

ASPHALT

THE SMOOTH QUIET RIDE



2016 Local Roads Workshop

Selecting the Right Mix for Your Project



MICHIGAN RIDES ON US

Asphalt.

Asphalt Pavement Association Of Michigan Selecting the Right Mix for Your Project



2937 Atrium Drive, Suite 202

Okemos, MI 48864

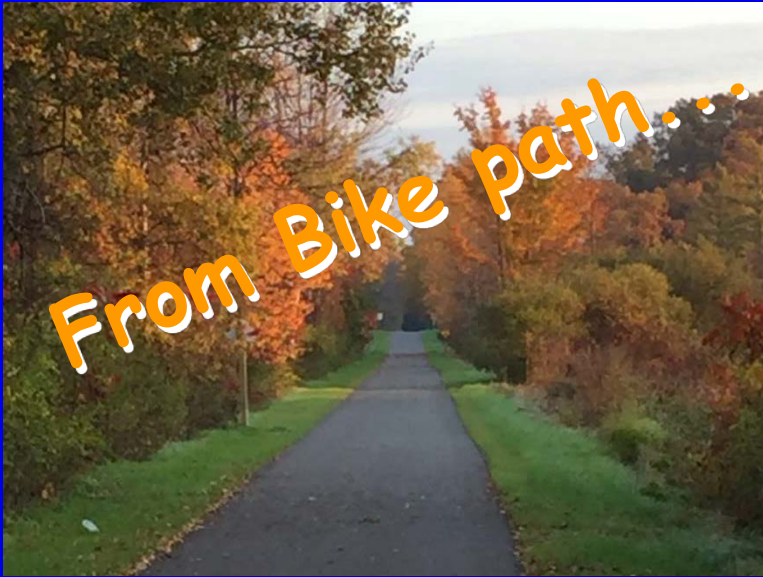
517-323-7800 www.apa-mi.org

Asphalt Pavement Association Of Michigan Selecting the Right Mix for Your Project

***The Right Mix
at
The Right Place***



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For each there are:

- **Right mixes**



- **Wrong mixes**



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Outline

- History
- Performance Graded Binders
- MDOT Local Agency Guide
- NAPA Guide
- Other Considerations

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Mix History



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Performance Mixes (Marshall)

1990's

- 2B, 2C Bases
- 3B, 3C Leveling
- 4B, 4C Top
- 11A Base, Leveling
- 13, 13A Base, Leveling, Top
- 36A, 36B Leveling, Top



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Marshall Mix Spec

Table 1: Mix Design Criteria and Volumetric Properties

	Mixture No.				
	2C	3C	4C	13A	36A
Target Air Void, % (a)	3.00	4.00	4.00	4.00	4.00
VMA (min) (b)	11.00	13.00	14.00	14.00	15.00
VFA	65-78	65-78	65-78	65-78	65-78
Fines to Binder Ratio (max) (c)	1.2	1.2	1.2	1.2	1.2
Flow (0.01 inch)	8 -16	8 -16	8 -16	8 -16	8 -16
Stability (min), lbs	1200	1200	1200	900	900

a. Lower target air voids by 1.00% if used in a separate shoulder paving operation. Consider reducing air void targets to 3.00% for lower traffic volume roadways when designing 13A and 36A mixtures for local agency use.

b. VMA calculated using Gsb of the combined aggregates.

c. Ratio of the weight of aggregate passing the No. 200 sieve to total asphalt binder content by weight; including fines and binder contributed by RAP.

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Marshall Mix Spec

Additional Requirement for Local Federal Aid projects:

From 10-15-2015 SP 501J local agency HMA acceptance:

For all mixtures, field regress air void content to 3.5 percent with liquid asphalt cement unless specified otherwise on HMA application estimate.

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Marshall Mix Spec

Table 2: Aggregate Properties

	Mixture No.				
	2C	3C	4C	13A	36A
	Percent Passing Indicated Sieve or Property Limit				
1 1/2 inch	100				
1 inch	91-100	100			
3/4 inch	90 max.	91-100	100	100	
1/2 inch	78 max.	90 max.	91-100	75-95	100
3/8 inch	70 max.	77 max.	90 max.	60-90	92-100
No. 4	52 max.	57 max.	67 max.	45-80	65-90
No. 8	15-40	15-45	15-52	30-65	55-75
No. 16	30 max.	33 max.	37 max.	20-50	
No. 30	22 max.	25 max.	27 max.	15-40	25-45
No. 50	17 max.	19 max.	20 max.	10-25	
No. 100	15 max.	15 max.	15 max.	5-15	
No. 200	3-6				3-10
Crushed (min), % (MTM 117)	90	90	90	25	60
Soft Particle (max), % (a)	12.0	12.0	8.0	8.0	8.0
Angularity Index (min) (b)	4.0	4.0	4.0	2.5	3.0
L.A. Abrasion (max), % loss (c)	40	40	40	40	40
Sand Ratio (max) (d)	-	-	-	50	50

a. The sum of the shale, siltstone, structurally weak, and clay-ironstone particles must not exceed 8.0 percent for aggregates used in top course. The sum of the shale, siltstone, structurally weak, and clay-ironstone particles must not exceed 12.0 percent for aggregates used in base and leveling courses.

