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Strategies for Handling Plastic Bottle Waste in Gorontalo City Through the Utilization of Asphalt Concrete Wearing Course (AC-WC) Additives

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ABSTRACT

The amount of plastic waste, especially disposable plastic bottle waste (PET), needs to be utilized. plastic bottle waste is a flexible material that can be used as an alternative additive to the pavement mixture so as to reduce the production of PET disposable bottle waste. So this research needs to be done to find out its utilization. The purpose of this research is to analyze Polyethylen Terephtalate (PET) plastic bottle waste can be used as an additive and analyze the amount of Polyethylen Terephtalate (PET) bottles needed for Asphalt Concrete Wearing Course (AC-WC) pavement mixtures. The method used is an experimental method carried out in two stages. The first stage of Marshall testing without using plastic to find the Optimum Asphalt Content (KAO) with variations of 4%, 4.5%, 5%, 5.5%, 6%, 6.5%. The second stage of Marshall testing using the optimum asphalt content (KAO) obtained from stage one with additional variations of Polyethylen Terephtalate (PET) plastic bottle waste 1%, 2%, 3%, 4%, 5% to get the optimum PET content. The results of stage one Marshall testing obtained an optimum asphalt content of 5.675%, while Marshall in the second stage obtained an optimum PET content of 0.45% equivalent to 0, 0026 gr and all types of Marshall parameters met the Bina Marga 2018 revision 2 specifications for mixing Asphalt Concrete Wearning Course (AC-WC). Each production of one ton of Asphalt Concrete Wearning Course (AC-WC) requires 204.3 bottles of Polyethylen Terephtalate (PET) plastic.

Keyword: Polyethylen Terephtalate, Marshall parameters, plastic, asphalt, waste

1. INTRODUCTION

According to the World Health Organization (WHO) definition, waste is something that is unused, not used, disliked or discarded that arises from human actions and does not occur by itself (Budiman, 2006) . Waste is an item that is considered obsolete and discarded by the previous owner/user community but for some people it can still be used with proper management and correct actions (Nugroho, 2013). "Waste Management Law Number 18 of 2008 states that waste is the residue of daily human activities and / or from natural processes in solid form" (Republik Indonesia, 2008).

The waste generated by the Indonesian population in 2022 amounted to 36,218,012.28 tons/year (Kehutanan et al., 2022). Waste itself is the result of human activity and the amount is directly proportional to the population (Putra at al, 2010). PET plastic has a melting point of 160°C to 260°C, a specific gravity of 1.38 g/cm3 (20°C), a tensile strength of 55-75 MPa and an elastic limit of 50-15%, an elastic modulus of 2800-3100 Mpa (Simangunsong et al., 2021). Polyethylene terephtalate, often called PET, is made from glycol (EG) and terephtalic acid (TPA) or dimethyl ester or terepthalic acid (DMT) (Mujiarto, 2005).

Waste sources in Gorontalo come from various activities of the population that are concentrated in locations such as residential, commercial and public facilities. Each waste source has its own characteristics for generation,

In the preparation of this master plan, waste sources are divided into households and non-households. The amount of waste generation in Gorontalo City in 2022 was 51,646.51 tons/year, with plastic waste production of 36% per year (Kehutanan et al., 2022). composition, and characteristics of the waste generated. According to the data released by SIPSN, plastic waste is the most produced waste in Gorontalo City.

Due to the large amount of plastic waste, especially disposable plastic bottle waste (PET), it is necessary to utilize it. plastic bottle waste is a flexible material that can be used as an alternative additive to the pavement mixture so as to reduce the production of PET disposable bottle waste. So this research needs to be done to find out its utilization.

The objectives of this research are analyzing Polyethylene Terephtalate (PET) plastic bottle waste can be used as an additive to Asphalt Concrete Wearing course (AC-WC) pavement mixtures and analyzing the amount of Polyethylene Terephthalate (PET) plastic bottle waste required for Asphalt Concrete Wearing course (AC-WC) pavement mix. The benefit of this research is that it is one of the solutions to reduce disposable plastic bottle waste which is difficult to decompose.

2. RESEARCH METHOD

This research was conducted at the Transportation Laboratory of the Faculty of Engineering, Gorontalo State University to obtain the characteristics of each material. Research time started from July to September.

2.1. Materials

In this research, the materials used are: mineral water plastic bottle waste Polyethylene Terephtalate (PET), coarse aggregate, medium aggregate, fine aggregate, asphalt 60/70 penetration and filler or cement (portland cement).

2.2. Tools

A set of sieves, Penetration tester, oven, balance, ductility tester, pycnometer, Los Angeles machine, dryer, Marshall characteristics tester, cylinder, compector, ejector, water bath, pan, stove, asphalt thermometer and spoon.

