Selection of Mechanical Design Indexes for Supporting Layer Based on Sensitivity of Asphalt Content

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Abstract: In order to optimize the mechanical design index of asphalt pavement supporting which is sensitive to asphalt content, the mechanical parameters (dynamic modulus, compressive resilience modulus, compressive strength, shear strength, splitting strength and failure strain) of AC-20 mixture are selected as the research object, and the changes of these parameters with asphalt content are analyzed. The sensitivity of each parameter to asphalt consumption was analyzed by one-way ANOVA. The results show that the dynamic modulus and failure strain of asphalt mixture increase first and then decrease regularly with the increase of asphalt content, and the change of dynamic modulus is independent of loading frequency. However, the change of compressive strength, resilient modulus, shear strength and splitting strength is not significant with the increase of asphalt content. Dynamic modulus is most responsive to asphalt content under different asphalt types and gradations. Hence, it is suggested that dynamic modulus should be considered as the mechanical design index of load-bearing of asphalt pavement.

1. Introduction

The design parameters of asphalt pavement are the core method of asphalt pavement material design, but different design methods have conspicuous differences in road performance of asphalt mixture due to different design parameters. Since the 1940s, Marshall method has become a commonly used method for asphalt mixture design. As it’s based on its design parameter stability, flow value, void ratio and density to design the mix proportion of asphalt mixture, it is a method of asphalt mixture design based on volume parameters. However, its design parameter stability and flow value is only an empirical indicator [1], and is not directly related to the road performance of asphalt pavement. The American Superpave design theory system [2] proposed a new asphalt mixture design method, which design is based on the climate and design traffic volume of the project site, the design of the material and the design of the mix ratio require that the asphalt pavement be fully considered the influence of temperature on the road performance during the service period. However, the Superpave design theory system is still based on the volume parameters of the material to design the asphalt mixture, which cannot avoid the design defects of the volume method, so it cannot meet the road performance...
requirements for the structure region of the pavement material well [3]. The research found that the stress levels of different layers of the pavement are different. It is horizontally stretched under 0~3cm of the road surface. The shear stress is larger between 3~10cm under the road surface and under the dynamic load, 2cm~8cm from the road surface is a region with large shear stress [4]. Therefore, it is especially important to explore the design parameters based on the structural performance of the asphalt mixture for the functional requirements of the various structures of the pavement.

In theory, the rut of asphalt pavement is mainly composed of permanent deformation of the subgrade, the base layer and the surface layer. However, at present, the semi-rigid base layer is widely used in high-grade highways, so the proportion of permanent deformation at the roadbed and the base layer generated by ruts is less and less. The survey results show that more than 90% of the semi-rigid base asphalt pavement surface layer produced permanent deformation is rutting deformation [5]. As the main bearing layer of asphalt pavement, the middle layer is mainly resistant to permanent deformation (rutting) performance. For this reason, rutting has been widely studied as a high temperature indicator. The splitting strength of asphalt mixture has a good correlation with the test results of the rutting test. Therefore, Marshall stability and flow value can be used to replace the splitting strength, so as to the design parameters of high temperature performance of asphalt mixture [6]. Wang Gang et al. calculated the permanent deformation results of the pavement structure and concluded that the high modulus asphalt concrete under different temperature gradients has better shear strength and compressive rebound modulus, especially in the case of high temperature, so the advantage is adopted. The shear strength and compressive rebound modulus are reasonable as the deformation index of asphalt concrete pavement rutting [7]. In addition, many scholars [8] also combined experimental and theoretical analysis to show that the traditional Marshall, rutting and other test methods to evaluate the high temperature performance of asphalt mixture has obvious limitations, and the recommended shear strength index of Superpave shear test is recommended. To evaluate the high temperature performance of the asphalt mixture. It can be seen that the high temperature performance of the mixture has not yet formed a more uniform mechanical index.

