Superpave 5

Assessing Superpave5 Implementation in Massachusetts:

Evaluating the Impact on the Compactibility and Performance of MassDOT Mixtures

NEAUPG

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Professor Walaa S. Mogawer, P.E. (MA & RI), F.ASCE
Commonwealth Professor of Civil & Environmental Engineering
Director - Highway Sustainability Research Center

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Acknowledgement

Edmund Naras
Pavement Management Engineer
MassDOT – Highway Division

Mazen Kandil
Graduate Student – Ph.D. Candidate
Highway Sustainability Research Center
University of Massachusetts Dartmouth

Kevin Stuart
Consultant
Previously with FHWA

Ramon Bonaquist, Ph.D., P.E.
Chief Operating Officer
Advance Asphalt Technologies, LLC

Shane Underwood, Ph.D.
Civil, Construction, and
Environmental Engineering
North Carolina State University

Michael Nichols
Technical Services Manager
Northeast Region
Holcim, US

Bud Clough
Quality Control
All States Material Group

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Overview

- Introduction
- Objectives
- Experimental Plan
- Mixture Preparation & Designs
- Mixture Evaluations
- Conclusions

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Introduction

- To improve field performance and compaction, MassDOT increased the target VMA for Superpave4 mixtures by 1% above the minimum specified in AASHTO M 323-22, while maintaining the target air voids at 4%.

- Recently, MassDOT began investigating whether adopting Superpave5 could further help field compaction.

- Previous research indicated that reducing the N_{des} can increase the risk of rutting. Since Superpave5 uses a lower N_{des} compared to Superpave4 mixtures, MassDOT wanted to ensure that adopting Superpave5 would not compromise the rutting resistance of its asphalt mixtures.

Introduction

Volumetric Properties	Superpave4 Mixtures		Superpave5 Mixtures	
	SP4 AASHTO	SP4 MASSDOT	SP5 AASHTO	SP5 MASSDOT
Target Air Voids	4%	4%	5%	5%
Min. VMA (12.5mm NMAS)	14%	15%	15%	16%
V_{be}	10%	11%	10%	11%
N_{des}	100	100	50	50

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Introduction

- According to previous studies, decreasing N_{des} by 25 gyrations for a given mixture can increase the air void content by approximately 1%.

- Using the same aggregate gradation as the Superpave4 mixture would result in an air void increase of approximately 2%, leading to around 6% air voids, which would not meet the Superpave5 volumetric requirements.

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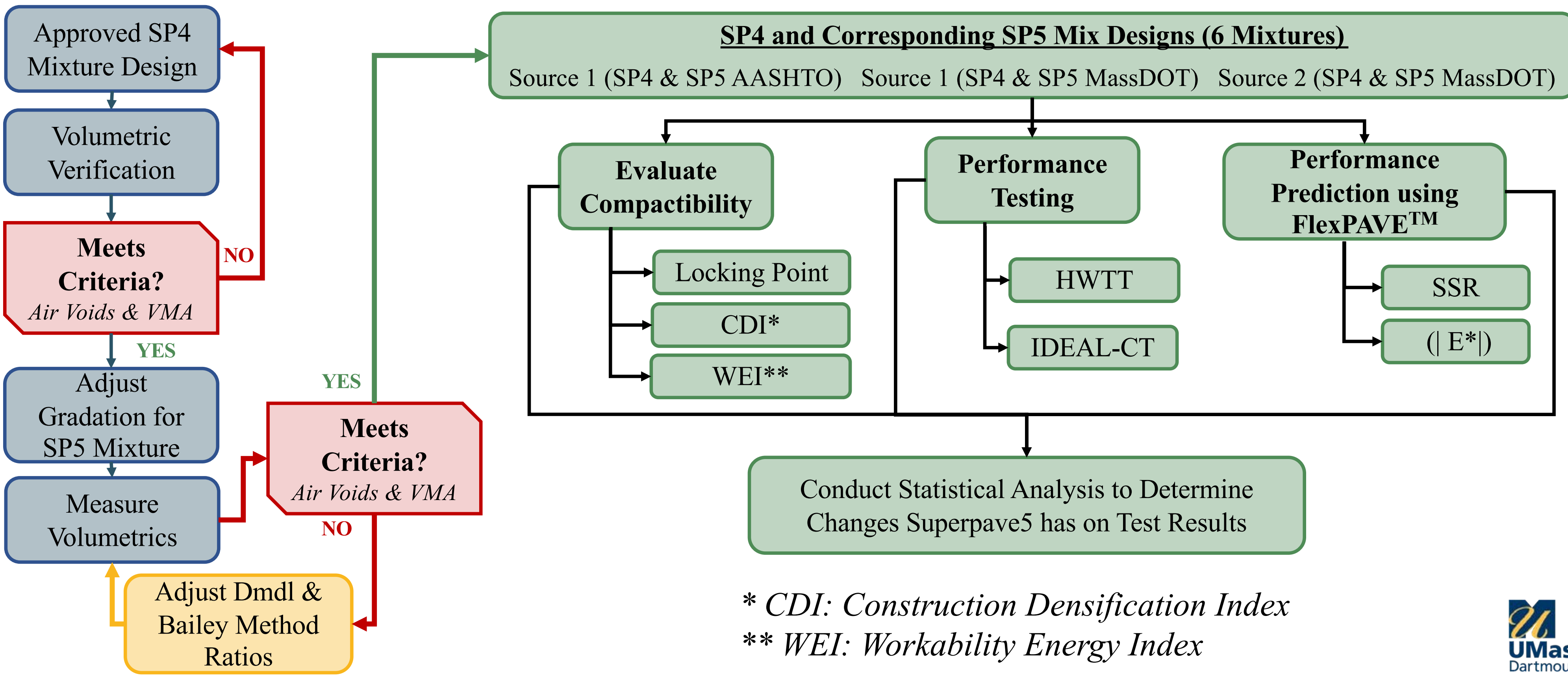
Objectives

