Volume: 12 | Number: 02 | October 2023 | ISSN: 1907-4247 (Print) | ISSN: 2477-4863 (Online) | Website: http://cantilever.id
Cantilever Jurnal Penelitian dan Kajian Bidang Teknik Sipil

Research Article

IMPROVING PERFORMANCE IN MIXTURE POROUS ASPHALT: APPLICATION POLYETHYLENE-TEREPHTHALATE (PET) AND LAWELE GRANULAR ASPHALT (LGA)

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Received: 18 February 2023, Accepted: 1 October 2023, Published: 24 February 2024

Abstract

Plastic has various types, one of which is PET (Polyethylene Terephthalate) plastic, which is often used as a raw material for plastic bottles. One type of asbuton that is often used for road pavement is LGA (Lawele Granular Asphalt) asphalt. Repairs by adding asbuton to the porous asphalt mixture need to be done. This is because porous asphalt has several weaknesses, namely low strength or stability compared to other asphalt mixtures. The addition of PET and LGA waste to porous asphalt is a topic in this article. This research design uses a quantitative design with a type of experimental research. The results of the study concluded that: (1) The results of testing the characteristics of the constituent ingredients of the porous asphalt mixture meet the specifications of SNI, and (2) The test results of the addition of PET (Polyethylene Terephthalate) plastic and LGA (Lawele Granular Asphalt) to porous asphalt mixture meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012. It is hoped that this research can be an alternative to the mixture of PET plastic waste and LGA asbuton in a porous asphalt mixture. In addition, the newness of this material is expected to also help the construction of roads.

Key Words: *porous asphalt, Polyethylene Terephthalate (PET), Lawele Granular Asphalt (LGA)*

1. INTRODUCTION

Waste is production from the process of industrial and household activities. Currently, waste is a common problem among the community. One of the wastes that are found around the environment is plastic. Plastic is a relatively non degradable material so the use of plastic must be considered considering the amount of waste produced (Ragossnig & P, 2021). There are various types of plastic, one of which is often used is PET plastic (Polyethylene Terephthalate). This plastic is a type of plastic used as a raw material for drink bottles (Horvath et al., 2018; Sarda et al., 2021). In addition to the use of plastic, there are several studies related to the utilization of waste such as fly ash and used tire powder that are interesting enough to be done more in-depth research (Oktaviastuti et al., 2018, 2020, 2021; Oktaviastuti & Yurnalisdel, 2020).

Loaded in Antaranews.com, based on the results of laboratory tests in 2017 by the Ministry of PUPR's Road R&D Center, the hot paved mixture with additional plastic waste showed a 40% increase in Marshall stability value and was more resistant to deformation and tired cracks when compared to standard hot paved mixtures (Sujatmiko & Suryanto, 2017). Asphalt is a binding material that plays an important role in the strength of a paved mixture (Patil et al., 2018; Ramdhani et al., 2021). Modifications to the asphalt mixture by adding natural asphalt such as Buton asphalt to the mixture need to be done. Natural asphalt that is a source of natural wealth in Indonesia is quite potentially located on Buton Island, Southeast Sulawesi, namely Asbuton (Amrin et al., 2017). One type of grain asbuton that is often used for road pavement is LGA asphalt (Lawele Granular Asphalt). LGA asphalt has a bitumen content that is quite equivalent to 60 penetration asphalt so that when processed it can reduce the oil content in it (MUKTI, 2017).

Porous asphalt or porous asphalt is a new method of pavement that is currently developed in the world of highway construction. Porous asphalt has several advantages, including reducing the surface water load, reducing the level of noise caused by vehicles, and not harmful to road users because porous asphalt has a high level of hardness (skid resistance), so the wheels do not easily slip when driving at high speeds (Laksono, 2017; Ma et al., 2020). The use of porous asphalt can be used for moderate traffic such as rural roads, parking lots, or other medium-load roads. Porous asphalt has several disadvantages, namely lower strength or stability compared to other asphalt

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DOI: https://doi.org/10.35139/cantilever.v12i2.203

mixtures due to the composition of porous asphalt which is dominated by coarse aggregates, so that porous asphalt becomes stiff and tends to be brittle (Chen & Yang, 2020).

In this case, it is necessary to make improvements that add asbuton to the porous asphalt mixture. Asbuton not only has advantages in improving the stability value, but has the disadvantage that the use of asbuton needs to be extracted first as a substitution in porous asphalt mixtures in order to meet specifications (MUKTI, 2017). The existence of this asbuton capability makes porous asphalt can improve its low stability value. Knowing the availability of increasingly rare oil asphalt, alternative ways to mix porous asphalt can be used LGA asphalt as a added material in increasing the value of stability in the mixture.

