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STRUCTURAL REQUIREMENTS OF BITUMINOUS PAVING MIXTURES

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ABSTRACT

In this work, the autors present some of the principal issues and challenges associated with the design and production of bituminous mixtures that can meet the ever-increasing structural needs of modern pavements.

1.Introduction

Bituminous paving mixtures are used as surface or base layers in a pavement structure to distribute stresses caused by loading and to protect the underlying unbound layers from the effects of water.

To adequately perform both of these functions over the pavement design life, the mixture must also withstand the effects of air and water, resist permanent deformation, and resist cracking caused by loading and the environment.

Many factors affect the ability of a bituminous paving mixture to meet these structural requirements.

Mixture design, construction practices, properties of component materials, and the use of additives all play important roles in the resulting structural characteristics of a pavement.

It is also important to recognize the interaction between mixture design and pavement design to arrive at the most cost-effective solutions.

Although great strides have been made in understanding the behavior of bituminous mixtures and the factors that affect their performance, much work remains.

Basic engineering research on the properties of asphalt, aggregate, and additives and their effects on specific distress mechanisms has significantly contributed to the ability of engineers to develop materials that will perform well under specific environmental and traffic conditions.

Much of this progress has been possible through continuing and dramatic reductions in computing costs and improvements in laboratory testing technology.

2. Structural requirements

To perform satisfactorily in pavement systems, bituminous mixtures should exhibit:

- ability to distribute stresses;
- stability when resisting permanent deformation;
- resistance to cracking;
- resistance to freeze-thaw and moisture damage.

Numerous factors and associated properties affect a bituminous mixture's ability to meet these structural requirements:

Factors:

- binder characteristics;
- aggregate characteristics;
- additives;
- temperature;
- moisture;
- loading history;
- aging characteristics;
- stress state;
- compaction method.

Properties:

- stiffness;
- rheological properties;
- permanent deformation properties;
- cracking properties.

2.1. Stability

Stability can be simply described as the ability of the bituminous mixture to resist excessive permanent deformation.

Bituminous mixtures are typically designed for stability, because stability problems typically occur within a few years or even months or weeks after construction.

Principal factors affecting the stability of bituminous mixtures include the following:

- Magnitude, frequency, pressure, and speed of loading;
- Temperature;
- Aggregate gradation, shape, and texture;

- Binder type and amount;
- Construction variables such as compaction, quality control, and segregation.

Important issues related to stability that need to be addressed include the following:

- Quantification of the key factors known to affect mixture stability;
- Development of tests and analysis procedures for predicting mixture stability in the laboratory during design and in the laboratory and the field during construction;
- Development of models for evaluating mixture stability and predicting performance.

2.2. Durability

Durability of a bituminous mixture is defined as its resistance to weathering and the abrasive action of traffic.

This definition includes changes in mixture properties resulting from hardening of the asphalt caused by exposure in air, degradation or disintegration of the aggregate caused by traffic or freeze-thaw effects, and the action of water and water vapor.

This action of water and water vapor may cause moisture damage, including a reduction in mixture stiffness, stripping of the binder from the aggregate, and further hardening of the binder resulting from exposure of new binder film surfaces as water soluble oxidation products are removed.

Durability is desirable in mixtures to ensure that structural requirements are met throughout the life of the pavement, but the measurement and evaluation of this property is not as straightforward as the evaluation of the effects of load on mixture response.

In assessing durability, a mixture is subjected to environmental conditioning, and a mixture property associated with load-related or environmental distress is measured before and after theconditioning process.

Abrasion characteristics of the aggregate in the mixture must also be considered in the assessment of durability.

3. Evaluation of mixtures to meet structural requirements

The development of reliable and practical approaches to evaluate a bituminous mixture's ability to meet structural requirements remains a major challenge.

A variety of tools is needed to evaluate mixtures during hot-mix asphalt production, including simple yet effective tests for use in specifications and for mixture optimization during design; even simpler, processoriented tests for quality control during production; and more sophisticated tests to determine fundamental properties to ensure that mixtures will meet a minimum standard of performance when used in a pavement system.

The measurement of fundamental mixture properties offers the advantage of being able to represent a variety of loading and environmental conditions through numerical modeling.

Rapid developments in instrumentation and computer capabilities continue to make this measurement a more viable approach for mixture evaluation.

4. Conclusions

Identification and verification of the most appropriate constitutive models for bituminous mixtures is a major challenge.

Bituminous mixture behavior is highly complex: its response to stress can be elastic, viscous, plastic, or dilatant, and may also include microdamage and fracture.

Behavior is dependent on stress state, temperature, and boundary conditions to which the material is subjected, either in the laboratory or in the field.

Changes in properties resulting from the effects of aging and moisture sensitivity further complicate mixture behavior and its evaluation.

One of the major challenges for developing proper methods for bituminous mixture evaluation is to sort out the effects of all these complexities and arrive at a more complete understanding of bituminous mixture behavior.

This understanding can then be used to identify simple yet effective approaches to design, specify, and control mixtures with suitable structural characteristics.

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