The Influence of Local Materials Laterite Stone and Plastic Bag Waste on the Marshall Characteristics of Asphalt Concrete - Wearing Course

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Abstract: Use of local material laterite stone as a road pavement material has not been fully utilized optimally, based on previous research that laterite stone can be an alternative road pavement material, besides that another problem is the large number of plastic bag produced by Pupuk Kaltim Companies, this causes the company to experience problems and difficulties in minimizing the plastic bag waste. Some of the ways that have been done include burning the waste which will have an impact on environmental pollution, in this study trying to combine the use of laterite local materials with plastic bag waste in asphalt mixtures so that it is expected to be useful in the use of local materials and minimize the presence of plastic bag waste. The purpose of this study was to determine the characteristics of Marshall and determine the Optimal Asphalt Content from Asphalt Concrete – Wearing Course. In this study, the use of laterite stone as a substitute for coarse aggregate is 75% with the addition of planned variations of plastic bag waste of 1%, 2%, 3%, 4% and 5% of the asphalt weight. Based on the results of the study, it was found that the addition of a maximum value of 3% plastic waste bag at the Optimum Asphalt Content of 6.11% with Marshall characteristics, including the discovery value of 1820 kg, flow 3.55%, VIM 3.82%, VMA 17.15%, VFA 77.52% and MQ 515 kg/mm. Use of laterite stone and addition of plastic bag waste can increase of stability and reduce use of asphalt compared to before the addition of plastic bag, this is due to the inter-molecular binding of asphalt and plastic bag in the asphalt mixture.

1 INTRODUCTION

The use of materials for road pavement construction in East Kalimantan is still very dependent on stone and Palu sand, so that road construction costs in East Kalimantan are expensive (Putrawirawan, Ibayasid, 2020). So it is necessary to make an effort so that how to utilize local natural resources in East Kalimantan as an alternative material for making asphalt. One of the natural resources owned by East Kalimantan is Laterite Stone. This study also wants to discuss related to plastic bag waste produced by Pupuk Kaltim (Kalimantan Timur) companies. The problems is the number of plastic bag produced so that the company's management has difficulty minimizing the presence of this waste, several ways have been done by burning the waste which will certainly cause air pollution around it.

The purpose of this study was to determine the effect of laterite stone substitution on coarse aggregate and also the addition of plastic bags Pupuk Kaltim Company on Marshall characteristics of the Asphalt mixture, and determine the value of the Optimum Asphalt Content (OAC) Asphalt Concrete-Wearing Coarse (AC-WC). Use of laterite stone as a substitute for coarse aggregate in AC-WC was a maximum of 75% and the optimum asphalt content value was 6.22% with Marshall characteristics including the stability value of 1480 kg, flow 3.85%, VIM 4.20%, VMA 16.40%, VFA 74.00% and MQ 390.00 kg/mm. The results showed that the Asphal Concrete – Wearing Course AC-WC with a substitute for coarse aggregate using laterite stone met the requirements for

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the Asphal Concrete – Wearing Course (AC-WC) (Putrawirawan, Ibayasid, 2020).

2 MATERIAL AND METHOD

2.1 Asphalt Concrete

Asphalt concrete is a layer on highway construction consisting of a mixture of hard asphalt and well graded aggregate, mixed, spread out in a hot state and compacted at a certain temperature (Sukirman, 2003). As a surface layer of road pavement, Asphalt concrete (AC) has structural value, is waterproof and has high stability. Another characteristic is that it has few voids in its aggregate structure, interlocking with each other, therefore asphalt concrete has high stability and is relatively rigid.

2.2 *Asphalt Concrete - Wearing Course* (AC-WC)

Asphalt Concrete - Wearing Course (AC-WC) is the topmost pavement layer and functions as a wear layer. Even though it is non-structural, AC-WC can increase pavement resistance to quality degradation so that overall it increases the service life of the pavement construction. AC-WC has the smoothest texture compared to other types of Asphalt Concrete.