The analysis of the effect of LGA salt addition substitution on 60/70 penetration asphalt against porous asphalt mixtures concluded that LGA substitution can improve stability performance even though its permeability value decreases (MUKTI, 2017). On the other hand, in terms of reducing the amount of waste, the use of plastic bottle waste can also be used as an addition in porous asphalt mixtures. The combination of LGA added materials and PET bottle waste is expected to increase the stability value of porous asphalt to the maximum.

2. METHOD

This research uses quantitative research design with the type of research experiment. In this study there are several stages of research that are divided into three parts:

a. Materials selection and testing stages include aggregate selection and testing, asphalt selection and testing, and PET plastic selection.
b. The preparation phase of the test object includes aggregate preparation, asphalt preparation, and preparation of additive materials namely PET plastic and LGA asbuton.
c. The research and data analysis stage includes calculation of material needs, planning of optimum asphalt levels, manufacture of test objects with optimum asphalt levels, manufacture of test objects with optimum asphalt levels and addition of PET and LGA, testing of test objects, and data processing.

A. Research Test Object Planning

1) Aggregate Material Needs Planning

The following is the aggregate requirement in one test object:

Table 1. Aggregate Requirement on One Test Object

No. Filter	Filter Size (mm)	Aggregate Requirements for Porous Asphalt Mixture			
		% Rough Gradation Specifications	% Escape	% Restrained	Weight (gram)
1”	25				
¾”	19	100	100	-	-
½”	12,5	85-100	92,5	7,5	82,5
No.4	4,75	10-25	17,5	75	825
No.8	2,36	5-10	7,5	10	110
No.200	0,075	2-4	3	4,5	49,5
PAN				3	33
			Total Weight	100	1100

Information:
The % pass value is the middle value of the gradation specification
The value of the % held is the result of the previous %escape reduced afterwards
Weight value is the value calculated by the formula = (% held back: 100) x total weight

2) Optimum Asphalt Level Planning (KAO) for Test Objects

Uptake of 5 levels of asphalt to determine the value of the optimum asphalt rate (KAO) with the value of Pb as the middle value. Other provisions of 4 asphalt levels include: Pb-1, Pb-0.5, Pb+0.5, and Pb+1. There are variations in asphalt levels to find KAO values including 4%, 4.5%, 5%, 5.5%, and 6%.

3) Planning for PET and LGA Plastic Requirement

In this case, PET and LGA needs are planned for one test object with variations in the ratio of levels of 0%:0%, 5%:5%, 10%:10%, 15%:15%, and 20%:20% to KAO weight. To see more clearly, you can see the following table 2 and table 3.

Table 2. PET Needs on One Test Object

No.	KAO Weight (gram)	PET rates (%)	PET Weight (gram)	Number of Test Objects	Total Necessity PET (gram)
1.	57,75	0	0	1	0
2.	57,75	5	2,89	1	2,89
3.	57,75	10	5,78	1	5,78
4.	57,75	15	8,66	1	8,66
5.	57,75	20	11,55	1	11,55
			Total PET Weight		28,88

Table 3. LGA Needs on One Test Object

No.	KAO weight (gram)	LGA rates (%)	LGA weight (gram)	Number of Test Objects	Total LGA Needs (gram)
1.	57,75	0	0	1	0
2.	57,75	5	2,89	1	2,89
3.	57,75	10	5,78	1	5,78
4.	57,75	15	8,66	1	8,66
5.	57,75	20	11,55	1	11,55
			Total Weight of LGA		28,88

B. Manufacture Of Research Test Objects

1) Manufacture of Test Objects to Determine KAO Value

The manufacture of test objects is carried out with collisions of 2x50 collisions in accordance with the provisions of the porous asphalt mixture used for medium traffic. The total number of test objects in determining KAO is 15 test objects. To find out the test object planning data for KAO, more clearly can be seen in Table 4.

Table 4. Optimum Asphalt Level Planning for Test Objects

No	Test Object Code	Asphalt Rate (%)	Aggregate Weight (gram)	Asphalt Weight (gram)	Number of Test Objects (pieces)	Number of Asphalt Needs (gram)
1.	K.4,5	4,5	1100	49,5	3	148,5
2.	K.5	5	1100	55	3	165
3.	K.5,5	5,5	1100	60,5	3	181,5
4.	K.6	6	1100	66	3	198
5.	K.6,5	6,5	1100	71,5	3	214,5
				Total Number	15	907,5

2) KAO Test Object Manufacturing with PET and LGA Additions

The manufacture of test objects with the addition of PET and LGA is made as many as 60 pieces, because there are 4 types of testing in porous asphalt, namely Marshall testing, Permeability, Cantabro Loss, and Binder Drain Down so that in each test made test objects as many as 15 pieces. To find out the test object data with the addition of PET and LGA, more clearly can be seen in Table 5.

