Joint Transportation Research Program

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SPR-4325 2022

Development of Volumetric Acceptance and Percent Within Limits (PWL) Criteria for Stone Matrix Asphalt (SMA) Mixtures in Indiana

Introduction

The stone matrix asphalt (SMA) mixture design process is based on volumetric properties, but for quality assurance (QA) purposes, the Indiana Department of Transportation (INDOT) currently accepts SMA based on aggregate gradation and binder content. Thus, there is a discrepancy between the design criteria and the mixture acceptance. This suggests that the feasibility of using volumetric properties as SMA QA measurements needs to be investigated. However, INDOT has transitioned from using single test value volumetric properties to accept hot-mix asphalt (HMA) mixtures to using percent-within-limits (PWL) criteria for HMA QA procedures. This leaves a wide gulf in the QA procedures for HMA and SMA, as the latter still uses adjustment points that are not based on robust statistics. Since PWL procedures rely heavily on a statistical assumption of normality, robust statistical analysis is needed for the development of updated SMA PWL specifications, which will provide a better understanding of the data and maximize its interpretation and use.

SMA QA samples and QA data sets were collected from projects constructed in 2019 and subsequently tested in the laboratory. The Hamburg Wheel Track Test (HWTT) was performed on 2019 QA samples to evaluate SMA rutting performance. Additionally, the PWL for HMA was applied to the 2019 SMA QA data to see if the HMA PWL method would work for SMA. Possible SMA QA measurements were compared to past QA data and HMA QA measurements. Additionally, voids in the coarse aggregate (VCA) were evaluated as a possible SMA QA measurement. Finally, using the suitable QA measurements for SMA, a PWL parameter study was performed to find PWLs that provide a pay factor (PF) equivalent to the current SMA adjustment point (AP) PF.

Findings

The study reviewed the INDOT SMA QA and developed a new SMA QA PWL. First, possible SMA QA measurements were reviewed using past QA data and HMA QA measurements. In addition, VCA was evaluated as a possible SMA QA measurement. A PWL parameter study was performed using the selected QA measurements to find PWL providing pay factors similar to the current SMA AP PFs.

Reviewing VCAs and QAs in the 2019 SMA mix designs indicated that the Indiana SMA had negligible VCA problems. In addition, because of the VCA practicality limitation requiring significant efforts (i.e., in-place loose mix sampling, gyratory compactions, G_{mb} measurements, etc.) to obtain in-place VCA, the study determined not to include VCA in QA measurements. The outstanding rutting performance of SMA was confirmed by HWTT using the selected SAM QA core samples obtained from the projects constructed in 2019. The HMA PWL application using the 2019 SMA volumetric properties resulted in numerous failed QA SMAs, mainly due to the large V_a deviations caused by significant V_a sensitivity to the steel slags. Consequently, the SAC decided to exclude V_a and V_{be} (closely related to V_a) from the possible SMA QA measurements. Thus, it was determined that the study should use the current

SMA QA measurements (i.e., binder content, gradation, and density) for the SMA PWL development. The study developed a framework to develop SMA PWL, which results in contractor payments equivalent to those being paid with the current SMA AP system. A PWL parameter study was successfully performed using reasonable specification limits obtained from the SAC, the limit optimization with respect to the AP percent material failure, the bonus-penalty scale adjusted pay factors, pay factor equations in terms of PWLs, and measurement-weight factors.

Implementation

The current SMA QA measurements (i.e., binder content, gradation, and density) are recommended for Indiana's SMA PWL. Therefore, PFs may be calculated for the binder content; 2.36-mm, 600-µm, and 75-µm sieves; and density. To get the SMA PWL to have PF equivalent to the current AP PF, the SMA PF is calculated using the following equations.

Estimated PWL greater than 90:

$$PF = ((0.50 \times PWL) + 55.0)/100$$

Estimated PWL greater than 50 and equal to or less than 90:

$$PF = ((0.75 \times PWL) + 32.5)/100$$

A weight factor of 35% for binder content, 30% for gradation, and 35% for density is recommended. The composite PF of each lot may be calculated as follows:

$$\text{Lot PF} = 0.35(PF_{\%Binder}) + 0.10(PF_{2.36mm}) + 0.10(PF_{600\mu m}) + 0.10(PF_{75\mu m}) + 0.35(PF_{Density})$$

Based on the results of applying PWL to SMA QA data for the last 4 years, the following SMA PWL specification limits are recommended.

Recommended Citation for Report

Lee, J., Haddock, J. E., & Jeon, J. (2022). *Development of volumetric acceptance and percent within limits (PWL) criteria for stone matrix asphalt (SMA) mixtures in Indiana* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2022/29). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317580

View the full text of this technical report here: https://doi.org/10.5703/1288284317580

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Specification Limits		
Mixture		
	LSL	USL
Binder Content, %	DMF -0.5	DMF +0.5
Percent passing 2.36-mm sieve	DMF -5.0	DMF +5.0
Percent passing 600-µm sieve	DMF -4.0	DMF +4.0
Percent passing 75-µm sieve	DMF -2.5	DMF +2.5
In-Place Density		
	LSL	USL
Roadway Core Density (%Gmm), %	91.0	n/a

Specification limits.