LOUISIANA TRANSPORTATION RESEARCH CENTER

Technical Summary

LTRC Report 702

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Development of a 4.75-mm Asphalt Mixture Design

Introduction

Road agencies across the United States are exploring strategies to maximize their budget for various maintenance needs. One promising approach involves using asphalt mixtures with a smaller nominal maximum aggregate size (NMAS). These mixtures can extend the service life of roadways by allowing more miles to be covered within a given budget. In 2002, the National Center for Asphalt Technology (NCAT) conducted a study to develop Superpave mix design criteria for a 4.75-mm NMAS mixture. NCAT used permeability testing to identify specific aggregate properties that have the potential to enhance the performance of 4.75-mm NMAS mixtures. Building on this research, several state highway agencies have adopted these recommendations for maintenance, leveling courses, and thin-lift applications. This approach offers benefits such as reduced construction time and a cost-effective surface mix for low-volume roadways. DOTD aims to achieve multiple objectives by utilizing a 4.75-mm NMAS mix:

1. Reduced construction time;
2. Economical surface mix for low-volume roads;
3. Smooth riding surfaces;
4. Thin-lift asphalt overlays;
5. Correction of surface defects;
6. Leveling material;
7. Reduced permeability; and
8. Reduced demand for fine aggregate stockpiles.

Figure 1. 12.5-mm (left) and 4.75-mm (right) NMAS mixtures

Figure 1 (right) shows typical images of 4.75-mm and 12.5-mm NMAS mixtures.

DOTD has recently implemented the balanced mix design (BMD) framework for asphalt mixtures to enhance long-term performance. This framework relies on the Hamburg Wheel Tracking Test (HWT) to evaluate rutting and moisture resistance, and the Semi-Circular Bend Test (SCB) to assess intermediate temperature cracking resistance. Given the role of the BMD framework in ensuring the production of durable mixtures in Louisiana, it will be a valuable tool in assessing the quality of the proposed 4.75-mm NMAS mixtures.

Objective

This study aimed to evaluate the economic viability of implementing newly developed mixture design criteria for 4.75-mm NMAS mixtures in Louisiana.

Methodology

Aggregate types that are commonly used on Louisiana roads were selected for this study. Four aggregate types were chosen: gravel, limestone (LS), sandstone, and 910LS (910 represents the size, and LS is the aggregate type). Multiple aggregate blends were

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designed with one or two aggregate types that satisfied the 4.75-mm NMAS aggregate criteria established by AASHTO. Two asphalt binder types were used in the study: unmodified PG 67-22 and styrene-butadiene-styrene (SBS)-modified PG 76-22 asphalt binders. Additionally, a crumb rubber additive (M7) was included in selected mixtures. The four aggregate sources were combined with two different binder types and M7, resulting in 15 total mixtures for this study. The mixture design parameters were varied to understand the effects of aggregate, crumb rubber, and binder type on 4.75-mm NMAS mixtures' performance.

Performance testing consisted of the Hamburg Wheel Tracking (HWT) test to determine rutting resistance, the Semi-Circular Bend (SCB) test to determine cracking potential, the dynamic modulus test to determine stiffness at different temperatures, and a friction test to evaluate the friction resistance of the proposed mixtures. Additionally, an economic analysis was conducted to determine the viability of 4.75-mm mixtures through a life-cycle cost analysis (LCCA) of pavement sections designed with 4.75-mm mixture overlays compared to sections designed with 9.5-mm and 12.5-mm mixtures. The Pavement Mechanistic-Empirical (ME) design software was used for the LCCA.

Conclusions

Based on the evaluation of the laboratory test results for different 4.75-mm NMAS mixtures and mechanistic-empirical pavement design of pavement sections designed with 4.75-mm NMAS mixtures, the following conclusions were drawn regarding the effects of aggregate type, binder type, and crumb rubber modification on the performance of these mixtures:

- 4.75-mm NMAS mixtures generally exhibited acceptable performance in the SCB and LWT tests. The results suggest that using a polymer-modified binder can enhance the cracking or rutting resistance of 4.75-mm NMAS mixtures.
- Crumb rubber-modified mixtures showed enhanced aggregate coating properties, which delayed the polishing of the aggregates and therefore increased the friction resistance after polishing.
- While higher-PG-grade mixtures are expected to exhibit higher stiffness values in the dynamic modulus test, it was observed that aggregate type and gradation significantly influence the elastic performance of fine aggregate mixtures. Mechanistic-empirical analysis results indicated that asphalt mixtures with higher dynamic modulus values resulted in pavements with shorter fatigue lives.
- The cost analysis of the mixtures demonstrated a significant advantage of using 4.75-mm NMAS mixtures due to their lower application thickness.
- The comparison between years of performance and cost per lane mile identified gravel and sandstone mixtures as the most cost-effective among the 4.75-mm mixtures.

Recommendations

Based on the findings of this study, recommended design parameters for a 4.75-mm NMAS mixture are presented in Table 1 below.

Gradations	Percent Passing
12.5 mm (1/2 in.)	100
9.5 mm (3/8 in.)	96-100
4.75 mm (No. 4)	90-96
2.36 mm (No. 8)	
1.18 mm (No. 16)	40-55
0.6 mm (No.)	
0.3 mm (No. 50)	
0.15 mm (No. 100)	
0.075 mm (No. 200)	6-12
Design Criteria	
Air Voids (%)	2.5-4.5
VMA (%)	>16
VFA (%)	>74
DP	1.0-2.0
Performance Criteria	
LWT, rut depth, mm, 50°C, wet	12 mm max @ 12,000 passes
SCB, J_c, 25°C kJ/m^2	0.5 min

Table 1. DOTD 4.75-mm specification recommendations