Therefore, considering the permanent deformation of asphalt pavement is the main disease form of semi-rigid base asphalt pavement in China, this paper will carry out research on the design parameters of load-bearing asphalt mixture based on structural functional requirements. Firstly, some mechanical parameters related to the road performance of the load-bearing asphalt mixture are selected as the research object, and the variation law of each parameter on the asphalt dosage is analyzed. And combined with the mathematical statistics theory, the design parameters most sensitive to the change of asphalt dosage are determined. The design of the surface structural layer in the subsequent mixture provides guidance.

2. Raw material experiment

2.1 Raw material properties
The selected stone used in the test is the Anshan rock of Heilongjiang Province, and the ore powder is made by grinding limestone from Jilin; the basic properties of the stone are carried out according to the requirements and methods of the specification (JTG F40-2004) (JTG E42-2005) Tests, physical indicators as shown in Table 1, all meet the requirements of the specification.

| indicator          | Result | Technical Requirements (Expressway) | Test method |
|--------------------|--------|------------------------------------|-------------|
| Content of the flat particles (%) | 8.6    | ≤15                                | T0312       |
| Crushing value (%)  | 5      | ≤24                                | T0316       |
| Firmness (%)       | 2.7    | ≤12                                | T0314       |
| Wear value (%)     | 14.3   | ≤30                                | T0616       |
| Adhesion           | 4      | ≥4                                 | T0317       |
The asphalt used in the test is 90# petroleum asphalt, 30# low grade asphalt and rubber modified asphalt. The performance indexes of various asphalts are shown in Table 2, which meet the requirements of the specification JTGF40-2004.

### Table 2 three asphalt performance indicators

| Asphalt                    | Performance indicator          | Company Result | Company Result |
|---------------------------|--------------------------------|----------------|----------------|
| 90# petroleum asphalt     | Penetration (25℃, 5s, 100g)   | 0.1mm          | 83.7           |
|                           | Softening point (R&B)         | ℃              | 51.4           |
|                           | Ductility (15℃,5cm/min)      | cm             | 132.9          |
|                           | 60℃ Viscosity                | Pa·S           | 187            |
| 30# low grade asphalt     | Penetration (25℃,5s,100g)    | 0.1mm          | 29             |
|                           | Softening point (R&B)        | ℃              | 73.2           |
|                           | Ductility (15℃,5cm/min)      | cm             | 56             |
|                           | 60℃ Viscosity                | Pa·S           | 742            |
|                           | 135℃ Viscosity               | Pa·S           | 0.67           |
| Rubber modified asphalt   | Penetration (25℃,5s,100g)    | 0.1mm          | 65             |
|                           | Softening point (R&B)        | ℃              | 65.6           |
|                           | Ductility (5℃,5cm/min)       | cm             | 41             |
|                           | 60℃ Viscosity                | Pa·S           | 13014          |
|                           | 135℃ Viscosity               | Pa·S           | 8.646          |

2.2 Gradation design

This paper relies on the middle layer AC-20 physical engineering design method of the test section of the K13+600~K314+750 sunshine direction of G1511 Rilan highway in Shandong Province. In combination with China's semi-rigid base asphalt pavement, the load-bearing layer hot mix asphalt mixture usually adopts medium-grain dense grade asphalt mixture, so the load-bearing layer used in this paper is medium-grain AC-20 grade with a design thickness of 14cm (Fig. 1). According to the screening results of mineral materials and the "Technical Specifications for Highway Asphalt Pavement Construction" (JTG F40-2004), the requirements for the grading range of AC-20 materials. According to the different trend of the gradation curve, three different grades of AC-20 were selected for comparison test. The gradation curve is shown in Fig. 2.
3. Variation of mechanical properties of mixtures under different asphalt dosages

Design parameters that are sensitive to changes in asphalt usage can be used to guide the design of load-bearing asphalt mixes. Firstly, according to the requirements of the structural function of the bearing layer, the dynamic modulus, compressive strength, compressive elastic modulus, shear strength, splitting strength and splitting failure strain as six parameters that related to bearing layer stress characteristics or deformation performance of the asphalt mixture are preliminarily formulated as design parameters [9-10]. The variation of various parameters with the amount of asphalt oil was studied through laboratory tests. This section is based on the above-mentioned three different grades and nine kinds of asphalt mixtures composed of three different asphalts. The test results and analysis are as follows:

