Short- and Long-Term Performance of Modified SMA Produced with WMA Additives

Imad L. Al-Qadi

Jongeun Baek, Angeli Gamez, Zhen Leng, Jeff Kern,
Hao Wang, Matthew Doyen, and Steven L. Gillen

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Illinois Center for Transportation
University of Illinois at Urbana-Champaign

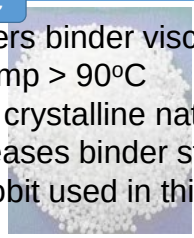
Warm Mix Asphalt

- Technology that reduces production temp
  - WMA: 212-280ºF
  - HMA: 300-350ºF
- WMA expected to perform equal or better than HMA/SMA with enhanced sustainability
- Three main techniques
  - Organic additives
  - Chemical additives
  - Foaming process

WMA Additives

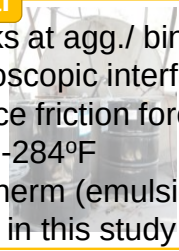
Organic

- Lowers binder viscosity at temp > 90°C
- Fine crystalline nature increases binder stiffness
- Sasobit used in this study



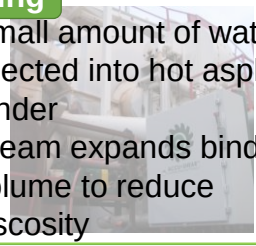
Chemical

- Works at agg./ binder microscopic interface to reduce friction forces, ~185-284°F
- Evotherm (emulsion) used in this study



Foaming

- Small amount of water is injected into hot asphalt binder
- Steam expands binder volume to reduce viscosity



Motivation of the Study

- Illinois Tollway have used SMA widely in their expressway within Chicago area
- Apply WMA to heat-sensitive mixture (polymer or GTR modified) designed for heavy traffic volume

Main objective

Determine short-term performance of warm-SMA via laboratory performance testing and field evaluation

2010 Field Test Sections

- I-355 Southbound
- Driving lane
- MP 21 ¾
- 3” overlay on top of JPCP
- Control and Sasobit SMA

- I-355 Northbound
- Driving lane
- MP 26 ¼
- 3” overlay on top of JPCP
- Control and Evotherm (emulsion) SMA

- I-90 Westbound Genoa Road Ramp
- Foamed asphalt SMA (cold day construction, ~40°F)

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Material Characterization

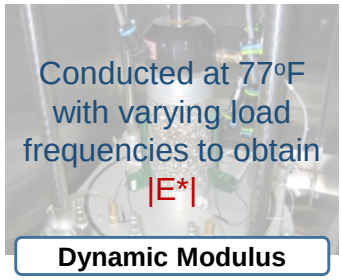
SMA with WMA Additive

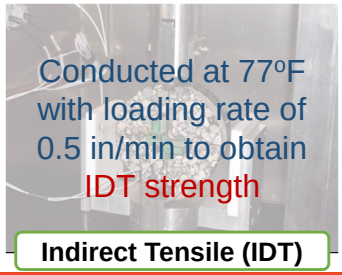
Control SMA Volumetrics

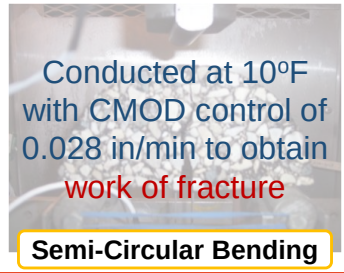
N_{des}	NMAS	Asphalt Content	G_{mb}	G_{mm}	Air void
80	12.5 mm	6.2%	2.440	2.529	3.5%