2.3. Stages Of Research

The first test carried out is testing the characteristics of the material, one of which is to get a combined gradation that will be used to determine the planned asphalt content to be used for the laston asphalt concrete wearing course (AC-WC) mixture. the planned asphalt content is obtained using the following formula:

$$Pb = 0{,}035\ (\%CA) + 0{,}045\ (\%FA) + 0{,}18\ (\%\ FF) + K$$

Where:
Pb: Middle or ideal asphalt content, (percent by weight of the mixture)
CA: Percent of aggregate retained on sieve No.8
FA: Percent of aggregate passing sieve No.8 and retained sieve No.200
FF: (filler), Percent of aggregate at least 75% passes sieve No.200
K: Constant value (for constant value used ± 0.5 for Laston)

After obtaining the asphalt content value, the maximum specific gravity (BJ Max) was calculated by taking data from the material characteristics experiment, namely the specific gravity of coarse and fine aggregates. Then after obtaining the planned asphalt content and specific gravity of asphalt, test specimens were made without using Polyethylene Terephthalate (PET) plastic bottle waste to obtain the planned optimum asphalt content (KAO) with variations of 4%, 4.5%, 5%, 5.5%, 6%, 6.5% each as many as 5 pieces per asphalt content. mixing of aggregate and asphalt material is carried out at an optimum temperature of ± 150 ℃. The optimum asphalt content (KAO) obtained will be used in asphalt mixtures using Polyethylene Terephthalate (PET) materials with a mixture variation of 1%, 2%, 3%, 4%, 5% as many as 3 pieces per each PET content. Polyethylene Terephthalate (PET) mixture is done by dry method, where Polyethylene Terephthalate (PET) is mixed into the aggregate material when heating the aggregate material with an optimum temperature of ±150℃.

After the test object is finished, testing is carried out to determine the weight of the dry sample, dry surface and sample weight in water. after that, testing is carried out with a Marshall tool, previously the sample or test object is immersed in a soaking tub with a temperature of 25 C for 60 minutes. then analyze the data obtained from the test results. The research stages can be seen in the research flow chart as follows:

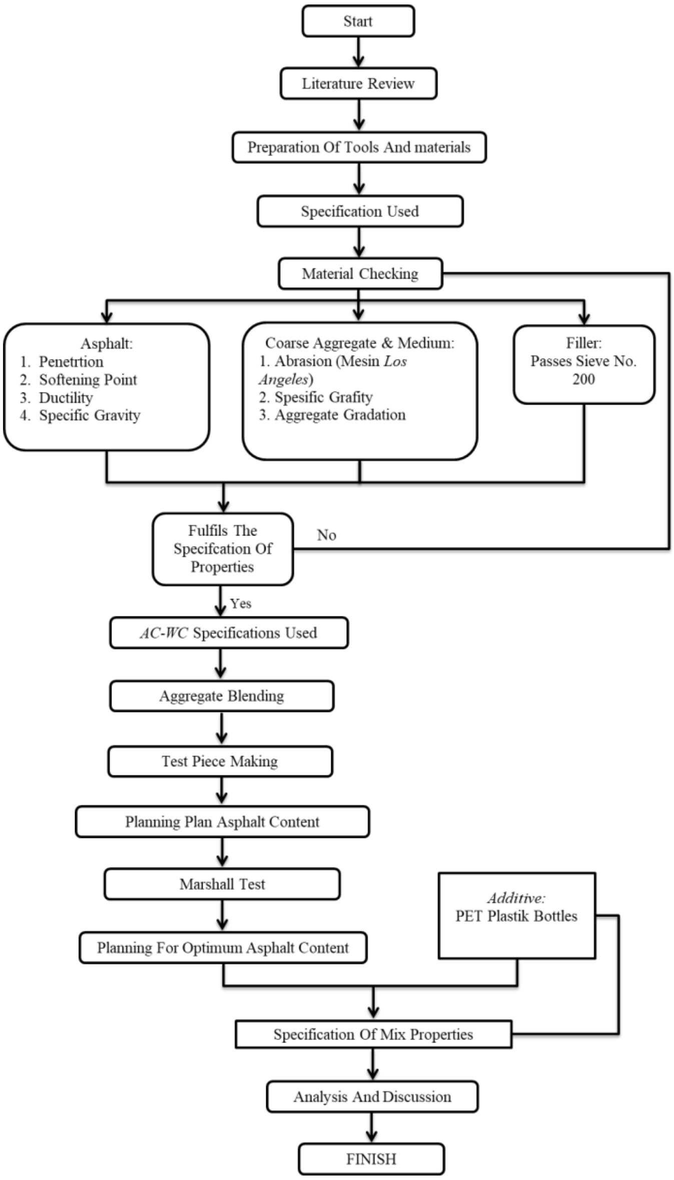

Figure 1: Research flow chart

3. RESULTS AND ANALYSIS

3.1. Aggregate Characteristics

The aggregate materials used in this research are coarse aggregate, fine aggregate and filler obtained from CV. Permata Indah Gorut. The combined aggregate gradation sieve analysis test results can be seen in Table 3.1, and the aggregate physical properties test results can be seen in Table 3.1.