3.1 Analysis of dynamic modulus test results

When the dynamic modulus test was performed, the temperature was controlled to 25 °C and the repeated loading frequency range was 25 to 0.1 Hz. Figure 3 shows the dynamic modulus of the mixture at different asphalt dosages.
The influence of loading frequency on dynamic modulus is analyzed by using gradation one as an example. For three different asphalt mixtures, the dynamic modulus changes with the amount of asphalt under different frequency conditions. With the increase of asphalt dosage, the dynamic modulus of each frequency increases first and then decreases. And the position where the peak point appears does not change with the frequency of the load action. It can be inferred that the dynamic modulus varies with the amount of asphalt and has nothing to do with the frequency.

When the loading frequency is 10Hz, the loading time is 0.016s, which is roughly equivalent to the driving speed of 60–65km/h for the asphalt pavement surface. That is, the loading rate of 10Hz is the closest to the actual road driving speed. For the convenience of analysis, the dynamic modulus under the condition of 10Hz is taken as the standard in the following dynamic modulus test analysis, and the variation law of dynamic modulus with the amount of asphalt is studied.

![Fig.4 Relationship between dynamic modulus of asphalt mixture and asphalt dosage](image)

It can be seen from Figure 4 that in addition to rubber asphalt gradation three, the dynamic modulus of different asphalt types and grading conditions show the same law with the change of asphalt dosage. With the increase of asphalt dosage, the dynamic modulus increases first and then decreases. The small trend is that the position of the peak point of the dynamic modulus and the variation of its curve are slightly different due to the difference in the type and gradation of the asphalt. The peak value of 90# asphalt gradation two and gradation three dynamic modulus appeared at 3.9% of asphalt, while the peak of dynamic modulus of 90# asphalt gradation one appeared at 3.6% of asphalt. The peak of 30# asphalt gradation two and gradation three dynamic modulus appeared at 4.2% of asphalt, while the peak of 30# asphalt graded dynamic modulus appeared at 3.9% of asphalt. The peaks of the rubber asphalt graded and gradation two dynamic modulus were found at 4.2% of the asphalt. When the dynamic modulus exceeds the peak point, the dynamic modulus decreases slightly with the increase of the asphalt dosage under the three asphalt conditions. For every 3% increase in asphalt usage, the dynamic modulus reduction is about 8% for 90# asphalt, about 6.5% for 30# asphalt, and about 5.5% for rubber asphalt. It can be seen that the dynamic modulus of the asphalt mixture increases regularly and then decreases with the increase of the amount of asphalt, and this law does not change with the change of asphalt type and gradation type.

3.2 Compressive strength test results

The test results of the compressive strength of the asphalt mixture with the amount of asphalt used are shown in Figure 5. The test temperature is 15 °C and the loading rate is 2 mm/min.
As shown in Figure 5, the compressive strength of the asphalt mixture does not change significantly with the change of the amount of asphalt. For 90# asphalt, gradation one and gradation three, the compressive strength increases first and then decreases with the increase of asphalt dosage; while for gradation two, the compressive strength shows volatility with the increase of asphalt dosage, no significant law. For 30# asphalt, under the condition of grading, the compressive strength basically remains unchanged with the increase of asphalt dosage; while under the grading condition, the compressive strength has no obvious change with the increase of asphalt dosage; for gradation three, The compressive strength increases first and then decreases with the increase of the amount of asphalt. For rubber asphalt, under the condition of grading, the compressive strength shows a significant increase and then decrease with the change of asphalt dosage. Under the other two grades, the law is not obvious. Therefore, under different asphalt types and grading conditions, the compressive strength of asphalt mixture has no obvious change with the change of asphalt dosage.