Mix	Binder	Fine FRAP	RAS	Compaction Temperature (°F)	Warm mix additive (% of binder)	AC (%)	VMA (%)	VFA (%)
Control SMA	PG 64-22 12% GTR	8%	N/A	305	N/A	6.2	15.7	77.7
Evotherm (chemical) WMA-SMA	PG 64-22 12% GTR	8%	N/A	260	0.5%	6.2	15.7	77.7
Sasobit (wax) WMA-SMA	PG 70-22 SBS modified	5%	5%	260-280	1.5%	6.0	16.0	78.1
Foamed SMA	PG 64-22 12% GTR	13%	N/A	260	1.0%	6.0	15.7	77.7

Testing Suite



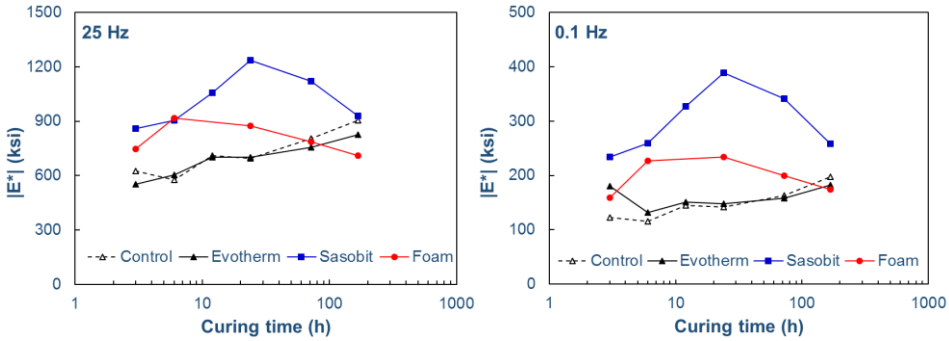




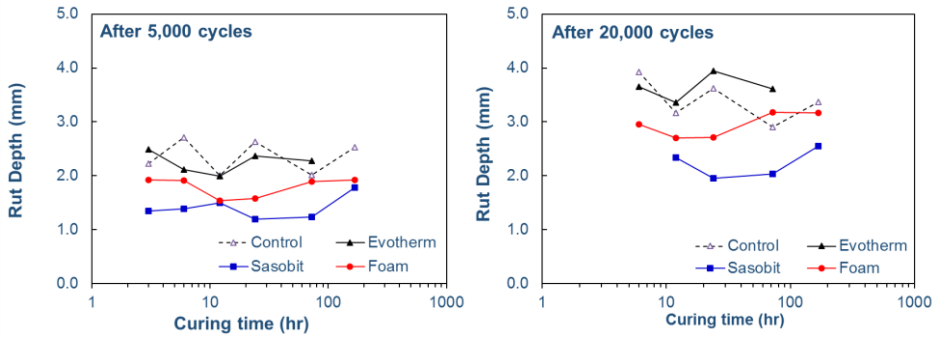
Fast Track Testing

Dynamic Modulus Test Results

- Control and WMA chemical additive (Evotherm) followed the same increasing trend
- WMA wax additive (Sasobit) and foamed WMA experienced modulus increase but converged towards control SMA modulus at 7 days