1. Verify that state-approved Superpave4 mixtures from two sources meet MassDOT specifications for air voids and VMA. Adjust these mixtures to align with Superpave5 volumetric criteria by optimizing the aggregate gradation using the Bailey Method.

2. Evaluate the compactibility, rutting resistance, and intermediate-temperature cracking susceptibility of Superpave4 and Superpave5 mixtures.

3. Use FlexPAVE™ software to predict the long-term performance of Superpave4 and Superpave5 mixtures in terms of rutting.

Experimental Plan



** CDI: Construction Densification Index*
*** WEI: Workability Energy Index*

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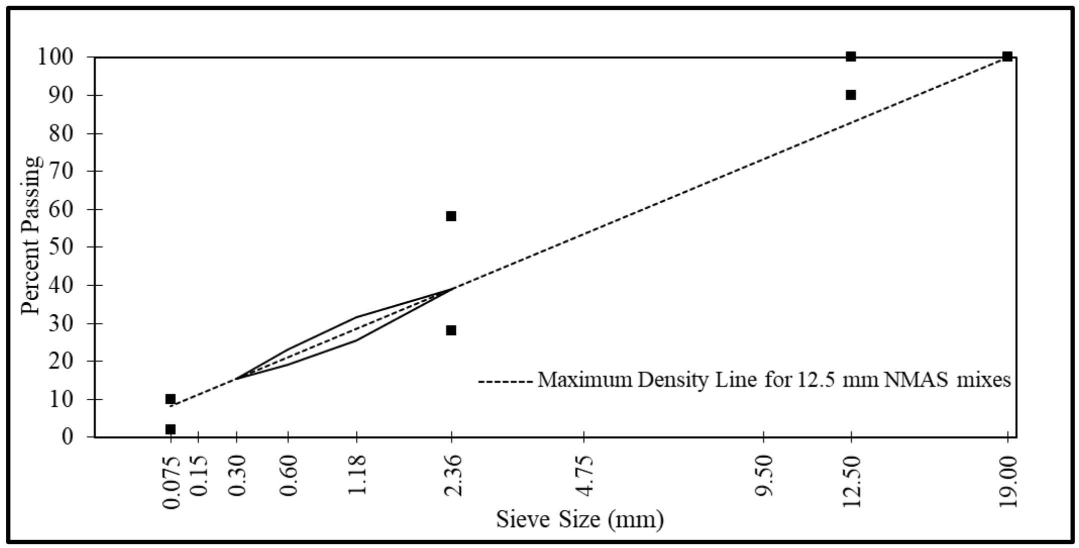
Mixture Preparation & Designs

Distance to the Maximum Density Line (Dmdl)

$$\text{Dmdl} = \sum_{\text{minimum sieve size}}^{\text{maximum sieve size}} |\%\text{Passing of the sieve} - \%\text{Passing of the sieve on MDL}|$$

- The Dmdl represents how close a gradation is to the MDL.



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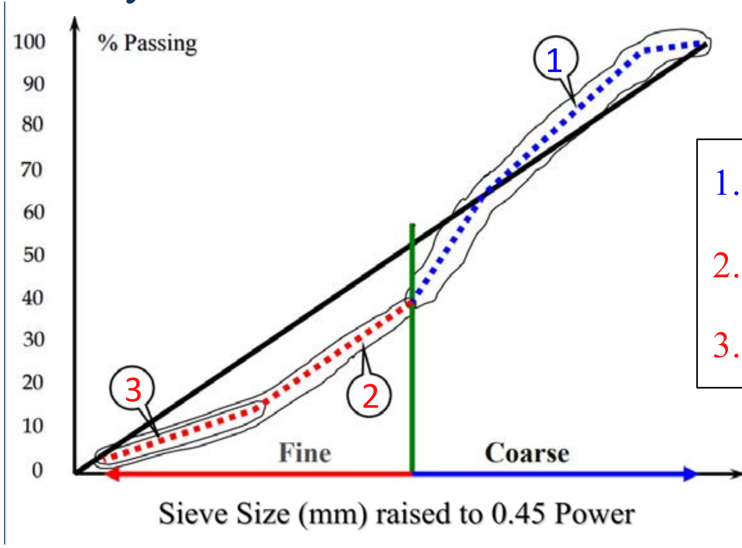
Mixture Preparation & Designs

Bailey Method

- The Bailey Method is a structured approach to optimize aggregate gradation for desired volumetric properties such as the VMA.

