ASPHALT

THE SMOOTH QUIET RIDE

ASPHALT 100% RECYCLABLE

2014 Local Roads Workshop

February & March, 2014

ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN

MICHIGAN RIDES ON US Asphalt.

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

2937 Atrium Drive, Suite 202

Okemos, MI 48864

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Outline

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

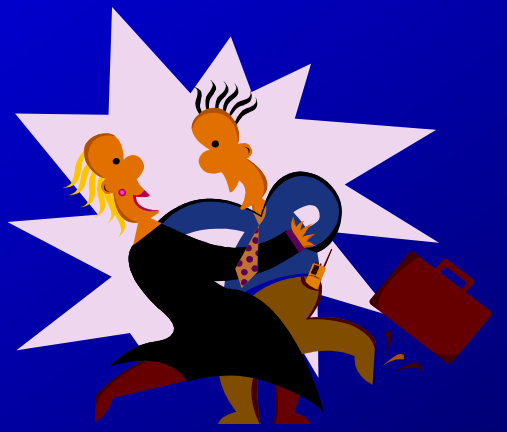
Asphalt Pavement Association Of Michigan
Selecting the Right Mix

…to Interstate

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

For each there are:

- Right mixes



- Wrong mixes

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Mix History

ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

SuperPave Mixes

2000's

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

SuperPave Mixes

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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	3-6	3-6	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.

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Superpave Mix Spec

Table 902-6
Superpave Final Aggregate Blend Physical Requirements

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	100/100	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.

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Superpave Mix Spec

Table 501-1
Superpave Mix Design Criteria

Design Parameter	Mix Number 5	4	3	2	LVSP
Percent of Maximum Specific Gravity (%G_{mm}) at the design number of gyrations, (N_d) (c)	96.0% (a)				
%G_{mm} at the initial number of gyrations, (N_i)	See Table 501-3				
%G_{mm} at the maximum number of gyrations, (N_m)	98.0%				
VMA min % at N_d (based on aggregate bulk specific gravity, (G_{sb})) (c)	15.00	14.00	13.00	12.00	14.00
VFA at N_d	See Table 501-2 (b)				
Fines to effective asphalt binder ratio (P_{No200}/P_{be})	0.6–1.2				
Tensile strength ratio (TSR)	80% min				

a. For mixtures meeting the definition for base course, design mixtures to 96.0% of Maximum Specific Gravity %G_{mm} at the design number of gyrations, (N_d). During field production, increase %G_{mm} at the design number of gyrations, (N_d) to 97.0%.
b. For base course or regressed shoulder mixtures, the maximum criteria limits do not apply.
c. Lower Target Air Voids by 1.0% if used in a separate shoulder paving operation, unless otherwise shown on the plans.

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Superpave Mix Spec

Table 501-3
Superpave Gyratory Compactor (SGC) Compaction Criteria

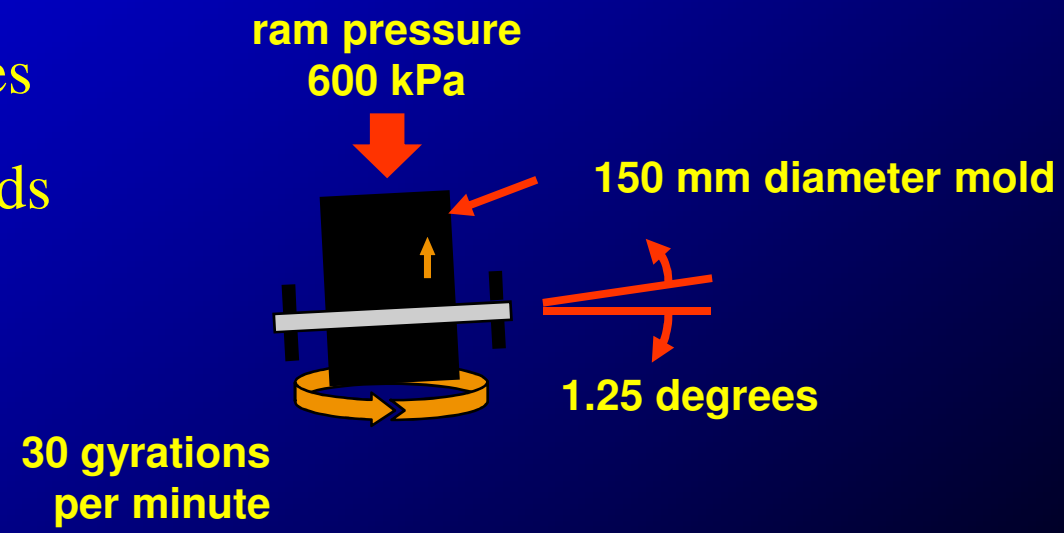
Estimated Traffic (million ESAL)	Mix Type	%G_{mm} at (N_i)	Number of Gyrations (a)		
			N_i	N_d	N_m
≤0.3	LVSP	91.5%	6	45	70
≤0.3	E03	91.5%	7	50	75
>0.3 – ≤1.0	E1	90.5%	7	76	117
>1.0 – ≤3.0	E3	90.5%	7	86	134
>3.0 – ≤10	E10	89.0%	8	96	152
>10 – ≤30	E30	89.0%	8	109	174
>30 – ≤100	E50	89.0%	9	126	204

