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WISCONSIN ASPHALT PAVEMENT ASSOCIATION

WisDOT Experiences with SMA

NAPA International SMA Conference
Atlanta, GA
November 6, 2018

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Overview

- Historical Perspective
- Evolution of Specifications
- Best Practices
- Challenges
- Future Needs for SMA

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WisDOT SMA Pilot Program Overview

- Prior to this effort the first SMA in the US was placed on I-94 near Waukesha, WI (1991)
  - Partnering effort between WisDOT and Industry
  - 6 projects located throughout the state
  - Constructed between 1992 and 1994

Objectives

1. Evaluate ease of construction of different SMA pavement types
2. Compare performance against standard HMA pavement

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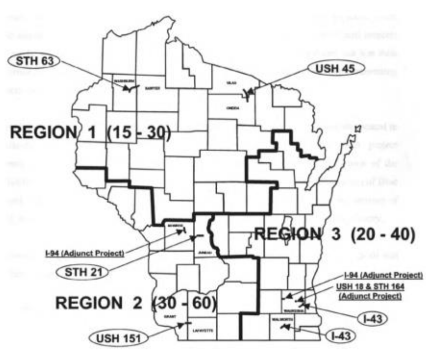
WisDOT SMA Pilot Program



Location of SMA Projects and Control Sections
Regions Separated by LA Wear Values

- **Factors investigated**
  - Traffic
  - Aggregate LA Wear
  - Stabilizer type & dosage
  - NMAS (5/8” vs. 3/8”)
  - Base material
- **Performance monitoring after 5 years**
- **Performance measures**
  - Pavement Distress Index (PDI)
  - Ride - IRI
  - Rutting/Cracking
  - Friction and Noise

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WisDOT SMA Pilot Program

Detailed Project Information

Project	Base Pavement	ADT/Yr. Const.	Max Agg. Size	Hardness Region	LA Wear
I-43, Waukesha	CRCP	42,200 1992	3/8" (9.5 mm)	3	26
I-43, Walworth	JRCP	11,650 1993	5/8" (16 mm)	3	27
USH 151, Lafayette	AC over thin-edged PCC	6,350 1993	5/8" (16 mm)	3	38
STH 21, Juneau	AC over dense base over PCC	4,200 1994	3/8" (9.5 mm)	2	31
USH 45, Vilas and Oneida	AC	5,940 1993	5/8" (16 mm)	1	21
STH 63, Washburn	AC	5,872 1993	3/8" (9.5 mm)	1	24

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WisDOT SMA Pilot Project

Test Section Layout

Test Section	Description
F1	SMA w/Cellulose Fiber Stabilizer
F2	SMA w/ Mineral Fiber Stabilizer
P1	SMA w/Polymer (Thermoplastic) Stabilizer (Low Dosage)
P2	SMA w/Polymer (Thermoplastic) Stabilizer (High Dosage)
E1	SMA w/Polymer (Elastomeric) Stabilizer (Low Dosage)
E2	SMA w/Polymer (Elastomeric) Stabilizer (High Dosage)
Control	Dense Graded Asphalt Mix

- Minimum 4000 foot test sections
- Minimum total project length = 5.5 miles

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WisDOT SMA Project

Construction Details

- Mixing and Laydown Temperatures:
  - 295 - 310°F/ 285 - 300°F
- Rolling Pattern:
  - Tightened for SMA to account for faster mix cooling
- Density:
  - 91% to 93% by nuclear density gauge (Spec = 92%)
  - FHWA core density minimum = 94%
  - Follow up efforts indicated an offset between core and nuclear gauge readings

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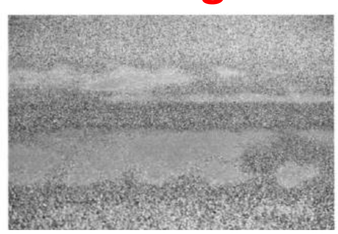
WisDOT SMA Pilot Project