2.3 Laterite Stone

Laterite stones is a hardened soil formed naturally resembling rock from the deposition of substances such as nickel and iron. Laterite itself is naturally formed in which there are many elements and nutrients that make up the soil layer hardened like stone. Laterite stones are commonly found in hot and humid tropical climates. As a result of the content of iron and nickel oxides are so much that the lateritic soil hardens to resemble rock. The mineral and chemical composition of laterite stones is very influential on the parent rock, laterites generally contain large amounts of quartz and oxides of titanium, zircon, iron, tin, manganese and aluminum, which are left behind from wear and tear. In some countries, the presence of laterite is abundant, but laterite has a few properties and characteristics different from some other place. This makes their performance diverse and unpredictable (Gidigasu, 1976). These varied properties have limited their use in some construction sites, especially road construction. these limitations, many have been overcome, namely by adding stabilizers to improve its properties or in various other ways to improve soil, especially road construction (Oluyemi, Ayibiowu, 2016). The term Laterite is derived from the Latin word- later, meaning brick. It was first used in 1807 by Buchanan to describe a red iron-rich material found in the southern parts of India. Laterites are widely distributed throughout the world in the regions with high rainfall, but especially in the inter-tropical regions of Africa, Australia, India, South-East Asia and South America, where they generally occur just below the surface of grasslands or forest clearings. Their extension indicates that conditions were favorable for their formation at some point in time in the history of the world, but not necessarily simultaneously in all regions (Maignien, 1966). Alexander et al., (1962) (West, Jenbarimiema, Nyebuchi, & Azeruibe, 2020) compiled the physical, chemical and morphological definitions from various researchers and then redefined laterite as a highly weathered material, rich in secondary oxides of iron, aluminum, or both, it is nearly void of bases and primary silicates, but it may contain large amounts of quartz and kaolinite, and it is either hard or capable of hardening on exposure to wetting and drying (West, Jenbarimiema, Nyebuchi, & Azeruibe, 2020).

Figure 1: Laterite stone.

2.4 Plastic

Plastic is a polymer which has unique and extraordinary properties. PET materials such as plastic bottles and plastic cups were used. Plastic waste was collected from houses and schools. The collected PET materials were chosen with a maximum thickness of 60 micron. This would facilitate mixing them with asphalt at the laboratory under its softening point. Also, in order to provide appropriate plastic particles, the bottles and cups were cleaned then slashed into small pieces then crushed and sieved such that it passes through 3-5 mm sieve using shredding machine (Naghawi H. at al, 2018). Asphalt and plastic waste coated aggregates caused by the intermolecular bonding which improves

asphalt mix strength. This would be reflected in the enhanced durability and stability of the asphalt mix which would lead to enhancing pavement resistance to fatigue cracking and rutting or permanent deformation (Naghawi, Ajarmeh, Allouzi, & Alklub, 2018).
The local recycled wastes (PP, HDPE and LDPE) were identified and handpicked from Dammam municipality recycling programme. This waste was then processed for easier blending. The processing involved washing, shredding and grinding (Dalhat M. at al, 2016). The effect of polypropylene, high-and low-density polyethylene (PP, HDPE and LDPE)-recycled plastic wastes (RPW) on the viscoelastic performance of the local asphalt binder has been investigated. The recycled plastics were obtained by shredding and grounding the RPW to a desirable size for easier blending with the asphalt binder (Dalhat & Wahhab, 2015)**.** Recycled plastic wastes (RPW) such as polypropylene (PP), polyethylene (PE) packages and polyvinyl chloride (PVC) has been previously utilised to enhance the performance of asphalt concrete (AC) (Dalhat & Wahhab, 2015).
Polypropylene when interacted with 80 pen base bitumen enhances it's performance characteristics which were brought about by altered rheological properties of the modified bitumen (Habib, Kamaruddin, Napiah, 2011). Polypropylene can be found in food packaging, microwave-proof containers, pipes, and automotive parts. It has been used as a mixture modifier through the wet process in percentages that range between 0.5% and 11% by weight of bitumen, while the most common percentage used for the production of RPMB ranges between 3% and 5% (Brasileiro, at al, 2019).