- Three main parameters from the Bailey Method can be used to control the VMA.

Ratio	Effect on VMA
CA Ratio	Increasing by 0.2 increases the VMA from 0.5% to 1.0%
FA_c Ratio	Decreasing by 0.05 increases the VMA from 0.5% to 1.0%
FA_f Ratio	Decreasing by 0.05 increases the VMA from 0.5% to 1.0%



1. $\text{CA Ratio} = \frac{\%\ \text{Half Sieve} - \%\text{PCS}}{100 - \%\ \text{Half Sieve}}$
2. $\text{FA}_C\ \text{Ratio} = \frac{\%\ \text{SCS}}{\%\ \text{PCS}}$
3. $\text{FA}_f\ \text{Ratio} = \frac{\%\text{TCS}}{\%\text{SCS}}$

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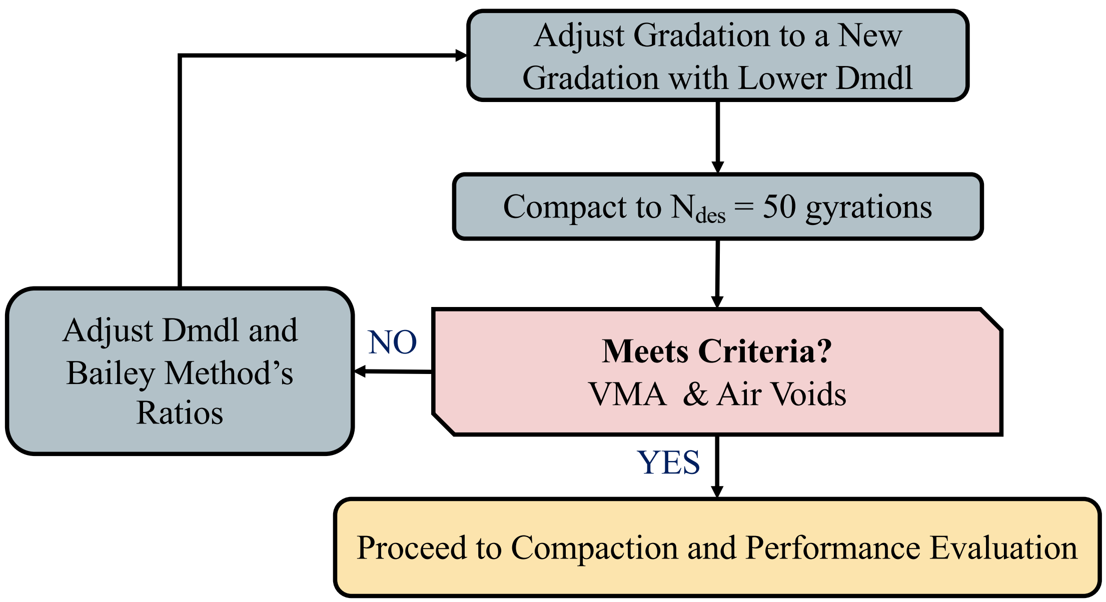
Mixture Preparation & Designs

Superpave5 Mixtures



Mixture Designs

- Superpave4 MassDOT for Source 1 and Source 2 both share the same gradation.
- The Dmdl values for Superpave4 mixtures are higher than that for the corresponding Superpave5 mixtures.
- The Dmdl values for Superpave MassDOT mixtures are higher than that for the corresponding AASHTO mixtures.

Source	**Source 1 Mixes**				**Source 2 Mixes**	
	Superpave AASHTO		Superpave MassDOT		Superpave MassDOT	
Sieve Size	Superpave4	Superpave5	Superpave4	Superpave5	Superpave4	Superpave5
	Percent Passing %					
19.0	100	100	**100.0**	100	**100.0**	100.0
12.5	94	94	**94.0**	92	**94.0**	98.0
9.5	77	74	**86.0**	80	**86.0**	77.8
4.75	52	52	**61.0**	57	**61.0**	50.9
2.36	38	38	**42.0**	43.8	**42.0**	36.7
1.18	26	28	**30.0**	30	**30.0**	26.0
0.6	17	18	**20.0**	20	**20.0**	17.6
0.3	11	13	**13.0**	13	**13.0**	10.7
0.15	7	8.1	**8.0**	7	**8.0**	8.3
0.075	4	4	**4.0**	4	**4.0**	4.5
Dmdl and Bailey Method Ratios						
Dmdl	37.5	28.4	46.9	37.7	46.9	42.6
CA	0.589	0.546	0.932	0.618	0.932	0.605
FA_c	0.447	0.474	0.476	0.457	0.476	0.480
FA_f	0.412	0.450	0.400	0.350	0.400	0.472

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Mixture Designs

Source	Source 1 Mixtures				Source 2 Mixtures	
	Superpave AASHTO		Superpave MassDOT		Superpave MassDOT	
	Superpave4	Superpave5	Superpave4	Superpave5	Superpave4	Superpave5
N_{des}	100	50	100	50	100	50
Voids (%)	4.4	5.3	4.3	5.3	4.0	5.2
VMA (%)	14.7	15.5	15.4	16.5	15.7	16.9
P_b (%)	5.0	5.0	5.4	5.4	5.4	5.4
P_{be} (%)	4.5	4.5	4.8	4.9	4.9	5.0

