The effect of additional sugar palm fibres on the durability of mixed Laston AC-WC

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Abstract. To obtain a good quality concrete asphalt, in the process of planning a mixture must consider the characteristics of a concrete asphalt mixture including durability which is the resistance of the asphalt mixture to the effects of weather, water, temperature changes, as well as wear due to vehicle wheel friction. Sugar palm fibres are many and easy to obtain because they come from agriculture. Sugar palm fibres have durable nature and are not easy to rot either in an open state (resistant to weather) or embedded in the soil. In this study, we will examine the effect of adding sugar palm fibres to the durability of the Laston AC-WC mixture, and sugar palm fibres as an addition to the binding of asphalt to the aggregate. The method used in this study is the Marshall method. The results showed that the durability of the mixture with 2% fibres added ingredients was still stronger than those using 1.5% so that the use of sugar palm fibres added in the Laston AC-WC mixture would help the durability of the mixture because the cavities in the mixture were getting smaller, so it was more waterproof, also the bond between aggregates which is the stability of the mixture can be maintained while maintaining the flexibility of the mixture. While the Marshall Immersion test results obtained strong mixture durability if the use of sugar palm fibres as added 2% in the mixture.

1. Introduction

Road construction flexible pavement systems usually use a mixture of asphalt and aggregate as a surface layer. Asphalt mixture functions as structural and non-structural layers. Asphalt mixture that functions as a structural layer is a layer that holds and spreads the wheel load. As a non-structural asphalt concrete layer, it functions as a waterproof and wears course or a layer that suffers directly from friction due to vehicle brakes.

Palm fibres are one of the ingredients derived from palm trees. Sugar palm fibres are many and easy to obtain because they come from agriculture. Sugar palm fibres have a durable nature and are not easy to rot either in an open state (resistant to weather) or embedded in the soil [1].

Several previous studies that tested Laston by using natural added ingredients include Yuniarto (2006) testing the durability of Laston with peat ash filler [1], Fathoni et al. (2013) utilization of fibres in fibres asphalt concrete-wearing coarse (AC-WC) for reducing earthquake cracks [2]. Syaiful (2013) Study of the addition of coal ash as filler in asphalt mixes [3]. Setiawan (2011) Study of the use of Asbuton grain in asphalt binder course (AC-BC) concrete mixes [4]. Tahir (2009) The durability
performance of asphalt concrete mixtures viewed from factor variations in compaction temperature and soaking time [5]. Lubis (2009), a study of the use of rice husk ash filler to test laston's durability [6].

To get a good quality concrete asphalt, in the planning process of the mixture must be considered to the characteristics of the concrete asphalt mixture, including stability and durability. Roadwork layer stability is the ability of the pavement layer to accept traffic loads without permanent changes in shape such as waves, grooves or bleeding while durability is the resistance of asphalt mixes to the effects of weather, water, temperature changes, and wear due to vehicle wheel friction [7].

In this study, we will examine the effect of adding fibres to the durability of the Laston AC-WC mixture and fibres as an addition to the binding of asphalt to the aggregate. The method used in this study is the Marshall method. Marshall testing aims to measure the durability (stability) of the mixture of aggregate and asphalt against plastic discharge (flow). Flow is defined as a change in deformation or strain of a mixture from no load to maximum load and expressed in millimetres.

2. Methodology

2.1. Location

The material used in this study is coarse aggregate, fine aggregate from the Jeneberang River, Bili-Bili quarry in South Sulawesi, Portland Cement Type 1 as filler and asphalt with penetration of 60/7. Type of fibre is sugar palm fibre that is obtained from North Toraja Regency.

2.2. Experimental program

The amount of aggregate material was about 1200 grams. From the selected target gradation, the weight of each aggregate can be determined so that the total aggregate weight is about 1200 grams. The selection of initial asphalt levels is 6.5% based on the 2010 Bina Marga Specifications. The number of test specimens shown in figure 1.

Table 1. The number of specimens.

| Asphalt content (%) | Sugar palm fibres (%) | Number of specimens | Marshall Immersion Test (Durability) (hour) |
|---------------------|-----------------------|---------------------|------------------------------------------|
| 0                   | 0                     | 3                   | 6, 12, 18, 24, 30, 36                     |
| 0.5                 | 0.5                   | 3                   | 3, 3, 3, 3, 3, 3                        |
| 6.50                | 1.0                   | 3                   | 3, 3, 3, 3, 3, 3                        |
|                     | 1.5                   | 3                   | 3, 3, 3, 3, 3, 3                        |
|                     | 2.0                   | 3                   | 3, 3, 3, 3, 3, 3                        |
| Total               |                       | 15                  | 24                                      |

The parameters are Stability, Flow, Marshall Question (MQ), VIM, VMA and VFB. Furthermore, a graph is made that connects the asphalt content with each of these parameters. From the chart made, it can be determined the optimum level of fibres use, that is the level of sugar palm fibres in the range that consistent with all the design criteria of AC-WC asphalt mixture. In this study, the optimum levels of fibres obtained later will be called the Optimum Fibres Levels.

