59th Annual Meeting

Maximizing Pavement Life

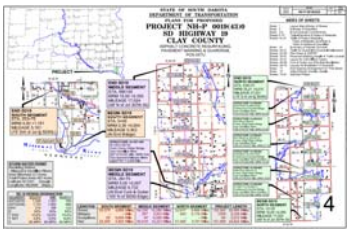
Considerations for Pavement Design and Construction

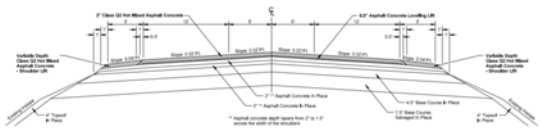
Madison, Wisconsin
Nov. 27th, 2018

Mark D. Blow P.E.
Sr. Regional Engineer
Asphalt Institute

Pavement Design Reminders

- Binder Type
- Pavement Thickness
- Lift Thickness & Mix Type

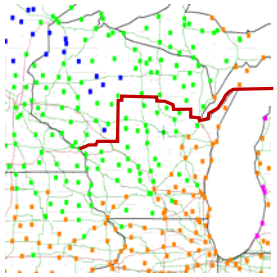


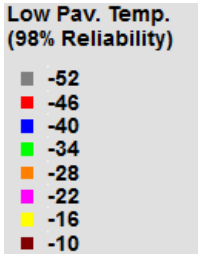


Binder Type

Prevent Thermal Cracking

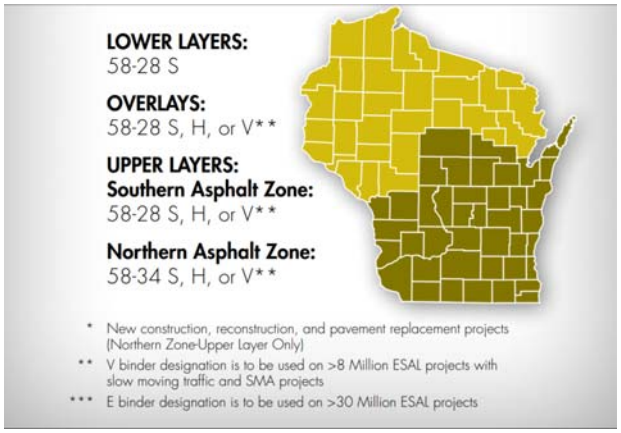
- Use PG -34 Binders on New Construction
- 25 year old SHRP recommendation





LTPPBind v3.1

WisDOT Binder regions



Iowa HIPRO Thin Lifts

Utilizing 58-28 E(+)
% Recovery >90%

On overlays

Consider high performance binders on overlays

- Reduced rutting
- Reduced cracking
- Better crack seal performance
- Maintain existing crack resistance

PG 64-22 modified, no rutting

PG 67-22 unmodified, 15mm rut

Better Joint Performance

I-29 Project

- Orig. 1962 PCC
- 1999 - 3" HMA
- 2004 – 1.5" SMA
  - ✓PG 70-28
- 2004 – Saw/Seal
- 2009 – Sealed secondary cracks

But what does it cost?

2016 DOT Ave. Unit Bid Prices

Description		Unit	Total Quantity	Average Bid Price
PG 58-28	Asphalt Binder	Ton	15,547.30	$433.74
PG 58-34	Asphalt Binder	Ton	125,661.00	$485.86
PG 64-22	Asphalt Binder	Ton	519.60	$470.63
PG 64-28	Asphalt Binder	Ton	182,175.80	$457.38
PG 64-34	Asphalt Binder	Ton	61,502.20	$499.15

Highest to Lowest Difference = $65.41/ binder ton @ 6% Binder = $3.92 / ton of mix

Simple county overlay

10 mile overlay, No milling

Item	Quantity	Units	Unit Price	Amount	% of Project Cost
PG64-28	1,575.50	Ton	$ 462.07	$ 727,991.29	48.5%
Class E Mix	25,627.20	Ton	$ 22.82	$ 584,812.70	39.0%
		Tot. Mix Cost =		$ 1,312,803.99	87.5%
		Tot Project Cost =		$ 1,500,814.57	100.0%

Assuming a $65.41 binder cost increase,

		Expected Service Life (Years)	Needed increase in Life (Years)
Binder cost increase	14.2%	15	1.0
Project cost increase	6.9%	20	1.4
		25	1.7

Complicated Interstate overlay

20 + mile overlay, underdrains etc.