Construction Issues - Bleeding

- Higher temperature sensitivity observed for PMA mixes
  - Draindown above 305°F
  - Sticking in truck box below 290°F
- Projects constructed well before the invention of WMA/compaction aide additives



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WisDOT SMA Pilot Project

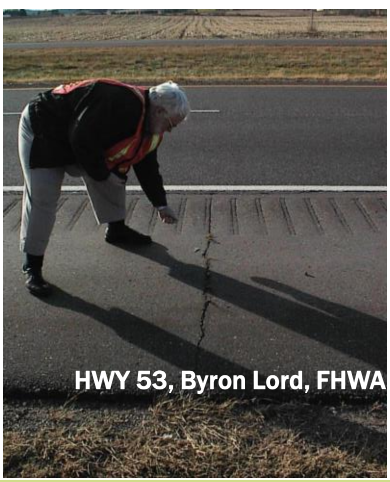
Performance – Cracking and PDI

Test Sections (LA Wear Region)	% Cracking			PDI		
	Mean SMA	Mean Control	%Diff.	Mean SMA	Mean Control	%Diff.
STH 63 (Reg 1)	26	69	-63%	24	48	-51%
STH 21 (Reg 2)	72	78	-7%	20	27	-26%
I-43 Wauk. (Reg 3)	48	68	-29%	21	38	-45%
USH 45 (Reg 1)	11	12	-6%	19	13	49%
USH 151 (Reg 2)	52	67	-22%	25	30	-16%
I-43 Wal. (Reg 3)	6	38	-84%	18	47	-62%

- Pavement was surveyed pre-overlay. Cracking extent was used as a baseline to evaluate SMA effectiveness
- PDI = f(Cracking, Flushing, Ravelling, Rutting). PDI > 60 triggers rehab.

SMA Field Survey

Resistance to Reflective Cracking

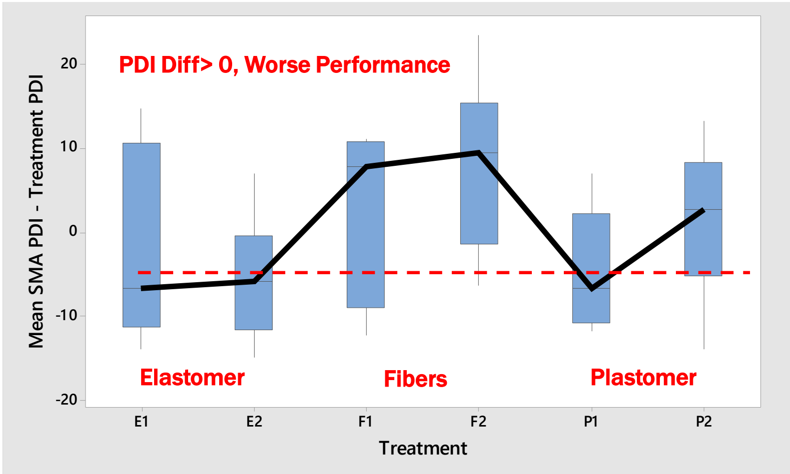


- Overlay of existing PCC. SMA used for mainline, HMA for shoulders
- Low to moderate severity crack observed in shoulder
- Crack growth immediately stopped at SMA

Mechanisms of Crack Prevention

- Gap-Graded Aggregate structure
- High asphalt content
- Polymer modified asphalt

WisDOT SMA Pilot Project
Performance – Effect of Stabilizers



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WisDOT SMA Pilot Project
Conclusions

- Cracking resistance: SMA 30% to 40% improvement
  - Results consistent with NCHRP Report 425 (Brown, 1999)
- Pavement performance (PDI): SMA 40% improvement
- Effect of mix components:
  - LAR: High quality aggregate (low LAR) had 52% better cracking resistance than HMA. High LAR 14% better.
  - Stabilizers: All performed better than HMA, use of fibers resulted in the least performance improvement
- Overall the pilot project was a success and led to use of SMA in Wisconsin

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Evolution of SMA Specifications

