

Study on Structure and Strength of Asphalt Stabilized Crushed Stone

Tianyong CAI

College of Civil Engineering, Chongqing Jiaotong University, Chongqing, 400074, CHINA

Abstract: The asphalt mixture is formed by fully mixing the mixture material with certain viscosity and appropriate dosage of asphalt materials with certain gradation of mineral aggregate. Due to the difference between different asphalt properties, production technology and construction method of asphalt mixture with the ratio and the mixture of differences, loading time and temperature of different reasons caused the asphalt mixed material as a kind of composite material, has the extremely complex performance. Asphalt stabilized crushed stone base mixture is a kind of asphalt mixture. It has the common structure characteristics of common asphalt mixture, but also has its own unique properties because of its larger particle size and coarse aggregate.

Keywords: Asphalt mixture; Asphalt stabilized crushed stone; Strength theory; Structural characteristics

1. Introduction

In recent years, with the rapid growth of China's economy, China's highway traffic construction has made rapid development. As of the end of 2005, the total mileage of the country reached a total of 193.05 km. Expected in 2030, China will spend about two trillion yuan to build a total mileage of eighty-five thousand kilometers of highway network. The network is made up of seven capitals, nine north-south longitudinal lines, and eighteen East-West lines, connecting the cities of more than two hundred thousand people. By the end of 2020, to achieve the conditions of the township (town) and the establishment of the village path, the basic form of a higher level of service rural road network, farmers travel will be more convenient, more comfortable and more secure. At present stage of our country, in spite of asphalt pavement achieved a certain degree of improvement in certain technical aspects, but compared with the unprecedented scale of construction, the problems of asphalt pavement performance in the long term is quite serious, the outstanding performance of the asphalt pavement early damage problems. The emergence of these problems[1], forcing most of the region's highway authorities had to reflect on the past experience and lessons of highway asphalt pavement construction. The so-called mixed pavement is made of asphalt concrete surface layer, asphalt stabilized crushed stone base, inorganic binding material stable aggregate structure type. Because our country has a rich experience in the application of semi-rigid base, in order to have a full grasp, the use of such pavement structure for the current economy is not developed in China has practical significance.

2. Structure and Strength of Asphalt Mixture

2.1. Composition structure theory of asphalt mixture

Asphalt mixture is composed of asphalt, coarse aggregate, fine aggregate and powder according to a certain proportion in a certain temperature mixing of a composite. Due to the difference of the quality of the asphalt mixture and the gradation, different components can be formed, which show different mechanical characteristics under different temperature and load as well as different loading methods[2]. It has formed two kinds of different views of the asphalt mixture material structure theory, namely surface theory and mortar theory.

1) Surface theory

The theory is that the asphalt mixture is composed of coarse and fine aggregate and filler according to a certain proportion of the composition of dense gradation mineral skeleton structure, consistency thin asphalt as a cementing material (binder) and distribution on its surface, binding them to a certain strength of the whole. This theoretical understanding can be illustrated as follows[3].

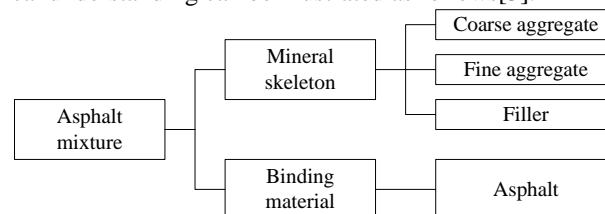


Figure 1. Schematic diagram of surface theory

According to the viewpoint of fluid mechanics and many research results, it is shown that the dynamic characteris-

tics of asphalt binder is one of the most direct and key factors of asphalt pavement structure performance. Asphalt binder for the mixture of high temperature rutting contribution rate of 29%, for the contribution rate of fatigue was 52%, the contribution rate of temperature cracks reached 87%[4]. Therefore, this theory emphasizes the important role of the asphalt binder in the asphalt mixture.

2) Mortar theory

According to the theory, asphalt mixture is a kind of multi phase dispersion system with spatial network structure, and it is a coarse disperse system with coarse aggregate as dispersed phase and dispersed in asphalt mortar. Similarly, the mortar is to fine aggregate as the dispersed phase dispersed in the medium of asphalt mortar a subdivision dispersion, mucilage, and filler as disperse phase dispersed in the high consistency of asphalt medium a dispersed system. The three grade dispersion formed in asphalt mortar cohesion is the most important.

