# Asphalt Pavement Association Of Michigan
# Selecting the Right Mix


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# 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
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…to Interstate

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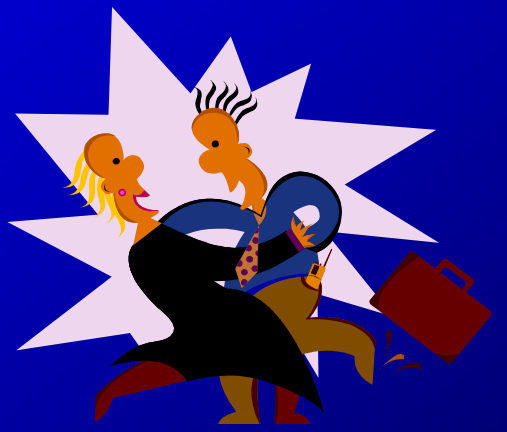
For each there are:

- Right mixes



- Wrong mixes

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## Mix History

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## Asphalt Mix History

## 1970's

- 4.11 Bituminous Aggregate Pavement
- 4.12 9A Binder
- 25A Leveling/Wearing
- 31A Wearing

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## Stability Mixes

## 1980's

- #500 & #700 20C Bases
- #1100 L & T 20A, 20AA
- #1300, #1500, #1800 L &T 20AA

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## Performance Mixes

## 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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## SuperPave Mixes

## 2000's


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

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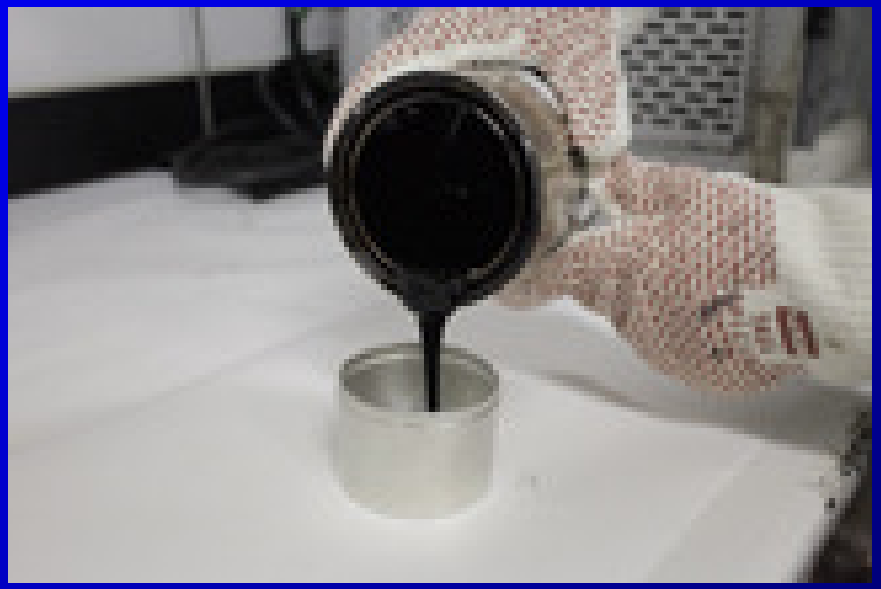

## Asphalt Cement History

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# Asphalt Pavement Association Of Michigan
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## Asphalt Cement History

- Penetration Grades – 1920's
  - 85-100
  - 120-150
  - 200-300
- Viscosity Grades – 1960's
  - AC-2.5
  - AC-5
  - AC-10
- PG Binders:  Mid 90's
  - PG 58-28

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## Performance Graded Binders

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## 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

