Long Lasting Asphalt Binder Systems and Evolving Binder Specifications

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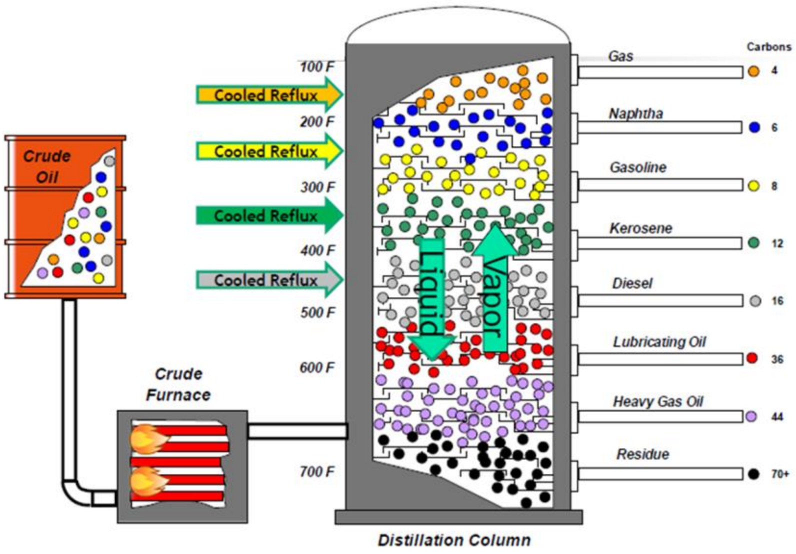
Sustainable Pavements Workshop

Objectives

- Identify the factors affecting the sustainability of asphalt binder.
- Name two classes of long-lasting asphalt binder systems.
- Explain the properties of these binder systems that are measured to estimate their longevity.
- Describe the distinguishing characteristic of evolving tests and specifications in asphalt.

Origins of Asphalt

- Modern industrial asphalt cements originate from the fractional distillation of petroleum.
- Factors affecting material properties
  - Nature of the original asphalt source
  - Refinery decisions
  - Terminal/formulation decisions



To learn more about processing visit: http://pavement.engineering.asu.edu/wordpress/wp-content/uploads/2014/04/Bob-McGennis.pdf

Sustainability of Asphalt

- Energy requirements and emissions associated with extraction, refining, storage, and transport of crude oil and asphalt.
- Exists as a finite resource
  - Approximately 56 of 131 U.S. refineries produce asphalt (EIA).
- Extending the durability of binder systems to improve the longevity of asphalt pavements
  - Appropriate use of polymers, rubber, and other modifiers in asphalt systems.

