



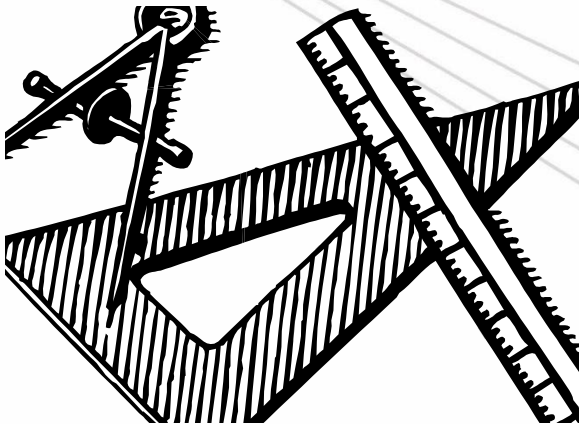
# Materials Selection in Pavement Design

## Flexible Pavements



# Pavement Design

- AASHTO Pavement Design Guide (1993)
- AASHTOWare Pavement ME



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



100 trucks/day



Need SN = 2.59



R-value = 20  
 $M_R = 12,000$  psi

AC Layer (.44)

$$4" \times 0.44 = 1.76$$

AB Layer (.14)

$$6" \times 0.14 = 0.84$$

Subgrade  
R-value = 20

$$\text{Total} = 2.60$$

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)



100 trucks/day



Need SN = 2.59



R-value = 20  
 $M_R = 12,000$  psi

AC Layer (.44)

$$4" \times 0.44 = 1.76$$

AB Layer (.14)

$$6" \times 0.14 = 0.84$$

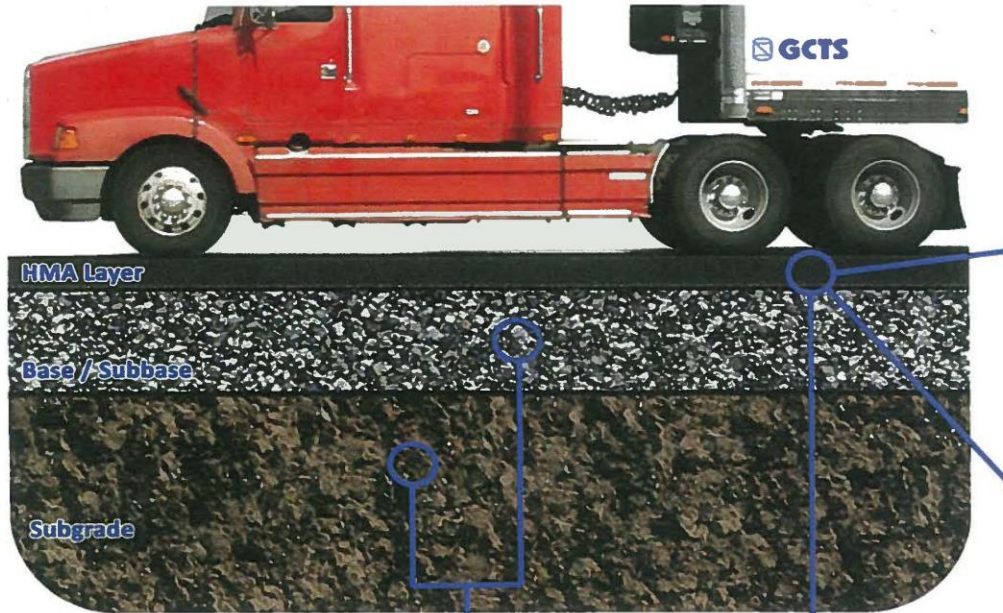
Subgrade  
R-value = 20

$$\text{Total} = 2.60$$

Factors used for  
Climate and Drainage

***AASHTO 1993 Design Guide***

# ADVANCED ASPHALT PERFORMANCE TESTS



AASHTOWare Pavement ME  
Computer Software



**Resilient Modulus**

AASHTO T 307-99, NCHRP 1-28, SHRP  
P46, ASTM D3999-1 & D5311-92



**Dynamic Complex Modulus**

AASHTO TP 62-07, NCHRP 9-29, ASTM  
D3497-2003, EN12697 25

# Complete Pavement Design

- Structural Capacity (Pavement Thickness)
  - AASHTO Pavement Design Guide (1993)
  - 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