b. The fine aggregate angularity of blended aggregates, determined by MTM 118, must meet the minimum requirement. In mixtures containing RAP, the required minimum fine aggregate angularity must be met by the virgin material. NAA fine aggregate angularity must be reported for information only and must include the fine material contributed by RAP if present in the mixture.

c. Los Angeles abrasion maximum loss must be met for the composite mixture, however, each individual aggregate must be less than 50

d. Sand ratio for 13A and 36A no more than 50% of the material passing the No. 4 sieve is allowed to pass the No. 30 Sieve.

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SuperPave Mixes

- Superpave System
 - PG Binders (Climate)
 - Traffic Level
 - Gyratory Compactor

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SuperPave Mixes

2000's

- LVSP, E03, E1, E3, E10, E30, E50
- 2EO3 thru 5E50



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SuperPave Mixes

2E03:

2 = Mixture Number (2 thru 5)

corresponds to gradation

2 = Base Mix

5 = Top Mix

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SuperPave Mixes

2E03:

E03 = Mixture Type

corresponds to estimated traffic
(million BSAL)

03 = less than 300,000 BSAL

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SuperPave Mix Specification

2012 MDOT Standard Specifications

1. Mix Design and Volumetric Requirements
 - Tables 501-1, 2 & 3
2. Gradation and Aggregate Requirements
 - Tables 902-5 & 6
3. PG Binder Specification
 - Table 904-2

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Superpave Mix Spec

Est. Traffic (million ESAL)	Mix Type	Percent Crushed Minimum Criteria		Fine Aggregate Angularity Minimum Criteria		% Sand Equivalent Minimum Criteria		Los Angeles Abrasion % Loss Minimum Criteria		% Soft Particles Maximum Criteria (b)		% Flat and Elongated Particles Maximum Criteria (c)	
		Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course	Top & Leveling Courses	Base Course
< 0.3	LVSP	55/—	—	—	—	40	40	45	45	10	10	—	—
< 0.3	E03	55/—	—	—	—	40	40	45	45	10	10	—	—
≥0.3 - <1.0	E1	65/—	—	40	—	40	40	40	45	10	10	—	—
≥1.0 - < 3	E3	75/—	50/—	40(a)	40(a)	40	40	35	40	5	5	10	10
≥3 - <10	E10	85/80	60/—	45	40	45	45	35	40	5	5	10	10
≥10 - <30	E30	95/90	80/75	45	40	45	45	35	35	3	4.5	10	10
≥30 - <100	E50	100/10 0	95/90	45	45	50	50	35	35	3	4.5	10	10

(a) For an E3 mixture type that enters the restricted zone as defined in Table 902-5, the minimum is 43. If these criteria are satisfied, acceptance criteria and associated incentive/disincentive or pay adjustment tied to this gradation restricted zone requirement included in contract, do not apply. Otherwise, final gradation blend must be outside of the restricted zone.

(b) Soft particles maximum is the sum of the shale, siltstone, ochre, coal, clay-ironstone and particles that are structurally weak or are non-durable in service.

(c) Maximum by weight with a 1 to 5 aspect ratio.

Note: "85/80" denotes that 85 percent of the coarse aggregate has one fractured face and 80 percent has at least two fractured faces.

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Superpave Mix Spec

Table 3: PWL - HMA Quality Index Parameter Specification Limits

Quality Index Parameter	Specification Limits
Air Voids, (%@ N_{des})(a)	Target Air Voids \pm 1.00
VMA	Target VMA \pm 1.00
	VMA Targets
LVSP	15.00
2	13.00
3	14.00
4	15.00
5	16.00
GGSP (Gap SMA)	18.00
Binder Content (b)	JMF \pm 0.40
Mat Density, % G_{mm}	92.00% minimum
a.	Unless noted otherwise on the plans, all mixtures must be designed to 96.0% of Maximum Specific Gravity (% G_{mm}) at the design number of gyrations, (N_d). During field production Percent of Maximum Specific Gravity (% G_{mm}) at the design number of gyrations, (N_d) will be increased to 97.0%.
b.	The Binder Content used as the target will be the value on form 1911.