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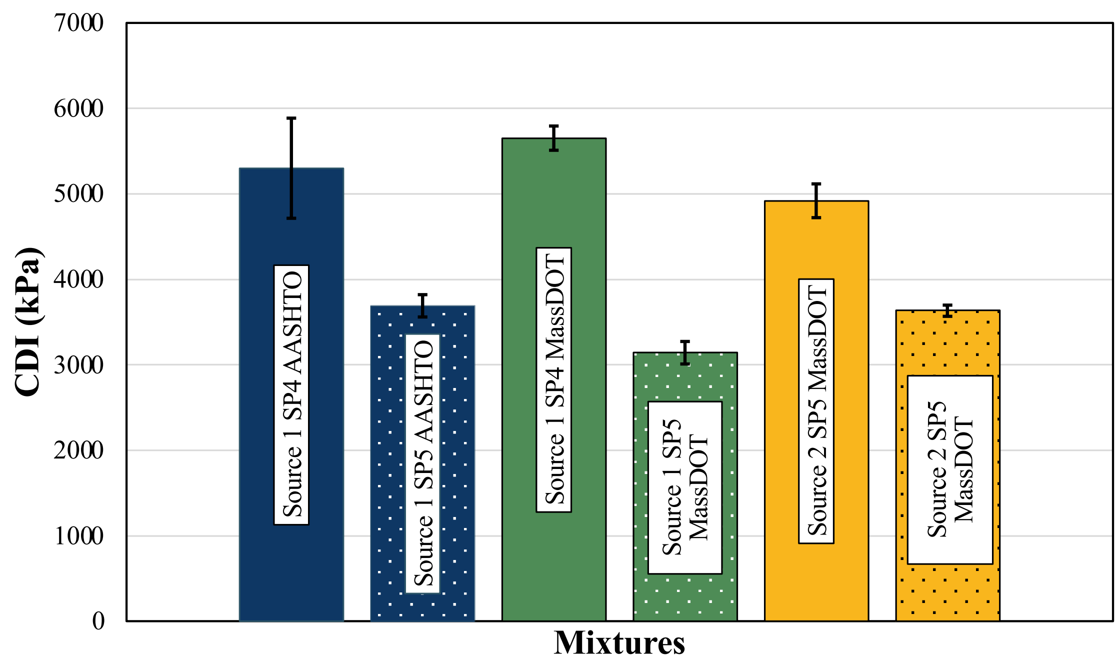
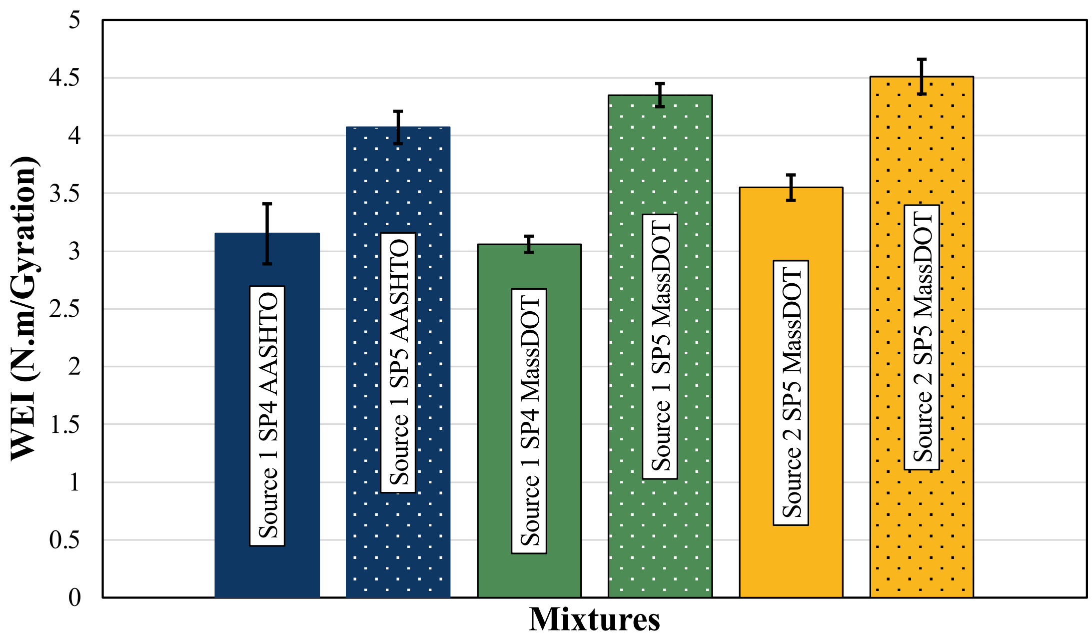
Mixture Evaluation: Compactibility - CDI

- The higher the CDI the more difficult it is to compact the mix to 95% G_{mm}.
- For each two corresponding mixtures, it is shown that the Superpave4 mixture had higher CDI values.



Mixture Evaluation: Compactibility - WEI

- The higher the WEI the easier it is to compact the mix to 95% G_{mm}.
- For each two corresponding mixtures, it is shown that the Superpave5 mixture had higher WEI values.



