Improving HMA Performance with Superpave®

Federal Highway Administration

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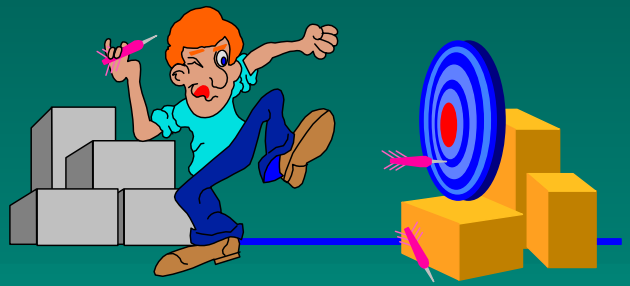
Highway Pavements R&T

- Critical issues



  - Pavements are the backbone of transportation.
  - Growing expectations of the highway user for smoother ride and reduced delay and disruption.

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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.

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Changes

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

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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

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Business as usual will not work !

Distress Modes in Asphalt

- Primary three are:
  - Rutting
  - Fatigue cracking
  - Low-temperature cracking

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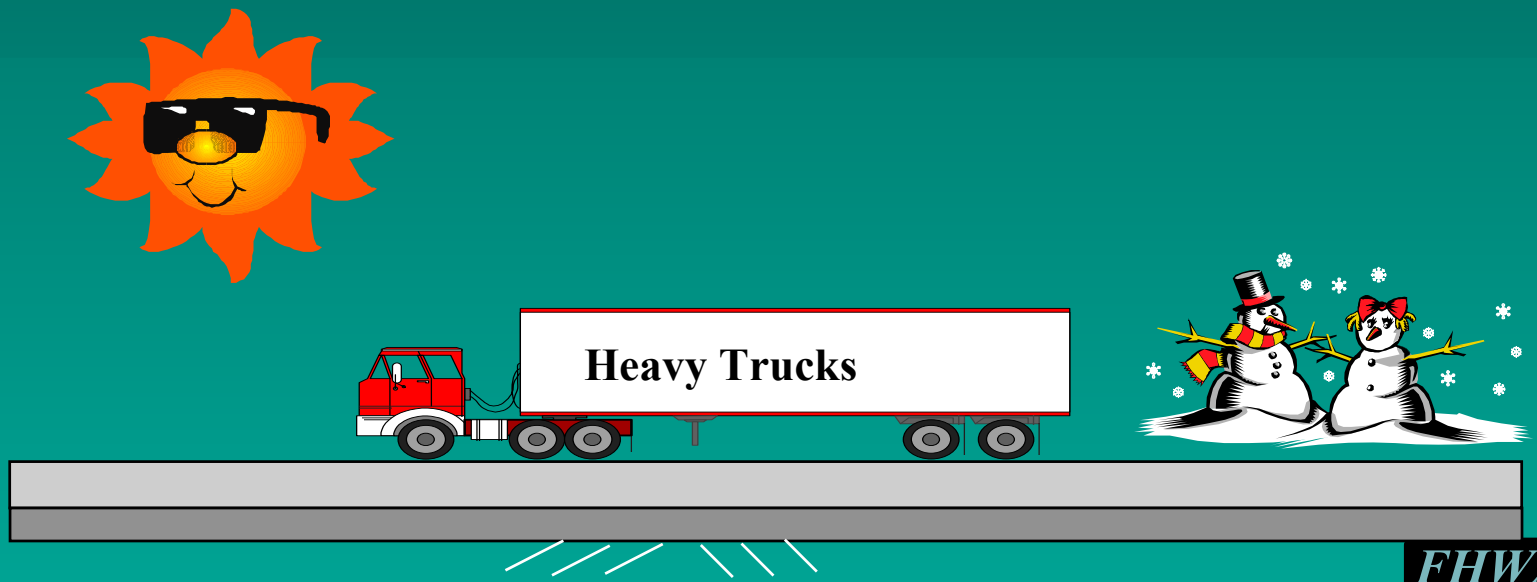
Rutting


Fatigue Cracking

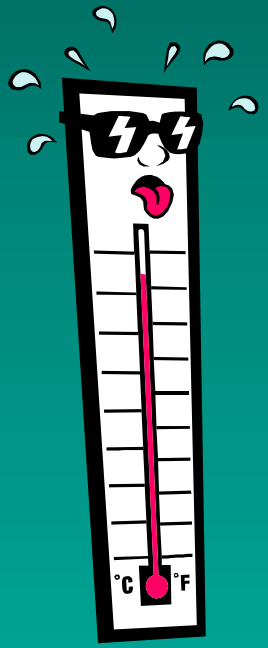
Low Temperature Cracking

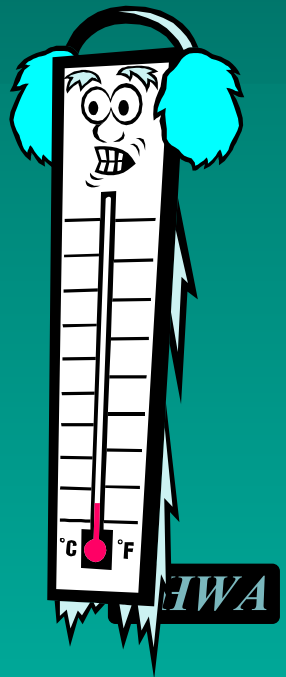
Binder Specifications

- The pavement see many temperatures and loads.



