, it is necessary to have Marshall testing on the test object with variations in asphalt content in the asphalt concrete wearing course (AC-WC) mixture. This had to be done to find the OAC was needed to achieve the best asphalt concrete wearing course (AC-WC) mixture, so that later in the manufacture of marshall specimens with variations of plastic waste substitution in the best composition conditions. In the calculation of the estimated asphalt content, the estimated asphalt content value (Pb) was 5.5%, so that the test objects were made with variations in asphalt content of 4.5%, 5%, 5.5%, 6%, 6.5% and 7%. The optimum asphalt content is sought by analyzing the relationship between variations in asphalt content with marshall parameters consisting of density, VMA (Void in Mineral Aggregate), VIM (Void In the Mix), VFA (Void filled with Asphalt), marshall stability,marshall flow, and marshall quotient. The results of the marshall test for finding OAC are presented in Table 7.

Table 7. Marshall Test Results for finding KAO

Description	Unit	Spesification		Asphalt Content (%)					
		min	max	4.5	5	5.5	6	6.5	7
Density	gr/cc	-		2.27	2.322	2.333	2.34	2.361	2.33
Void in Mineral Aggregate (VMA)	%	15		16.87	15.72	15.35	15.44	15.15	16.74
Void Filled with Asphalt	%	65		48.25	60.02	69.45	76.76	86.5	84.02
Void In the Mix (VIM)	%	3		8.73	6.3	4.7	2.43	2.41	2.33
Marshall Stability (MS)	kg	1000		1021.7	1112.46	1196.13	1196.52	1097.03	988.17
Marshall Flow	mm	2		2.69	2.86	3.02	3.26	4.14	4.57
Marshall Quotient	kg/mm	250		382.1	390.73	398.63	377.45	264.89	216.49

Source: Marshall Test Analysis Results (2020) and Bina Marga Specification (2018)

Table 8. Analysis of Marshall Test Results for finding OAC



Source: Marshall Test Analysis Results (2020) and Bina Marga Specification (2018)

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From the results of the Marshall test, it was found that the OAC value was 5.6% which was then used as a mix design with the addition of variations in the plastic content of LDPE and HDPE..

