Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2022, 9(8):103-107**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Study on the effect and sensitivity of aggregate mud content on the properties of water reducing agent

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Abstract The purpose of the asphalt mixture design method is to determine the optimum proportion of aggregate and asphalt cement to be used in the asphalt pavement. Highway agencies across the country typically use a mix of two experiential designs, Marshall and Hvim. Superpave, a new mix design developed by the Strategic Highway Research Program (SHRP), is being considered for full implementation by highway agencies in the near future as a design approach. The main advantage of Superpave over the mix design method currently used is that it is performance-based, meaning that there is a direct relationship between post-construction laboratory analysis and field performance. Other design methods are empirical and therefore cannot accurately predict how the pavement will behave after construction.

Keywords Asphalt mixture design method; Marshall; hveem; Superpave

1. Introduction

In recent decades, with the rapid development of road transportation, the mileage of asphalt pavement has increased rapidly, which has promoted the economic and social development of China. However, in China, due to the increase of traffic volume and axle load, especially the impact of overloaded traffic, early damage of asphalt pavement occurs frequently, which has become a constraint factor for the development of road transportation. Early damage of asphalt pavement is generally caused by many factors, such as material properties, construction methods, construction quality, harsh environment, traffic volume and load. Improper design method of asphalt mixture is also the main reason for early damage of asphalt mixture. The design of asphalt mixture is a process of laboratory simulation. It simulates the production, construction and performance of actual asphalt mixture as much as possible. Through this simulation, we can predict what kind of asphalt mixture is suitable for a specific project and how to achieve this goal. However, as a simulation, the design of asphalt mixture has obvious limitations, mainly due to the significant difference between the laboratory and the actual pavement conditions. It can be seen that the actual production, construction and performance of asphalt mixture can not be completely replicated by only a small number of test pieces, compaction equipment and other test equipment in the laboratory. However, the laboratory design of asphalt mixture can help the actual mixture selection relatively effectively and almost accurately.

Asphalt mixture is a very complex material, which must meet many different and even contradictory performance requirements. It must have durability, driving comfort, deformation resistance, crack resistance and water damage resistance, and must meet the economic and construction technical requirements. Asphalt mixture is used for the surface course of road and airport pavement. This mixture usually consists of aggregate and asphalt cement. Certain types of asphalt mixtures are also used for base course coarse materials. Like the design of other engineering materials, the design of asphalt pavement mixture is to a large extent a problem of selecting and proportioning materials to obtain the required performance in the final pavement structure [1].

The ideal performance of asphalt mixture is: resistance to permanent deformation: the mixture shall not be deformed or displaced when subjected to traffic load. Resistance to permanent deformation is more important at high temperature; Fatigue resistance: the mixture shall not crack for a period of time under repeated load; Low temperature cracking resistance. This mixing characteristic is very important at low temperature; Durability: the mixture shall contain sufficient asphalt cement to ensure sufficient film thickness around aggregate particles. The compacted mixture should not have high voids, which will accelerate the aging process; Resistance to moisture damage; Skid resistance; Workability: the mixture must be able to be placed and compacted with reasonable efforts; Low noise and good drainage performance: if the mixture is used for pavement structure of surface (wear-resistant) layer [2].

The asphalt mixture with reasonable design can not only bear large traffic load under adverse weather conditions, but also meet the requirements of pavement structure and pavement characteristics. The purpose of asphalt mixture design is to determine the economic mixture through multiple tests. The gradation of aggregate and the corresponding binder content shall ensure that the composite mixture meets the following conditions: there is enough binder, waterproof, to ensure that the pavement is firm and durable; coating is applied on the aggregate particles, and they are combined under proper compaction; Sufficient stability to resist sustained or repeated loading. This resistance in the mixture comes from the interlocking and cohesion of aggregates, which is usually formed by the binder in the mixture; Have enough flexibility to withstand deflection and bending without cracking. In order to obtain the desired flexibility, an appropriate amount and grade of asphalt is required. There is sufficient void in the whole compacted mixture to provide additional space for compression under flow load; Have sufficient operability to carry out effective laying works for the mixture.

There are three commonly used asphalt mixture design methods. They are Marshall method, Hveem method and Superpave method. The following is an introduction.