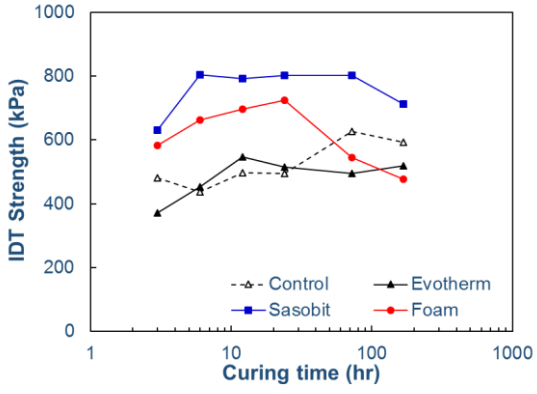


Hamburg Wheel Track Test Results



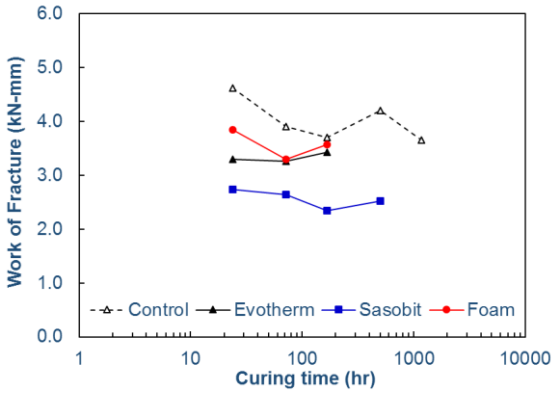
- Compared to the modulus trends, control and Evotherm SMAs had the similar rutting resistance
- Sasobit and foamed warm-SMAs resulted in lower rut depths

IDT Strength Test Results



- Control and warm with chemical additive (Evotherm) SMAs resulted in similar IDT strength
- WMA with wax additive (Sasobit) and foamed warm-SMAs resulted in higher strength values

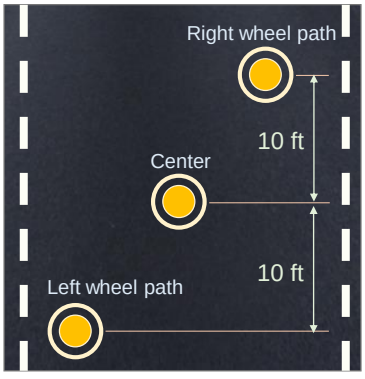
SCB Test Results (-12°C)



- Fracture energy for the control SMA was greater than all warm-SMAs
- WMA with wax additive (Sasobit) resulted in lowest energy values during various curing times

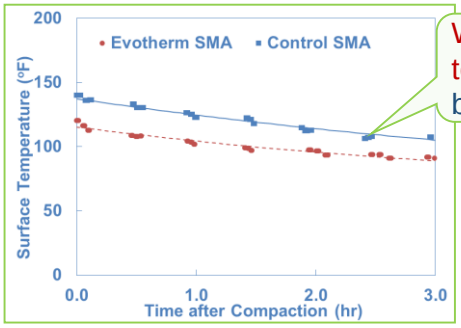
In-Situ Modulus

Surface modulus obtained using a Light-Weight Deflectometer (LWD)

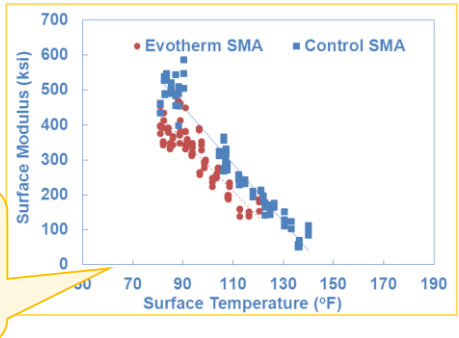


I-355 NB test site

LWD Results



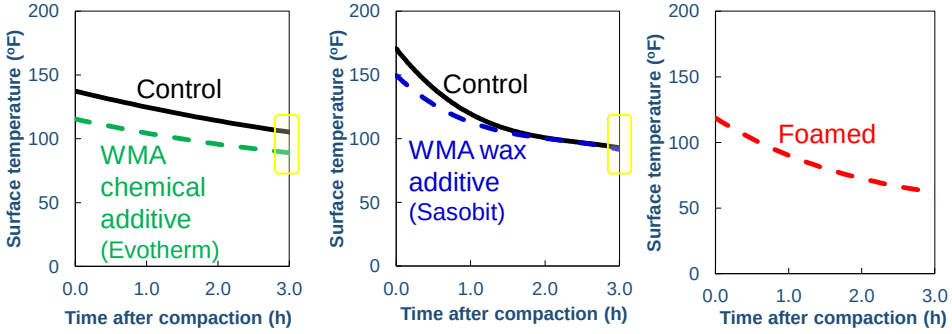
Warm SMA had lower surface temperature than the control SMA but with similar cooling rates