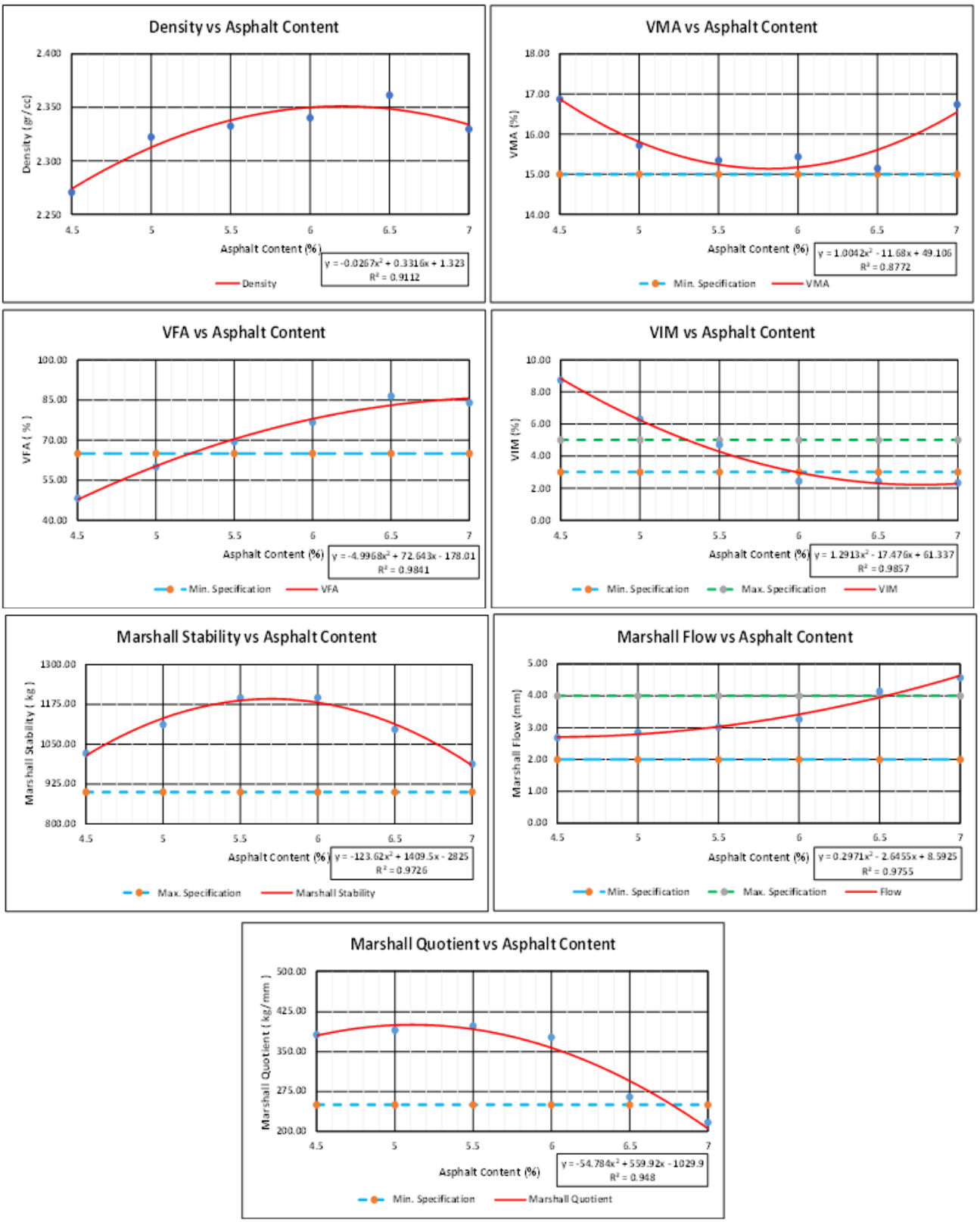

Fig 1. Marshall Test Design Summary to find OAC
Source : Marshall Test Analysis Results (2020)

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C. Optimum Plastic Content (OPC)

a. *Low Density Polyethylene (LDPE)*

Making marshall test objects for LDPE plastic content at optimum asphalt content, namely 5.6% with variations in plastic content of 1%, 3%, 5%, and 7% of the weight of asphalt according to table 2. Here are the results of marshall testing with variations in adding LDPE plastic content;

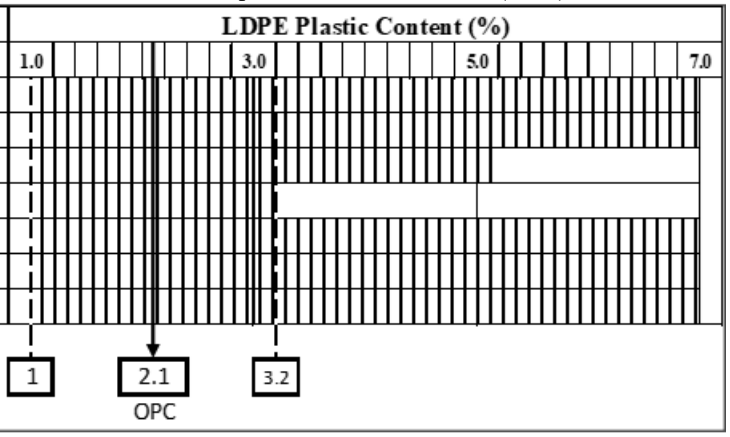
Table 9. Marshall Test Results to find LDPE Optimum Plastic Content (OPC)

Description	Unit	Spesification		Asphalt Content (5.6%) LDPE Plastic Content(%)			
		min	max	1	3	5	7
Density	gr/cc	-		2.330	2.330	2.320	2.300
Void in Mineral Aggregate (VMA)	%	15		15.54	15.71	16.21	17.09
Void Filled with Asphalt	%	65		69.3	68.39	65.83	60.92
Void In the Mix (VIM)	%	3		4.78	4.97	5.60	6.69
Marshall Stability (MS)	kg	1000		1057.57	1122.65	1262.69	1153.69
Marshall Flow	mm	2		3.83	3.43	3.17	3.27
Marshall Quotient	kg/mm	250		276.09	327.57	400.35	353.17