Key Aspects

- Mix Design
  - Maximum aggregate size
  - Selection of gyration levels
  - Recycled materials
- Test Strip
  - Main objectives
  - Acceptance
- Density Testing
  - Nuclear gauges vs. cores

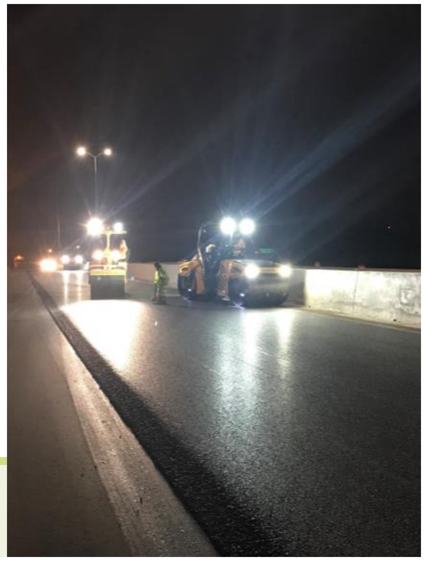
Evolution of SMA Specifications

Mix Design

Parameter	Past	Current	Discussion
NMAS	12.5 mm	12.5 mm & 9.5 mm	Success with smaller NMAS mixes. Allows for thinner lifts and has higher VMA
Design Gyrations	75	65	Adjustments made to address varying aggregate hardness throughout the state
Recycled Materials	None	RAP, RAS, or FRAP up to 15% PBR	Work has shown benefits of using recycled binders. 15% PBR limits risk.
WMA Additives	Didn't exist	Allowed	Draindown is influenced by viscosity. WMA additives help the temperature sensitivity issue referenced in the pilot project.

Evolution of SMA Specifications
Test Strip & Density Testing

- Purpose of Test Strip
  1. Verify mix meets volumetric requirements
  2. Establish rolling pattern
  3. Correlate nuclear gauge to cores (post gauge to gauge correlation)
  4. Verify mix integrity (i.e. no broken aggregate)



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Evolution of SMA Specifications
Test Strip & Density Testing

- Density Testing
  - Past: Acceptance based on mean of 12 nuclear density readings from the test strip
  - Current: Gauge vs. Core correlation accomplished in the test strip and used throughout the project
  - Target density = 93% G_{mm}

WI STH 53, 2011

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SMA Best Practices
Contractor Perspective

Numerous SMAs with 10 to 15 years performance history

- Stabilization:
  - Polymer modified asphalt (PMAC): Low temperature grade of -28°C and "H" or "V" modification
  - Fines: Off spec fly ash (6% to 8%) has been used for economics and sustainability (i.e. keep material out of landfill). Also used lime fines on numerous SMA projects.
  - Successfully used WMA additives and reduced plant temps
  - Fibers have been used successfully as well with and without PMAC
  - RAS has had a positive impact on mixtures (<5% by weight)

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SMA Best Practices
Contractor Perspective

- Aggregate: Wear resistant and consistent gradation, particle shape is critical (cubical particle shape coarse and fine)
- Lab: Limit technicians for consistency with sampling and splitting of materials. Keep utensils/equipment clean.
- Construction: Emphasize consistency in paver speed, rolling pattern (breakdown roller close to paver), etc…
- Production:
  - Heat the plant prior to shipping mix to the project (add AC for the last ~5 tons)
  - Proper loading to prevent segregation
  - Consistent mix production rates including feed rates of fillers/fibers/dust/recycle/etc…
  - Mix is temperature sensitive

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SMA Challenges
Contractor Perspective

- Consistency of off-spec fly ash
  - Material is a by-product. Lime and moisture content can vary.
  - Variance causes clumping and other issues with feed
  - Improvement observed with lime fines
  - Filler and fines are not the same. Fines reincorporated into mix should be that from the SMA design aggregates.
- Binder and Stabilizer selection for northern climates
  - Recent spec. changes requires a PG XX-34 for northern WI. Is thermal cracking a concern with SMA? Is the softer binder grade needed?
  - If yes confirm stabilizer. Increased polymer? Others?