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.

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Marshall vs. Superpave Mix

1. Compaction of mix design samples
   a. Marshall Hammer
   b. Gyratory Compactor
2. Aggregate Properties
3. Mix Design Air Voids



Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Performance Graded Binders

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Performance Graded Binders

- PG Specification
- Testing
- Binder Selection
  - Location/Environment
  - Reliability
  - Traffic level
  - Traffic speed
  - Depth in Pavement Structure

SUPERPAVE Performance Grade (PG) Binder Specification

- Fundamental properties related to pavement performance
- In-service & construction temperatures
- Short and long term aging

Performance Grades – Table 1

CEC

Avg 7-day Max, °C	PG 46			PG 52						PG 58					PG 64						PG 70						PG 76					PG 82				
1-day Min, °C	-34	-40	-46	-10	-16	-22	-28	-34	-40	-46	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34	-10	-16	-22	-28	-34
ORIGINAL																																					
≥ 230 °C	(Flash Point) FP																																				
≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) RV																																				
≥ 1.00 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ																																				
	46			52						58					64						70						76					82				
(ROLLING THIN FILM OVEN) RTFO Mass Loss ≤ 1.00 %																																					
≥ 2.20 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ																																				
	46			52						58					64						70						76					82				
(PRESSURE AGING VESSEL) PAV																																					
20 Hours, 2.07 MPa	90			90					100		100					100 (110)						100 (110)						110 (110)									
≤ 5000 kPa	(Dynamic Shear Rheometer) DSR G* sin δ																																				
	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13	31	28	25	22	19	16	34	31	28	25	22	19	37	34	31	28	25	40	37	34	31	28
S ≤ 300 MPa m ≥ 0.300	(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value																																				
	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24
Report Value	(Bending Beam Rheometer) BBR Physical Hardening																																				
≥ 1.00 %	(Direct Tension) DT																																				
	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24