# 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)

# Performance Grades – Table 1

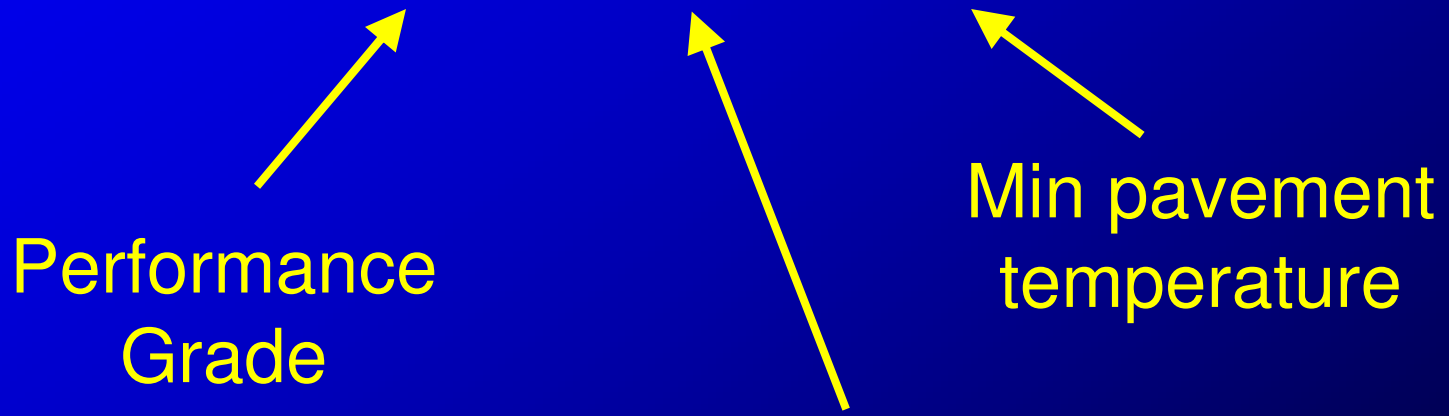
CEC

| 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 |

# Superpave Asphalt Binder Specification

The grading system is based on climate

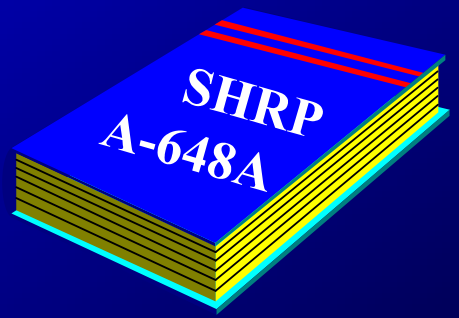
**PG 58 - 28**



# Developed from Air Temperatures

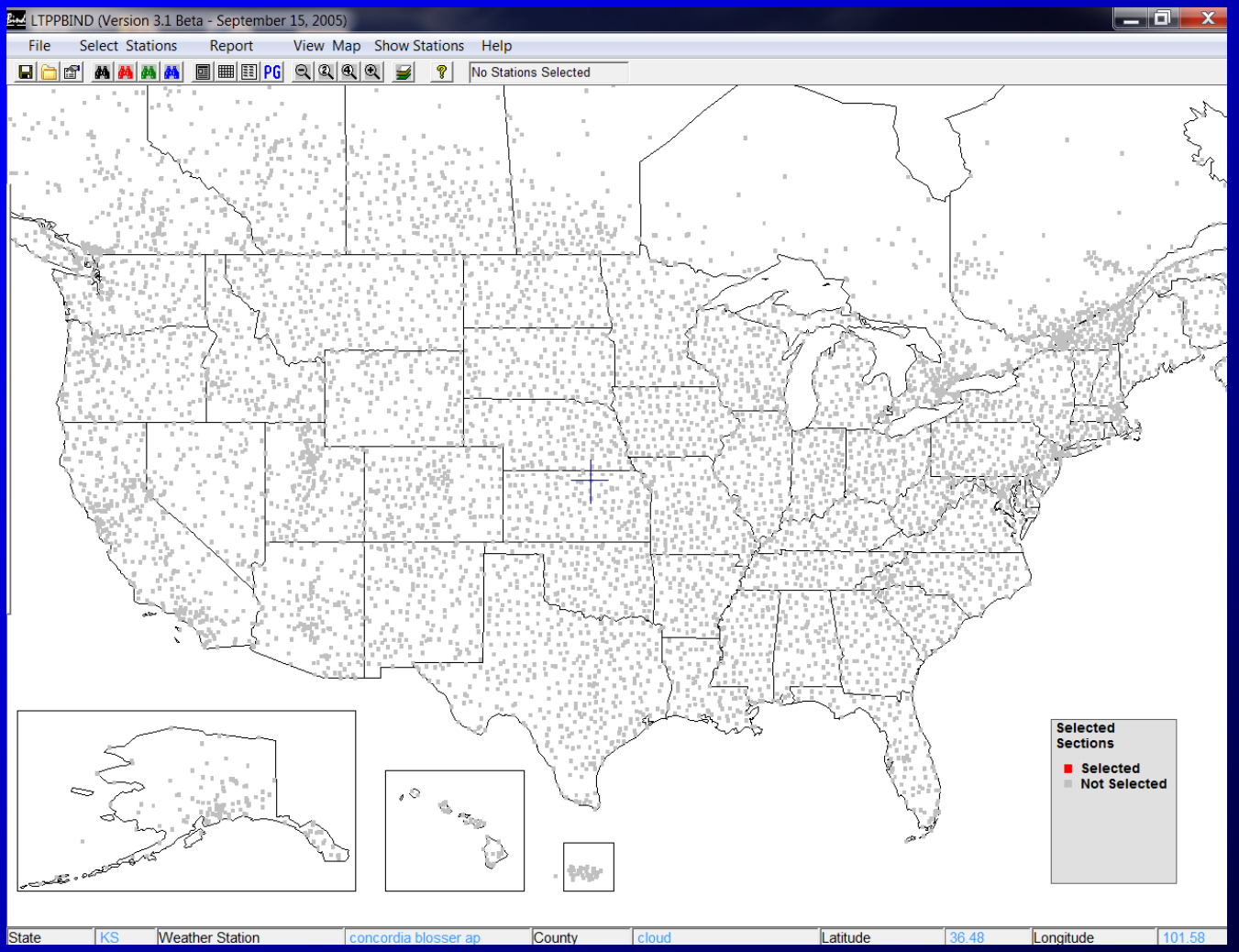
- **Superpave Weather Database**
  - **6500 stations in U.S. and Canada http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/ltppbind.cfm**
- **Annual air temperatures**
  - **hottest seven-day temp (avg and std dev)**
  - **coldest temp (avg and std dev)**
- **Calculated pavement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