Figure 2: Plastic bag from Pupuk Kaltim Company.

In this study, 3 specimens were made of each sample bricket on variations in asphalt content, with 5 variations in the content of plastic bag as additives, 75% laterite stone composition which had been determined according to previous research. Before making the sample, the plastic bag is cut into pieces with a size of 0.5-1.0 cm and then weighed according to the composition of the mixture that has been determined. Design the composition of the mixture and then make a bricket sample, then marshall testing is carried out to determine the marshall properties and characteristics of the asphalt mixture. The total number of test objects is 75 sample bricket.

3 RESULTS AND DISCUSSION

3.1 Result of Testing Material

Based on the results of testing in the asphalt testing laboratory, the values of specific gravity, penetration, softening point and ductility meet the requirements of asphalt, then the results of testing the physical characteristics of aggregates that meet the requirements of technical specifications can be seen in the following tables.

Table 1: The Result of Asphalt properties.

No.	Type of testing	Requirement	Result
1	Penetration, 25°C	60-70	64.6
2	Softening point (°C)	Min. 48	50.75
3	Ductility 25°C (cm)	Min. 100	133
4	Spcific Ggrafity	Mi. 1	1.020

Table 2: The results of testing the specific gravity and absorption of coarse aggregate.

Type of testing	Requirement	Result
Dry bulk density	Min. 2.5	2.64
Saturated surface dry (SSD)	Min. 2.5	2.66
Apparent density	Min. 2.5	2.70
Absorption	Maks. 3%	0.77
Abration	Maks. 40%	20.63

Table 3: The results of testing the specific gravity and absorption of fine aggregate.

Type of testing	Requirement	Result
Dry bulk density	Min. 2.5	2.65
Saturated surface dry (SSD)	Min. 2.5	2.68
Apparent density	Min. 2.5	2.73
Absorption	Maks. 3%	1.01

Table 4: The results of testing the specific gravity and absorption of Palu sand.

Type of testing	Requirement	Result
Dry bulk density	Min. 2.5	2.55
Saturated surface dry (SSD)	Min. 2.5	2.60
Apparent density	Min. 2.5	2.68
Absorption	Maks. 3%	1.83

Table 5: The results of testing the specific gravity and absorption of Laterite stone.

Type of testing	Requirement	Result
Dry bulk density	Min. 2.5	2.54
Saturated surface dry (SSD)	Min. 2.5	2.59
Apparent density	Min. 2.5	2.67
Absorption	Maks. 3%	2.93
Abration	Maks. 40%	29.63

All material tests which include asphalt, coarse aggregate, fine aggregate, filler and laterite stone have met the requirements of the 2018 Bina Marga technical specifications.

3.2 Marshall Characteristic

3.2.1 Relation of Plastic Bag Waste with Stability

Stability is the ability of the road pavement layer to accept the load without deformation in accordance with the planned traffic load level. Low stability will facilitate the occurrence of deflection, on the other hand, too high stability can cause the mixture to become stiff and cause the mixture to crack relatively quickly. Stability occurs due to shear between grains, locking between aggregates and the binding capacity of the asphalt.

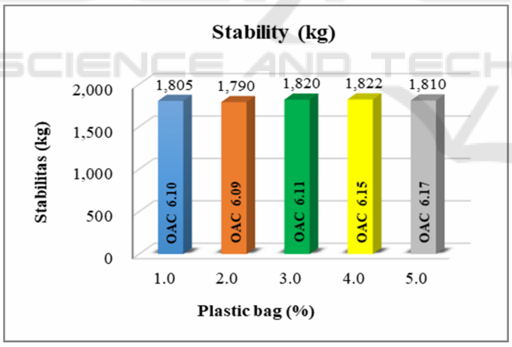

Figure 3: Graph of the relationship between stability and variations in use of plastic bags.