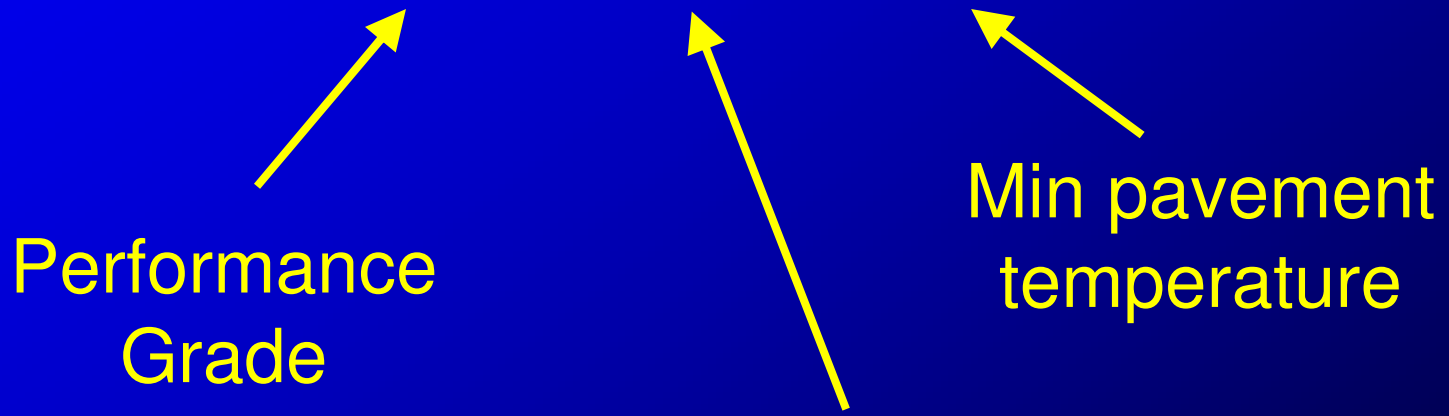
PG Specifications

- Based on rheological testing
  - Rheology: study of flow and deformation
- Asphalt cement is a viscoelastic material
- Behavior depends on:
  - Temperature
  - Time of loading
  - Aging (properties change with time)

Superpave Asphalt Binder Specification

The grading system is based on climate

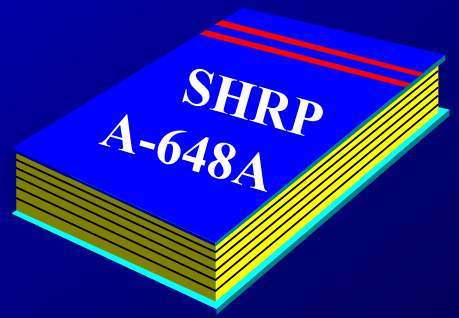
PG 58 - 28