Table 5. Optimum Asphalt Level Planning with the Addition of PET and LGA for Test Objects

No.	Test Object Code	Optimum Asphalt Rate (%)	KAO weight (gram)	PET and LGA levels (%)	PET weight (gram)	LGA weight (gram)	Number of Test Objects (pieces)	Total PET Needs (gram)	Total LGA Needs (gram)
1.	PL.0	5,25	57,75	0	0	0	3	0	0
2.	PL.5	5,25	57,75	5	2,89	2,89	3	8,67	8,67
3.	PL.10	5,25	57,75	10	5,78	5,78	3	17,34	17,34
4.	PL.15	5,25	57,75	15	8,66	8,66	3	25,98	25,98
5.	PL.20	5,25	57,75	20	11,55	11,55	3	34,65	34,65
						Total Number of Marshalls	15	86,64	86,64
						Total Amount of Permeability	15	86,64	86,64
						Total Amount of Cantabro Loss	15	86,64	86,64
						Total Number of Binder Drain Down	15	86,64	86,64
						Total Total Test Objects	60	346,56	346,56

C. Research Test Object Testing

Testing of research test objects aims to obtain the properties and characteristics of porous asphalt. Tests include Marshall testing, Permeability, Cantabro Loss, and Binder Drain Down.

3. RESULTS AND DISCUSSION

A. Characteristics of Porous Asphalt Building Materials

1) Aggregate Testing and Fillers

Aggregate test results according to table 6.

Table 6. Aggregate Testing Results

No	Type of Testing	Research Methods	Specifications Min	Specifications Max	Test Results
1.	Rough aggregate type weight:	SNI 1969:2008			
	a. Bulk Type Weight		2,5		2,68
	b. SSD Type Weight				2,75
	c. Pseudo-Type Weight				2,88
	d. Absorption			3%	2,57
2.	Fine aggregate type weight:	SNI 1970:2008			
	a. Bulk Type Weight		2,5		2,56
	b. SSD Type Weight				2,63
	c. Pseudo-Type Weight				2,75
	d. Absorption			3%	2,67
3.	Weight type of filler ash stone	SNI 03-4142-1999	2,25	2,7	2,67
4.	Los angeles abrasion testing	SNI 2417:2008		40%	17,26

Based on the tests on aggregates and fillers that have been conducted, it can be concluded that the overall testing of coarse aggregates, fine aggregates, and fillers has met the specifications in RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 which refers to SNI so that it is suitable for use as a material for porous asphalt mixture (Direktorat Jenderal Bina Marga, 2019).

2) Asphalt Testing

Asphalt that will be used in this study is asphalt penetration 60/70. The test was conducted based on RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 which refers to SNI (Direktorat Jenderal Bina Marga, 2019). Table 7 is the data of asphalt testing results.

All testing on asphalt has met the specifications of RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 (Direktorat Jenderal Bina Marga, 2019). It is explained that the weight value of the type of asphalt used in the study is more than 1.0 gr/cm^3, penetration values of at least 60 mm and a maximum of 70 mm, the value of the flash point and fuel point is more than 232^{o}C, the soft point value is more than 48^{o}C, and the ductility value is more than 100 cm, so that asphalt can be used as a binding material in porous asphalt mixtures. Therefore, it can be said that asphalt as a binding material is suitable for use in porous asphalt mixtures.

Table 7. Asphalt Test Results

Type of Testing	Testing Methods	Testing Specifications		Test Results
		Min	Max	
Type Weight (gr/cm³)	SNI 2441:2011	1 gr/cm³		1,104 gr/cm³
Penetration (mm)	SNI 2456:2011	60 mm	70 mm	60,7 mm
Flabby Point (°C)	SNI 2434:2011	48°C	58°C	50,85°C
Flashpoint and Burn Point (°C)	SNI 2433:2008	232°C		338°C / 344°C
Daktilitas (cm)	SNI 2432:2011	100 cm		150 cm
Loss of Weight	SNI 06-2440-1991		0,8%	0,63 %

3) PET Testing *(Polyethylene Terephthalate)*

Pet plastic that will be used in this study is the melt of all types of plastic that has the number 1 on the recycling symbol. Pet used is a plastic bottle of drinking water. This test is done to find out the melting point and weight of the type of PET. Pet test results can be seen in Table 8 below.