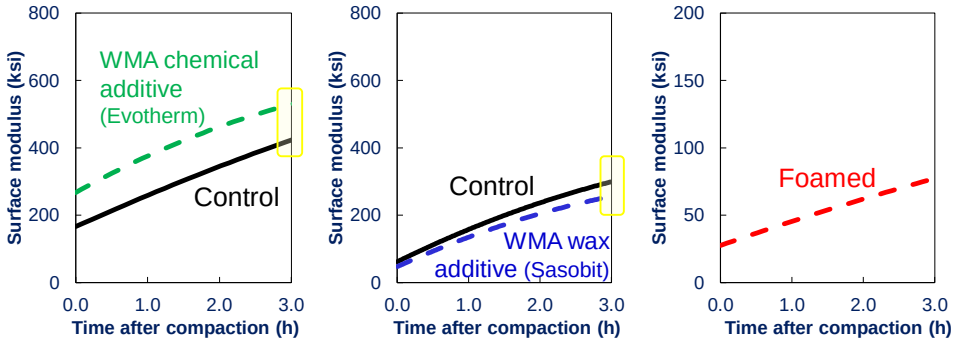
Expected increasing moduli as temperature decreased; at same modulus, warm SMA has lower temperature.

Surface Temperature

- WMA chemical additive resulted in 15% lower surface temperature than control
- WMA wax additive and control SMAs converged to the same surface temperature



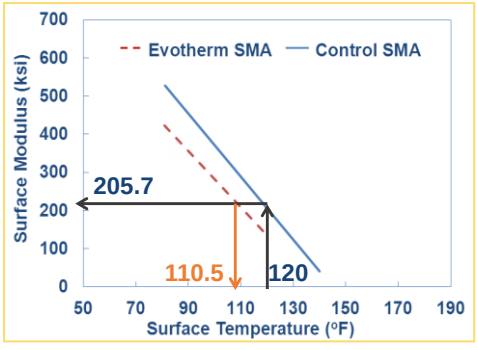
Surface Modulus Variation

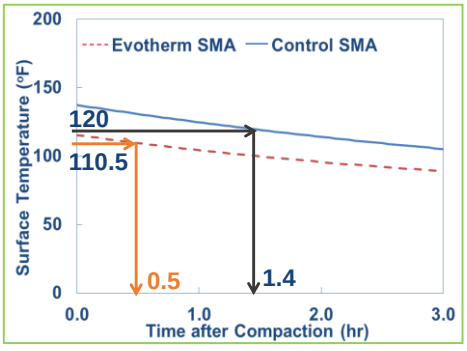


- WMA chemical additive resulted in 33% higher modulus
- WMA wax additive led to 25% lower modulus at relatively close temperatures

Early Opening Time

Use of surface modulus as opening time criterion between control and warm SMAs





Nearly an hour difference between the control and warm SMAs

Test Section Evaluation

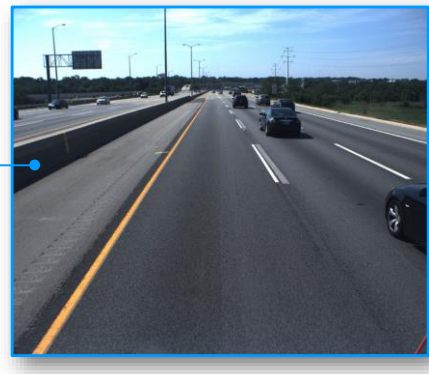
I-355 SB Test Section (Sasobit)

I-355 Southbound

- SMA with Sasobit warm-mix additive
- Constructed in September 2010 over JPCP
- Milepost 21 ¾
- Lane 1 (innermost)
- 2010 ADT = 55,070 (1,391,499 ESALs)

2010

I-355 SB Test Section (Sasobit)