Figure 3 shows that the value of stability has decreased and increased from normal conditions. The lowest stability value was obtained at 2% plastic bags, which was 1,790 kg and the highest value was obtained at 4% laterite stone, which was 1,822 kg. The decrease in stability was caused by the addition of plastic sacks to the mixture which resulted in a lack of in-locking between the aggregates and the asphalt added with plastic bags so that it was no longer effective in covering the aggregates which could result in a decrease in the stability value.

3.2.2 Relation of Plastic Bag Waste with Flow

Flow is the amount of deformation that occurs in the pavement layer due to holding the load it receives. Good mix density, sufficient asphalt content and good stability will have an effect on decreasing the flow value. A low flow value can cause the mixture to become stiff so that the pavement layer becomes easy to crack, while a high flow value will produce a plastic pavement layer so that the pavement will easily deform such as waves (washboarding) and grooves (rutting).

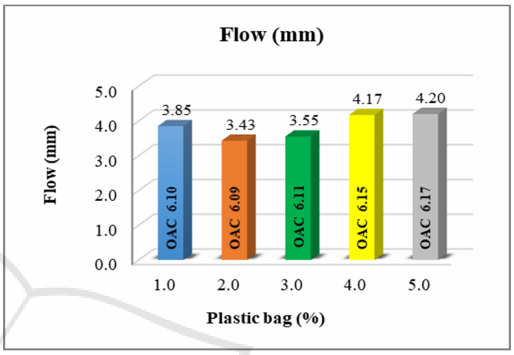

Figure 4: Graph of the relationship between Flow and variations in use of plastic bags.

Figure 4 shows that the flow value has decreased and increased from normal conditions. The highest flow values were obtained at levels of 4% and 5% of plastic sacks, namely 4.12 mm and 4.20 mm, not meeting the requirements of the 2018 General Specifications, namely a minimum of 2.0 mm and a maximum of 4.0 mm. The lowest flow value is 2% and 3%, which is 3.55 mm. The increase in the average flow value can be caused by the increasing amount of asphalt required so that the properties of the mixture are plastic and easily deformed when loaded.
A mixture that has a flow value that is too high can cause the aggregate grains to be more easily shifted from their position, this shows that the locking properties between aggregates are low so that the aggregates easily shift when loaded with traffic. However, if the amount of compaction is increased, the asphalt mixture will become denser so that the vertical deformation decreases.

3.2.3 Relation of Plastic Bag Waste with Void in Mixture (VIM)

Voids in the mixture (VIM) is the percentage of voids present in the total mixture. The VIM value affects the durability of the pavement, the higher the VIM value means the larger the cavity in the mixture. This causes the mixture to become less dense so that water and air can easily enter the cavities in the mixture and cause the mixture to be porous. VIM value that is too low will cause bleeding due to high temperatures, so asphalt viscosity will decrease according to its thermoplastic properties.

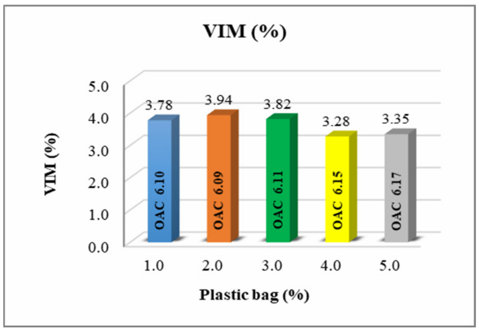

Figure 5: Graph of the relationship between VIM and variations in use of plastic bags.

Figure 5 shows that the VIM value decreased at 4% plastic bag content. This is because the increasing content of plastic bag causes asphalt to fill voids in the aggregate because it has smaller voids and the more asphalt content filled in the mixture can make the mixture denser. The VIM value in all variations of the plastic bag content still meets the minimum requirements of 3% and a maximum of 5%

3.2.4 Relation of Plastic Bag Waste with Void in Mineral Agregat (VMA)

Voids Mineral aggregate (VMA) are air voids that exist between the particles of the asphalt aggregate mixture that have been compacted including the space filled with asphalt which is expressed in percent of the total volume of the mixture. The expected value of VMA in the asphalt mixture is the minimum possible, with the aim of providing sufficient space for the asphalt to adhere to the aggregate.