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Regression of Mix design

Michigan Department of
Transportation form
1931 B

Report of Test HMA Mix Design - Regression

Control Section:

Job Number:

Mix Design:

Date:

AC%	Gmb	Gmm	Air	VMA	VFA	P200/Pbe
5.00	2.336	2.509	6.90	16.78	58.9	1.24
5.10	2.341	2.505	6.53	16.66	60.8	1.21
5.20	2.346	2.501	6.18	16.56	62.7	1.18
5.30	2.351	2.497	5.84	16.47	64.6	1.16
5.40	2.356	2.494	5.51	16.40	66.4	1.13
5.50	2.360	2.490	5.19	16.33	68.2	1.11
5.60	2.365	2.486	4.89	16.27	70.0	1.09
5.70	2.368	2.482	4.59	16.23	71.7	1.07
5.80	2.372	2.479	4.31	16.20	73.4	1.04
5.90	2.375	2.475	4.05	16.18	75.0	1.02
6.00	2.377	2.471	3.79	16.17	76.6	1.01
6.10	2.380	2.468	3.55	16.18	78.1	0.99
6.20	2.382	2.464	3.32	16.19	79.5	0.97
6.30	2.384	2.460	3.10	16.22	80.9	0.95
6.40	2.385	2.457	2.90	16.25	82.2	0.94
6.50	2.387	2.453	2.71	16.30	83.4	0.92

AC Optimized for 4% air voids

AC%	Gmb	Gmm	Air Voids	VMA	VFA	P200/Pbe
5.92	2.375	2.474	4.00	16.18	75.3	1.02

AC Optimized for 3.5% air voids

AC%	Gmb	Gmm	Air Voids	VMA	VFA	P200/Pbe
6.12	2.380	2.467	3.50	16.18	78.4	0.98

AC Optimized for 3% air voids

AC%	Gmb	Gmm	Air Voids	VMA	VFA	P200/Pbe
6.35	2.385	2.458	3.00	16.23	81.5	0.94

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Regression of Mix design

Effective Jan. 2015: regress Air
Voids to 3% on all MDOT mixes

AC Optimized for 4% air voids

AC%	Gmb	Gmm	Air Voids	VMA	VFA	P200/Pbe
5.92	2.375	2.474	4.00	16.18	75.3	1.02

AC Optimized for 3.5% air voids

AC%	Gmb	Gmm	Air Voids	VMA	VFA	P200/Pbe
6.12	2.380	2.467	3.50	16.18	78.4	0.98

AC Optimized for 3% air voids

AC%	Gmb	Gmm	Air Voids	VMA	VFA	P200/Pbe
6.35	2.385	2.458	3.00	16.23	81.5	0.94

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Superpave Mix Spec

Estimated Traffic (million ESAL)	Mix Type	%G _{mm} at (N _i)	Number of Gyration (a)		
			N _i	N _d	N _m
≤0.3	LVSP	91.5%	6	45	70
≤0.3	E03	91.5%	7	50	75
>0.3 – ≤1.0	E1	90.5%	7	76	117
>1.0 – ≤3.0	E3	90.5%	7	86	134
>3.0 – ≤10	E10	89.0%	8	96	152
>10 – ≤30	E30	89.0%	8	109	174
>30 – ≤100	E50	89.0%	9	126	204

a. Compact mix specimens fabricated in the SGC to N_d. Use height data provided by the SGC to calculate volumetric properties at N_i. Compact mix specimens at optimum P_b to verify N_m for mix design specimens only.

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Selecting the Right Mix for Your Project