Item	Quantity	Units	Unit Price	Amount	% of Project Cost
PG64-28	1,823.80	Ton	$ 400.00	$ 729,520.00	3%
PG64-34	11,152.60	Ton	$ 430.00	$ 4,795,618.00	21%
		Tot Project Cost =		$ 22,565,024.00	

Assuming a $65.41 binder cost increase,

		Expected Service Life (Years)	Needed increase in Life (Years)
Binder cost increase	15.4%	15	0.6
Project cost increase	3.8%	20	0.8
		25	0.9

Smaller Urban / Grading

1 mile 3-Lane, grading, C&G, sidewalks, lighting and new asphalt surface

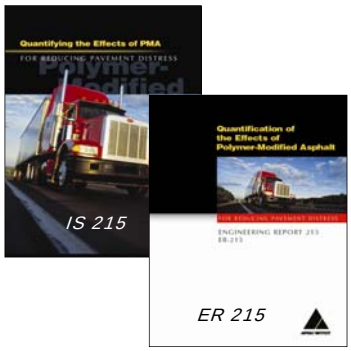
Item	Quantity	Units	Unit Price	Amount	% of Project Cost
PG58-28	447.70	Ton	$ 730.00	$ 326,821.00	9.3%
Class HR	9,518.50	Ton	$ 33.00	$ 314,110.50	8.9%
		Tot. Mix Cost =		$ 640,931.50	18.2%
		Tot Project Cost =		$ 3,521,707.00	

Assuming a $65.41 binder mix cost increase,

		Expected Service Life (Years)	Needed increase in Life (Years)
Binder cost increase	9.0%	15	0.12
Project cost increase	0.8%	20	0.17
		25	0.21

LTPP Studies

Quantifying the Effects of PMA for Reducing Pavement Distress



This study (published in Feb 2005) used national field data to determine enhanced service life of pavements containing polymer modified binders versus conventional binders. The data is from a variety of climates and traffic volumes within North America.

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Summary of Expected Increase in Service Life, Years, Based on M-E Damage Based Analysis

Assumptions: Unmodified sections designed for 20 yr. life. Also, PMA in top 4 inches.

Site Factor	Condition Description		Added Life
Foundation	Non-expansive, coarse soils		5-10
	Expansive and plastic soils (PI>35)		2-5
	Frost Susceptible in cold climate		2-5
Water Table & Drainage	Deep		5-10
	Shallow; adequate		5-8
	Shallow; inadequate		0-2
Existing Pavement Condition	HMA	Good	5-10
		Poor-extensive cracking	1-3
	PCC	Good	3-6
		Poor-faulting & cracking	0-2

Continued: Summary of Expected Increase in Service Life, Yrs

Assumptions: Unmodified sections designed for 20 yr. life. Also, PMA in top 4 inches.

Site Factor	Condition Description		Added Life
Climate; Temp. Fluctuations	Hot	Hot Extremes	5-10
	Mild		2-5
	Cold	Cold Extremes	3-6
Traffic, Truck Volumes	Low	Intersections	5-10
		Thoroughfares	3-6
		Heavy Loads	5-10
	Moderate		5-10
	High		5-10

Recycled Binders

NCHRP Project D9-12

NCHRP REPORT 452 - Results

- Blending occurs at higher RAP contents. At low RAP contents, effects are not significant.
- Results from all phases support concept of a tiered system.
- Mix ETG recommendations were largely confirmed.

NCHRP 9-12 Recommendations

RAP mixtures should be able to perform at least as well as virgin mixes.