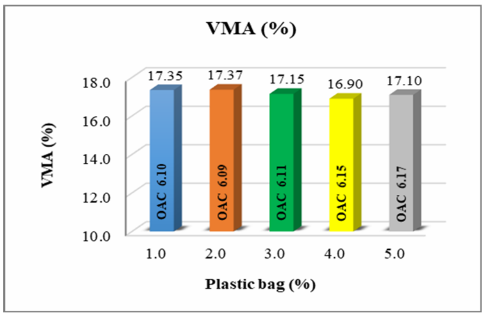

Figure 6: Graph of the relationship between VMA and variations in use of plastic bags.

Figure 6 shows that the addition of plastic bag to asphalt causes the VMA value to decrease from the use of 4% plastic bag. VMA values on the use of plastic bag 1%, 2%, 3%, 4%, 5% respectively 17.35%, 17.37%, 17.15%, 17.10%, 17.10%. The decrease in VMA value along with the increase in the content of plastic bag on the asphalt, causing the mixture form a thick enough blanket against the aggregates, as a result, the cavities between aggregates are getting smaller. VMA value that is too high indicates that the air voids between mineral aggregates are larger, this condition will cause the pavement to not last long.

3.2.5 Relation of Plastic Bag Waste with Void Filled with Asphalt (VFA)

Void filled with asphalt (VFA) is the percentage of the void that can be filled with asphalt. The higher the VFA value, the more voids in the mixture filled with asphalt, so that the mixture's resistance to water and air is also higher, but VFA value that is too high will cause bleeding. VFA value that is too small will cause the mixture to be less impermeable to water and air because the asphalt film layer will become thin and will crack easily when receiving additional loads so that the asphalt mixture is easily oxidized which ultimately causes the pavement layer to not last long.

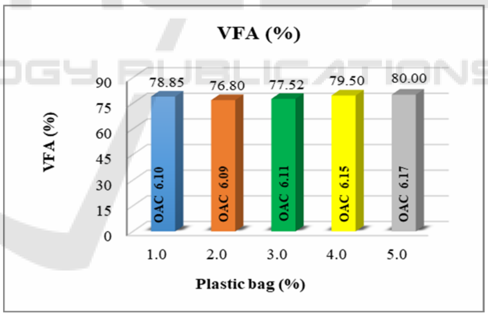

Figure 7: Graph of the relationship between VMA and variations in use of plastic bags.

Figure 7 shows that the value of VFA has increased and decreased. Values for plastic bag content of 1%, 2%, 3%, 4%, 5% respectively are 78.85%, 76.80%, 77.52%, 80.00%, 80.00%. VFA value for each plastic bag content still meets the general specifications for 2018 which is at least 65%. VFA value that is too high will cause bleeding.

3.2.6 Relation of Plastic Bag Waste with Marshall Quotient (MQ)

Marshall Quotient (MQ) is the quotient between stability and flow. Marshall Quotient value will give mixed flexibility value. The larger the Marshall Quotient value, the more rigid the mixture will be, conversely the smaller the Marshall Quotient value, the more flexible the mixture will be.

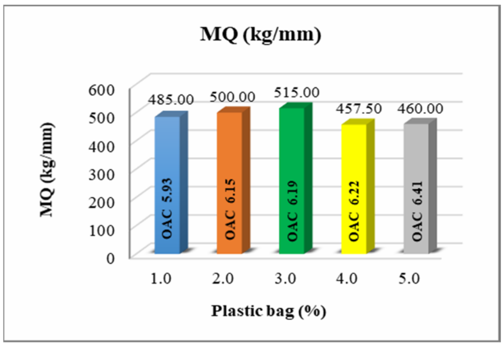

Figure 8: Graph of the relationship between MQ and variations in use of plastic bags.

