# The Effect of Addition of Plastic Waste in Porous Asphalt Concrete on Permeability and Properties Marshall

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Keywords: Porous Asphalt Concrete, Plastic Waste, Permeability

Abstract: Porous asphalt mixture has low stability but high permeability due to the cavities in the mixture. For this reason, it is necessary to add other materials in order to increase the stability of pavement mixture. The purpose of this study was to obtain the Marshall property value of the porous asphalt concrete mixture. This study is also analyze the effect of plastic waste in the porous asphalt concrete mixture on the permeability and properties of Marshall. This research used is the experimental method in the laboratory. The Optimum Asphalt Content (KAO) made with asphalt content 4.5%; 5%; 5.5%; 6%; and 6.5% without variation of plastic waste. Furthermore, it is also made by KAO and the addition of plastic waste by 0%; 5%, 10%, 15%, 20% and 25% and tested with Marshall test and permeability. The results of the research with 5,5% KA0, that the addition of plastic waste in the porous asphalt mixture can increase the value of stability, flow, and marshall quotient. with an average value of 25% plastic waste content of 1296.71 kg; 3.62 mm and 353.19 kg / mm. However, the VIM and permeability values decreased, respectively, with an average value 20.65% and 0.188 cm / s. The mixture of porous asphalt with plastic waste, for all parameters Marshall satisfied the specifications required by the Australian Asphalt Pavement Association (2004) for moderate traffic

## 1 INTRODUCTION

One of the pavement types currently being developed as a cover layer is porous asphalt concrete. This mixture has low stability but high permeability of cavities in the mixture. For this reason, it is necessary to add other materials to increase the stability value of the pavement mixture (Arlia, Sofyan, Renni, 2018). The porous asphalt mixture also contains a large percentage of coarse aggregate, a small percentage of fine aggregate, thus providing a large air cavity that can drain water from the surface into the soil. The large cavity makes porous asphalt has a low stability value. To increase stability, added materials are needed (Supriyadi, 2018 dan Ghulam, 2017). The high cavity content results in a larger oxidized asphalt surface which reduces the ability of the binder to maintain the aggregate position, therefore an asphalt with strong durable, and high viscosity binding capacity is required. The porous asphalt mixture is a mixture of hot asphalt between open-graded aggregate and modified asphalt with a certain ratio (Affan, 2006).

Plastic is a commodity that is often used in everyday life. The most possible way to handle plastic waste is to reuse plastic (reuse), reduce plastic consumption (reduce), and recycle (Anonim, 2018). Recycling plastics can be used as a mixture of asphalt concrete. Asphalt concrete plastic has been developed in several areas such as Bekasi and Bali. Asphalt Concrete plastics has several advantages, namely having a high level of pavement better, it is not easy to leave a trail of wheels when wet asphalt is traversed vehicle, and its durability also increases when compared to ordinary asphalt (Sumadilaga, 2017). According to (Zulfiani,2012) that plastic flakes can dissolve in 60/70 penetration asphalt at a temperature of 1540C. The substitution of plastic flakes for 60/70 penetration asphalt can save the use of asphalt by 2.5% of the weight of asphalt used in the mixture asphalt concrete AC-WC. With the percentage of PE and HDPE as an asphalt mixture of 0%, 2%, 4% and 6% of the weight of the asphalt tends to increase the value of stability, flow, and VFA but tends to decrease the values of VIM, VMA, and MQ. The effect of adding HDPE on the application of asphalt mixture



Wiyono, E., Susilowati, A. and Pratikto, .
The Effect of Addition of Plastic Waste in Porous Asphalt Concrete on Permeability and Properties Marshall.
DOI: 10.5220/0010560201270132
In *Proceedings of the 9th Annual Southeast Asian International Seminar (ASAIS 2020)*, pages 127-132
ISBN: 978-989-758-518-0