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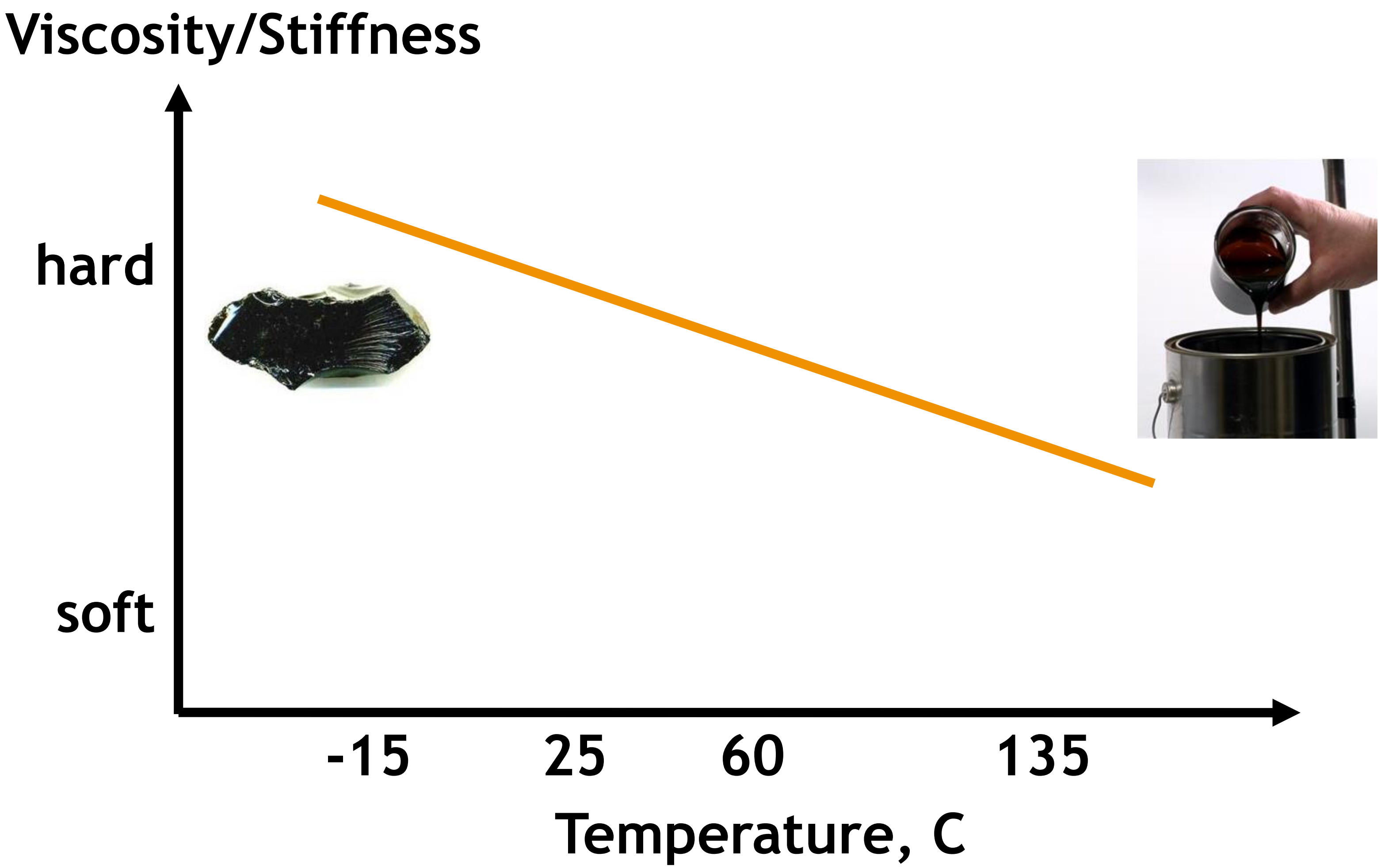