Figure 8 shows that the addition of plastic bags causes the Marshall Quotient value to increase and decrease. The highest Marshall Quotient value was at 3% plastic bag content, which was 515 kg/mm. While the levels of 4% and 5% decreased. This decrease is caused by a decrease in stability along with the increase in the flow value in the mixture. The decrease in the Marshall Quotient value indicates the mixture tends to become soft and not brittle when the asphalt mixture has an increase in the amount of compaction.

3.2.7 Relation of Plastic Bag Waste with Optimum Asphalt Content (OAC)

From the results of the Marshall test, the optimum asphalt content for each variation was 6.10% for 1% plastic bag; 6.13% for 2% plastic bag; 6.11% for 3% plastic bag; 6.15% for 4% plastic bag; 6.12% for 5% plastic bag. It can be seen that the effect of adding plastic sacks in the mixture will increase the value of the optimum asphalt content in the Asphalt Concrete-Wearing Course (AC-WC). This means that the addition of plastic bags can affect the optimum asphalt content value. Which can be seen in Figure 8.

After getting Marshall test results from each test object in the mixture with the addition of plastic bag content ranging from 1%, 2%, 3%, 4% and 5%, then the results of Marshall parameter inspection on each variation of plastic bag content in the form of stability, (flow), Voids In the Mixture (VIM), Voids Mineral Aggregate (VMA), Voids Filled With Asphalt (VFA), Marshall Quotient (MQ) and Optimum Asphalt Content (OAC) value for each variation of the content of plastic bag which can be seen in Table 6.

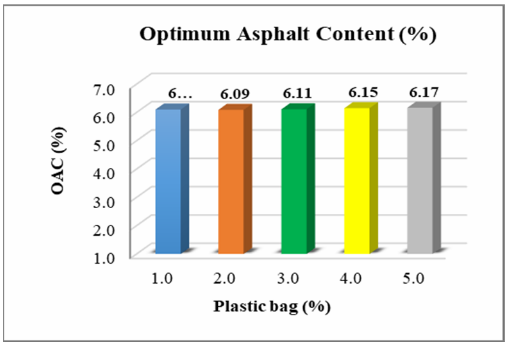

Figure 9: Graph of the relationship between Optimum Asphalt Content and variations in use of plastic bags.

Table 6: The Results of Marshall Characteristic Asphalt Concrete – Weraing Course.

Plastic (%)	1%	2%	3%	4%	5%	Spec.
OAC (%)	6.10	6.13	6.11	6.15	6.12	-
Stability (kg)	1,805	1,790	1,820	1.822	1,810	Min. 800
Flow (mm)	3.85	3.55	3.55	4.12	4.20	2 – 4
VIM (%)	3.78	3.94	3.82	3.28	17.10	3 – 5
VMA (%)	17.35	17.37	17.15	17.10	17.50	Min. 15
VFA (%)	78.85	76.80	77.52	80.00	80.00	Min. 65
MQ (kg/mm)	485	500	515	457.50	460	Min. 250

Based on the table 6, the addition of 1%, 2% and 3% plastic bags has a Marshall characteristic value, but at the addition of 4% and 5% the flow value does not in the requirements, having a high flow value of 4.12 mm and 4.20 mm, the addition of 4% and 5% plastic bag does not meet the technical specifications Bina Marga 2018, second Revision.

4 CONCLUSIONS

The test results of the Asphalt mixture using 75% Laterite Stone as a substitute for coarse aggregate and the addition of plastic bag can affect the value of Marshall characteristics. The optimum value of plastic bag content was 3%, with Marshall characteristic values, Stability = 1820 kg, Flow = 3.55 mm, VIM = 3.82%, VMA = 17.15%, VFA = 77.52%, and MQ = 515 kg/mm. The test results of AC-WC obtained the Optimum Asphalt Content (OAC) of 6.11%. Use of laterite stone and addition of plastic bag can increase of stability and reduce use of asphalt compared to before the addition of plastic bag, this is due to the inter-molecular binding of asphalt and plastic bag in the asphalt mixture.

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