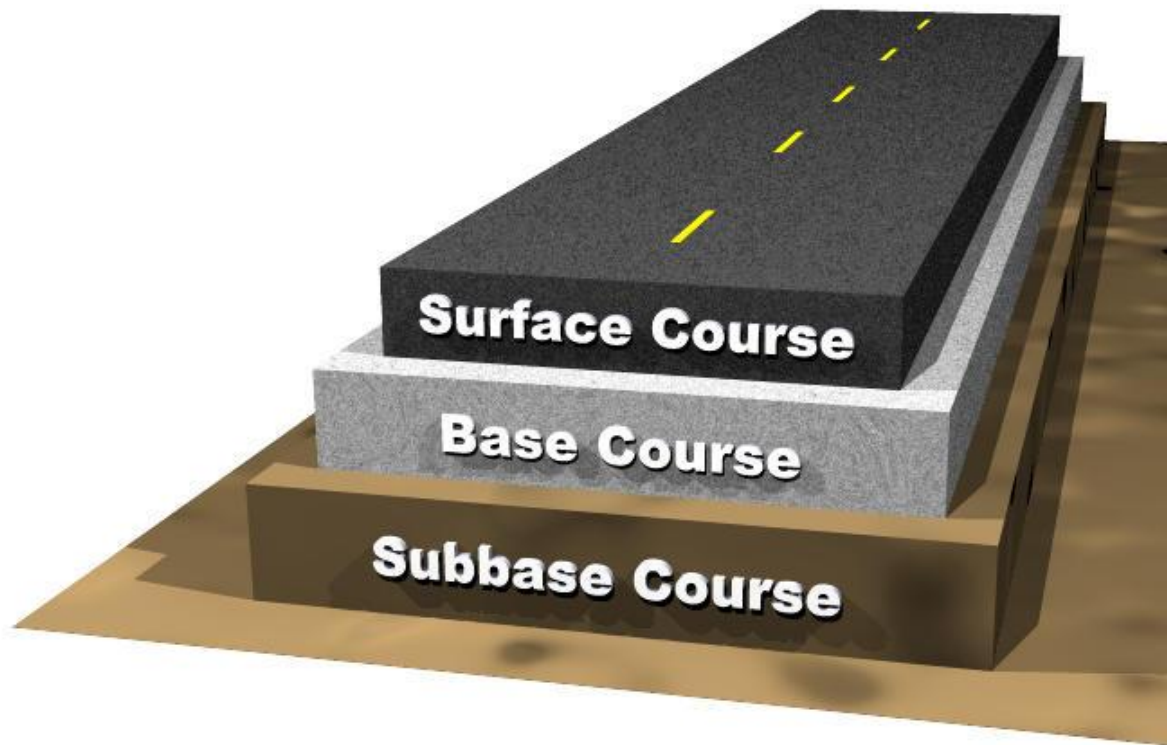
# ADOT Pavement Design Requirements

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 it's 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