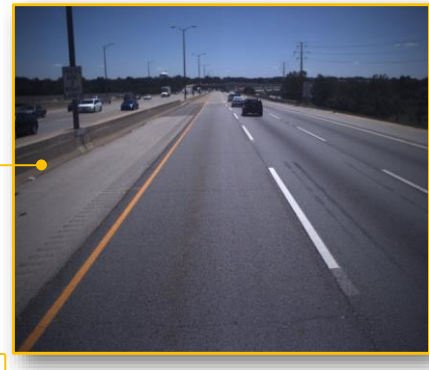


- SMA with Sasobit WMA
- Constructed at Lane 1 (innermost)

2010

2012

I-355 SB Test Section (Sasobit)



- SMA with Sasobit WMA
- Constructed at Lane 1 (innermost)

- Low severity reflective cracks
- Low severity centerline deterioration

2010

2012

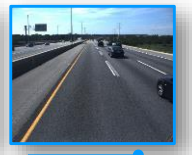
2014

Notice the reflective cracks through warm-SMA?

I-355 SB Test Section (Sasobit)

- SMA with Sasobit WMA
- Constructed at Lane 1 (innermost)

2010



- Low severity reflective cracks
- Low severity centerline deterioration

2012

- Reflective crack width > 0.25 in
- Medium severity centerline deterioration

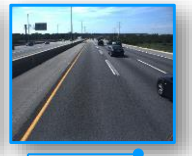
2014

2015

I-355 SB Test Section (Sasobit)

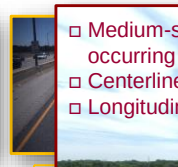
- SMA with Sasobit WMA
- Constructed at Lane 1 (innermost)

2010



- Low severity reflective cracks
- Low severity centerline deterioration

2012



- Reflective crack width > 0.25 in
- Medium severity centerline deterioration

2014

- Medium-severity reflective cracks frequently occurring
- Centerline deterioration with spalling
- Longitudinal cracking at mid-lane

2015

2016

I-355 SB Test Section (Sasobit)

- SMA with Sasobit WMA
- Constructed at Lane 1 (innermost)

2010

- Low severity reflective cracks
- Low severity centerline deterioration

2012

- Reflective crack width > 0.25 inch
- Medium severity centerline deterioration

2014

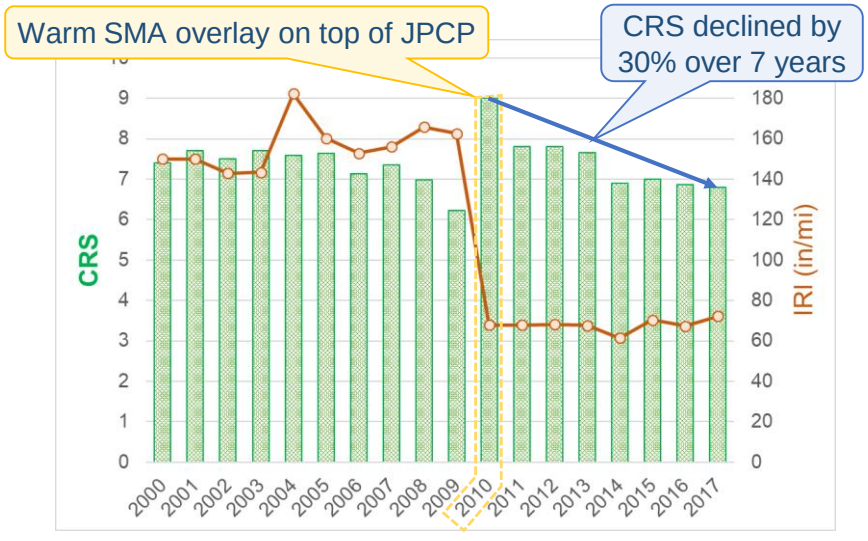
- Same distress and severity levels as in 2014 evaluation