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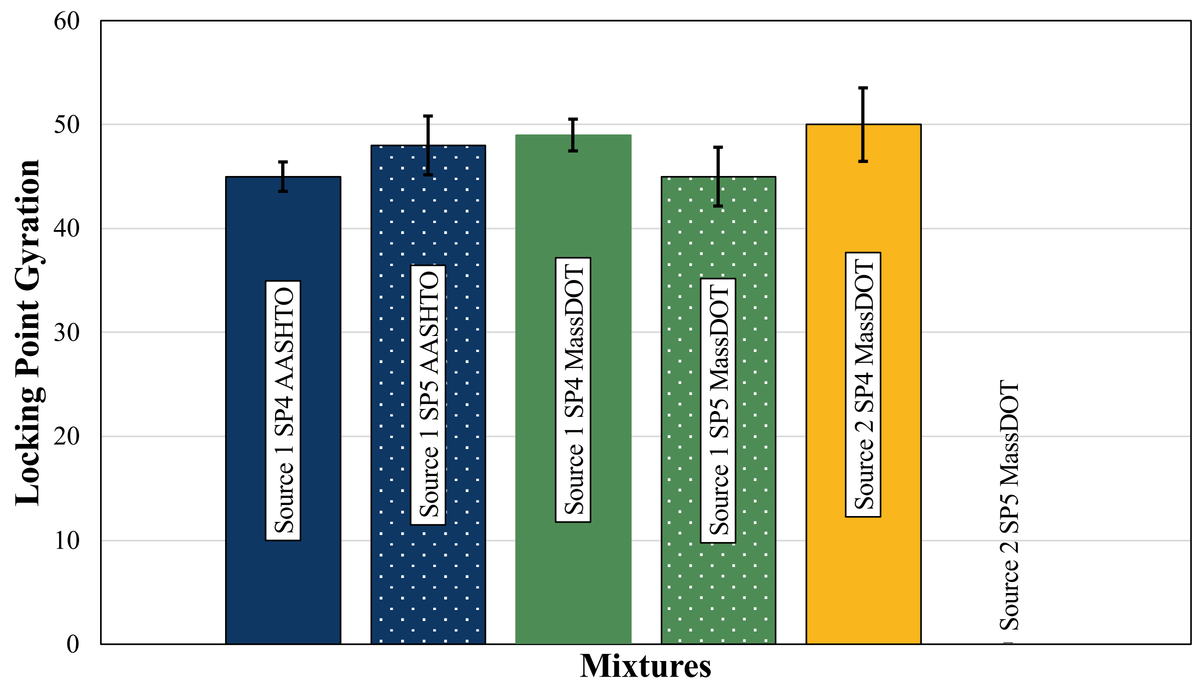
Mixture Evaluation: Compactibility - Locking Point

- Refers to the stage during the compaction of an asphalt mixture in a SGC where the mixture reaches a stable density, and further compaction results in minimal or no additional reduction in height.

- The locking points for all mixtures were observed between 45 and 50 gyrations, with the exception of the Superpave5 mixture produced with materials from Source 2, which did not exhibit a distinct locking point.



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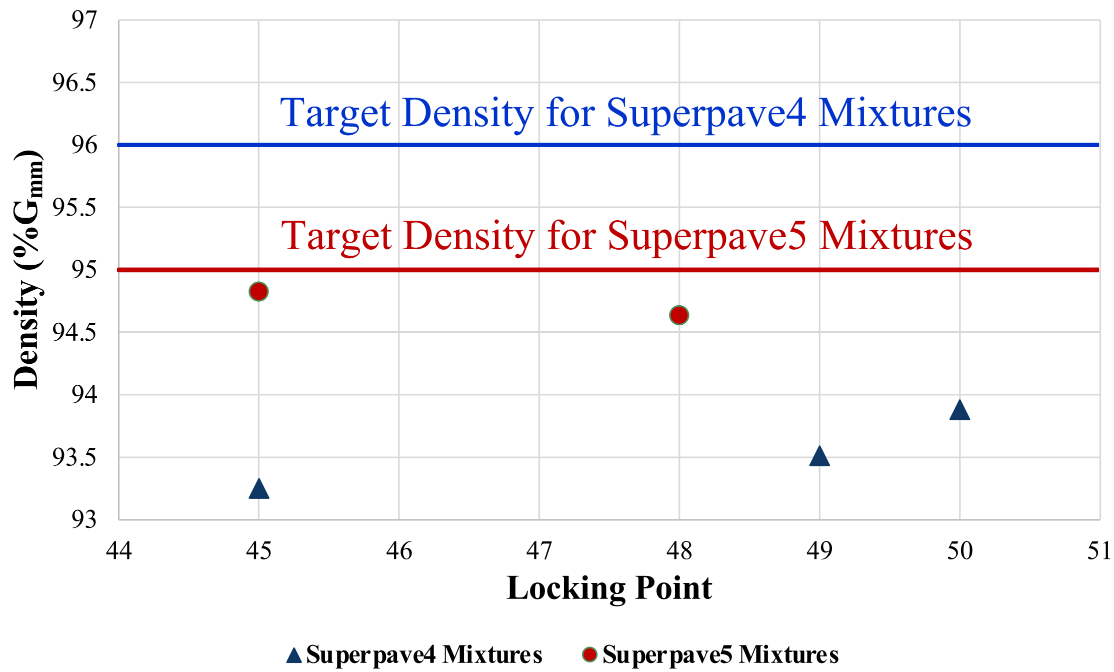
Mixture Evaluation: Compactibility - Locking Point

- It was observed that Superpave4 mixtures achieve a density of approximately 93% to 94% at the locking point.
- Superpave5 mixtures reach a density of about 95% at the locking point, which aligns with the target field density.