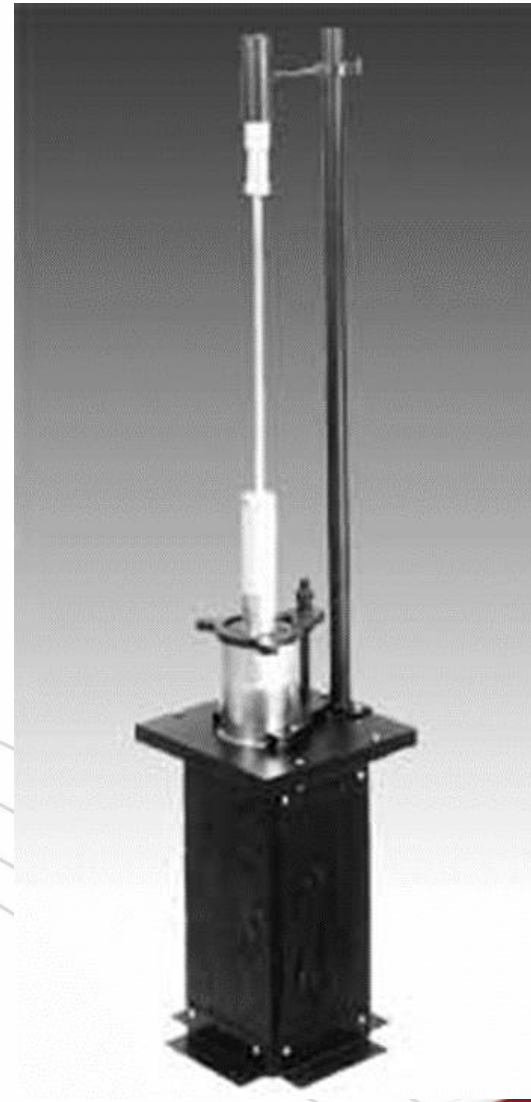
Three Things Pavement Designers Need to Specify about the Mix Design