Source: Marshall Test Analysis Results (2020) and Bina Marga Specification (2018)

Table 10. Analysis of Marshall Test Results to find LDPE Optimum Plastic Content (OPC)

Description	LDPE Plastic Content (%)
Density	
Void in Mineral Aggregate (VMA)	
Void Filled with Asphalt	
Void In the Mix (VIM)	
Marshall Stability (MS)	
Marshall Flow	
Marshall Quotient	



Source: Marshall Test Analysis Results (2020) and Bina Marga Specification (2018)

From the Marshall test results, the LDPE optimum plastic content value was 2.1%.

b. *High Density Polyethylene (LDPE)*

Making marshall test objects for HDPE plastic content at optimum asphalt content, namely 5.6% with variations in plastic content of 1%, 3%, 5%, and 7% of the weight of asphalt according to table 2. Here are the results of marshall testing with variations in adding HDPE plastic content;

Table 9. Marshall Test Results to find the HDPE Optimum Plastic Content

Description	Unit	Spesification		Asphalt Content (5.6%) HDPE Plastic Content(%)			
		min	max	1	3	5	7
Density	gr/cc	-		2.331	2.335	2.321	2.286
Void in Mineral Aggregate (VMA)	%	15		15.59	15.55	16.16	17.52
Void Filled with Asphalt	%	65		68.95	69.31	65.85	58.7
Void In the Mix (VIM)	%	3		4.84	4.78	5.52	7.25
Marshall Stability (MS)	kg	1000		1045.3	1315.29	1358.29	1450.91
Marshall Flow	mm	2		3.97	3.7	3.63	3.33
Marshall Quotient	kg/mm	250		263.69	355.61	373.94	435.8

Source: Marshall Test Analysis Results (2020) and Bina Marga Specification (2018)

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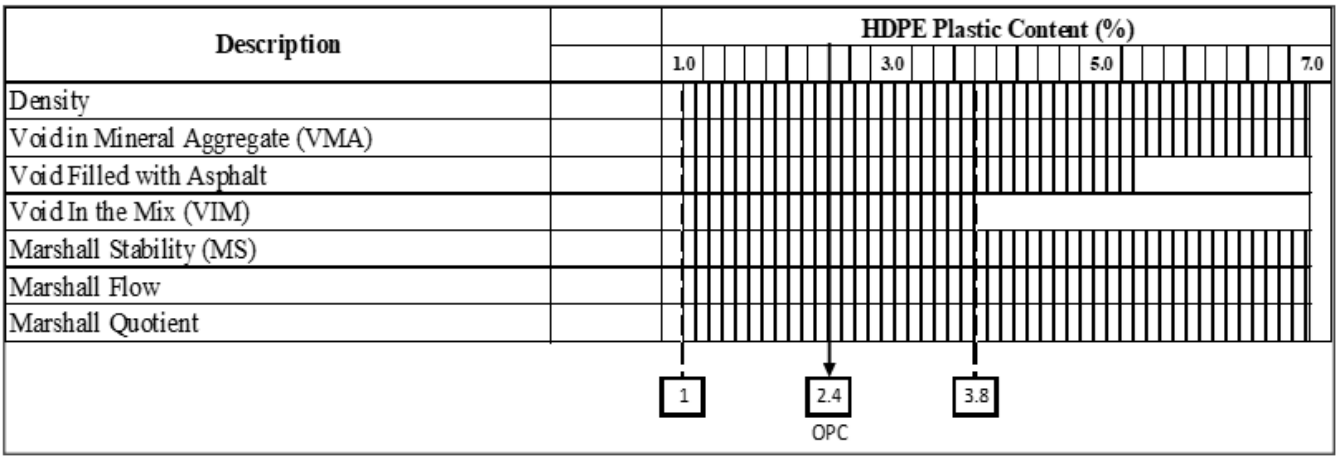
Table 10. Analysis of Marshall Test Results to find Optimum HDPE Plastic Content



Source: Marshall Test Analysis Results (2020) and Bina Marga Specification (2018)

From the marshall test results, the optimum HDPE plastic content value was 2.4%..

