STONE MASTIC ASPHALT

Kim Schofield, PE

Washington Asphalt Pavement Association

Technical Director

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OUTLINE

- SMA Fundamentals
- SMA Benefits
- When and where to use SMA
- Costs
- Performance
- WSDOT Project Experience
- Summary

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WHAT IS SMA?

- Stone Mastic Asphalt or Stone Matrix Asphalt
  - Has both mastic and a strong aggregate matrix
- When constructed correctly, it is deformation-resistant and can be used for roadways that need durability
  - Resistant to studded tire wear
- It has a high cubical coarse aggregate content that interlocks and forms the stone skeleton that resists permanent deformation – the Matrix
- Then the stone skeleton is filled with a Mastic – a combination of the binder and mineral filler
- Fibers are usually added as well to prevent draindown

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SMA COMPOSITION

- 65-80% Coarse Aggregate
- 15-25% Fine Aggregate
- 8-12% Filler
- 6.0-7.0% Binder
- 0.2-0.4% Fiber

- 100% crushed aggregate
- Low water absorption

Mix Design Targets

- Air Voids of 4.0%
- VMA of >18%
- $VCA_{drc} > VCA_{mix}$
- Hamburg (SIP)
- IDT

- In-place density target of 94% minimum
  - No vibratory roller

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AGGREGATE STRUCTURE – CONTROL POINTS

HMA is Dense-Graded

Class ½”

SMA is Gap-Graded

Percent Passing

100
90
80
70
60
50
40
30
20
10
0

#200 #50 #40 #10 #8 #4 1/4" 3/8" 1/2" 3/4"

Sieve Size

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HMA ½" VS. SMA ½" GRADATION CONTROL POINTS

Sieves	½" HMA		½" SMA	
	JMF	Control Points	JMF	Control Points
¾"	100	99-100	100	100
½"	94	90-100	93	90-98
3/8"	82	90 max	65	59-71
#4	54		29	21-31
#8	35	28-58	19	16-23
#200	5.9	2.0-7.0	10.6	8.6-11.0

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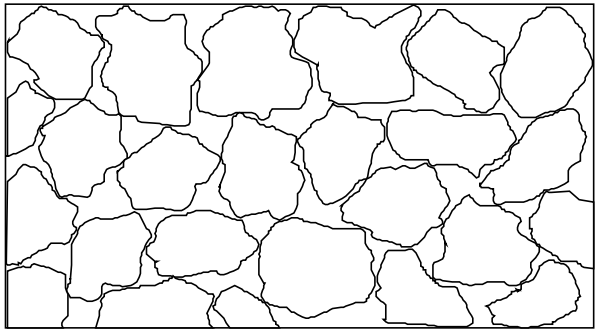
SMA

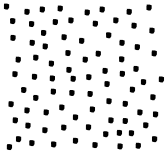
Stones

Stone Skeleton

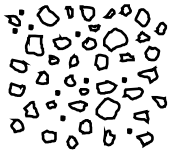


Mastic

Filler

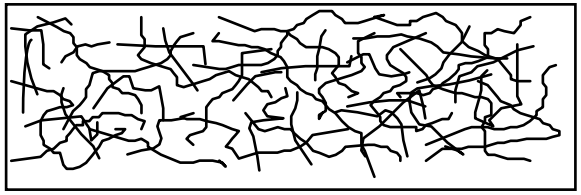


Sand



Binder

Fibers



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SMA SURFACE TEXTURE

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SMA CONSTRUCTION DETAILS

- Only steel wheel rollers – no vibratory mode
- Need material transfer device
- Roller train close to paver
- In-place density target of 94%
- Draindown/fat spots
- Higher temperatures

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SMA BENEFITS

- Deformation resistant
- Resists studded tire wear
- Reduced splash and spray
- Increased wet weather friction – after initial paving
- Low tire-pavement noise due to macro-texture (for a while)
- Less severe reflective cracking
- Increased pavement life
- Usually used as a wearing course with heavy traffic loads and/or slow-moving vehicles

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WHEN AND WHERE TO USE SMA

- Highways or roadways with high percentage of trucks/heavy loads
- Pavements susceptible to rutting (not structural rutting)
- Intersections
- Bus locations
- Gradients
- Runways
- Bridges

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SMA COSTS

- 25 to 50 percent higher than conventional mix, due to:
  - 100% crushed aggregates and ability to meet gradation
  - Fibers
  - Modified binder
  - Fly ash

- Added cost is offset by increased performance
  - Typically 2-8 years or more
  - SR 524 - +8 years from last overlay
  - I-90 Moses Lake - +2 years from EB and still in place

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SMA COST PER TON

SR	Section	Year	SMA Cost	HMA Cost	SMA tonnage	Still in place
524	64th Ave W	1999	$72.50		5,800	Yes
90	Ritz to Tokio	2000	$34.00		17,500	No
90	SR21 to Ritz	2001	$28.00	$23.50	3,195*	No
90	Moses Lake	2004	$41.50	$23.50	21,617	Yes
90	SR21 to Ritz	2019	$90.00	$70.00	26,217	Yes

*Note: This SMA was meant to be a much larger tonnage, hence the smaller cost difference.

