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Research on Aging Detection of Asphalt Mixture

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Abstract: With the continuous growth of China's national economy, the diverse travel demands of people have led to greater pressure and challenges on roads. Asphalt mixture, as the main material for road construction, has received increasing attention in terms of aging detection. Aging tests on asphalt mixtures ensure that their performance is not affected after long-term use and that they do not negatively affect road safety. This paper first presents an overview of asphalt mixtures and asphalt mixture aging, and then conducts an in-depth study of asphalt mixture aging detection from multiple perspectives. This study aims to provide a valuable reference for future research.

Keywords: Asphalt; Mixture; Aging test

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1. Introduction

In the context of the new era, asphalt mixtures, as a new type of high-quality pavement material, have very high application advantages and value. However, due to the fact that it is easily affected by air, moisture and other factors during actual use, attention should also be paid to the detection of aging. The detection of asphalt mixture aging is conducive to a deeper understanding of its aging mechanism and influencing factors, enabling the asphalt mixture to have higher application value. This also requires a thorough understanding of the asphalt mixture and its specific aging conditions in order to conduct more detailed detection studies.

2. Asphalt mixture

Asphalt mixture is a kind of composite material used in road construction, which requires aggregates and fillers to be mixed together in certain proportions to ensure its true value in different application scenarios. The classification of asphalt mixtures is very diverse. According to the composition and structure of the materials, asphalt mixtures can be divided into discontinuous graded mixtures and continuous graded mixtures. There are also differences in the properties of different types of asphalt mixtures. In practical applications, it is necessary to make a choice based on the actual situation to ensure that it can meet the standard construction requirements. For example, a mixture with a nominal maximum particle size greater than 37.5 mm is an extra-coarse mixture, which can be used to build impermeable walls. By taking advantage of its impermeability and low-temperature resistance, problems such as deformation of the impermeable walls can be effectively avoided.

The most commonly used asphalt mixtures in engineering can be mainly divided into the following two types:

(1) Asphalt concrete mixture, which is a mixture of mineral materials with a specified gradation composed of coarse aggregates, fine aggregates and fillers in appropriate proportions and asphalt mixture, with a residual porosity of less than 10% after compaction.

(2) Asphalt-crushed stone mixture, which is made by mixing and extruding the appropriate proportion of coarse aggregates, fine aggregates and other fillers with concrete, with a porosity of more than 10%.

The main types include road petroleum asphalt, soft coal tar pitch and liquid petroleum asphalt, emulsified petroleum asphalt, etc. In practical applications, various types of asphalt should be selected based on actual conditions such as road traffic volume, climate environment, construction technology, type of asphalt surface layer, and source of materials. When using asphalt for each layer, it is generally advisable to use thicker asphalt on the upper part and thinner asphalt on the lower part and at the junctions. Emulsified petroleum asphalt can be classified into three types based on setting rate: fast setting, medium setting and slow setting. It is mainly used in asphalt surface treatment, asphalt penetration pavement, or the surface of normal-temperature asphalt mixture, as well as prime coat, tack coat and seal coat.

3. Overview of aging of asphalt mixtures

3.1. Definitions

Asphalt mixture aging is a very common phenomenon, an irreversible change in chemical composition and deterioration of physical properties, which can have a very serious impact on the service performance of asphalt. Asphalt mixture aging mainly occurs during the mixing process and the application of asphalt mixture on the road surface. Once it is exposed to factors such as oxygen, ultraviolet light or moisture, it is inevitable that its softening point, brittle point and other properties will change. As the road surface is in use, it is easily affected by external factors, causing cracking or damage to the asphalt mixture road surface [1].

3.2. Performance

Asphalt mixture aging can be affected in multiple processes, resulting in changes in its properties and internal structure. Such as enhanced high-temperature performance, changes in flow characteristics, weakened water stability, etc., are the main performance characteristics of asphalt mixture after aging, which will eventually lead to the asphalt mixture being difficult to meet the requirements of traffic load, and will also cause serious consequences due to cracking. For the performance of the asphalt mixture, test items such as penetration, viscosity and ductility can be evaluated. And since the degree of the asphalt mixture is closely related to aspects such as porosity and pavement density, once the penetration drops to 30, the asphalt mixture reaches its service limit. There are two types of asphalt mixtures: discontinuous graded asphalt mixtures and continuous graded asphalt mixtures. Discontinuous graded asphalt mixtures are more susceptible to the effects of oxygen and ultraviolet light, which can lead to evaporation and oxidation. In addition, since the road surface is subjected to greater pressure on a daily basis, appropriately increasing the density of the asphalt mixture can also effectively optimize its performance.

4. Research on aging detection of asphalt mixtures

4.1. Methods for aging detection of asphalt mixtures

4.1.1. Softening point detection method

The softening point test method is to test the temperature stability of the asphalt mixture, as the softening point of the asphalt mixture can reflect the high-temperature viscosity of the asphalt. The procedure is as follows: First, prepare the test specimen, prepare the external environment required for the test, and control the temperature between 80 and 135 °C. The specimens are then cured to adjust the temperature to approximately 5 °C. Finally, place the specimen properly to ensure there are no air bubbles on its surface. Once these preparations are done, you can start the test and record the temperature increase per minute during the test.