D. Comparison of Marshall parameter values and residual stability

a. Comparison of Marshall parameter values

At the optimum asphalt content of 5.6%, the optimum LDPE plastic content was 2.1% and the optimum HDPE plastic content was 2.4% made of test objects to be compared, with the optimum asphalt content of 5.6% as a comparison. Following are the test results and their discussion

Table 11. Marshall Laston WC Test Results on Optimum Asphalt Content, Optimum LDPE Plastic Content, and Optimum HDPE Plastic Content

Description	Unit	LDPE (2,1 %)	Without Plastic	HDPE (2,4 %)
Density	gr/cc	2.334	2.335	2.335
Void in Mineral Aggregate (VMA)	%	15.55	15.41	15.54
Void Filled with Asphalt	%	69.17	68.37	69.35
Void In the Mix (VIM)	%	4.79	4.88	4.77
Marshall Stability (MS)	kg	1130.00	1211.00	1216.00
Marshall Flow	mm	3.53	3.20	3.27
Marshall Quotient	kg/mm	319.85	382.67	373.10

Source: Marshall Test Analysis Results (2020) and Bina Marga Specification (2018)

From the test data above, then compared by making a bar graph between the LDPE plastic content of 2.1%, HDPE plastic content of 2.4% and asphalt content of 5.6% for each Marshall parameter. The comparison bar graph can be seen in Figure 2.

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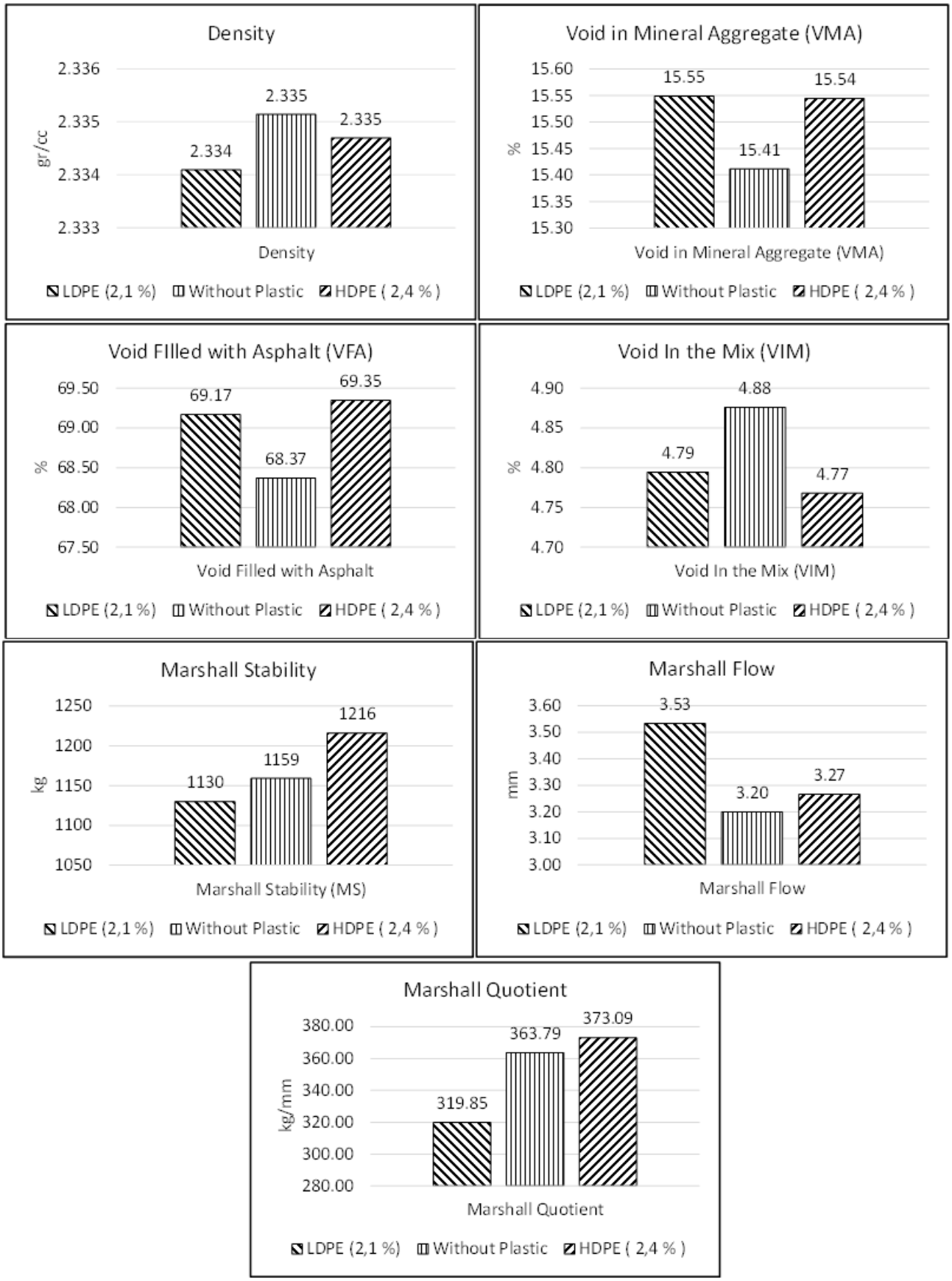

