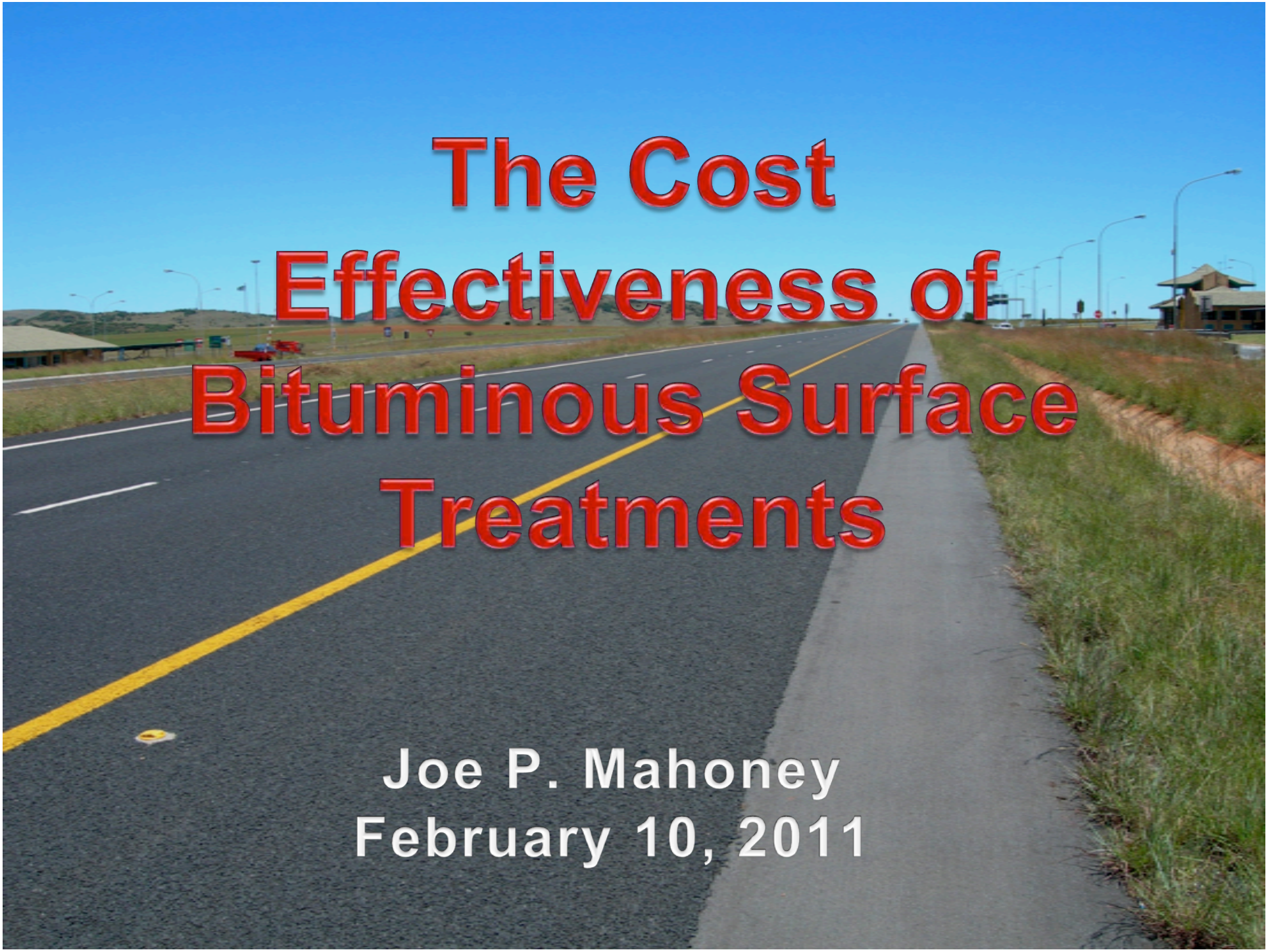
The Cost Effectiveness of Bituminous Surface Treatments
Joe P. Mahoney
February 10, 2011

Outline

- WSDOT Preservation Statistics and Costs
- Preservation Costs and Lives
- Life Cycle Cost Analysis
- Pavement Distress Considerations
- Continuous Improvement

Cost Effectiveness

- What do we mean by "cost effectiveness."
  - Costs should include a life cycle view
  - When to place a chip seal?
  - How best to place a chip seal?
  - How to design a chip seal?
  - How long will it last?