4.1.2. Methods for measuring ductility

Specimen preparation should also be carried out first, using the same method for temperature and softening point testing. But when curing the specimens later, they need to be placed in water for about 1 hour. When placing the test piece later, make sure it is free of air bubbles and that it is about 20 mm above the water surface. During the subsequent test, stretch about 5cm per minute to obtain accurate test results.

4.1.3. Method for detecting penetration

This method involves not only temperature control but also sieving and mold filling during the initial specimen preparation. During the subsequent curing of the specimens, keep the temperature at 15 °C to 30 °C and ensure that the temperature does not change much within 1 hour. During the subsequent placement of the specimen, make sure the load is 100 g so that the specimen and the needle cone are in perfect contact. During the test, the time to drop the cone should be controlled within about 5 seconds to obtain the corresponding test results.

4.2. Evaluation of asphalt mixture aging test

By evaluating the aging test of asphalt mixtures, it is possible to effectively understand the specific causes of their aging and achieve a more comprehensive and scientific evaluation and analysis of them. This aspect of the evaluation is mainly done from several aspects.

4.2.1. Chemical composition

In road asphalt mixtures, the factors that cause aging are due to the chemical composition within them. Because the chemical composition of the asphalt mixture changes with aging, oxidation reactions occur, etc. Evaluating from the chemical composition aspect can provide a deeper understanding of its aging mechanism.

4.2.2. Physical properties

The physical properties of asphalt mixtures include aspects such as softening point, viscosity and degree of polymerization. Evaluating from the aspect of physical properties can effectively understand the impact of physical properties on asphalt concrete. Under normal circumstances, the lower the density of the asphalt mixture and the lower the degree of polymerization, the lower the probability of aging.

4.2.3. Microappearance

The evaluation of this aspect requires observations based on both optical microscopes and scanning electron microscopes to achieve more detailed analysis and evaluation. This aspect of the evaluation can provide a clear understanding of the internal cracks and fragmentation of the asphalt mixture, and can determine the specific extent of its aging. As shown in **Figure 1**, it is the basic appearance of the asphalt mixture under a microscope. By observing it, one can understand the specific situation of the asphalt mixture. The evaluation in this aspect still needs to be based on a comprehensive assessment of experimental data and theoretical models, so as to clarify the mechanism and degree of asphalt mixture, and provide a basic technical guarantee for the construction and maintenance of roads [2].

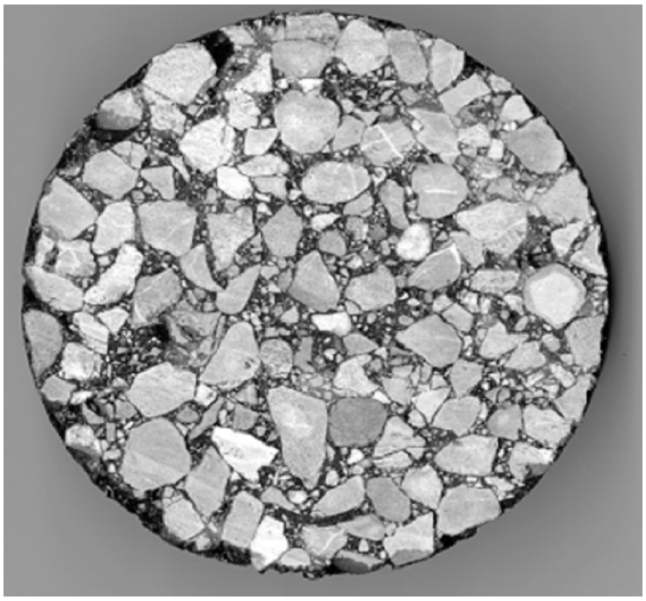

Figure 1. Basic appearance of the asphalt mixture under a microscope.

4.3. Data from asphalt mixture aging tests

Asphalt mixtures age to varying degrees both in use and in the process of use. To study the aging detection of asphalt mixtures, it is important to focus on the study of detection data. By studying the possible effects on the asphalt mixture, analyze the actual causes of its aging. Because the asphalt mixture becomes brittle and hard after aging, the analysis of the test data is more accurate. For the data on aging detection of asphalt mixtures, it should mainly be analyzed from the following aspects.

One aspect is the geographical aspect. By analyzing the aging of the asphalt mixture by testing the region and measuring the specific test indicators, the specific impact can be analyzed. The analysis of this aspect of data can effectively understand the specific causes of asphalt mixture aging. Among them, the eastern region is the area with the highest precipitation and the temperature is relatively low. The west, on the other hand, has less precipitation and, due to its drought, has relatively higher temperatures. Analysis of **Figure 2** shows that the softening point of the asphalt mixture is the highest in the central region.