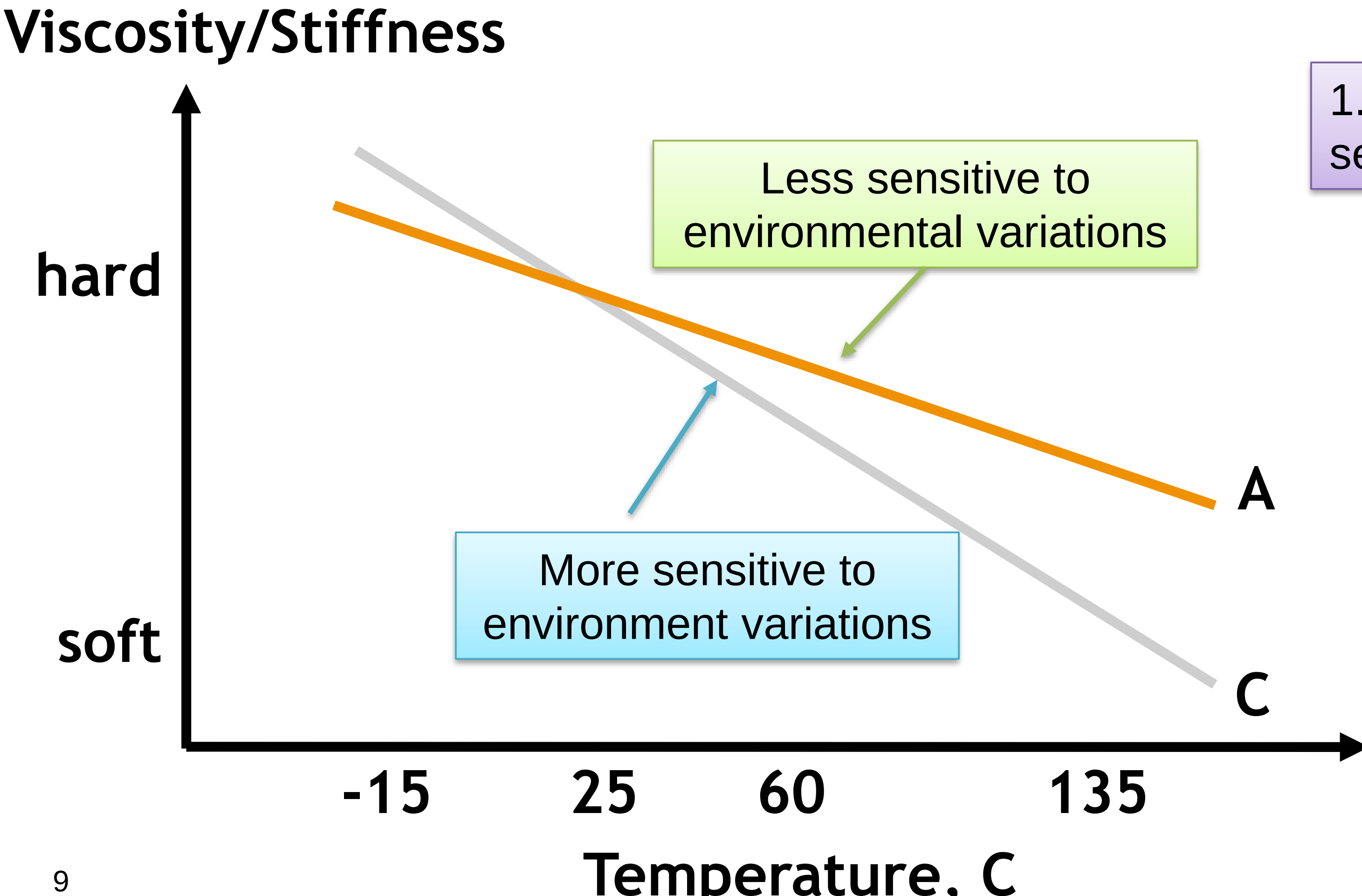
How Asphalt Behaves