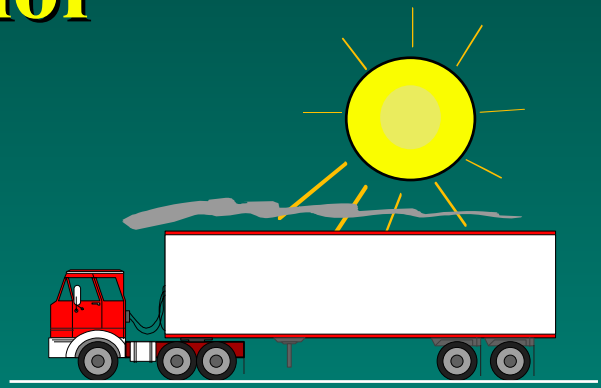
Binder Grade is a function of environment and traffic level

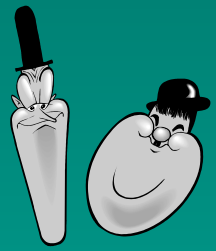




HMA Behavior

- 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





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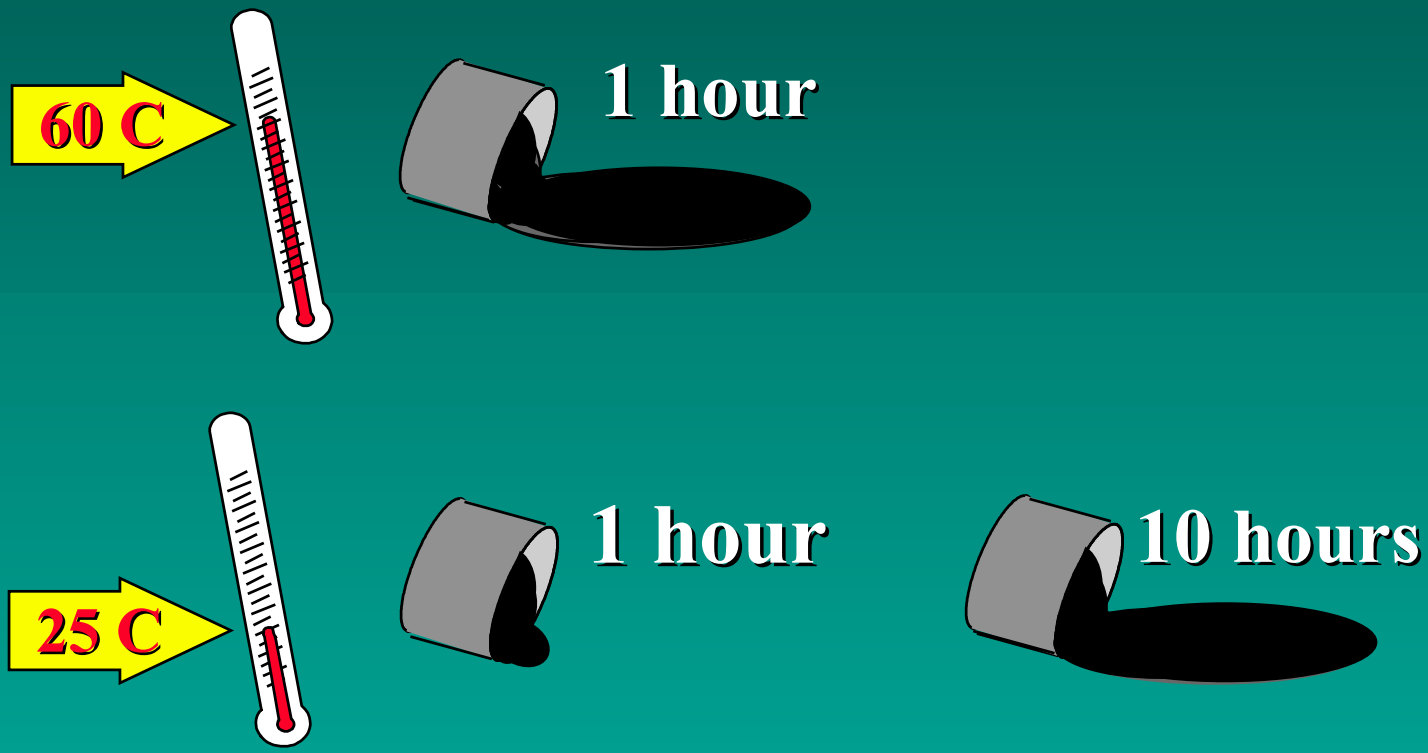
Time vs. Temperature