The durability of the asphalt mixture is obtained from the immersion of the asphalt mixture which is done with different durations. The duration of immersion is 6, 12, 18, 24, 30, and 36 hours. After the immersion in water temperature of ± 25ºC, the marshel test is then performed for each specimen that has a different duration of immersion to get the stability and flow values. The total composition of the mixture to be used is shown in table 2.
Table 2. Mixture composition.

| Number of Sieves | Mixed composition (%) |
|------------------|-----------------------|
| Inchi            | mm        |              |
| 1½”              | 37.500    |              |
| 1”               | 25.000    |              |
| 3/4”             | 19.000    |              |
| 1/2”             | 12.500    |              |
| 3/8”             | 9.500     |              |
| No.4             | 4.750     |              |
| No.8             | 2.360     |              |
| No.16            | 1.180     |              |
| No.30            | 0.600     |              |
| No.50            | 0.300     |              |
| No.100           | 0.150     |              |
| No.200           | 0.075     |              |
| Pan (filler)     | 5.85      | Filler      |
| Asphalt          | 6.50      | Asphalt     |
| Total            | 100.00    |              |

3. Result and discussion

3.1. Marshall characteristics

The results of testing the Marshall characteristics of the Laston AC-WC mixture that uses the proportion of sugar palm fibres 0%, 0.5%, 1%, 1.5% and 2% of the total weight of the mixture obtained values of VIM, Stability, VFB, Flow and VMA are shown in table 3.

Table 3. Marshall characteristics test results.

| Sugar Palm Fibres (%) | 3-5 (%) | Min 800 (KgF) | Min 65 % | 2-4 (mm) | Min 15 % |
|-----------------------|---------|---------------|----------|----------|----------|
|                       | VIM     | Stability     | VFB      | Flow     | VMA      |
| 0                     | 4.06    | 1.874,52      | 77.11    | 3.50     | 17.72    |
|                       | 4.10    | 1.862,80      | 76.93    | 3.45     | 17.75    |
|                       | 4.18    | 1.886,23      | 76.56    | 3.35     | 17.82    |
| 0.5                   | 3.73    | 1.968,24      | 78.61    | 3.10     | 17.44    |
|                       | 3.77    | 1.956,53      | 78.42    | 3.00     | 17.48    |
|                       | 3.81    | 1.991,68      | 78.22    | 3.15     | 17.51    |
| 1                     | 3.65    | 2.120,55      | 78.97    | 2.80     | 17.37    |
|                       | 3.61    | 2.108,83      | 79.16    | 2.75     | 17.34    |
|                       | 3.57    | 2.143,98      | 79.37    | 2.90     | 17.30    |
| 1.5                   | 3.31    | 2.172,74      | 80.60    | 2.60     | 17.08    |
|                       | 3.36    | 2.138,43      | 80.39    | 2.55     | 17.12    |
|                       | 3.27    | 2.149,87      | 80.79    | 2.65     | 17.05    |
| 2                     | 3.15    | 1.780,79      | 81.40    | 3.15     | 16.94    |
|                       | 3.19    | 1.733,93      | 81.19    | 3.30     | 16.98    |
|                       | 3.07    | 1.757,36      | 81.81    | 3.25     | 16.87    |
From Figure 1, it can be seen that the use of the proportion of sugar palm fibres which is more and more will increase the stability of the mixture to the proportion of 1.5% and the stability returns down if the proportion of sugar palm fibres tightly to 2%. This is because the sugar palm fibres will help the asphalt bind the aggregate (interlocking) to be strong so that the stability of the mixture increases, but if the sugar palm fibres increase again the asphalt will cover a lot so that the bond between the aggregates becomes weak and the stability of the mixture decreases. Based on Table 2 and Figure 1 and the curve line equation $y = -317.4x^2 + 624.2x + 1828$ shows that stability increases by an average of 93.05 Kg.F up to the proportion of sugar palm fibres 1.5% and will return down by 396.32 kg.F along with the increase in the proportion of sugar palm fibres. The regression equation shows that the maximum stability/turning point of the curve is at the proportion of 0.98% Sugar palm fibres with a Stability value of 2134.89 kg.F.