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SMA COST COMPARISON EXAMPLES

HMA ½ inch PG 64-28 @$36.00/ton = $145,576/ln-mi

SMA ½ inch PG 76-28 @$50.00/ton = $166,592/ln-mi

Typical pavement life of HMA on East side of state = 12 years
(longer life with preventive maintenance)
Annualized cost - $15,500

Pavement life required for SMA (same annualized cost)

14.5 years

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SMA PAVEMENT LIFE

SR	Section	Year Placed	Still in place	Pavement Life
524	64th Ave W	1999	Yes	***24***
90	Ritz to Tokio	2000	No	<1
90	SR21 to Ritz	2001	No	18
90	Moses Lake	2004	Yes	***19***
90	SR21 to Ritz	2019	Yes	***4***

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WSDOT EXAMPLE PROJECTS

- SR-524, Lynnwood (1999)
- I-90, Ritzville to Tokio (2000)
- I-90, SR-21 to Ritzville (2001)
- I-90, Moses Lake West (2004)
- I-90, SR 21 to Ritzville (2019)

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SR-524, LYNNWOOD

- 64th Avenue Vicinity to I-5
- Placed in 1999
- ADT = 37,000 with 4% trucks
- 1,700,000 $ESALS_{15}$
- Distress prior to SMA
  - Intersection shoving, flushing, raveling, patching and cracking
- Rehabilitation treatment
  - Grind and inlay with 0.15 ft SMA (1/2 inch) PG64-22
  - Grind and inlay with 0.20 ft SMA PG64-22 at intersections

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Fat Spots (2004)

Intersection Approach (2004)

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44th Avenue Intersection Approach (2004)

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44th Avenue Intersection Approach (2004)

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Minor Intersection Approach (2004)

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I-90, RITZVILLE TO TOKIO

- Placed in 2000
- ADT = 8,000 with 24% trucks
- 16,000,000 $ESALS_{15}$
- Distress prior to SMA
  - Rutting, raveling and cracking
- Rehabilitation treatment
  - Grind and inlay with 0.15 ft SMA (1/2 inch)
  - Outside lane (EB and WB)

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I-90, RITZVILLE TO TOKIO

- Binder – PG64-34
- Potential causes of failure
  - Gradation coarser than JMF
    - Resulting in high AC
  - Use of vibratory roller
  - Flushing due to windrow material left in place
  - Insufficient mixing of fiber and mineral filler
  - Insufficient fiber quantity
  - Couldn't control volumetrics
  - Soft binder