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Mixture Evaluation: Performance Testing - HWTT

Test	Distress Addressed	Aging	MassDOT Criteria
Hamburg Wheel Tracking Test (AASHTO T 324)	Rutting	Short Term Aging 4 hrs @ 135°C	45°C Test Temperature < 12.5 mm & No SIP before 15,000 passes

Source	Mixture	Target Air Voids (%)	Rut Depth (mm)	Stripping
Source 1	SP4 AASHTO	7.0 ± 0.5 %	2.5	No Stripping
	SP5 AASHTO	5.0 ± 0.5 %	1.9	
	SP4 MassDOT	7.0 ± 0.5 %	3.4	
	SP5 MassDOT	5.0 ± 0.5 %	2.6	
Source 2	SP4 MassDOT	7.0 ± 0.5 %	2.6	
	SP5 MassDOT	5.0 ± 0.5 %	1.7	

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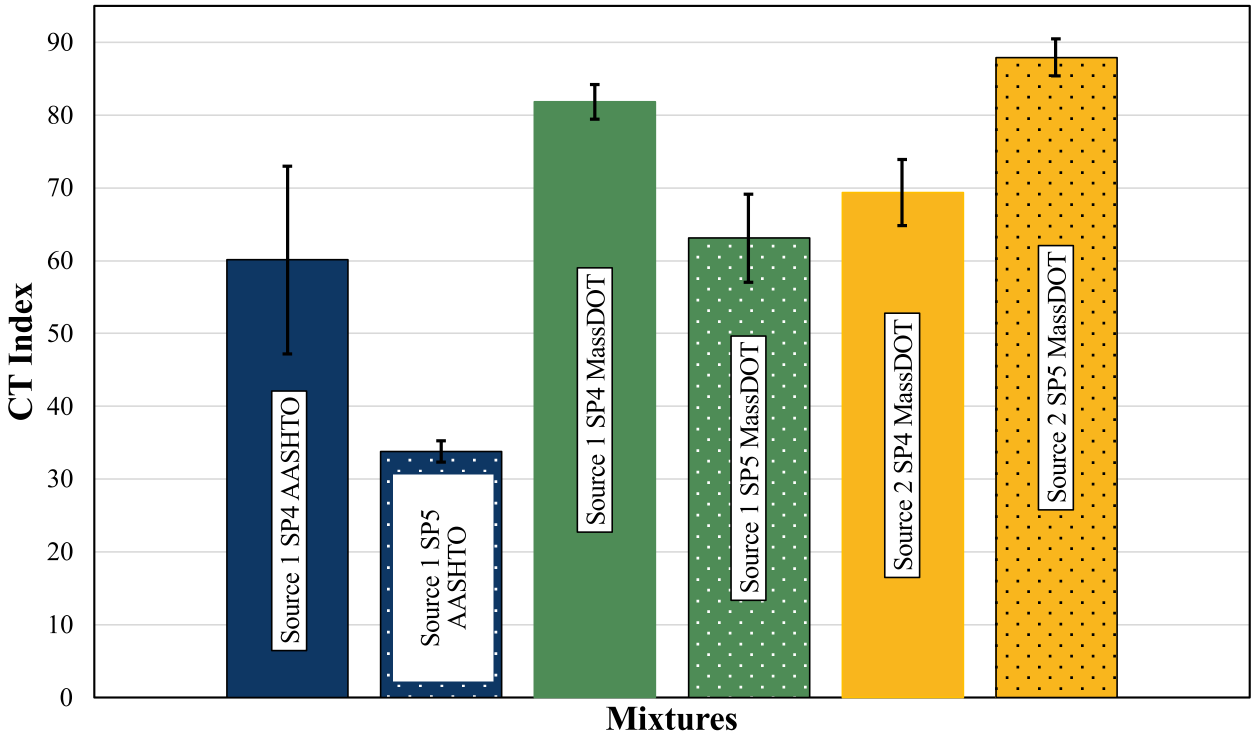
Mixture Evaluation: Performance Testing - IDEAL-CT



