The Analysis and Evaluation of Buton Rock Asphalt Mixture Performance

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ABSTRACT: The modification mechanism of Buton rock asphalt is physical modification, without changing the original structure of the mixture, joined the Buton rock asphalt, rutting depth deformation of asphalt mixture decreases. It can improve the dynamic stability, and high temperature stability has improved significantly. Buton rock asphalt mixture anti water damage material performance improved slightly, bending stiffness modulus is lower than that of the common asphalt mixture. Comparative analysis of various performance tests, 25% of the dose of the Buton rock asphalt to improve the performance of asphalt mixture is the best.

INTRODUCTION

OVERVIEW OF BUTON ROCK ASPHALT

In recent years, a similar natural bitumen was found in Indonesia buton Island, it is called Buton rock asphalt (BRA), belongs to a kind of rock asphalt. Because BRA was tested with the nature of the coexistence of bad environment over a long period of time, so the self nature is stable and has good aging properties. At the same time with very small mineral particles of BRA asphalt, it can play the role of absorbing asphalt, the adhesion between asphalt and aggregate can be effectively improved. Therefore, the modified principle of Buton rock asphalt is physical modification, under the premise of not affecting the properties of the material to obtain a better use of the results.

Buton rock asphalt, with its excellent properties, simple production process and good social and economic benefits and other advantages, will be more and more applied to the asphalt pavement in our country, and gradually change the current situation of the main use of polymer modified asphalt.

TO DETERMINE THE OPTIMUM ASPHALT AGGREGATE RATIO

The mix proportion design of asphalt mixture is the key factor that determines the performance and service life of asphalt mixture. It mainly includes two parts, the ratio of mineral mixture and the optimum dosage of asphalt.

Considering the above layer Buton rock asphalt mixture is mainly applied to the pavement, so this study gradation selecting AC-13. Figure 1 shows the grading curve.
According to the study to determine the optimum gradation, using 70# asphalt in intervals of 0.5%, 4.3%, We selected 3.8%, 4.3%, 4.8%, 5.3%, 5.8%, five proportion Marshall test, The test piece is formed by the method of double side each shot 75 times. Specimen molding temperature is 155 °C, size is 101.6mm × (63.5±1.3) mm. qualified molding specimens according to the above method, determination of the aggregate ratio conditions Marshall sample volume index and the stability and flow value, the results shown in table 1.

<table>
<thead>
<tr>
<th>Aggregate ratio (%)</th>
<th>Bulk density (g/cm$^3$)</th>
<th>VV(%)</th>
<th>VMA (%)</th>
<th>VFA (%)</th>
<th>MS(KN)</th>
<th>FL (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8</td>
<td>2.491</td>
<td>2.7</td>
<td>14.3</td>
<td>80.9</td>
<td>12.1</td>
<td>3.2</td>
</tr>
<tr>
<td>5.3</td>
<td>2.483</td>
<td>3.5</td>
<td>14.2</td>
<td>73.7</td>
<td>12.8</td>
<td>2.9</td>
</tr>
<tr>
<td>4.8</td>
<td>2.472</td>
<td>3.9</td>
<td>14.2</td>
<td>67.4</td>
<td>14.0</td>
<td>2.8</td>
</tr>
<tr>
<td>4.3</td>
<td>2.463</td>
<td>4.6</td>
<td>14.0</td>
<td>63.3</td>
<td>13.2</td>
<td>2.7</td>
</tr>
<tr>
<td>3.8</td>
<td>2.452</td>
<td>5.8</td>
<td>14.1</td>
<td>54.0</td>
<td>12.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Design requirement</td>
<td>—</td>
<td>3~5</td>
<td>≥14</td>
<td>65~75</td>
<td>&gt;8</td>
<td>2~4</td>
</tr>
</tbody>
</table>

Through the calculation, combined with the actual experience, determine the AC-13 type 70# asphalt mixture optimum asphalt aggregate ratio is 4.8%.