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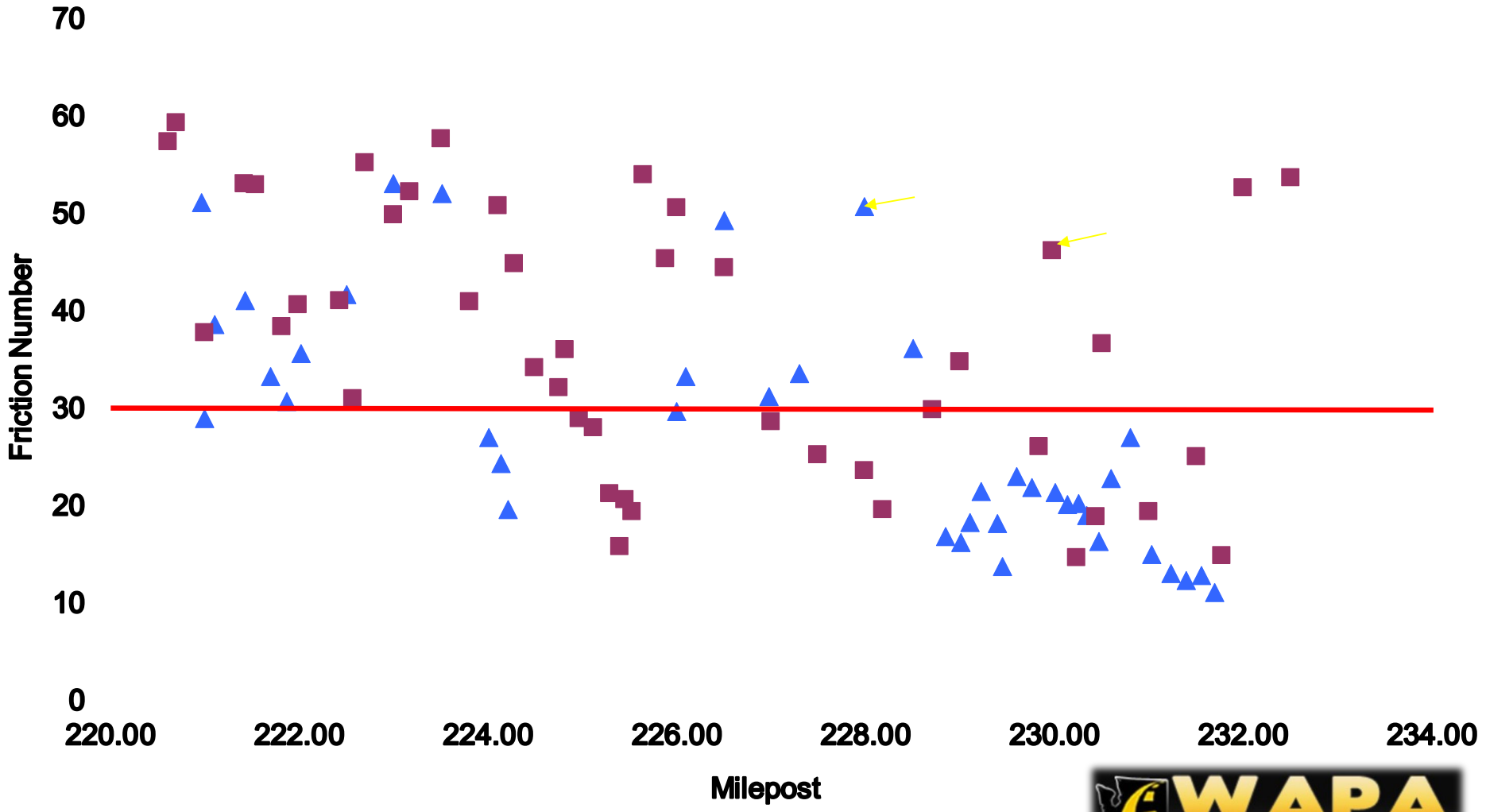
I-90, RITZVILLE TO TOKIO



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I-90, RITZVILLE TO TOKIO

- Summer 2001 Contract
  - Remove SMA
  - Replace with Superpave
    - This too has rutted…but that's another story that we won't get into!

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I-90, SR-21 TO RITZVILLE

- Placed in 2001
- MP 211.53 to 214.28
- ADT = 4,900 with 23% trucks
- 7,000,000 $ESALS_{15}$
- Distress prior to SMA
  - Rutting and cracking
- Rehabilitation treatment
  - Grind and inlay with 0.20 ft SMA (1/2 inch)
  - Outside lane and shoulder (WB)
- Binder – PG76-28

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I-90, SR-21 TO RITZVILLE

- This was mostly HMA with a short SMA section of 3,000 tons
- Had better control of the gradation, mineral filler and binder but still struggled with VMA and Air Voids
- This section of SMA outlasted the companion HMA

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I-90, SR-21 TO RITZVILLE

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I-90, SR-21 TO RITZVILLE

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I-90, SR-21 TO RITZVILLE

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I-90, MOSES LAKE WEST

- Dodson Road to Prichard Road
- Placed in 2004
- ADT = 6,000 with 23% trucks
- 10,000,000 $ESALS_{15}$
- Distress prior to SMA
  - Alligator and transverse cracking as well as rutting
- Rehabilitation treatment
  - Overlay with 0.20 ft SMA (1/2 inch)
  - Full roadway width (EB)
- Binder – PG76-28

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I-90, MOSES LAKE WEST

- Required VMA was 18% minimum
  - Had to adjust the gradation to meet this requirement
- Did have some draindown issues during construction

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SURFACE TEXTURE

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REFLECTIVE CRACKING – SMA VS. HMA

SMA in lane

HMA placed 1 year later 1 mile W of SMA

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I-90 MOSES LAKE – AFTER CONSTRUCTION

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I-90 MOSES LAKE – COMPARISON

2004

2023

I-90 MOSES LAKE

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19 YEARS OLD
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I-90 SR21 TO RITZVILLE

- Placed in 2019
- ADT was 12,000 with 21.7% trucks
- 8,600,000 $ESALS_{15}$
- Distress prior to SMA
  - High rutting and severe fatigue and transverse cracking
- Rehabilitation treatment
  - Grind and inlay with 0.15 ft SMA (1/2") & 3/8" HMA
  - Outside lane/shoulder & Inside lane/shoulder
- Binder – PG64V-28