Fig 2 Bar Graph Comparison of Marshall Parameters on Optimum LDPE Plastic Content, Optimal Asphalt Content, and Optimum HDPE Plastic Content
Source : Marshall Test Analysis Results (2020)

The following is a description of the discussion of the results of Marshall stability testing at optimum LDPE plastic content, optimum asphalt content (without plastic), and optimum HDPE plastic content.

The density value between LDPE and HDPE asphalt concrete wearing course (AC-WC) and asphalt concrete wearing course without plastic has a small difference, namely 0.04% and 0.02% lower. The lowest density value is in asphalt concrete wearing course (AC-WC) with the addition of LDPE plastic, namely 2.334. Meanwhile, the highest is asphalt concrete wearing course (AC-WC) without the addition of plastic, namely 2,335. So it can be concluded that the addition of plastic to the mixture reduces the density of asphalt concrete wearing course (AC-WC).

The VMA value between LDPE and HDPE plastic asphalt concrete wearing course (AC-WC) and asphalt concrete wearing course without plastic has a small difference, namely 0.89% and 0.86% higher. The lowest value is in asphalt concrete wearing course without the addition of plastic, namely 15.41%. Meanwhile, the highest level is asphalt concrete wearing course with the addition of LDPE plastic, namely 15.55%. Bina Marga's requirement for VMA is a minimum of 15% so that the three types of asphalt concrete wearing course studied have met the specifications. So it can be concluded that the addition of plastic to the mixture can fill the voids between the aggregates which increase the durability and tightness of WC concrete asphalt and prevent stripping.

The VFA value between the LDPE and HDPE plastic asphalt concrete wearing course (AC-WC) with the asphalt concrete wearing course without plastic has a insignificant difference, namely 1.17% and 1.43% higher. The lowest value is in asphalt concrete wearing course without the addition of plastic, namely 68.37%. Whereas the highest was asphalt concrete wearing course with the addition of HDPE plastic, namely 69.35%. Bina Marga's requirement for VFA is a minimum of 65% so that the three types of asphalt concrete wearing course studied have met the specifications. So it can be concluded that the addition of plastic to the mixture can fill the cavities in the asphalt which increases the durability and tightness of asphalt concrete wearing course and prevents the mixture from being oxidized with air.

The VIM value between LDPE and HDPE plastic asphalt concrete wearing course (WC) and the asphalt concrete wearing course without plastic has a relatively small difference, namely 1.67% and 2.21% lower. The lowest value is in asphalt concrete wearing course with the addition of HDPE plastic, namely 4.77%. Whereas the highest was asphalt concrete wearing course without the addition of plastic, namely 4.88%. Bina Marga's requirements for VFA are 3-5% so that the three types of asphalt concrete wearing course studied have met the specifications. So it can be concluded that the addition of plastic to the mixture can fill the cavities in the asphalt which increases the durability and tightness of Asphalt concrete wearing course.