Marshall characterization value is better than the mixture of asphalt with PE (Rahmawati, 2015). According to Veranita, 2016) with an optimum asphalt content of 5.88%, a permeability of 0.28% was obtained and the higher the retona blend content of 55 in the porous asphalt mixture, the stability, and durability values increased while the permeability and cavity levels continued to decrease. (Novrianto, 2016) that the use of LDPE plastic values for density, stability, and Marshall Quotient (QM) all meet the requirements (General Specifications of Bina Marga 2018). According to (Ismayalomi, 2019) the addition of PET plastic: LGA can increase the stability value due to the same PET properties as asphalt and the presence of bitumen content in the LGA granules, an increase also occurs in the value flow because the more PET: LGA content can make the mixture more flexible. HDPE plastic waste as bitumen binder provides better resistance to permanent deformation due to its high stability and high Marshall Quotient and contributes to the recirculation of plastic waste for environmental protection.

There are several advantages of porous asphalt, according to Kraemer, (1997) in (Falderika, 2004); Greater slip resistance; Rapid drainage of water from the pavement surface which reduces wet time from the surface; and Flexibility without fatigue or rutting. Apart from these advantages, there are several disadvantages of porous asphalt mixtures, including (Falderika, 2004): Low stability; Requires a high cost; Has low durability so that the service life of the pavement ranges from 7 to 10 years.

(Hendrastianto, 2019) Plastic waste is a waste material made of plastic that is no longer used and is no longer useful for human life. Plastic waste can become useful again after being recycled. As for PP plastic (polypropylene) seeds, it is a seed plastic made of propylene monomer which has rigid, odorless, and properties resistant to chemical solvents, acids, and alkalis.The process of recycling plastic waste into plastic pellets (pellets).

(Veranita. 2016) The addition of 2% -4% UF on KAO, shows that the permeability coefficient value of the open-graded asphalt concrete mixture is increasing, this indicates that the greater the addition of UF, the greater the cavities produced by the mixture and the faster the water flow time from the surface to the bottom of the concrete asphalt. this addition of UF will provide stiffness and reduce the elasticity of the asphalt. Typical mean values of porous asphalt aggregate grading for a maximum diameter of 10 mm, 14 mm and 20 mm are quoted from AAPA (2004).One of the aggregates grading for porous asphalt according to (Australian Asphalt Pavement Association,2004) is as in Table 1 below.

Table 1. Aggregate Grading Limits for Porous Asphalt Mixtures, (According to Australian Asphalt Pavement Association, 2004)

| Sieve Size (mm) | Filter Pass Specifications (%) | |
|---|---|---|
| | Range | Ideal |
| 19,0 | 100 | 100 |
| 12,7 | 85 – 100 | 92,5 |
| 9,5 | 45 – 70 | 57,5 |
| 4,75 | 10 – 25 | 17,5 |
| 2,36 | 7 – 15 | 11 |
| 1.18 | 6 – 12 | 9 |
| 0.6 | 5 – 10 | 7,5 |
| 0.3 | 4 – 8 | 6 |
| 0.15 | 3 – 7 | 5 |
| 0.075 | 2 – 5 | 3,5 |

The specifications of porous asphalt concrete mixture according to (According to Australian Asphalt Pavement Association, 2004) as shown in Table 2

Table 2. Specifications of mix concrete asphalt Porus ,according to (According to Australian Asphalt Pavement Association, 2004)

| No | Planning Criteria | Unit | Value |
|---|---|---|---|
| 1. | *Cantabro loss* | % | Mak 20 |
| 2. | *Asphalt flow down* | % | Mak 0,3 |
| 3. | Stability *Marshall* | Kg | Min. 500 |
| 4. | Flow | Mm | 2 – 6 |
| 5. | Voids | % | 10 – 28 |
| 6. | *Marshall Quotient* | Kg/mm | Maks. 400 |
| 7. | *Density* | gr/cm3 | Min. 2 |
| 8. | Durability | % | ≥75 |
| 9. | Permeability | cm/dt | 0.187-0.844 |