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SMA Challenges
Contractor Perspective

- Eliminate draindown/bleeding issues in the field
- Mix trouble shooting can be different for SMA
- Tack bonding is critical to achieve proper compaction
- Focus on density along the longitudinal joint
- QC/QA testing inconsistencies
  - Significant differences in QC and verification testing
    - Try to run mixtures hot to hot as much as possible
    - Discuss comparison testing prior to start up
    - Required use of CoreLok® to establish Gmb
    - Larger sample sizes for additional specimens (Gmm/Gmb)
  - Communication: Review test protocols before project
  - Training: Regular industry/agency joint SMA testing workshops

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SMA Next Steps
Mixture Performance Testing

1. **Performance based selection of stabilizer system & AC Content**

2. **Quality Assessment**

- Draindown
- Aging resistance
- Moisture Damage Resistance
- Other aspects unique to SMA?

- Is current drain down test sufficient?
- Design mix based on performance, adjust for draindown if needed

SMA Next Steps
Mixture Performance Testing

- Limits: SMAs are considered high quality products, define testing requirements accordingly
- Transition from prescriptive to performance based specification Examples:
  - Is PG 58S-28 + Fibers equivalent to PG 58H-28 + Filler?
  - Evaluating need for PG XX-34 grades in SMAs
  - Evaluate higher levels of modification
- Quantitative evaluation of new products
  - Inclusion of RAP/RAS or GTR. How much?
  - Plastomers vs. Elastomers
  - Different stabilizers (fibers, fillers, etc.)
- Utilize more statewide and give credit for additional service life

SMA Next Steps

Performance Testing Examples - TxDOT

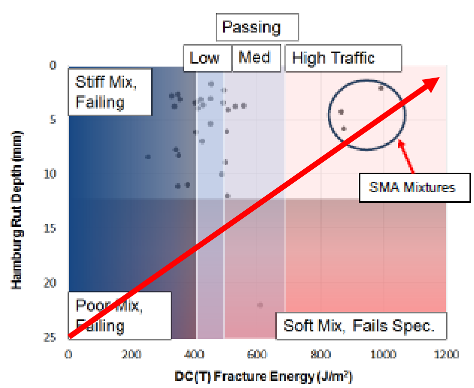
Table 3. CTIndex Criteria for Asphalt Mixes (Zhou et al. 2018).

Mix Type	CT_{Index}	OT Cycles
Crack Attenuating Mix	320	750
Thin Overlay Mix	185	300
SMA	145	200
Superpave mixes	105	120
Dense-graded mixes	65	55

- Results suggest that SMA mixes have higher cracking resistance than conventional surface courses

SMA Next Steps

Performance Testing Examples Illinois



Improving Performance

Figure 12. *Hamburg-DC(T) Plot for Recent Mixtures Tested in Illinois, with Typical Specification Limits Superimposed.*

SMA Next Steps

Performance Testing Examples – IL Tollway

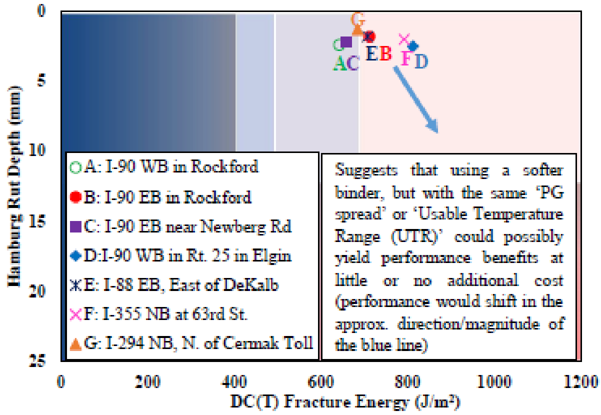


Figure 8. *Performance-space diagram of test sections.*

All SMA Mixes

- Minimal rutting
- High fracture energy

Thank You!!!!

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