ACTION	RAP
No Change in Binder Grade	15% or less
One Grade Lower	16 - 25%
Use Blending Charts	>25%

Adopted in AASHTO M323
Superpave Volumetric Mix Design

Acknowledgement

WHRP
Wisconsin Highway Research Program

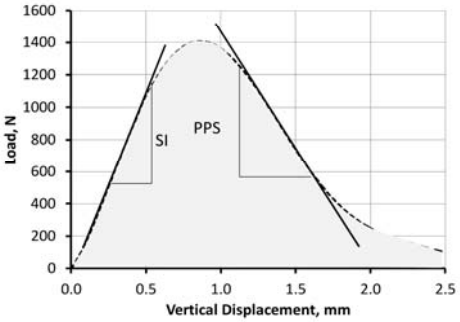
- Project 0092-14-06 Critical Factors Affecting Asphalt Durability
  - Evaluate changes to the composition of asphalt mixtures that WisDOT should consider to improve durability
    - Resistance to load associated cracking
    - Resistance to aging

http://wisconsindot.gov/documents2/research/14-06-revised-final-report.pdf

Advanced Asphalt Technologies, LLC
"Engineering Services for the Asphalt Industry"

Illinois SCB (Flexibility Index)

SI = Stiffness Index
Slope @ 50% of Peak Load
AI=Aging Index
$=SI_{LTOA}/SI_{STOA}$



FI = Energy/Post Peak Slope
Resistance to cracking increases with increasing FI

Advanced Asphalt Technologies, LLC
"Engineering Services for the Asphalt Industry"

Effect of Recycled Binder

No Grade Change					AASHTO M 323 Change				
VBE	Low Grade	RBR	FI	% of Control Life	VBE	Low Grade	ABR	FI	% of Control Life
10.5	-28	0.00	6.5	100	10.5	-28	0.00	6.5	100
10.5	-28	0.05	6.0	92	10.5	-28	0.05	6.0	92
10.5	-28	0.10	5.5	84	10.5	-28	0.10	5.5	84
10.5	-28	0.15	5.0	77	10.5	-28	0.15	5.0	77
10.5	-28	0.20	4.5	69	10.5	-34	0.20	6.9	105
10.5	-28	0.25	4.0	61	10.5	-34	0.25	6.3	97
10.5	-28	0.30	3.5	53	10.5	-34	0.30	5.8	89

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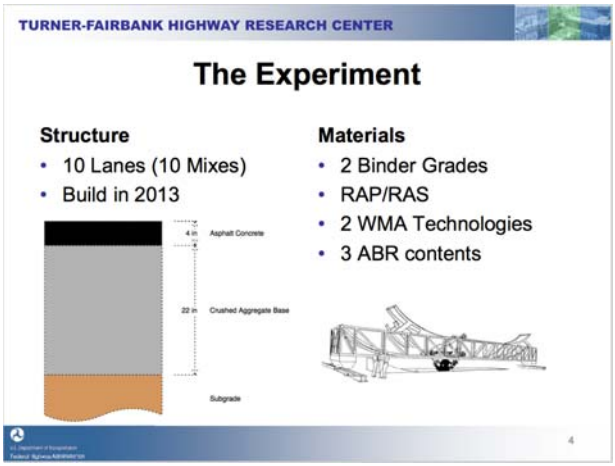
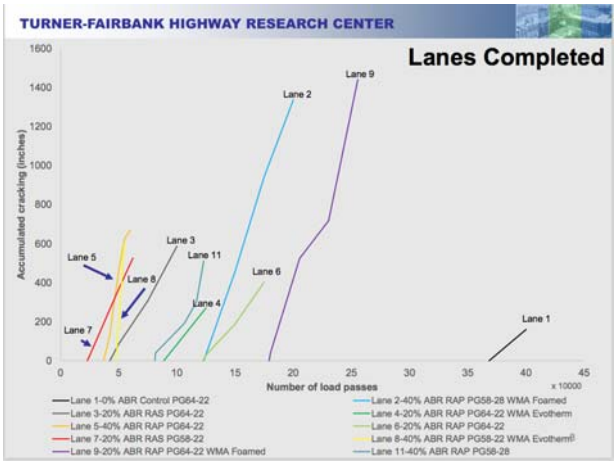