Table 3.1 Combined Aggregate Gradation Sieve Analysis Results

sieve size		Spec.	% Weight Passed to Total Aggregate						Total Mix
ASTM	mm		coarse aggregate (CA) 15%		Medium Agregate (MA) 40%		Fine Agregate (FA) 45%		
3/4"	19,0	100	100	15	100	40	100	45	100
1/2"	12,5	90-100	33,57	5,04	100	40	100	45	90,04
3/8"	9,5	77-90	5,73	0,86	93,84	37,53	100	45	83,39
#4	4,75	53-69	0,75	0,11	23,74	9,50	100	45	54,61
#8	2,36	33-53	0,65	0,10	23,74	9,50	79,74	35,59	45,48
#16	1,18	21-40	0,64	0,10	1,67	0,67	52,42	23,59	24,35
#30	0,600	14-30	0,62	0,09	1,51	0,60	33,84	15,23	15,93
#50	0,300	9-22	0,60	0,09	1,39	0,56	23,23	10,45	11,10
#100	0,150	6-15	0,59	0,09	1,35	0,54	17,84	8,03	8,65
#200	0,075	4-9	0,56	0,08	1,25	0,50	14,07	6,33	6,92

Source: Research Data, 2023

The results of the combined gradation sieve analysis test obtained the percentage of retained sieve No.4 (4.75 mm) of 54.61%, fine aggregate passed sieve No.4 (4.75 mm) of 45.48% and Filler passed sieve No.200 (0.075 mm) of 6.92%.

Table 3.2 Test Results for Physical Properties of Aggregates

Check	Coarse Agregate (CA)	Medium Agregate (MA)	Fine Agregate (FA)	Spec.
Bulk Specific gravity (gr/cm3)	2,63	2,59	2,53	-
Surface Dry Saturated Specific gravity (SSD) (gr/cm3)	2,66	2,64	2,58	-
Apparent Specific gravity (gr/cm3)	2,72	2,72	2,68	-
Absorption %	1,27	1,82	2,32	Maks. 3%
Wear (abrasion) %	20,15	25,75	-	Maks.40%

Source: Research Data, 2023

From the results of testing the physical properties of aggregates in coarse aggregate (CA), fine aggregate (MA) and stone ash filler (FA), the average Bulk specific gravity of 2.63 gr/cm3, 2.59 gr/cm3, and 2.53 gr/cm3 was obtained. Saturated Dry Specific gravity (SSD) averaged 2.66 gr/cm3, 2.64 gr/cm3 and 2.58 gr/cm3. Apparent specific gravity averaged 2.72 gr/cm3, 2.72 gr/cm3 and 2.68 gr/cm3. Absorption averaged 1.27%, 1.82% and 2.68 gr/cm3. Wear or abrasion amounted to 20.15%, 25.75% and 2.32%. The results of testing the physical properties of aggregates have met the General Specifications of Bina Marga 2018 Revision two with a maximum absorption of 3% (Direktorat Jenderal Bina Marga, 2018).

3.2. Asphalt characteristic test results

Based on Table 3.3, the test results of the characteristics of asphalt 60/70, obtained a penetration value of 62 (0.1 mm), a softening point value of 56 ° C and an asphalt specific gravity value of 1.054. The test results of 60/70 penetration pertamina asphalt have met the General Specifications of Bina Marga 2018 Revision Two.

Table 3.3 Test Results of Asphalt 60/70 Characteristics

Testing	Method	Spesifikasi		Result
		Min.	Maks.	
Penetration at 25°C (0,1 mm)	SNI 2456:2011	60	70	62
softening point (°C)	SNI 2434:2011	48	-	56
Specific gravity	SNI 2441:2011	1	-	1,054

3.3. Lanning the planned asphalt content (Pb)

Determination of the planned asphalt content is made after obtaining the results of the combined gradation mixture as follows:

Pb = 0,035 (%CA) + 0,045 (%FA) + 0,18 (% FF) + Konstanta

CA = (100 – 54,61) = 45,39 %

FA = (54,61 – 6,92) = 47,69 %

FF = 6,92 %

K = 0,5

Pb = 0,035 (45,39) + 0,045 (47,69) + 0,18 (6,92) + 0,5

= 5,5 %

The result value of the asphalt content plan obtained is 5.5%. Then take the range of asphalt content values two down 5.5% and two up 5.5% with an interval of 0.5%. So the five values of asphalt content variation are 4.5%, 5%, 5.5%, 6%, 6.5%. The total weight of the aggregate used is 1200 gr.

3.4. Aggregate and Asphalt Composition

Table 3.4 Asphalt Concrete Wearing Course (AC-WC) mix composition design without using Polyethylene Terephthalate (PET) plastic.

Plan Asphalt Rate		**4,50%**	**5,0%**	**5,5%**	**6,0%**	**6,5%**
Total Mix			1200,00	1200,00	1200,00	1200,00
Total Asphalt			60,00	66,00	72,00	78,00
Weight of 60/70 Penetration Asphalt			60,00	66,00	72,00	78,00
Aggregate Weight (Gr)			1140,00	1134,00	1128,00	1122,00
Total Agregate (%)			95,00	94,50	94,00	93,50
CA	15,00%	171,90	171,00	170,10	169,20	168,30
MA	40,00%	458,40	456,00	453,60	451,20	448,80
FA	45,00%	515,70	513,00	510,30	507,60	504,90
Total Agregate	100%	1146,00	1140,00	1134,00	1128,00	1122,00
Total Mix			1200,00	1200,00	1200,00	1200,00

The composition of the mixture of each aggregate with varying asphalt content then made as many as five samples per each variation of asphalt content.