3.3 Rebound modulus test result
Through the uniaxial compression test, not only the compressive strength of the asphalt mixture but also the elastic modulus of the asphalt mixture can be obtained. The test results of the rebound modulus as a function of asphalt dosage are shown in Figure 6:

As can be seen in Figure 6, for 90# asphalt and rubber asphalt, the elastic modulus of the asphalt mixture increases first and then decreases with the increase of asphalt dosage; while for 30# asphalt, although it is the modulus of elastic modulus of gradation one increases first and then...
decreases with the increase of asphalt dosage. However, under the condition of gradation two/three, the modulus of resilience lacks obvious trend with the change of asphalt dosage. Therefore, different asphalt types and grading conditions. The change law of the elastic modulus of the asphalt mixture is not significant as the amount of asphalt increases.

3.4 Shear strength test results

The shear strength of the asphalt mixture was measured by uniaxial penetration test to determine the penetration strength of the test piece and the shear strength of the test piece was calculated. The test temperature was 60 °C, the loading rate was 1 mm/min, and the shear strength varied with the amount of asphalt. The test results are shown in Figure 7.

![Figure 7](image)

Figure 7 Asphalt mixture test results of shear strength

It can be seen from Figure 7 that for 90# asphalt gradation two, gradation three, 30# asphalt gradation two, gradation three, rubber asphalt gradation one, gradation three conditions, the trend of asphalt mixture compressive strength with asphalt dosage increase increasing first and then decreasing. For the 90# asphalt gradation one and 30# asphalt gradation one, the compressive strength of the asphalt mixture gradually decreases with the increase of the asphalt dosage. For the rubber asphalt graded condition, the compressive strength of the asphalt mixture gradually increases with the increase of the asphalt dosage. It can be seen that the shear strength of asphalt mixture is greatly affected by the type and grade of asphalt. The asphalt mixture of different asphalt types and different grades has no obvious change with the increase of asphalt.

3.5 Splitting strength test result

In this paper, MTS-810 universal testing machine is used, the test control temperature is 25 °C, and the time-deformation curve of asphalt mixture loading process is recorded in real time with digital speckle test instrument. The relevant speckle processing software is used to obtain the splitting strength of the test piece. Destruction strain test indicators The test results of the splitting strength with the amount of asphalt used are shown in Figure 8:
Figure 8 Splitting strength test results of 90# asphalt mixture

It can be seen from Figure 8 that for 90# asphalt, the splitting strength of the three graded asphalt mixtures increases first and then decreases with the increase of the amount of asphalt, and the difference is the increase of the splitting strength with the increase of the amount of asphalt. Under different conditions, the amount of asphalt increased from 3.9% to 4.2%, and the splitting strength increased by about 18%. Under the condition of grading 2, the amount of asphalt increased from 4.2% to 4.5%, and the value of splitting strength increase about 11%; under the grading 3 conditions, the asphalt dosage increased from 3.9% to 4.2% and the splitting strength only increased by about 2.8%. For 30# asphalt, the splitting strength of the three graded asphalt mixtures increased first and then decreased with the increase of asphalt dosage, but the variation of splitting strength of gradation one and gradation three was smaller. When the amount of asphalt increased from 3.9% to 4.2%, the splitting strength increased by only 2.4% and 6.3%. For rubber asphalt, under the condition of grading, the splitting strength increases with the increase of asphalt dosage. Under the condition of grading 2 and grading 3, the splitting strength increases first and then decreases with the increase of asphalt dosage. However, under the condition of grading, the peak of the splitting strength appeared at 4.5% of the asphalt. Under the gradation three conditions, the peak of the splitting strength appeared at 4.8% of the asphalt. It can be seen that the variation trend of the splitting strength of the asphalt mixture is affected by the type of asphalt and the type of grading, and the value of the asphalt mixture is not significantly changed with the amount of asphalt.

