Outline

- History
- Performance Graded Binders
- MDOT Local Agency Guide
- NAPA Guide
- Other Considerations
Asphalt Pavement Association Of Michigan
Selecting the Right Mix

The Right Mix
at
The Right Place
Asphalt Pavement Association Of Michigan

Selecting the Right Mix

For each there are:

- **Right mixes**

- **Wrong mixes**
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Selecting the Right Mix

Mix History
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 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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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
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)
<table>
<thead>
<tr>
<th>Avg 7-day Max, °C</th>
<th>PG 46</th>
<th>PG 52</th>
<th>PG 58</th>
<th>PG 64</th>
<th>PG 70</th>
<th>PG 76</th>
<th>PG 82</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-day Min, °C</td>
<td>-34</td>
<td>-40</td>
<td>-46</td>
<td>-10</td>
<td>-16</td>
<td>-22</td>
<td>-28</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Flash Point) FP</th>
<th>≥ 230 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Rotational Viscosity) RV</td>
<td>≤ 3 Pa·s @ 135 °C</td>
</tr>
<tr>
<td>(Dynamic Shear Rheometer) DSR G*/sin δ</td>
<td>≥ 1.00 kPa</td>
</tr>
<tr>
<td>46</td>
<td>52</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(ROLLING THIN FILM OVEN) RTFO</th>
<th>Mass Loss ≤ 1.00 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Dynamic Shear Rheometer) DSR G*/sin δ</td>
<td>≥ 2.20 kPa</td>
</tr>
<tr>
<td>46</td>
<td>52</td>
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</table>

<table>
<thead>
<tr>
<th>(PRESSURE AGING VESSEL) PAV</th>
<th>20 Hours, 2.07 MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Dynamic Shear Rheometer) DSR G* sin δ</td>
<td>≤ 5000 kPa</td>
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<tr>
<td>90</td>
<td>90</td>
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</table>

<table>
<thead>
<tr>
<th>(Bending Beam Rheometer) BBR “S” Stiffness &amp; “m”- value</th>
<th>S ≤ 300 MPa, m ≥ 0.300</th>
</tr>
</thead>
<tbody>
<tr>
<td>-24</td>
<td>-30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(Bending Beam Rheometer) BBR</th>
<th>Physical Hardening</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Direct Tension) DT</td>
<td>≥ 1.00 %</td>
</tr>
<tr>
<td>-24</td>
<td>-30</td>
</tr>
</tbody>
</table>

Performance Grades – Table 1

- Mass Loss: ≤ 1.00 %
- Physical Hardening: ≥ 1.00 %
Superpave Asphalt Binder Specification

The grading system is based on climate

PG 58 - 28

Performance Grade

Min pavement temperature

Average 7-day max pavement temperature
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

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)
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 been taken into account an assumed future traffic growth rate.

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th>Com. ADT 0-300</th>
<th>Com. ADT 301-700</th>
<th>Com. ADT 701-1000</th>
<th>Com. ADT 1001-3400</th>
<th>Com. ADT 3401-9999</th>
</tr>
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<tbody>
<tr>
<td>Top</td>
<td>13A, 36A, or LVSP</td>
<td>4C</td>
<td>5E3, or 4E3</td>
<td>5E10 or 4E10</td>
<td>5E30 or 4E10</td>
</tr>
<tr>
<td>Leveling</td>
<td>13A or LVSP</td>
<td>4E1</td>
<td>4E3</td>
<td>5E10</td>
<td>4E30</td>
</tr>
<tr>
<td>Base</td>
<td>13A</td>
<td>2C</td>
<td>3E3</td>
<td>3E10</td>
<td>3E30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Binder Grades by Region</th>
<th>Superior</th>
<th>Macro</th>
<th>All Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 58-34</td>
<td>PG 58-34</td>
<td>PG 58-34</td>
<td>PG 58-34</td>
</tr>
<tr>
<td>PG 58-34</td>
<td>PG 64-22</td>
<td>PG 64-22</td>
<td>PG 70-22P</td>
</tr>
<tr>
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<td>PG 64-22</td>
<td>PG 64-22</td>
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</tr>
</tbody>
</table>

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 58-38. 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 28% 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 Mixture 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
Binder Grade Selection

Grade varies with:

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

- Percent probability of not exceeding design temp

> using Normal Distribution

Frequency of observed temps (Total area under curve = 100 %)

Reliability is area under curve to the left of $T_{des}$
32 35

7-Day Maximum Air Temperatures

Lansing, MI

50 % reliability

average summer

98 % reliability

very hot summer

> this data - standard deviation of 1.5°C

Observed Air Temperatures

average summer very hot summer
Observed Air Temperatures
Lansing, MI

very cold winter

average winter

> standard deviation of $3.5^\circ C$
PG Binder Grades
Lansing, MI

PG 58-28 (98% minimum reliability)

PG 52-22 (50% minimum reliability)

PG grades - six degree increments
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

55 mph
Effect of Loading Rate on Binder Selection

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

55 mph
Slow
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
Binder Grade Selection

Resources:

- LTTPBind Software

- 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!)
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

Low Temperature Cracking

Courtesy of FHWA
LOCAL AGENCY PROGRAMS
HOT MIX ASPHALT (HMA) SELECTION GUIDELINES
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<td>5E5, or</td>
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<td></td>
<td></td>
<td></td>
<td>4E1</td>
<td>4E1</td>
<td>5E10</td>
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<tr>
<td>Leveling</td>
<td>15A or LVSP</td>
<td>5C</td>
<td>4E5</td>
<td>4E10</td>
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<td>2C</td>
<td>3E3</td>
<td>3E10</td>
<td>3E10</td>
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</tbody>
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Binder Grades by Region

| Superior     | PG 58-34       | PG 58-34         | PG 58-34         | PG 58-34         | PG 58-34         |
| Macro        | PG 58-22       | PG 64-22         | PG 64-22         | PG 70-22P        |
| All Other    | PG 58-22       | PG 64-32         | PG 64-28         | PG 70-22P        |

Note: The recommended PG binder grades for mixtures used as a base course is PG 58-34 for all regions, except in the Superior Region use PG 58-38. 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.

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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.
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
## HMA Selection Guidelines

### Local Agency Programs

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<thead>
<tr>
<th>Commercial ADT</th>
<th>0 – 300</th>
<th>301 – 700</th>
<th>701 – 1000</th>
<th>1001 – 3400</th>
<th>3401 – 9999</th>
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<tr>
<td></td>
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<td></td>
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<tr>
<td><strong>Mixture Type</strong></td>
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</tr>
<tr>
<td><strong>Surface</strong></td>
<td>13A or 36A or LVSP</td>
<td>4C 5E1</td>
<td>5E3 or 4E3</td>
<td>5E10 or 4E10</td>
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Asphalt Pavement Association Of Michigan
Selecting the Right Mix

Local Agency Programs
HMA Selection Guidelines

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<td>PG 58-34</td>
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<td>PG 58-34</td>
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<tr>
<td>Metro</td>
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<td>PG 64-22</td>
<td>PG 64-22</td>
<td>PG 64-22</td>
<td>PG 70-22P</td>
</tr>
<tr>
<td>All Other</td>
<td>PG 58-28</td>
<td>PG 64-28</td>
<td>PG 64-28</td>
<td>PG 64-28</td>
<td>PG 70-28P</td>
</tr>
</tbody>
</table>

For Surface and Leveling Courses
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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
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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
Binder Selection

Economics:

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

Example:

- 1 ½” resurfacing of existing road
  - 98% reliability binder grade is PG 58-28

- Consider using PG 58-22?
  - Reflective cracking
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Selecting the Right Mix

Local Agency Programs
HMA Selection Guidelines

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th>Marshall Mixture</th>
<th>Superpave Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36A</td>
<td>13A</td>
</tr>
<tr>
<td>Min. #/syd</td>
<td>110</td>
<td>165</td>
</tr>
<tr>
<td>Max. #/syd</td>
<td>165</td>
<td>275</td>
</tr>
</tbody>
</table>

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

Local Agency Programs
HMA Selection Guidelines

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

<table>
<thead>
<tr>
<th>ADT/Lane</th>
<th>Minimum AWI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100</td>
<td>None</td>
</tr>
<tr>
<td>100 – 2000</td>
<td>220</td>
</tr>
<tr>
<td>&gt; 2000</td>
<td>260</td>
</tr>
</tbody>
</table>
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
Questions?

www.apa-mi.org
517.323.7800    800.292.5959