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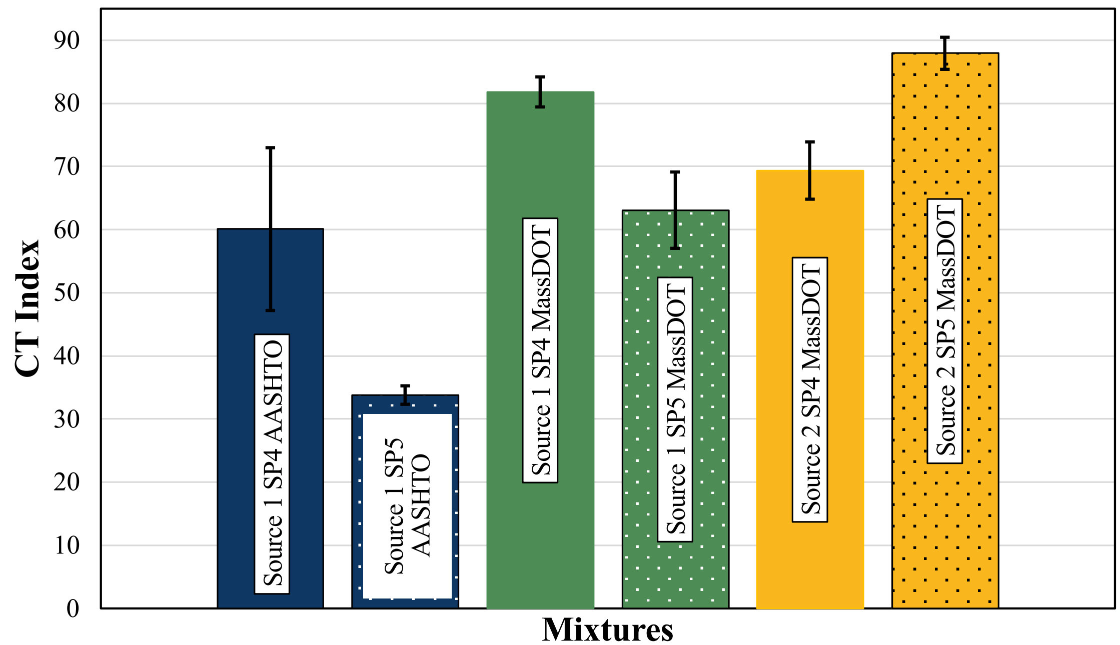
Mixture Evaluation: Performance Testing - IDEAL-CT

- This variation in CT_{Index} between sources indicates that the effect of switching to Superpave5 on cracking resistance may be influenced by factors such as aggregate properties, binder characteristics, or other project-specific variables.



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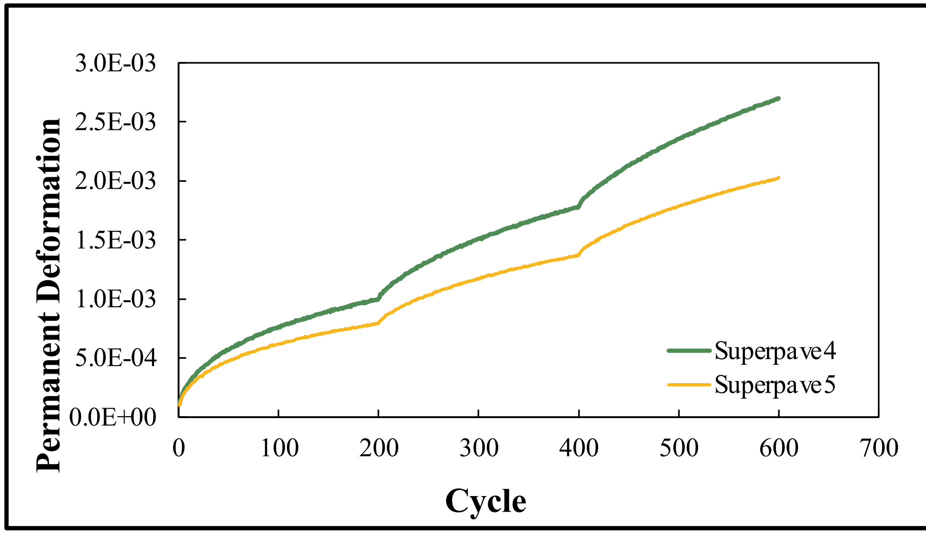
Mixture Evaluation: Performance Prediction with FlexPAVE^{TM}

Required Test Data to Input into FlexPAVE^{TM} Software to Predict Rutting of the Mixtures:

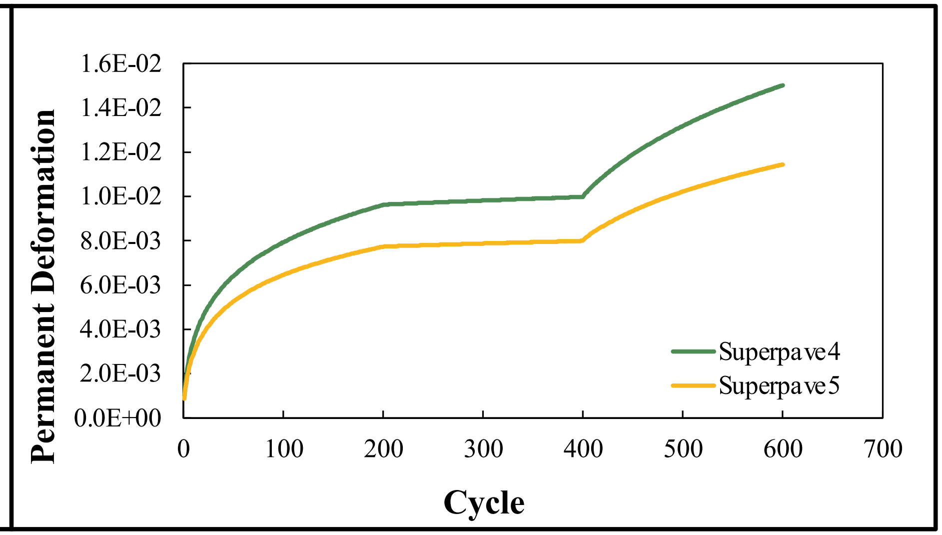
- Stress Sweep Rutting Test (SSR) – AASHTO TP 134
- Dynamic Modulus Test (| E*|) – AASHTO TP 132

Mixture Evaluation: SSR Test

- Two test temperatures (20°C & 42.2°C). Two replicate specimens at each temperature.
- Superpave5 mixes exhibited lower permanent deformation values compared to Superpave4 mixes at both test temperatures.