Developed from Air Temperatures

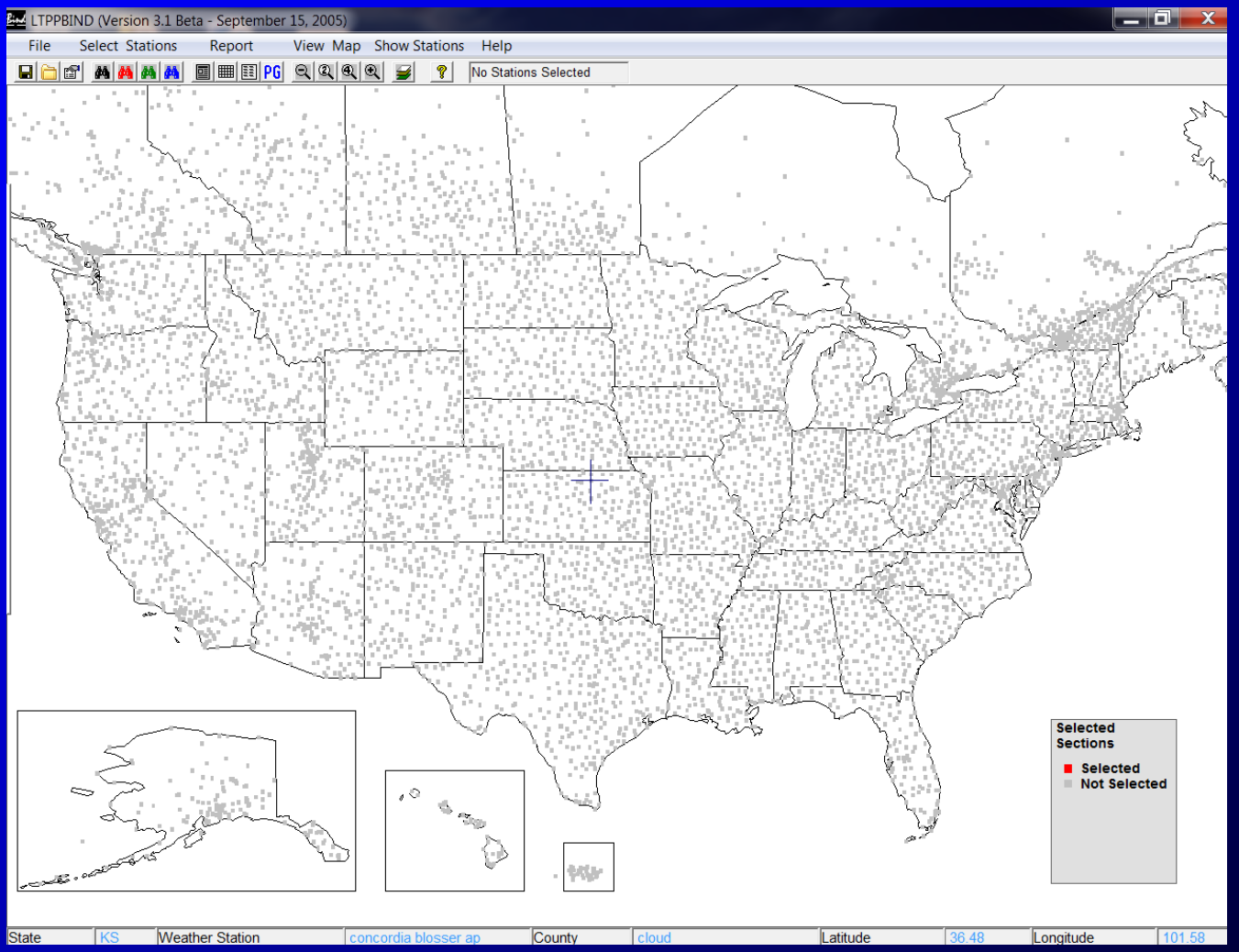
- **Superpave Weather Database**
  - **6500 stations in U.S. and Canada http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/ltppbind.cfm**
- **Annual air temperatures**
  - **hottest seven-day temp (avg and std dev)**
  - **coldest temp (avg and std dev)**
- **Calculated pavement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