3.5. Marshall testing without waste polyethylene terephthalate (PET) bottles.

3.5.1. Density Testing Results

The results of the density test with 4.5%, 5%, 5.5%, 6% and 6.5% asphalt content have density values of 2.23%, 2.24%, 2.27%, 2.28% and 2.29%. As shown in Figure 3.1 as follows:

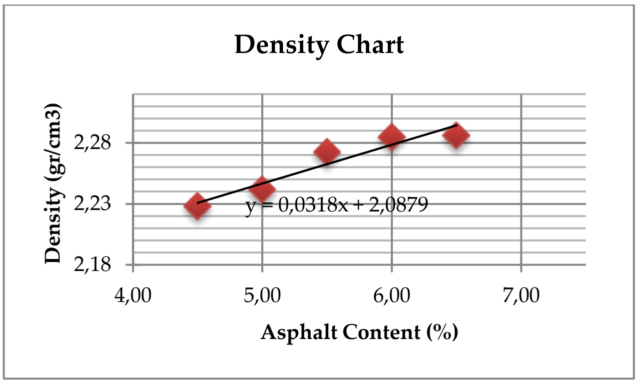

Figure 3.1 Chart of Density Testing Results

From Figure 3.1 the graph of density test results shows that the density value increases with the increase in the amount of asphalt content. Due to the increase in the value of asphalt content, more fine aggregate enters the cavity between grains.

3.5.2. Void In Mix Testing Result

The results of marshall testing obtained void in mix (VIM) values with asphalt content of 4.5%, 5%, 5.5%, 6% and 6.5% VIM values of 7.45%, 6.24%, 4.29%, 3.10% and 2.38%. As shown in Figure 3.2 as follows:

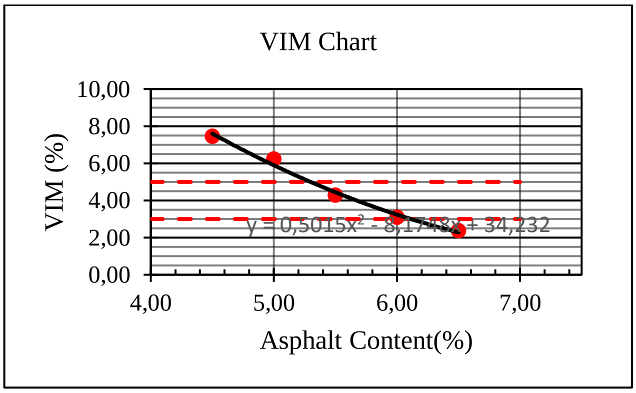

Figure 3.2 Voids in Mixture (VIM) Chart

Water and air easily enter the pavement due to the process that occurs, thus accelerating the oxidation process which results in rapid aging of the asphalt. The minimum limit of VIM value is 3% and a maximum of 5% according to the 2018 revision Two of Bina Marga General Specifications. The values that match the specifications are 5.5% asphalt content with a VIM value of 4.29% and 6% asphalt content with a VIM value of 3.10%.

3.5.3. Void in Mineral Aggregate (VMA) Value

From the marshall test results, the Void in Mineral Aggregate (VMA) value is obtained with asphalt content of 4.5%, 5%, 5.5%, 6% and 6.5% VMA values of 17.22%, 17.15%, 16.46%, 16.44% and 16.85%. As shown in Figure 3.3 as follows:

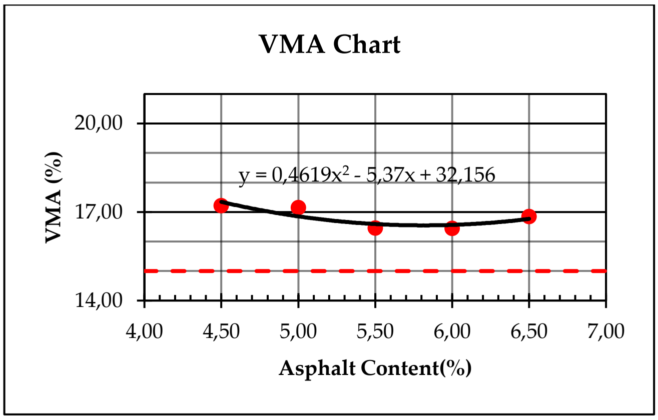

Figure 3.3 Graph of Void in Mineral Aggregate (VMA)

The graph above shows that as the asphalt content of the mixture increases, the voids in the aggregate decrease. The decrease occurred at the addition of 5.50%, 6% and rose again at 6.5% asphalt content.

3.5.4. Void Filled Asphalt (VFA)

Void Filled Asphalt (VFA) with asphalt content of 4.5%, 5%, 5.5%, 6% and 6.5% VFA values are 56.70%, 63.63%, 73.93%, 81.17% and 85.87%. As shown in Figure 3.4 as follows:

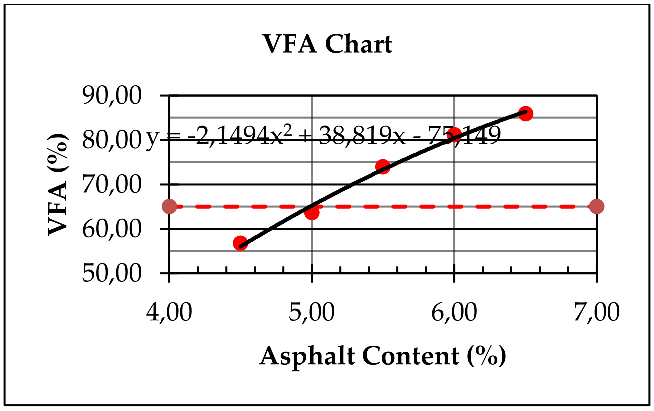

Figure 3.4 Void Filled Asphalt (VFA) Chart

The graph above shows the Void Filled Asphalt (VFA) value where the asphalt content of 4.5% and 5% does not meet the specifications because the value obtained is below 65%, for asphalt content 4.5% has a VFA value of 56.70% and 5% has a VFA value of 63.63%. Asphalt levels 5.5%, 6% and 6.5% meet the General Specifications of Bina Mrga 2018 Revision Two, with respective VFA values of 73.93%, 81.17% and 85.87%.