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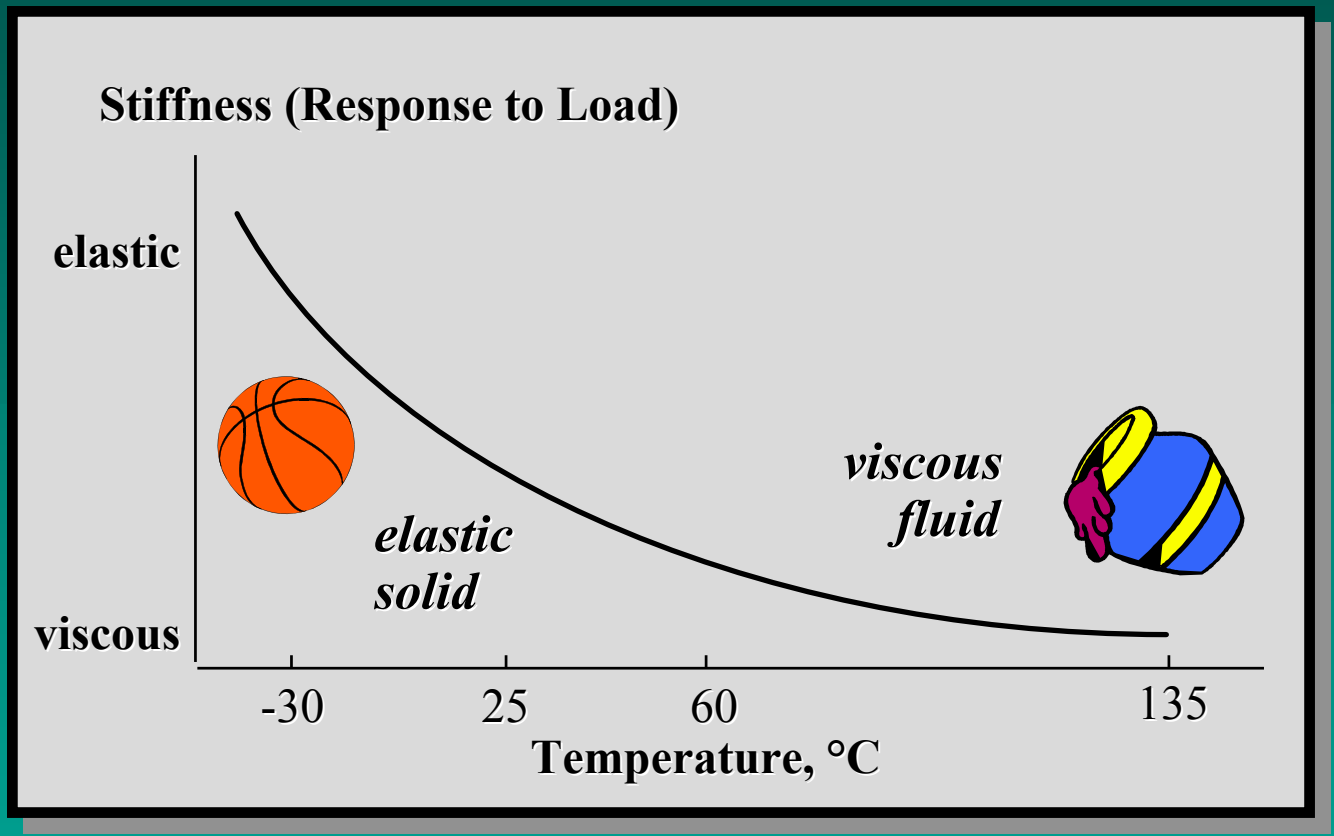
Stiffness (Response to Load)
elastic
viscous
elastic
solid
viscous
fluid
-30
25
60
135
Temperature, °C

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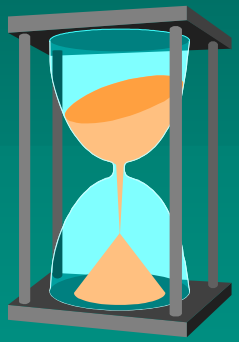
Binder Behavior - Aging

- 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



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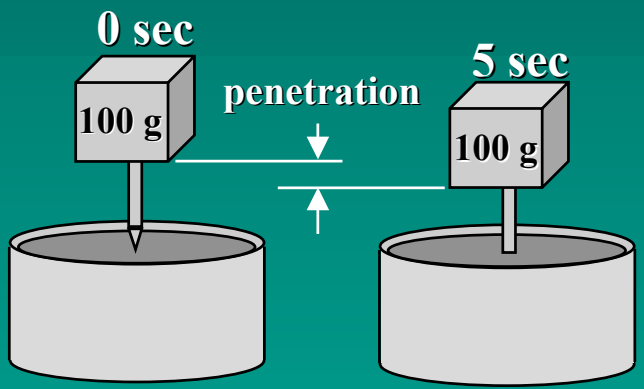
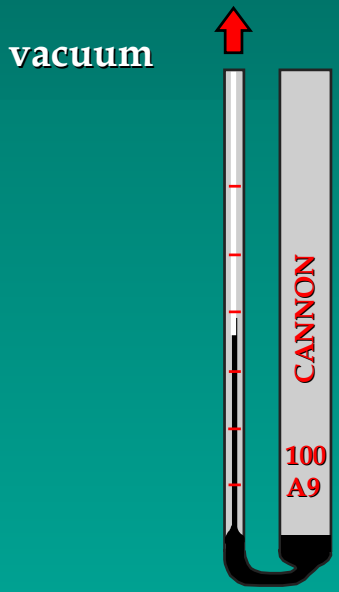
Pre-Superpave Asphalt Property Measurements

Penetration
(1900s)



Viscosity
(1950s)