Table 8. PET Test Results

Type of Testing	Testing Methods	Testing Specifications		Test Results
		Min	Max	
Melting Point (°C)				200°C
Type Weight (gr/cm³)	SNI 2441:2011			1,425 gr/cm³

The test results in the table above prove that the weight of the type and melting point on PET is almost the same as the study on (Ahmad et al., 2017). Produced physical properties of PET including a density of 1.41 gcm^{-3} and a melting temperature of 255-265°C. Testing the weight of this type and melting point serves to find out the weight of the type and melting point that can be mixed into the porous asphalt mixture. This suggests that this PET is suitable for use as an additive to the porous asphalt mixture.

4) Marshall Testing for Optimum Asphalt Levels

Asphalt levels used are 4%, 4.5%, 5%, 5.5%, and 6%. In this case the optimum asphalt level value (KAO) is obtained through testing of Marshall parameters. The result is as follows:

a. Stability

Based on Figure 1 obtained stability value at asphalt level 4% by 504.69 kg, 4.5% level increased by 540.19 kg, asphalt levels 5% increased by 585.03 kg, levels 5.5% decreased by 570.43 kg, and 6% levels decreased by 551.89 kg. This proves that all test objects that have been marshall tested meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with a stability value of at least 350 kg. That the value of stability increases then decreases as asphalt levels increase (Kusumawardani et al., 2021). This increase is influenced by the aggregate mixture and compaction process at the right temperature so that it has good locking properties (Sa'dillah et al., 2021)

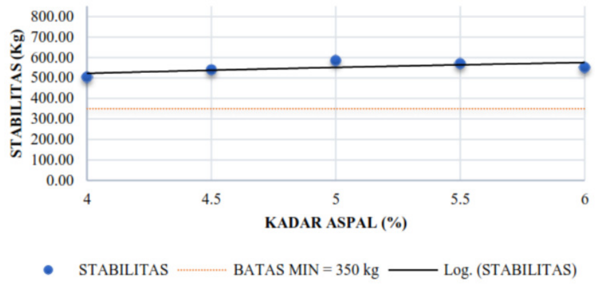

Figure 1. Connection Between Asphalt Levels and Stability Values

Asphalt rates and stability have a directly proportional relationship. This is because the higher the level of asphalt, the stability value will increase as well. However, if the asphalt level has reached the maximum limit, the stability value will decrease with the high level of asphalt. From this study it can be concluded that stability will increase if it has reached its maximum level. However, if the increasing level of asphalt that exceeds the limit then the mixture is more flabby so that the value of stability decreases.

b. Flow

Based on figure 2, obtained flow value at asphalt level 4% by 1.96 mm, 4.5% level decreased by 1.80 mm, asphalt levels 5% increased by 2.22 mm, levels 5.5% decreased by 2.13 mm, and 6% levels decreased by 2.12 mm. This proves that all test objects that have been marshall tested meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with a flow value between 2-4 mm.

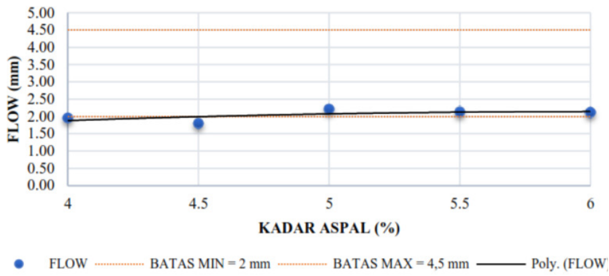

Figure 2. Connection Between Asphalt Levels and Flow Values

The results of this study are in line with the old research, which showed that flow values increased and decreased (Amrin et al., 2017; Kusumawardani et al., 2021), (Mabui et al., 2020). Flow values increase because they have low stability values and tend to be plastic or easily deformed. But on the contrary, the flow value decreases because it has a high stability value so it tends to be bitter or easy to experience cracks.

c. *Void in Mixture* (VIM)

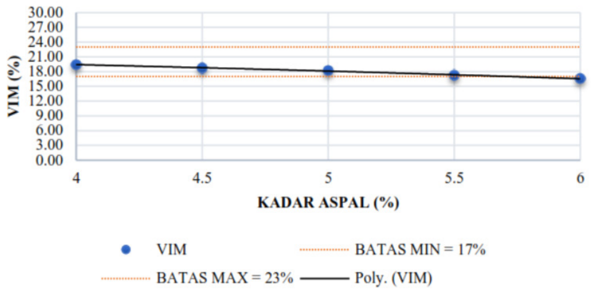

Figure 3. Connection Between Asphalt Levels and VIM Values

Based on figure 3 obtained VIM value at asphalt level 4% by 19.44%, 4.5% rate decreased by 18.75%, asphalt levels 5% decreased by 18.22%, levels 5.5% decreased by 17.28%, and 6% levels decreased by 16.57%. This proves that all test objects with levels of 4%, 4.5%, 5%, and 5.5% that have been marshall tested meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with VIM value of at least 17% and maximum 23%.