> 20 years

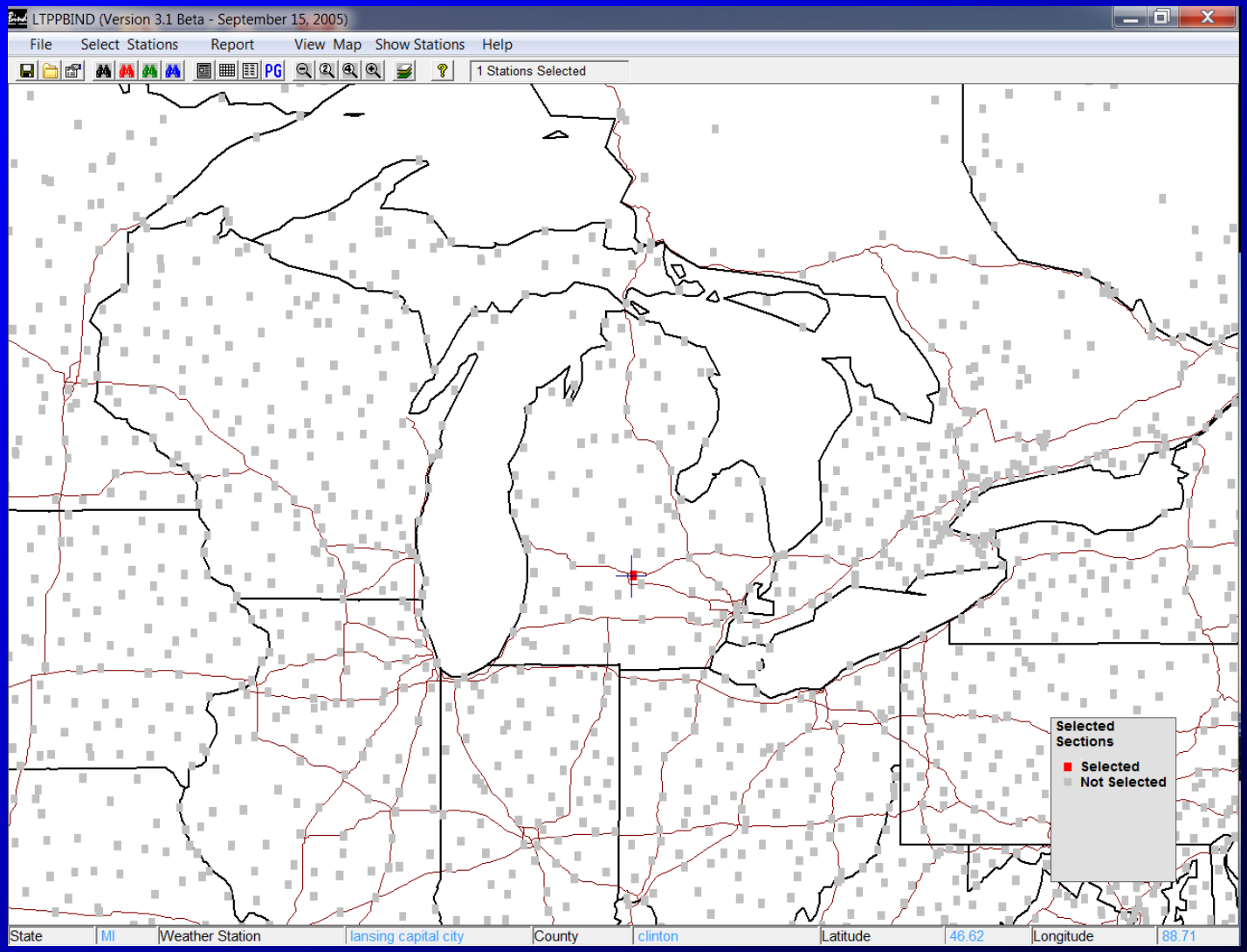


LTPP Bind Software

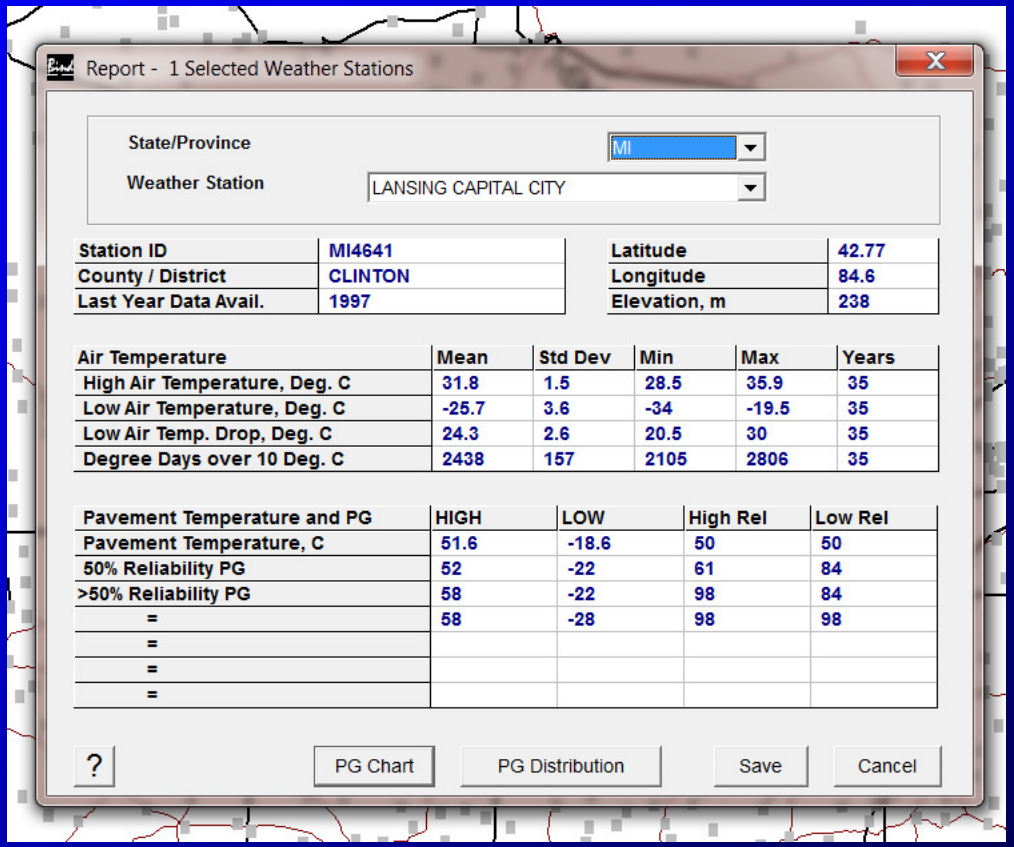
LTPP Bind Software



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)