2. Marshall Design method

2.1 Introduction Marshall design method

The Marshall design method was originally developed by Bruce Marshall, an asphalt Engineer in the Mississippi highway department. Engineers of the U.S. Army Corps improved and added the procedures and developed the mix design criteria. he methods recorded in ASTM d1559 and AASHTOT245 are only applicable to mixtures with a maximum particle size of 25 mm. This method can be used in laboratory design and field control.

2.2 Main steps of Marshall design method

(1) Create aggregate mixes that meet grading specifications.

(2) Determine the mixing and compaction temperature according to the viscosity temperature diagram.

(3) Compress three specimens for each of the five asphalt contents within the expected optimum asphalt content range.

(4) Determine the relative density and mixing volume of each specimen.

(5) The performance of each sample was measured at 60°C (140°F).

2.3 Advantages and disadvantages of Marshall design method

The advantage of Marshall design method is that it pays attention to void ratio [17], strength and durability [3]. The test equipment is relatively cheap and economical, and the test process is easy to control, simple and easy to promote. Its development time is early and its technology is mature. The mixture designed in a certain period and under certain conditions meets the requirements of pavement use and has become the standard design method of many countries.

The disadvantages of Marshall design method: it is unable to optimize mineral aggregate gradation, some regulations on mineral aggregate gradation are not suitable for the requirements of asphalt mixture on the current pavement surface, and it is difficult to determine the optimal asphalt aggregate ratio[4].

3. Hveem Design method

3.1 Introduction to Hveem design method

Francis Hveem, a resident engineer in California, developed the Hveem design method. In the late 1920s, Hveem began to study oil mixture, which is a combination of high-quality aggregate and slow curing asphalt. At that time, many different agencies in California used blended oil as an intermediate type of surface for use in moderate traffic conditions.

Over time, Hveem noticed that in order to maintain a consistent appearance in the asphalt mixture, there is a relationship between the gradation of the aggregate and the amount of oil required. This eventually led Hveem to develop kerosene equivalent tests. This test takes into account the difference in oil demand as a function of the absorption and surface area of the aggregate. Then, Hveem developed another test to evaluate the stability of asphalt mixture with Hveem stabilizer. The stabilizer was used to measure the kerosene equivalent test developed by Hveem [5]. This test takes into account the demand for oil.

The difference varies with aggregate absorption and surface area. Then, Hveem developed another test to evaluate the stability of asphalt mixture with Hveem stabilizer. The stabilizer measures the horizontal transfer of the vertical load on the asphalt sample. Hveem also developed a test to determine the cohesion performance of the mixture using the cohesion meter. However, since HMA has replaced the oil mixture and the adhesion value is large enough to prevent loosening of the road surface, the adhesion meter is rarely used again. The Hveem method formed its final form in 1959. About 25% of the state highway departments, mostly in the western states, have adopted this method [6].

3.2 Main steps of Hveem design method

(1) Centrifugal kerosene equivalent (CKE) of polymer passing 4.75mm (No. 4) sieve.
(2) Surface capacity of coarse aggregate, all materials retained on a 4.75mm (No. 4) sieve.
(3) Estimate the optimum asphalt content.
(4) Preparation of specifications for stability meter and expansion test.
(5) Expansion and permeability tests.
(6) Hveem stabilizer test.
(7) Density and void analysis.
(8) The test results are tabulated and plotted.
(9) Analyze the test results.
(10) The optimum asphalt content is determined to be consistent.

3.3 Advantages and disadvantages of Hveem design method

The Hveem design method has two advantages: first, the indoor compaction rubbing method can better simulate the compaction characteristics of the actual pavement; Secondly, the VIM stability is a direct measurement index of the internal friction component of the shear strength, and also an index to test the lateral displacement resistance of the specimen under the vertical load.

The disadvantages of the Hveem design method are that the test equipment is expensive and inconvenient to carry, and the important mixture volume characteristics related to the mixture durability are usually not determined as part of the Hveem design method. Some engineers think that the Hveem design method is too subjective in the selection of asphalt consumption, which may lead to too little asphalt consumption and poor durability of the mixture.

4. Superpave Design method

4.1 Introduction to Superpave design method

The strategic highway research program (SHRP) completed in 1993 proposed a method of kneading and molding the specimen with superpavellator (SGC). This molding method establishes a closer relationship between the surrounding conditions and the pallet conditions, and the compaction process is closer to the compaction effect of the actual pavement, reducing the crushing of the aggregate during the compaction process, and the arrangement of the aggregate shape is closer to the actual pavement conditions.