3.5.5. Stability

Stability values from marshall test readings with a calibration number of 16.72 kg at 4.5%, 5%, 5.5%, 6% and 6.5% asphalt content are 1711.52 kg, 2018.41 kg, 2010.94 kg, 1563.81 kg and 1508.70 kg. as shown in the figure below:

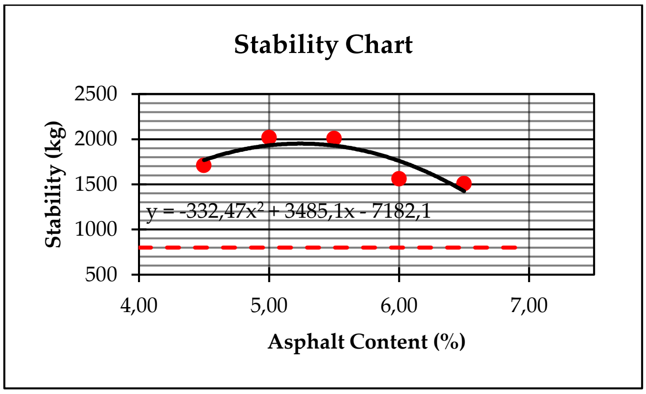

Figure 3.5 Stability Chart

The stability graph above shows that the stability value continues to increase with increasing asphalt content in the mixture. However, at 6% and 6.5 asphalt content decreased. The maximum stability value is at 5% asphalt content with a stability value of 2018.41 kg. stability decreases when it reaches maximum stability.

3.5.6. Flow

The flow value is obtained from the calculation of the plan and the results of the marshall test with asphalt content of 4.5%, 5%, 5.5%, 6% and 6.5% with values of 3.09 mm, 3.15 mm, 3.65 mm, 3.60 mm and 3.85 mm. can be seen in Figure 3.6 as follows:

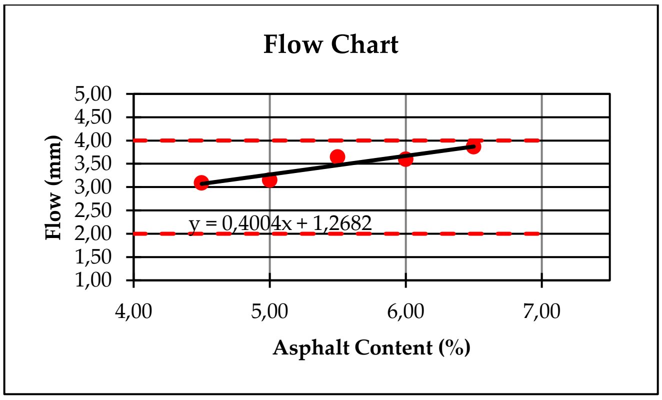

Figure 3.6 Flow chart

The flow graph above increases from 4.5%, 5%, 5.5% asphalt content and decreases again at 6% asphalt content then increases at 6% asphalt content. The highest flow value is located at 6% asphalt content with a value of 3.86 mm.

3.5.7. Marshall Quotient (MQ)

From the test results and calculations according to the plan, the marshall quotient values with asphalt content of 4.5%, 5%, 5.5%, 6% and 6.5% were 554.25 kg/mm, 640.76 kg/mm, 550.94 kg/mm, 434.39 kg/mm and 390.45 kg/mm.

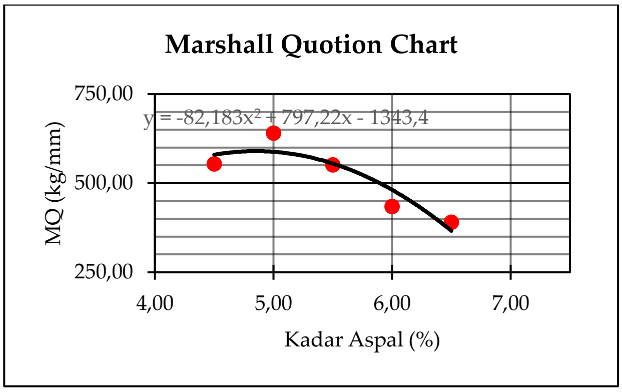

Figure 3.7 Marshall Quotion Chart

The graph above shows the Marshall Quotion value starts to increase from 4.5% to 5% asphalt content to reach the maximum value and decreases at 5.5% - 6.5% asphalt content. The Marshall Quotion value still meets the general specifications of bina marga 2018 revision two.