Before going any further…

Typical BST Gradations

Our favorite

Sieve Size	South African 9.5 mm	Minnesota (FA-3)	Minnesota (FA-4)	WSDOT		
				½-No.4	3/8-No.4	Choke No.4-0
3/4	--	--	100			
5/8	--	--	--	100	--	
1/2	100	100	90-100	90-100	100	
3/8	85-100	85-100	40-70	60-85	70-90	100
1/4	0-30	40-70	0-15		--	--
No.4	0-5	0-15	0-5	0-3	0-5	76-100
No.8	--	0-5		--	--	--
No.10	--	--		--	--	30-60
No.40	--	--		--	--	--
No.200	0-1	0-1	0-1	0-1.5*	0-1.5*	0-10

WSDOT gradations from 2010 Standard Specifications.
MnDOT gradations from 2005 Standard Specifications.

Typical BST Gradations

Similar

Sieve Size	South African 9.5 mm	Minnesota (FA-3)	Minnesota (FA-4)	WSDOT		
				½-No.4	3/8-No.4	Choke No.4-0
3/4	--	--	100			
5/8	--	--	--	100	--	
1/2	100	100	90-100	90-100	100	
3/8	85-100	85-100	40-70	60-85	70-90	100
1/4	0-30	40-70	0-15		--	--
No.4	0-5	0-15	0-5	0-3	0-5	76-100
No.8	--	0-5		--	--	--
No.10	--	--		--	--	30-60
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Typical BST Gradations

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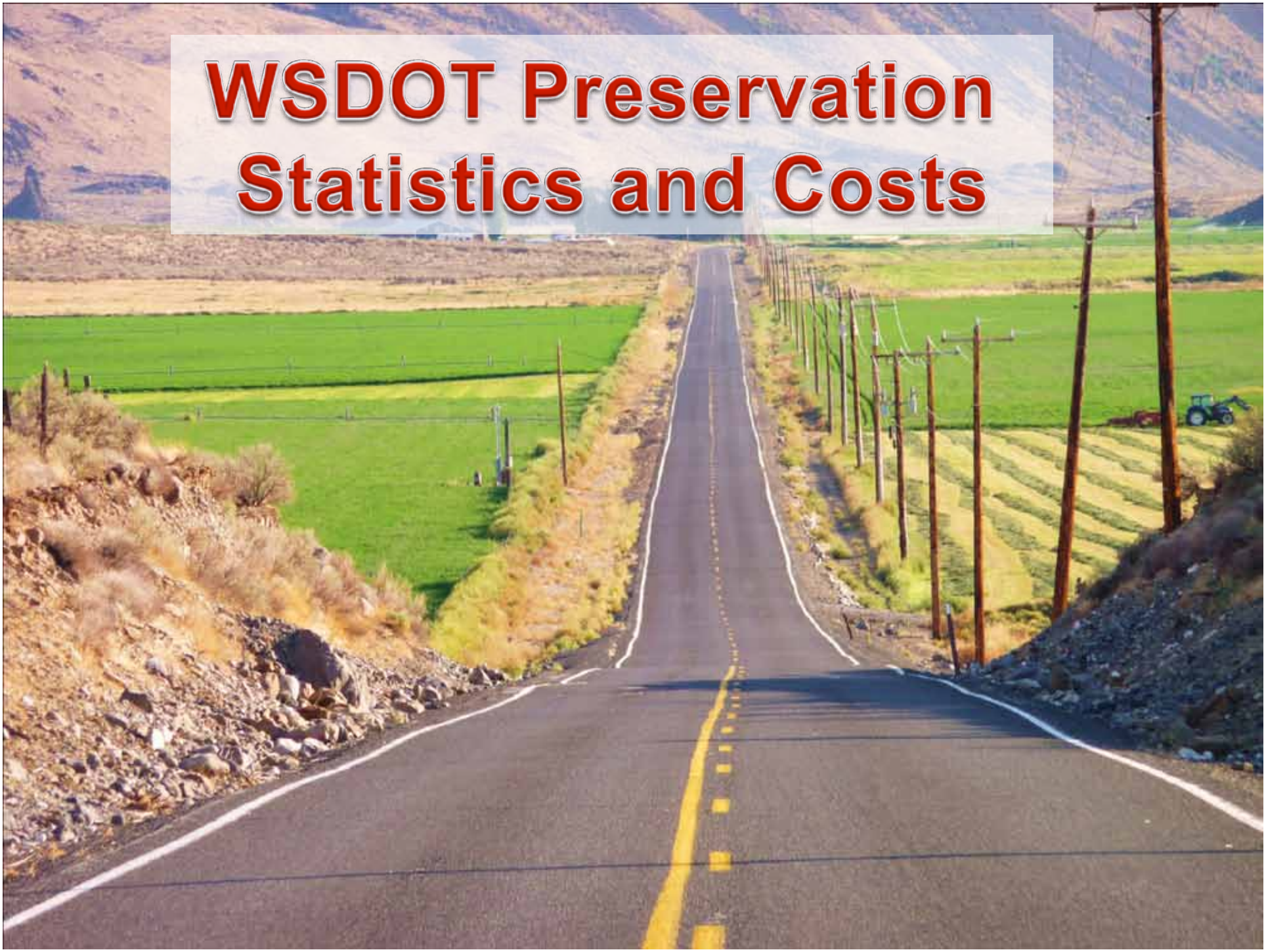