Asphalt levels that meet for the determination of KAO values are asphalt rates of 5% and 5.5%. In this case, the KAO value used based on the middle value of both asphalt levels meets the overall specifications of RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012. Therefore, the value of KAO = (5%+5.5%)/2 = 5.25%. Based on the calculation of the KAO, so that the KAO value used in this study is 5.25%.

~~B.~~A. Addition of PET Plastic and LGA Asbuton to Porous Asphalt Mixture

1) Marshall Testing

a. Stability

The figure above shows that the stability value increased and reached the breaking point at the rate of addition of PET:LGA (10%:10%) by 616.37 kg and decreased as the rate of PET and LGA addition increased at asphalt levels (0%:0%) by 509.65 kg. In this case, the highest stability value lies in the pet and LGA (10%:10%) addition rate of 616.37 kg and the lowest stability value on asphalt (0%:0%) of 461.47 kg. The results prove that all test objects that have been tested by Marshall with the addition of PET: LGA meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with a stability value of at least 350 kg.

The influence of the addition of PET plastic bottles can increase the stability of optimum asphalt levels (Kusumawardani et al., 2021). Then the stability value tends to increase because LGA has a penetration value equivalent to oil asphalt 60/70 and due to the addition of mineral content resulting in attachment between aggregates in the mixture is getting stronger (MUKTI, 2017). So, it can be concluded that the higher the rate of addition of PET: LGA, the stability will increase. This proves that with these additions the stability value will be better so that it can make porous asphalt resistant to deformation and able to carry the load of the wheel to the maximum.

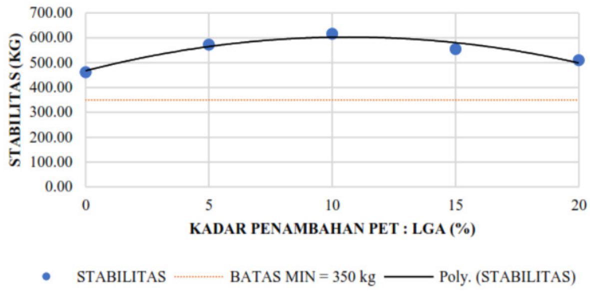

Figure 4. Connection Between PET:LGA Addition Rate and Stability Value

b. Flow

Directly proportional to the results of stability, the flow value also increased with the addition of PET:LGA. Figure 5 indicates that the flow value has increased. The lowest flow value at the PET:LGA (0%:0%) additional rate is 2.37 mm and the highest flow value at pet and LGA (20%:20%) is 2.80 mm. Unlike the flow without addition, the highest value is 2.22 mm and the lowest value is 1.80 mm. When compared with asphalt concrete (AC-WC) with the addition of fly ash, the flow value is inversely proportional. The more fly ash content is added, the lower the flow value (Sadillah et al., 2018). The addition of PET and LGA shows that all test objects that have been marshall tested with the addition of PET: LGA meets the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with a flow value between 2-4.5 mm.

As per the results of the study it can be concluded that the increasing rate of addition of PET: LGA then the flow value increases. This proves that the greater the addition of PET:LGA, the softer the mixture, indicating that the mixture tends to be plastic and easily deformed.

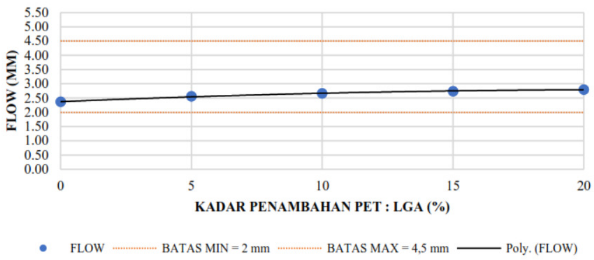

Figure 5. Connection Between PET:LGA Addition Rate and Flow Value

c. *Void in Mixture* (VIM)

VIM is basically a cavity or pore contained in a mixture of asphalt, especially on porous asphalt. Figure 6 shows that the VIM value has decreased. The highest VIM values lie in the rate of addition of

PET: LGA (0%:0%) by 21.40% and the value decreased consecutively at rates (5%:5%), (10%:10%), (15%:15%), and (20%:20%) by 20.42%, 19.07%, 16.35% and 15.28%. The results proved that all test objects with additional levels (0%:0%), (10%:10%), and (20%:20%) that have been marshall tested meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with VIM value of at least 17% and maximum 23%.