How Asphalt Behaves

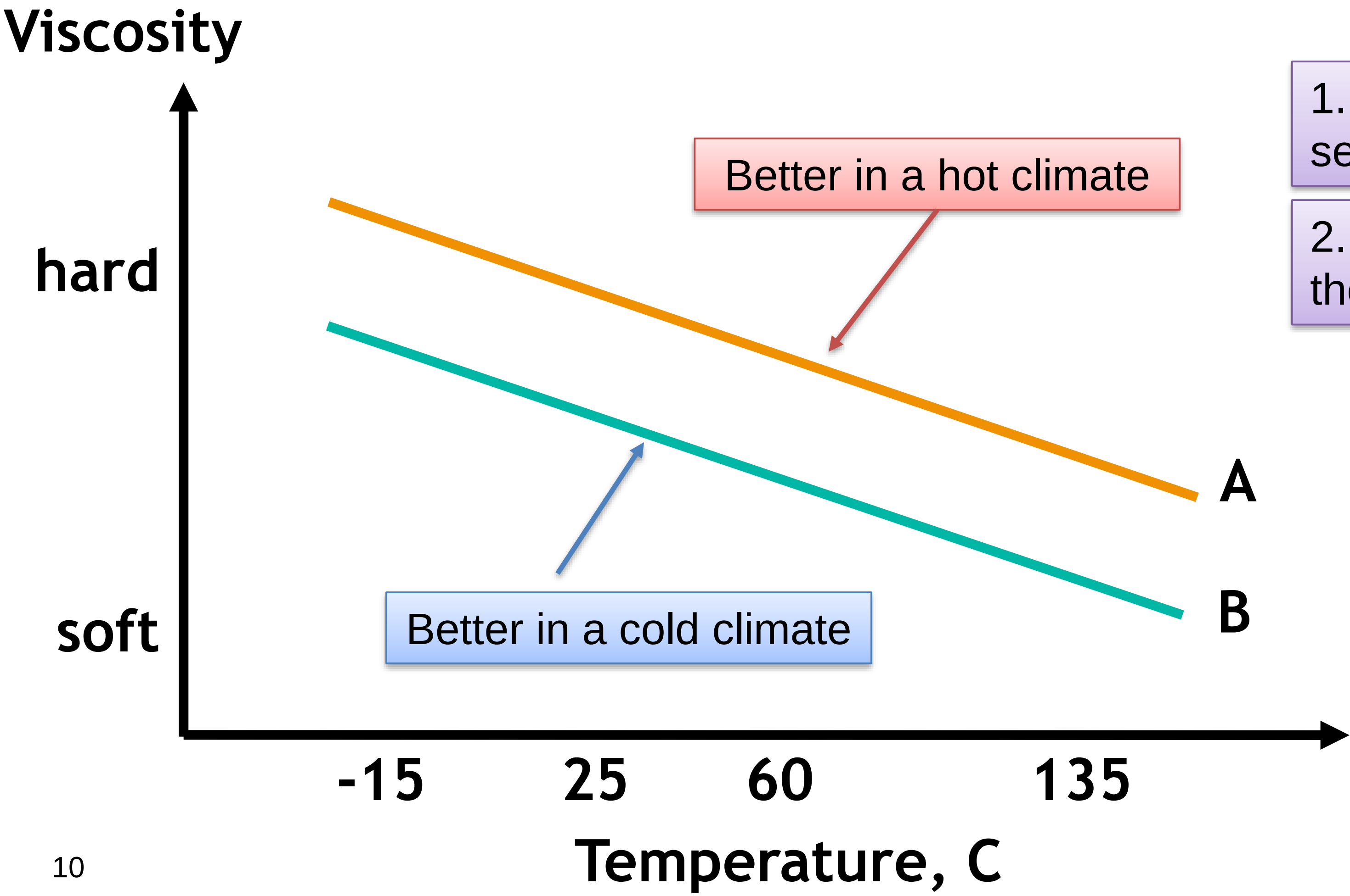
Silly Putty®

So what helps make a binder system long-lasting?



