Influence of short term oven aging on volumetric properties of asphalt concrete mixture containing modified Buton asphalt and limestone powder filler

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Abstract. In an effort to develop the use of modified Buton asphalt (MBA), this study designed a concrete asphalt mixture using the MBA as the main binding material and modified it with limestone powder fillers to produce concrete asphalt that has good resistance to aging. Short-term aging test was simulated in the laboratory on a loose mixture. The volumetric void in mixture (VIM), void in mineral aggregate (VMA) and void filled asphalt (VFB) values were evaluated on compacted specimens and had experienced STOA. Based on VIM, VMA and VFB values, it can be noted that mixture that only used MBA or mixture that combined MBA and limestone powder can provide resistance to bleeding or cracking, sufficient durability and stable interface adhesion between asphalt films and aggregate surfaces.

1. Introduction

Natural rock asphalt deposits cover some areas in southern Buton regency, Indonesia. Hydrocarbon material (bitumen) has been strongly integrated with sediment to form natural rock asphalt deposits. Buton rock asphalt (BRA) is composed of about 30% bitumen and 70% minerals. Bitumen in BRA has properties that are mostly like petroleum bitumen. One of the products from BRA in the form of granular can be used as a substitute for partial petroleum bitumen to make concrete asphalt mixture [1, 2, 3]. The latest development of BRA is that its bitumen can be extracted and mixed with petroleum bitumen to produce modified Buton Asphalt (MBA). The research in this paper is part of an effort to develop the use of BRA's processed products, including the MBA.

As it is known that filler has two main functions where the first function is the filler is a mineral aggregate that fills the interstices between larger aggregates while the second function is bitumen and mineral fillers create a blend known as bituminous mastic. A number of studies have shown that filler has a large influence on the behavior of asphalt concrete mixtures [4, 5, 6].

In general, bitumen binding aggregates will experience short-term and long-term aging. Short-term aging phase occurs in bitumen during production where asphalt undergoes volatilization and oxidation at high temperatures during the mixing process at asphalt mixing plant (AMP) and transportation to the laying location. Volatilization and oxidation due to short-term aging results in hardening of the bitumen which further affects the ability of the bitumen to bind to the aggregate during compaction.
In order to widely accepted and used, it is important to discuss several key concerns about concrete asphalt mixture containing locally available MBA as main binder and lime particle as filler including the important issue of ageing.

Volumetric properties in the form of VIM, VMA, VFB etc, are other important parameters of a compacted asphalt mixture. In addition, this study also evaluates the effect of short-term aging on the volumetric of a compacted mixture.

2. Materials and Methods

2.1. Modified Buton Asphalt (MBA)

Table 1 show physical characteristics of modified Buton asphalt (MBA). Commercial MBA was used as a prominent binder in this research. Properties of MBA are mostly similar to the petroleum bitumen.

| No. | Kinds of testing                              | Testing result |
|-----|----------------------------------------------|----------------|
| 1   | Penetration before weight loss (mm)          | 78.6           |
| 2   | Softening point (°C)                         | 52             |
| 3   | Ductility in 25°C, 5cm/min (cm)              | 114            |
| 4   | Flash point (°C)                             | 280            |
| 5   | Specific gravity                             | 1.12           |
| 6   | Weight loss                                  | 0.5            |
| 7   | Penetration after weight loss (mm)           | 86             |

2.2. Physical characteristics of Limestone powder filler

Table 2 shows several properties of limestone powder filler.

| No. | Properties                        | Testing result |
|-----|-----------------------------------|----------------|
| 1   | Specific gravity                  | 2.70           |
| 2   | Sieve analysis                    | > 30% pass sieve No. 200 |

2.3. Physical Characteristics of Aggregates

Two fractions of coarse aggregates derived from crushed river stone were used: one with aggregate diameter 5-10 mm and the other with crushed stone diameter 10-20 mm. Stone dust obtained from stone crushed process were used as fine aggregate and main filler, respectively. The properties of coarse aggregates, fine aggregate and filler are shown in table 3, table 4 and table 5, respectively. The aggregates used for material component in cold mixture were collected from Jeneberang river in Gowa regency.

