

# **DEVELOPMENT OF MIX DESIGN GUIDELINES FOR IMPROVED PERFORMANCE OF ASPHALT MIXTURES**

## **PROBLEM STATEMENT**

The importance of aggregate structure on asphalt mixture performance has been well established on the basis of experience and is well documented in the literature. Coarse aggregate structure is most important for resistance to rutting, and recent work has shown that it can also play a significant role in resistance to damage and fracture. Unfortunately, the methods and specifications for current mix design provide little in terms of guidance or criteria to assure that the aggregate gradation selected will result in a favorable aggregate structure that increases mixture resistance to rutting and cracking.

Consequently, there is a clear need for mix design guidelines and criteria, particularly as related to the gradation of the coarser aggregate used in the mixture. Such information would provide mix designers with the tools necessary to improve substandard mixtures, to optimize mixtures for performance, and to minimize the use of mixtures that are sensitive to small changes in gradation caused by variability during construction. It would also result in more effective performance-related gradation specifications for asphalt mixture.

## **OBJECTIVES**

The main purpose of this research was to develop an approach to analyze and evaluate mixture gradation to determine whether the coarse aggregate will interlock sufficiently to provide necessary resistance to deformation and fracture. The approach would provide the basis for developing mix design guidelines and specifications for improved performance of asphalt mixtures. Detailed objectives may be summarized as follows:

- Develop a numerical approach to describe the aggregate structural characteristics based on gradation.
- Identify and develop an approach to determine the range of interactive coarse aggregate particles for a specified gradation.
- Identify a criterion to assess whether the range of interactive coarse aggregate particles are sufficiently dense within the asphalt mixture to actually be in contact and provide the interlock necessary to resist deformation and fracture.
- Evaluate the approach and the criterion developed using mixtures of known performance.
- Recommend guidelines for mixture design, specifications, and further development of systems that can help to optimize mixture performance.

## **FINDINGS AND CONCLUSIONS**

A gradation analysis procedure was developed to calculate the center-to-center spacing between specific size particles within a compacted assemblage of particles of known gradation. Calculations performed

with this procedure indicated that the relative proportion of particles from two contiguous size ranges, as defined by the standard arrangement of Superpave sieves, can be no greater than 70/30 in order to form an interactive network. Thus, the 70/30 proportion can be used to determine whether particles on contiguous Superpave sieves can form an interactive network of particles in continuous contact with each other. The range of particle sizes determined to be interactive was referred to as the dominant aggregate size range (DASR), and its porosity must be no more than 50% for the particles to be in contact with each other. The mixture component between the DASR was referred to as the Interstitial Component (IC), and its corresponding volume was referred to as the Interstitial Volume (IV). Analysis and evaluation of a broad range of mixtures of known performance, including dense-graded mixtures (coarse and fine) and SMA, indicated that mixtures identified as having poor gradations, according to the system developed, did not perform as well as mixtures having good gradations.

Several key conclusions were drawn based on the findings of this study:

- DASR porosity of asphalt mixture, determined using the gradation analysis system developed in this study, should be less than 50% to ensure coarse aggregate interlock, which is required for good mixture performance.
- The relative proportion of particles from contiguous size ranges within the DASR must be no greater than 70/30 to ensure proper interaction (interlock) among the different size particles in the DASR.
- Gradation evaluation for asphalt mixture should include a sensitivity analysis to evaluate the effects of potential changes in gradation on DASR porosity. Adjustments should be made to JMFs when accepted gradation variances result in DASR porosity greater than 50%.
- Relative proportions between contiguous aggregates in the DASR should be significantly lower than 70/30 (e.g., 65/35) when the interaction of these sizes is critical to maintain the DASR porosity below 50%.
- Mixtures with excessively low DASR porosity (low IV) should be avoided, as they may be brittle. However, additional study is necessary to identify specific criteria, which will likely depend on other variables such as mixture type and characteristics of the interstitial components.

## **BENEFITS**

The approach developed in this investigation provides materials engineers and mixture designers with a powerful tool to evaluate the acceptability of specific gradations without any mixture preparation or testing. The criteria identified provide the basis for the development of performance-based gradation specifications for mixtures. In addition, the guidelines established can be used to effectively modify mixtures determined to be substandard and to identify gradations for optimal mixture performance. The approach also allows for the identification of gradations that would likely be excessively sensitive to expected construction variance. It is expected that implementation of the approach would lead to improved mixture performance, extended pavement life, and associated reductions in construction costs.

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