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

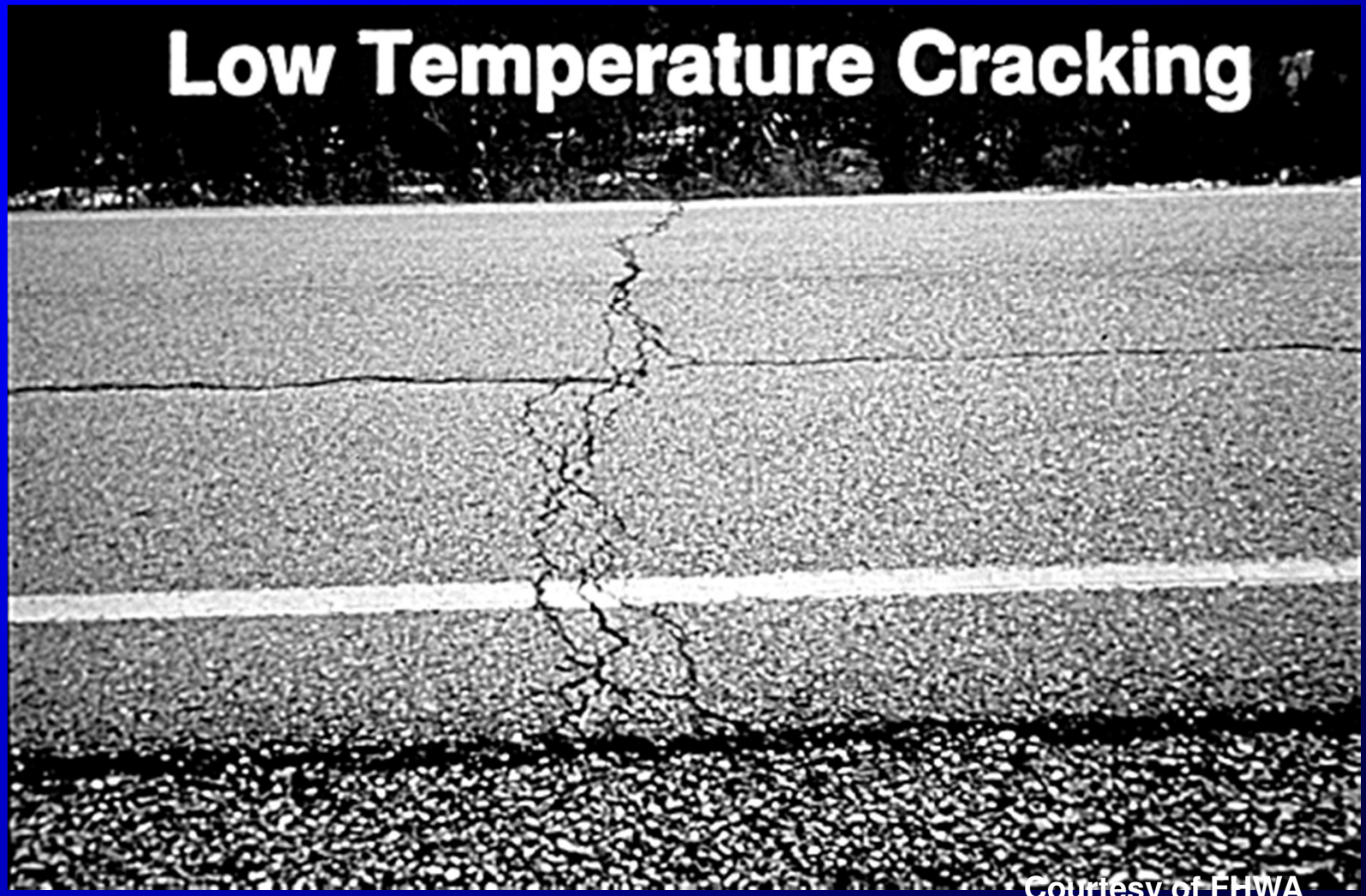
Other Performance Factors:

- Rutting - shear strength of mix, aggregate properties
- Fatigue Cracking - pavement structure, traffic