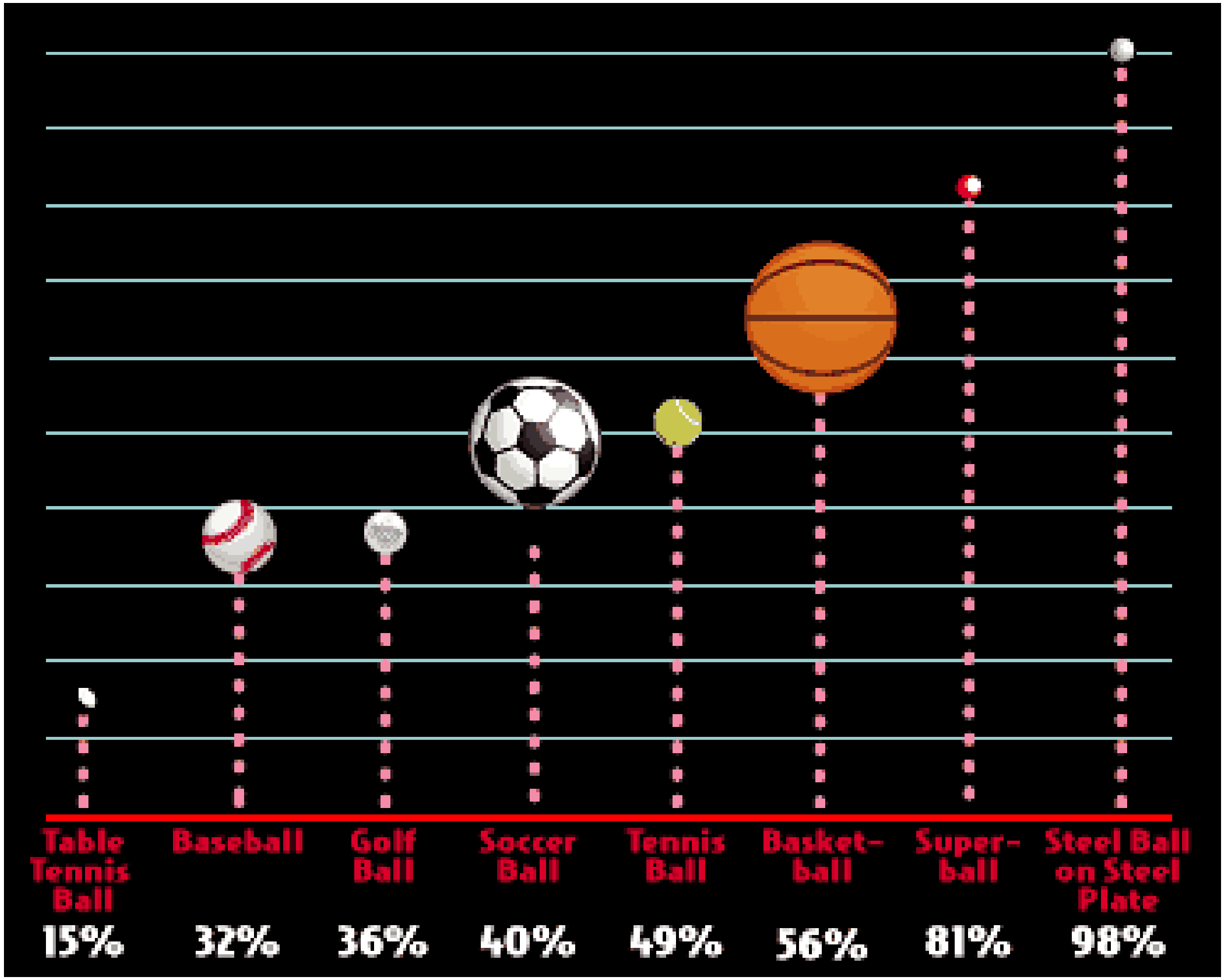
1. Less temperature sensitivity

So what helps make a binder system long-lasting?



