TOPS
Targeted Overlay Pavement Solutions

EDC

Source: https://www.fhwa.dot.gov/innovation/everydaycounts/about-edc.cfm

Evaluation of Three FHWA Targeted Overlay Pavement Solutions (TOPS) for Asphalt Pavements Based on Their Performances and Potential to Increase Pavement Service Life

NEAUPG

North East Asphalt User Producer Group (NEAUPG) 2023 Annual Meeting

Providence, RI ✦ October 25th, 2023

Commonwealth Professor Walaa S. Mogawer, P.E., F.ASCE

University of Massachusetts Dartmouth

TOPS & EDC Picture Source: www.fhwa.dot.gov/pavement/tops/ & www.fhwa.dot.gov/innovation/everydaycounts/about-edc.cfm

Acknowledgment

- MassDOT
  - Edmund Naras
  - Mark Brum, P.E.
  - Bryan Engstrom
- Contractors
  - Aggregate Industries (Holcim)
  - JH Lynch & Sons Inc.
  - Northeast Paving
  - Warner Bros., LLC & Trew Stone, LLC (All States Materials Group)
- Binder Suppliers
  - Bitumar
  - Brox Industries
  - All States Asphalt

Acknowledgment

Alexander Austerman, P.E.
Senior Research Engineer
Highway Sustainability Research Center
University of Massachusetts Dartmouth

Ibrahim Abdalfattah, Ph.D.
Senior Research Engineer
Highway Sustainability Research Center
University of Massachusetts Dartmouth

Mr. Kevin Stuart
Consultant/Formerly with FHWA

Outline

- Background
- Objective
- Pilot Specifications
- Experimental Plan
- Results and Analysis by Distress
- Evaluation of Service Life Extension
- Conclusions
- Recommendations

Background

- The FHWA Everyday Counts (EDC) program was established to identify and deploy underutilized innovations that have been proven to be effective by the transportation agencies using them.

- In the EDC sixth round (EDC-6) for 2021-2022, seven new innovations were identified, with one of those innovations being **T**argeted **O**verlay **P**avement **S**olution **(TOPS)**.

Background

- TOPS presents innovative overlays for both asphalt and concrete pavements that have proven to be effective in enhancing the performance of high-priority or high-maintenance pavements such as interstate pavements, intersections, bus lanes, ramps, and curves.

Background

For ***asphalt pavements***, the FHWA had chosen the following eight TOPS:

- Asphalt Rubber Gap-Graded (ARGG)
- Crack Attenuating Mix (CAM)
- Enhanced Friction Overlay
- Highly Modified Asphalt (HiMA)
- High-Performance Thin Overlay (HPTO)
- Open-Graded Friction Course (OGFC)
- Stone Matrix Asphalt (SMA)
- Ultra-Thin Bonded Wearing Course (UTBWC)

Background

- MassDOT wanted to investigate some of these eight TOPS to expand its selection of overlay strategies.
- Three TOPS were selected - **ARGG, SMA**, and **HPTO**.

Objective

➢ To conduct a comparative evaluation of the three selected TOPS (ARGG, SMA & HPTO) in terms of the following:

- Performance
- Potential to extend pavement service life
- Whether or not they can be used interchangeably

Pilot Specifications

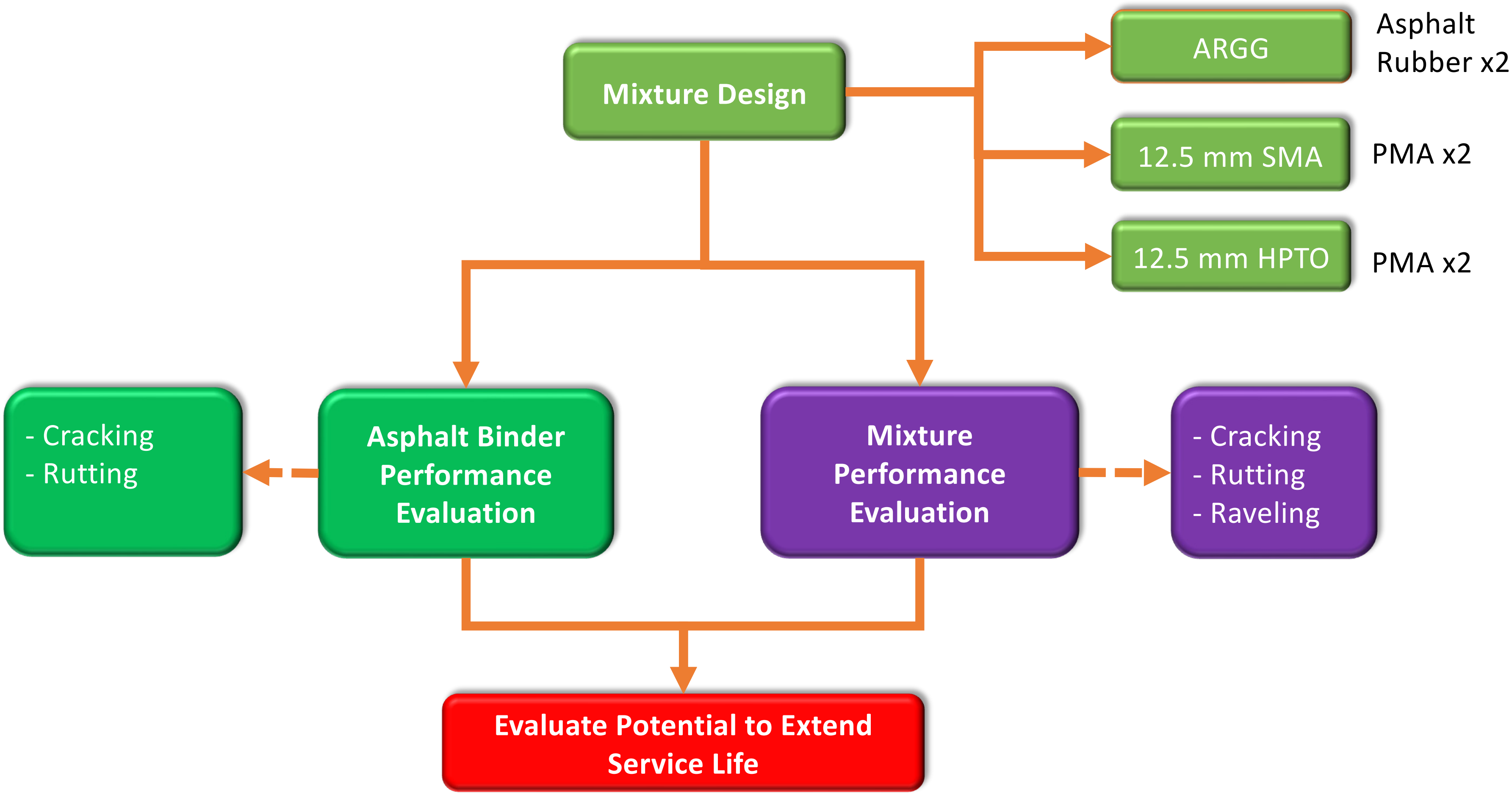
	ARGG	SMA	HPTO
Binder PG	64E-28	76E-34	76E-34
Design Gyrations	100	100	75
P_b , minimum	7.6	6.0	6.4
% Air Voids	3 - 5	4	3.5
% RAP, maximum	10	10	10

