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The Evaluation of The use of Palm Shell Ash Waste to Polymer Modified Asphalt Mixture

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Abstract. The palm oil industry's development has a strategic role in Indonesia's economy because Indonesia is the largest country and the largest exporter of palm oil globally. On the other hand, a new problem arises from increasing palm oil ash waste. This has encouraged the use of palm oil ash as filler mix asphalt. In this study, an evaluation of the asphalt mixture's performance on the surface layer (AC-WC) will be carried out by utilizing palm ash waste as a filler using Starbit E-55 polymer asphalt. Testing the asphalt mixture's performance using the Marshall method with asphalt content of $6\% \pm 0.5$ and variations in the percentage of palm ash filler used, namely 3, 4, 5, and 6%. Samples are prepared and tested to obtain the stability and volumetric values of the mixture. Based on the results, it was found that the addition of palm ash waste as a filler could increase the stability performance at 3% filler content but there was a decrease in the filler content of 4, 5, and 6% in the test object without the addition of palm ash filler, the highest stability was obtained, namely 2358, 4 kg while the test object with the addition of 3% palm ash filler has a stability of 2503.03 kg at each asphalt content of 6.5%. The flow parameter in the test object continues to decrease along with the increase in the addition of oil palm ash filler, this is in line with the increase in the Marshall Quotient parameter which causes the mixture to become stiffness, this indicates that the mixture can withstand deformation due to traffic loads and shows that this oil palm ash potentially suitable for use as a filler in asphalt mixtures.

Keywords: asphalt, filler, palm oil, Marshall, waste

1. Introduction

Indonesia is one of the largest palm oil producing countries globally, contributing 59% of world palm oil production [1], especially in the last 25 years, where we can find oil palm plantations in almost all parts of Indonesia. But on the other hand, a lot of waste in the form of liquid and solid is produced from palm oil mills that have the potential to pollute the environment, so there is a need for better waste utilization in addition to environmental improvement and its positive impact on the economy [2]. Palm oil processing only produces 10% palm oil while the remaining 90% remains in the form of biomass or waste is still untapped for industry, with higher yields and increasing production in the world can produce more than 295 million tonnes of waste every year [3]. So it is necessary to further utilize palm oil waste in Indonesia due to the large production that has a positive impact on sustainable and environmentally friendly development.

The development of road infrastructure is one of the important needs in the development of the transportation system in Indonesia, a good transportation network will have an impact on the development of activities in a region [4]. The selection of suitable material is one of the requirements in hot asphalt mixture as a pavement layer, one



of which is filler. The use of alternative materials to substitute aggregates in road construction has been widely used, including fly ash, slag, waste glass, and palm ash shells, where the use of palm ash shells is widely used as a substitute for filler [5-8]. The use of waste materials to replace the aggregate composition leads to asphalt pavement green, sustainable, and environmentally friendly construction, which ultimately conserves nature by reducing the need for materials from natural sources [9].

The use of palm shell ash as an alternative to filler in asphalt mixtures contains silicon dioxide (SiO_2), where silicon dioxide is the most abundant chemical element in portland cement and is suitable as a binder. The silicon dioxide content allows it to bind asphalt and aggregates to obtain a stronger asphalt mixture [10]. The use of palm ash waste of 1% to 5% gives an optimum value of 3% against permanent deformation resistance and moisture [11], while for mixed performance using 0, 1, 3, 5, and 7% gives different results on stability values, resilient modulus, creep, and fatigue with an optimum value of up to 5% when compared to the control mixture [5]. With a lot of oil palm production in Indonesia and producing ash waste from burning oil palm shells that have not been utilized, on the other hand, the materials contained in this waste contain beneficial chemical elements as filler substitutes, so it is necessary to research pavement technology development using palm ash waste as a filler using polymer modified bitumen Starbit E-55 in a wearing course asphalt concrete (AC-WC).

