Overview

Asphalt concrete mix design procedures currently in use are empirical in concept and primarily function as a tool to select an asphalt content for an aggregate gradation selected on the basis of local experience. Over the period of time they have been used, strong correlations have been developed between the mix design parameters measured and pavement performance. But, because they are empirically based, they are valid only for those materials, mixtures, and field conditions for which the correlations with performance were established.

In the past 15 to 20 years, major changes have occurred, and are still occurring, in the loading conditions under which pavements are being required to perform. Legal axle loads and tire pressures have increased dramatically, as have the percentages of heavy axle loads on our major highways. Changes in material properties—and therefore mixture properties—have also been occurring. With the development and increased use of asphalt modifiers, the properties of today's and tomorrow's pavement mixtures may bear little resemblance to the properties of mixtures for which empirical correlations have been developed. When conditions change, new correlations must be established. Such correlations are costly and take years to develop and confirm. Thus, the need for a more rational approach is evident.

This ASTM Special Technical Publication has been published as the result of a symposium held in Bal Harbour, Florida, in 1987 organized to present a review of current efforts to develop more rational approaches to asphalt concrete mix design and to encourage further effort in this direction. It is the outgrowth of the work of several subcommittees of ASTM Committee D-4 on Road and Paving Materials. It presents a historical review of mix design procedures, answering the questions: "Where are we?" and "How did we get here?" It also includes papers describing current efforts to develop rational mix design procedures that answer the following questions. "What distress modes need to be considered, and are they independent or interdependent?" "What critical stresses need to be considered, and how can we design a mix to accommodate them?" "Is an integrated mix design system possible or practical?" "To what extent is it necessary or desirable to duplicate field conditions?" (that is, aggregate orientation, asphalt absorption, asphalt hardening, service environment, etc.).

The paper by Professor Goetz reviews the historical development of the empirical methods now in common use, along with the theoretical concepts on which they are based, and points out that while they have served usefully, they lack a fundamental, rational point of view and serve to emphasize the need for a system that relates engineering properties to mix parameters and translates to design that would resist failure in all of its various modes.

The Von Quintus et al. paper presents the philosophy of the AAMAS (Asphalt-Aggregate Mixture Analysis System) concept and discusses those factors that must be included in the design of optimum paving mixtures based on performance-related criteria. The focus of the development of AAMAS was to develop new laboratory mixture design procedures or modify existing procedures based on engineering properties, structural behavior, and pavement performance.

Specific items addressed in the paper include compaction of laboratory mixtures to simulate the characteristics of mixtures placed in the field, preparation and mixing of materials in the laboratory to simulate the asphalt concrete plant production process, simulation of the long-term effects of traffic and the environment (this includes accelerated aging and densification of the mixes caused by traffic), and the conditioning of laboratory samples to simulate the effects of moisture-induced damage and hardening of the asphalt.

The AAMAS concept is applicable to hot-mixed asphalt concrete and includes mixture variables such as binders, aggregates, and fillers used in the construction of asphalt concrete pavements. AAMAS currently excludes such materials or layers as open-graded friction courses and drainage layers.

The paper by Monismith et al. represents an alternative approach to an integrated mix design procedure. Its focus is based on the concept that the design of an asphalt concrete mix consists, essentially, of the following steps:

1. select type and gradation of aggregate;
2. select type and grade of asphalt, with and without a modifier; and
3. select proportionate amount of asphalt in asphalt/aggregate blend.

Monismith incorporates these steps into a general framework for design, which serves as the basis for the mix design procedure presented in this paper.

Essentially, the system consists of a series of subsystems in which the mix components and their relative proportions are selected in a step-by-step procedure to produce a mix that can then be tested and evaluated to ensure that it will perform adequately in the specific pavement section for which it has been formulated. The latter evaluation phase includes the influence of environmental factors, effects of traffic, and the consequence of the anticipated structural cross-section design at the designated site in the following distress modes: fatigue, rutting, thermal cracking, and raveling. This paper also includes a discussion of the important factors associated with the various steps of the design process and recommended test procedures to be followed.

The paper by Ruth et al. focuses more on the role of the asphalt binder and includes a discussion on the selection of asphalts and polymer modifiers, illustrating deficiencies in current test methods and specifications. Because of his concern about brittle cracking at low temperatures, he advises that low-temperature viscosity tests should be incorporated in all asphalt specifications. A comprehensive model asphalt specification is presented that includes viscosity tests at 15 and 25°C. An example is given to demonstrate how the viscosity-temperature relationships enhance our ability to interpret asphalt, polymer modified asphalt, and mix behavior at low temperature.

The remaining papers focus more on modifications to currently used procedures or equipment. In the Baladi and Harichandran paper, the features of a new indirect tension test apparatus is introduced. Analytical models to reduce the test data and to calculate the structural properties of asphalt mixes are presented and discussed. A summary of the findings along with the resulting statistical equations are also presented. It is shown that the structural properties of asphalt mixes obtained from the indirect tension test using the new apparatus are consistent and the test data are reproducible.

Yandell and Smith focus on the specific failure modes of rutting and cracking and suggest looking more closely at the plastic, as well as the elastic behavior of asphalt concrete mixtures. They present data from a field trial site near Sidney, Australia, to demonstrate theoretically how both rutting and fatigue cracking life can be greatly extended by adjusting the elastic and plastic properties of asphalt concrete pavement. Based on simulated temperature changes, they found that maximum rutting and cracking life can be achieved by grading the asphaltic concrete properties from stiff nonplastic at the surface down to soft elasto-plastic at the bottom of the asphalt concrete.

Mr. Charles also focuses on rutting and fatigue cracking and presents a structural analysis of full-depth asphalt pavement sections used to generate strain-stiffness profiles for both types of distress. These profiles were combined with the selected criteria to establish a target mix stiffness. Through trial testing with a selected binder, and use of the Shell Nomograph analysis, it is shown that the target mix stiffness can be converted into stability criteria that can be substituted into Asphalt Institute criteria to provide a complete set of mix design specifications.

The papers in this ASTM Special Technical Publication have clearly answered the question that the symposium was intended to answer. The empirical methods currently being used are not adequate for today's loading conditions nor are they adequate to address the altered binder properties we can expect with the increased use of modifiers. New methods are required that will take into account all modes of pavement distress. These new methods should be based on fundamental properties that will permit extrapolation or recalculation of design parameters to meet changes in loading conditions or alteration of material properties. The papers in this publication describe several approaches that can be taken.

It is hoped these papers will also generate additional interest in the development and implementation of rational design procedures. To gain widespread acceptance, however, any new approaches developed must meet certain objectives that have historically been among the objectives of the currently used empirical methods. The new methods must not only determine the nature and proportions of the mix components and be sensitive to mixture or loading variables, they must also exhibit reasonable precision and accuracy, while being simple enough to be run efficiently in our laboratories. In short, they must be both effective and efficient.

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