3.5.8. Optimum Asphalt Content (KAO)

Determination of the optimum asphalt content to be used in the manufacture of asphalt mixture specimens using polyethylene terephthalate (PET) plastic waste bottles, can be seen in the following graph:

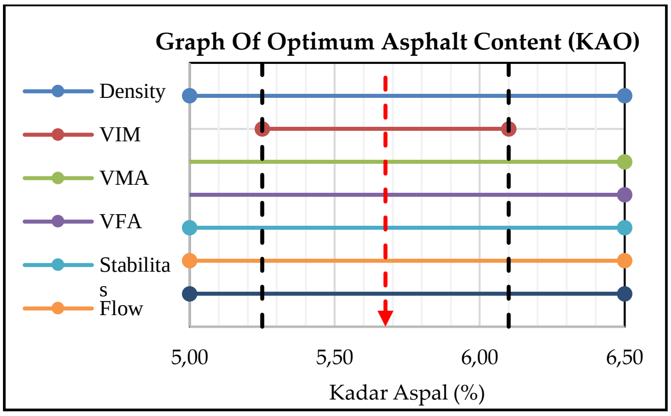

Figure 3.8 Graph of Optimum Asphalt Content (KAO)

Figure 3.8 shows the optimum asphalt content value of 5.675%, the asphalt content obtained will be used as the reference asphalt content of the sample mixture using polyethylene terephthalate (PET) plastic waste bottles.

3.6. Marshall Testing Using Polyethylene Terephthalate (PET) Plastic Bottle Waste

After obtaining the optimum asphalt content of 5.675% from the previous experiment, 15 asphalt mixture samples were mixed using PET. The PET content used was 1%, 2%, 3%, 4% and 5% of the optimum asphalt content.

Table 3.5 Total mix design of asphalt concrete wearing course and polyethylene terephthalate PET

Plan Asphalt Level	4,5%	5,0%	5,5%	6,0%	6,5%	7,0%
Total Mix	1200,00	1200,00	1200,00	1200,00	1200,00	1200,00
Total Asphalt	68,10	60,00	66,00	72,00	78,00	84,00
Weight of Asphalt Penetration 60/70	68,10	60,00	66,00	72,00	78,00	84,00

Plan Asphalt Level		4,5%	5,0%	5,5%	6,0%	6,5%	7,0%
Aggregate Weight (Gr)		1131,90	1140,00	1134,00	1128,00	1122,00	1116,00
Total Aggregate (%)		94,33	95,00	94,50	94,00	93,50	93,00
CA	**15,05%**	170,40	171,62	170,72	169,81	168,91	168,01
MA	**35,16%**	398,01	400,86	398,75	396,64	394,53	392,42
FA	**49,78%**	563,49	567,53	564,54	561,55	558,56	555,58
Total Aggregate	**100%**	1131,90	1140,00	1134,00	1128,00	1122,00	1116,00

The manufacture of asphalt mixtures is done in a dry way, where chopped Polyethylene Terephthalate (PET) is incorporated into the aggregate when heated. After mixing with PET plastic, it was then mixed with liquid asphalt pen 60/70 according to the asphalt content that has been determined based on the asphalt variation.

3.6.1. Density

Density testing results for aphalt concrete wearing course (AC-WC) mixtures with 1%, 2%, 3%, 4% and 5% PET content are 2.26 gr/cm3, 2.25 gr/cm3, 2.25 gr/cm3, 2.23 gr/cm3 and 2.23 gr/cm3..

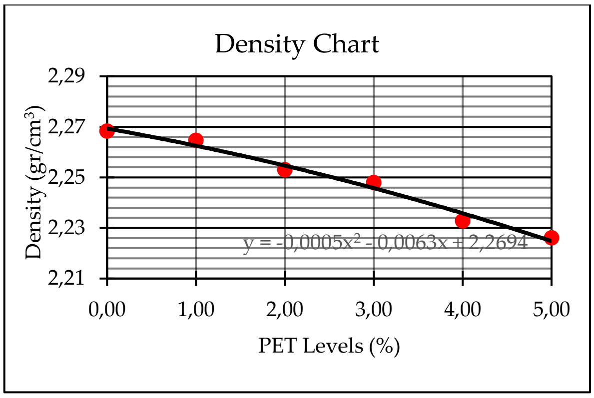

Figure 3.8 Density graph using PET additives

From the graphical image of the density test results, it shows that the density value decreases along with the addition of PET content due to the cavity filled by PET plastic material.

3.6.2. Void in Mix (VIM) with added PET

The results of marshall testing obtained void in mix (VIM) values with 1%, 2%, 3%, 4% and 5% PET content of 4.20%, 4.67%, 4.87%, 5.12% and 5.38%.

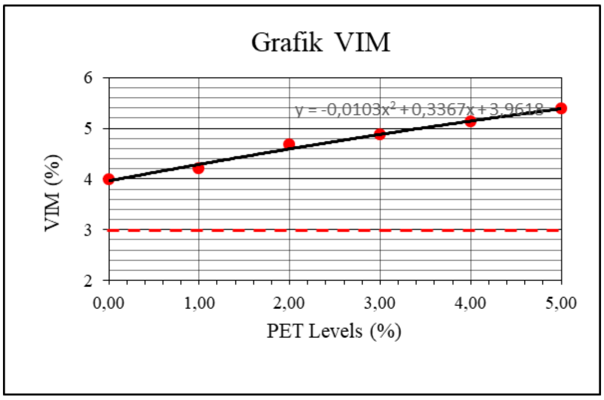

Figure 3.9 Graph of void in mix (VIM) with added PET

The value of voids in the asphalt mixture or VIM with the addition of PET can be seen in Figure 4.11 shows that it continues to increase. Those that meet the specification requirements are at 1%, 2% and 3% PET content.