Based on Figure 2, it can be seen that the higher the proportion of sugar palm fibre used, the smaller the VIM value and vice versa, if the proportion of fibres used is less, the VIM value will be greater, because the sugar palm fibres fiber will help the asphalt with a function as a binder and filler cavity in the asphalt mixture, but the decline still fulfils the specified requirements. From the line equation in Figure 2, $y = 0.052x^2 - 0.585x + 4.096$, the value of VIM (Void In Mix) will be reduced by an average of 0.24% along with the increasing use of fibres-added ingredients. Regression equation shows that the VIM reaches the minimum limit of 3% with a proportion of sugar palm fibres 2.38%. 
Based on figure 3, it can be seen if the use of sugar palm fibres in asphalt mixture is increasing to a proportion of 1.5%, then the bond between the aggregates becomes stronger which causes slight flexibility. But if the use of fibres increases to a proportion of 2%, the bond between the aggregates in the mixture becomes less resulting in the flexibility of the mixture will increase, which means the strength of the mixture/stability will be inversely proportional to the flow of the mixture but still limited to tolerance. The equation of the curve line in figure 3, \( y = 0.576x^2 - 1.329x + 3.498 \) shows that the flow/flexibility of the mixture will decrease by an average of 0.28 mm to the proportion of fibres 1.5% and again increase by 0.63 mm with increasing proportion of mixed sugar palm fibres. Regression equation shows that the flow / minimum flexibility/turning point of the curve is at 1.15% sugar palm fibres with a flow value of 2.73 mm.

In figure 4, it appears that the higher the proportion of the sugar palm fibres fibre used, the cavities in the aggregate filled with asphalt decreases. This is influenced by the number of sugar palm fibres fiber that are used, because asphalt whose function is to cover the cavity between the aggregate and also in the aggregate particles, which means that asphalt has not had time to fill the cavity in the rock because it has been attached to the sugar palm fibres fibre first. From this figure, the curve equation \( y = 0.045x^2 - 0.502x + 17.754 \) shows the value of the cavities in the aggregate filled by asphalt decreases by an average of 0.21% as the proportion of sugar palm fibres increases. This is because the value of Void in Mineral Aggregate (VMA) is strongly influenced by asphalt levels and the fibres will bond together so that the asphalt does not enter the cavities in the aggregate/rocks.

Regression equation shows that VMA (Void in Mineral Aggregate) will not reach the minimum limit of 15%.
Figure 5 shows the higher the proportion of sugar palm fibres fibre as added material, the greater the value of VFB, because the sugar palm fibres will help asphalt to fill cavities, especially cavities between aggregate particles. The line equation in figure 5, \( y = -0.193x^2 + 2.663x + 76.93 \) shows an increase of an average of 1.15% as the Proportion of fibres in the mixture. The equation of the line shows that VFB is still within tolerance limits.

3.2. Optimum sugar palm fibre proportion

Based on the results of the Marshall test and analysis of the characteristics of the Laston AC-WC Mix can be determined the optimum proportion of sugar palm fibres fiber in the Laston mixture that is the proportion of additional fibres that meets all the criteria or characteristics of the mixture and the proportion of practical sugar palm fibres fiber is the range of the proportion of sugar palm fibres fiber 0.5% - 2 For the next testing stage, Duron AC-WC Mixture Duration due to immersion, the mixture that has the highest stability is determined by the proportion of sugar palm fibres fiber 1.5% and the smallest stability is the proportion of 2%.

3.3. Mixed durability

After determining the optimum proportion of fibres, the next step is to make a test difference based on the optimum proportion of fibres, 1.5% and 2% for the mixture of Laston AC-WC which is then soaked for ± 6, 12, 18, 24, 30 and 36 hours at a temperature of ± 60˚C. The durability of the Laston AC-WC mixture is obtained from the ratio/stability ratio of the mixture after being immersed at a particular time duration with the stability of the immersed mixture for 0.5 hours. The test results are shown in figure 6.

Figure 6. Relationship between immersion time and durability.
4. Conclusion

From the results of the Marsh all immersion test as shown in figure 6, the Durability of the AC-WC Laston Mix obtained using sugar palm fibres fibre added fibres as much as 0%, 1.5% and 2% will decrease the resistance of the mixture to the immersion duration of 36 hours but the phenomenon is still present within the tolerance limit, so that water can still enter the mixture using sugar palm fibres fibres added ingredients. But based on the comparison of the three types of Laston AC-WC mixture that uses fibres added ingredients as much as 0%, 1.5% and 2%, it is seen that the Durability of the mixture with 2% fibres added sugar palm fibres is still higher (stronger) than those using 1.5% and even those that do not use sugar palm fibres added ingredients (0%). So based on Figure 6 it can be concluded that the use of fibres-added ingredients in the Laston AC-WC mixture will help the durability/resistance of the mixture because the cavities in the mixture get smaller so that it is more waterproof, also the bond between the aggregates (interlocking) which is the stability/strength of the mixture can be maintained while maintaining the flexibility of the mixture. Marshall Immersion test results obtained Durability / Resistance of the mixture is excellent if the use of sugar palm fibres as added 2% in the mixture. But if the use of fibres added ingredients is 1.5% or even does not use added ingredients, and if soaking is more than 30 hours, the Duration / Resistance of the Laston AC-WC mixture will decrease even smaller than the specification which is 90%.

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