**> 20 years**

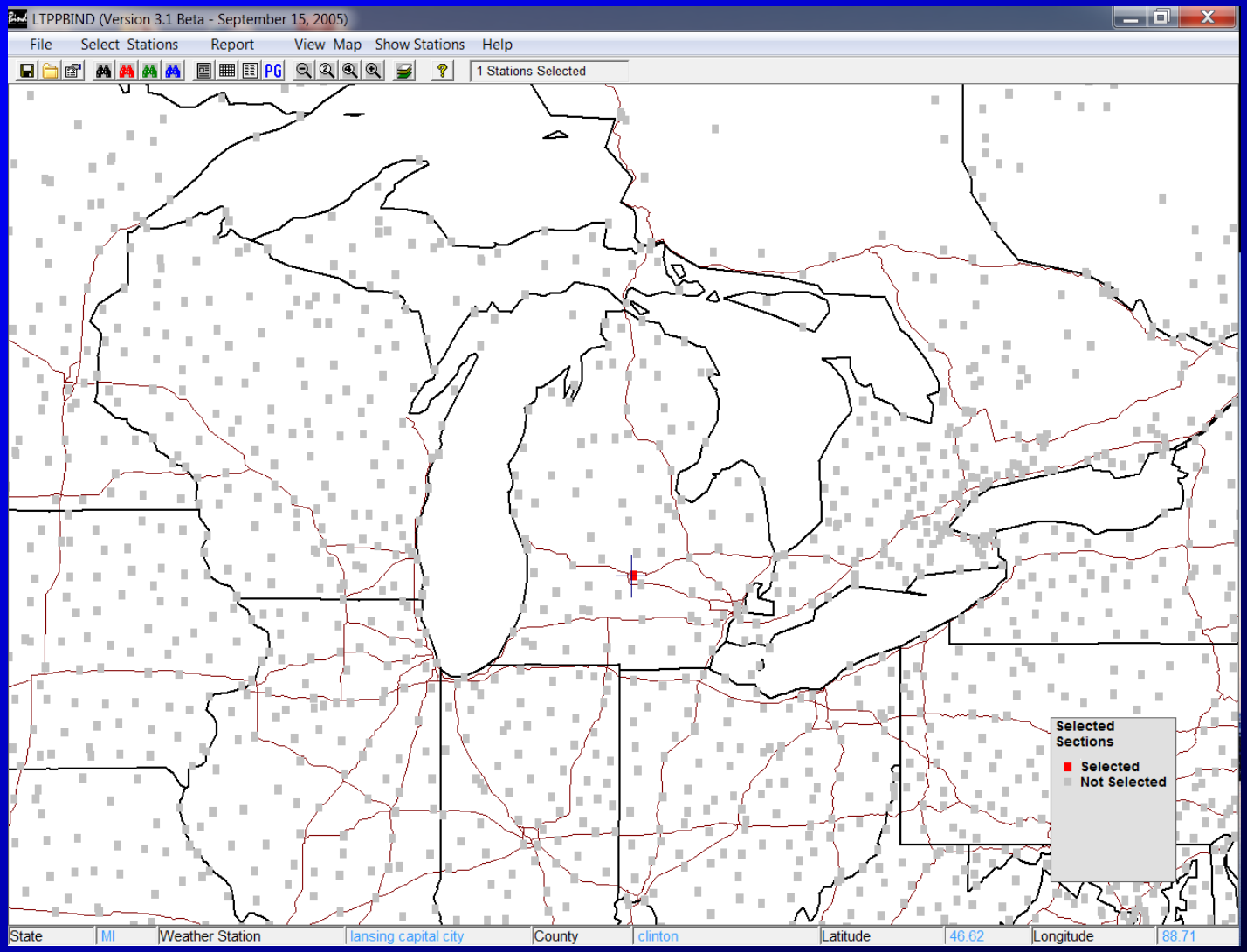



**LTPP Bind Software**

# LTPP Bind Software



# LTPP Bind Software



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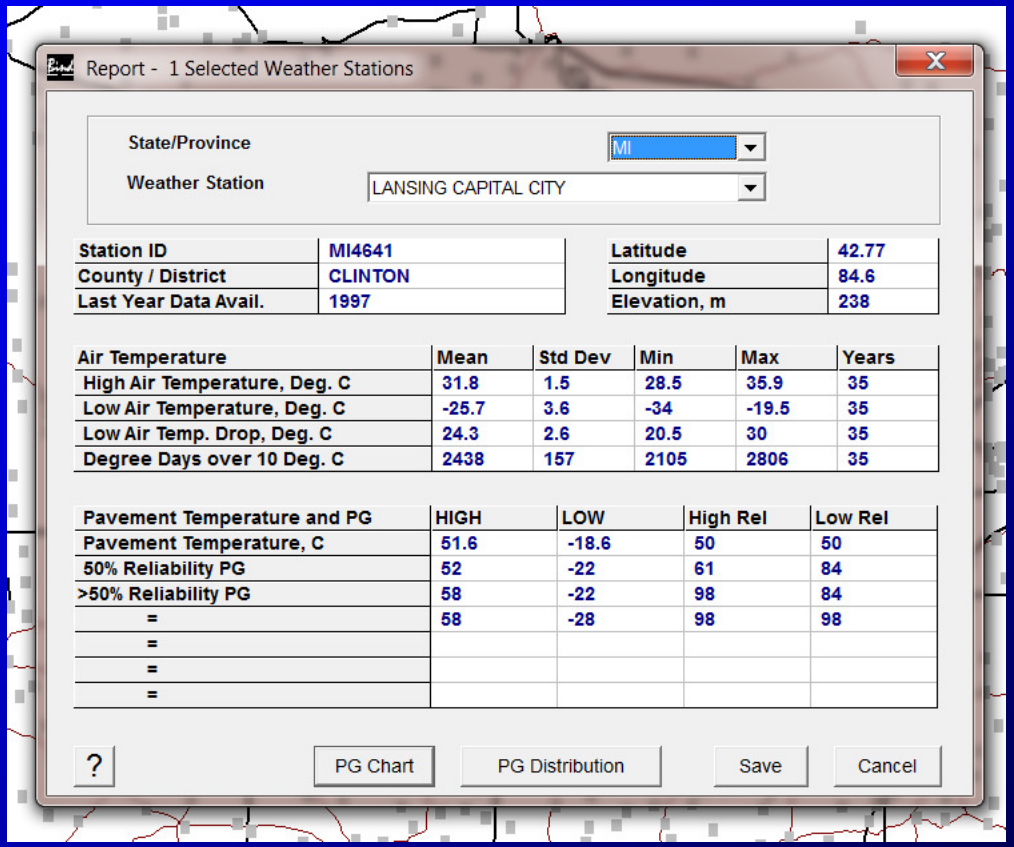


# Convert to Pavement Temperature

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

# 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<br>5E1 | 5E3, or<br>4E3 | 5E10, or<br>4E10 | 5E30, or<br>5E10 |
| Leveling | 13A or LVSP | 3C<br>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.

