Research on Performance of BRA Modified Asphalt

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Abstract. For estimating the performance indexes of Buton rock asphalt (BRA) modified asphalt and the influence of different Buton asphalt content on the property of BRA modified asphalt, an indoor pitch performance index experiment was carried out. The test study uses Buton asphalt as the modifier, and the percentage of Buton asphalt relative to the total asphalt is used as the mixing ratio (namely internal mixing method), with 5% as the interval, select 10%, 15%, 20%, 25% and 30% five blending ratios to prepare BRA modified pitch. In addition, related tests will be done on the prepared BRA modified asphalt, and the high temperature property, low temperature property and durability of Buton asphalt modified pitch were evaluated. The analysis of the test results shows that the function of the BRA modified asphalt prepared by adding the base asphalt to Buton asphalt has changed. With the increase of Buton asphalt content, the high temperature property of BRA modified asphalt is significantly improved, but the low temperature property decreases with the increase of the content, and the durability performance is roughly the same as that of the unmodified matrix asphalt.

Keywords. BRA modified asphalt, internal mixing method, high temperature property, low temperature property.

1. Introduction
The rapid growth of traffic volume and the increase of load in our country put forward higher requirements for asphalt mixture pavement, and modified asphalt mixture has been paid more and more attention and applied [1]. In a variety of physical and chemical modifiers, Buton asphalt has attracted increasing attention for its good compatibility with base asphalt and convenience of production [2-3]. Buton asphalt is in the form of solid particles and powder at room temperature, its appearance is dark brown, the maximum particle size is less than 2 mm, and it has a slight kerosene smell [4]. Extraction tests show that it contains about 20% of asphalt and the remaining 80% is mineral content [5]. According to related research [6], the softening point of Buton asphalt reaches 70-90 ℃. Because Buton asphalt has been tested by the environment for countless years, it has a very good high temperature performance, and it will perform well as a modifier of matrix asphalt.

2. Experimental Materials
2.1. Buton Rock Asphalt
According to Indonesia's Buton Asphalt Quality Standard, the indoor test of Buton Asphalt is carried out in advance, and the table 1 is the experimental result.
Table 1. Experimental Results of Buton Rock Asphalt.

| Item                      | Result | Indonesian National Standard Min | Max |
|---------------------------|--------|----------------------------------|-----|
| Asphalt Content (%)       | 22.0   | 18                               |     |
| Solubility (Trichloroethylene %) | 24.0   | 18                               |     |
| Density (25°C) (g/cm³)    | 1.85   | 1.70                             | 1.90|
| Open Flash Point (°C)     | 265    | 230                              |     |
| Heating loss (%)          | 0.53   | 2.0                              |     |
| Water content (%)         | 0.65   | 2.0                              |     |
| Maximum mineral size (mm) | 1.16   | 2.0                              |     |

2.2. The Matrix Asphalt

The matrix asphalt used in this test is AH-70 pavement petroleum asphalt. Table 2 is the experimental result.

Table 2. Test results of AH-70 asphalt and specification limits.

| Item                              | Unit          | Requirements | Test Results | Tset Method       |
|-----------------------------------|---------------|--------------|--------------|------------------|
| Penetration (25°C, 5 s, 100 g)   | 0.1 mm        | 60~80        | 66           | T0604-2011       |
| Penetration Index (PI)            | --            | -1.5~+1.0    | -0.65        | T0604-2011       |
| Softening Point (°C) (Ring and Ball Apparatus) | °C | ≥46          | 47.0         | T0606-2011       |
| Ductility (15°C, 5 cm/min)       | cm            | ≥100         | 150          | T0605-2011       |
| RTFOT-Residue Mass loss %        | %             | ≤±0.8        | -0.092       | T0610-2011       |
| RTFOT-Penetration Ratio %        | %             | ≥61          | 65           | T0604-2011       |
| Ductility (15°C)                 | cm            | ≥6           | 6.5          | T0605-2011       |
| Solubility (Trichloroethylene)   | %             | ≥99.5        | 99.7         | T0607-2011       |
| Open Flash Point °C              | °C            | ≥260         | 302          | T0611-2011       |

2.3. Preparation of BRA Modified Asphalt

Before preparing BRA modified pitch, it is necessary to crush the blocky Buton asphalt, and then sieve it with a 1.18 mm square hole sieve to obtain the final powdered Buton asphalt. When preparing BRA modified asphalt, first heat the base asphalt to 150 °C, add the Buton asphalt according to the predetermined mixing ratio, continue heating and stirring to make it evenly mixed, and then put it into the oven at 160 °C~170 °C. In the middle, take out after 1h of development, and finally the high speed shear instrument was used to shear the product at 160 °C~170 °C for 30 min [7]. When the asphalt has a uniform texture during the mixing process and a smooth mirror surface after cooling, the BRA modified asphalt required for successful preparation is prepared. It should be noted that due to the large amount of limestone minerals contained in the asphalt, it might be necessary to evenly stir the modified pitch before each test to reduce the adverse impact of particle settlement on the nature of the modified bitumen. In addition, the temperature when preparing BRA modified bitumen [8] needs to be controlled below 180 °C to reduce the aging effect of high temperature on the neat asphalt.

3. Testing and Performance of BRA Modified Asphalt

3.1. High Temperature Performance of BRA Modified Bitumen

The high-temperature property of bitumen refers to its resistance to high-temperature shape-change. As asphalt is an amorphous polymer material without a fixed melting point, asphalt will gradually soften as the temperature increases. The softening point refers to the conditional temperature at which asphalt reaches a certain viscosity under certain experimental conditions. It is usually used as an index to reflect the thermal stability of the asphalt. The higher the softening point, the better the
high-temperature deformation resistance of the asphalt binder. Therefore, the softening point was measured by ball and ball method in this study to evaluate the high-temperature performance of BRA modified asphalt. The table 3 is the test result.

