Study of Laston BC durability and permeability using coconut shell addition materials

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Abstract. Durability is the ability of asphalt concrete to accept repetition of traffic loads, friction, and weather and climate wear, while permeability is the ability of pavement surfaces to hold water seepage into pavement. Besides, the pore volume in the mixture is one of the most important AC-WC characteristics which are related to the level of water impermeability in the pavement layers. The purposes of this study is to investigates the effect of adding coconut fibers by 0%, 0.5%, 1%, 1.5% and 2% on durability and permeability the surface layer of Laston BC. The results obtained are the stability of the asphalt mixture in accepting the load without changing the plastic shape and following the trend of the 2nd order polynomial line. VIM values tend to rise then decrease until 48 hours immersion. It is found that the use of coconut fibers improved the impermeability properties of the surface layer of Laston BC. The value of mixed flow is influenced by the addition of coconut fibers, where if the fibers increase to 1%, then the flow will decrease. The durability value due to the addition of 1% and 1.5% coconut fibers can only be tolerated at the submergence limit of Laston BC for 30 hours while the addition of coconut fibers from 0% to 2% Laston BC can only submerged for 12 hours. The permeability values of the mixture decreases by 0.51 cm/sec for each addition of 0.5% coconut fibers.

1. Introduction

Asphalt concrete is a type of road pavement consisting of a mixture of aggregate and asphalt with or without additives. Asphalt concrete forming materials are mixed in a mixing plant at a certain temperature, then transported to the location, spread out, and compacted. The mixing temperature is determined based on the type of asphalt to be used. If asphalt cement is used, the mixing temperature is generally between 145 °C and 155 °C, so it is called hot mix asphalt concrete [1].

Roads that serve light traffic such as passenger cars should prefer the type of asphalt concrete which has high durability and flexibility than choosing the type of asphalt concrete with high stability, and vice versa if the road serves high traffic volumes and the majority of heavy vehicles require pavement with high stability [2]. There are seven characteristics of the mixture that must be owned by asphalt concrete including permeability and durability. Permeability is the ability of the pavement surface to hold water seepage into the pavement, besides the pore volume in the mixture (total voids) is one of the characteristics of AC-WC which is very important in relation to the level of impermeability to the pavement layers. This means that the pavement layer must have a small permeability value. Durability is the ability of asphalt concrete to accept repetition of traffic load, friction, and weather and climate wear and tear [1]. One of the main reasons for the damage and
decrease in the strength of the flexible pavement of the highway is the low strength and durability in the wear layer and the binding material of the pavement construction. To overcome this we need an added material that can increase the asphalt concrete layer. Based on several studies of coconut shell ash (coconut shell ash), it is seen that there are similarities with fly ash which has been widely used as a filler for asphalt mixtures. Stone ash, cement and fly ash are commonly used as fillers in asphalt mixtures. However, this type of filler is difficult to obtain and the price is relatively expensive. Coconut fiber ash which has a specific gravity greater than asphalt, is expected to be one of the alternatives [4]. Santosa, B (2009) has conducted tests on coconut fiber ash (ASK) and obtained the composition of ASK compounds (in units of weight percent). The results of silica oxide studies found in coconut fiber ash (ASK) can be reactive 5 (amorphous) which allows SiO2 to react chemically with Ca (OH) 2 or free lime from the hydration reaction of cement with water. [5]. Safriani (2016) examined the effect of using coconut coir ash as a filler in Asphalt Retona Blend 55 mixture. [6]. The purpose of this research is to study the surface layer of Laston BC and analyze the effect of adding coconut fibers with variations in the addition of 0%, 0.5%, 1%, 1.5% and 2% on durability and permeability.

2. Materials and Method

2.1. Materials
Coarse aggregate was obtained from Jeneberang River, Bili-bili District, Gowa Regency. Sampling is done to get samples of materials that are examined in the laboratory and can represent all available materials. The asphalt tested was obtained from the asphalt testing and research center of the Department of Public Works (DPU) Baddoka, Makassar. The oil asphalt used was asphalt with 60/70 penetration. In this study, a filler type, namely cement Portland type I, is used as the added ingredient of coconut fibers obtained from the Daya traditional market.

2.2. Preparation of coconut fiber
Coconut fibers are put into water and soaked for ± 24 hours, so that the coconut fibers are easily separated and decomposed during mixing. Coconut fiber was washed with clean water until the powder attached to the fiber is completely detached and clean (this coconut fiber powder which is easy to rot/organic). The drying process can be done by drying in direct sunlight, or put in an oven with a constant temperature of ± 105°C for ± 24 hours. The process of cutting coconut fibers was carried out by scissors or a knife with a length of 1-2 cm.