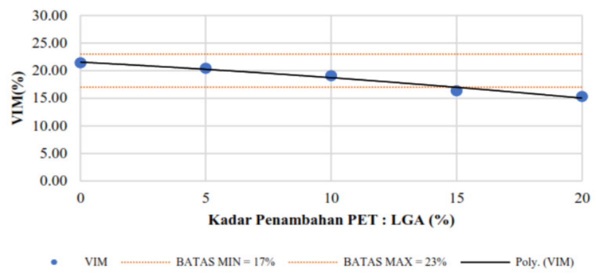

Figure 6. Connection Between PET:LGA Addition Rate and VIM Value

The VIM value before addition will be higher than the VIM value after the addition of PET:LGA, this is because the cavity in the mixture will be more closed as the material that enters the porous asphalt mixture increases. The presence of a PET mixture with asphalt that gets bigger and thickens, allowing the mix cavity to be small and closed also with LGA granules added to the mixture. From this study it can be concluded that the value of VIM will decrease along with the increasing rate of addition of PET:LGA. This is because the addition of PET: LGA will fill the cavity in the mixture, thus making the mixture will be tighter and watertight.

2) Permeability Testing

This test is used to determine the ability to drain water on porous asphalt test objects. The test results described in Figure 7, obtained the highest water permeability coefficient values located in the rate of addition of PET:LGA (0%:0%) by 0.032 cm/second and the value decreased consecutively at a rate (5%:5%), (10%:10%), (15%:15%), and (20%:20%) by 0.024 cm/second, 0.018 cm/second, 0.015 cm/second and 0.012 cm/second. PET:LGA addition rate on all test objects that have been tested permeability meets the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with a water permeability coefficient value of at least 0.01 cm/second.

The decreasing permeability coefficient value indicates that the mixture is experiencing a closed cavity. This is because the larger the PET mixture with asphalt, the binder becomes thicker. In addition, the addition of LGA granules also makes the mixture more bound and fused, resulting in the mixed cavity will be closed and water difficult to enter the cavity of the test object. So it was concluded that the water permeability coefficient value will decrease along with the increase in the rate of addition of PET: LGA.

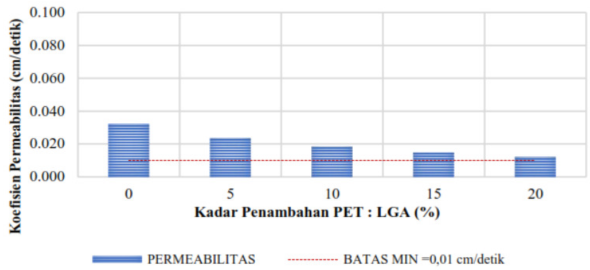

Figure 7. PET:LGA Addition Rate Connection to Water Permeability Coefficient Value

3) Cantabro Loss Testing

The resistance of the test object to grain release using a Los Angeles machine serves to determine the percentage of wear on porous asphalt. Based on figure 8, the highest cantabro loss percentage values in the rate of addition of PET:LGA (10%:10%) by 19.48% and the values decreased consecutively in PET:LGA (15%:15%) and (20%:20%) by 18.57% and 17.01%. PET:LGA (0%:0%) by 27.37% and (15%:15%) by 23.62% did not meet the cantabro loss percentage specification due to results exceeding the maximum value of 20%. PET:LGA addition rate in this study proves that all test objects with additional levels of 10%, 15%, and 20% that have been tested cantabro loss meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mix 2012 with a maximum percentage value of 20% loss.

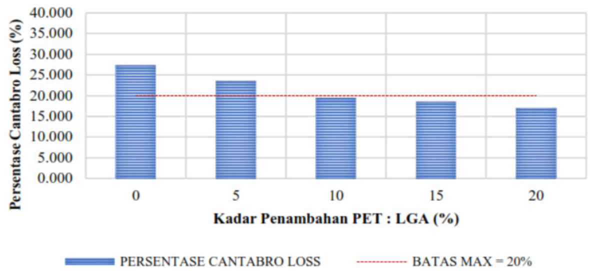

Figure 8. PET:LGA Addition Rate Connection to Cantabro Loss Percentage Value

The declining cantabro loss value indicates the better the resilience of the mixture. This is because PET mixed with asphalt and added LGA granules makes the mixture more bonded so that it is able to defend against the release of grains with the Los Angeles abrasion engine. It was concluded that the greater the addition of PET:LGA mixed in porous asphalt, the mixture binds well so that the percentage will be greater in the resistance of the mixture to grain release.

4) Binder Drain Down Testing

Binder drain down test is done to find out the amount of asphalt drainage that comes out or evaporation in the material mixed porous asphalt after venting for ± 1 hour. Based on Figure 9, it shows that the percentage value of binder drain down has increased. The highest drain down binder percentage value lies in the PET:LGA 20% addition rate of 0.150% and the lowest value at the rate (0%:0%) of 0.091%. The test results prove that all test objects that have been tested binder drain down meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012 with a maximum binder drain down percentage value of 0.3%.