Pilot Specifications

Distress	Test	Test Method Specification	Criteria
Rutting	Hamburg Wheel Tracking Test (HWTT)	AASHTO T 324 @ 45°C	< 12.5 mm at 20,000 Passes
Moisture Damage	HWTT Stripping Inflection Point	AASHTO T 324 @ 45°C	> 15,000 passes
Intermediate Temperature Cracking	Flexibility Index (FI)	AASHTO T 393 @ 25°C	≥ 20*
Low Temperature Cracking	Thermal Stress Restrained Specimen Test (TSRST)	EN 12697-46	SMA Only & For Information Only

**FI shall be an average of 4 specimens with no individual specimen with an FI < 15*

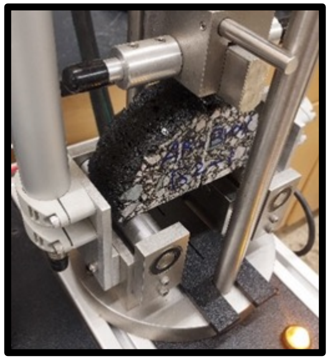
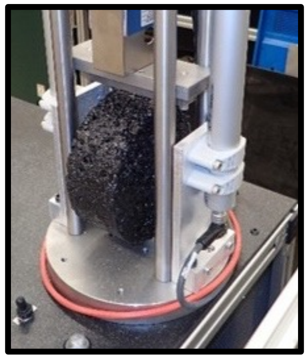
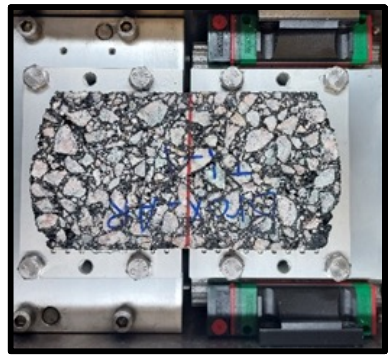
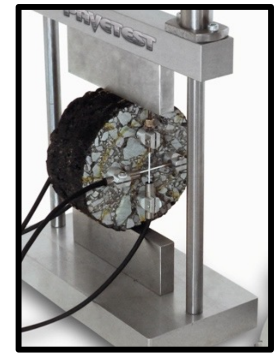
Experimental Plan



Asphalt Binder Performance Evaluation

Distress	Test	Specification
Low Temperature Cracking	Extended BBR (EBBR)	AASHTO TP 122
	Asphalt Binder Cracking Device (ABCD)	AASHTO T 387
	BBR Creep Stiffness (S) and m-value	AASHTO T 313 and M 320
Intermediate Temperature Cracking	Double Edge Notched Tension (DENT)	AASHTO TP 113
	G*Sinδ	AASHTO T 315 and M 320
Non-Load Associated Cracking	Delta T_c (ΔT_c)	AASHTO T 313
Rutting	MSCR	AASHTO T 350 and M 332
	G*/Sinδ	AASHTO T 315 and M 320

