Materials Selection in Pavement Design

Flexible Pavements
Pavement Design

- AASHTOWare Pavement ME
Traffic = 100 Trucks/day
Over 20 Years (730,000 ESAL’s)

Need SN = 2.59

R-value = 20
\( M_R = 12,000 \text{ psi} \)

\[ 4” \times 0.44 = 1.76 \]
\[ 6” \times 0.14 = 0.84 \]
Total = 2.60

Factors used for Climate and Drainage

AASHTO 1993 Design Guide
Problem with Pavement Design?

Transverse Cracking
Problem with Pavement Design?

Transverse Cracking
Problem with Pavement Design?

Longitudinal Cracking
Problem with Pavement Design?

Block Cracking
Problem with Pavement Design?

Rutting
Traffic = 100 Trucks/day
Over 20 Years
(730,000 ESAL’s)

Need SN = 2.59

R-value = 20
M_R = 12,000 psi

AC Layer (.44)

AB Layer (.14)

Subgrade

R-value = 20

100 trucks/day

4” x 0.44 = 1.76

6” x 0.14 = 0.84

Total = 2.60

Factors used for Climate and Drainage

AASHTO 1993 Design Guide
ADVANCED ASPHALT PERFORMANCE TESTS

AASTHOware Pavement ME Computer Software
Complete Pavement Design

- Structural Capacity (Pavement Thickness)
  - AASHTOWare Pavement ME
  - FAARFIELD (FAA)
  - PCASE (UFC – Military Airfields)

- Materials Selection
  - Select the right materials considering the likely failure mechanism
  - Select the most cost effective materials
  - Consider Constructability
ADOT Pavement Design Requirements

Geotechnical Investigation with analysis and design including 3 reports

- Geotechnical Engineering Report
- Pavement Design Summary (thickness)
- Materials Design Report (materials)
  - Selection of all materials specifications with special provisions
  - Quantities and cost estimates
Pavement Materials Selection
What Mix is Right for My Project?
Sustainable Pavement Materials

**Sustainable**
- Lasts for its design life
- Base layers resist fatigue or other damage
- Replace or rehabilitate surface layers periodically (say every 15 years)
- Premium Products to extend rehabilitation cycles (20+ years?)

**Not Sustainable**
- Early failure
- Replace entire pavement periodically
Mix Design Considerations

Three Things Pavement Designers Need to Specify about the Mix Design

- Mix Design Type
- Aggregate Properties
- Asphalt Cement (Binder) Selection
Mix Design Type

Marshall Mix Design

- 50 Blow
- 75 Blow
- Gradation spec’s tend to be finer
Mix Design Type

Gyratory Mix Design

- $N_{Des} = 60$
- $N_{Des} = 75$
- $N_{Des} = 100$
- Gradation Spec’s tend to be more coarse
Aggregate Selection

- Nominal Maximum Aggregate Size
  - ½ inch
  - ¾ inch

- Gradation
  - Dense graded
  - Open graded
  - Gap graded
Aggregate Selection

- Angularity
  - Fractured Faces (coarse agg)
  - Fine Aggregate Angularity (fine agg)
Asphalt Binder Selection

- **PG Binder Grading**
- **PG XX-XX** (ex: PG 70-10)
  - First number - high temperature
  - Second number - low temperature
- **Example:**
  - High Temp = 68.0 °C
  - Low Temp = -4.7 °C
  - PG 70-10 meets both
- **Bump PG for high or slow traffic**
Modified Binders

- Asphalt Rubber Binder (20% tire rubber)
- Polymer Modified Asphalt (2-3% polymer)
- Tire Rubber Modified Asphalt - Terminal Blend (1-3% polymer, 5 - 15% tire rubber)
Mix Design Selection

Three Things to Consider

- What is the Controlling Failure mode
  - Traffic
  - Environment

- Cost

- Constructability
Failure will be caused by Traffic loads.
Load Related Distress

Need a Mix that is resistant to:

- Fatigue – Alligator Cracking
- Rutting
- Bleeding
Mix Design Selection

- High Traffic Mixes
  - Freeways
  - Heavy Duty Parking Lots (Distr. Centers)
  - Arterial Roadways/Highways
Example Mix Design Selection for High Traffic

- Arterial Roadway – Metro Phoenix Area
- Traffic – 12 M ESAL’s
- 6”AC / 10”AB
- Avg. Speed 40 mph (Intersection 10 mph)
Example Mix Design Selection for High Traffic

- Marshall (50 or 75 Blow?)
- Gyratory (Gyrations at $N_{des} = 60, 75, \text{ or } 100$?)
- Max Aggregate size
  - Surface Mix – $\frac{1}{2}”$
  - Interm. and Base Mix – $\frac{3}{4}”$
Asphalt Binder Selection for High Traffic - Phoenix

Binder Selection (Use LTPPBind software)

- **High Temperature**
  - 68.0 °C - Light traffic
  - 70.4 °C - Medium traffic
  - 76.0 °C - High traffic with bump
  - 80.4 °C - Slow moving high traffic with bump

- **Low Temperature**
  - -4.7 °C - All traffic & speed
Asphalt Binder Selection for High Traffic Example