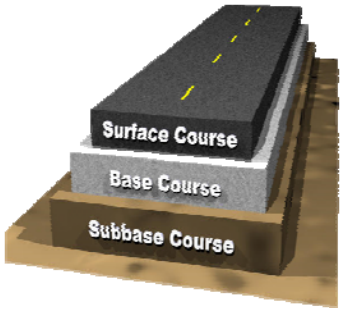
Moderation is the key

Thickness Design

Design - Section 2

Pavement Design

MEPDG *(AASHTO 2000)*



AASHTO has been developing MEPDG for high volume roads, but a gap has developed for local roads and lower volume roads.

www.PaveXpressDesign.com 28

What Is PaveXpress?

A free, online tool to help you create simplified pavement designs using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

- Accessible via the web and mobile devices
- Free — no cost to use
- Based on AASHTO pavement design equations
- User-friendly
- Share, save, and print project designs
- Interactive help and resource links

www.PaveXpressDesign.com

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Perpetual Pavement Design Software

PerRoad is uses the mechanistic-empirical design philosophy. The program couples layered elastic analysis with a statistical analysis procedure (Monte Carlo simulation) to estimate stresses and strains within a pavement. In order to predict the strains which would prove detrimental for fatigue cracking or structural rutting.

www.asphaltroads.org/perpetual-pavement

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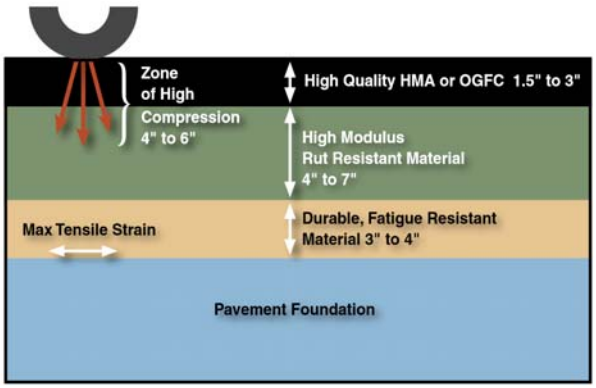
What does a P. P. look like?



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Ya But, Ya But Does Asphalt Really Last ?

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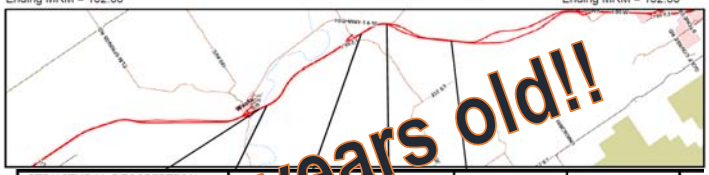
HIGHWAY 090 E
Beginning MRM = 98.14
Ending MRM = 102.00

RURAL

HIGHWAY 090 E
Beginning MRM = 98.14
Ending MRM = 102.00



65+ years old!!

STRUCTURAL DESCRIPTION				
Surface Type		THK	FD	FD
Shoulder Type - Prim/Secndry		AC/N/D	AC/N/D	AC/N/D
Surf Width	32 (032)	24 (024)	24 (024)	24 (024)
Lf Shldr Width-Prim/Secondry	00) / (0)	4 (04) / (0)	4 (04) / (0)	4 (04) / (0)
Rt Shldr Width-Prim/Secondry	0 (00) / (0)	10 (10) / (0)	10 (10) / (0)	10 (10) / (0)
Widths-RDWY/ROW-Predom/Min	032/470/470	038/470/470	038/470/470	038/470/253
Roadbed Layer 1		2015/AS3/1.3	2015/AS3/1.3	2015/AS3/1.3
Roadbed Layer 2		2002/TC/0.0	2002/TC/0.0	2002/TC/0.0
Roadbed Layer 3		1999/AH3/1.5	1999/AH3/1.5	1999/AH3/1.5
Roadbed Layer 4		1999/AH3/1.5	1993/AG3/2.0	1999/AH3/1.5
Roadbed Layer 5		1977/AE4/3.5	1993/AG3/3.0	1977/AG4/2.0
Roadbed Layer 6		1964/AF3/1.5	1993/AG3/3.0	1969/AG3/2.0
Roadbed Layer 7		1964/B83/4.0	1993/B55/12.0	1969/AE3/6.0
Roadbed Layer 8		1964/BU8/4.0		1969/BU8/12.0
Roadbed Layer 9		1964/BU8/6.0		