Mixture Performance Evaluation

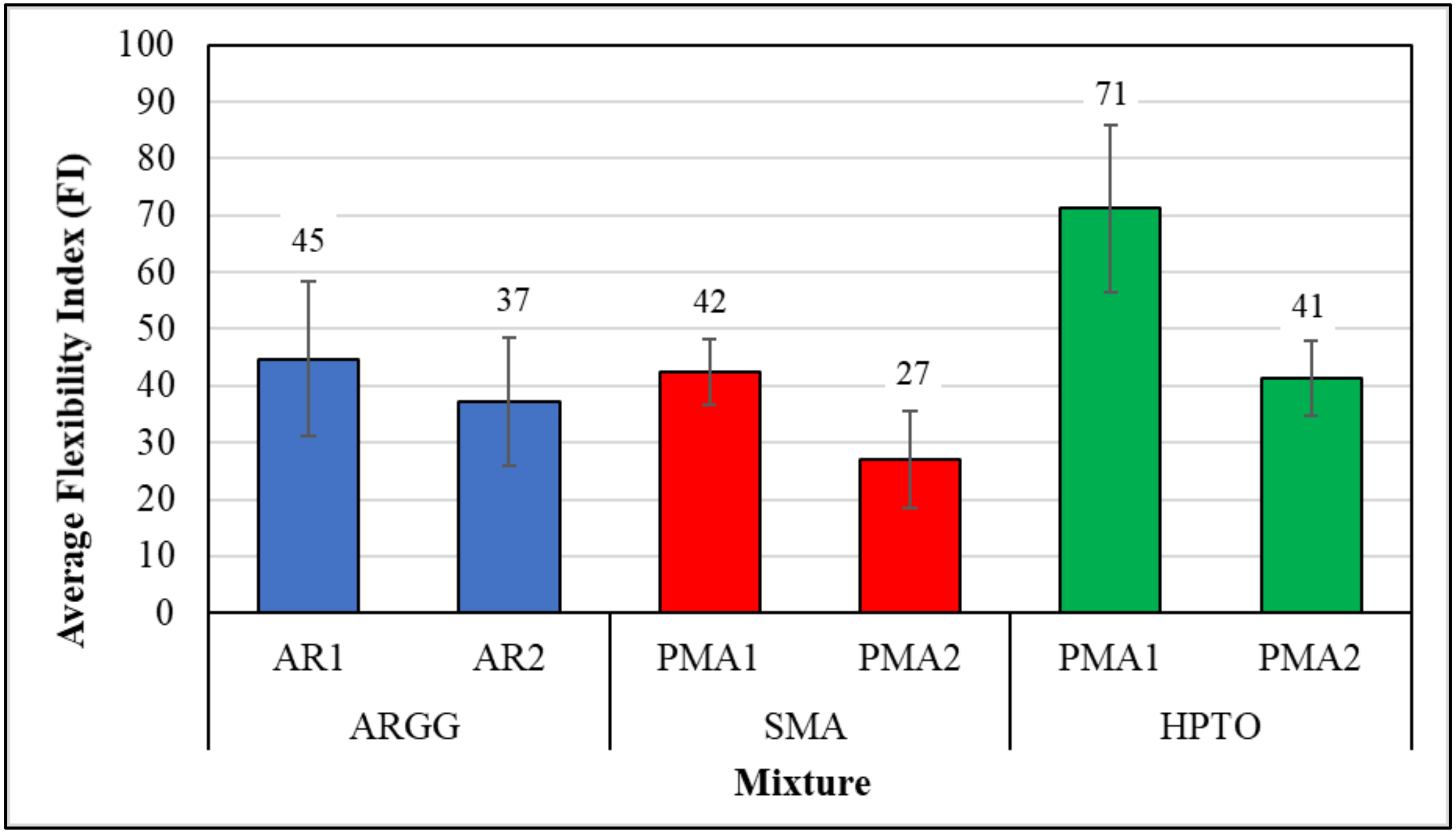
	Intermediate Temperature Cracking Tests		Reflective Cracking	Low Temperature Cracking	
Test	I-FIT 	IDEAL-CT 	Overlay Test 	TSRST 	Creep Compliance 
Specification	AASHTO T 393	ASTM D 8225	Tex-248-F	AASHTO TP 10-93	AASHTO T 322
Test Temperature	25°C	25°C	25°C	n/a	0ºC, -10ºC & -20ºC

Creep Compliance Picture from: https://www.matest.com/en/product/b253-creep-compliance