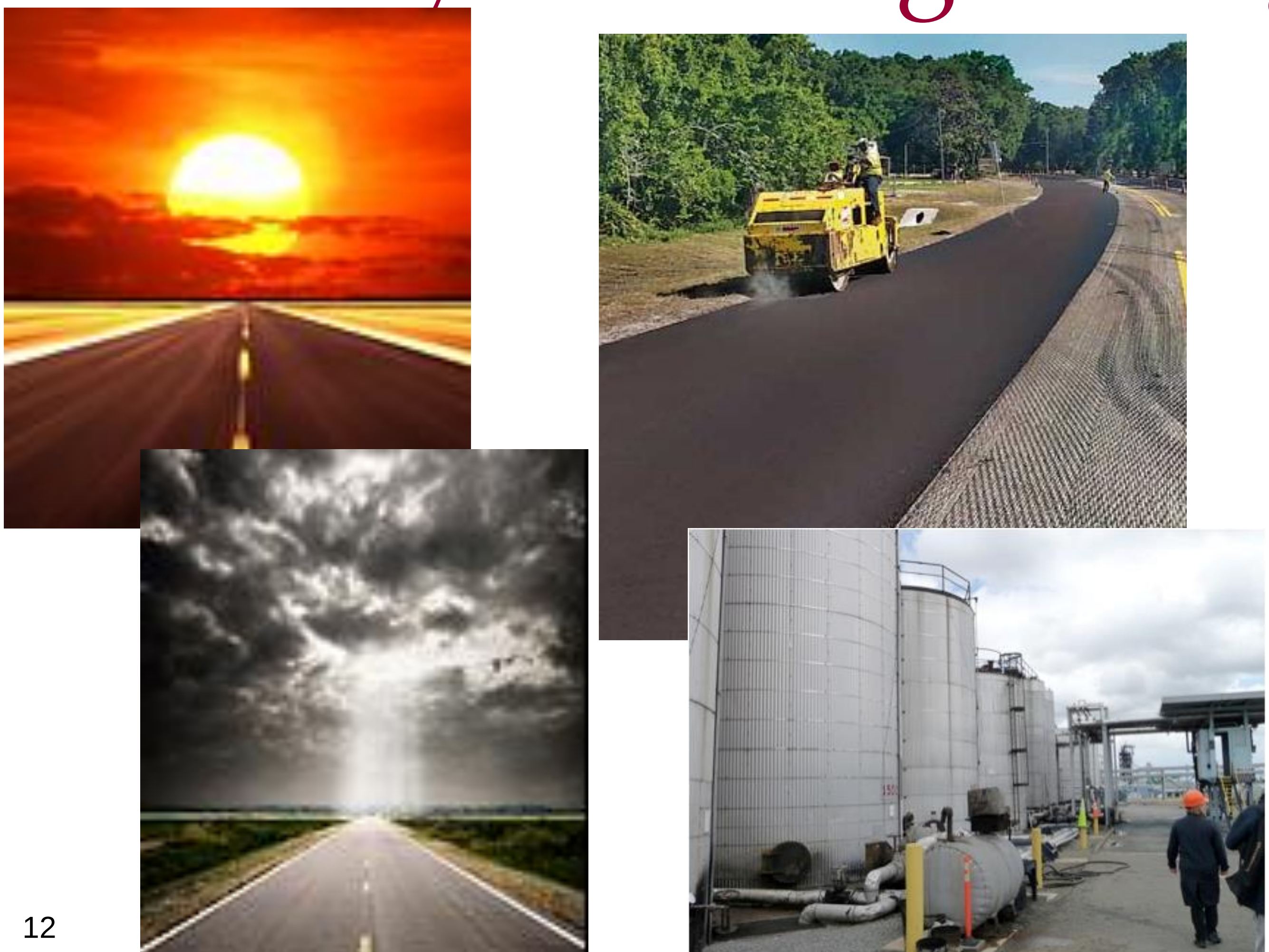
1. Less temperature sensitivity
2. Right binder for the right application

So what helps make a binder system long-lasting?



1. Less temperature sensitivity
2. Right binder for the right application
3. Elastic binder

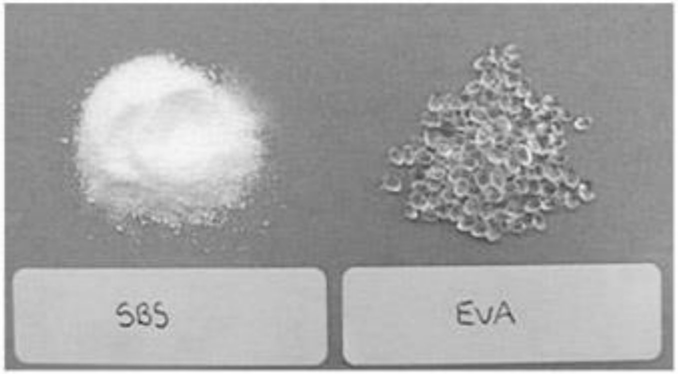
So what helps make a binder system long-lasting?



1. Less temperature sensitivity
2. Right binder for the right application
3. Elastic binder
4. UV, oxidation, and moisture resistant
5. Constructable
6. Available in large and stable supplies

Long Lasting Binder Systems

- Polymer modified asphalt
  - Elastic Type
    - ✓ SB diblock (Dynasol 1205)
    - ✓ SBS (Kraton D1184)
    - ✓ SBR latex (Ultrapave 1156)
    - ✓ Natural latex (Firestone Hartex 104)
    - ✓ Waste rubber (CRM WRF-14)
  - Plastic Type
    - ✓ Honeywell Titan 7686
    - ✓ EVA (Exxon Polybilt 103)
    - ✓ polyethylene (Novaphalt)



For more information see: http://pavement.engineering.asu.edu/wordpress/wp-content/uploads/2014/04/Chris-Lubbers.pdf