WSDOT Preservation
Statistics and Costs

WSDOT Lane-Miles by Pavement Type

Type of Pavement	Lane-miles	% of Total
HMA	10,776	60
BST	4,843	27
PCC	2,262	13
Totals	17,881	100

Source: WSDOT

Bottom line: BST surfaces constitute a major portion of WSDOT's pavements.

WS e-Miles by ADT

Most of these HMA surfaces will be converted to BST surfaces

AADT	Lane-miles				
	BST	HMA	Flexible (BST+HMA)	All Types (BST+HMA+PCC)	
0-2000	3,157	1,834	4,991	4,993	(28%)
2000-4000	819	1,645	2,464	2,486	(14%)
4000-6000	190	1,423	1,613	1,631	(9%)
6000-8000	8	840	848	934	(5%)
8000-10000	1	567	568	660	(4%)
10000-20000	4	2,094	2,098	2,572	(15%)
20000-40000	0	1,610	1,610	2,029	(11%)
40000-80000	0	1,032	1,032	1,360	(8%)
80000-160000	0	436	436	640	(4%)
>=160000	0	132	132	360	(2%)

42%

FHWA IRI Thresholds for Interstate Highways

FHWA Ride Quality Terms	All Functional Classifications	
	IRI, m/km	PSR Rating
Good	< 1.5	Good
Acceptable	≤ 2.7	Acceptable
Not Acceptable	> 2.7	Not Acceptable

Existing IRI Sorted by ADT

ADT (2002)	Average IRI (m/km)
0-2000	1.7
2000-4000	1.6
4000-6000	1.7
6000-8000	1.6
8000-10000	1.8
10000-20000	2.0
20000-40000	1.4
40000-80000	1.3
80000-160000	1.2
>=160000	1.6

Preservation Policies and Practices

Surface	Common Preservation	Comments
Hot Mix Asphalt	45-mm overlay	• 8-16 year intervals most common • All traffic levels • All ESAL levels
Bituminous Surface Treatment	Single shot BST (mostly)	• 5-10 year intervals most common • Lower traffic pavements • AADT < 10,000 • AADT ≤ 5,000 (by policy)
Portland Cement Concrete	Either HMA overlay or dowel bar retrofit plus grinding	• Most over 30 years old • Most prevalent on NHS routes

Percentages of Pavement Preservation Funding by Type

Biennium	HMA	BST	Other
1995-1997	63%	6%	31%
1997-1999	77%	6%	17%
1999-2001	77%	9%	14%
2001-2003	86%	7%	7%
2003-2005	83%	10%	7%
2005-2007	70%	18%	12%
2007-2009	73%	19%	8%

Preservation Funds by Lane-Mile per Year

Biennium	Overall Funding Per Lane Mile Per Year[1,2]	Preservation Funds by Pavement Type $/Lane-Mile/Year[1,2]		
		HMA	BST	PCCP
1995-1997	7,200	7,600	1,700	6,300
1997-1999	8,500	10,900	1,900	8,000
1999-2001	7,300	9,200	2,500	6,000
2001-2003	6,900	9,900	1,800	1,200
2003-2005	6,200	8,500	2,200	400
2005-2007	5,800	6,700	3,900	4,400
2007-2009	6,800	8,200	4,800	3,700
Averages (1995-2009)	7,000	8,700	2,700	4,300

Note 1: Funding shown includes project engineering, construction engineering, safety, and taxes.
Note 2: Amounts shown not adjusted for inflation.