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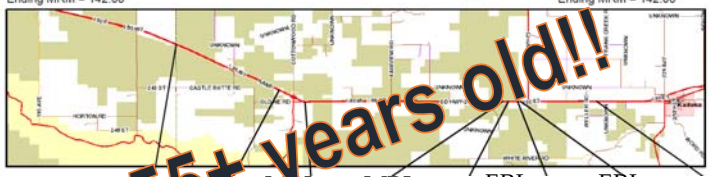
HIGHWAY 090 W
Beginning MRM = 124.23
Ending MRM = 142.00

RURAL

HIGHWAY 090 W
Beginning MRM = 124.23
Ending MRM = 142.00



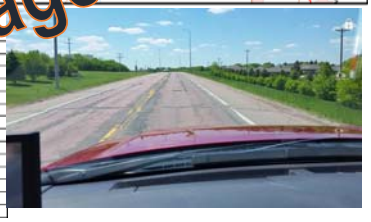
55+ years old!!

STRUCTURAL DESCRIPTION		WBL	EBL	EBL
STRUCTURAL DESCRIPTION				
Surface Type	FD	FD	CRCP	TK5JD
Shoulder Type - Prim/Secndry	AC/N/D	AC/N/D	AC/N/D	AC/N/D
Surf Width	24 (024)	24 (024)	24 (024)	26 (026)
Lf Shldr Width-Prim/Secondry	10 (10) / (0)	10 (10) / (0)	4 (04)/ (0)	4 (04) / (0)
Rt Shldr Width-Prim/Secondry	4 (04) / (0)	4 (04) / (0)	10 (10)/ (0)	8 (08) / (0)
Widths-RDWY/ROW-Predom/Min	038/220/220	038/220/220	038/200/200	038/250/200
			1974/CC1/8.0	
Roadbed Layer 1	2012/TM/0.4	2012/TM/0.4	1974/BL3/4.0	2014/CD1/10.5
Roadbed Layer 2	2002/AS3/1.3	2002/AS3/1.3		2014/B54/5.0
Roadbed Layer 3	2002/AH3/1.5	2002/AH3/1.5		
Roadbed Layer 4	1990/AR4/1.2	1974/AG3/3.0		
Roadbed Layer 5	1974/AG3/1.8	1974/AE3/9.0		
Roadbed Layer 6	1974/AE3/9.0	1974/BL3/12.0		
Roadbed Layer 7	1974/BL3/12.0			
Roadbed Layer 8				

HIGHWAY 115
Beginning MRM = 104.13
Ending MRM = 107.51

RURAL

Died, after 1 Overlay, at the age of 51!!



STRUCTURAL DESCRIPTION	
Surface Type	FD
Shoulder Type - Prim/Secndry	AC/N/D
Surf Width	24 (024)
Lf Shldr Width-Prim/Secondry	6 (06) / (0)
Rt Shldr Width-Prim/Secondry	6 (06) / (0)
Widths-RDWY/ROW-Predom/Min	036/200/200
Roadbed Layer 1	2008/TS3/0.4
Roadbed Layer 2	1999/TC/0.0
Roadbed Layer 3	1990/TS3/0.5
Roadbed Layer 4	1986/AG3/2.0
Roadbed Layer 5	1975/TS3/0.5
Roadbed Layer 6	1967/AG3/3.0
Roadbed Layer 7	1967/AE3/5.0
Roadbed Layer 8	1967/BU8/12.0