Research shows[5] that the high temperature stability of asphalt mortar structure decision of asphalt mixture, low-temperature deformation and anti fatigue performance. When the powder binder ratio is the same, the dynamic shear factor decreases rapidly with the increase of temperature; For different powder ratio, temperature is the same with the increase in the ratio of powder, dynamic shear factor increases gradually, namely to improve powder ratio can be significantly improved the high temperature stability of asphalt mortar. Therefore this theory emphasizes the use of high consistency of asphalt and asphalt content, as well as the use of intermittent gradation of mineral mixture.

2.2. Structure type of asphalt mixture

The asphalt mixture according to the strength of the principle of different, can be divided into block according to the principle of compaction and according to the principle of density of two categories. According to the structural strength of the interlocking principles constitute the asphalt mixture is to mineral particles between the interlocking force and internal frictional resistance based asphalt binding material adhesion supplemented by the constitution. The structure is made up of coarse particles with uniform particle size, the asphalt binder fills the gap, and the aggregate is bonded to a relatively stable whole[6]. The structure strength of this kind of asphalt mixture is less affected by temperature. The structural strength of the formed according to the principle of dense gradation asphalt mixture is dominated by adhesion between asphalt and aggregate, mineral particles between the interlocking force and internal frictional resistance, supplemented by form. Due to the thermal performance of asphalt binder, the structure strength of this kind of asphalt mixture is greatly influenced by temperature. According to the different proportion of the structure and the compact structure of the mixture, the asphalt mixture

can be divided into the following three types according to its composition structure[7]:

1) Suspended dense structure

Continuous type dense gradation asphalt mixture (as shown in Figure 2 a), because of close packed coarse aggregate secondary set material receiving trough interference, before the aggregate is crowded open secondary aggregates, not directly close to form a framework, such as suspended between the secondary aggregates and asphalt mastic. Mixture of this kind of structure has a high density, high cohesion, but internal friction angle is lower, so waterproof good but anti high temperature stability is poor. Suspended dense structure for more rain and traffic volume is small area.

2) Skeleton void structure

When using continuous open gradation of mineral mixture (as shown in Figure 2 (b)) and asphalt composition of asphalt mixture, the skeleton void structure of coarse aggregate, the higher the number and contact with each other to form a framework, but the fine aggregate quantity is less, not enough to fill the gap formed between the coarse aggregate, mineral admixture decreasing coefficient is larger, the formation of open graded skeleton void structure. The structure of this kind of structure is larger and the density is lower, the frictional resistance is larger, the cohesive strength is lower, and the high temperature stability is better.

3) Framework dense structure

When using the discontinuous graded (discontinuous gradation) of mineral admixture (as shown in Figure 2 c) and asphalt composition of asphalt mixture, mixing material both skeleton void and suspended dense two structure characteristics, not only coarse aggregate higher number, contact with each other to form a framework, because of the broken to the intermediate size of aggregate, therefore, there is a considerable amount of fine aggregate infill skeleton void, forming a sophisticated type of skeleton dense structure.



Figure 2. The typical constitute structure of the bituminous mixture

From the above analysis, we can see that asphalt mixture in the ore material arranged in different positions, will lead to the change of the mixture bulk properties or strength, therefore only in-depth analysis of asphalt mixture internal composition structure, we can design to meet the practical requirements and excellent performance of asphalt mixture.

2.3. Structure characteristics and strength formation mechanism of large size asphalt stabilized crushed stone

1) Structural properties of asphalt stabilized crushed stone

The composition structure of the large size asphalt is also divided into skeleton void structure, suspended dense structure and framework dense structure. Skeleton void structure corresponding to the gradation is open graded; grading of suspended dense structure corresponding to the dense gradation; skeleton dense structure corresponding to the gradation gradation[8]. Due to the coarse aggregate packing characteristic and paired mixture volumetric parameter and intensity has a great influence, and from the asphalt mixture material composition of view, the most stable is skeleton dense mixture, so in order to achieve the excellent road performance, large grain diameter asphalt macadam should with skeleton dense structure.