Pavement Preservation
Costs and Lives

Pavement Preservation Costs and Lives

Treatment	Cost ($/SY)	Expected Treatment Life
Slurry Seal	0.75 to 1.00	3 to 5 yr
Microsurfacing (single)	1.50 to 3.00	3 to 6 yr
Chip Seal (single) Conventional	1.50 to 2.00	3 to 7 yr
Chip Seal (single) Polymer Modified	2.00 to 4.00	5 to 10 yr
Thin HMA Overlay (0.875 to 1.5")	3.00 to 6.00	5 to 12 yr
Ultra-Thin HMA Overlay (0.625 to 0.75")	2.00 to 3.00	4 to 8 yr
Ultra-Thin Whitetopping (2 to 4")	15.00 to 25.00	NA

Source: SHRP2 R26


LCCA

LCCA

- LCCA
  - Discount Rate = 4%
  - Analysis Period = 40 years
  - No user costs
- Costs (loaded costs includes contractor and agency project related costs)
  - BST (single shot) with CRS-2P = $25,000/lane-mile
  - HMA overlay 1.8” thick (dense graded) = $250,000/lane-mile
- Basic assumption: The pavement section is structurally adequate.

LCCA

Treatment	Scenario	Present Value
BST	Place BST every **10 years**	$66,000
HMA Overlay	Place HMA overlay every 15 years	$489,000

LCCA

Treatment	Scenario	Present Value
BST	Place BST every **5 years**	$141,000
HMA Overlay	Place HMA overlay every 15 years	$489,000

LCCA

Treatment	Scenario	Present Value
BST	Place BST every **5 years**	$141,000
HMA Overlay	Place HMA overlay every **20 years**	$364,000

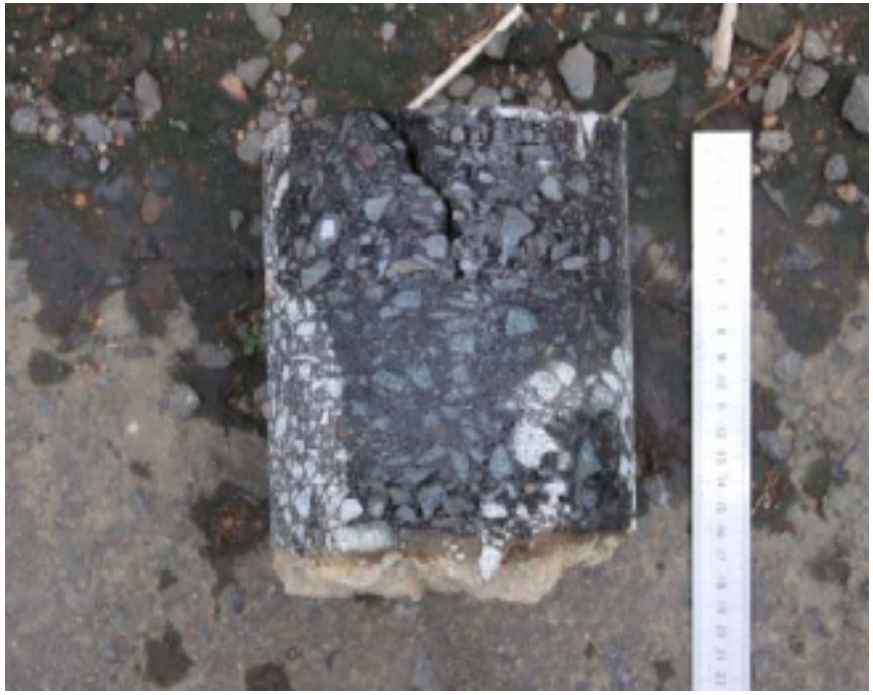

Pavement Distress
Considerations

Does everyone check for top down cracking?