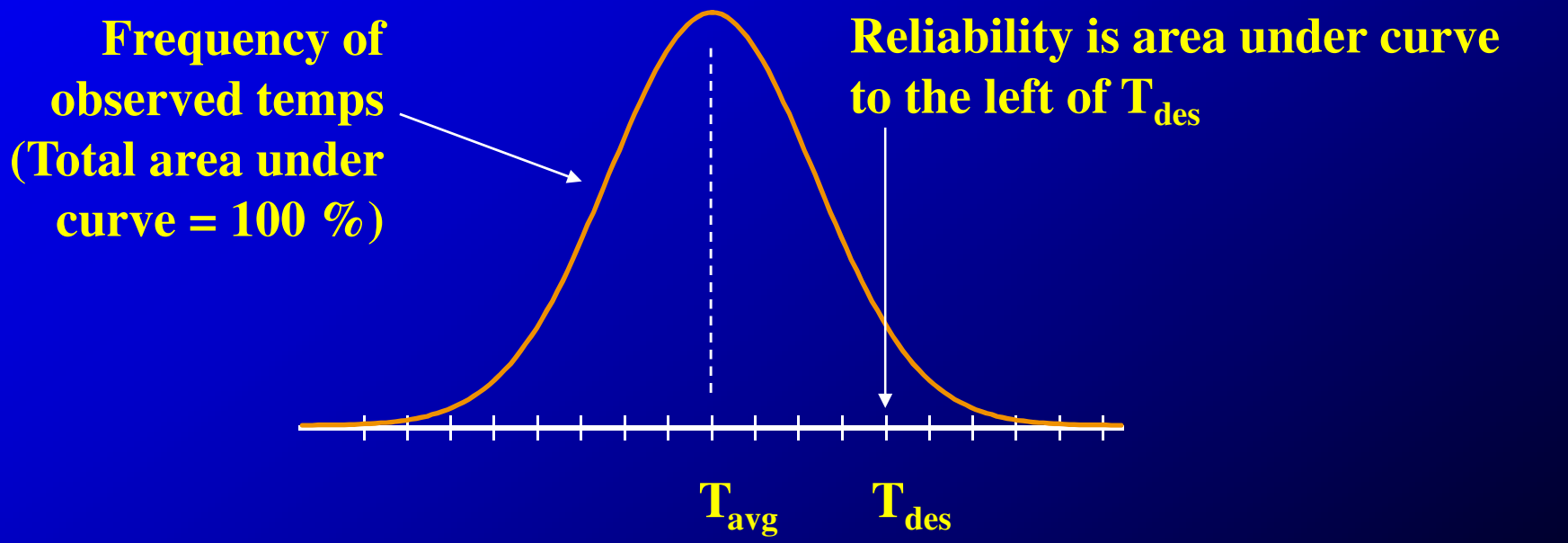
# Binder Grade Selection

Grade varies with:

- Location/Environment
- **Reliability**
- Traffic level
- Traffic speed
- Depth in Pavement Structure

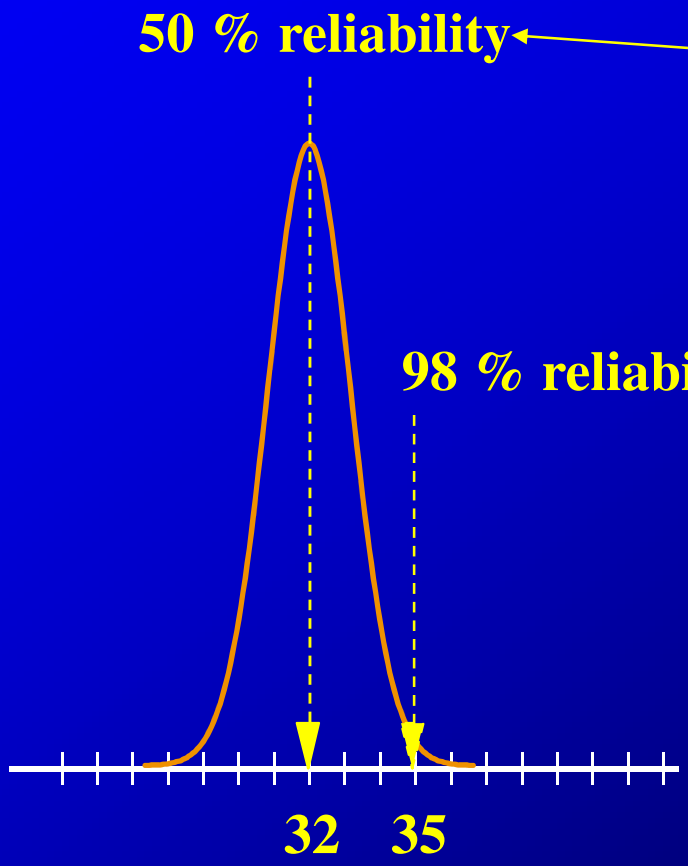
# Reliability

- **Percent probability of <u>not</u> exceeding design temp**
  - **> using Normal Distribution**