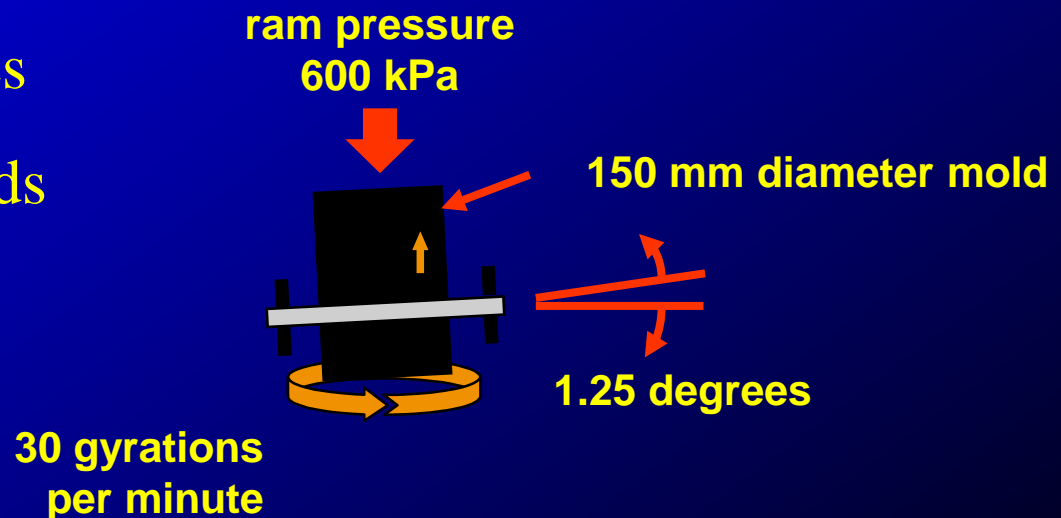
Marshall vs. Superpave Mix

1. Compaction of mix design samples

- a. Marshall Hammer
- b. Gyrotory Compactor

2. Aggregate Properties

3. Mix Design Air Voids



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Marshall vs. Superpave Mix

	5E	4E	LVSP	13A	36A	4C
1 ½ inch	---	---	---	---	---	---
1 inch	---	---	---	---	---	---
¾ inch	---	100	100	100	---	100
½ inch	100	90-100	75-95	75-95	100	91-100
3/8 inch	90-100	≤ 90	60-90	60-90	92-100	≤ 90
No. 4	≤ 90	---	45-80	45-80	65-90	≤ 67
No. 8	47-67	39-58	30-65	30-65	55-75	15-52
No. 16	---	---	20-50	20-50	---	≤ 37
No. 30	---	---	15-40	15-40	25-45	≤ 27
No. 50	---	---	10-25	10-25	---	≤ 20
No. 100	---	---	5-15	5-15	---	≤ 15
No. 200	2 - 10	2 - 10	3 - 6	3 - 6	3 -10	3 - 6

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Performance Graded Binders

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Performance Graded Binders

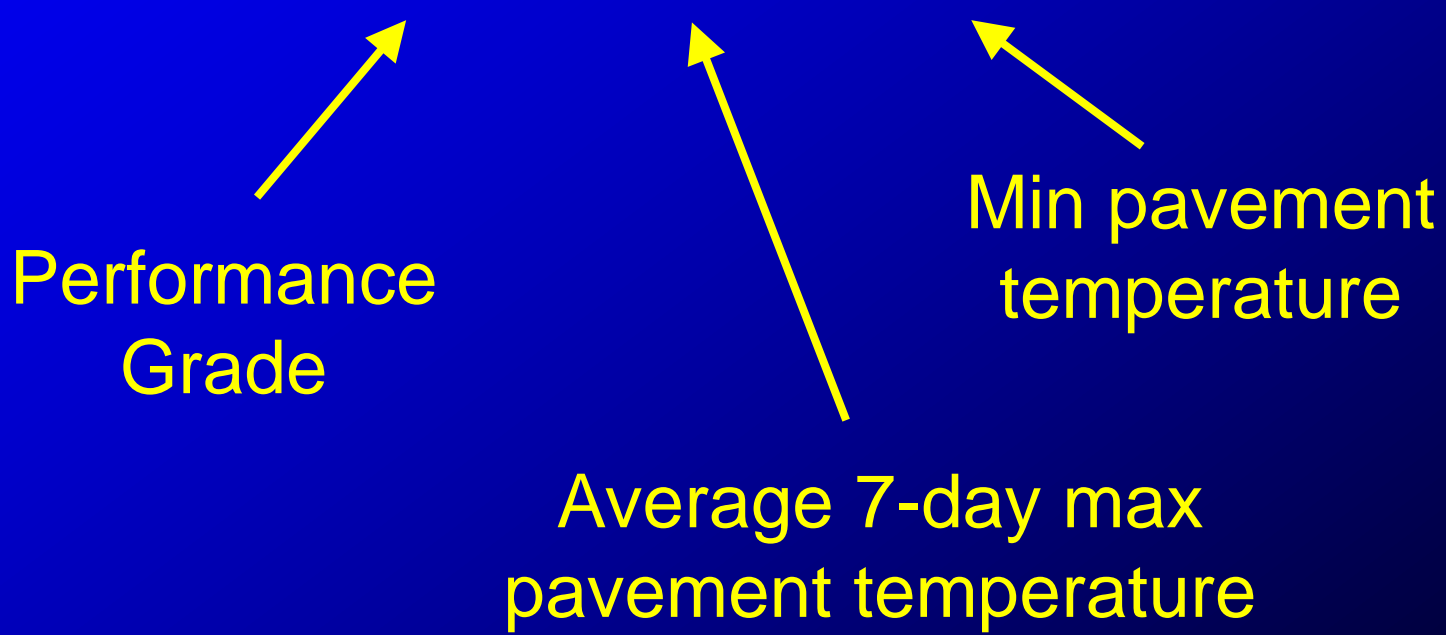
- PG Specification
- Testing
- Binder Selection
 - Location/Environment
 - Reliability (exceeding High & Low pav't temp.
 - Traffic level
 - Traffic speed
 - Depth in Pavement Structure