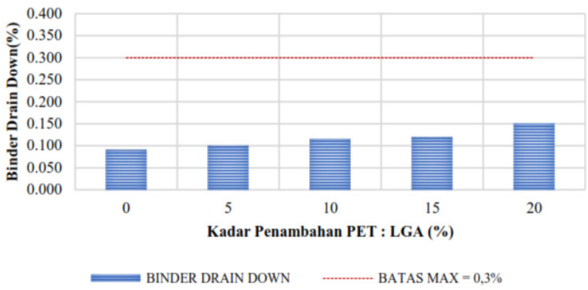

Figure 9. PET:LGA Addition Rate Connection to Binder Drain Down Value

Increasing value of binder drain down is caused by the increasing addition of PET with asphalt that has similar properties, namely thermoplastic. The properties of both materials make the binding material can react well so that the mixture will be more flabby. In addition, with the addition of an increasingly large LGA, the mixture will have an increasing asphalt content so that when done the mix of test objects will easily experience drainage due to the greater amount of asphalt content in the mixture.

4. CONCLUSION

The results of testing the characteristics of the constituent materials of the mixture of porous asphalt with stages: (a) the value of type weight and absorption of coarse aggregates; (b) the value of type weight and absorption of fine aggregates; (c) filler value; (d) wear value; (e) the weight value of the type of asphalt; (f) asphalt penetration value; (g) the soft spot value of asphalt; (h) the value of the flash point and the asphalt burn point; (i) asphalt notyility value; (j) the value of weight loss; and (k) the value of the melting point and weight of the PET type, meets the SNI specifications. Then, the results of testing the addition of PET (Polyethylene Terephthalate) plastic and LGA (Lawele Granular Asphalt) asbuton to the porous asphalt mixture were reviewed based on Marshall Testing, Permeability, Cantabro Loss, and Binder Drain Down, meet the specifications by RSNI 2 Design and Implementation of Porous Asphalt Mixture 2012.

It is hoped that this research can be an alternative to the mixture of PET plastic waste and LGA asbuton in porous asphalt mixture. In addition, the newness of this material is expected to also help the construction of roads.

REFERENCES

Ahmad, A. F., Razali, A. R., Razelan, I. S. M., Jalil, S. S. A., Noh, M. S. M., & Idris, A. A. (2017). Utilization of polyethylene terephthalate (PET) in bituminous mixture for improved performance of roads. *Mechanical Engineering, Science and Technology International Conference*, 1–10. https://doi.org/10.1088/1757-899X/203/1/012005

Amrin, M. A., Gaus, A., & Darwis, M. (2017). STUDI KUAT TARIK TIDAK LANGSUNG PADA CAMPURAN ASPHALT CONCRETE MENGGUNAKAN ASBUTON. *Jurnal SIPILsains: Universitas Khairun*, *7*(14), 1–11. https://doi.org/http://dx.doi.org/10.33387/sipilsains.v7i14.499.g340

Chen, J.-S., & Yang, C. H. (2020). Porous asphalt concrete: A review of design, construction, performance and maintenance. *International Journal of Pavement Research and Technology*, *13*, 601–612. https://doi.org/https://doi.org/ 10.1007/s42947-020-0039-7

Direktorat Jenderal Bina Marga. (2019). *RSNI 2 (Pedoman Bahan Konstruksi Bangunan dan Rekayasa Sipil) Perancangan dan Pelaksanaan Campuran Aspal Porus*.

Horvath, T., Kalman, M., Szabo, T., Roman, K., Zsoldos, G., & Kollar, M. S. (2018). The mechanical properties of polyethylene-terephthalate (PET) and polylactic-acid (PDLLA and PLLA), the influence of material structure on forming. *IOP Conference Series: Materials Science and Engineering*, 012018. https://doi.org/10.1088/1757-899X/426/1/012018

Kusumawardani, D. M., Wong, Y. D., & Trinh, D. T. (2021). Value-Add Application of Plastic Waste in Porous Asphalt Mixture. *CIGOS 2021, Emerging Technologies and Applications for Green Infrastructure*, 957–965.

Laksono, R. A. (2017). PENGARUH PENAMBAHAN SLAG SEBAGAI BAHAN SUBSTITUSI AGREGAT HALUS TERHADAP KARAKTERISTIK MARSHALL DAN PERMEABILITAS PADA CAMPURAN PANAS (HOT MIX) ASPAL PORUS. *Jurnal Rekayasa Teknik Sipil: Universitas Negeri Surabaya*, *1*(1), 56–64.