2015

- Increase severity and frequency of distresses
- Mid-lane longitudinal cracking

2016

Sasobit SMA Performance

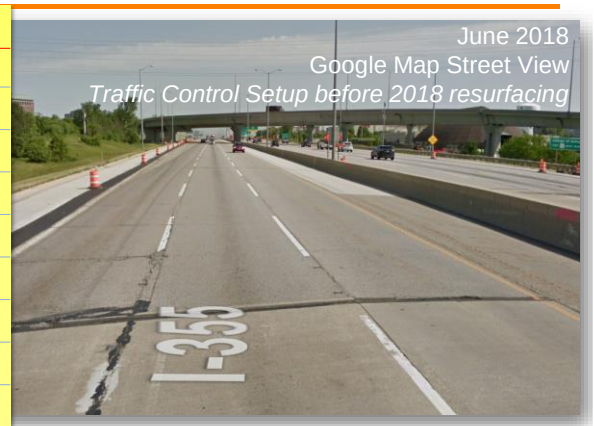


I-355 SB Test Section

Evaluation Notes

- ✓ Sasobit SMA
- ✓ Reflection cracks
- ✓ Centerline deterioration
- ✓ Overlaid patch reflective cracks
- ✓ Longitudinal cracks (mid-lane)

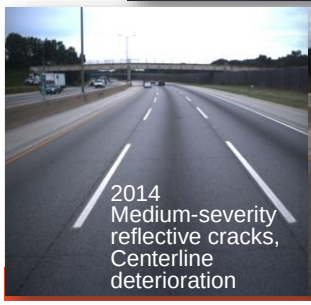
CRS (2017) = 6.82

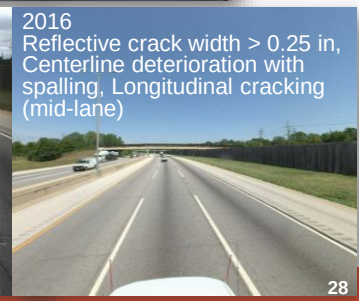


First major rehab of section since the section was constructed in 2010

I-355 NB Test Section (Evotherm)

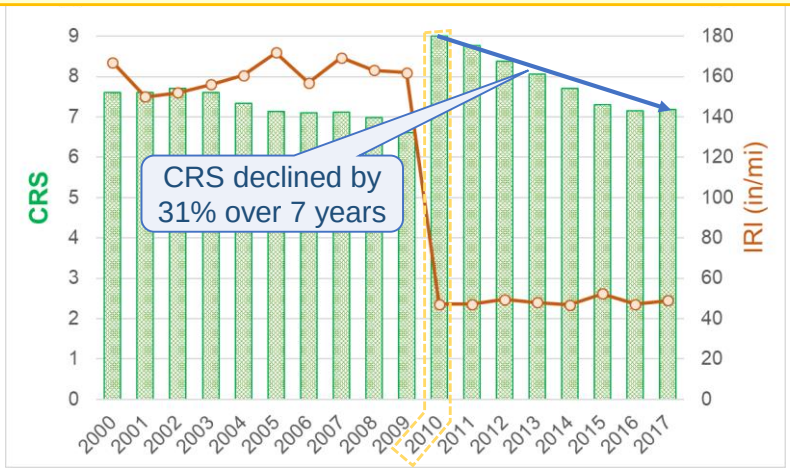
Similar to SB section, first major rehab in 2018