2.3. Mixtures Composition and testing methods
The composition of the mixture is based on the aggregate gradation of the mixture chosen. The composition of the mixture is divided into three fractions, namely: coarse aggregate fraction, fine aggregate fraction, and filler fraction. The fraction size of material is based on the Bina Marga General Specifications [7]. The mixture proportions used for the manufacture of test specimens was a mixture of Asphalt Laston Lapis Support (AC-BC) with gradation specifications is shown in figure 1. The amount of aggregate material used refers to the total aggregate ± 1200 grams. From the selected target gradation, the weight of each aggregate fraction can be determined so that the total aggregate weight is ± 1200 grams. The amount of aggregate used for ± 1200 grams of asphalt content was 6.5%. Table 1 presents the total specimen used in this study. The parameters obtained in the permeability test are the flowing values of the AC-BC mixture with and without coconut fiber addition. Then a correlation is made to obtain the amount of use of coconut fibers with the drainage value of each mixture. The durability of the asphalt mixture is obtained from the immersion of the asphalt specimens with different duration of 6, 12, 24, 36 and 48 hours, respectively. After going through the immersion
(water temperature \(\pm 25^\circ C\)), Marshall Test is performed for each specimen that has different duration of immersion to get the stability and flow values.

### Table 1. Number of Specimens

| Asphalt (%) | Material Rate of Coconut Fiber (%) | Permeability Test | Marshall Immersion Test |
|-------------|-----------------------------------|------------------|-------------------------|
|             |                                   | Specimen number  | Specimen number         |
|             |                                   | 6h               | 12h                     | 24h | 36h | 48h |
| 0           |                                   | 3                | 3                       | 3   | 3   | 3   |
| 0.5         |                                   | 3                | 3                       | 3   | 3   | 3   |
| 1.0         |                                   | 3                | 3                       | 3   | 3   | 3   |
| 1.5         |                                   | 3                | 3                       | 3   | 3   | 3   |
| 2.0         |                                   | 3                | 3                       | 3   | 3   | 3   |

3. **Result And Discussion**

3.1. **Materials properties**

The results of the aggregate analysis test as shown in figure 1. It is observed that the combination design of the mixture between the upper and lower limits of the grading size according to the established standards.

![Aggregate Combination](image)

**Figure 1. Aggregate Combination**

The results of abrasion of aggregate using four fractions of each combination in the ranges of 15.72 – 28.04% which is fulfill the standard specification (below 40%). It can be said that these aggregates could be used as road pavement aggregates. Results of density and absorption test of coarse aggregate were 2.73% and 1.05%, respectively. These value met the requerments of density and water absorption of coarse aggregate that used for road pavement. Testing the level of sludge using 2 (two) samples obtained the average results for the Sand Equivalent (SE) value is 96.26% where the requirements are permitted at a minimum of 60%. While the results of testing the sludge level obtained a value of 3.74% where the permitted requirements is a minimum of a maximum of 5%.

Based on tests results of asphalt characteristics, it is found that the 60/70 penetration asphalt characteristics testing for the AC-WC mixture design can be seen in table 2.
Table 2. Asphalt Characteristics Test Results.

| Test                          | Result | Bina Marga Specification | Unit |
|-------------------------------|--------|---------------------------|------|
| Penetration 25°C              | 68.8   | 60                        | 79   | (0.1) mm |
| Ductility                     | 148.67 | 100                       |      | cm       |
| Softening Point               | 50     | 48                        | 58   | °C       |
| Flames and Burning Point      | 300    | 200                       |      | °C       |
| Asphalt Specific Gravity      | 1.07   | 1.0                       |      | gr/cc    |
| Losing Weight                 | 0.14   | -                         | 0.8  | %        |
| Penetration TFOT              | 95.78  | 54                        |      | % initial |

3.2. Marshall Test and Marshall Immersion
Laston AC-BC specimens were made with asphalt content of 6.5%. Marshall immersion test results with variations in the addition of coconut fiber waste by 0%, 0.5%, 1%, 1.5% and 2%, and soaking duration of 6 hours, 12 hours, 24 hours, 36 hours and 48 hours.

3.2.1. Analysis of Stability
The results of the study were tabulated using Microsoft Excel and then made a line equation graph as shown in figure 2.