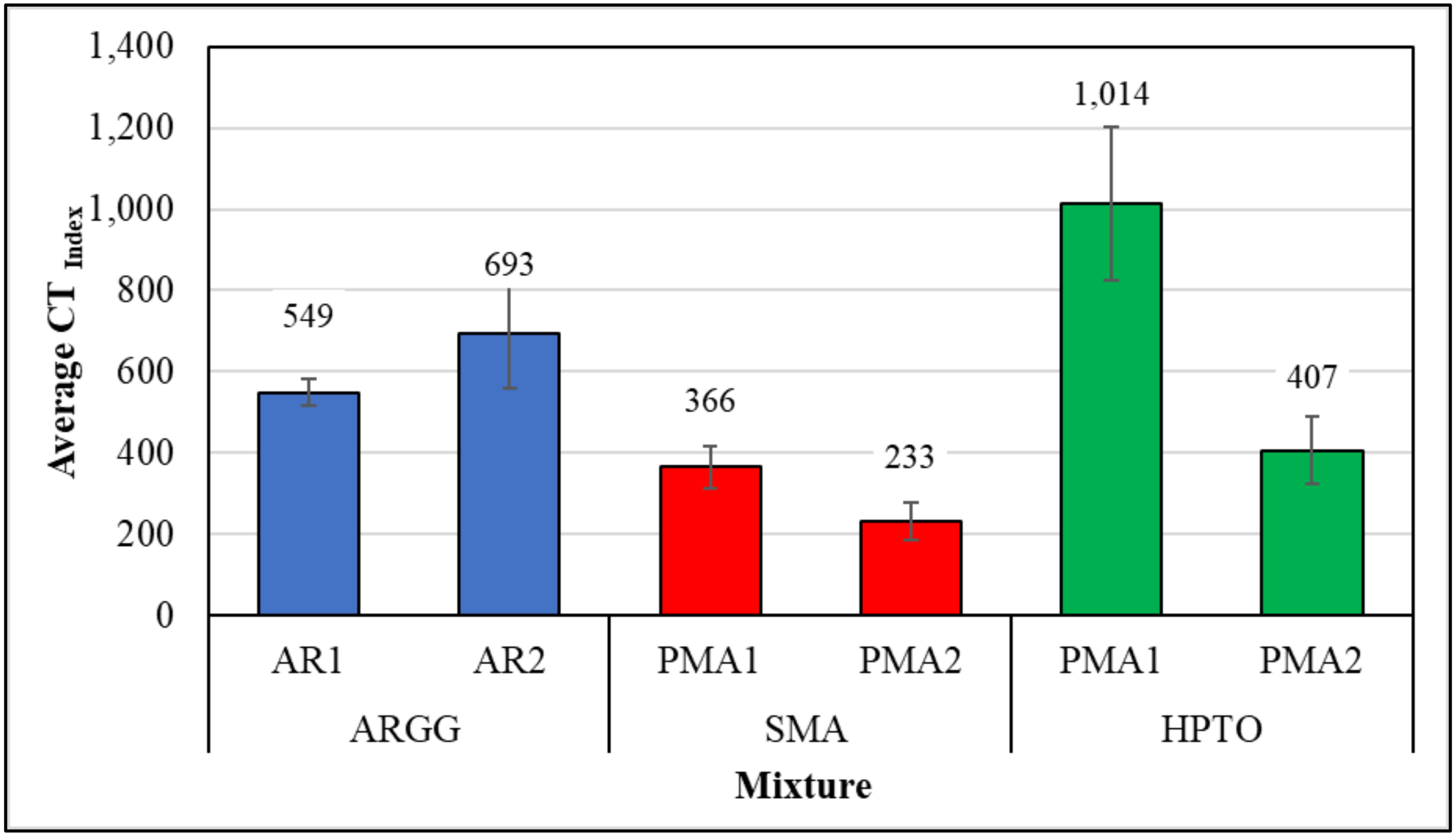
Mixture Performance Evaluation

	Rutting	Raveling
Test	Hamburg Wheel Tracking Test (HWTT) 	Cantabro  Picture from: *https://www.matest.com/en/product/a075n-los-angeles-machine*
Specification	AASHTO T 324	AASHTO TP 108
Test Temperature	45°C	25°C

Performance Results – Intermediate Temperature Cracking



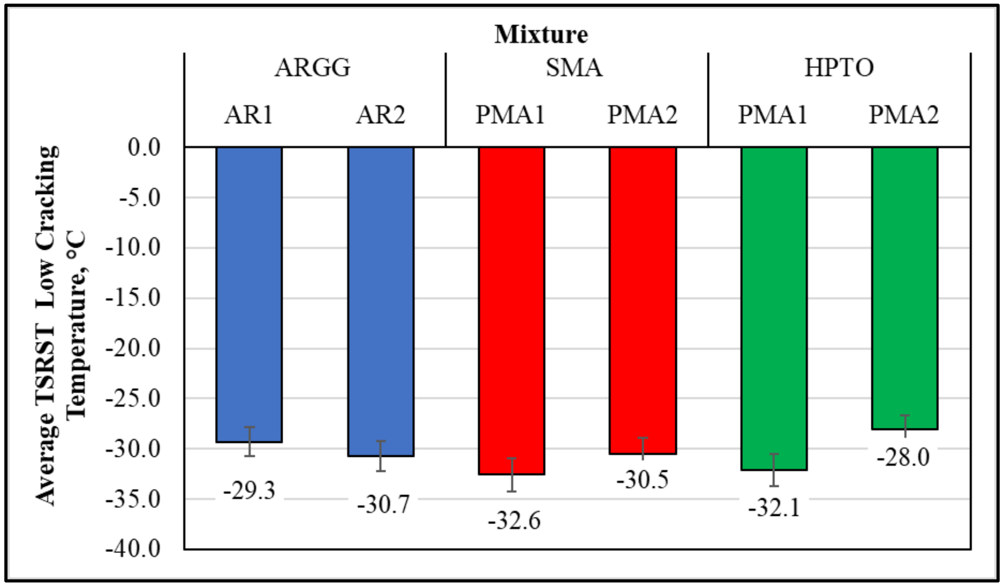
Performance Results – Intermediate Temperature Cracking

