Improving HMA Performance with Superpave®

Federal Highway Administration
Highway Pavements R&T

- Critical issues
  - Pavements are the backbone of transportation.
  - Growing expectations of the highway user for smoother ride and reduced delay and disruption.
Long Life Pavements for the 21st Century

Critical issues

- “Just in time” delivery has increased from 10% in 1990 to over 60% in 2000.

- Of every dollar invested in highways more than 50 cents goes to pavements.

- 4 million miles of roadways in US
Why Superpave?

- Pavement performance for the US highways was not improving.
- Demands on the system were increasing.
- New materials coming on the market were difficult to evaluate.
Changes

- Increased traffic and loadings
- Supply sources
- Use of baghouses
- Use of recycled materials (RAP)
- Drum plants vs. batch plants
- Personnel experience
- Staff reductions
Evolution of Traffic

- **Interstate highways - 1956**
- **AASHTO Road Test - 1958-62**
  - still widely used for pavement design
  - legal truck load - 73,280 lbs
- **Factors for higher stresses**
  - 75% increase in truck miles (1973 - 1993)
  - Legal truck load limit increase in 1982 (73,280 to 80,000 pounds)
  - Advent of radial tires
Business as usual will not work!

Pavement Performance
Distress Modes in Asphalt

- Primary three are:
  - Rutting
  - Fatigue cracking
  - Low-temperature cracking
Rutting
Fatigue Cracking
Low Temperature Cracking
Binder Specifications

The pavement see many temperatures and loads.

Heavy Trucks
Binder Grade is a function of environment and traffic level.
HMA Behavior

- **Asphalt Binder Behavior**
  - Temperature
  - Time of Loading
  - Age also important

- **Aggregate Behavior**
  - Surface Characteristics
  - Particle Shape
  - Gradation

- **Asphalt Mixture Behavior**
  - Asphalt Behavior
  - Aggregate Behavior
  - Characteristics of combination
Time vs. Temperature

60°C: 1 hour

25°C: 1 hour

25°C: 10 hours
Binder Behavior - Aging

- Asphalt Reacts with Oxygen
  - “oxidative” or “age” hardening

- During Construction - Short Term
  - hot mixing
  - placing/compaction

- In Service - Long Term
  - hot climate worse than cool climate
  - summer worse than winter

- Volatilization - Short Term
  - volatile components evaporate during construction
Pre-Superpave Asphalt Property Measurements

**Penetration** (1900s)

- 0 sec
- 5 sec

**Viscosity** (1950s)

- Vacuum

100 g

CANNON

100 A9

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Pre-Superpave Shortcomings

- Viscosity
  - viscous effects only

- Penetration
  - empirical measure of viscous and elastic effects

- No Low Temperature Properties Measured

- Problems with Modified Asphalt Characterization

- Specification Proliferation

- Long Term Aging not Considered
Temperature, C

Consistency (pen or vis)

hard

soft

pen

vis

-15 25 60 135

A

B

C

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Superpave Binder Measurements

- Temperature Relationships
- Pavement Age Relationships
Asphalt Mixture Behavior

- Permanent Deformation
- Fatigue Cracking
- Low Temperature Cracking
Rutting in Asphalt Layer

- Original profile
- Weak asphalt layer
- Shear plane
Repeated Shear Deformation

Deformation vs. Number of Loads

- Elastic
- Plastic (permanent)
Mixture Resistance to Rutting

- **Asphalt Binder**
  - stiff and elastic at high temperatures

- **Aggregate**
  - high inter-particle friction
  - gradation acts like *one large elastic stone*
Fatigue Cracking

- Distress in Wheel path
- Progressive Damage
  - longitudinal cracking
  - alligator cracking
  - potholes
- Affected by
  - asphalt binder
  - aggregates
  - pavement structure
HMA must be strong & resilient
HMA Fatigue Behavior

- Longer Fatigue Life
  - flexible materials
  - low stress/strain level

- Shorter Fatigue Life
  - stiff materials
  - high stress/strain level

- Exception
  - thick pavements
  - non-deflecting support layers

Heavy Trucks

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Low Temperature Cracking

- Environmental Distress
- Stresses/Strains Induced by Temperature Change
- Transverse Cracks
- One Cycle vs Many Cycles
- Affected Primarily by Asphalt Binder
Cures for Low Temperature Cracking

- Use Less Stiff Asphalt Binder
  - lower stiffness at low temps
  - relaxation of stresses
- Use Asphalt Binder Less Prone to Aging
- Construct HMA with Proper Air Voids
The Superpave System

- What is Superpave
  - A performance-related binder specification
  - A performance-related mix specification
  - Mixture analysis tools
Superpave Performance Testing

*What Are We Doing?*

Still under development
Final Payoff

Better asphalt pavements
Extended service life