| Properties                              | (River crushed Stone) |
|-----------------------------------------|-----------------------|
| Water absorption, %                     | 2.071 2.08            |
| Bulk specific gravity                   | 2.622 2.627           |
| Saturated surface dry specific gravity | 2.677 2.682           |
| Apparent specific gravity              | 2.773 2.779           |
| Flakiness index, %                      | 20.1 9.38             |
| Abrasion aggregate, %                   | 25.72 24.36           |
Table 4. Properties of fine aggregate (stone dust).

| Property                          | Value   |
|----------------------------------|---------|
| Water Absorption, %              | 2.792   |
| Sand Equivalent, %               | 89.66   |
| Bulk Specific Gravity            | 2.449   |
| Saturated surface dry specific gravity | 2.518   |
| Apparent Specific Gravity        | 2.629   |

Table 5. Properties of main filler.

| Property                          | Value   |
|----------------------------------|---------|
| Water Absorption, %              | 2.283   |
| Sand Equivalent, %               | 69.57   |
| Bulk Specific Gravity            | 2.595   |
| Saturated surface dry specific gravity | 2.654   |
| Apparent Specific Gravity        | 2.758   |

2.4. Mixtures Design

The combined aggregate gradation is shown in figure 1. The combined aggregate gradation was kept constant for all mixtures. The mixtures were all prepared in the laboratory. Based on the preliminary experiment the optimum content of asphalt MBA was obtained at 6.50% of the total weight of the mixture. Table 6 shows the mixture by weight of HRS-WC (Hot Rolled Sheet-Wearing Course) mixture without limestone and with 25 and 50% limestone filler. The weight of the limestone used is based on the weight of the filler (particle pass sieve No. 200, MBA, aggregates and filler were mixed and compacted into the cylindrical mold with capacity of 1,200 gram and diameter of 101.6 mm. The specimens were compacted with 75 blows each face by using Marshall compactor. Mixing and compaction process were carried out at temperature of 150°C.

![Combined aggregates gradation](image)

Figure 1. Combined aggregates gradation.
### Table 6. Mixes design HRS-WC for 1,200 gram total of weight.

| No | Description                      | Unit | Limestone content (%) |
|----|----------------------------------|------|-----------------------|
|    |                                  |      | 0         | 25         | 50         |
| A  | Limestone weight                 | gr   | 66        | 72         | 78         |
| B  | MBA weight (6.50%)               | gr   |           |            |            |
| C  | Combined aggregate gradation     | Weight of aggregate by sieve size       |
|    | Sieve                           | % pass | % Retained |            |            |
| 1  | 3/4"                            | 100.00 | 0.00 | gr | - | - | - |
| 2  | 1/2"                            | 91.80  | 8.20 | gr | 269.36 | 267.94 | 266.51 |
| 3  | 3/8"                            | 68.17  | 23.63 | gr | 219.66 | 218.50 | 217.34 |
| 4  | No. 4                            | 56.27  | 11.90 | gr | 62.28  | 61.95  | 61.62  |
| 5  | No. 8                            | 51.26  | 5.01  | gr | 135.88 | 135.17 | 134.45 |
| 6  | No. 16                           | 39.40  | 11.86 | gr | 118.80 | 118.17 | 117.54 |
| 7  | No. 30                           | 28.93  | 10.47 | gr | 95.87  | 95.36  | 94.85  |
| 8  | No. 50                           | 20.47  | 8.46  | gr | 90.81  | 90.33  | 89.85  |
| 9  | No. 100                          | 12.46  | 8.01  | gr | 73.17  | 72.78  | 72.39  |
| 10 | No. 200                          | 6.01   | 6.45  | gr | 68.17  | 67.81  | 67.45  |
| 11 | PAN                              | 0.00   | 6.01  | gr | 68.17  | 67.81  | 67.45  |
|    | Total                            | 100.00 |      | gr | 1,134  | 1,128  | 1,122  |
| D  | Weight of test object design     | gr    | 1,200 | 1,200 | 1,200 |

2.5. Short Term Oven Aging (STOA)

Short term oven aging (STOA) process was performed by subjecting the prepared HRS-WC mixture containing 25 and 50% limestone and mixture without limestone. The prepared HRS-WC samples were subjected in an oven at 135˚C for 4 hours to perform short term aging (Kliewer, 1995) [7].

