Practicability Analysis of High Modulus Technology Path

Jinyi Liu, Lijie Ma

School of Civil Engineering, North China University of Science and Technology, Tangshan, Hebei, 063210, China

Abstract

In this paper, the mechanism analysis and technical comparison of low-grade hard asphalt technology, composite modified asphalt technology and high modulus additive technology are carried out. Combined with my country's climatic characteristics and actual road conditions, it is believed that additive type high modulus asphalt is used in road construction in my country. There are broad application prospects.

Keywords

High modulus technology; Low-grade hard asphalt; Composite modified asphalt; High modulus asphalt.

1. Preface

With the continuous growth of passenger traffic on highways in my country, under the combined effects of overloading and many unfavorable effects on the environment, highways have problems such as insufficient strength and poor durability. Improving the performance of asphalt mixtures has become a major problem at this stage. The methods for improving the stiffness modulus of asphalt mixtures are mainly divided into the use of low-grade asphalt configuration mixtures, modified asphalt configuration mixtures using high modulus addition, etc. The performance of the mixtures obtained by different preparation methods are also different. The use of suitable working methods to improve the modulus of asphalt mixture is of great significance to ensure its good road performance.

2. Modulus Concept

Asphalt mixture is a viscoelastic material. Under the action of different temperatures and different loads, the asphalt mixture will have different elasticity, plasticity and viscoelasticity. When the load action time is short, the deformation of the asphalt mixture is basically elastic deformation. When the load is repeatedly applied, residual deformation will occur due to the plastic nature. Asphalt mixture basically undergoes elastic deformation under the action of low temperature or small load, but as the temperature rises, especially the action time and load increase, the asphalt mixture will become plastic body, and the deformation characteristics will also become plastic deformation. It can be seen that there is a nonlinear relationship between the stress and strain of the asphalt mixture. In order to express the strength characteristics of the mixture more clearly, the modulus of the ratio of stress to strain is introduced as a new concept for better Express the characteristics of the mixture.

2.1. Static Modulus

The static modulus is the modulus under the condition of constant stress and strain. It is the ability to resist deformation under the constant action of external force. The measurement of static modulus is generally obtained by uniaxial compression experiment. By adding and unloadingq_i, Record the Springback deformation:ΔL_i, Draw a curve $q_i - \Delta L_i$. Our country takes static modulus as the main design parameter in the design of pavement structure, and guarantees the service level and road performance of the mixture in practical application by evaluating the ability of the mixture to resist deformation. The limitation of the static modulus is that its measurement conditions are measured in an incomplete elastic state, which cannot reflect the instantaneous load generated by the car passing the road. Ignoring the sensitivity of the mixture in the force time, this is quite different from the actual pavement force state, and the mechanical properties reflected by different loading frequencies are also different. At this time, the dynamic model measured under the simulated dynamic load is different. The amount is more in line with the actual road conditions.

2.2. Dynamic Modulus

In the asphalt mixture, there is a mixture of polymer hydrocarbons and metal derivatives that can affect the adhesion of the asphalt. The time and temperature dependence of polymer movement makes asphalt have time and temperature sensitivity, and the asphalt mixture also depends on the load time and temperature when deformation occurs. The real part modulus and the complex imaginary part modulus of the dynamic modulus can fully express the linear and nonlinear viscoelastic characteristics of the material. The measurement of the dynamic modulus is more convenient and accurate, which can better describe the deformation characteristics of the mixture.

3. High Modulus Technology Path Analysis

3.1. Low-grade Hard Asphalt Technology

3.1.1 Basic introduction of low-grade hard asphalt technology

Low-grade asphalt is a hard asphalt with a penetration of less than 25. Hard asphalt can be roughly divided into three grades. Classification and technical indicators at all levels as shown in the table 1

Table 1. Technical indicators of grade three hard asphalt

grade	Softening Point/°C	PI	170°C dynamic viscosity /mm2·s-1	Complex modulus at different temperatures (°C) (7.8Hz)/MPa			
				0	10	10	60
15/25	66	+0.2	420	425	180	70	0.4
10/20	62~72	+0.5	700	700	300	110	0.7
5/10	87	+1.0	980	980	570	300	7

Low-grade asphalt configuration high-modulus asphalt uses the high strength and excellent mineral mix of hard asphalt to prepare a high-to-oil ratio mixture to improve the high-temperature rutting resistance, bearing capacity and downward load transfer of the asphalt mixture Ability. And the use of low-grade asphalt can save engineering construction costs.