SSR Results at Low Test Temperature (20°C)



SSR Results at High Test Temperature (42.2°C)

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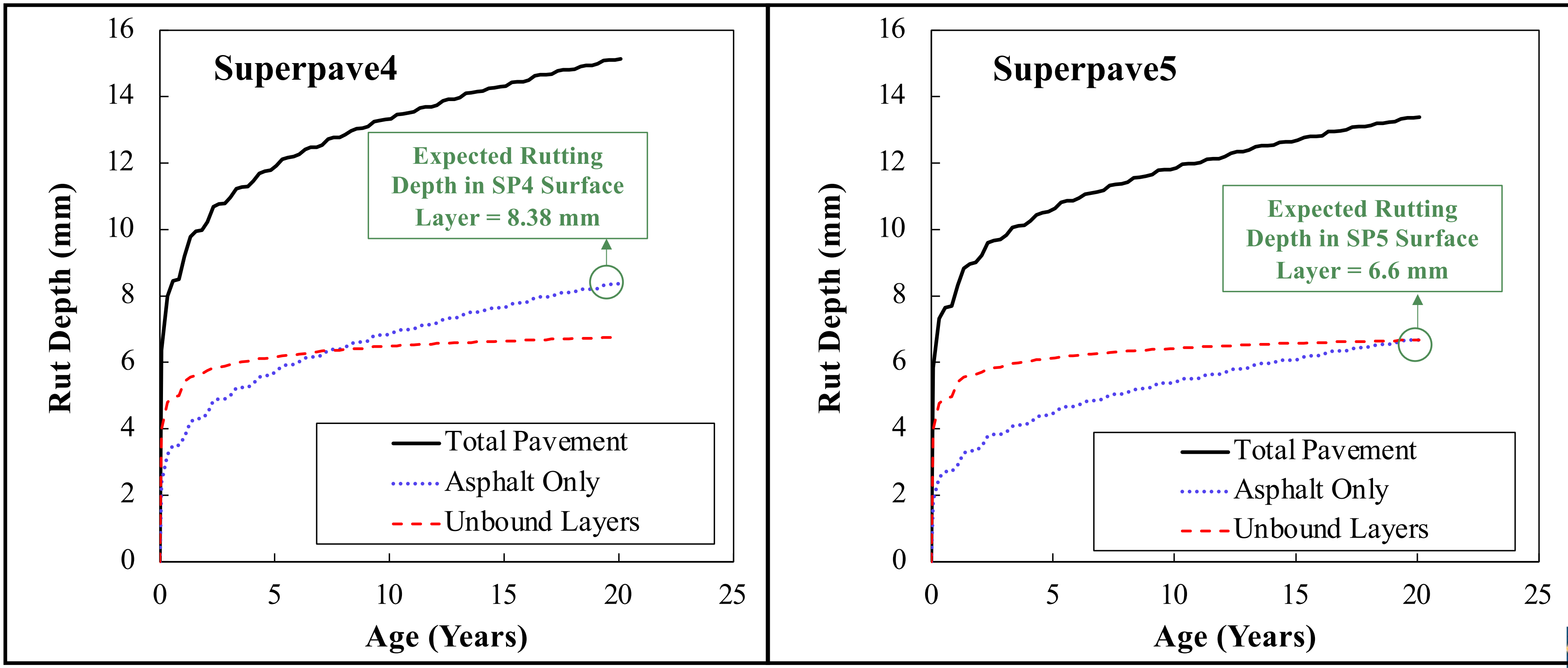
Mixture Evaluation: FlexPAVE™ Analysis



Conclusions

- Dmdl & the Bailey Method are tools that can be iteratively used to adjust aggregate gradations, facilitating the transition from SP4 to SP5.

- SP5 mixtures demonstrated improved compactibility and workability compared to SP4 mixtures in the mixtures tested.

- In terms of locking point density, SP4 mixtures achieved 93% to 94% G_{mm}, which correlates with the noted difficulties in reaching the desired field density with SP4 mixtures.

- SP4 MassDOT mixtures required more compactive effort to achieve a 95% G_{mm} than SP5 AASHTO mixtures with a lower effective binder volume.

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Conclusions

- CT_{Index} results for intermediate-temperature cracking varied between sources. This suggests that cracking performance is dependent on source materials.

- HWTT results showed that all mixtures met MassDOT's rutting performance criteria.

- FlexPAVE™ simulations further validate the long-term rutting resistance of Superpave5.

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Thank you!