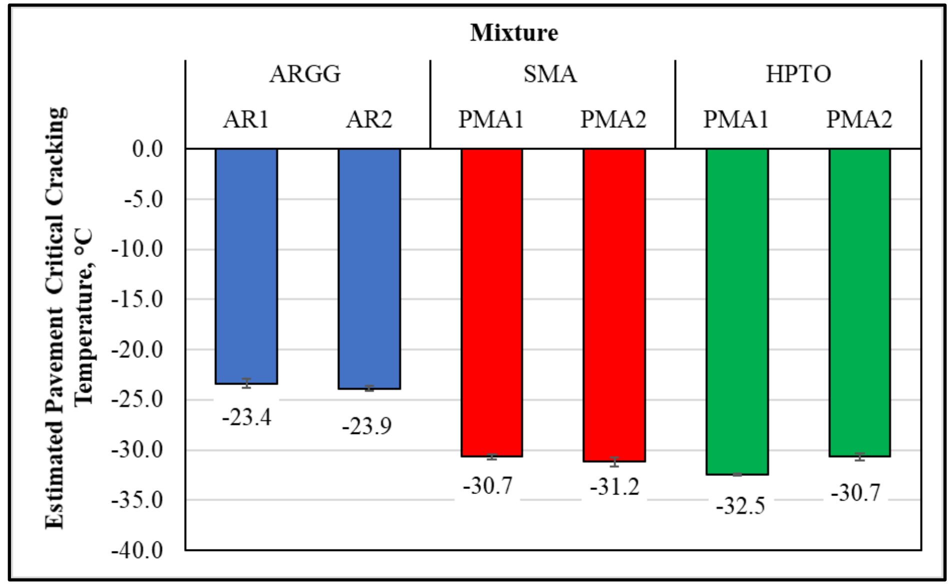


Intermediate Temperature Cracking - Conclusions

- All mixtures passed the FI criteria listed in MassDOT's pilot specification. Accordingly, MassDOT can use the three TOPS interchangeably to address intermediate temperature cracking.
- The IDEAL-CT was performed as it is the test that MassDOT is planning to include in its BMD protocol.

Performance Results – Low Temperature Cracking



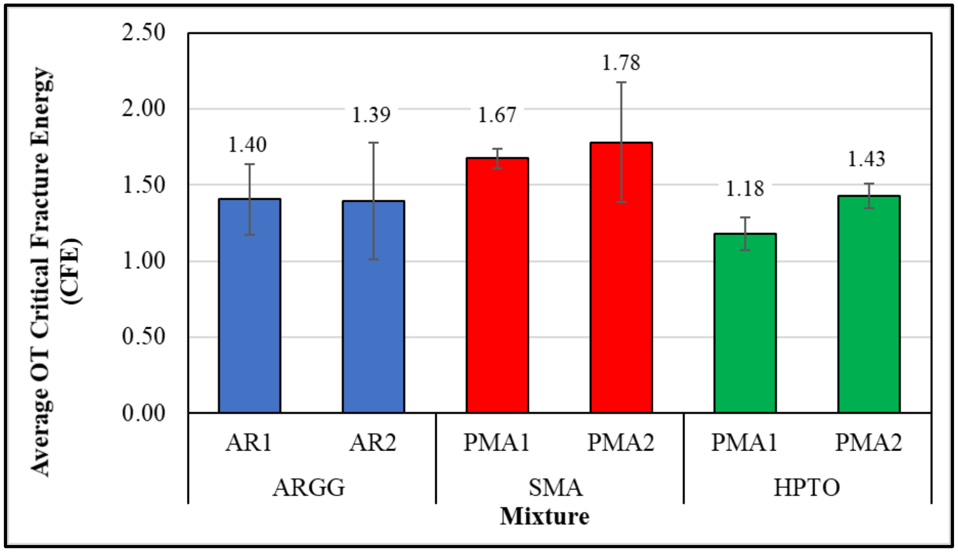


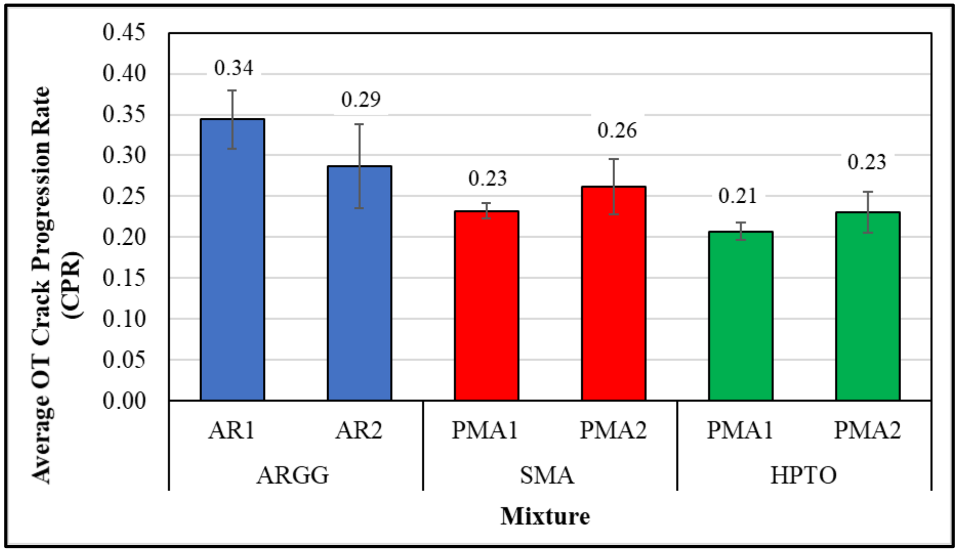
Low Temperature Cracking - Conclusions

- MassDOT specifies a low-temperature PG of -28°C in their asphalt mixture surface layers. According to the TSRST, the three TOPS can be used interchangeably because regardless of the binder source, each mixture provided a low temperature cracking of -28°C or colder.

- According to creep compliance analyses, the SMA and the HPTO can be used interchangeably. However, the analyses showed less thermal cracking resistances for the ARGG.