![Figure 2. Relationship of stability, coconut fiber, and soaking Time.](image)

From figure 2, using the 2nd order polynomial line equation where $y = 0.0173x^2 - 7.7586x + 1875.8$, the stability value with immersion duration is obtained as shown in table 3.
Table 3. Duration of soaking time with stability.

| Time (Hour) | Stability Additional of Coconut Fiber (%) |
|-------------|--------------------------------------------|
|             | 0.00 | 0.50 | 1.00 | 1.50 | 2.00 |
| 0           | 1,875.80 | 1,955.10 | 2,091.20 | 1,757.80 | 1,709.60 |
| 6           | 1,829.87 | 1,915.71 | 2,055.77 | 1,708.05 | 1,766.15 |
| 12          | 1,785.19 | 1,875.66 | 2,019.52 | 1,659.92 | 1,824.03 |
| 18          | 1,741.75 | 1,834.94 | 1,982.44 | 1,613.41 | 1,883.25 |
| 24          | 1,699.56 | 1,793.54 | 1,944.52 | 1,568.52 | 1,943.80 |
| 30          | 1,658.61 | 1,751.48 | 1,905.79 | 1,525.25 | 2,005.68 |
| 36          | 1,618.91 | 1,708.74 | 1,866.22 | 1,483.60 | 2,068.89 |
| 42          | 1,580.46 | 1,665.34 | 1,825.82 | 1,443.57 | 2,133.43 |
| 48          | 1,543.25 | 1,621.27 | 1,784.60 | 1,405.16 | 2,199.31 |

By using a variation of 0% coconut fibers with the duration of immersion time 0 hours - 48 hours obtained stability values between 1,975.80 kg to 1,543.25 kg. For the addition of 0.5%, values were obtained between 1955.10 kg and 1,621.27. The addition of 1% content obtained the stability value of 2,091.20 to 1,784.60. Coconut fiber fibers with 1.5% levels obtained stability values between 1,757.80 kg, while the addition of 2% levels obtained stability values between 1,709.60 kg and 2,199.31 kg. Based on table 3 and figure 2, it can be seen that the addition of coconut fibers tends to decrease; however, stability is still limited to tolerance.

3.2.2. Analysis of VIM

The results of VIM test obtained line equations as shown in the figure 3. VIM value analysis, using the line equation in figure 3, obtained VIM values as in table 4.

![Figure 3. Relationship of VIM, variation of coconut fiber and duration of soaking time.](image)
Table 4. VIM Value Analysis Results.

| Time (hour) | VIM (%) | Coconut fiber |
|-------------|---------|--------------|
|             | 0.00%   | 0.50%        | 1.00% | 1.50% | 2.00% |
| 0           | 4.7286  | 4.4423       | 3.9626 | 3.5113 | 3.2446 |
| 6           | 4.7430  | 4.4452       | 3.9822 | 3.5401 | 3.2554 |
| 12          | 4.7538  | 4.4466       | 3.9961 | 3.5617 | 3.2626 |
| 18          | 4.7610  | 4.4466       | 4.0042 | 3.5761 | 3.2662 |
| 24          | 4.7646  | 4.4452       | 4.0065 | 3.5833 | 3.2662 |
| 30          | 4.7646  | 4.4423       | 4.0031 | 3.5833 | 3.2626 |
| 36          | 4.7610  | 4.4380       | 3.9939 | 3.5761 | 3.2554 |
| 42          | 4.7538  | 4.4322       | 3.9790 | 3.5617 | 3.2446 |
| 48          | 4.7430  | 4.4250       | 3.9583 | 3.5401 | 3.2302 |

From the results of the analysis the VIM values in table 4 obtained for the duration of immersion 0 hours to 48 hours, for 0% obtained VIM values between 4.73% - 4.74%. Addition of 0.5% coconut fiber content obtained VIM values by 4.44% to 4.42%, by adding 1% obtained VIM values by 3.96% to 3.96%. The addition of 1.5% coconut fiber content obtained VIM values ranged 3.51% to 3.54% while the addition of coconut fiber fiber 2% value ranged 3.24% to 3.23%.

3.2.3 Analysis of Flow
Flow test results are obtained line equations as shown in the figure 4. Flow value analysis, using the line equation in figure 4, obtained flow values as in table 5.