Superpave Asphalt Binder Specification

The grading system is based on climate

PG 58 - 28

Performance
Grade



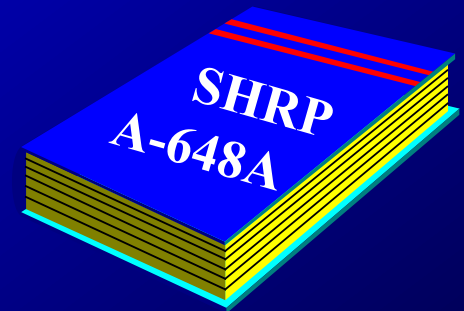
```
graph TD; A[Performance Grade] --> B[PG 58 - 28]; C[Average 7-day max pavement temperature] --> B; D[Min pavement temperature] --> B;
```

Average 7-day max
pavement temperature

Min pavement
temperature

Developed from Air Temperatures

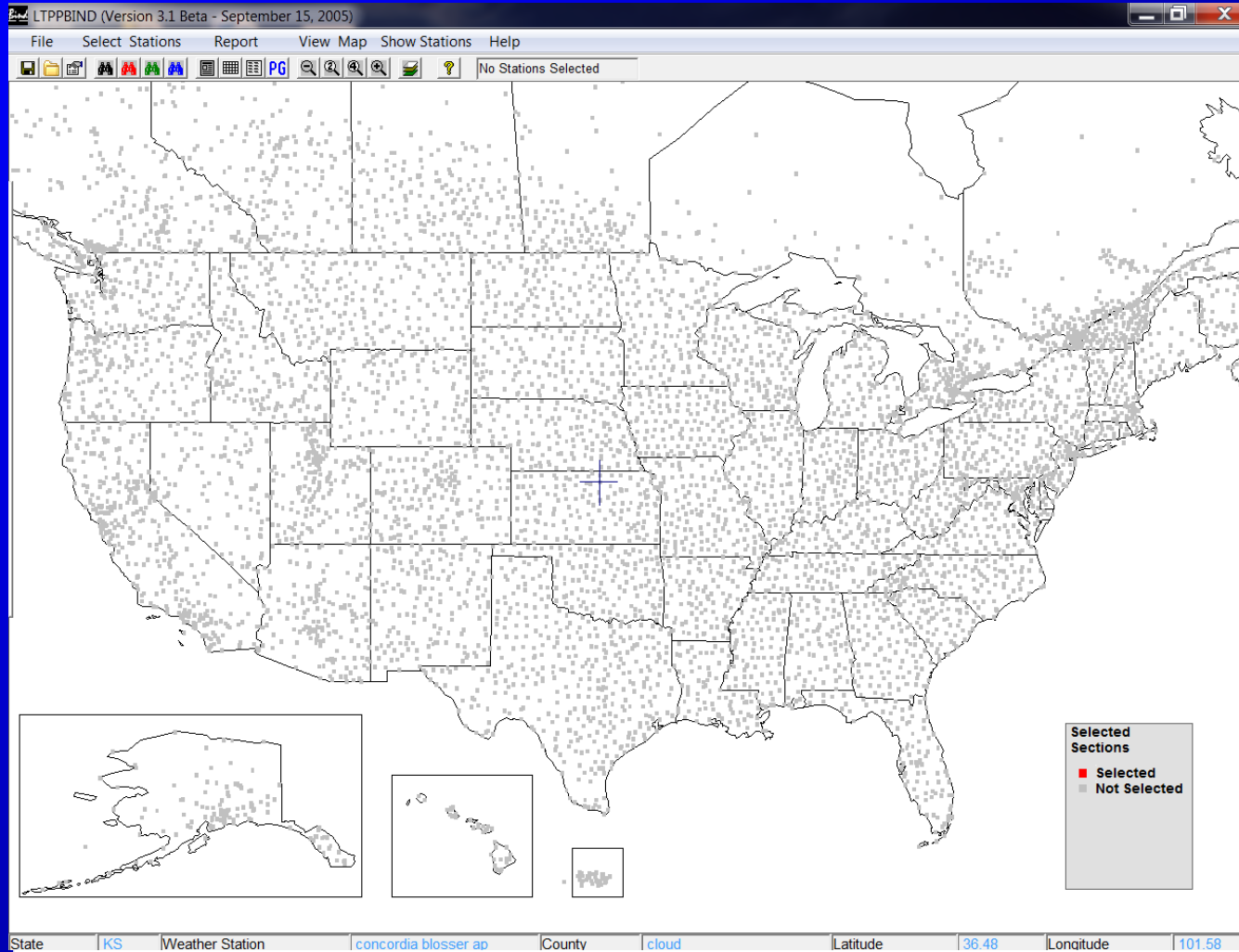
> 20 years



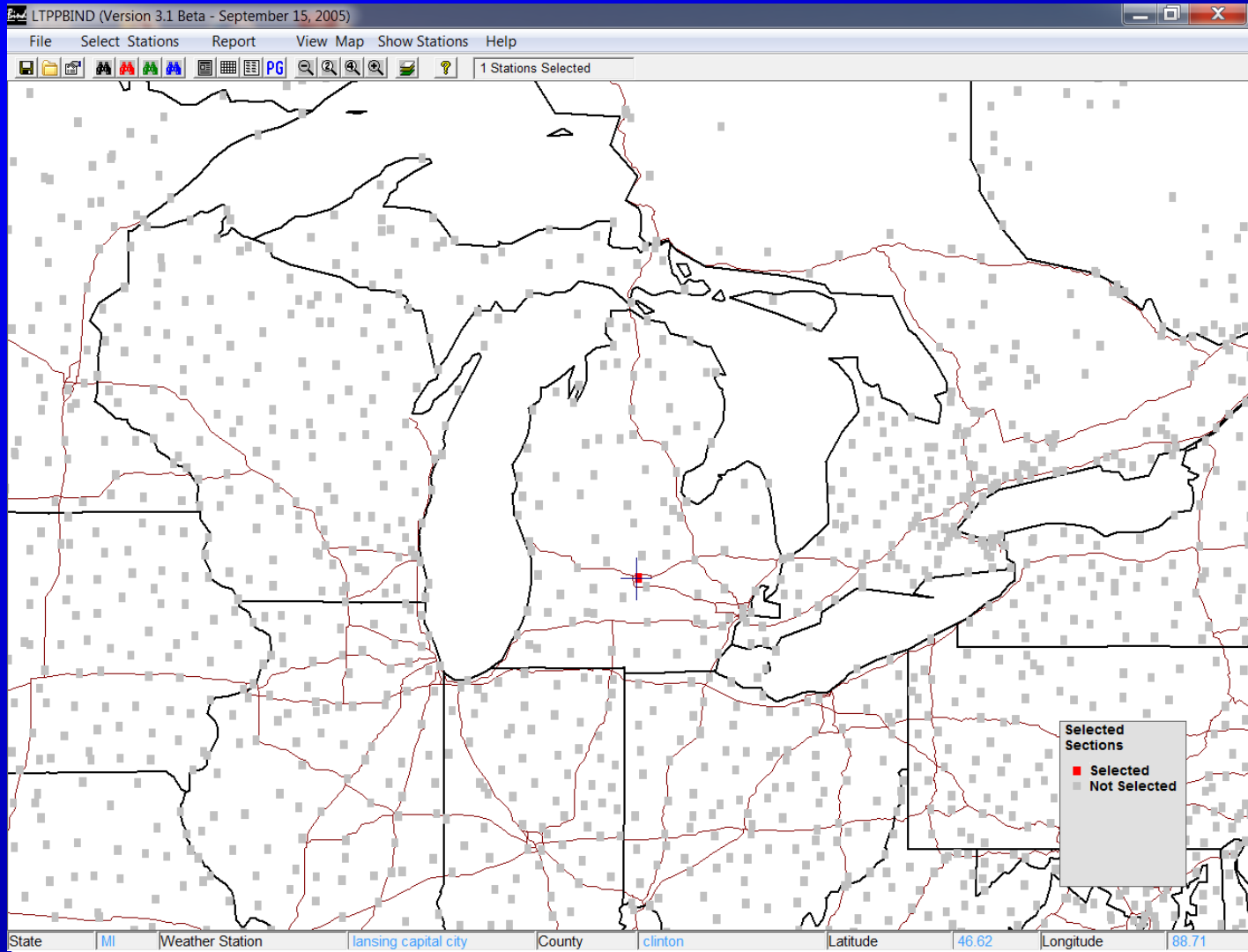
- **Superpave Weather Database**
 - 6500 stations in U.S. and Canada
<http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpb/ltpbbind.cfm>
- **Annual air temperatures**
 - hottest seven-day temp (avg and std dev)
 - coldest temp (avg and std dev)
- **Calculated pavement temps used in PG selection**

LTPP Bind Software

LTPP Bind Software



LTPP Bind Software



Convert to Pavement Temperature

- Calculated by Superpave software
- High Temperature (20 mm below surface of mixture)
- Low Temperature (at surface of mix)



LTPP Bind Software

Report - 1 Selected Weather Stations

State/Province: MI

Weather Station: LANSING CAPITAL CITY

Station ID	MI4641	Latitude	42.77
County / District	CLINTON	Longitude	84.6
Last Year Data Avail.	1997	Elevation, m	238

Air Temperature	Mean	Std Dev	Min	Max	Years
High Air Temperature, Deg. C	31.8	1.5	28.5	35.9	35
Low Air Temperature, Deg. C	-25.7	3.6	-34	-19.5	35
Low Air Temp. Drop, Deg. C	24.3	2.6	20.5	30	35
Degree Days over 10 Deg. C	2438	157	2105	2806	35