Performance Results – Reflective Cracking



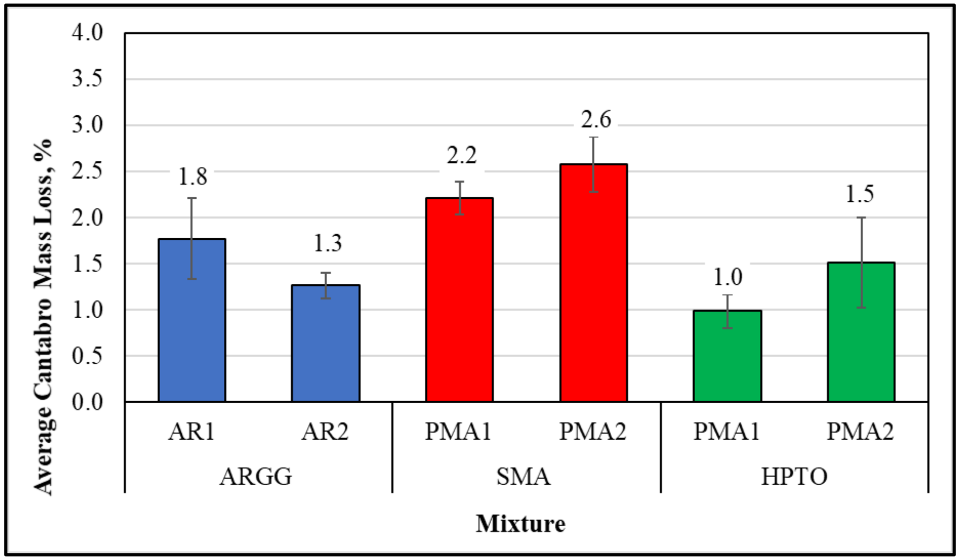


Reflective Cracking - Conclusions

- The N_f for all mixtures exceeded 1,200 cycles.
- Accordingly, the MassDOT can use the three TOPS interchangeably to address reflective cracking.

Performance Results – Raveling

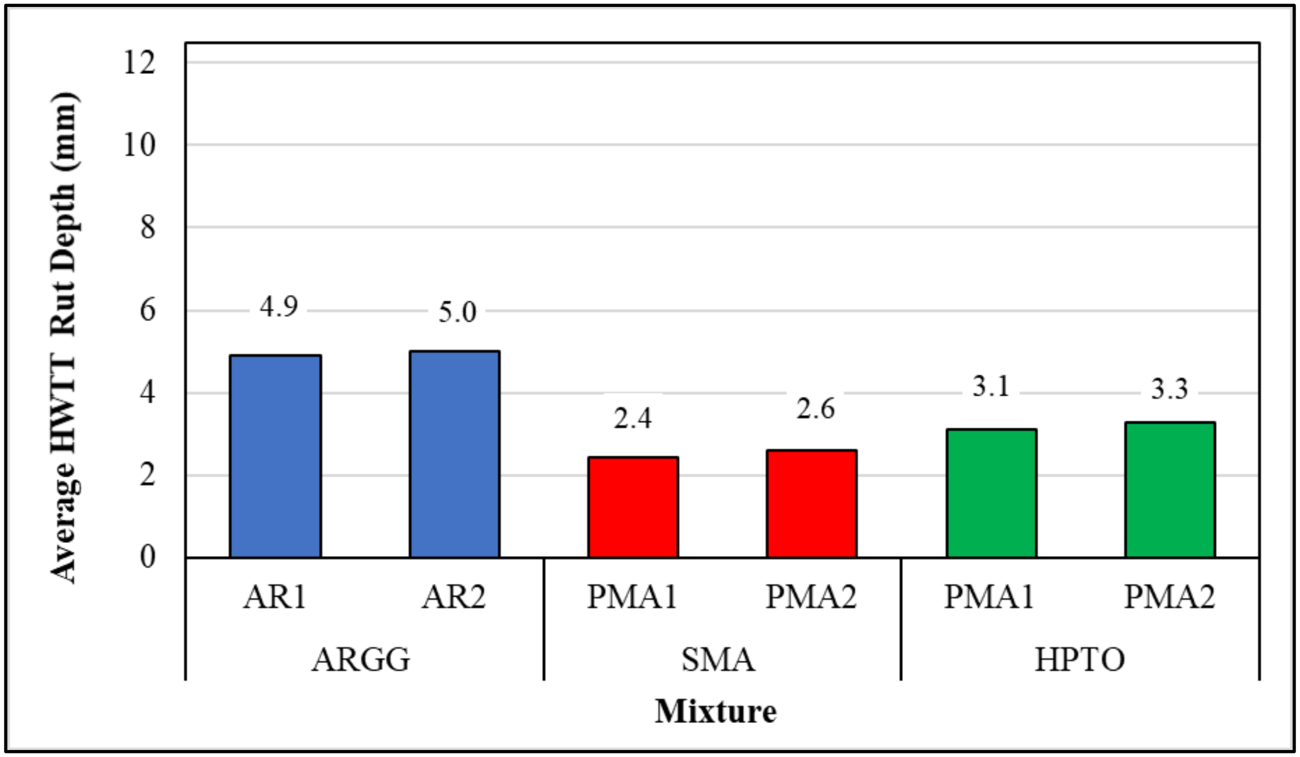
- MassDOT has no pass/fail criteria for the Cantabro test.
- Virginia DOT is utilizing a criterion of ≤ 7.5% loss based on extensive testing of surface mixtures for developing their BMD protocol.



Raveling - Conclusions

- All mixtures tested passed the Virginia DOT criterion.
- Accordingly, MassDOT can use the three TOPS interchangeably to address raveling.

Performance Results - Rutting



Rutting - Conclusion

- All mixtures passed the agency's criteria for rutting.
- Accordingly, MassDOT can use the three TOPS interchangeably to address rutting.