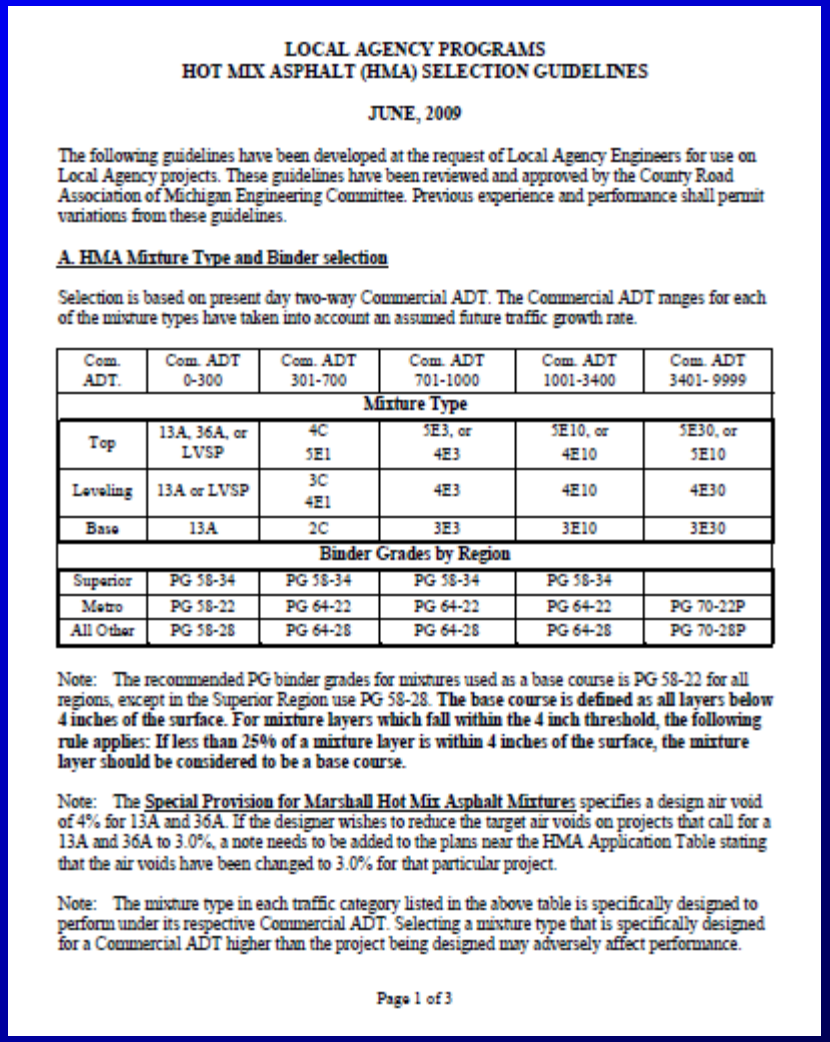
Important Factor:

- Low temperature Cracking – correlates well to binder properties

Thermal Cracking



Asphalt Pavement Association Of Michigan
Selecting the Right Mix



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.

Page 1 of 3

Local Agency Guide

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Local Agency Programs
HMA Selection Guidelines

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Local Agency Programs
HMA Selection Guidelines

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Local Agency Programs
HMA Selection Guidelines

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Local Agency Programs
HMA Selection Guidelines

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Binder Selection

Economics:

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Binder Selection

Example:

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Lift Thickness based on Nominal Maximum Aggregate Size (NMAS)

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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 ½"

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Lift Thickness vs. Performance

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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

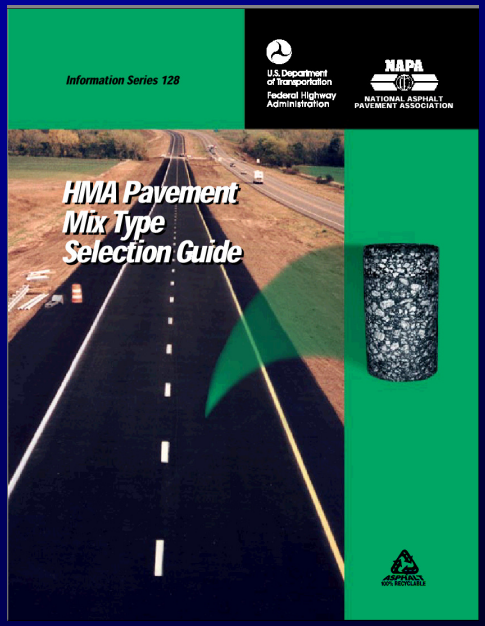
Asphalt Pavement Association Of Michigan
Selecting the Right Mix

NAPA Guide

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

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



Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Conclusions

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

Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Questions?

www.apa-mi.org
517.323.7800 800.292.5959