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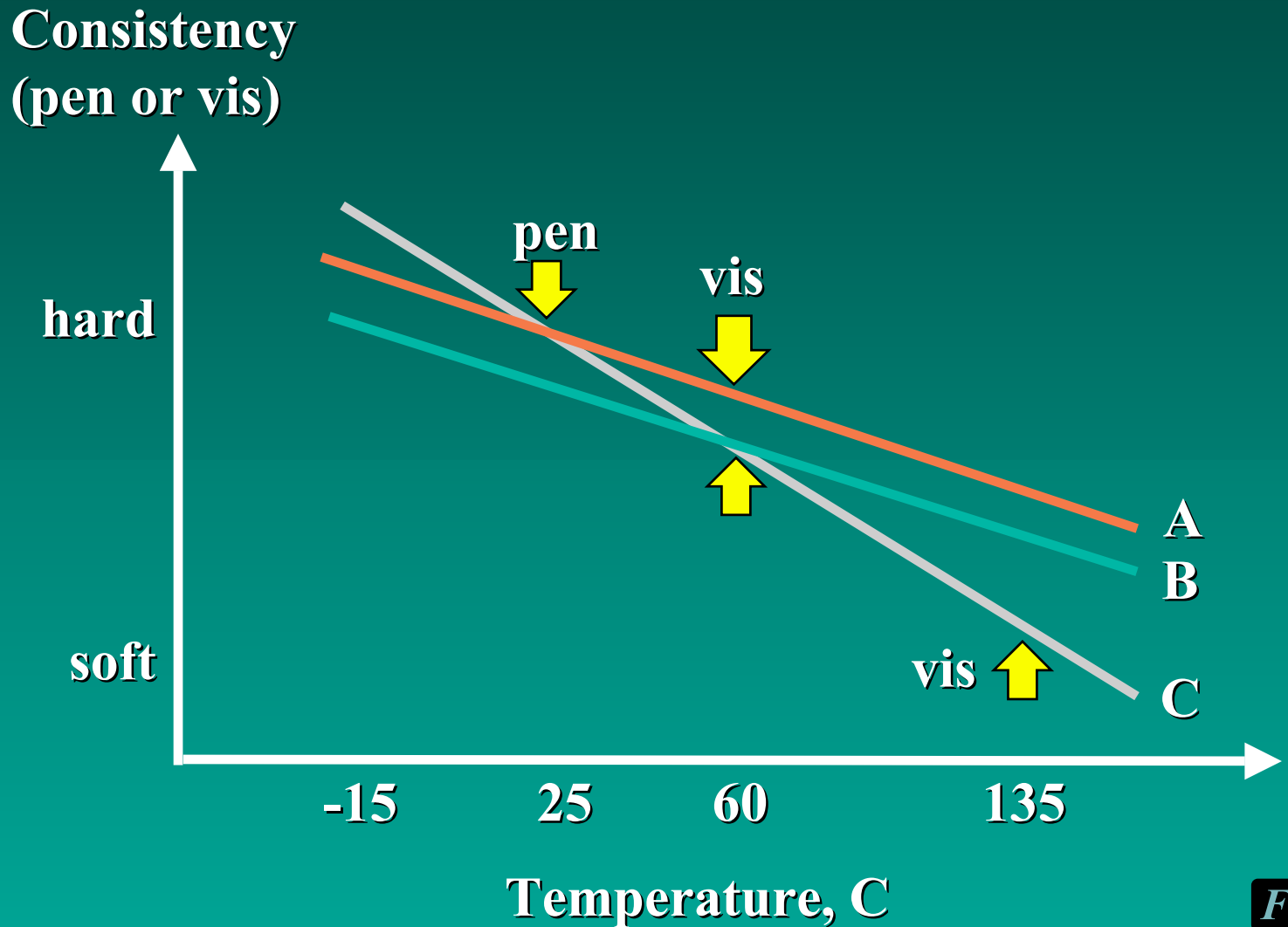
Pre-Superpave Shortcomings

- 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


Consistency
(pen or vis)
hard
soft
pen
vis
vis
A
B
C
-15
25
60
135
Temperature, C

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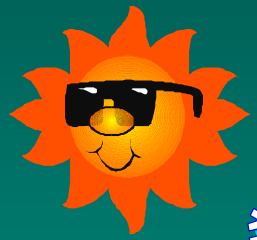
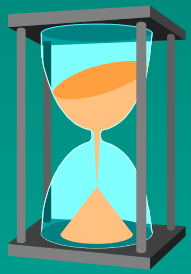
Superpave Binder Measurements