![Figure 4. Relationship of flow, variation of coconut fibers and soaking duration.](image-url)
### Table 5. Analysis of Flow Results.

| Time (Hour) | Flow Coconut Fiber |
|-------------|--------------------|
|             | 0.00%  | 0.50%  | 1.00%  | 1.50%  | 2.00%  |
| 0           | 2.3618 | 2.2538 | 2.0122 | 2.6103 | 2.7729 |
| 6           | 2.6048 | 2.5034 | 2.2600 | 2.7987 | 2.9709 |
| 12          | 2.8262 | 2.7746 | 2.4862 | 2.9727 | 3.1545 |
| 18          | 3.0260 | 3.0674 | 2.6908 | 3.1323 | 3.3237 |
| 24          | 3.2042 | 3.3818 | 2.8738 | 3.2775 | 3.4785 |
| 30          | 3.3608 | 3.7178 | 3.0352 | 3.4083 | 3.6189 |
| 36          | 3.4958 | 4.0754 | 3.1750 | 3.5247 | 3.7449 |
| 42          | 3.6092 | 4.4546 | 3.2932 | 3.6267 | 3.8565 |
| 48          | 3.7010 | 4.8554 | 3.3898 | 3.7143 | 3.9537 |

From the results of the analysis of flow values such as table 5 obtained for the duration of immersion 0 hours to 48 hours, where for the duration of immersion 0% obtained flow values between 2.36% to 3.70%. The addition of 0.5% coconut fibers content obtained flow values between 2.25% to 4.85%, the addition of 1% coconut fibers obtained flow values between 2.01% to 3.83%. The addition of 1.5% coconut fiber content obtained flow values between 2.61% to 3.71% while the addition of coconut fiber 2% value between 2.77% to 3.95%. Based on figure 4 and table 5, the trend line on the 0 hour immersion up to 48 hours flow values tend to increase. But this trend line is still limited by tolerance. The use of coconut fibers will make the mixture waterproof. Where the flexibility of the mixture is influenced by the addition of coconut fibers, where if the fibers increase to 1%, then the flow decreases. This is because coconut fibers help the asphalt to bond in the mixture so that stability increases. But if the coconut fibers increase a lot, then the mixed bond is reduced due to asphalt which is much attached to the fibers, so that stability decreases and reverse flow increases.

![Figure 5. Relationship durability, variation in coconut fiber and soaking duration.](image)

#### 3.3. Durability

Durability test results were obtained by line equations as shown in figure 5. Durability value analysis, using the line equation in figure 4, obtained the flow value as in table 6. From figure 5 and table 6, we can see some variations in the immersion time below the tolerance limit, but there are some values that
are still above the tolerance limit such as the duration of soaking time from 0 to 12 hours for the
addition of coconut fibers from 0% to 2%.

| Time (Hour) | Durability Coconut Fiber |
|-------------|-------------------------|
|             | 0.00% | 0.50% | 1.00% | 1.50% | 2.00% |
| 0           | 94.3670 | 95.6370 | 97.0030 | 93.0390 | 91.9420 |
| 6           | 93.6206 | 94.9854 | 96.2536 | 93.2652 | 91.2928 |
| 12          | 92.5718 | 94.0098 | 95.2594 | 93.1098 | 90.1684 |
| 18          | 91.2206 | 92.7102 | 94.0204 | 92.5728 | 88.5688 |
| 24          | 89.5670 | 91.0866 | 92.5366 | 91.6542 | 86.4940 |
| 30          | 87.6110 | 89.1390 | 90.8080 | 90.3540 | 83.9440 |
| 36          | 85.3526 | 86.8674 | 88.8346 | 88.6722 | 80.9188 |
| 42          | 82.7918 | 84.2718 | 86.6164 | 86.6088 | 77.4184 |
| 48          | 79.9286 | 81.3522 | 84.1534 | 84.1638 | 73.4428 |

4. Conclusion

Addition of coconut fibers with levels of 0%, 0.5%, 1%, 1.5% and 2% with variations of immersion 6
hours, 12 hours, 18 hours, 24 hours, 30 hours, 36 hours, 42 hours and 48 hours obtained the stability of
the asphalt mixture in accepting the load without changing the shape of the plastic and following the
trend of the 2nd order polynomial line. VIM values tend to increased then decreased to 48 hours
immersion. However, this trend line is still limited by tolerance. The use of coconut fibers will make
the mixture waterproof. The value of mixed flow is influenced by the addition of coconut fibers, where
if the fibers increase to 1%, then the flow is decreased. The durability value due to the addition of 1%
and 1.5% coconut fibers can only be tolerated at the submergence limit of Laston BC for 30 hours
while the addition of coconut fibers from 0% to 2% Laston BC submerged for 12 hours. The
permeability of the mixture decreases in value by an average of 0.51 cm/sec for each addition of 0.5%
coconut fibers.

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