Pavement Temperature and PG	HIGH	LOW	High Rel	Low Rel
Pavement Temperature, C	51.6	-18.6	50	50
50% Reliability PG	52	-22	61	84
>50% Reliability PG	58	-22	98	84
=	58	-28	98	98
=				
=				
=				

? PG Chart PG Distribution Save Cancel

<http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpb/download.cfm>

What Binders are Used in Michigan

- 76-28P
- 70-22P, 70-28P
- 64-28, 64-34P
- **64-22**
- **58-28**
- 58-22, 58-34

Binder Grade vs. Pavement Performance

Other Pavement Performance Factors:

- Rutting - shear strength of mix, aggregate properties
- Fatigue Cracking - pavement structure, traffic
- What you are paving on!

Important Factor:

- Low temperature Cracking – correlates well to binder properties

Thermal Cracking



Asphalt Pavement Association Of Michigan Selecting the Right Mix for Your Project

LOCAL AGENCY PROGRAMS HOT MIX ASPHALT (HMA) SELECTION GUIDELINES

JUNE, 2009

The following guidelines have been developed at the request of Local Agency Engineers for use on Local Agency projects. These guidelines have been reviewed and approved by the County Road Association of Michigan Engineering Committee. Previous experience and performance shall permit variations from these guidelines.

A. HMA Mixture Type and Binder selection

Selection is based on present day two-way Commercial ADT. The Commercial ADT ranges for each of the mixture types have taken into account an assumed future traffic growth rate.

Com. ADT.	Com. ADT 0-300	Com. ADT 301-700	Com. ADT 701-1000	Com. ADT 1001-3400	Com. ADT 3401- 9999
Mixture Type					
Top	13A, 36A, or LVSP	4C 5E1	5E3, or 4E3	5E10, or 4E10	5E30, or 5E10
Leveling	13A or LVSP	3C 4E1	4E3	4E10	4E30
Base	13A	2C	3E3	3E10	3E30
Binder Grades by Region					
Superior	PG 58-34	PG 58-34	PG 58-34	PG 58-34	
Metro	PG 58-22	PG 64-22	PG 64-22	PG 64-22	PG 70-22P
All Other	PG 58-28	PG 64-28	PG 64-28	PG 64-28	PG 70-28P

Note: The recommended PG binder grades for mixtures used as a base course is PG 58-22 for all regions, except in the Superior Region use PG 58-28. The base course is defined as all layers below 4 inches of the surface. For mixture layers which fall within the 4 inch threshold, the following rule applies: If less than 25% of a mixture layer is within 4 inches of the surface, the mixture layer should be considered to be a base course.

Note: The Special Provision for Marshall Hot Mix Asphalt Mixtures specifies a design air void of 4% for 13A and 36A. If the designer wishes to reduce the target air voids on projects that call for a 13A and 36A to 3.0%, a note needs to be added to the plans near the HMA Application Table stating that the air voids have been changed to 3.0% for that particular project.

Note: The mixture type in each traffic category listed in the above table is specifically designed to perform under its respective Commercial ADT. Selecting a mixture type that is specifically designed for a Commercial ADT higher than the project being designed may adversely affect performance.

Local Agency HMA Guide

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Local Agency Programs HMA Selection Guidelines

- Developed for use on Local Agency Projects
- Reviewed and Approved by CRAM
- Variations Allowed

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Selecting the Right Mix for Your Project

Local Agency Programs HMA Selection Guidelines

- SuperPave and Marshall mix designs
- SuperPave for Commercial ADT > 700

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Selecting the Right Mix for Your Project

Local Agency Programs HMA Selection Guidelines

- Selection based on Present Day two-way commercial ADT (Truck traffic)
- Assumed future growth

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Local Agency Programs HMA Selection Guidelines

Commercial ADT	0 – 300	301 – 700	701 – 1000	1001 – 3400	3401 – 9999
Mixture Type					
Surface	13A or 36A or LVSP	4C 5E1	5E3 or 4E3	5E10 or 4E10	5E30 or 5E10
Leveling	13A or LVSP	3C 4E1	4E3	4E10	4E30
Base	13A	2C	3E3	3E10	3E30

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Selecting the Right Mix for Your Project

Local Agency Programs HMA Selection Guidelines

Commercial ADT	0 – 300	301 – 700	701 – 1000	1001 – 3400	3401 – 9999
Binder Grades by Region					
Superior	PG 58-34	PG 58-34	PG 58-34	PG 58-34	
Metro	PG 58-22	PG 64-22	PG 64-22	PG 64-22	PG 70-22P
All Other	PG 58-28	PG 64-28	PG 64-28	PG 64-28	PG 70-28P

For Surface and Leveling Courses

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Selecting the Right Mix for Your Project