- Temperature Relationships

- Pavement Age Relationships



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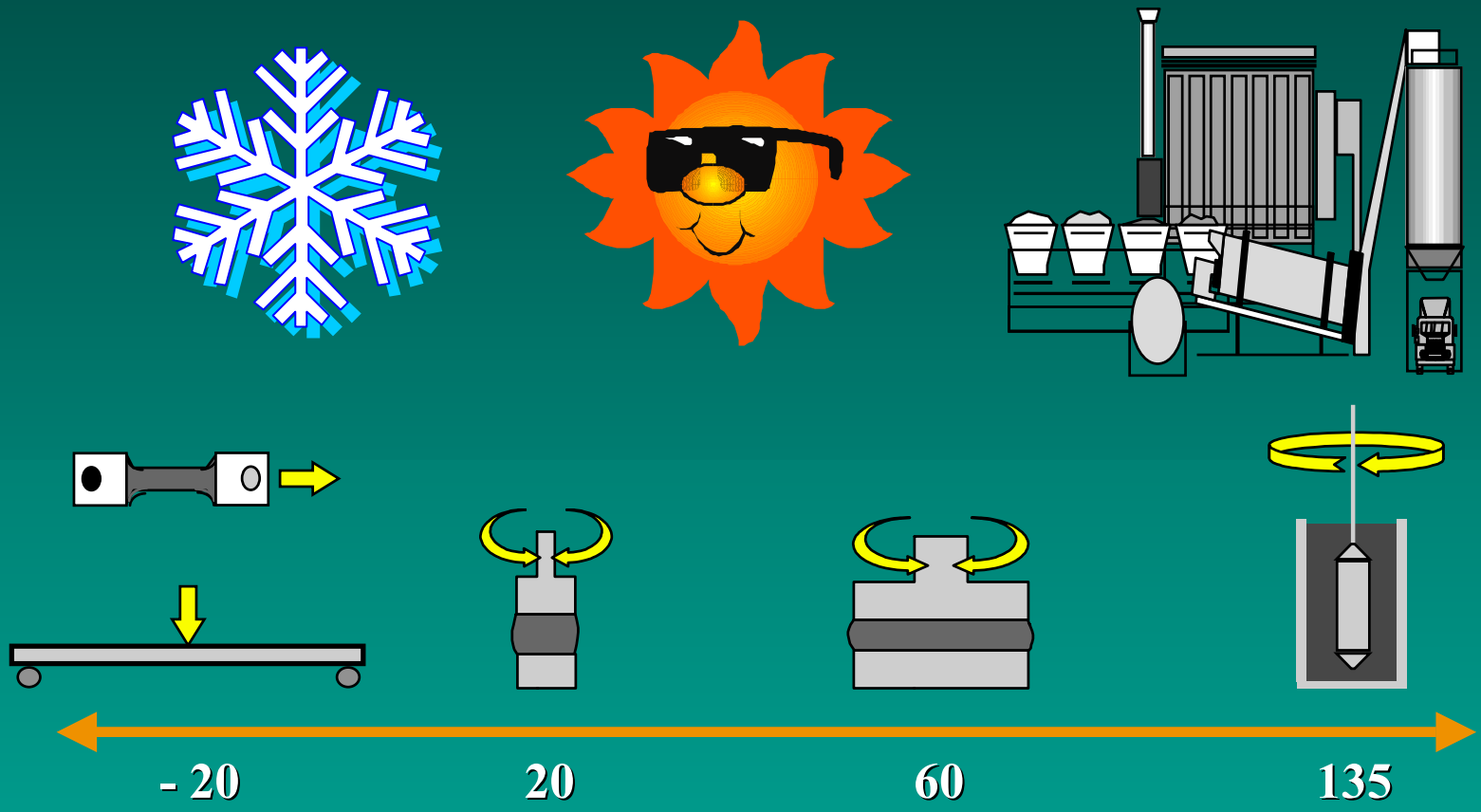

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Asphalt Mixture Behavior

- Permanent Deformation
- Fatigue Cracking
- Low Temperature Cracking

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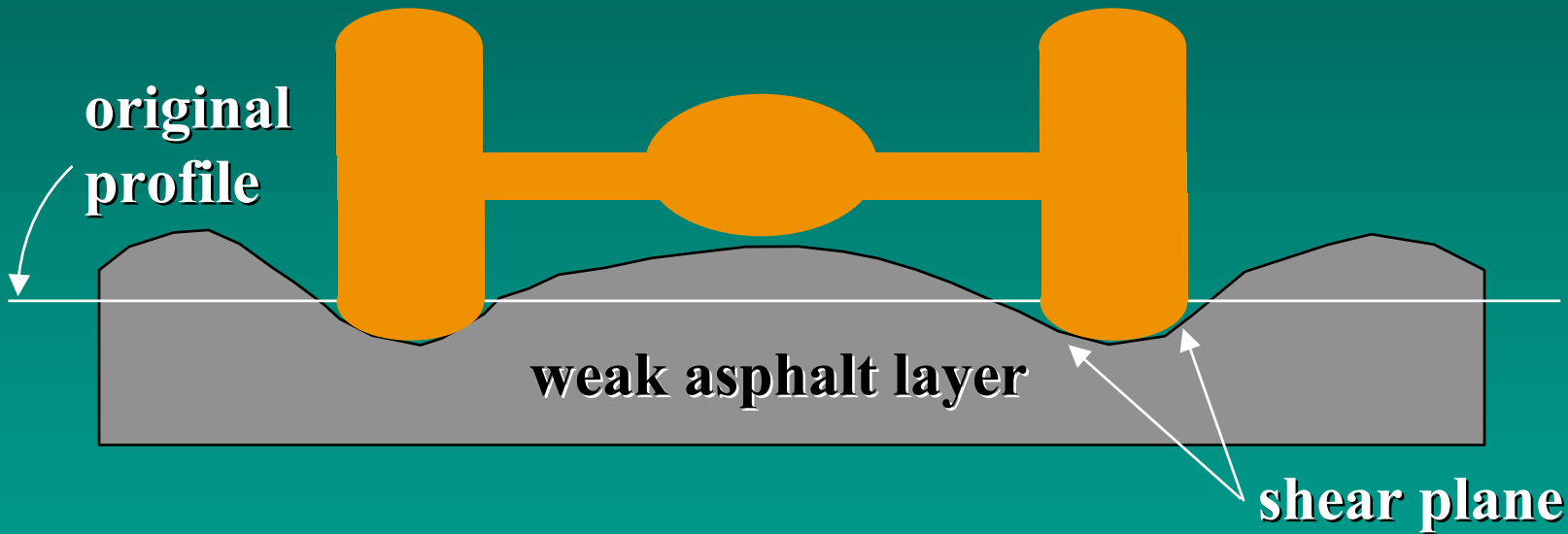
Rutting in Asphalt Layer