3.6 Destructive strain test results

According to the method of splitting test, combined with digital speckle instrument and related data processing software, the test results of the strain of asphalt mixture tested with the amount of asphalt are calculated as shown in Figure 9:

Figure 9 90# asphalt mixture failure strain test results

It can be seen from Figure 9 that the failure strain of the nine asphalt mixtures increases first and then decreases with the increase of the asphalt dosage. However, the variation amplitude of failure
strain of different asphalt mixtures varies greatly with the gradation type and asphalt type. Among them, the failure strain of 90# asphalt mixture is larger and the variation range is larger. When the asphalt dosage increases from 4.2% to 4.5%, the failure strain of the graded 90# asphalt mixture increases from 6629με to 8368με, which increases 26.2%. The failure strain of 30# asphalt mixture is small, but the variation range is the largest. When the asphalt dosage increases from 4.2% to 4.5%, the failure strain of grading a 30# asphalt mixture increases from 2580με to 5212με, increasing by 100%. The rubber asphalt mixture has a small failure strain and a small change range, and its failure strain value fluctuates around 5500 με. Therefore, in terms of strain failure, it shows a significant increase and then decrease with the increase of asphalt dosage, but the sensitivity of the strain to the change of asphalt dosage depends on the type of grading and the type of asphalt.

4. Sensitivity analysis of mechanical properties of mixture on asphalt dosage

4.1 One-way ANOVA

It can be seen from the previous research results that with the increase of asphalt dosage, the dynamic modulus and failure strain of each design parameter show a significant increase and then decrease; due to the type of asphalt and the type of grading, the variation of the resilience modulus and the splitting strength with the amount of asphalt is not significant; while the compressive strength and shear strength change irregularly with the amount of asphalt. In order to eliminate the influence of asphalt type and gradation type to find the most sensitive design parameters with the change of asphalt dosage. In this section, One-way ANOVA was used to analyze the sensitivity of the selected design parameters to asphalt consumption from a statistical perspective.

One-way ANOVA, also known as “F-test”, is a statistical method used to estimate whether there is a difference in the population mean represented by two or more sample means by data variation analysis. Based on the principle of small probability of hypothesis testing, the hypothesis of negation is taken as the null hypothesis H₀, that is, “the change in asphalt dosage has no significant effect on the mechanical design index”. In this paper, the amount of asphalt used as the test object (factor) has a number of different levels ranging from 3.6% to 5.1%. Through the F test, the mechanical design index with significant difference in the amount of asphalt can be judged.

4.2 Analysis of Influence of Asphalt Consumption on Dynamic Modulus

The dynamic modulus test has a high frequency, the highest frequency is 25 Hz, and the lowest frequency is 0.1 Hz. When the loading frequency is 10 Hz, the loading rate is closest to the actual road driving speed, and 10 Hz is also the frequency used in most indoor repeated loading tests. Therefore, in order to eliminate the influence of frequency on the test results, this section selects 3 different load frequencies of 25Hz, 10Hz and 0.1Hz, combined with 3 kinds of asphalt and 3 different grades to form 27 groups of mixed test groups. The modulus results were analyzed by one-way ANOVA. The results are shown in Table 3:

| Gradation | Asphalt type | F value 25HZ | F value 10HZ | F value 0.1HZ | F0.05 |
|-----------|--------------|--------------|--------------|---------------|-------|
| Gradation1| 90#          | 24.71        | 58.34        | 9.48          | 4.35  |
| Gradation1| 30#          | 40.40        | 36.49        | 10.18         | 3.20  |
| Gradation1| Rubber asphalt| 6.30        | 5.29         | 3.57          | 3.63  |
| Gradation2| 90#          | 9.69         | 14.68        | 19.43         | 3.94  |
| Gradation2| 30#          | 7.11         | 8.12         | 13.94         | 3.94  |
| Gradation2| Rubber asphalt| 9.47        | 13.83        | 4.8           | 3.94  |
| Gradation3| 90#          | 11.60        | 16.0         | 29.4          | 3.20  |
| Gradation3| 30#          | 6.40         | 14.6         | 33.4          | 3.20  |
| Gradation3| Rubber asphalt| 8.10        | 7.5          | 27.3          | 3.20  |
F<sub>0.05</sub> in the table is obtained by checking the F distribution threshold table. For the case where the F value is less than F<sub>0.05</sub>, the assumption that the change in the amount of the asphalt does not significantly affect the dynamic modulus is established. It can be seen from the results in Table 3 that, except for the grading of a rubber asphalt mixture, F=3.75 is slightly less than F<sub>0.05</sub>=3.94 under the loading condition of 0.1 Hz, and the F value is greater than the corresponding F<sub>0.05</sub> value in the other 26 cases. This shows that the dynamic modulus of the AC-20 asphalt mixture for different types of asphalt and different grading types is sensitive to changes in the amount of asphalt used.