3.1.2 Preparation mechanism analysis

Asphalt is a mixture composed of four parts: aromatic, saturated, asphaltene and gum. Among them, the asphaltene molecule with the largest mass and the strongest polarity adsorbs the more polar colloid to form a group, and the less polar colloid forms a mesophase around the group. The peptization of the group makes it disperse and dissolve in the dispersion medium composed of saturated components and the relatively low molecular weight and polarity will form a stable colloid in the weak aromatic components. The content of asphaltenes in hard asphalt is high. The micelles break through the connection of the gums to form a three-dimensional network structure, which makes the micelles move in the continuous phase formed with greater resistance, thereby improving the high temperature stability and viscoelasticity of the asphalt. The high modulus hard asphalt itself has the performance of strong stiffness and good cohesiveness. In addition, the stiffness modulus of the mixture with high asphalt content and low porosity in the mixture has been improved, thereby enhancing the high temperature resistance to rutting, bearing capacity and The ability to transfer loads downward.

3.1.3 Related project examples

Cai Junhua [1] and others tried to verify the applicability of low-grade hard asphalt, The APA rutting test was used to compare the high temperature stability of 30# low-grade asphalt mixture and SBS I-D modified asphalt mixture widely used in the upper and middle layers of the highway in Fujian Province. Tests show that 30# matrix asphalt has good rutting resistance under standard test temperature and extreme high temperature conditions, and can replace the use of SBS I-D modified asphalt in the upper and middle layers. This shows that in southern China where the climate is mild in winter, low-grade hard asphalt with relatively poor low-temperature performance but cheaper prices can replace SBS modified asphalt and be used on asphalt pavements with higher requirements for rutting resistance.

3.2. Composite Modified Asphalt Technology

3.2.1 Basic introduction of composite modified asphalt technology

Composite modified asphalt is a composite modified asphalt with better high temperature stability and low temperature crack resistance, which is prepared by adding a basic modified asphalt to a polymer with special properties or a natural asphalt with a rich network structure. The elastic deformability of composite asphalt is higher than that of other asphalt mixtures, and the stiffness modulus is higher to resist the deformation caused by the high temperature and low temperature of the road surface.

3.2.2 Preparation mechanism analysis

High modulus bitumen adds natural bitumen or polymers with special properties to the base bitumen through a special preparation method. The physical reaction that occurs after mixing enhances the intermolecular forces, and successively produces chemical reactions and polymerization to form a macromolecular network structure. The movement resistance is enhanced. In addition, the charge on the surface of the asphaltene is enhanced, which increases the lubricity and adsorption of the asphalt and the surface of the mineral aggregate and the precision modulus of the asphalt mixture.

3.2.3 Related project examples

He Dongpo [2] et al. conducted DSR and BBR tests by changing the mix of rock asphalt and basalt mineral fiber,and basalt mineral fiber was selected for composite modification of rock modified asphalt to improve the comprehensive performance of asphalt at high and low temperature. According to the high and low temperature continuous grading temperature range of the composite modified asphalt obtained from the test, it was found that 6% (mass fraction) of basalt mineral fiber and 4% (mass fraction) of Iranian rock asphalt composite modified asphalt were mixed into the matrix asphalt for continuous grading temperature range. It has the largest span and the best comprehensive performance of high and low temperature.

3.3. High Modulus Asphalt Additive Technology

3.3.1 Basic introduction of high modulus asphalt additive technology

High modulus additives are mainly composed of polymer materials, elastomers, polymer fibers and other special additives. The functional additives are added directly when the asphalt mixture is mixed. The surface of the additives will adhere to the molten polymer molecules during high temperature mixing. Because the functional groups in the polymer molecules are similar to those in the asphalt mixture, the characteristics of the asphalt binder are improved. Significantly improve the complex modulus of the asphalt mixture, thereby enhancing the resistance to deformation of the pavement. The method has simple process, high-modulus

ISSN: 2688-8645

modified asphalt is easy to segregate, the problems of poor construction and workability caused by excessively high high-temperature heating temperature are solved, and the operation difficulty is low, which can effectively reduce the overall cost. See the table 2 for related technical indicators of asphalt additives.