# Observed Air Temperatures

Lansing, MI

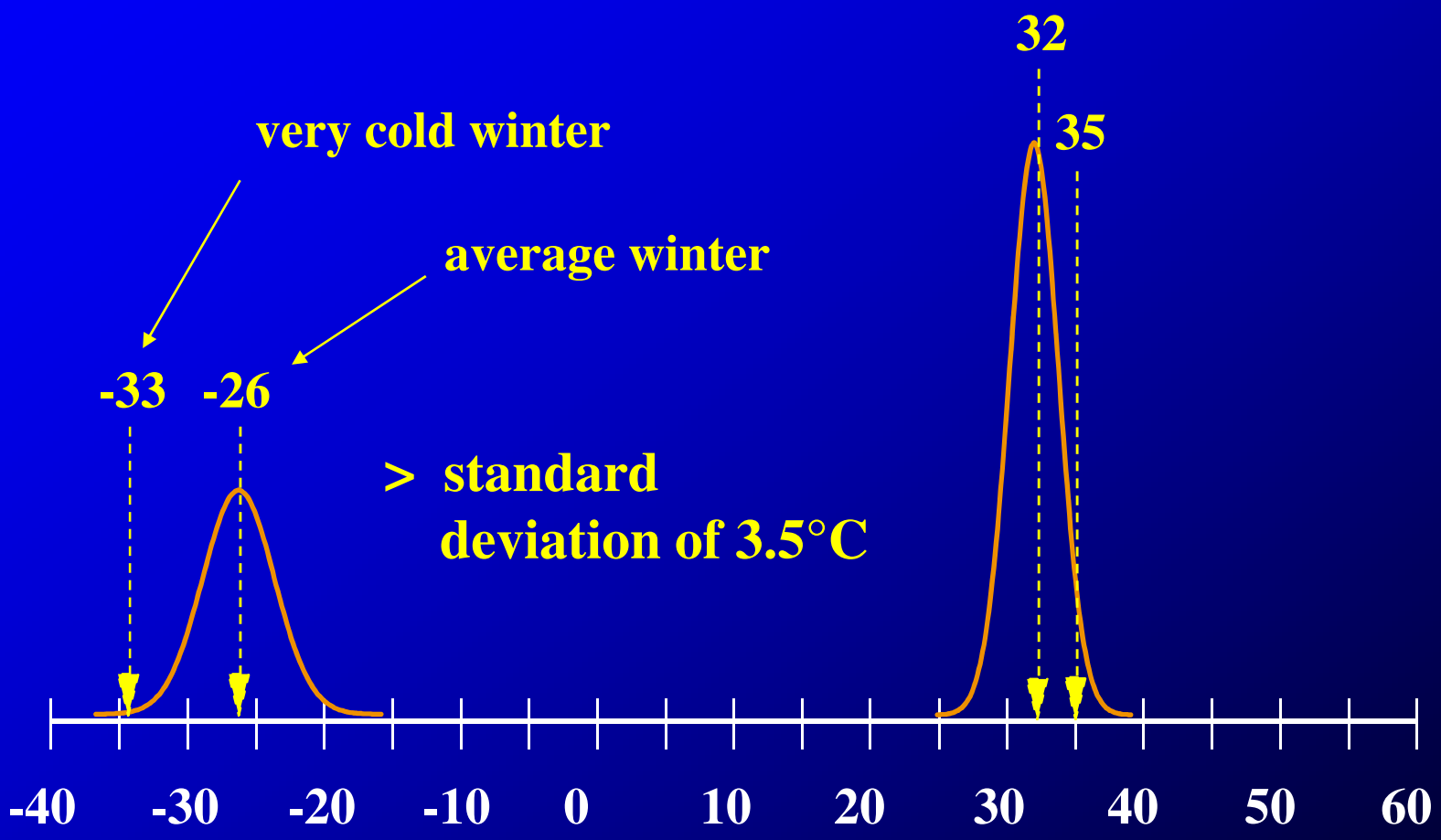



> this data - standard deviation of 1.5°C

**7-Day Maximum Air Temperatures**

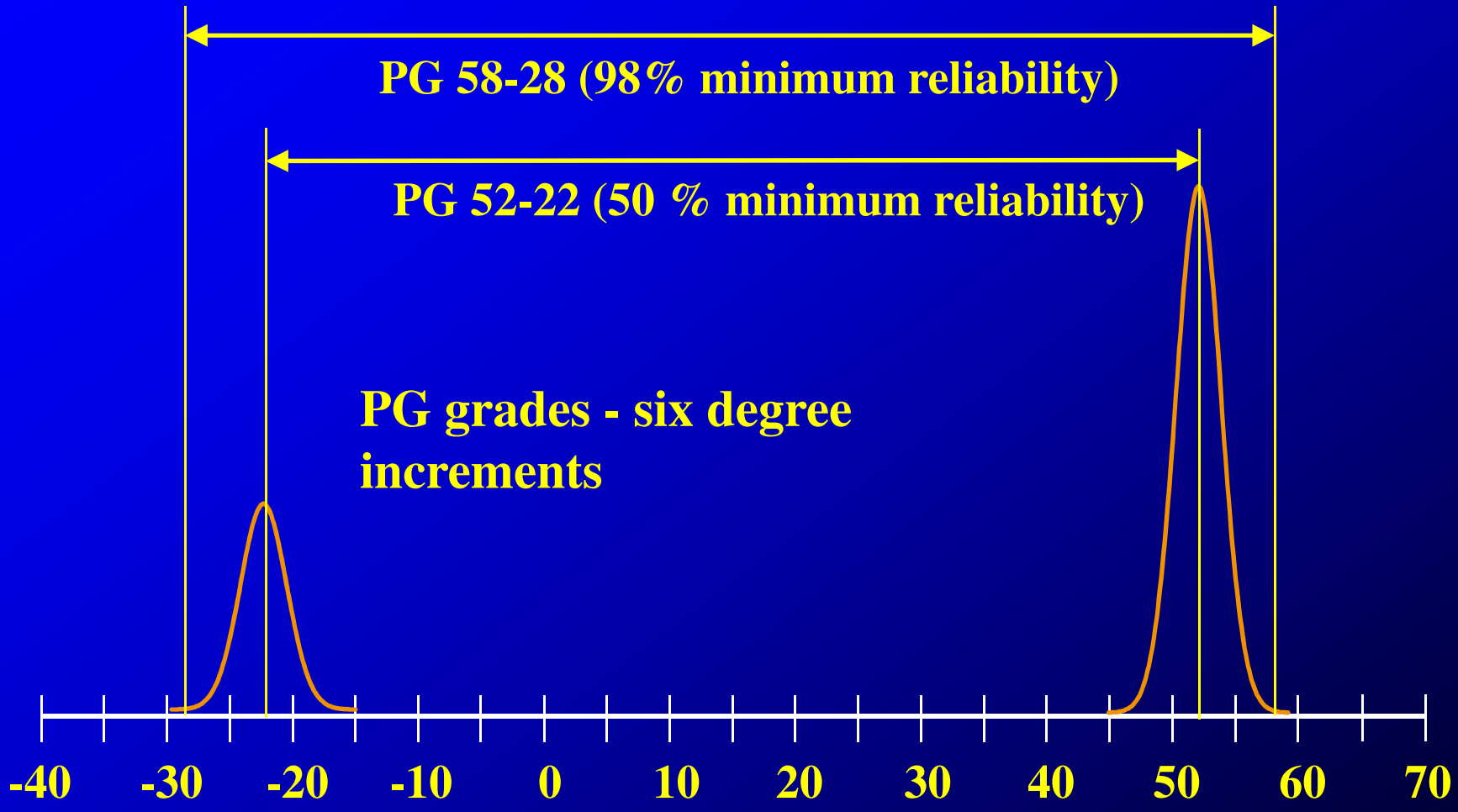
# Observed Air Temperatures

Lansing, MI



# PG Binder Grades

Lansing, MI

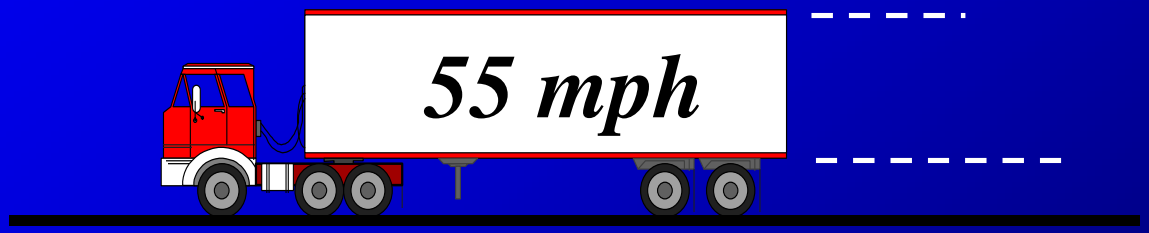


# Binder Grade Selection

Grade varies with:

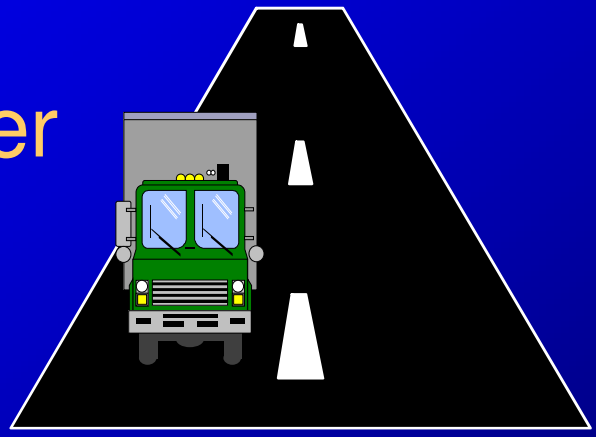
- Location/Environment
- Reliability
- Traffic level
- Traffic speed
- Depth in Pavement Structure

# Effect of Loading Rate on Binder Selection




- Dilemma
  - Specified DSR loading rate is 10 rad/sec
  - What about longer loading times ?
- Use binder with more stiffness at higher temps
  - Slow - - increase one high temp grade
  - Stationary - - increase two high temp grades
  - *No effect on low temp grade*

# Effect of Loading Rate on Binder Selection



*55 mph*

- Example
  - for toll road — PG 64-22
  - for toll booth — PG 70-22 — Slow
  - for weigh stations — PG 76-22

Stopping

# Effect of Traffic Amount on Binder Selection

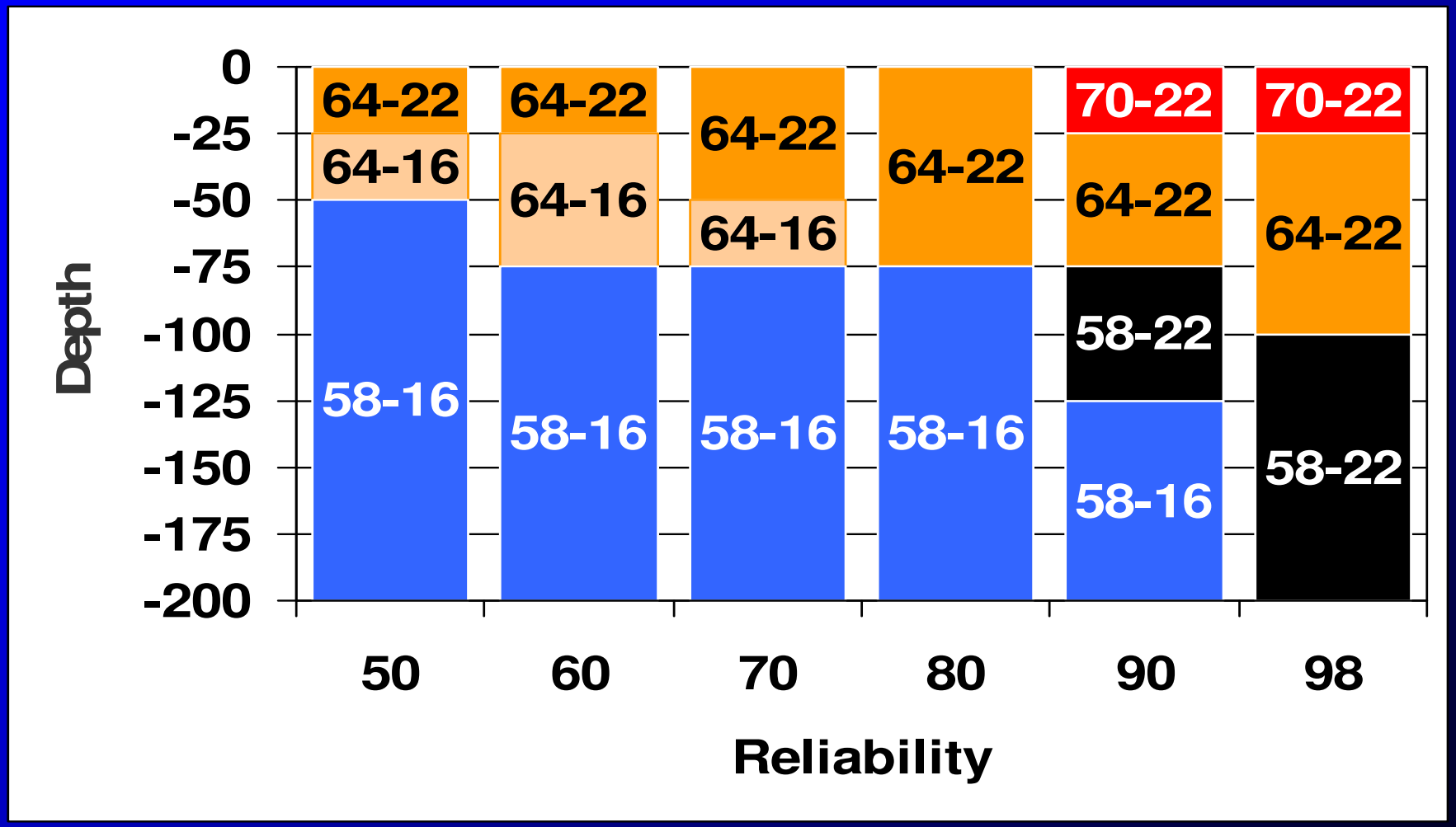

- **10 to 30 Million ESALs**
  - **Consider increasing - - one high temp grade**
- **> 30 Million ESALs**
  - **Recommend increasing - - one high temp grade**