4.3 Analysis of the Influence of Asphalt Consumption on Other Mechanical Indexes

Using the one-way ANOVA method, the parameters such as compressive strength, rebound modulus, shear strength, splitting strength, and strain at failure were analyzed with the sensitivity of asphalt dosage. The results are shown in Table 4:

| Gradation | Asphalt type | F value | | | | | |
|-----------|--------------|---------|---------|---------|---------|---------|---------|
|           |              | Compressive strength | Rebound modulus, | Shear strength | Splitting strength | Strain at failure | F0.05 |
| Gradation1 | 90#          | 5.10     | 2.49    | 2.30    | 2.97    | 8.87    | 3.63    |
|           | 30# Rubber asphalt | 1.07     | 4.76    | 4.08    | 3.31    | 4.04    | 3.63    |
| Gradation2 | 90#          | 3.27     | 2.64    | 1.92    | 2.97    | 5.02    | 3.63    |
|           | 30# Rubber asphalt | 4.22     | 4.53    | 4.56    | 3.31    | 4.30    | 3.63    |
| Gradation3 | 90#          | 6.66     | 2.70    | 5.76    | 1.97    | 4.13    | 3.63    |
|           | 30# Rubber asphalt | 3.62     | 4.81    | 4.03    | 1.06    | 3.71    | 3.63    |
|           |              | 1.29     | 1.56    | 2.50    | 1.91    | 1.22    | 3.63    |

It can be seen from the results of the splitting strength test that the F value of the splitting strength of the above nine different asphalt mixtures is less than the corresponding F<sub>0.05</sub>. The results show that the type of asphalt and the type of grading have a great influence on the splitting strength of the asphalt mixture. The assumption that the change of the amount of asphalt has no significant effect on the splitting strength is established, that is, the splitting strength of AC-20 asphalt mixture is insensitive to changes in asphalt consumption.

For the test results of three mechanical indexes of compressive strength, shear strength and rebound modulus, under the conditions of different grades and asphalt types, half of the test results have F values greater than their corresponding F<sub>0.05</sub>. This indicates that the change in the amount of asphalt has a certain influence on the three mechanical indexes of compressive strength, shear strength and rebound modulus, but at the same time, the external conditions such as asphalt type and gradation type have a significant influence on the sensitivity of these parameters. That is, the compressive strength, shear strength and rebound modulus of the AC-20 asphalt mixture are partially sensitive to the change in the amount of asphalt used, and partially insensitive.

According to the results of the failure strain test, the failure strain F values of the 6 different asphalt mixtures of 90# asphalt and 30# asphalt are all greater than F<sub>0.05</sub>; and the failure strain F values of the three different grade rubber asphalt mixtures are less than F<sub>0.05</sub>. The results show that the change of asphalt dosage has a certain influence on the failure strain, but the influence of asphalt type is not negligible. The failure strain of 90# and 30# asphalt mixture is sensitive to the change of asphalt dosage, while the failure strain of rubber asphalt mixture is not sensitive to the change of asphalt content.

The summary of the sensitivity analysis results of each selected parameter with the amount of asphalt used is shown in Table 5. It can be seen from Table 5 that the sensitivity of the parameters such
as compressive strength, rebound modulus, shear strength, splitting strength, and strain to failure with the change of asphalt dosage has a great influence on the amount of asphalt and the type of grading, which is not obvious.