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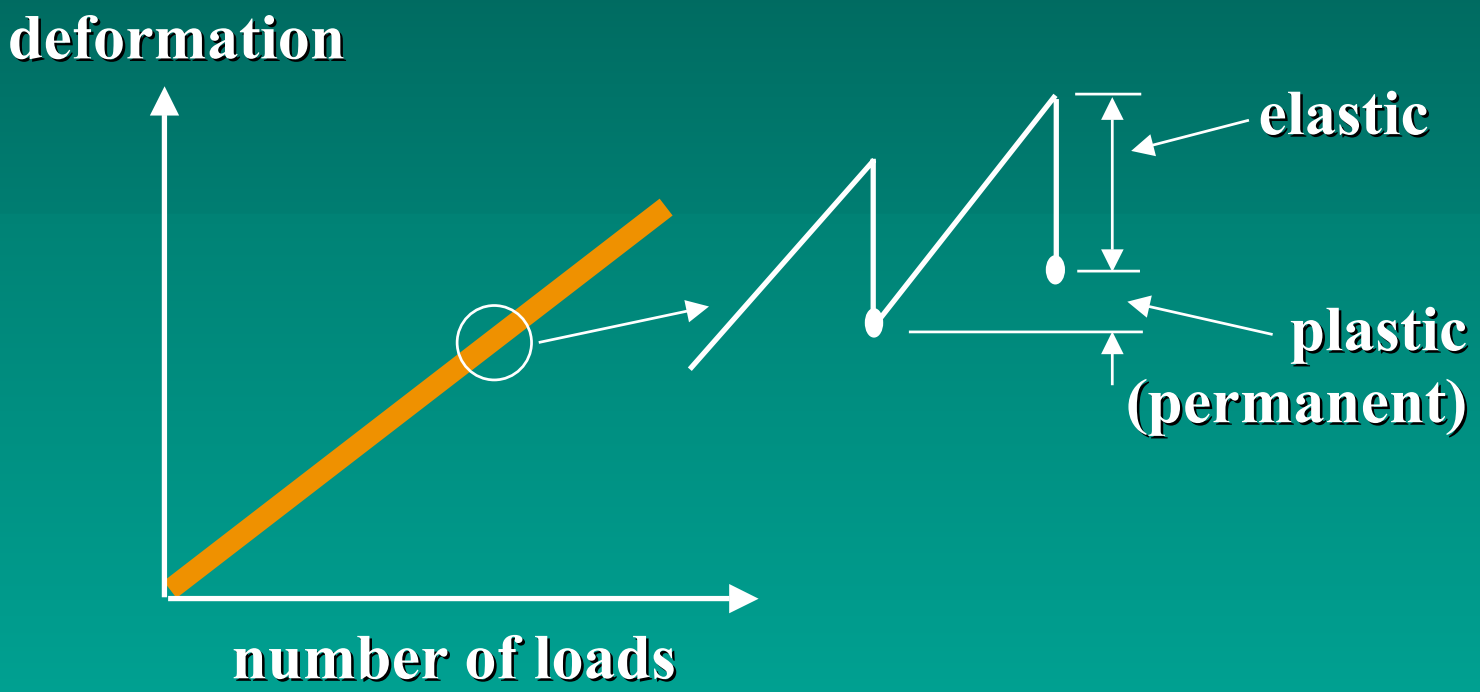
Repeated Shear Deformation



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Mixture Resistance to Rutting

- Asphalt Binder
  - stiff and elastic at high temperatures
- Aggregate
  - high inter-particle friction
  - gradation acts like *one large elastic stone*

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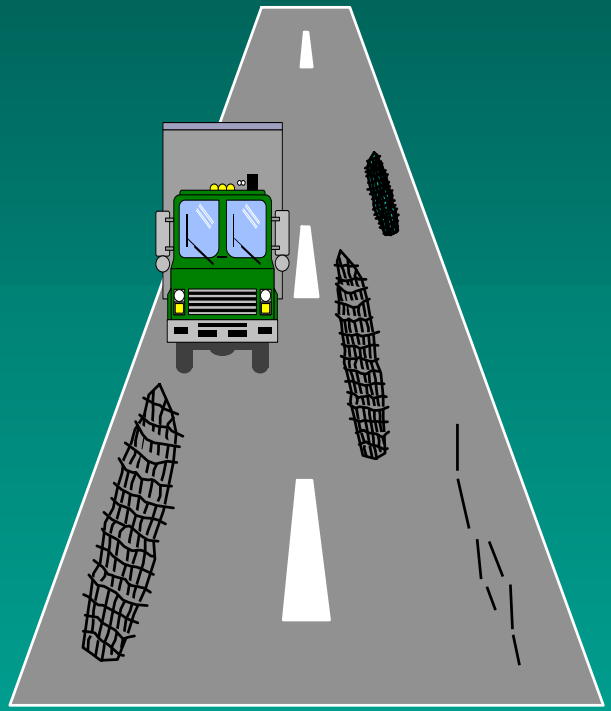
Fatigue Cracking