In the ordinary asphalt mixture and Buton rock asphalt mixture on the basis of the optimal proportion, mainly from the asphalt pavement performance study of comparative analysis of the overall performance of common asphalt mixture and Buton rock asphalt mixture. The test uses the AC-13 gradation type, the base asphalt is 70# asphalt, the asphalt content of Buton rock asphalt was 0%, 20%, 25%, 30%. For comparison and test, the optimum asphalt content of different Buton rock asphalt mixture ratio was 4.8%.

**ROAD PERFORMANCE RESEARCH**

**HIGH TEMPERATURE STABILITY**

Test with a standard conditions, the temperature of 60°C, the load rate of 0.7MPa, rate of 42 /min, in the indoor molding specimens after cooling 12h at room temperature, The tested samples were placed in a rut instrument of 60°C for 1 hours, dynamic stability calculation method is as follows:
\[ DS = \frac{(60 - 45) \times 42}{D_{60} - D_{45}} \times C_1 \times C_2 \quad \text{(1)} \]

The mixture in the mixing amount of Buton rock asphalt under different molding plate specimens and rutting test, evaluation of high temperature anti rutting performance by using dynamic stability index, 3 parallel test specimens, the dynamic stability of the average value as the test result, dynamic stability with the content change of histogram is shown in figure 2.

**Figure 2. Different dosage of Buton rock mixture dynamic stability.**

It can be concluded from figure 2:

(1) The different dosage of Buton rock asphalt mixture dynamic stability can meet the requirements of China's current construction technical specification, the asphalt mixture dynamic stability for 1250 number/mm, 20%, 25% and 30% of the dosage of Buton rock asphalt mixture dynamic stability were compared with matrix asphalt the growth of 2.31, 3.02 and 3.33 times. Standard for dynamic stability of modified asphalt mixture is significantly higher than that of the specification. Added Buton rock asphalt, high temperature to produce rutting deformation is obviously reduced, the asphalt mixture's resistance to permanent deformation is improved, significantly improve the high temperature performance of asphalt mixture.

(2) By a column chart can be seen, the index of dynamic stability with increasing dosage of Buton rock asphalt showing a growing trend. The growth rate is first increased and then decreased, showed that with the increase of Buton rock asphalt content, high temperature stability is increasing, but the increase is obviously tend to be gentle. Considering the balance of economy and road performance, Buton rock asphalt content about 25% more appropriate.

**LOW TEMPERATURE CRACKING RESISTANCE**

According to the 《Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering》 (JTG E20-2011), by rolling cut small beam size is 250mm × 30mm × 35mm, test temperature of -10℃, the loading rate of 50mm/min. Determination of asphalt mixture flexural failure strength, failure strain and damage stiffness modulus. The bending strength of the specimen is obtained by the maximum load when the specimen is broken, The failure bending strain of the mixture is obtained by the mid span deflection of the failure, the bending stiffness modulus is compared with that of the two, gauge See formula (2) ~ (4). The results are shown in figure 3.
① Flexural tensile strength of the specimen when the specimen is damaged.

\[ R_B = \frac{3LP_B}{2bh^2} \]  

(2)

② The maximum bending strain of the beam at the time of failure

\[ \varepsilon_B = \frac{6hd}{L^2} \]  

(3)

③ Bending stiffness modulus of specimen failure

\[ S_B = \frac{R_B}{\varepsilon_B} \]  

(4)

Figure 3. Different dosage of Buton rock mixture dynamic stability.

It can be concluded from figure 3:

1. Different Buton rock asphalt content of mixture flexural failure strain largest meet the technical specification for construction of our current demand for modified asphalt mixture. A mixture of different Buton rock asphalt dosage material tensile failure strain can satisfy the current technical specification for construction of the modified asphalt mixture. The dosage of 25% Buton rock asphalt mixture modified maximum bending tensile strain of asphalt mixture is improved this shows that the ability of 7.3%. Buton Rock Modified Asphalt can improve asphalt mixture to resist deformation.

2. With the increase of Buton rock asphalt content, the low temperature bending test mixture increased first and then decreased, and the content is 20%, the maximum flexural tensile failure strain is less than the results of matrix asphalt mixture, the content is 30%, the bending stiffness modulus is small in matrix asphalt mixture. The low temperature performance of Buton rock asphalt mixture of asphalt mixture is improved, but the degree of improvement is not. In Buton rock asphalt mixing amount is about 25% when can play a better low temperature performance comprehensive improvement requirements.