Evaluation of TOPS Service Life Extension

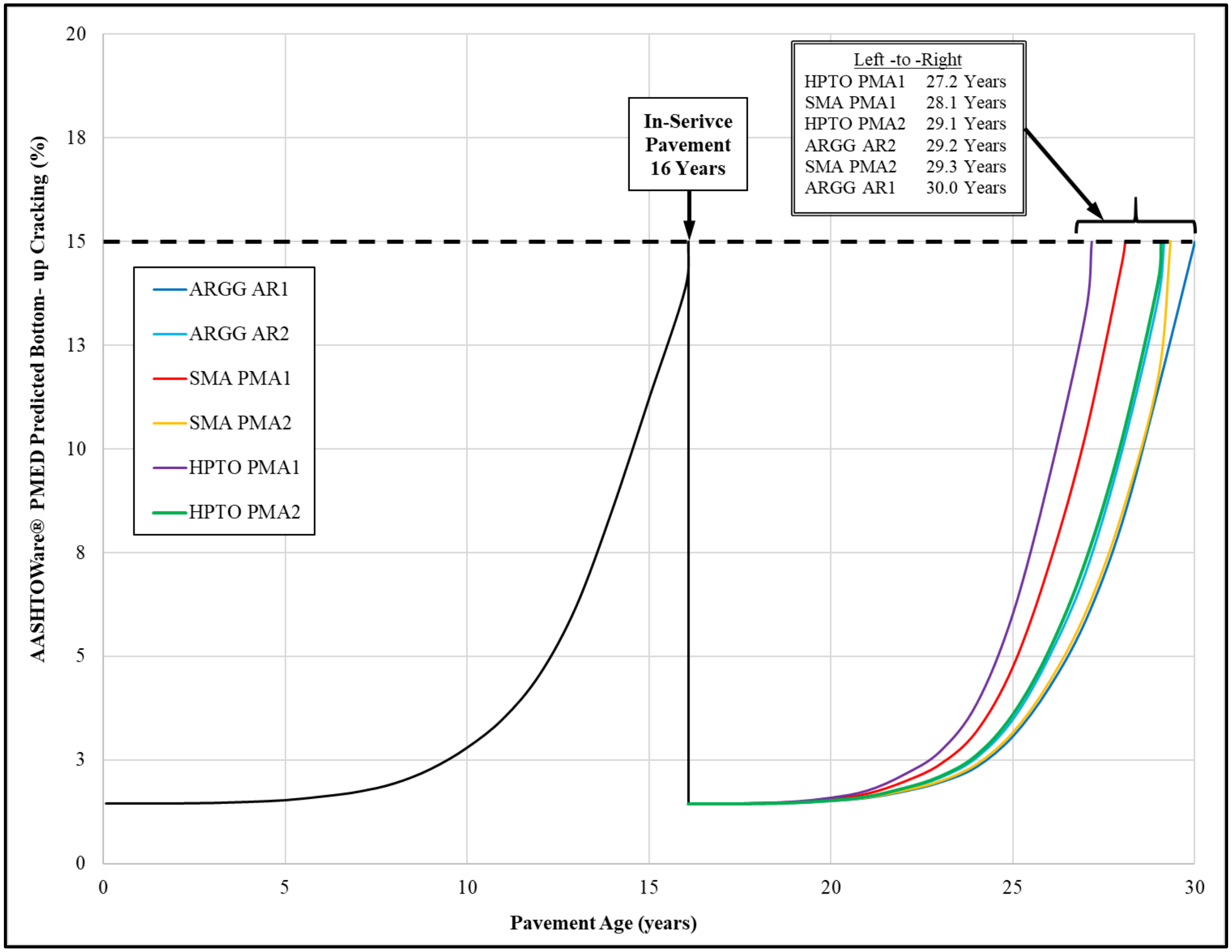
- AASHTOWare® PMED version 2.6.2 was used.
- The pavement structure composed of a 9-in asphalt pavement surface layer; a 15-in crushed stone base layer with a resilient modulus of 22 ksi, and a prepared A-2-4 subgrade soil with a modulus of 7 ksi.

Evaluation of TOPS Service Life Extension

- AASHTOWare® PMED analysis determined that a typical flexible pavement structure would exhibit fatigue cracking in 15% of the pavement surface at 16 years of service life and almost no thermal cracking throughout its entire design period.

- The top 2 inches (51 mm) of the surface layer was removed when the predicted fatigue cracking reached 15% of the lane area. It was replaced with 2 inches of a TOPS (3 TOPS x 2 binder sources = 6 total AASHTOWare® PMED simulations). When a TOPS was applied, the simulation was continued using the AADTT at that time with a 3% annual traffic growth rate until the minimum 20-year design life was reached.

Evaluation of the Three TOPS Potential Service Life Extension



TOPS Service Life Extension - Conclusions

- The three TOPS using two binder sources extended the service life of the pavement between 11.2 and 14 years depending on the type of TOPS and binder source.

- The three TOPS using two binder sources exhibited thermal cracking substantially lower than the MassDOT definition of “light” thermal cracking.

Overall Conclusions

- The three TOPS met the MassDOT pilot specification criteria for rutting, moisture damage, and intermediate-temperature cracking, and met other DOTs' established criteria for reflective cracking and raveling. This indicated that the three TOPS can be used interchangeably.

- Depending on the type of TOPS and binder source, the three TOPS can extend the pavement service life between 11.2 and 14 years.