Marshall stability's value between LDPE and HDPE plastic asphalt concrete wearing course (AC-WC) and asphalt concrete wearing course without plastic has a relatively small difference, namely 2.51% lower and 4.90% higher respectively. The lowest value is in asphalt concrete wearing course (AC-WC) with the addition of LDPE plastic, namely 1130 kg. Meanwhile, the highest level is asphalt concrete wearing course (AC-WC) with the addition of HDPE plastic, namely 1216 kg. Bina Marga's requirements for the stability of marshall asphalt concrete wearing course (AC-WC) are 800 - 1800 kg, while for modified asphalt concrete wearing course (AC-WC) is 1000 - 2250 kg, so the three types of asphalt concrete wearing course (AC-WC) studied have met the specifications. So it can be concluded that the addition of HDPE plastic to the mixture can increase the stability of asphalt concrete wearing course (AC-WC) in withstanding loads.

Marshall flow's value between LDPE and HDPE plastic asphalt concrete wearing course (WC) and asphalt concrete wearing course without plastic has a significant difference, namely 10.42% and 2.08%, respectively. The lowest value is in Asphalt concrete wearing course without the addition of plastic, namely 3.20 mm. Meanwhile, the highest level is Asphalt concrete wearing course with the addition of LDPE plastic, namely 3.53 mm. Bina Marga's requirements for marshall asphalt concrete WC and modified asphalt concrete wearing course are 2 - 4 mm, so that the three types of Asphalt concrete wearing course studied have met specifications. So it can be concluded that the addition of plastic increases the melting of Asphalt concrete wearing course which can make Asphalt concrete wearing course become plastic and experience deformation compared to asphalt concrete wearing course without the addition of plastic. The yield value for Marshall between the LDPE and HDPE plastic asphalt concrete wearing course (WC) with the asphalt concrete wearing course without plastic has a significant difference, namely 12.08% lower and 2.56% higher respectively. The lowest value is in Asphalt concrete wearing course with the addition of LDPE plastic, namely 319.85 kg / mm. While for the highest is Asphalt concrete wearing course with the addition of HDPE plastic, namely 373.09 kg / mm. Bina Marga's requirement for the results for Marshall asphalt concrete WC and modified Asphalt concrete wearing course is 250 kg / mm, so that the three types of Asphalt concrete wearing course studied have met specifications. So it can be concluded that adding LDPE plastic makes Asphalt concrete wearing course flexible, flexible and tends to be plastic so it is easier to deform than Asphalt concrete wearing course with the addition of HDPE plastic and without the addition of plastic.

b. Residual Stability

Index of Retained Strength (IRS) is the ratio between the stability of the test object after immersion with a fixed temperature of 60 ° C between 24 hours and 30 minutes expressed in percent. Index of Retained Strength is one of the parameters used by Bina Marga to determine durability of asphalt concrete. The higher the IRS value, the more durable the asphalt concrete will be. Following are the results of the durability test data:

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Table 12. Residual Stability Test Results

Type of Object	Stability at Immersion Temperature 60°C (kg)		Residual Strength (%)
	30 minutes	24 Hours	
LDPE 2,1 %	1130	1080	95,6
WITHOUT PLASTIC	1158	1047	90,5
HDPE 2,4 %	1216	1139	93,7

Source : Test Result and Data Analysis (2020)

From the data above, the difference between the residual stability value between the three types of Asphalt concrete wearing course, the addition of LDPE type plastic has a high durability value of 95.6% while HDPE plastic is 93.7% which has a better durability value than asphalt concrete. The toilet without the addition of plastic is only 90.5% with the specifications required by Bina Marga, namely a minimum of 90%. So it can be concluded that Asphalt concrete wearing course with a mixture of both LDPE and HDPE plastic can increase the durability of Asphalt concrete wearing course..