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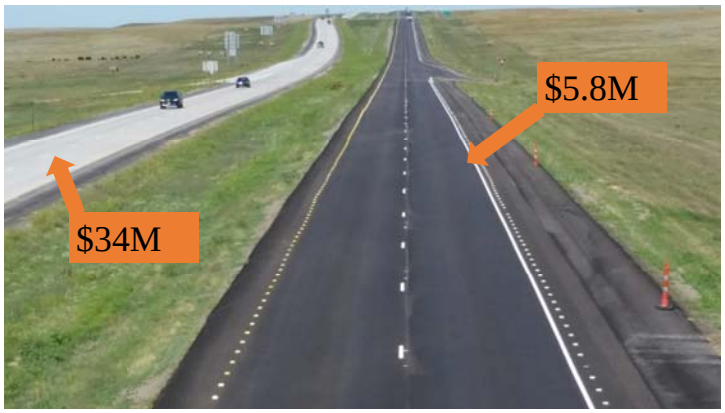
How it looks today



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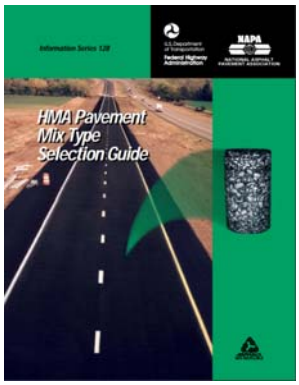
Lift Thickness and Mix Type

Design - Section 3

Mix Type



https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/asphalt/HMA.pdf

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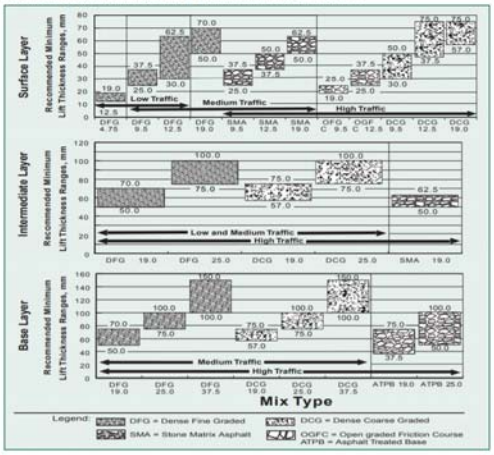
Recommended Lift Thickness

FIGURE 3: Recommended Mix Types for Surface, Intermediate and Base Courses



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Mix Type

NMAS grading is different than older "Topsize" Grading

Old Rule of Thumb - Minimum lift thickness = 2x Topsize

NMAS - Minimum compacted thickness
- ✓4 times nominal aggregate size
- ✓3 times nominal aggregate size for fine graded mixtures

- Thicker lifts are easier to compact
- Cool slower providing longer compaction time

Minimum ----------NOT MAXIMUM !

Specified Mix Gradations

TABLE 460-1 AGGREGATE GRADATION MASTER RANGE AND VMA REQUIREMENTS

SIEVE	PERCENT PASSING DESIGNATED SIEVES						
	NOMINAL SIZE						
	No. 1 (37.5 mm)	No. 2 (25.0 mm)	No.3 (19.0 mm)	No. 4 (12.5 mm)	No. 5 (9.5 mm)	SMA No. 4 (12.5 mm)	SMA No. 5 (9.5 mm)
50.0-mm	100						
37.5-mm	90 –100	100					
25.0-mm	90 max	90 -100	100				
19.0-mm	___	90 max	90 -100	100		100	
12.5-mm	___	___	90 max	90 -100	100	90 - 97	100
9.5-mm	___	___	___	90 max	90 -100	58 - 72	90 - 100
4.75-mm	___	___	___	___	90 max	25 - 35	35 - 45
2.36-mm	15 - 41	19 - 45	23 - 49	28 - 58	32 - 67	15 - 25	18 - 28
75-µm	0 - 6.0	1.0 - 7.0	2.0 - 8.0	2.0 - 10.0	2.0 - 10.0	8.0 - 12.0	10.0 - 14.0
% MINIMUM VMA	11.0	12.0	13.0	14.0[1]	15.0[2]	16.0	17.0

[1] 14.5 for LT and MT mixes.
[2] 15.5 for LT and MT mixes.