Recommendations

- To confirm that the three TOPS can be used interchangeably, it is recommended that MassDOT selects at least one pavement site to construct the three TOPS adjacent to each other and monitor their performances over time. It is important that these experiments have the same underlying layers, traffic, and climate.
- Perform a Life-Cycle Cost Analysis (LCCA) so that MassDOT can determine whether the life-cycle costs of the three TOPS are the same.
- Perform Life-Cycle Assessments (LCA) to quantify the environmental impacts of each of the three TOPS.

Evaluation of Three FHWA Targeted Overlay Pavement Solutions (TOPS) for Asphalt Pavements Based on Their Performances and Potential to Increase Pavement Service Life

Description of the Three Selected TOPS

ARGG

- A gap-graded asphalt mixture with AR binder incorporating approximately 20% ground tire rubber. ARGG has been reported to be very durable with resistance to reflective cracking, thermal cracking, and rutting, while also exhibiting good friction resistance. Generally placed at a thickness of 1.25 to 2.25 inches.

SMA

- A gap-graded asphalt mixture consisting of a stable stone-on-stone coarse aggregate skeleton and a rich asphalt binder content along with a stabilizing agent such as fibers and/or polymer-modified asphalt modifiers. SMA's stone-on-stone coarse aggregate skeleton can reduce rutting, while the rich asphalt binder content can reduce cracking.

HPTO

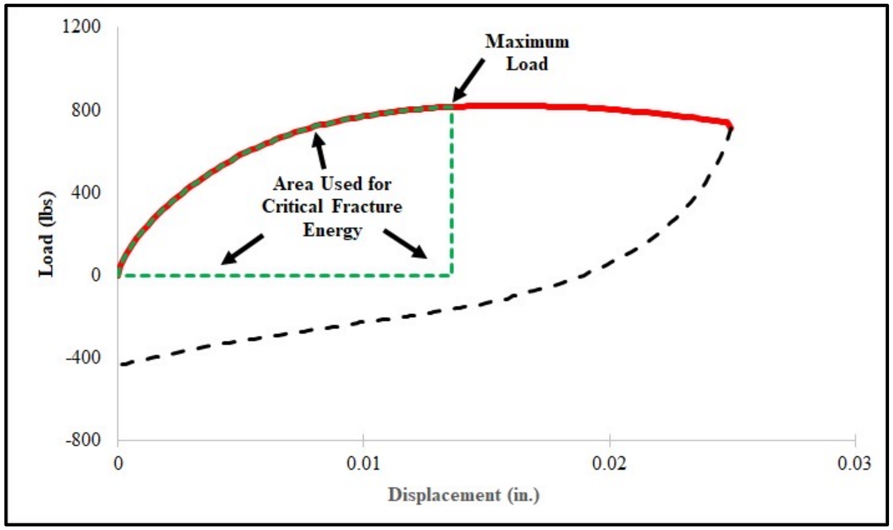
- A fine-graded polymer-modified asphalt mixture. HPTO mixtures have been reported to improve cracking and rutting resistances and extend pavement life. It is generally placed at a thickness of 1 inch.

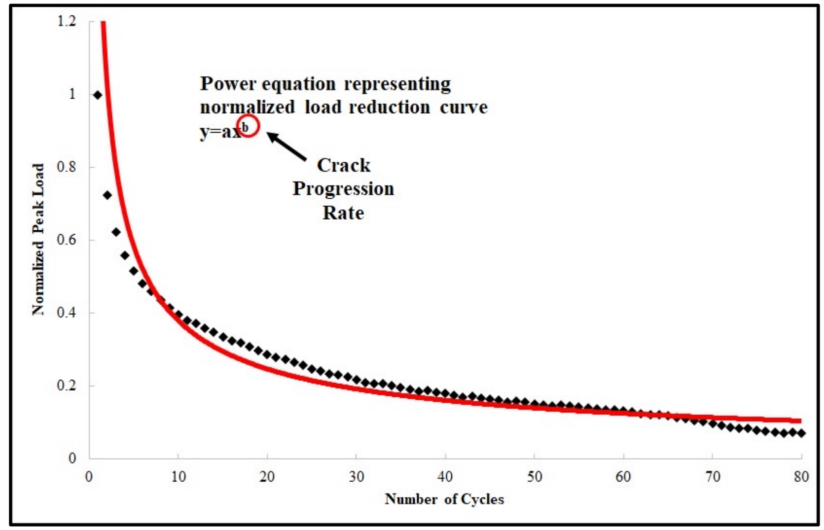
https://www.fhwa.dot.gov/pavement/tops/

Asphalt Binders

	Base Binders			ARGG Binders		PMA Binders	
	Used for AR1 & PMA1	Used for PMA2	Used for AR2	AR1	AR2	PMA1	PMA2
Continuous Grade	61.0-30.0	55.9 -34.3	65.4-30.3	87.4-28.2	87.4 -33.3	89.5-36.0	77.7-34.2
Performance Grade (PG)	58S-28	52H-34	64S-28	64E-28	64E-28	76E-34	76E-34

Reflective Cracking Evaluation – Overlay Test





- CFE gives an indication of the cracking response during the first load cycle (crack initiation phase).
- CFE is the area under the load-displacement curve up to the peak load during the first cycle
- **A high CFE is desirable**, as it indicates that more energy is required to initiate a crack

- The CPR is the exponent of the normalized load reduction curve obtained while the crack propagates under the cyclic loading.
- CPR is used to characterize the flexibility of the specimen as it is indicative of a mixture's resistance to crack propagation.
- **A low CPR is desirable** as it indicates more mixture flexibility.