2.6. Volumetric Test of AC-BC Mixture

The Marshall volumetric test was conducted on HRS-WC mixture specimens according to SNI 06-2489-1991 [8].

3. Results and Discussion

Volumetric in asphalt mix especially VIM has a large influence on strength and durability so it is very important to measure every paved mixture. Table 7 shows the volumetric test results for asphalt mixes consisting of VIM, VMA and VFB values on all variations of test specimens both using 25% and 75% limestone powder filler and without limestone powder filler after experiencing STOA. At limestone powder filler levels of 0, 25 and 50%, it can be seen that the VIM, VMA and VFB values obtained after STOA met VIM, VMA and VFB of the asphalt concrete requirements.

Based on VIM value analysis of mixtures that have been compacted and previously subjected to STOA, it can be noted that all mixtures that did not contain limestone powder filler or those made from limestone powder filler can provide an adequate amount of air void in the mixture that had undergone STOA and were compacted so that there will be no bleeding due to the amount of air less than 4% and will not experience cracking due to the amount of air that exceeds 6% [9, 10].

The results of VMA analysis on mixtures that have been compacted and previously subjected to STOA showed that in the mixture with MBA only or with MBA and limestone powder filler, the thickness of the film covering the aggregate was available in sufficient quantities because the amount of VIM formed was more than the 18% requirement. With the amount of VIM more than 18%, all mixture can have required durability [9, 10]. VFB analysis shows that both the mixture containing
MBA only and asphalt mastic mixture made from the MBA and limestone powder filler that have experienced STOA have sufficient stiffness and sufficient numbers to penetrate into the voids of aggregate particles to form a stable interface adhesion [9, 10].

### Table 7: Volumetric values of mixture after STOA.

| No. | Limestone powder filler (%) | VIM (%) | VMA (%) | VFB (%) |
|-----|-----------------------------|---------|---------|---------|
| 1   | 0                           | 5.20    | 18.90   | 74.00   |
| 2   | 25                          | 5.25    | 18.80   | 72.00   |
| 3   | 5.15                        | 18.70   | 71.50   |
| α   | 5.20                        | 18.80   | 72.50   |
| 1   | 4.80                        | 20.00   | 84.96   |
| 2   | 25                          | 4.65    | 20.10   | 84.84   |
| 3   | 4.60                        | 19.64   | 84.69   |
| α   | 4.68                        | 19.91   | 84.83   |
| 1   | 4.39                        | 25.73   | 86.87   |
| 2   | 50                          | 2410    | 86.96   |
| 3   | 4.18                        | 27.10   | 87.69   |
| α   | 4.24                        | 25.73   | 86.87   |

**Specification**

| 4 - 6 | > 18 | > 68 |

4. **Concluding Remarks**

In an effort to develop the use of modified Buton asphalt (MBA), this study designed a concrete asphalt mixture using the MBA as the main binding material and modified it with limestone powder filler to produce concrete asphalt that has good resistance to aging. Short-term aging test is simulated in the laboratory on a loose mixture. The (VIM), (VMA) and (VFB) values were evaluated on compacted specimens and had experienced STOA. The test result showed that mastic asphalt which is formed from the MBA only or made from MBA and limestone powder filler had sufficient stiffness so that it can be compacted and has VIM, VMA and VFB values that meet the requirements. Based on the VIM, VMA and VFB values obtained, it worthy to note that mixture that only used MBA or mixture combined the MBA and limestone powder filler can provide resistance to bleeding or cracking, sufficient durability and stable interface adhesion between asphalt films and aggregate surfaces.

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