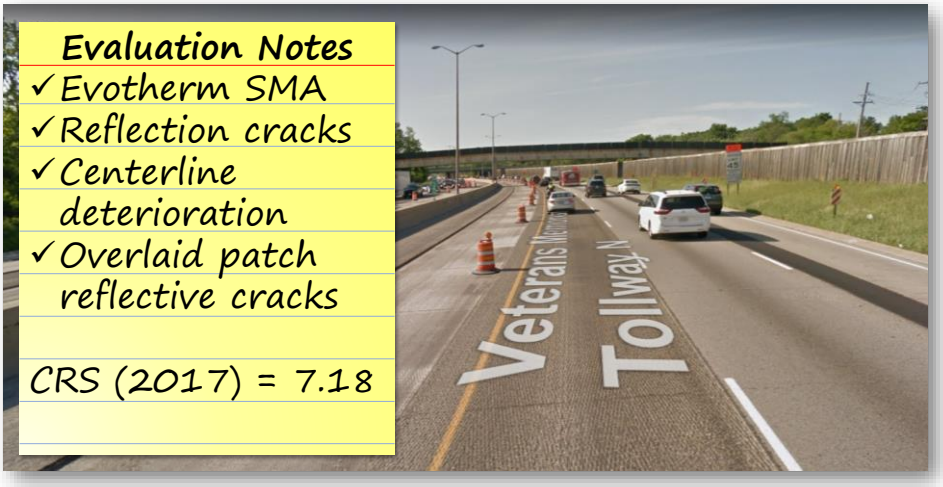


Evotherm SMA Performance

Sasobit and Evotherm SMA sections performed similarly



I-355 NB Resurfacing



I-90 Genoa Ramp Test Section

2016 ADT = 4,600

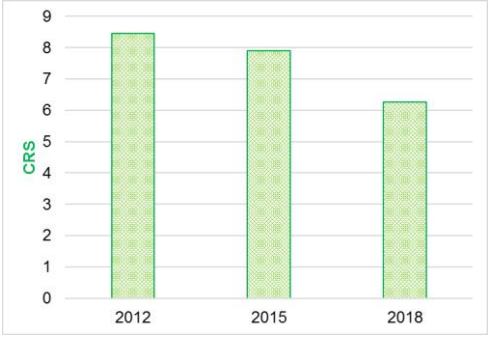
I-90 WB Ramp Resurfacing

Evaluation Notes

2018 Distresses

- ✓ Block cracks
- ✓ Alligator cracks
- ✓ Joint reflection cracks
- ✓ Centerline deterioration

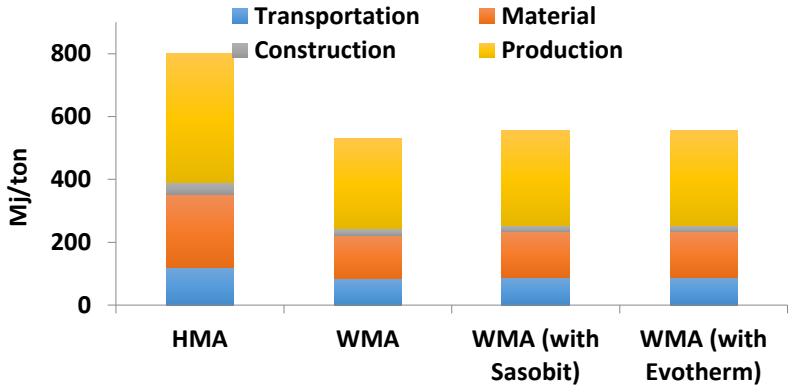
CRS (2018) = 6.26



Ramp evaluation completed every 3 years

Energy Consumption

Item	Reduction due to WMA
GHG, mt	32.7%
CO (g/ton)	8.63%
VOC (g/ton)	69.42%
NOx (g/ton)	51.3%
SO2 (g/ton)	19.64%



Summary

- In general, warm-SMA showed comparable performance with control SMA
- Lab and field data suggested that pavement w/ warm SMA may be open to traffic earlier, wherein threshold is needed.
- Heavily trafficked expressway sections with warm-SMA had eight years of service life
- Incorporating GTR, RAP, and RAS should be carefully evaluated for optimized use

Acknowledgements

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Illinois Tollway

ARA

S.T.A.T.E. TESTING

Contractors: Geneva, K-Five, and Rock Road

Thank You

Any Question?

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