2. Material and Methods

The materials used in this study were aggregated from some aggregate fractions such as $\frac{3}{4}$ ”, $\frac{1}{2}$ ”, $\frac{3}{8}$ ” fractions, and dust from Cilegon Banten, Starbit E-55 polymer asphalt from PT. Bintang Djaja and palm shell ash, for the testing tool are used Marshall. Determination of mixed grading using the results of the filter analysis then adjusted to the limitation of surface layer grading (Asphalt Concrete - Wearing Course) based on the general specifications of roads and bridges of Bina Marga 2010. From the results of mixed grading, the percentage for the aggregate weight of each aggregate fraction is obtained, namely split 1-2 by 15%, screening by 24%, and stone ash by 61%, can be seen in Figure 1.

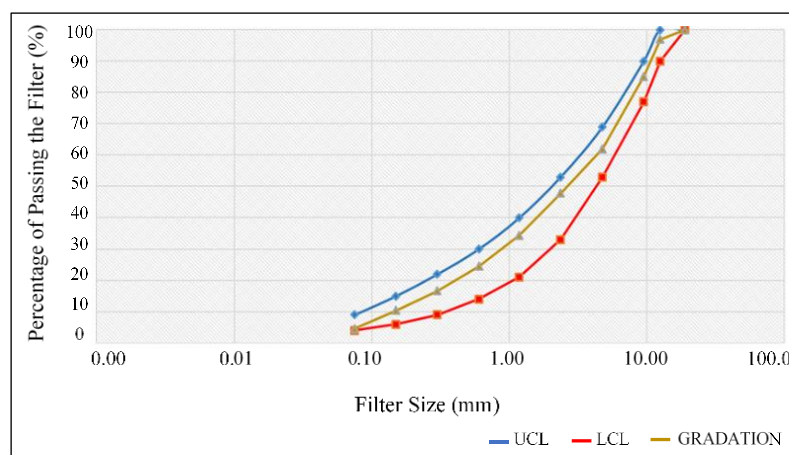


Figure 1. Gradation asphalt concrete -wearing course mixture (AC-WC).

The mixed design methodology in research using oil palm ash waste starts from the preparation of the materials used, testing the aggregate characteristics consisting of aggregate density and absorption, aggregate wear, filter analysis using the Indonesian national standard (SNI), then testing the characteristics of asphalt consisting of penetration, bitumen, asphalt specific gravity, ductility following the procedure from SNI, British Standard (BS), AASHTO. Furthermore, checking the ash of the oil palm shell is like preparing the material to be filtered with sieve no. 200 for the added material for the asphalt mixture, after that the variations in the ash content of the oil palm shell are 0%, 3%, 4%, 5%, and 6% then all the ingredients are mixed for the test object manufacturing stage, testing the test object using the Marshall method and the final part will be presented processing and data analysis. More details can be seen in Figure 2.

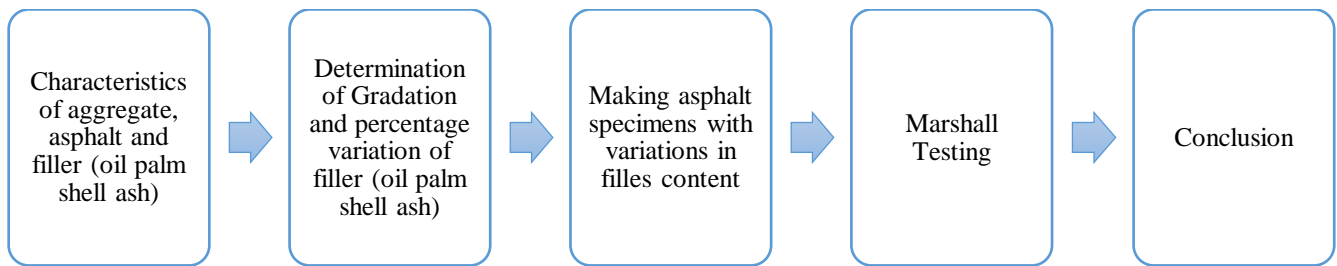


Figure 2. Research Methodology

3. Data Analysis

Based on the results of tests performed on the material used in this study, do further analysis to test the Marshall method.