3.6.3. Void in Mineral Aggregate (VMA) Value with PET Addition

From the marshall test results, the Void in Mineral Aggregate (VMA) values with 1%, 2%, 3%, 4% and 5% PET content were 16.73%, 17.16%, 17.34%, 17.90% and 18.15%.

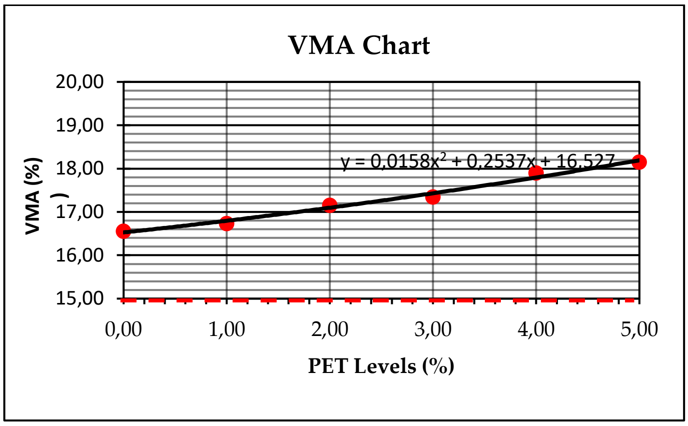

Figure 3.10 Graph of Void in Mineral Aggregate (VMA) with added PET

The graph above shows that with the addition of PET content in the mixture, the voids in the aggregate increase from 1% to 5% PET content. The VMA value obtained is included in the Bina Marga 2018 Revision two specification with a minimum VMA limit of 15%.

3.6.4. Value of Voids Filled with Asphalt (VFA) with PET Addition

From the marshall test results, the VFA values with 1%, 2%, 3%, 4% and 5% PET content were 74.89%, 72.77%, 71.92%, 71.37 and 70.29. The VFA value can be seen in the graph below:

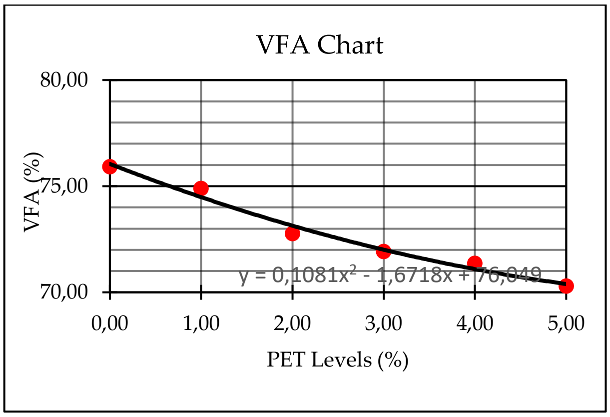

Figure 3.11 Void Filled Asphalt (VFA) Graph with PET Addition

The maximum VFA value obtained is 74.89% with 1% PET content and the minimum VFA value is 70.29%. The VFA value obtained meets the general specifications of bina marga 2018 revision two with a minimum VFA value of 65% for the laston Aphalt Concre Wearing Course (AC-WC) asphalt mixture.

3.6.5. Marshall Stability Value with PET Addition

The stability value with the addition of PET from the reading results of the marshall test with 1%, 2%, 3%, 4% and 5% PET content is 1634.30 kg, 1366.16 kg, 1352.11 kg, 1329.93 kg and 1312.94 kg. calibration number 101.97 kg. stability value can be seen in the graph below:

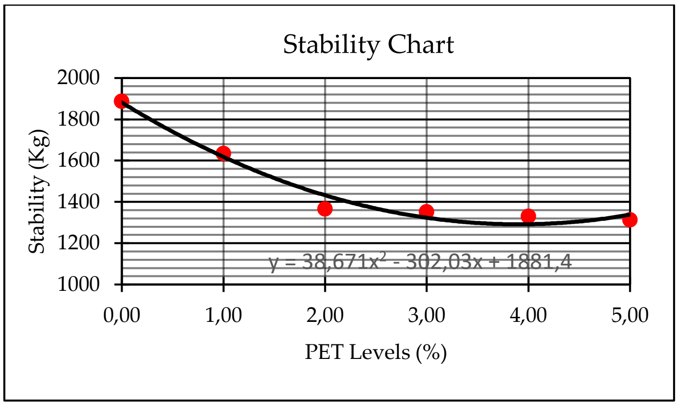

Figure 3.12 Marshall Stability Graph with PET Addition

The stability graph above shows that the stability value continues to decrease with increasing PET content in the mixture. The maximum stability value is found at 1% asphalt content with a stability value of 1643.30 kg. stability decreases when it reaches maximum stability.