Field Tolerances

460.2.8.2.1.5 Control Limits

(1) Conform to the following control limits for the JMF and warning limits based on a running average of the last 4 data points:

ITEM	JMF LIMITS	WARNING LIMITS
Percent passing given sieve:		
37.5-mm	+/- 6.0	+/- 4.5
25.0-mm	+/- 6.0	+/- 4.5
19.0-mm	+/- 5.5	+/- 4.0
12.5-mm	+/- 5.5	+/- 4.0
9.5-mm	+/- 5.5	+/- 4.0
2.36-mm	+/- 5.0	+/- 4.0
75-µm	+/- 2.0	+/- 1.5
Asphaltic content in percent	- 0.3	- 0.2
Air voids in percent[1]	+1.3/-1.0	+1.0/-0.7
VMA in percent[2]	- 0.5	- 0.2

[1] For SMA, JMF limits are +/-1.3 and warning limits are +/-1.0.
[2] VMA limits based on minimum requirement for mix design nominal maximum aggregate size in table 460-1.

(2) Warning bands are defined as the area between the JMF limits and the warning limits.

Lift Thickness

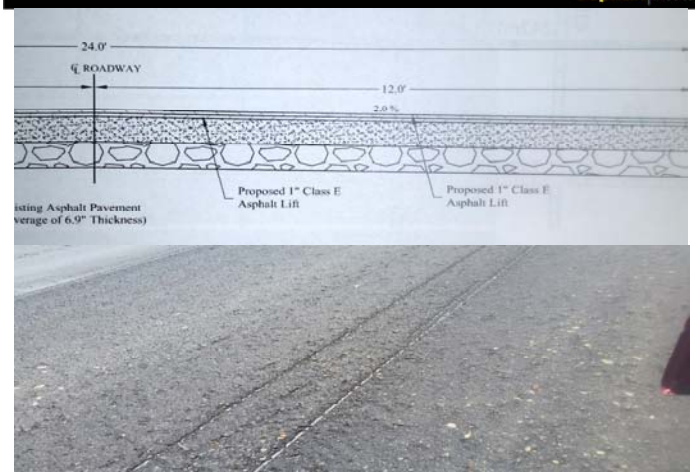
NCAT Test Track 1st Cycle

Limestone		Gravel	Slag & Lms	Granite	
Fine	Intermed.	Fine	Fine	Coarse	Intermed.
Limestone		Slag & Lms	Gravel	Granite	
Fine	Coarse	Coarse	Coarse	Intermed.	Fine

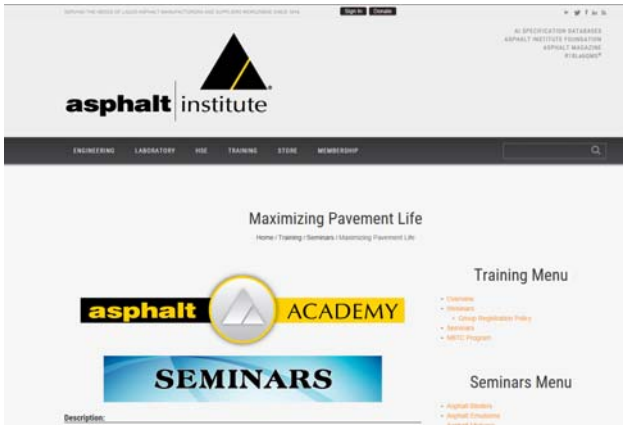
Coarse, intermediate, and fine gradations. No differences in rutting performance!

Courtesy of NCAT

Lift Thickness



New 2-day Workshop in 2019



Thank you to our Members

Thank you for your attention

Discussion/Questions?