2) Strength formation mechanism of asphalt stabilized crushed stone

Professor Brown of the United Kingdom proposed different aggregate nominal maximum particle size significantly influence the performance of asphalt mixture, using a larger nominal particle size of aggregate, in reducing the dosage of asphalt can improve asphalt mixture stability and skid resistance. Davis et al found that the larger particle size as 37.5mm instead of 19mm mixture, its capacity is obviously enhanced; Abdulshafi found large particle size of asphalt stabilized crushed stone mixture and conventional mixed material compared, no side limit compression strength to 2 to 3 times higher, and lower creep deformation.

Large size asphalt mixture on its strength formation mechanism can be borrowed from foreign research results, the formation of its strength has the following effect.

① With larger internal frictional resistance and block extrusion force

Large grain size gravel asphalt in the design process[9], must ensure the formation of skeleton interlocking structure to withstand higher loads, otherwise it is difficult to guarantee large size asphalt macadam comprehensive performance. Aggregate should be good angularity, particles close to the cube, elongated particles and flat particles content to be less, so as to have large internal frictional resistance and block extrusion force.

② Has a better stability of the skeleton

When the large size asphalt mixture is not formed, the structure of the high temperature, slow loading, coarse aggregate formation of the structural layer is too thick or the combination of poor stability, it is possible to produce unstable failure. Once the coarse aggregate skeleton instability, will greatly weaken the supporting effect of skeleton, large particle asphalt macadam mixture by

force and force transmission effect will no longer dominated by solid particles play. It is done by the friction of solids, the most vulnerable to damage fracture surface is along the set between the material space larger contact surface. This can be seen to ensure and improve the structure of large size asphalt mixture of asphalt gravel mixture is to improve stability and avoid the premise of stability.

③ Slow decay of strength

Large particle size of asphalt macadam mixture strength is mainly by the friction force and cohesive and internal friction depends on the size of the low temperature sensitivity of the internal friction angle; Cohesion depends on the amount of asphalt, the quantity and quality of the mortar, and with the extension of time and attenuation. Large particle size of asphalt macadam mixture material is less than that of the other mixture of asphalt content, but asphalt film thickness is not reduced, and the cohesion of the attenuation is not obvious. In addition, the strength of asphalt mixture with large size asphalt mixture under natural or harsh climatic conditions is slow, which will undoubtedly be very beneficial to extend the pavement life.

Through the analysis of the strength mechanism of the large size asphalt mixture, it can be summarized as the strength mechanism characteristics of large size asphalt mixture, which can be summarized as friction force and large force, high stability of skeleton and slow decay of strength

3. Summary

In this paper, the structural characteristics and strength formation mechanism of asphalt stabilized crushed stone base mixture are analyzed, and some requirements are put forward to the pavement structure.

From the characteristics of asphalt mixture, the most stable is skeleton dense type mixture, so in order to achieve the good performance of the road, asphalt stabilized crushed stone base should adopt the framework of dense structure.

Strength from the view of formation mechanism, the asphalt stabilized macadam mixture material with friction and block extrusion strength, skeleton high stability, strength degradation and other characteristics of the slow, these characteristics have to improve pavement anti shearing capability and extend the service life of the pavement.

Asphalt stabilized crushed stone must have the following characteristics as a base material: enough anti deformation ability, enough anti fatigue ability, enough water stability and frost stability, and the surface layer good combining ability.

References

-
- [1] Zhang Dengliang. Asphalt and asphalt mixture. Beijing: People's Communications Press, 1993.6.
- [2] Lv Weimin. Design principles and methods of asphalt mixture. Shanghai: Tongji University press, 2001.
- [3] Wang C p. Performance-based mixture design of asphalt-treated base [J]. Journal of the Institution of Engineers,2004,44 (2) 176-181.
- [4] Zhang Fangfang. Research on anti rutting performance of asphalt mixture. Master Thesis of Chang'an University. 2004.5.
- [5] Liu Zhonglin, Tian Fang. History, with large stone asphalt mixture structure research. Hebei transportation science and technology information network, 2004.10.
- [6] Jia Yu, Zhang Jia. Asphalt pavement structure layer thickness and asphalt mixture type selection. Highway, 2004 (4): 25-27.
- [7] Huang Xiaoming, Deng Xuejun. Principle and method of pavement design. Beijing: People's Communications Press, 2001.3.
- [8] Sargand SM, Wu S, Figueroa J L. Rational approach for base type selection[J]. Journal of Transportation Engineering, 2006, 132 (10): 753-762.
- [9] Prithvi S Kandhal. Design of Large Stone Asphalt Mixes to Minimize Rutting. NCAT Report No. 90-1. 1990.