- Distress in Wheel path
- Progressive Damage
  - longitudinal cracking
  - alligator cracking
  - potholes
- Affected by
  - asphalt binder
  - aggregates
  - pavement structure



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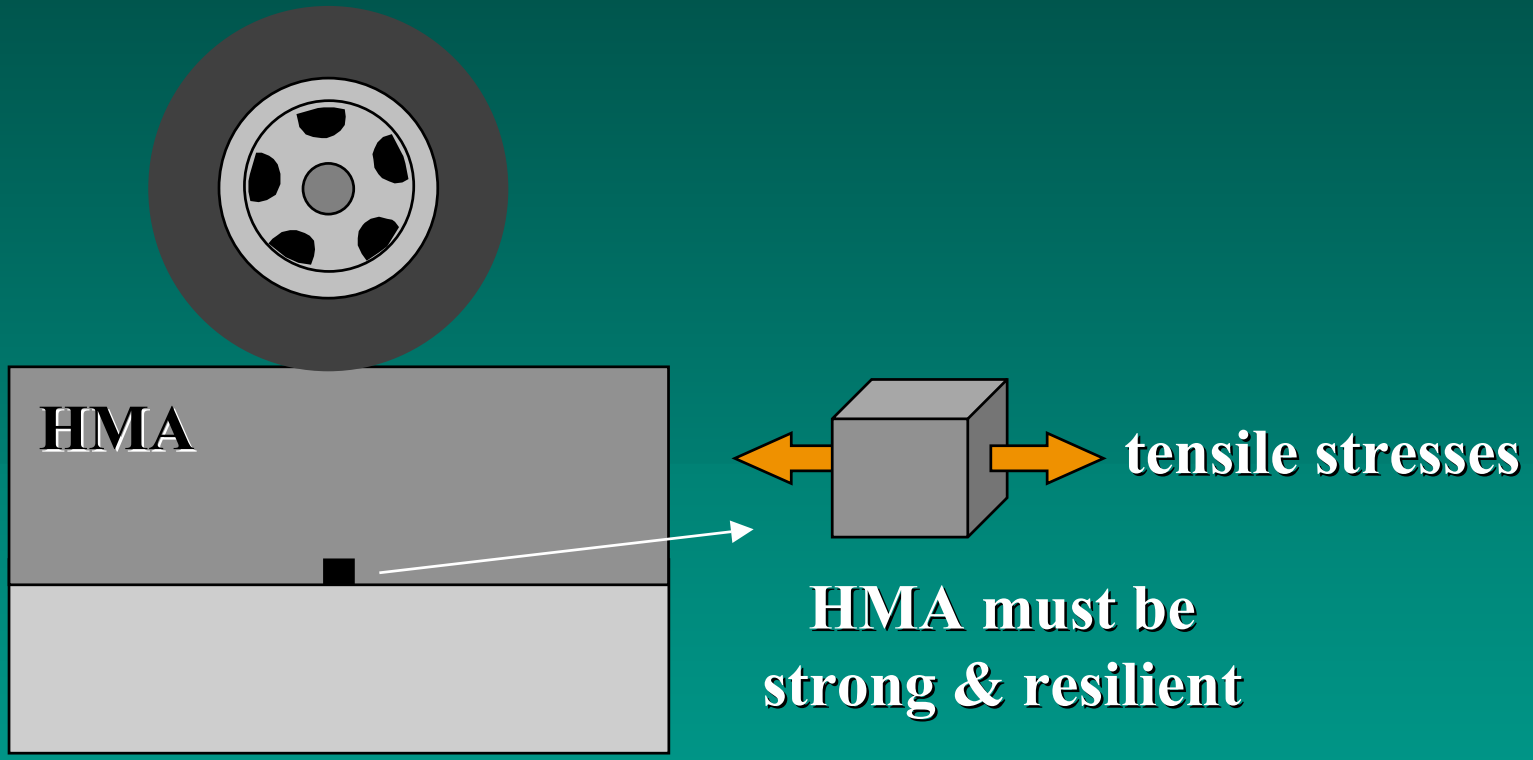

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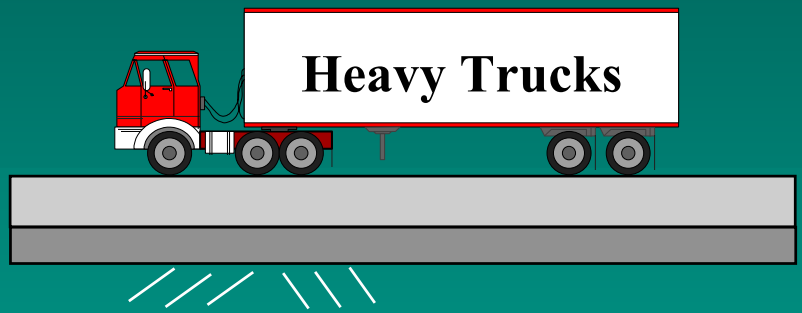
HMA Fatigue Behavior