Binder Selection (LTPPBind software)

- Light Traffic, PG 70-10
- Medium Traffic, PG 76-10
- Heavy Traffic, PG 76-10
- Heavy Slow Traffic, PG 82-10

Binder Choices

- PG 64-16
- PG 70-10
- PG 76-16
- PG 76-22P
- PG 76-22TR
Mix Design Selection High Traffic - Summary

- Surface, MAG ½” Gyratory mix ($N_{des} = 100$)
- Base, MAG ¾” Gyratory mix ($N_{des} = 100$)
- PG 76-22P or PG 76-22TR Binder

MAG Specifications
- High fractured faces (85, 1 or more)
- High fine aggregate angularity (45% min)
- Natural Sand (15% max)
Mix Design Selection High Traffic - Summary

Remember to Consider Lift Thickness

- $\frac{1}{2}''$ Gyratory mix (2” to 3”)
- $\frac{3}{4}''$ Gyratory mix (3” to 4”)
- 2 ½” (1/2” mix) & 3 ½” (3/4”mix) = 6”
- Verify asphalt thickness can be achieved within these limits or consider another mix.
Failure will be caused by Traffic and Aging
Mix Design Selection

- Medium Traffic Mixes
  - Light Arterials
  - Heavy Collector Roadways
  - Commercial Parking Lots with Trucks
Example Mix Design Selection for Medium Traffic

- Heavy Collector Roadway – Metro Phoenix Area
- Traffic – 3 M ESAL’s
- 5”AC / 6” AB
- Avg Speed 30 mph (Intersection 10 mph)
Example Mix Design Selection for Medium Traffic

- **Mix Type Selection (Marshall or Gyratory?)**
  - Marshall – 50 or **75** Blow?
  - Gyratory – Gyrations at $N_{des} = 60, 75, \text{ or } 100$?

- **Max Aggregate size**
  - Surface Mix – $\frac{1}{2}''$
  - Intermediate and Base Mix – $\frac{3}{4}''$
Asphalt Binder Selection for Medium Traffic Phoenix

Binder Selection (Use LTPPBind software)

- **High Temperature**
  - 68.0 °C - Light traffic
  - 70.4 °C - Medium traffic
  - 76.0 °C - Heavy traffic with bump
  - 80.4 °C - Slow moving heavy traffic with bump

- **Low Temperature**
  - -4.7 °C - All traffic & speed
Asphalt Binder Selection for Medium Traffic Example

Binder Selection (Use LTPPBind software)

- Medium Traffic – PG 76-16
- Binder Choices:
  - PG 64-16
  - PG 70-10
  - PG 76-16
  - PG 76-22P
  - PG 76-22TR
Mix Design Selection Medium Traffic - Summary

- Surface, MAG ½” Marshall mix (75 blows)
- Base, MAG ¾” Marshall mix (75 blows)
- PG 76-16 Binder
- MAG Specifications for Agg properties
- Lift Thicknesses
  - ½” Marshall mix (1½“ to 3”)
  - ¾” Marshall mix (2½“ to 4”)
- 2” (1/2” mix) & 3” (3/4” mix) = 5”
Low Volume Roadways - Failure Caused by Environmental Effects
Non Load Related Distress (Environmental Aging)

- Transverse and Longitudinal Cracking
- Block Cracking
- Weathering
Example Mix Design Selection for Low Traffic

- Residential Roadway – Metro Phoenix Area
- Traffic – 15,000 ESAL’s
- Average Speed 25 mph
Example Mix Design Selection for Low Traffic

- **Mix Type Selection (Marshall or Gyratory?)**
  - Marshall – 50 or 75 Blow?
  - Gyratory – Gyrations at $N_{des} = 60, 75, \text{ or } 100$?

- **Max Aggregate size**
  - Surface Mix – 3/8”
  - Surface Mix – ½”
  - Intermediate and Base Mix – ¾”
Asphalt Binder Selection for Low Traffic Phoenix

Binder Selection (Use LTPPBind software)

- **High Temperature**
  - 68.0 °C - Light traffic
  - 70.4 °C - Medium traffic
  - 76.0 °C - Heavy traffic with bump
  - 80.4 °C - Slow moving heavy traffic with bump

- **Low Temperature**
  - -4.7 °C - All traffic & speed
Asphalt Binder Selection for Medium Traffic Example

Binder Selection (Use LTPPBind software)

- Light Traffic – PG 70-10
- Binder Choices:
  - PG 64-16
  - PG 70-10
  - PG 76-16
  - PG 76-22P
  - PG 76-22TR
Mix Design Selection Low Traffic

- Surface, MAG ½”
- No Base Mix Needed
- Marshall mix (50 blows)
- Binder: PG 70-10
- Lift Thicknesses
  - ½” Marshall mix (1½“ to 3”)
- 1 ½” (1/2” mix) & 1 ½” (1/2”mix) = 3”
Questions?

WHAT IT SAYS

RIGHT LANE CLOSED AHEAD

WHAT PEOPLE READ

RIGHT LANE “MIGHT” BE CLOSED AHEAD. SO JUST STAY IN YOUR LANE AND MERGE AT THE LAST SECOND IF YOU HAVE TO.