Ma, Y., Chen, X., Geng, Y., & Zhang, X. (2020). Effect of Clogging on the Permeability of Porous Asphalt Pavement. *Advances in Materials Science and Engineering*, *2020*, 1–9. https://doi.org/https://doi.org/10.1155/2020/4851291

Mabui, D. S., Tjaronge, M. W., Adisasmita, S. A., & Pasra, M. (2020). PERFORMANCE OF POROUS ASPHALT CONTAINING MODIFICATED BUTON ASPHALT AND PLASTIC WASTE. *International Journal of GEOMATE*, *18*(65), 118–123. https://doi.org/https://doi.org/10.21660/2020.65.67196

MUKTI, A. S. (2017). Analisis Pengaruh Substitusi Asbuton LGA (Lawele Granular Asphalt) pada Aspal Penetrasi 60/70 terhadap Campuran Aspal Porus. *Jurnal Rekayasa Teknik Sipil: Universitas Negeri Surabaya*, *1*(1), 381–387.

Oktaviastuti, B., Leliana, A., & Abid, L. (2020). *PENGARUH BAHAN TAMBAH SERBUK BAN BEKAS PADA KONSTRUKSI HOTROLLED SHEET-WEARING COURSE*. *2008*, 4–9.

Oktaviastuti, B., Pandulu, G. D., & Lusyana, E. (2021). Kuat Tekan Beton Geopolymer Berbahan Dasar Abu Terbang (Fly Ash) Sebagai Alternatif Perkerasan Kaku di Daerah Pesisir (Compressive Strength of Geopolymer Concrete Based on Fly Ash as an Alternative to Rigid Pavement in Coastal Areas). *Reka Buana : Jurnal Ilmiah Teknik Sipil Dan Teknik Kimia*, *6*(1), 78–87. https://doi.org/https://doi.org/10.33366/rekabuana.v6i1.2271

Oktaviastuti, B., Wijaya, H. S., & Indrawan, P. (2018).

PENGARUH PENAMBAHAN SERBUK BAN BEKAS UNTUK BAHAN TAMBAH CAMPURAN ATB (ASPHALT TREATED BASE). *Reka Buana : Jurnal Ilmiah Teknik Sipil Dan Teknik Kimia*, *3*(1), 16–29.

Oktaviastuti, B., & Yurnalisdel, Y. (2020). Studi Kuat Tekan Beton Geopolymer Dengan Fly Ash Sebagai Perkerasan Kaku Di Pesisir Pantai. *Fondasi : Jurnal Teknik Sipil*, *9*(2), 201–214.

Patil, V., Patil, P., Patil, J., Patil, M., Sawant, K., & Patil, M. S. P. (2018). A Research Paper on Porous Asphalt Pavement. *International Journal of Trend in Scientific Research and Development (IJTSRD)*, *2*(4), 2026–2031. https://doi.org/https://doi.org/10.31142/ijtsrd14516

Ragossnig, A. M., & P, A. (2021). Plastic waste: Challenges and opportunities. *Waste Management & Research*, *39(5) 629*–(5), 629–630. https://doi.org/https://doi.org/10.1177/0734242X211013428

Ramdhani, F., Tisnawan, R., & Adly, E. (2021). Comparison of Fatigue Crack Resistance and Permanent Deformation to Asbuton Modified Asphalt and Rubber Modified Asphalt. *Proceedings of the 4th International Conference on Sustainable Innovation 2020–Technology, Engineering and Agriculture (ICoSITEA 2020)*, 80–82. https://doi.org/https://doi.org/10.2991/aer.k.210204.017

Sa'dillah, M., Fajarwati, Y. E., & Primasworo, R. A. (2021). KINERJA CAMPURAN ASPAL PORUS DENGAN SUBTITUSI LIMBAH BETON SEBAGAI BAHAN RAMAH LINGKUNGAN. *Jurnal Teknik Sipil*, *25*(1). https://ojs.unud.ac.id/index.php/jits/article/view/77684

Sadillah, M., Arifin, M. Z., & Wicaksono, A. (2018). Penggunaan Fly Ash Sebagai Filler Terhadap Karakteristik Marshall Beton Aspal Lapis Aus (AC-WC). *Jurnal Rekayasa Sipil & Lingkungan*, *2*(1), 87–98. https://doi.org/https://doi.org/10.19184/jrsl.v2i01.6425

Sarda, P., Hanan, J. C., Lawrence, J. G., & Allahkarami, M. (2021). Sustainability performance of polyethylene terephthalate, clarifying challenges and opportunities. *Journal of Polymer Science*, *60*, 7–31. https://doi.org/https://doi.org/10.1002/pol.20210495

Sujatmiko, E., & Suryanto. (2017). Pemerintah uji coba aspal plastik di Sulsel. In *antaranews*.