- **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



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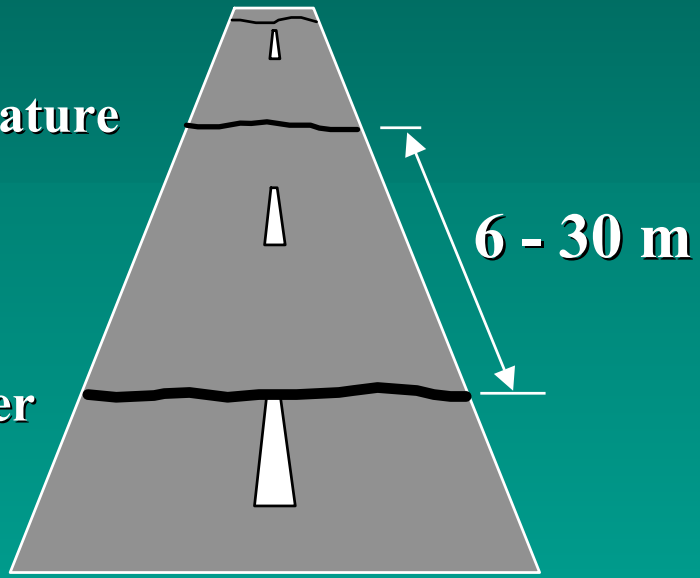
Low Temperature Cracking

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



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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

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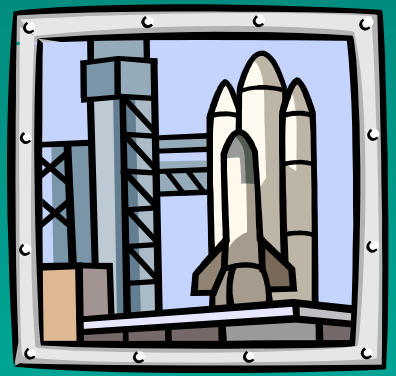
The Superpave System

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



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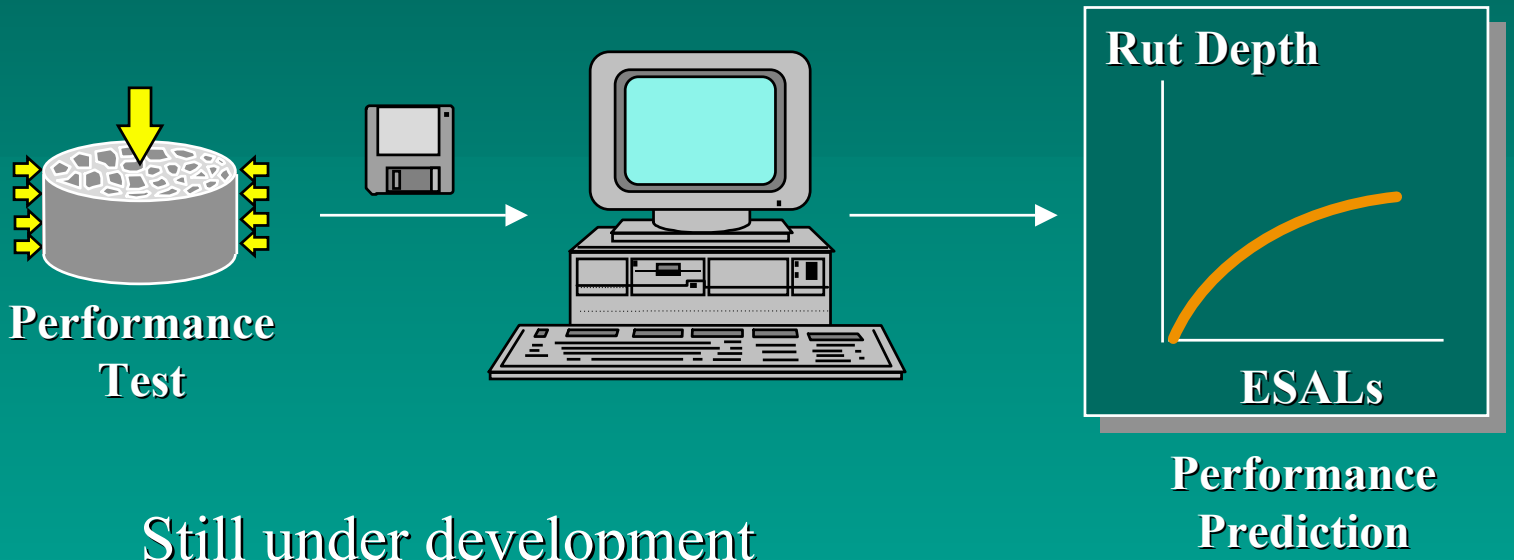
Superpave Performance Testing

What Are We Doing?



Still under development

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Final Payoff

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