Does everyone check for top down cracking?

Washington State

Does everyone check for top down cracking?

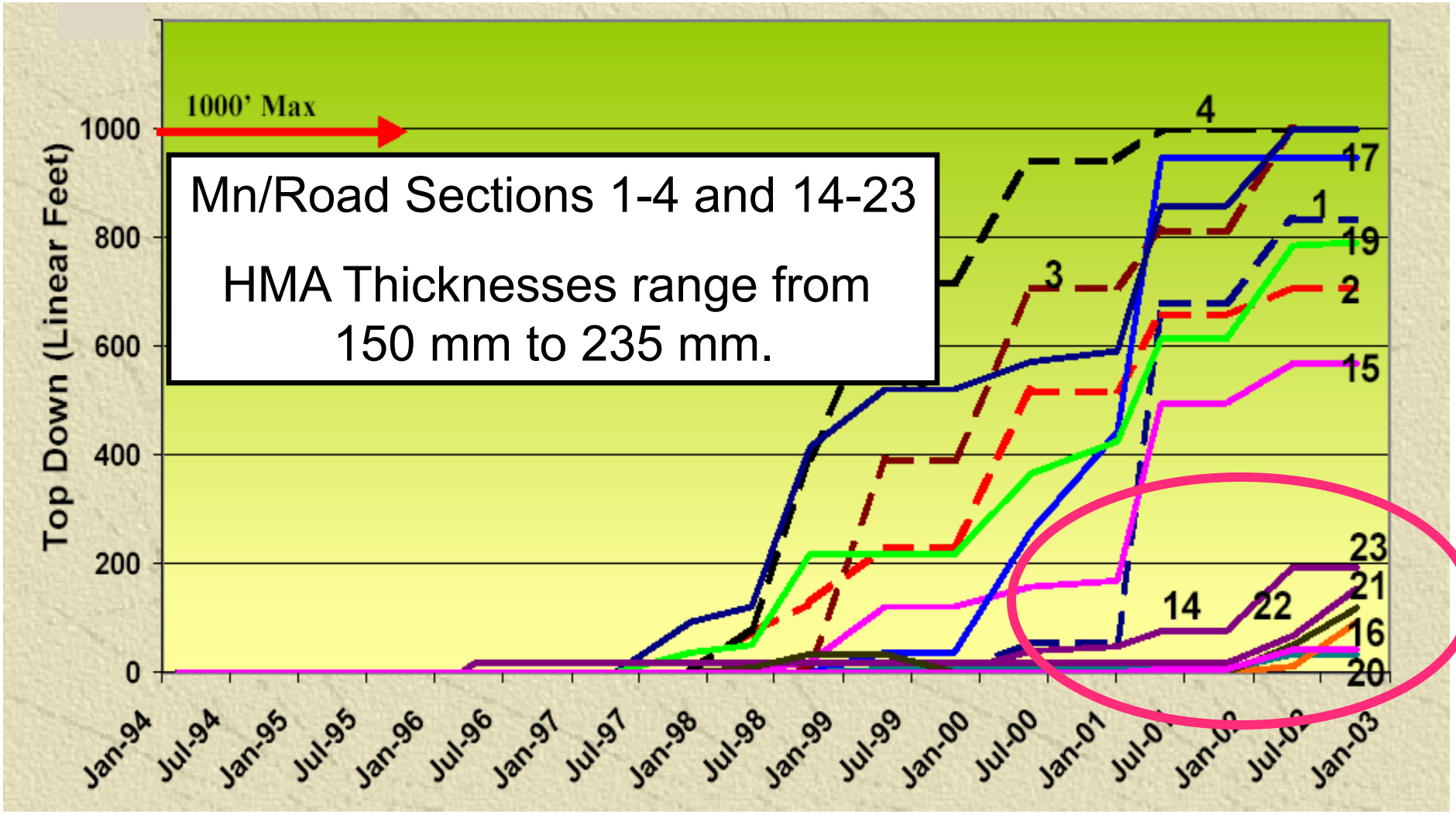


Panama

Top Down Cracking

- When does top down cracking start?
  - Japan: 1 to 5 years
  - France: 3 to 5 years
  - Florida: 5 to 10 years
  - UK: 10 years
  - MnROAD: 2 to 8 years
  - Washington State: 3 to 8 years (avg = 5 years)