Local Agency Programs HMA Selection Guidelines

- Base Course Binder Selection
 - Use PG 58-28 for Superior Region
 - Use PG 58-22 for all other Regions
- A Base Course is defined as:
 - All layers below 4” of the surface

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Local Agency Programs HMA Selection Guidelines

- Target Air Voids
 - Mixes are specified with 4% design AV
 - Can be reduced to 3% for 13A and 36A mixes
 - Add a note to the HMA Application Table
 - Reduce shoulder mixes to 2.5% AV

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Local Agency Programs HMA Selection Guidelines

- One Course Overlays
 - Decrease cold temperature number of the PG Binder by one grade

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Binder Selection

Economics:

- Existing Pavement Condition
- Fix Life
- Low Temperature Cracking “Protection”

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Binder Selection

Example:

- 1 ½” resurfacing of existing road
 - 98% reliability binder grade is PG 64-28
- Consider using PG 64-22 ?
 - Reflective cracking

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Lift Thickness based on Nominal
Maximum Aggregate Size (NMAS)

NMAS – 1 size larger than the first sieve to
retain more than 10%

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Selecting the Right Mix for Your Project

NMAS

Table 2: Aggregate Properties

	Mixture No.				
	2C	3C	4C	13A	36A
	Percent Passing Indicated Sieve or Property Limit				
1 1/2 inch	100				
1 inch	91-100	100			
3/4 inch	90 max.	91-100	100	100	
1/2 inch	78 max.	90 max.	91-100	75-95	100
3/8 inch	70 max.	77 max.	90 max.	60-90	92-100
No. 4	52 max.	57 max.	67 max.	45-80	65-90
No. 8	15-40	15-45	15-52	30-65	55-75
No. 16	30 max.	33 max.	37 max.	20-50	
No. 30	22 max.	25 max.	27 max.	15-40	25-45
No. 50	17 max.	19 max.	20 max.	10-25	
No. 100	15 max.	15 max.	15 max.	5-15	

Ex: 4C mix – NMAS is 1/2”

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Local Agency Programs HMA Selection Guidelines

Mixture Type	Marshall Mixture					Superpave Mixture		
	36A	13A	2C	3C	4C	3E_	4E_	5E_
Min. #/syd	110	165	350	220	165	330	220	165
Max. #/syd	165	275	500	330	275	410	275	220

Note: Application Rate of 110#/syd. Per 1 inch Thickness

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Selecting the Right Mix for Your Project

Lift Thickness vs. Performance

- In-place Density is Critical
 - Initial In-place Air Voids <8%
- Lift Thickness Affects Compaction
 - Consolidation “Room”
 - Cooling Rate

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Selecting the Right Mix for Your Project

Local Agency Programs HMA Selection Guidelines

- Aggregate Wear Index
 - Specified for Surface course mixes
 - Based on ADT (vehicular and commercial) per lane

ADT/Lane	Minimum AWI
< 100	None
100 – 2000	220
> 2000	260

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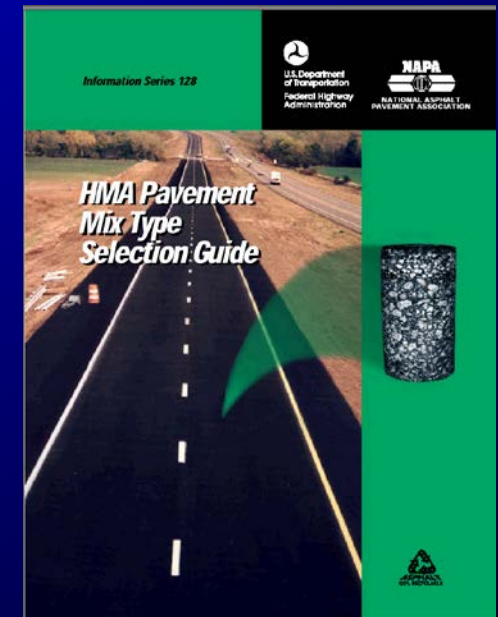


NAPA Guide

Asphalt Pavement Association Of Michigan Selecting the Right Mix for Your Project

What's in the Guide

- Pavement layers and traffic level definitions
- General surface preparation recommendations
- Mix Types
 - Definitions
 - Purpose
 - Materials
- Procedure for selecting mixes
- Examples



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Selecting the Right Mix for Your Project

Conclusions

- Selection of Mix for:
 - Optimum Performance
 - Economics
- Binder Selection Economics
- Lift Thickness vs. Performance

Asphalt Pavement Association Of Michigan

Selecting the Right Mix for Your Project

Examples

- New Parking Lot
- Overlay Low Volume County Road
- New City Street

Asphalt Pavement Association Of Michigan Selecting the Right Mix for Your Project



Questions?

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517.323.7800 800.292.5959