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I-90 PRIOR CONDITION

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I-90 CONSTRUCTION

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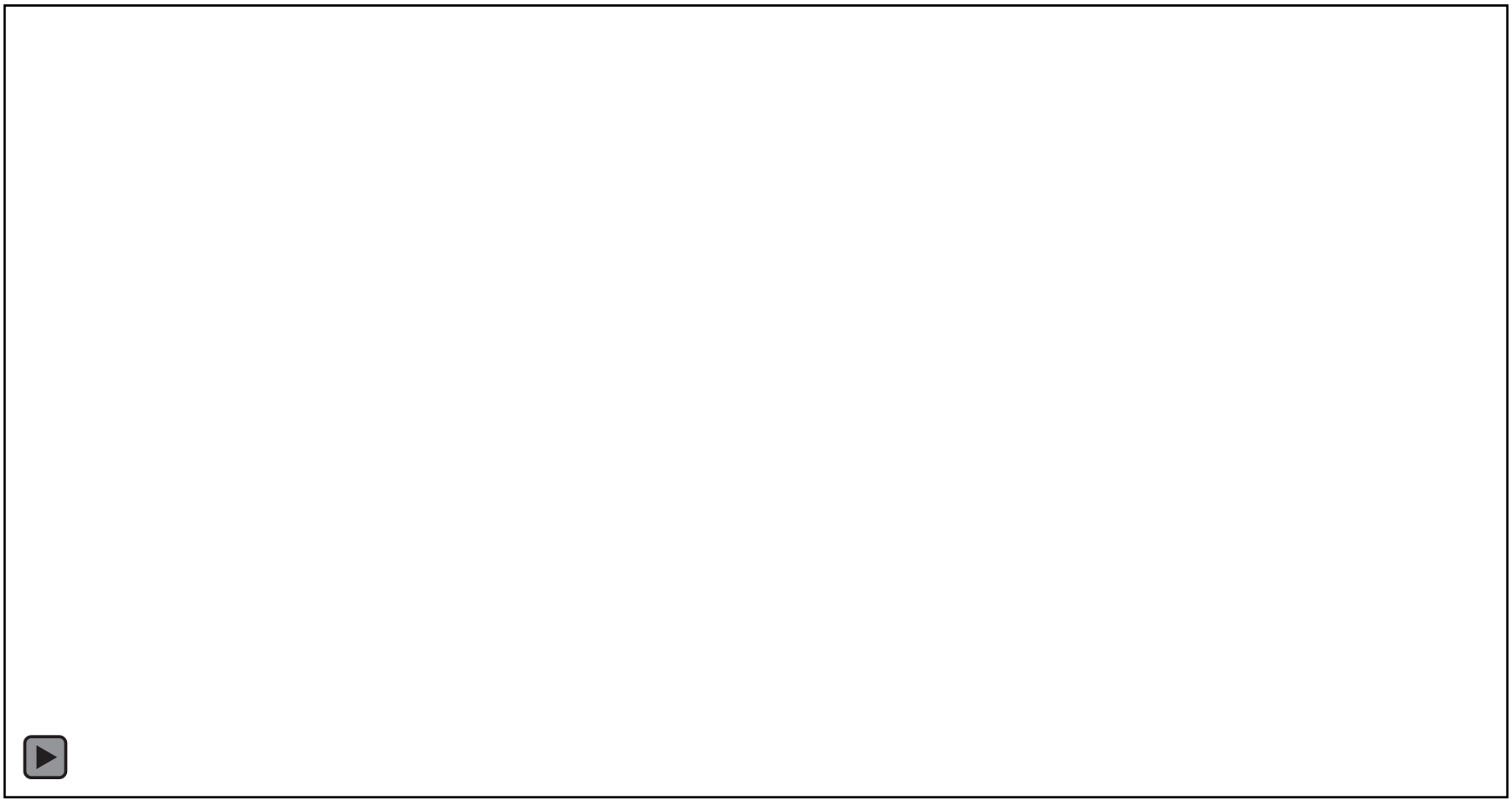
I-90 CONSTRUCTION



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COMPACTION

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SURFACE TEXTURE

FAT SPOTS AND JOINT DURING CONSTRUCTION

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2023 CONDITION

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POTENTIAL CHALLENGES

- Good quality, hard, cubical aggregate
- Ability to get fly ash
- No RAP allowed (right now)
- Constructability
- GGE/LCA
- Biggest performance issues can include the ability to meet volumetrics and draindown

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BENEFITS OF SMA

- Longer life
- Resistance to rutting
- Improved friction
- Lower cracking progression (even reflective cracking)
- Reduced splash and spray
- Lower noise

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SUMMARY

- SMA can work very well and have a long pavement life
  - Typical WSDOT HMA pavement life:
    - East side – 12 years
    - West side – 17 years
  - SMA pavements life
    - East side – 18 and 19 years (and counting)
    - West side – 24 years (and counting)
- Proper preparation from crushing to laydown critical to success!

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QUESTIONS

Kim Schofield, PE

Technical Director

Washington Asphalt Pavement Association

Kim.Schofield@AsphaltWA.com

(360) 561-4271

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