IV. CONCLUSION

Based on the results and analysis obtained, several conclusions can be drawn, namely:

The addition of LDPE and HDPE plastics can increase the stability value of the AC-WC mixture on plastic content < 3%;

- The VMA value in the mixture with 1% LDPE plastic content = 15.54%; 3% = 15.71%; 5% = 16.21%; 7% = 17.09%. HDPE plastic content 1% = 15.59%; 3% = 15.55%; 5% = 16.16%; 7% = 17.52%. The VMA value on all of LDPE and HDPE plastic contents used meets the specifications, namely a minimum of 15%.
- The VFA value in the mixture with 1% LDPE plastic content = 69.30%; 3% = 68.39%; 5% = 65.83%; 7% = 60.92%. HDPE 1% plastic content = 68.95%; 3% = 69.31%; 5% = 65.85%; 7% = 58.70%. The LDPE plastic content that meets Bina Marga's specifications for a minimum VFA value of 65% is 1 - 5%, while HDPE plastic is 1 - 5%.
- The VIM value of the mixture with 1% LDPE plastic content = 4.78%; 3% = 4.97%; 5% = 5.6%; 7% = 6.69%. HDPE plastic content 1% = 4.84%; 3% = 4.78%; 5% = 5.52%; 7% = 7.25%. The LDPE plastic content that meets Bina Marga's specifications for VIM values of 3 - 5% is 1 - 3% while for HDPE plastic content is 1 - 3%.
- The stability value of the mixture with 1% LDPE plastic content = 1057.57 kg; 3% = 1122.65 kg; 5% = 1262.69 kg; 7% = 1153.69 kg. 1% HDPE plastic content = 1045.30 kg; 3% = 1315.2 kg; 5% = 1358.29; 7% = 1450.91 kg. The contents of LDPE and HDPE plastic have met Bina Marga's specifications for a minimum AC-WC Mod marshall stability value of 1000 kg. From this value, it can be seen that for the addition of LDPE plastic, the stability value tends to increase to 5% plastic content and then decrease to 7% plastic content, while for the addition of HDPE plastic the stability value continues to increase.
- The flow value in the mixture with 1% LDPE plastic content = 3.83 mm; 3% = 3.43 mm; 5% = 3.17 mm; 7% = 3.27 mm. 1% HDPE plastic content = 3.47 mm; 3% = 3.20 mm; 5% = 3.17 mm; 7% = 3.03 mm. This shows that the mixture with the addition of LDPE plastic is plastic and easily changes shape, so that the amount of deformation due to traffic loads will increase. Meanwhile, the addition of LDPE plastic, the flow value shows that the mixture is relatively stiffer.

From the test results with variations in plastic content, the optimum plastic content for LDPE is 2.1% while HDPE is 2.4%, which is compared to the AC-WC mixture without the addition of plastic.

- The density value between asphalt concrete wearing course (AC-WC) using LDPE and HDPE plastic with asphalt concrete without plastic has a small difference, namely 0.04% and 0.02% lower. The lowest density value is on the toilet concrete asphalt with the addition of LDPE plastic, namely 2.334. Meanwhile, to be in the highest position, namely asphalt concrete WC without the addition of plastic is 2,335. Then it can be eliminated that the addition of plastic to the concrete density mixture of WC.
- The VMA value between asphalt concrete wearing course (AC-WC) using LDPE and HDPE plastic with asphalt concrete without plastic has a small difference, namely 0.89% and 0.86% higher. The lowest value is in Asphalt concrete wearing course without the addition of plastic, namely 15.41%. Meanwhile, the highest level is Asphalt concrete wearing course with the addition of LDPE plastic, namely 15.55%. Bina Marga's requirement for VMA is a minimum of 15% so that the three types of Asphalt concrete wearing course studied have met the specifications. So it can be concluded that the addition of plastic to the mixture can fill the voids between the aggregates which increase the durability and tightness of WC concrete asphalt and prevent stripping.
- The VFA value between the LDPE and HDPE plastic asphalt concrete wearing course (WC) with the asphalt concrete wearing course without plastic has a insignificant difference, namely 1.17% and 1.43% higher. The lowest value is in Asphalt concrete wearing course without the addition of plastic, namely 68.37%. Whereas the highest was Asphalt concrete wearing course with the addition of HDPE plastic, namely 69.35%. Bina Marga's requirement for VFA is a minimum of 65% so that the three types of Asphalt concrete wearing course studied have met the specifications. So it can be concluded that the addition of plastic to the mixture can fill the cavities in the asphalt which increases the durability and tightness of WC concrete asphalt and prevents the mixture from being oxidized with air.