(Suhardi, 2013) The addition of variations of PET (Polyethylene Terephthalate) to the AC-BC (Asphalt Concrete-Binder Course) mixture affect on Marshall characteristics, the higher the level of addition of PET (Polyethylene) Terephthalate) then the stability value will increase but for the value of the cavity content in the mixture the higher the percentage. Meanwhile, (Ali, 2013) a mixture of porous asphalt based on asbuton using Japanese grading has a permeability value of 0.143 cm / s, and a marshall stability value of 952.92 kg. These results indicate a sufficient of potential feasibility in using Asbuton-based porous asphalt mixtures. The purpose of this research was to obtain the properties Marshall of porous asphalt concrete mixtures with variations of plastic waste and to analyze the effects of plastic bag waste on the properties Marshall of asphalt concrete mixtures

# 2 RESEARCH METHOD

This research was carried out in the Laboratory of Civil Engineering Material Testing, State Polytechnic of Jakarta. The materials used in this study were Esso asphalt, coarse-aggregate of crushed stone, rock ash, and plastic waste. This research was conducted at the Laboratory of Civil Engineering Material Testing, State Polytechnic of Jakarta. The materials used in this study were Esso asphalt, coarse-aggregate of crushed stone, rock ash, and plastic waste.

The main research method used is an experimental method by making a specimen of porous hot asphalt concrete mixture. To determine the optimum asphalt content, a mixture of porous asphalt and plastic waste tannin was made with an asphalt content of 4.5; 5; 5.5; 6; and 6.5%. After obtaining KAO, then making the test object by adding variations of plastic waste of 0, 5, 10, 15, 20 and 25% to KAO. For each variation of asphalt content and variations in plastic waste, 3 test objects were made for each type of test. The total number of specimens in need in this study was 105 pieces, as shown in Table 3 as follows:

Table 3. Variation of plastic waste in Mixture Concrete asphalt Porous

| Number of | Variation of plastic waste (%) | | | | | Tottal Object Test |
|---|---|---|---|---|---|---|
| | 5 | 10 | 15 | 20 | 25 | |
| Marshall Standart | 3 | 3 | 3 | 3 | 3 | 15 |
| Cantabr o Loss | 3 | 3 | 3 | 3 | 3 | 15 |
| Asphalt Flow Down | 3 | 3 | 3 | 3 | 3 | 15 |
| Permeab ility | 3 | 3 | 3 | 3 | 3 | 15 |
| Total | 12 | 12 | 12<br>60 | 12 | 12 | 60 |

# 3 RESULTS AND DISCUSSION

## 3.1 Aggregates and Test Results Asphalt

From the test results of the physical properties of aggregates, each of them fine aggregate and coarse aggregate meet the specifications. The test results with a specific gravity greater than 2.5 indicate that the aggregate can be used for roads with high traffic volume. The results of the examination physical properties of aggregate and asphalt are presented in Table 4.

Table 4. Results of Aggregate and Asphalt Inspection

| Tests | Unit | Results of Testing | Requirement Bina Marga 2018 | |
|---|---|---|---|---|
| | | | Min | Max |
| FINE AGGREGATE | | | | |
| -Bulk Specific Gravity | | 2.57 | 2.5 | - |
| -Apparent Specific Gravity | | 2.68 | 2.5 | - |
| Water Absorption | % | 1.59 | - | 3 |
| COARSE AGGREGATE | | | | |
| - Bulk Specific Gravity | | 2.56 | 2.5 | - |
| -Apparent Specific Gravity | | 2.7 | 2.5 | - |
| Water Absorption | % | 2.15 | - | 3 |
| ASPHALT | | | | |
| Penetration | mm | 65 | 60 | 79 |
| Specific Gravity | | 1,02 | 0,92 | 1,06 |
| Softening Point | ºC | 48,5 | 45 | - |
| Ductility | mm | 101 | 100 | - |

## 3.2 Test Marshall Asphalt Concrete Mixtures

Results for Porous Marshall test results for porous asphalt concrete mixtures without plastic waste obtained KAO 5.5%. Furthermore, with KAO 5.5%, and variations of plastic waste 0, 5, 10, 15, 20 and 25%, the recapitulation is presented in Figures 1 to 7.