Table 3. Softening point testing of BRA modified asphaltum.

| Item            | BRA content (%) |
|-----------------|-----------------|
|                 | 0       | 10      | 15      | 20      | 25      | 30      |
| Softening Point (C) | 47.0   | 49.1    | 51.2    | 53.6    | 55.2    | 57.2    |

It can be known from the table that the softening point of BRA modified asphalt increases because of the increase of Buton asphalt content, and the change law of softening point is completely similar to the equivalent softening point [9]. This shows that Buton asphalt can enhance the high temperature constancy of asphalt. However, with the increase of the content, the growth rate of the 25% to 30% stage is slower than that of the 15% to 25% stage. This is because the ash content of the Buton asphaltum is absorbed by the too much Buton asphalt. More base asphalt is not conducive to its high temperature performance.

3.2. Low Temperature Property of BRA Modified Asphalt
The low temperature property of asphalt mainly refers to the capability of asphalt to resist low temperature cracks. In cold temperatures, the asphalt film between the asphalt mixtures is stretched and damaged, causing aggregate rupture. The ductility of asphalt refers to the length from both ends of the stretched standard specimen to the point of breaking at a specified speed and temperature. The ductility of asphalt is an important indicator for evaluating the low-temperature performance and fatigue resistance of asphalt. The greater the ductility, the more flexible the asphalt is. According to "Test code for asphalt and asphalt mixtures for highway Engineering" (JTG E20-2011), the ductility test was proceeded with the BRA modified asphalt under the condition of 10℃. However, due to the presence of more than 70% of the minerals in the Buton asphalt, it has high hardness and brittle fracture. Therefore, this study evaluated the low-temperature performance of BRA modified asphaltum by ductility at 15 ℃.

Table 4. Ductility test of BRA modified asphalt.

| Item          | BRA content (%) |
|---------------|-----------------|
|               | 0       | 10     | 15     | 20     | 25     | 30     |
| Ductility(15C, 5 cm/min) | 150    | 75.2   | 62.5   | 52.6   | 50.1   | 48.5   |

It can be known from table 4 that after Buton asphaltum is added, the elongation of the modified pitch of Buton decreases obviously. The higher the content, the lower the elongation is. When the content is 30%, the elongation of Buton modified bitumen is less than 20% of the base bitumen. It means that the low temperature performance of modified bitumen decreases with the increase of asphalt content. After analysis, it is believed that this phenomenon may be due to the large amount of mineral particles in Buton rock asphalt, which will have an influence on the test results due to the stress concentration of these particles when the asphalt is stretched.

3.3. Durability of BRA Modified Asphalt
Asphalt aging refers to the phenomenon that the properties of asphalt gradually deteriorate over time. As the asphalt is exposed to the external environment for a long time in all aspects of transportation and construction, physical and chemical reactions such as volatilization, oxidation, polymerization, etc. occur under the combined action of heating, oxygen, sunlight and water, and even the internal structure of the asphalt changes. Which makes the fluidity decrease, the consistency increases
gradually, and the asphalt hardens, which affects the service life of the bituminous mixture and the related performance such as low-temperature and fatigue [10].

In this study, a rotating film oven heating test (RTFOT) was used as a short-term asphalt aging test way to assess the anti-aging performance of BRA modified asphaltum. The evaluation indicators include asphalt quality loss, penetration ratio and residual ductility. Table 5 shows the results of the heating test in the rotating film oven.

| Item                      | Unit | Brahmos content (%) |
|---------------------------|------|----------------------|
| Mass loss                 | %    | 0.153 - 0.105 - 0.167 - 0.205 - 0.366 - 0.411 |
| Penetration at 25°C       | 0.1 mm | 47.5 - 33.9 - 30.5 - 25.4 - 23.8 - 21.6 |
| Penetration ratio         | %    | 73.5 - 68.9 - 66.6 - 63.6 - 61.3 - 60.2 |
| Residual ductility at 15°C | cm  | 75.0 - 38.4 - 30.5 - 25.4 - 21.4 - 19.8 |

The mass loss of the modified bitumen with different content of Buton bitumen is within ±0.8, which meets the specification requirements. After adding the Buton asphaltum, the mass loss is negative, and the absolute value of mass loss gradually increases with the addition of the content. The value gradually increases. This means that with the increase of Buton asphalt content, its quality loss becomes more and more serious, that is, the ability of asphalt mixtures to resist aging is weakening. The penetration degree after aging shows a downward trend with the increase of Buton asphalt content, which is consistent with the change rule of penetration degree before aging. As for the penetration ratio, with the increase of Buton asphalt content, the penetration ratio decreases gradually.

4. Conclusion
- Buton rock asphalt is a bituminous rock formed by volcanic eruption oil penetrating into the rock formations, after long-term seabed deposition after high temperature, and withstanding pressure and geological changes. Therefore, its high-temperature property is superior. Therefore, the BRA modified asphaltum was prepared, and the high temperature performance will also be significantly improved.
  - With the increase of Buton asphalt content, the ductility of Buton modified asphaltum will decrease. This may be due to the fact that the BRA contains a large number of mineral particles, which will cause the ductility to decrease.
  - The quality of BRA modified asphalt has been lost after heating test in rotating film oven. This is because BRA itself contains minerals, so the anti-aging function of BRA modified asphalt cannot be estimated through the loss of quality. The same penetration is not good. In fact, because BRA is natural asphalt, it coexists with nature for a long time, its performance is exceedingly stable, and it does not contain wax, it must have good anti-aging properties.

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