The height measurement of the minimum specimen is an important function of SGC. During the compaction process, the density of the sample can be estimated by the mass of the sample, the inner diameter of the sample and the height of the sample. During the experiment, the height of the sample is measured by recording the position of the loading head, and the compaction performance of the sample is determined.

In the Superpave design method, the compaction grade is a function of N, and N is the designed rotational compaction frequency. The design value n is used to distinguish different compaction functions of the designed mixture, which is a function of the flow level. Traffic grade is expressed by equivalent standard axle loads (esals) [7].

The optimum asphalt aggregate ratio of each asphalt mixture is determined by the super paving volume method. First, test the amount of asphalt and determine the bulk density of the sample by surface drying method.

4.2 Main steps of Superpave design method

(1) Selection of aggregates.
(2) Selection of cement.
(3) Preparation of test pieces.
(4) Performance test.
(5) Compactness and voidage analysis.
(6) Select the best asphalt dosage.
(7) Water sensitivity evaluation.

4.3 Advantages and disadvantages of Superpave design method

The asphalt consumption designed by Superpave design method is obviously low, which affects the pavement durability. Although this method can reduce the rutting problem, the pavement durability becomes poor and the pavement diseases become more. The reason is that the oil consumption of Superpave design method is low. Although the rotary compaction is related to the actual traffic volume, the laboratory compaction is much more than the actual compaction, resulting in a small amount of oil and a large void ratio, which seriously affects the durability of the pavement and causes diseases such as water seepage, cracks and potholes. This problem can be solved by reducing the number of rotary compaction and reducing the design void ratio. The calculation and adjustment of the volume parameters of the test pieces are very complicated. There are more than ten calculation formulas, which require a large amount of calculation, which is time-consuming and laborious and is not suitable for engineering application. The equipment of rotary compactor is expensive, and many engineering units can not afford it, resulting in the low popularization rate of this method. The design specification is 0.3~2. The area where the fine aggregate cannot pass through is often referred to as "Hump" grading. The designed mixture is difficult to compact during the construction and has tensile permanent deformation capacity; The cost of purchasing a rotary compactor is about 200000 yuan, and it is difficult for each project site, so the promotion method is difficult. At present, it only stays in the volume stage, and can not be directly hooked with asphalt mixture. The design formula is complex and requires a long time. The design process is not fully carried out according to the requirements of the design process, and the design process is too ideal [8].

Since the practice of Superpave Asphalt Mixture Design Method in China, it can be said that it is a concept change in the road field [9]. However, as a new design method, the viewpoints we use are divided into two aspects. There are many aspects of this design method that need us to study. For example, in the mix proportion design of mixtures, only a single volume index is used as the standard, and the coarse used in mechanical Superpave mixture gradation is not introduced. At present, there are too many roads with Superpave pavement permeability coefficient established in China. The grading restriction area of super paving mixture design also needs further experiments for the properties of our existing stones[10]. We believe that through a lot of research, we will have a deeper understanding and improvement of Superpave, and make contributions to the road industry by helping to improve the quality of asphalt mixture.

5. Conclusion and Prospect

To sum up, the design methods of asphalt mixtures in different countries are different. Some scholars have made slight improvements to the above design methods, and will not repeat them here. The road performance of asphalt mixture is very complex. Many domestic institutions and experts have conducted long-term and arduous research and exploration, and obtained many valuable conclusions, which have been applied to engineering practice and achieved good results. However, there are still many problems in the quality of domestic asphalt pavement, and the research on asphalt mixture is still continuing. With the continuous improvement and deepening of understanding and research, the design method and technical indicators of asphalt mixture mix proportion will be constantly modified and improved, and the quality of asphalt pavement will be steadily improved. In actual production. Considering the influence of various factors, it is important to optimize the mix proportion design of asphalt mixture to ensure the quality of asphalt pavement. At the same time, to become an excellent asphalt mixture design team, first of all, to ensure the quality of raw materials. Secondly, improve the operation skills of testers, ensure the accuracy of testing instruments, and test in strict accordance with test procedures to reduce test errors.

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