WATER DAMAGE RESISTANCE

China’s 《Standard Test Methods of Bitumen and Bituminous Mixtures for Highway Engineering》 (JTG E20-2011), at present, the water stability of asphalt mixture is studied by using the immersion Marshall test and freeze-thaw splitting test. Immersion Marshall test specimens of each side compaction 75 forming, in addition to the conditions of 48h and immersion Marshall test is different from the other, Other no change. In the freeze-thaw splitting test, the
specimen diameter 101.6mm, high 63.5mm, double the 50 times of compaction molding, specimens were divided into two groups: one group of specimens at room temperature; another set of test specimens were immersed in water at room temperature 20 minutes, 0.09Mpa vacuum packaging, -18 C freezer in 16h, ensure that the specimen voids filled with water after freezing, and then bath into 60℃ in insulation 24h. Finally, two groups of specimens are immersed in water at 25℃ after holding for 2h with 50mm/min loading rate splitting test. The splitting tensile strength calculation method of the formula 5.

\[ R_T = \frac{0.006287P_T}{h} \]  \………………… (5)

For different Buton rock asphalt content of mixture specimens were immersed Marshall stability test and freeze-thaw splitting test, the residual stability and freeze-thaw splitting strength ratio to evaluate the mixture water stability, different materials immersion Marshall test, freeze-thaw splitting test is shown in figure 4.

<table>
<thead>
<tr>
<th>Buton rock asphalt content</th>
<th>Residual stability</th>
<th>Freeze-thaw splitting strength ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>20%</td>
<td>93%</td>
<td>91%</td>
</tr>
<tr>
<td>25%</td>
<td>92%</td>
<td>90%</td>
</tr>
<tr>
<td>30%</td>
<td>91%</td>
<td>89%</td>
</tr>
</tbody>
</table>

Figure 4. Water stability test of different dosage of Buton rock mixture.

It can be concluded from figure 4:

(1) The different dosage of Buton rock asphalt mixture immersion residual Marshall stability and freeze-thaw splitting tensile strength ratio can meet the current technical specification for construction of the modified asphalt mixture, and Buton rock asphalt mixture modified values are higher than the matrix asphalt mixture. After adding that Buton rock asphalt, strengthen adhesion between asphalt and aggregate, and asphalt aggregate interface by reducing the water erosion, water stability is improved.

(2) With the increase of Buton rock asphalt content, Buton rock asphalt mixture immersion residual Marshall stability and freeze-thaw splitting tensile strength ratio increases, but the variation is not obvious, Buton rock asphalt content has showed very little effect on the mixture performance against water damage.

CONCLUSIONS

Mainly from the three aspects of high temperature stability, low temperature crack resistance and water damage resistance was studied, and finally discusses the modification mechanism of Buton rock asphalt.
After adding Buton rock asphalt, the rutting depth of asphalt mixture deformation decreases, dynamic stability is improved, compared with ordinary asphalt mixture, high temperature stability is significantly improved. With the increase of Buton rock asphalt content, high temperature stability increase rate slowed, Buton rock asphalt content of about 25% is more appropriate.

After adding Buton rock asphalt, the low temperature performance of asphalt mixture improvement is not obvious, and the low temperature performance of asphalt mixture are similar. When the content is 30%, Buton rock asphalt mixture bending stiffness modulus is lower than that of the common asphalt mixture.

After adding Buton rock asphalt, buton rock asphalt mixture immersion residual Marshall stability and freeze-thaw residual strength compared with the ordinary asphalt mixture has risen slightly, indicating Buton rock asphalt mixture anti water damage material performance slightly improved.

Modification of Buton rock asphalt for physical modification, without changing the original structure of the mixture, the mixture performance can be improved.

Comparative analysis of comprehensive performance test in this chapter, the Buton rock asphalt optimum content is 25%.

ACKNOWLEDGMENTS

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