3.1 Material testing

The coarse aggregates tested in this study were split 1-2, and the screening was held at sieve No. 4 or 4.75 mm sieve, while the fine aggregate used is rock ash that passes through sieve No. 4 or 4.75 mm sieve originating from Merak, Banten. The test results can be seen in Table 1.

Table 1. Aggregate Properties Test Results

| No | Checking type | Results | Testing Specifications | |
|----------------------------------------|---------------------------|---------|------------------------|---------|
| | | | Minimal | Maximal |
| I Coarse Aggregate | | | | |
| 1 | Specific Gravity Bulk | 2,63 | - | - |
| 2 | Specific Gravity Apparent | 2,71 | - | - |
| 3 | Specific Gravity SSD | 2,67 | 2,5 | - |
| 4 | Absorption (%) | 1,11 | - | 3 |
| 5 | Abrasion Testing (%) | 18,2 | - | 40 |
| II Coarse Aggregate (Screening) | | | | |
| 1 | Specific Gravity Bulk | 2,68 | - | - |
| 2 | Specific Gravity Apparent | 2,73 | - | - |
| 3 | Specific Gravity SSD | 2,70 | 2,5 | - |
| 4 | Absorption (%) | 0,72 | - | 3 |
| III Fine Aggregate | | | | |
| 1 | Specific Gravity Bulk | 2,47 | - | - |
| 2 | Specific Gravity Apparent | 2,49 | - | - |
| 3 | Specific Gravity SSD | 2,5 | 2,5 | - |
| 4 | Absorption(%) | 0,3 | - | 3 |

Based on the aggregate test, the results show that the bulk density, apparent density, surface dry saturated bulk density (SSD) meets SNI 1970-2008 with minimum requirements of 2.5 and absorption meets the maximum value of water absorption required that is 3%. The wear test with the Los Angeles machine shows that coarse aggregate is resistant to abrasion, which can be seen from the average wear value obtained is 20.05% with a maximum requirement of 40% for the asphalt concrete mixture [12].

The next material used in this research is polymer modified asphalt with the brand Starbit E-55, where polymer modified asphalt is a material produced from modification between natural polymers or synthetic polymers with 2-6% levels. Specified in the General Specifications of Roads and Bridges, Bina Marga, Year 2010 Revision 3

carry out testing of asphalt with the provisions of type II hard asphalt, namely modified asphalt for synthetic elastomers. They must meet the requirements to be used as a binder in the pavement mixture. Several laboratory tests carried out on the properties of asphalt can be seen in Table 2.

Table 2. Testing Results of Asphalt Properties

| No | Type of Testing | Test result | Testing Method |
|----|------------------------------------------------------|-------------|------------------|
| 1 | Penetration 25°C, 100gr, 5 seconds; 0.1 mm | 63,7 | SNI 06-2456-1991 |
| 2 | Specific gravity | 1,075 | SNI 06-2441-1991 |
| 3 | Penetration difference after weight loss; % original | 0,35 | SNI 06-2456-1991 |

In the penetration testing of polymer modified asphalt, Starbit E-55 meets the required Specified in the General Specifications of Roads and Bridges, Bina Marga, Year 2010 Revision 3 where the penetration of modified asphalt is a minimum of 40 mm (state the standard). The penetration value obtained indicates that the asphalt is asphalt with low penetration which is suited for hot climates or areas with high volumes of traffic. Inspection of the density of asphalt shows a value of 1.075 above the minimum value of 1.0 according to the Specified in the General Specifications of Roads and Bridges, Bina Marga, the Year 2010 Revision 3, and the amount of weight loss is the difference between the penetration value before and after heating shows that the asphalt is sensitive to weather and temperature, a value of 0.36% is obtained so that the weight loss test meets the requirements of the Indonesian National Standard (SNI) with a maximum limit of 0.8%.