### 3.2.1 VMA

Based on the results of statistical tests, the significance value is 0.002 <0.05, so it can be concluded that the variation of plastic waste has a significant effect on VMA and the value of R square is 0.930 which means that the variation of plastic waste has an effect of 93.0% on VMA. The test results also showed that the VMA value tended to decrease with the increase in plastic waste, although the decrease was small. (As in Figure 1).

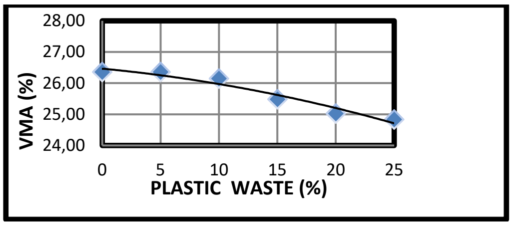


Figure 1. VMA Graph

### 3.2.2 VFB

The significance value of the statistical result tests was 0.0025 <0.050, so it can be concluded that the variation of plastic waste has a significant effect on VFB. The value of R square is 0.755 which means that the variation of plastic waste has an effect of 75.5% on VFB. The test results also show that the VFB value tends to increase with the addition of variations in plastic waste(as in Figure 2).

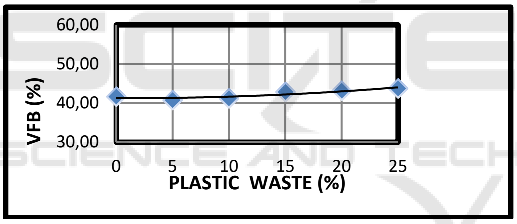


Figure 2. VFB Graph

### 3.2.3 VIM

The significance value of the result test was 0.001 <0.05, so it can be concluded that the variation of plastic waste has a significant effect on VIM. The value of R square is 0.959%, which means that the variation of plastic waste has an effect of 95.9% on VIM. The relationship between plastic waste and VIM shows a tendency for the cavity value to continue to decrease according to the addition of plastic waste because fills the mixed cavity. The VIM value was suitable to the required in the 2004 AAPA specifications, namely 10 - 28% ( Figure 3)

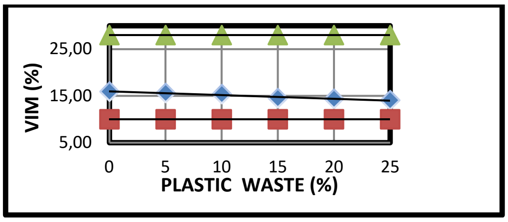


Figure 3. VIM Graph

### 3.2.4 Stability

The significance value of the result test was obtained a value of 0.001 <0.05, so it can be concluded that the variation of plastic waste has a significant effect on stability. This can be seen from the R square value of 0.963 which means that the variation of plastic waste has an effect of 96.3% on stability. The value of the stability of the mixture is higher along with the increasing variation of plastic waste in the mixture. This is because plastic waste is mixed with 60/70 penetration asphalt in the mixture, where this mixing causes the adhesion of the asphalt to be better so that the value of the stability of the mixture increases. The value of stability value was suitable to the required in the 2004 AAPA specifications, which is a minimum of 500 kg (As in Figure 4).