**> Equivalent Single Axle Loads**

# Binder Grade vs. Depth

- Example: Indianapolis, Medium Traffic, Fast Speed
  - LTPPBind Software http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/ltppbind.cfm

# PG vs. Depth
# 3-10 MESAL, Fast



# Binder Grade Selection

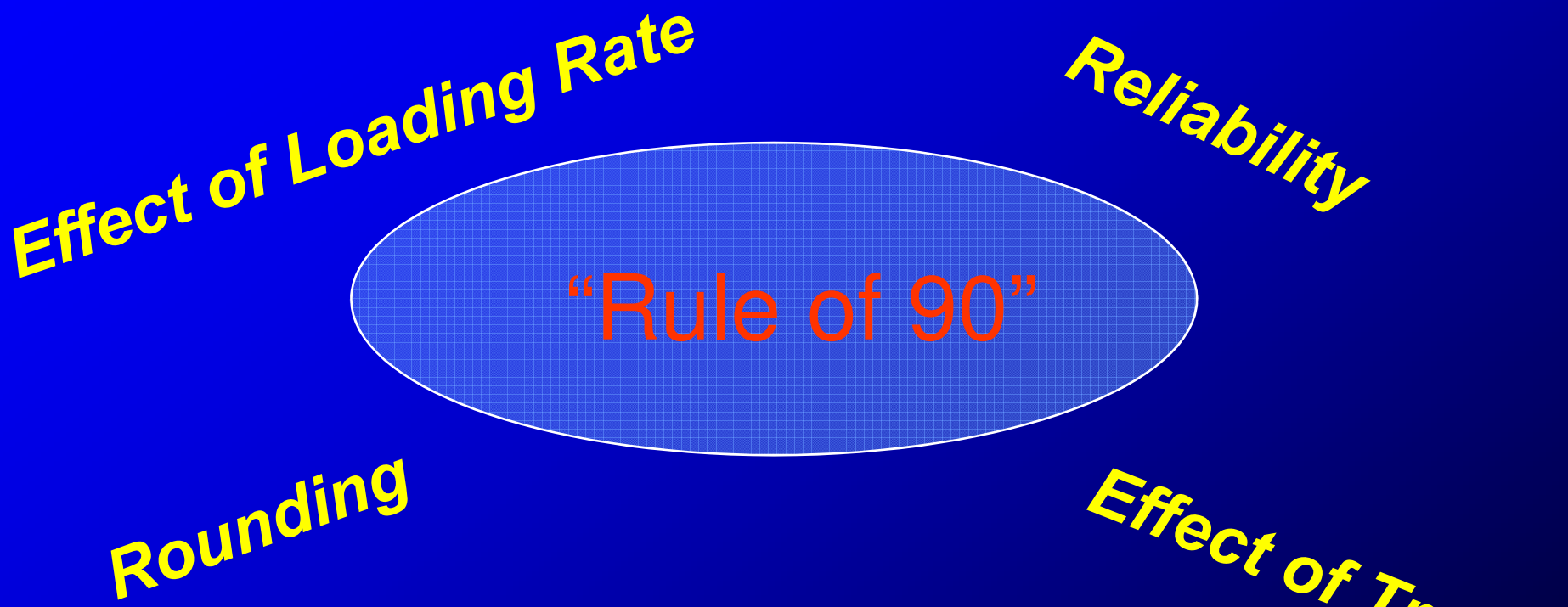
Resources:

- LTTPBind Software
  - http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/ltppbind.cfm
- Published Guides
  - MDOT Local Agency HMA Selection Guidelines
  - NAPA HMA Pavement Mix Type Selection Guide

# What Binders are Used in Michigan

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

# Is a PG a Modified Binder ?




**Example: PG 64 - 34 has a temperature range of 64 to - 34 or 98 C. Therefore, this binder is probably modified !!** ***(Depends on Asphalt Source!)***

# Binder Grade vs. Pavement Performance

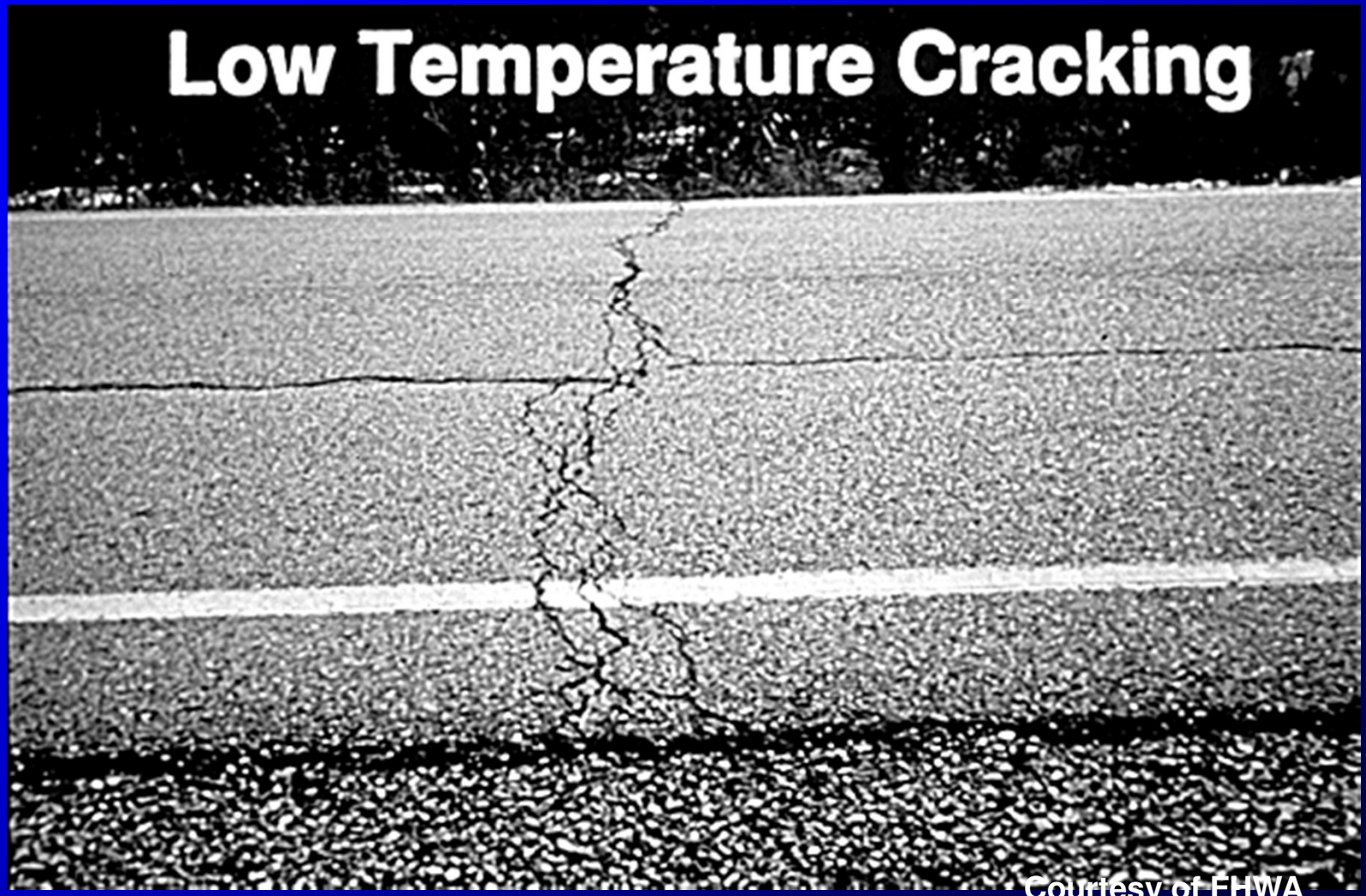
Other Performance Factors:

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

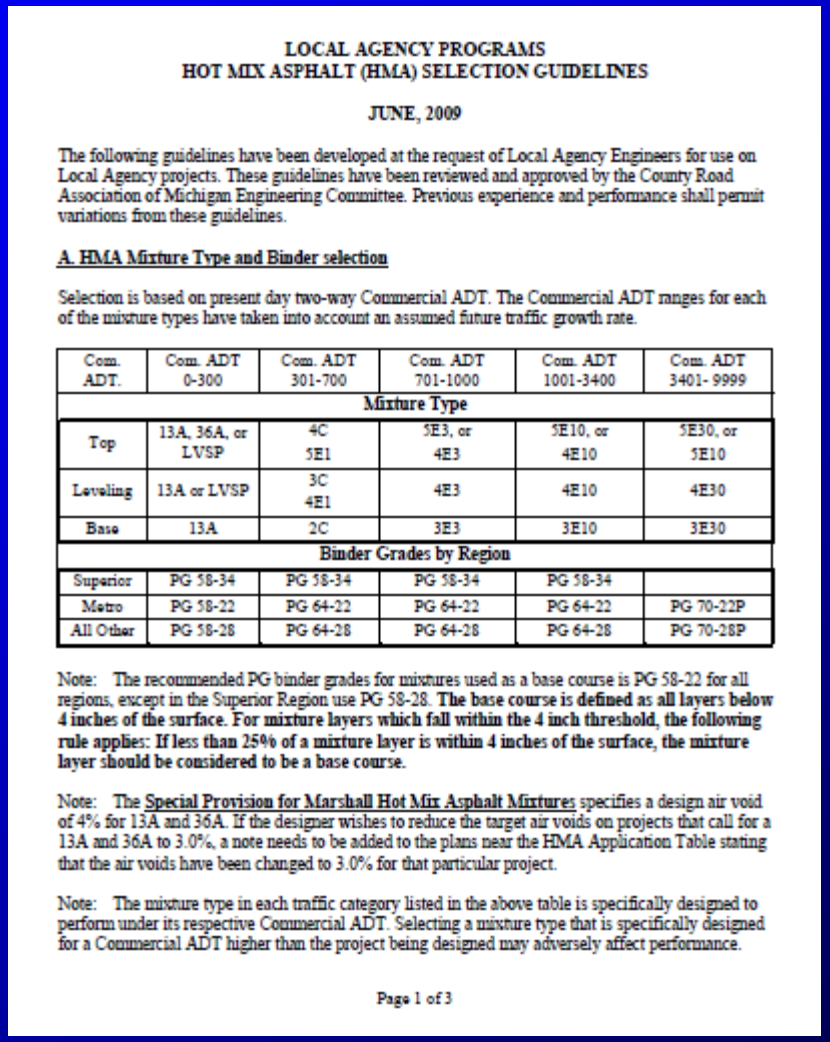
Important Factor:

- Low temperature Cracking – correlates well to binder properties

# Thermal Cracking



# Asphalt Pavement Association Of Michigan
# Selecting the Right Mix



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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
- 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<br>5E1 | 5E3 or<br>4E3 | 5E10 or<br>4E10 | 5E30 or<br>5E10 |
| Leveling | 13A or<br>LVSP | 3C<br>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 |
|---|---|---|---|---|---|
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**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
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## 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 58-28
- Consider using PG 58-22 ?
  - Reflective cracking

# 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

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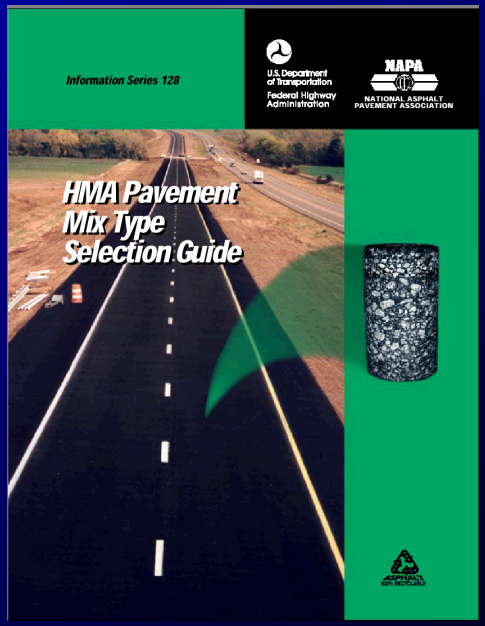
## What's in the Guide

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



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## Conclusions

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

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## Questions?

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