Table 5 Summary of the results of the sensitivity analysis of the selected parameters with the asphalt dosage

| Gradation type | Compressive strength | Rebound modulus | Shear strength | Splitting strength | Strain at failure | Compressive strength |
|----------------|----------------------|-----------------|----------------|-------------------|------------------|---------------------|
| Gradation 1    | 90#                  | √               | ×              | ×                 | ×                | √                   |
| Rubber asphalt | 30#                  | ×               | ×              | ×                 | ×                | ×                   |
| Gradation 2    | 90#                  | ×               | ×              | ×                 | ×                | ×                   |
| Rubber asphalt | 30#                  | ×               | ×              | ×                 | ×                | ×                   |
| Gradation 3    | 30#                  | ×               | ×              | ×                 | ×                | ×                   |

In summary, the main indicators of the sensitivity of the asphalt with the sensitivity of the various indicators are dynamic modulus indicators and failure strain indicators. The dynamic modulus of different asphalt mixtures has good sensitivity to the amount of asphalt, and the sensitivity of the failure strain to the amount of asphalt is also related to the type of asphalt. It can be seen that the applicability of the dynamic modulus index is greater than the failure strain. Moreover, the test instrument for destroying the strain parameters is expensive, the test operation is difficult, and the data processing process is also complicated. In general, it is reasonable to use the dynamic modulus as the design index of the bearing layer asphalt mixture.

5. Conclusion

(1) The dynamic modulus test of 9 kinds of asphalt mixture at different frequencies is obtained. The dynamic modulus changes with the asphalt content of the same law under different frequency conditions: with the increase of asphalt dosage, the dynamic modulus under various frequency conditions is increasing and then decreasing is first changed, and the position where the peak point appears does not change with the change of the frequency of the load.

(2) With the increase of asphalt dosage, the dynamic modulus and failure strain first increase and then decrease, but the peak point appears at different oil levels with asphalt type and gradation; The compressive strength, rebound modulus, shear strength and splitting strength of the asphalt mixture indifferent asphalt types and grading conditions did not change significantly with the change of asphalt dosage.

(3) The parameters such as compressive strength, modulus of resilience, shear strength, splitting strength, and failure strain have a great influence with the amount of asphalt and the type of grading as the amount of asphalt varies. The sensitivity is not significant. However, the dynamic modulus of different asphalt types and graded mixtures has higher sensitivity with the change of asphalt dosage. Therefore, it is recommended to select the dynamic modulus as the design parameter of the load-bearing asphalt mixture.

References:

[1] XU Hui-ning, TAN Yi-qi, LI Xiao-min. Research on Relationship Between Marshall Stability and Grading Curve Trait of Asphalt Mixture[J]. Highway, 2008, 08: 213-216.

[2] NCHRP. Simple Performance Test for Superpave Mix Design (Project 9-19 FY’98), NCHRP REPORT 465, Transportation Research Board, 2002.

[3] Goh T.S., Takahashi O., Maekawa R. Effect of the baley ratios in Superpave gradation design for Tokyo international airport pavement [J]. Baltic Journal of Road and Bridge Engineering, 2013, 8(2):98-106.

[4] TAO Li. Research on Design Index to Asphalt Mixture Based on Functional Properties [D]. Master's Degree Thesis of Harbin University of Technology, 2011.

[5] WANG Jian. Research on Rheological Course of Asphalt Mixture and Stiffness Change [D]. Master's Degree Thesis of Tongji University, 2010.
[6] ZHANG Zheng-qi, TAO Jing, YANG Bo. Research on Design Parameter for High Temperature Performance of Asphalt Mixture[J]. China Journal of Highway and Transport, 2009, 01: 23-28.

[7] WANG Gang, LIU Li-Ping, SUN li-jun. Research on Anti-deformation Properties of High Modulus Asphalt Concrete[J]. Journal of Tongji University, 2012, 02: 217-222.

[8] Gullberg D. Implementation and evaluation of an HMA fracture mechanics-based design module[D]. KTH Royal Institute of Technology, 2011.

[9] Thyagarajan S., Sivaneswaran N., Muhunthan B., et al. Statistical analysis of critical input parameters in mechanistic empirical pavement design guide [J]. Journal of the Association of Asphalt Paving Technologists. 2010, 79: 635-662.

[10] Yang C F, Pi H R, Xiao T, et al. Mechanical Response Analysis of Heavy Traffic on Semi-Rigid Base Pavement Performance[C]//Applied Mechanics and Materials. Trans Tech Publications, 2011, 97: 146-150.