Table 2. Technical indicators of PR.M high modulus additives

nature	unit	number
Particle size range	mm	2~4
density	g/cm3	0.926~0.975
Melting point	°C	175~180
Gradation	mm	0/5

3.3.2 Preparation mechanism analysis

During the high-temperature mixing process, the additives and aggregates, mineral powder and asphalt undergo corresponding physical and chemical reactions, and the following four methods are mainly used to improve the stiffness modulus of the mixture.

(1) Cementation. The additive and the asphalt mixture form a viscous flow state under the high temperature mixing state, which has high fluidity, so that the additive adheres to the surface of the mineral material. After cooling, the additive and the surface particles of the mineral material will form a cemented layer, which reduces temperature sensitivity, and has a low stiffness. The strength becomes stronger, and the high temperature resistance of the mixture is improved.

(2) Reinforcement. During the mixing process, the additive softens under the action of high temperature and collides with the mineral material to form a fibrous network structure, which enhances the overall performance of the asphalt and exerts a reinforcing effect, and the mineral material is tightly locked in the grid. To make the cementation between mineral powder, aggregate and asphalt closer.

(3) Squeeze effect. During mixing, the high temperature action causes the additive and the asphalt mixture to melt into a viscous flow state. After being rolled, it cools and solidifies, forming a dense embedded structure in the mineral material, which increases the force between the mineral materials and enhances the space. The structural stability improves the high temperature resistance to deformation.

(4) Bonding effect. The additive is an organic polymer material, which has the characteristic of absorbing the light oil in the asphalt, which increases the viscosity of the asphalt, and the high-temperature stiffness modulus of the asphalt mixture is also correspondingly improved.

3.3.3 Related project examples

Jia Jinxiu [3] combined with the traffic characteristics of Fudian first-class highways, adding pelletized polymer PLAST.S to the mixture. The results prove that adding PLAST.S can greatly improve the high temperature stability of the mixture. With the increase of PLAST.S dosage, the mixture gradually increases. The increase rate is larger when the mixing amount is 0.2% and 0.4%, and the effect of improving the dense structure of the skeleton is the most significant; the added asphalt mixture has relatively good road performance, and is suitable for paving on road sections with large traffic and heavy loads. And on highways in areas with high summer temperatures, the polymer can be used on special road sections such as steep slopes and ramps.

4. In Conclusion

At present, the country's hard asphalt road engineering is in its infancy, and many problems are still being explored and tested. There are still many problems in the preparation of high modulus mixtures with low-grade hard asphalt: such as high asphaltene content. The colloid content is small, the durability and low temperature crack resistance are low, and it is not enough to meet the current road load situation and climatic conditions in our country. According to my country's unique climate status and actual road conditions, most of the current engineering practice uses about 70 asphalt to prepare asphalt mixtures.

The main problems of using composite modified asphalt to prepare high modulus mixtures are: the mixing is relatively difficult to control and there is no corresponding standard evaluation index; The configuration of different polymers will cause a density difference with ordinary asphalt, which will cause segregation of the modified asphalt, which will affect the performance of the road.

Compared with the preparation process of low-grade hard asphalt concrete and compound modified asphalt. The high modulus asphalt addition technology has the advantages of simple production process and convenient construction. Directly input modifier for mixing, eliminating all processes related to modified asphalt. Additive feeding methods can also be selected between manual and mechanical feeding. The amount of feeding is simple and controllable, and the mixing is even and it is more convenient for real-time monitoring. The finished product is easy to store and does not affect the construction period. The high modulus asphalt addition technology has considerable application prospects.

References

[1] Cai Junhua,Tong Jusheng,Ma Tao,Huang Xiaoming,Yan Erhu.Application of low-grade asphalt in asphalt pavement in Fujian Province[J].Journalof Highway and Transport Technology, 2021, 38 (03): 1-6.

[2] He dongpo, Zuo huiyu.Research on high and low temperature performance of basalt mineral fiber modified rock asphalt based on rheology[J].Functional Materials, 2020, 51(10):10081-10088.

[3] Jia Jinxiu. Research on the Applicability of Adding Granulated Polymer to Asphalt Mixture[D]. Chang'an University, 2005.