Top-Down Cracking at Mn/Road



Source: Ben Worel Presentation—February 19, 2003

Top Down Cracking

- HMA mix aging has a strong role in top-down cracking.
  - UK research has shown in tropical environments that the binder in the upper 2 to 3 mm of HMA surface courses is 100 to 500X more viscous than a depth of 10 to 25 mm.
  - Application of a chip seal soon after construction reduced the HMA binder aging by a factor of 50X.


Continuous Improvement

Continuous Improvement

- Workshops held each year between WSDOT and the paving contractors
- Hosted and moderated by UW
- All issues “on the table” and everyone can offer opinions.
- No decisions binding on WSDOT
- Open discussions have had a role in numerous revisions of the Standard Specifications and BST practices.

First BST Summit 6 years ago

Most Recent BST Summit 2010
Wild Horse Wind Project


Recap of BST Summits
(a small selection)

Consensus Items

- **Chip seal design**
  - General view was this would be a good tool to have. [Becomes more important as aggregate payment by the SY becomes standard.]
- **Max surface temperature**
  - Max surface temperature dropped from 140°F to 130°F in 2010 SS.
- **P200**
  - Should be no more than 1%. Actual statistics show average for WSDOT projects about 0.9% given the 1.5% P200 in the statistic acceptance specification.

BST Gradation and Snow Plow Damage—February 2011

Consensus Items

- **Fog Seal**
  - ER, SCR, and OR fog their seal coats. Some choke and fog to reduce snow plow damage.
  - NCR does not fog their seal coats but is changing to choke and fog for all 2011 BSTs.
- **Pay by SY**
  - In general, contractors not in favor of aggregate payment by the SY as of 2009 meeting.
  - In general, WSDOT felt aggregate payment by SY is a good approach.
  - Idaho uses SY payment.

Consensus Items

- **Prelevel**
  - Pavement policy is 70 tons/lane-mile.
  - NCR: 70 tons/lane-mile OK.
  - OR: 70 tons/lane-mile should be OK.
  - Presealing of prelevel: Most WSDOT responses stated that their regions preseal prelevel.
- **HMA at intersections**
  - NCR uses 3/8” HMA at heavily trafficked intersections.
  - ER doing some of the same. Intersections with county roads typically only choke the seal coat.

Consensus Items

- **Optimal timing for a BST (converting a new HMA to a BST to maximize long life)**
  - Place same year as HMA but no more than 2 years (helps to prevent raveling and aging).
- **Regional views on seal coat performance**
  - Often Regions placing seal coats on a set cycle (as of 2009 meeting) but this is changing to PMS directed timing.

Consensus Items

- **Maximum ADT**
  - No real maximum for seal coats. The larger issue is traffic control.
- **Maximum Grade**
  - Seal coats possible on 12 to 15% grades. Again, key is traffic control. If paving on steep grades, do on very low volume routes.
- **Aggregate embedment**
  - ≥ 50% but not more than 70%.
  - Less than 50% unlikely to hold aggregate particularly with embedment levels of say 25 to 33%.
- **Training**
  - All about good, well-trained inspectors.
  - ER uses same inspectors for seal coat projects. Better results. Contractors supported ER direction.

Consensus Items

- **Reduction of rock loss**
  - Embedment critical
  - Use of fog seal (sweep before fogging)
  - Keep speeds down to about 25 mph following placing of seal coat.
  - Wet rock can contribute to rock loss.

Conclusions

- Given current funding issues, more pavement surfaces will be BSTs with less HMA (WSDOT).
- If a pavement section is structurally adequate, BST surfaces can be used over long spans of time.
- With use of HMA level-up, IRI values can be reasonable for BST surfaced routes (~ 1.6 to 1.8 m/km).

Conclusions

- BSTs can reduce top down cracking of HMA with timely application.
- Continuous improvement—agency/contractor meetings do not need to change specifications; although, that has been common. Meetings help to get all on the "same page."


The End
Loup Loup
Pass
ELEVATION 4020