3.6.6. Flow value with PET added

The flow value is obtained from the calculation of the plan and the results of the marshall test with 1%, 2%, 3%, 4% and 5% PET content of 4.13 mm, 4.28 mm, 4.72 mm, 5.15 mm and 5.23 mm. The flow value can be seen in the graph below:

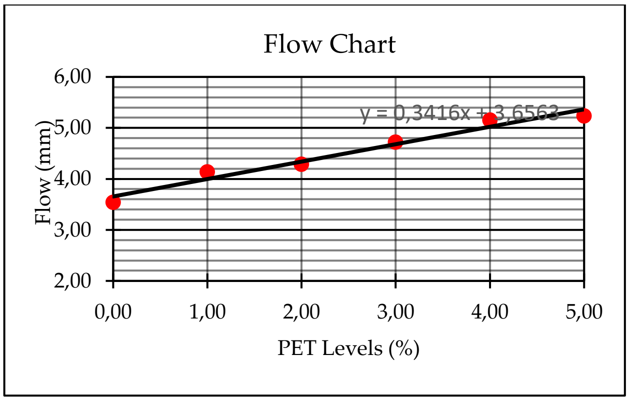

Figure 3.13 Flow chart with PET added

Figure 3.13 shows the flow graph increases from 1%, 2%, 3%, 4% and 5% asphalt content. The highest flow value is located at 5% asphalt content with a value of 5.23 mm.

3.6.7. Marshall Quotient (MQ) Value Using PET

The test results and calculations according to the plan obtained marshall quotient values with 1%, 2%, 3%, 4% and 5% PET content of 395.43 kg/mm, 318.95 kg/mm, 286.64 kg/mm, 258.21 kg/mm and 250.88 kg/mm.

3.6.8. Optimum Polyethylene Terephthalate (PET) Content Value

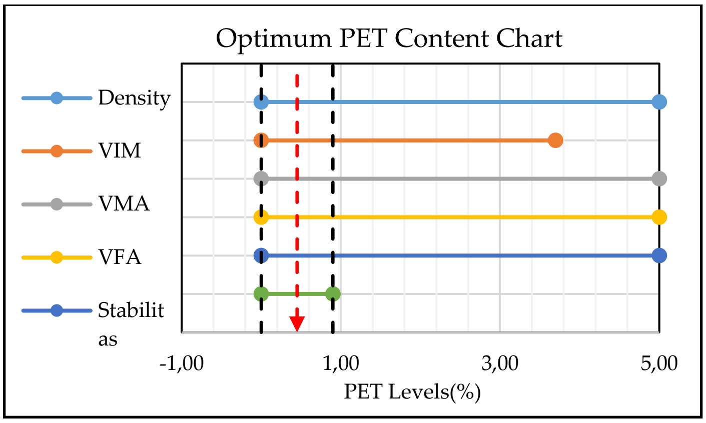

Figure 4.16 Shows the Optimum PET Content Value

The optimum PET content value is 0.45%, the PET content obtained will be used as a reference PET content for mixes in production units that use polyethylene terephthalate (PET) plastic waste bottles.

The Marshall Stability value of the mixture using Polyethylene Terephtalate (PET) decreased with a value of 1753.32 Kg compared to before the addition of Polyethylene Terephtalate (PET) plastic. Because the Marshall stability value decreased, the Flow value increased to 3.81 mm. Asphalt mixtures that have low flow and high stability tend to be stiff and brittle. The value of voids in the mixture or VIM increased with a value of 4.21% while the value of voids in the aggregate or VMA was 17.24%. The value of voids filled with asphalt or VFB has decreased with a value of 75.60% and the density has not increased with a value of 2.27gr / cc.

The optimum Polyethylene Terephtalate (PET) content value is 0.045% or equivalent to 0.0026 grams of Polyethylene Terephtalate (PET) plastic bottles from the value of asphalt content that can be used for one test object. From the research results that have been obtained through laboratory experiments and meet the general specifications of bina marga 2018 revision two, it is stated that plastic bottle waste can be used as an added material for Asphalt Concrete Wearing Course (AC-WC). For the use of hot asphalt mixture production Asphalt Mixing Plant (AMP) in each mixture of asphalt production per seributon of asphalt mixture requires 204.3 plastic bottles with 5.675% asphalt content.

4. CONCLUSION

From the research results, the following conclusions were obtained:

a. The Marshall Stability value for the use of Polyethylene Terephtalate (PET) plastic mixture of 1753.32 Kg meets the Bina Marga 2018 Revision two specifications.
b. The value of Cavity in Mixture or VIM of 4.21% meets the specifications of Bina Marga 2018 Revision two
c. The value of voids in the aggregate or VMA is 17.24% meets the specifications of Bina Marga 2018 Revision two
d. The value of voids filled with asphalt or VFB of 75.60% meets the specifications of Bina Marga 2018 Revision two
e. density of 2.27gr/cc meets the specifications of Bina Marga 2018 Revision two
f. Flow value of 3.81 mm meets the specifications of Bina Maarga 2018 Revision two
g. With the addition of Polyethylene Terephtalate (PET) plastic at a level of 0.45% or equivalent to 0.0026 gr plastic bottles can be used as a mixture of Asphalt Concrete Wearning Course (AC-WC)

h. In every production of one tonne of Asphalt Concrete Wearning Course (AC-WC) mixture, 204.3 plastic bottles of Polyethylene Terephtalate (PET) can be used.

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