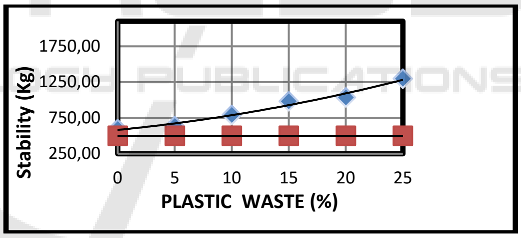


Figure 4. Stability Graph

### 3.2.5 Flow

The significance value of the result test, it is found that a significance value of 0.004 <0.05, so it can be concluded that the variation of plastic waste has a significant effect on melting.. This can be seen from the value of R square is 0.893, which means that the variation of plastic waste has an effect of 89.3% on melting. Meltability continues to increase with an increasing variety of plastic waste, as the asphalt blanket increases. The melting value was suitable to the required in the 2004 AAPA specifications, namely 2 - 6 mm ( Figure 5).

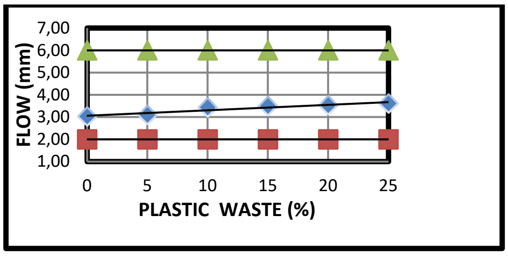


Figure 5. Flow Graph

### 3.2.6 Marshall Quotient

The significance value of the result test was obtained a value of 0.001 <0.05, so it can be concluded that the variation of plastic waste has a significant effect on the Marshall Quotient. This can be seen from the R square value of 0.866, which means that the variation of plastic waste has an effect of 86.6% on the Marshall Quotient. More and more plastic waste increases the Masrshall Quotient (MQ). The MQ value was suitable to the required in the 1997 AAPA specifications is a maximum of 400 kg / mm (as in Figure 6)

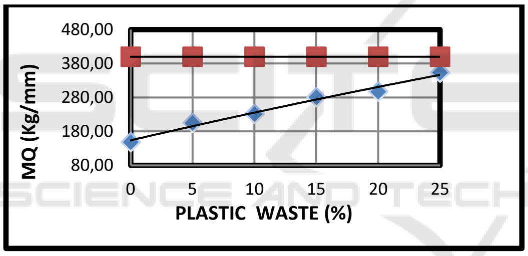


Figure 6. Marshall Quotient Graph

### 3.2.7 Permeability

The significance value of the result test was obtained a value of 0.001 <0.05, so it can be concluded that the variation of plastic waste has a significant effect on permeability. This can be seen from the R square value of 0.946, which means that the variation of plastic waste has an effect of 94.6% on permeability. The results test shows that the relationship between plastic waste and the permeability coefficient where the increase in plastic waste, the permeability coefficient value of the porous asphalt concrete object will decrease, this is because the increase in plastic waste, the volume of cavities inside the test object decreases due to the closure of the cavity. by the asphalt film so that the time to drain water from the surface will be longer. (as in Figure 7)

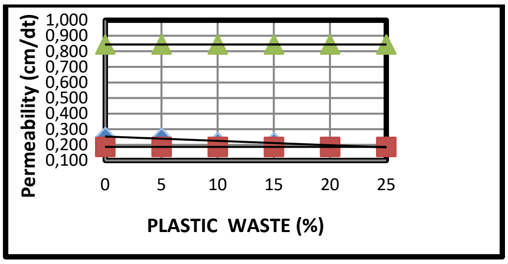


Figure 7. Permeability Graph

## 4 CONCLUSION

The results of this research shows that: The variation of plastic waste from 0 to 25% of the optimal asphalt content has a significant effect to the VIM, Stability, Meltness, and values Marshall Quotient, and permeability but did not significantly influence the VFB and VMA values because the significance value> 0.05.

In addition, the addition of plastic waste increases the% cavity filled with asphalt, stability, Melt, Marshall Quotient and melt and lower% cavity in the mixture, % voids between aggregates, and permeability.

As for the addition of plastic waste up to 25% to KAO for all parameters of Marshall has met the specifications required by the Australian Asphalt Pavement Association (2004) for moderate traffic

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