3.2 Palm Shell Ash

The processing of oil palm fruit into palm oil extract produces a large amount of solid waste in fiber, shells, and empty fruit bunches. Then the sell used again as fuel to produce steam in the palm oil mill. Burning in a steam boiler using oil palm shells will produce oil palm ashes with very fine grain size. The results of the chemical element composition test of oil palm shell ash [13] can be seen in Table 3.

Table 3. Testing Results of Asphalt Properties

| Chemical Elements | Percentage (%) |
|-----------------------------------------------------|----------------|
| Silikon Dioksida (SiO ₂) | 58,02 |
| Aluminium Oksida (Al ₂ O ₃) | 8,70 |
| Besi Oksida (Fe ₂ O ₃) | 2,60 |
| Kalsium Oksida (CaO) | 12,65 |
| Magnesium Oksida (MgO) | 4,23 |

With the addition of materials containing silica as an alternative filler, it is hoped that the optimum filler content will be obtained with the optimum bitumen content to increase the stability value of the asphalt concrete -wearing course (AC-WC).

3.3 Marshall Testing Using Palm Shell Ash

Testing of hot asphalt mixtures with the Marshall method on wear-layer concrete asphalt (AC-WC) mixtures with oil palm shell ash percentages 0, 3, 4, 5, and 6%. The results of the mixed volumetric test, stability, and flow are shown in Figure 3. The volumetric results from testing using the Marshall method can be seen for the void in the aggregate (VMA) of the four levels of the test object tends to increase along with the increase in the added filler content, this indicates that the filler provides a greater percentage of void or empty space so that the ability of the asphalt mixture in filling the reduced void aggregate. The value of VMA on the asphalt indicates a small percentage of void filled with asphalt.

The asphalt concrete wearing course specimen using polymer modified asphalt for each filler content requires a minimum value of void in the mixture (VIM) of 3% and a maximum of 5%. The addition of oil palm shell ash filler to the AC-WC mixture resulted in increased VIM value, which could reduce the asphalt's ability to fill the existing void so that it became less dense. However, the VIM value will continue to decrease with increasing asphalt content, this is due to the asphalt filling more void in the mixture, where the VIM value is too high. This can cause the asphalt is not watertight, the appearance of premature cracks, raveling, and stripping.

Asphalt levels with a percentage of 6.5 and 7%, the VFA value can meet the requirements of the General Specifications of Roads and Bridges, Bina Marga, the Year 2010 Revision 3. . The results of the stability test decreased with the increase in the percentage of oil palm shell ash filler content, where the maximum stability occurred at the addition of 3% filler, indicating that the mixture of asphalt with oil palm shell ash filler can withstand deformation due to traffic loads.

The effect of using palm shell ash filler in the AC-WC mixture resulted in lower flow values compared to the asphalt concrete mixture without the addition of palm ash filler. This indicates that the filler makes the asphalt less flexible so that the asphalt concrete mixture becomes more brittle. The value of the Marshall Quotient (MQ) increases with increasing palm ash filler levels, causing the mixture to become stiffer and brittle. The advantage of adding palm ash filler can improve the stability value of the asphalt concrete wearing mixture (AC-WC) by adding a limited amount of filler and using asphalt content from 6.5% to 7%. Meanwhile, the disadvantages of adding palm ash filler are that it causes the asphalt concrete mixture to become very brittle and stiff, reduces the impermeable level and flexibility to a decrease in the value of stability at the added content of more than 3%.