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- The VIM value between LDPE and HDPE plastic asphalt concrete wearing course (WC) and the asphalt concrete wearing course without plastic has a relatively small difference, namely 1.67% and 2.21% lower. The lowest value is in Asphalt concrete wearing course with the addition of HDPE plastic, namely 4.77%. Whereas the highest was Asphalt concrete wearing course without the addition of plastic, namely 4.88%. Highways requirements for VFA are 3-5% so that the three types of Asphalt concrete wearing course studied have met the specifications. So it can be concluded that the addition of plastic to the mixture can fill the cavities in the asphalt which increases the durability and tightness of Asphalt concrete wearing course.
- Marshall stability's value between LDPE and HDPE plastic asphalt concrete wearing course (WC) and asphalt concrete wearing course without plastic has a relatively small difference, namely 2.51% lower and 4.90% higher respectively. The lowest value is in Asphalt concrete wearing course with the addition of LDPE plastic, namely 1130 kg. Meanwhile, the highest level is Asphalt concrete wearing course with the addition of HDPE plastic, namely 1216 kg. Bina Marga's requirements for the stability of Marshall asphalt concrete WC are 800 - 1800 kg, while for modified Asphalt concrete wearing course is 1000 - 2250 kg, so the three types of Asphalt concrete wearing course studied have met the specifications. So it can be concluded that the addition of HDPE plastic to the mixture can increase the stability of WC concrete asphalt in withstanding loads.
- Marshall flow's value between LDPE and HDPE plastic asphalt concrete wearing course (WC) and asphalt concrete wearing course without plastic has a significant difference, namely 10.42% and 2.08%, respectively. The lowest value is in Asphalt concrete wearing course without the addition of plastic, namely 3.20 mm. Meanwhile, the highest level is Asphalt concrete wearing course with the addition of LDPE plastic, namely 3.53 mm. Bina Marga's requirement for Marshall asphalt concrete WC and modified Asphalt concrete wearing course is 2 - 4 mm, so that the three types of Asphalt concrete wearing course studied have met specifications. So it can be concluded that the addition of plastic increases the melting of Asphalt concrete wearing course which can make Asphalt concrete wearing course become plastic and experience deformation compared to Asphalt concrete wearing course without the addition of plastic.
- Marshall quotient's value between the LDPE and HDPE plastic asphalt concrete wearing course (WC) with the asphalt concrete wearing course without plastic has a significant difference, namely 12.08% lower and 2.56% higher respectively. The lowest value is in Asphalt concrete wearing course with the addition of LDPE plastic, namely 319.85 kg / mm. While for the highest is Asphalt concrete wearing course with the addition of HDPE plastic, namely 373.09 kg / mm. Bina Marga's requirement for the results for Marshall asphalt concrete WC and modified Asphalt concrete wearing course is 250 kg / mm, so that the three types of Asphalt concrete wearing course studied have met specifications. So it can be concluded that adding LDPE plastic makes Asphalt concrete wearing course flexible, flexible and tends to be plastic so it is easier to deform than Asphalt concrete wearing course with the addition of HDPE plastic and without the addition of plastic.

➢ For durability that can be seen from the residual stability test by dividing the results of the marshall stability test at 60 ° C immersion for 30 minutes with the marshall stability at 60 ° C immersion for 24 hours. The residual stability value for Asphalt concrete wearing course with the addition of LDPE plastic is 95.6%, HDPE plastic is 93.7% while for Asphalt concrete wearing course without the addition of plastic is 90.5%. This shows that the addition of plastic to the Asphalt concrete wearing course mixture can increase durability or durability.

SUGGESTION

Based on the results of the research that has been done, the authors have some suggestions as follows:

1. Need further reassessment with the same variation in plastic content, because the VFA test results have decreased.
2. It is necessary to do a physical test of the plastic used.
3. Further research is needed with variations in HDPE plastic content above 7% because the graph of marshall stability to plastic content has not decreased.
4. It is necessary to do penetration testing and asphalt softening point with variations in plastic content, either LDPE or HDPE.
5. For further research, it is necessary to consider from an economic point of view the implementation of mixing LDPE and HDPE plastics to asphalt concrete on a large scale.

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