TECHSUMMARY May 2018

State Project No. 736991104 / LTRC Project No. 03-3B

Optimization of Asphalt Mixture Design for Louisiana ALF Test Sections

INTRODUCTION

Hot mix asphalt (HMA) is the most common material used for paving applications, which primarily consists of asphalt binder and mineral aggregates. The binder acts as a gluing agent that binds aggregate particles into a cohesive mass. When bound by an asphalt binder, mineral aggregate acts as a stone framework that provides strength and toughness to the system. The behavior of HMA depends on the properties of the individual components and how they react with each other in the system.

To guarantee the acceptable performance of HMA, several mixture design methods have been developed and used in history. The most recent and currently popular design method is the Superpave system. The Superpave system is a great leap towards a better approach for designing asphalt mixture when compared to the older methods. However, it is still purely volumetric, relying solely on certain mixture volumetric properties rather than the actual performance of resisting the major pavement distresses, such as permanent deformation and fatigue cracking, through laboratory performance testing. Also, the Superpave system lacks due consideration on the major component of the mixture, mineral aggregate properties and design aggregate structures. Thus, there is a pressing need of finding an alternative methodology to designing aggregate structures based on sound principles of aggregate packing concepts. Also, it is desirable to introduce more rational and systematic steps to the current Superpave system for better design and evaluation of asphalt mixtures.

OBJECTIVE

The primary objective of this study was to develop an optimum asphalt mixture design methodology (i.e., a mixture design for determining the optimum aggregate gradation and asphalt content simultaneously), as determined by an analytical aggregate gradation design method and mixture mechanistic performance tests. The selected mixture design will be recommended for field performance verifications at the Louisiana Accelerated Loading Facility. A secondary objective of this research was to understand the effect of identifiable variables on mixture mechanical responses.

METHODOLOGY

The research was conducted in two phases: Phase 1 involved designing the aggregate structures and performing Superpave mixture design to determine the design asphalt content for meeting volumetric criteria at 4 percent air void as the dense graded mixture in the Superpave system. Figure 1 (on the next page) shows the schematic of Phase 1 and Phase 2 of research flow.

After the Superpave volumetric design, a suite of mixture evaluation tests was conducted to determine the best performing aggregate structure through the following evaluations:

- Determining compaction properties and frictional resistance of the mixtures using the pressure distribution analyzer (PDA).

LTRC Report 422

Read online summary or final report:
www.ltrc.lsu.edu/publications.html

PRINCIPAL INVESTIGATOR:
Louay N. Mohammad, Ph.D.

LTRC CONTACT:
Sam Cooper, III, Ph.D., P.E.
225.767.9164

FUNDING:
SPR: TT-Fed/TT-Reg

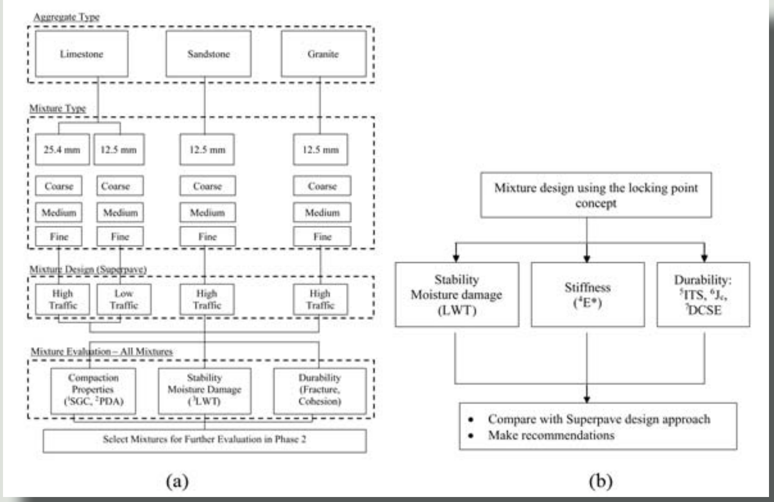
Louisiana Transportation Research Center

4101 Gourrier Ave
Baton Rouge, LA 70808-4443

www.ltrc.lsu.edu

- Measuring the permeability of each mixture as an important physical parameter for a successful performance of asphalt mixture.
- Performing simulative test (Hamburg Loaded Wheel Tracking Test) on the mixtures to determine their stability under harsh environment of moisture and high temperature.
- Conducting fundamental mechanistic tests to evaluate the performance of the designed mixtures.

These tests include Indirect Tensile Strength Test (ITS) and Fracture Energy Test. Those tests were conducted at 25°C on both aged and unaged specimens as part of the durability evaluation of the mixtures.



1 SGC: Superpave Gyratory Compactor; 2 PDA: Pressure Distribution Analyzer; 3 LWT: Hamburg Loaded Wheel Tracking; 4 E: Dynamic Modulus; 5 ITS: Indirect Tensile Strength; 6 Jc: Critical J-integral; 7 DCSE: Dynamic Creep Strain Energy*

Figure 1
Phase 1 and Phase 2 of project

Phase 2 involved utilizing the data from Phase 1 in selecting mixtures with specific attributes for further evaluation. The locking point concept was introduced and used to modify the current Superpave mix design for enhanced durability and acceptable stability. Fundamental mechanical tests were performed to determine promising performance parameters, which can complement the volumetric mixture design process.

CONCLUSIONS

In this study, a mixture design method using the concept of locking point was developed and a suite of tests were performed to evaluate the proposed mixture design method. The test results were compared to the corresponding results on the mixtures by the current Superpave design approach. Major findings of the study include:

- The Bailey Method was identified as a rational approach of aggregate blending and evaluation. Using the recommended Bailey ratios, coarse graded mixtures acquired acceptable Superpave volumetric properties. On the other hand, fine and medium graded mixtures had lower VMA than the current Superpave recommendations.
- A strong correlation was observed between the SGC and PDA data, implying that the SGC would provide good indication of mixture compatibility.
- Both SGC and PDA results showed that coarse mixtures were more difficult to compact than the medium and fine mixes. Compaction data also indicated that the current Superpave design number of gyrations would be too high.
- The CA ratio seemed to have strong correlations with mixture volumetrics, while FAC ratio was less sensitive to the volumetrics.
- Three power law gradation analysis parameters, such as CA ratio, nCA, and nFA, had the best correlation with the Compaction Densification Index (CDI), indicating that the particle size distribution is one of contributing factors to the compactability of the mixtures.
- All mixtures designed using the Bailey Method had highly dense aggregate structures that exhibited superior performance in the LWT test with a maximum rut depth of 4.0 mm after 20,000 passes. No signs of stripping were found at the end of the test period for all mixtures. Traffic Indices from SGC and PDA failed to capture plastic instability of asphalt mixtures as measured by the Hamburg Loaded Wheel Tracking Test (LWT).
- Designing mixtures to their locking points resulted in improved durability without compromising stability. The use of strict volumetric requirements was cautioned. Such requirements are likely to eliminate potentially well-performing mixtures.

RECOMMENDATIONS

It is recommended that the research findings documented in this report to be evaluated by a full-scale performance test in the Accelerated Loading Facility (ALF). It is also recommended that wider range of mixture types and gradations be designed and evaluated using the proposed design methodology in order to develop ranges of performance criteria adopted for this design method.