- 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



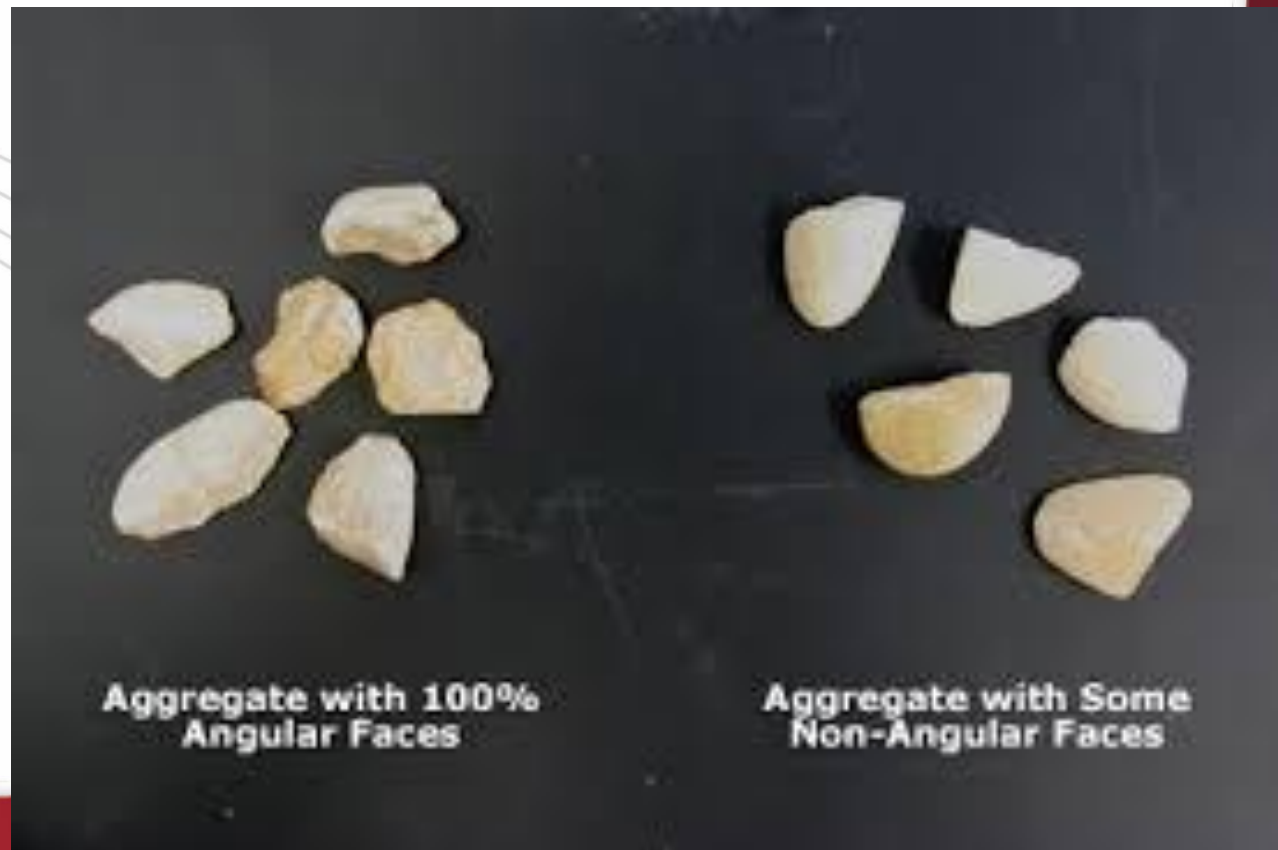
# Aggregate Selection

- Nominal Maximum Aggregate Size
  - 1/2 inch
  - 3/4 inch
- Gradation
  - Dense graded
  - Open graded
  - Gap graded



# Aggregate Selection

- Angularity
  - Fractured Faces (coarse agg)
  - Fine Aggregate Angularity (fine agg)



Aggregate with 100%  
Angular Faces

Aggregate with Some  
Non-Angular Faces

# 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

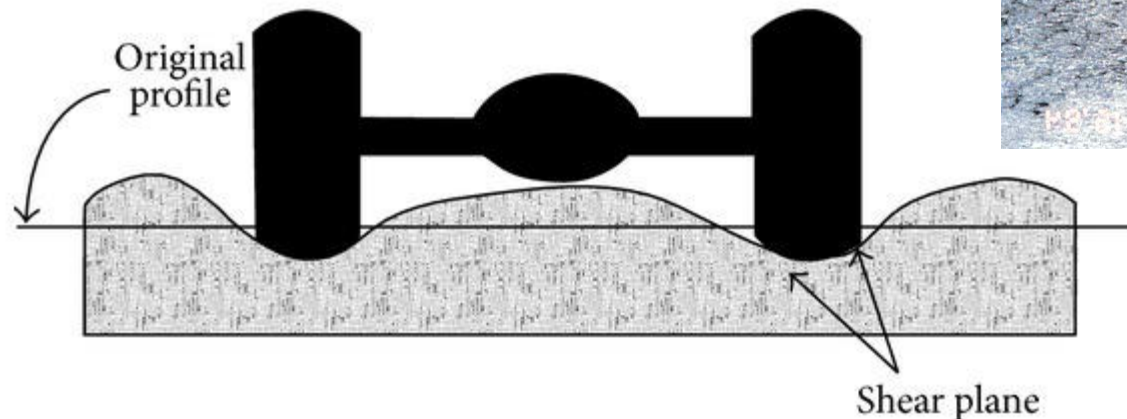
Failure will be caused by  
Traffic loads



# 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  $N_{des} = 60, 75, \text{ or } \underline{100?}$ )
- 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")
- $2\frac{1}{2}$ " ( $\frac{1}{2}$ " mix) &  $3\frac{1}{2}$ " ( $\frac{3}{4}$ " mix) = 6"
- Verify asphalt thickness can be achieved within these limits or consider adding 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 – Gyration at  $N_{des} = 60, 75, \text{ or } \underline{100}$ ?
- 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)