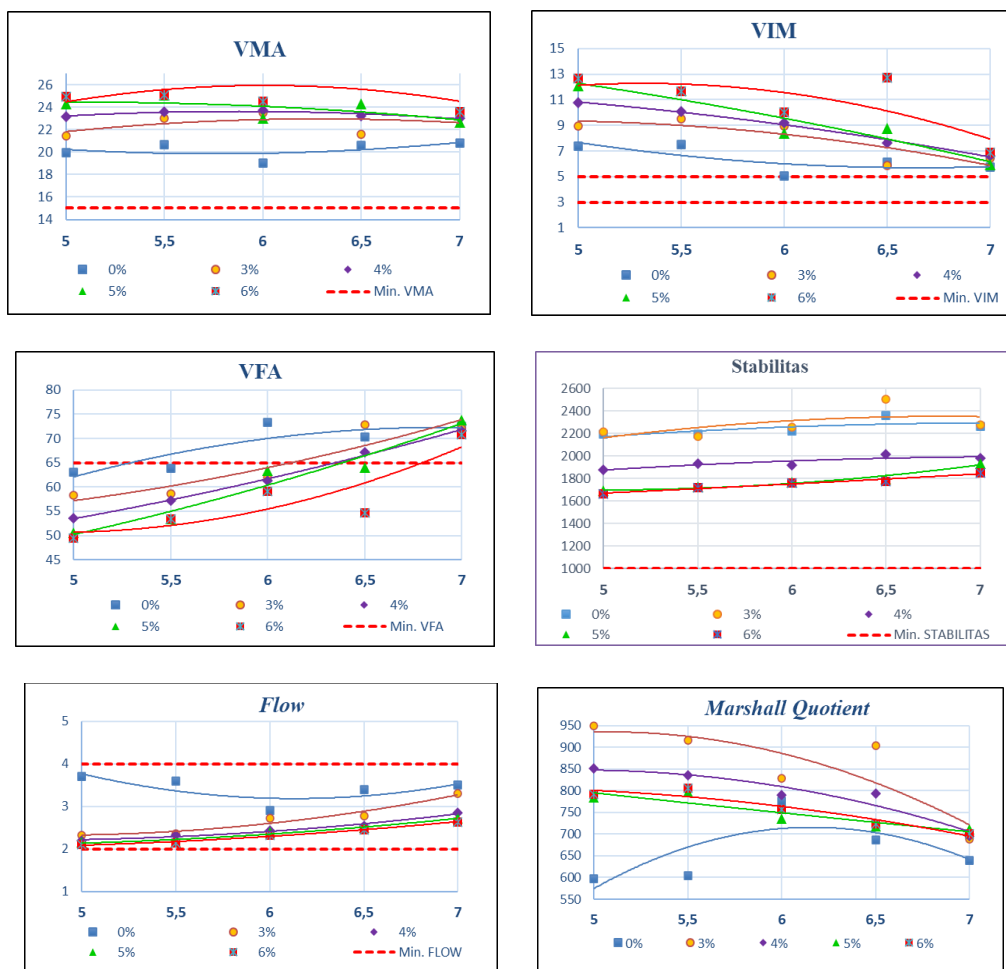


Figure 3. AC-WC Mix Test

4. Conclusion

Based on the results of research and discussion of the effect of adding palm shell ash filler to the polymer asphalt mixture, the following conclusions were obtained:

1. The aggregate and asphalt test characteristics fulfill the requirements set out in the Ministry of General Affairs specification revision 3 of 2010. Chemical elements of oil palm shell ash the biggest silicon dioxide (SiO₂) it can be profitable for asphalt mixture
2. The volumetric characteristics of the AC-WC asphalt mixture, with the addition of the percentage of oil palm shell ash filler, resulted in an increase in the value of the void in the aggregate (VMA) and the void in the mixture (VIM) which indicated a decrease in the void in the asphalt (VFA). Void in the asphalt (VFA) value continues to decline due to the addition of palm ash filler and fulfill the requirements with asphalt content of 6.5% and 7%. Experienced an increase in stability at 3% filler content, then continued to decrease at 4%, 5%, and 6% levels but fulfill the requirements. The flow value in the addition of filler 3%, 4%, 5%, 6% continues to decrease along with the increase in filler content.
3. Addition of oil palm shell ash filler by 3% with a VMA value of 21.63%, a VIM value of 5.88%, a VFA value of 72.83%, a stability value of 2503.03 kg, and a flow value of 2.1 mm. This results in the AC-WC asphalt mixture becoming stiffer this indicates that the mixture can withstand deformation due to traffic loads.

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