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Review

Moisture characteristics of mixtures with warm mix asphalt technologies – A review

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HIGHLIGHTS

- Warm mix asphalt has been widely used as an environmentally friendly technology.
- Moisture damage is considered as one of the main concerns for WMA mixtures.
- The commonly used test methods are tensile strength ratio (TSR) test.
- Materials, aggregate and asphalt played important roles in moisture characteristics.
- Compacting temperature and warm mix technologies influence the moisture behavior.

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ABSTRACT

Warm mix asphalt (WMA) has been widely used as an environmentally friendly technology. Due to the lower temperature than hot mix asphalt (HMA) and some influences of warm mix technologies, moisture damage is considered as one of the main concerns for WMA mixtures. This review focuses on the influences of various factors on the moisture susceptibility of WMA mixtures. The commonly used test methods are briefly introduced, while tensile strength ratio (TSR) test is the most commonly used method to evaluate the moisture susceptibility. Then the influence of materials and technologies are illustrated. Materials, aggregate and asphalt, play important roles in the moisture characteristics of mixtures. Compacting temperature and other warm mix technologies also significantly influence the moisture characteristics. The purpose of this review is to provide assistance to the project engineer when WMA technologies are employed.

Contents

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1. Introduction

With the development of economy, the transit construction is developing rapidly. Especially, highway pavement construction is developing rapidly as it is one of the most essential communal facilities. And the high-quality highway and pavement structures are subsequently required because of the increases of heavy vehicles and traffic loads. As a commonly used pavement, asphalt pavement needs to enhance its ability to meet the actual loads under various conditions. An example is that the modified asphalt is usually used to promote better adhesions and cohesions of the mixtures to satisfy the requirement of heavy-duty pavements. However, the modified asphalt pavement results in the increases of mixing and compaction temperatures of asphalt mixtures, which has caused the increasing emission of soot and exhaust gas, as well as the energy consumption. While global warming and energy shortage are gaining more and more attention, researchers are trying to find some environmentally friendly materials and technologies. Warm mix asphalt (WMA) is a mixture that can be mixed and compacted under a relatively low temperature (100 °C–120 °C) through some WMA technologies when compared with hot mix asphalt (HMA) at 140 °C–160 °C, while the performance properties of WMA mixtures are not significantly influenced. It has been proved that WMA technologies can significantly reduce energy consumption and emission during the production [1].

A number of additives and foaming technologies have now been used to produce WMA. Due to the variety of WMA technologies, a scientific classification is necessary. Nowadays there are some different classifications of WMA technologies, and one widely used method is based on the classification of additives. According to this method, WMA technologies can be divided into three types: organic additives technologies, chemical additives technologies, and foamed bitumen technologies.

Organic additives usually have low melting point generally around 100 °C, and they are adding into the mixture to decrease the viscosity of the binder in the process of mixing and compacting at a relatively low temperature. Organic additives can improve the performances of mixtures, which is attributed to the lattice structure formed by waxes after they cool down. Sasobit, Asphaltan-B are two of the most commonly used organic additives.

One type is called chemical additive, and it also contains several kinds. Chemical additives usually have complicated composition, including surfactants, emulsification agents, aggregate coating promoters and antistripping agents. These additives are generally added to asphalt binders in the process of production. Rediset and Cecabase are two of the popular chemical additives, containing surfactant and adhesion enhancers. These two additives can improve the adhesion between aggregate and binder, and also contribute to the aggregate coating. Some other chemical additives are used in forms of emulsion. Evotherm is a well-known chemical additive from America.

The third type is foamed bitumen technologies. Water is added straightly or through wet aggregates, or sometimes through zeolite like Aspha-min and Advera. The bitumen then foams at a high temperature. The foaming process can lead to a temporary increase of the binder volume caused by the water vapor, which can subsequently lead to a temporary drop of the binder viscosity [2].

Moisture damage is one complex but common form of distresses in asphalt pavement. It is exactly failure of adhesion between aggregate and binder or cohesion within the binder, which worsen the performance of mixtures, like strength, stiffness and durability [3,4]. Thus the presence of moisture significantly influences the mixture. It is generally considered that moisture damage results in the premature deterioration of asphalt pavements. Therefore the serviceability of the pavement is seriously harmed due to moisture induced damage. Moreover, some other pavement diseases, such as raveling, rutting, and cracking, would be much more likely to happen [5,6].

Consequently, moisture damage of asphalt pavement has been a hot area of research for many years, because the distress happens frequently and brings some extra costs. The problem needs to be paid a lot of attentions to, which has very important practical significance. Thus moisture damage is typically involved in the mix design in order to avoid it to the greatest extent.

So far, a lot of research studies have been done to investigate the moisture damage of asphalt pavement, including the study on the moisture damage of WMA. Researchers were trying to figure out the mechanisms of moisture damage, and then developed various tests and analytical methods to evaluate asphalt mixtures and prevent them from being damaged. Some laboratory tests aim to simulate the actual usage condition, while some aim to character-