- MediumTraffic – 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

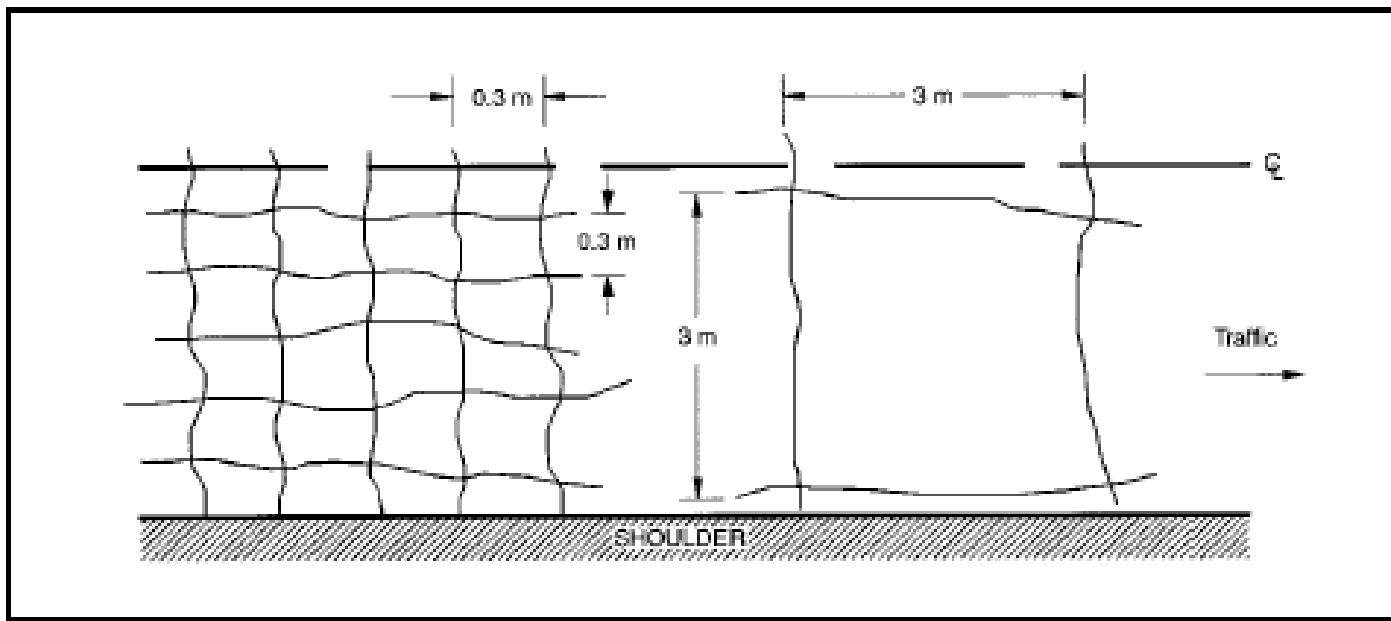
- Surface, MAG  $\frac{1}{2}$ " Marshall mix (75 blows)
- Base, MAG  $\frac{3}{4}$ " Marshall mix (75 blows)
- PG 76-16 Binder
- MAG Specifications for Agg properties
- Lift Thicknesses
  - $\frac{1}{2}$ " Marshall mix ( $1\frac{1}{2}$ " to 3")
  - $\frac{3}{4}$ " Marshall mix ( $2\frac{1}{2}$ " to 4")
- 2" ( $\frac{1}{2}$ " mix) & 3" ( $\frac{3}{4}$ " 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 – Gyration at  $N_{des} = 60, 75, \text{ or } 100$ ?
- Max Aggregate size
  - Surface Mix –  $3/8''$
  - Surface Mix –  $1/2''$
  - Intermediate and Base Mix –  $3/4''$

# 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 1/2"
- No Base Mix Needed
- Marshall mix (50 blows)
- Binder: PG 70-10
- Lift Thicknesses
  - 1/2" Marshall mix (1 1/2" to 3")
- 1 1/2" (1/2" mix) & 1 1/2" (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.