On the other hand, in terms of service life. This also has an impact on the aging of the asphalt mixture, which, over time, affects aspects such as the hardness and softening point of the asphalt mixture. It is known from the investigation of the service life of most pavements that the initial change in softening point is more obvious as the service life increases, and the subsequent change is more significant. The rate of pavement aging also shows a pattern of rapid aging in the first few years and slow aging in the subsequent years. From this, it can be seen that service life also has an impact on it. The lifespan of asphalt concrete is typically around 18 years, and the exact lifespan depends on a variety of factors, including materials, construction methods, and usage environments. Under normal usage conditions, asphalt concrete will age over time, and cracks and potholes will become more prominent.

4.4. Stability of asphalt mixture aging tests

Stability is also part of the asphalt mixture aging test. Studying this aspect helps to clarify the changes in the asphalt mixture under the influence of external factors and analyze its performance changes. The following aspects of stability need to be studied specifically.

4.4.1. High-temperature stability

Dynamic stability was used as an evaluation index by aging permeable asphalt mixtures with different porosities of 19%, 21%, and 24% and conducting rutting tests. The greater increase in permeable asphalt mixture may be due to its higher porosity, such as: the increase in asphalt mixture with a porosity of 24% is much greater than that of asphalt mixture with a porosity of 19%.

4.4.2. Low-temperature stability

By conducting trabecular low-temperature bending tests, it is possible to test permeable asphalt mixtures aged with void ratios of 19%, 21%, and 24% to determine their low-temperature resistance to deformation. According to the test results, the asphalt mixture shows different properties at different aging periods. For example, the flexural tensile strength and maximum flexural tensile strain of the permeable asphalt mixture will change, but the 24% porosity sample is more stable than the 19% low porosity sample. To optimize the low-temperature stability of the asphalt mixture, it is necessary to control the construction process well. By strictly controlling the construction time and temperature, the probability of rapid aging of the asphalt can be effectively reduced. Construction personnel should try to shorten the high-temperature storage time and transportation distance of the mixture, thereby effectively reducing the influence of external factors.

4.4.3. Water stability

The splitting strength of permeable asphalt mixtures increases with aging and decreases significantly within four hours. Observations showed that the 24 percent porosity test mold had local loose cracking due to long-term aging. For samples with porosity of 19%, 21%, and 24%, the initial freeze-thaw splitting ratios were 93.9%, 64.1%, and 79.9%, respectively. With different porosity measurements, the samples took on different shapes over time. Notably, when the time was extended to ten hours, the ratio of freeze-thaw splitting in samples with a porosity of 19% decreased by 14.9%. It can be concluded that the higher the asphalt concentration, the faster the aging rate.

4.5. Structure for aging detection of asphalt mixtures

A variety of different results are included in the asphalt mixture. By studying the structure of asphalt mixture aging detection, it is possible to clarify the impact of different structures on it, and it can also serve as one of the bases for detection. There are mainly the following types of structures.

4.5.1. Compact skeleton structure

Asphalt mixture is a composite material made by blending asphalt and aggregates (such as sand, crushed stone, etc.). The dense framework structure refers to the arrangement of aggregate particles in the asphalt. It is generally divided into two types: porous and unsaturated. The porous structure can effectively improve the stability and durability of the mixture. The dense structure of the asphalt mixture skeleton is one of the important factors affecting its performance and service life. Optimizing its dense skeleton structure can enhance the stability, durability and crack resistance of the mixture.

4.5.2. Skeleton void structure

The skeleton void structure of asphalt concrete refers to the void structure formed by the aggregate particles in the asphalt adhesive, which includes the voids between the aggregate particles, the voids between the cements formed after the asphalt adhesive fills the voids of the aggregate particles, and the voids between the molecules of the asphalt adhesive. The skeletal voids structure of asphalt concrete is closely related to its mechanical properties. The mechanical properties of asphalt concrete depend on the construction techniques at each stage and the characteristics of the aggregate particles.

4.5.3. Suspended compact structure

The suspended dense structure of asphalt mixtures refers to a three-dimensional spatial arrangement structure formed by asphalt with aggregates, air and other components. In this structure, the asphalt has colloidal properties, and its presence forms an asphalt colloid; Aggregates, air, etc. are dispersed in the asphalt colloid. The suspended and dense structure of the asphalt mixture has a significant impact on its performance. Better stability, durability and load-bearing capacity of the mixture can be achieved by reasonably controlling features such as the distribution of asphalt colloid, air porosity, porosity and particle arrangement [4].

5. Conclusion

To sum up, by conducting research on aging detection of asphalt mixtures, a more accurate analysis of the causes of aging of asphalt mixtures can be made, thus facilitating the subsequent adoption of scientific and effective anti-aging measures. This will effectively enhance the anti-aging performance of asphalt mixtures, thus making it a driving force for the sustainable development of roads in our country. Because asphalt is exposed to complex climate conditions for a long time, thermal oxidative aging leads to hardening of asphalt, which is an inevitable problem. Detection of aging can provide a reliable driving force for the development of roads in our country.

Disclosure statement

The author declares no conflict of interest.

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