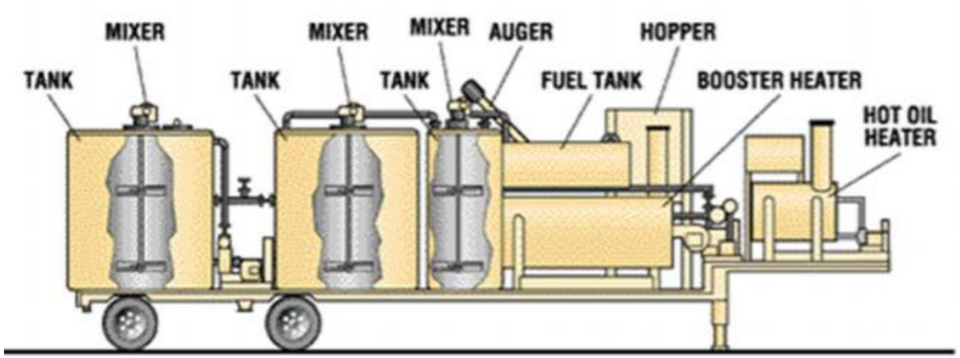
Long Lasting Binder Systems

- Advantages
  - Long performance history
  - Elastic effect
  - Improved cohesion
  - Many specs designed around stretchy polymers (no mysteries)
  - Favorable co-modifier with sulfur and PPA
- Disadvantages
  - Can be challenging to manufacture
  - Compatibility can be a problem
  - Tougher to handle
  - Not heat stable
  - Challenge to emulsify
  - Relatively expensive
  - Specifications may not capture benefits (or overstate benefits)

For more information see: http://pavement.engineering.asu.edu/wordpress/wp-content/uploads/2014/04/Chris-Lubbers.pdf

Long Lasting Binder Systems

- Rubber modified asphalt
  - On-site blend
    - ✓ Particulate based systems (non-homogeneous)
  - Terminal blend asphalt
    - ✓ Particulate based systems
    - ✓ Non-particulate based systems (TR+ with 8-10% rubber + 1-3% SBS)



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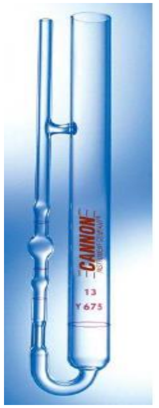
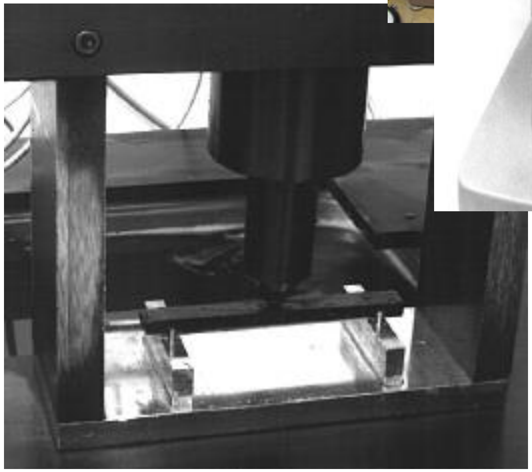
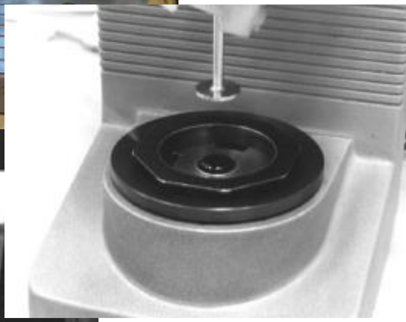
Specification and Testing of Asphalt

- Relevant asphalt properties are related to its flow response under loading.
  - Chewing (pre-1880's)
  - Penetration, ductility, viscosity with and without oxidation (late 1880's – 1990's)
  - Viscoelastic modulus across temperatures (oxidized and non-oxidized) (**Superpave**)





Source: Bob McGennis, AZP&MC Workshop 2014

For more information see: http://pavement.engineering.asu.edu/wordpress/wp-content/uploads/2014/04/Modified-Binder-Testing-presentation-4-10-14.pdf

Superpave Specifications

The PG grading system (AASHTO M32) is based on Climate

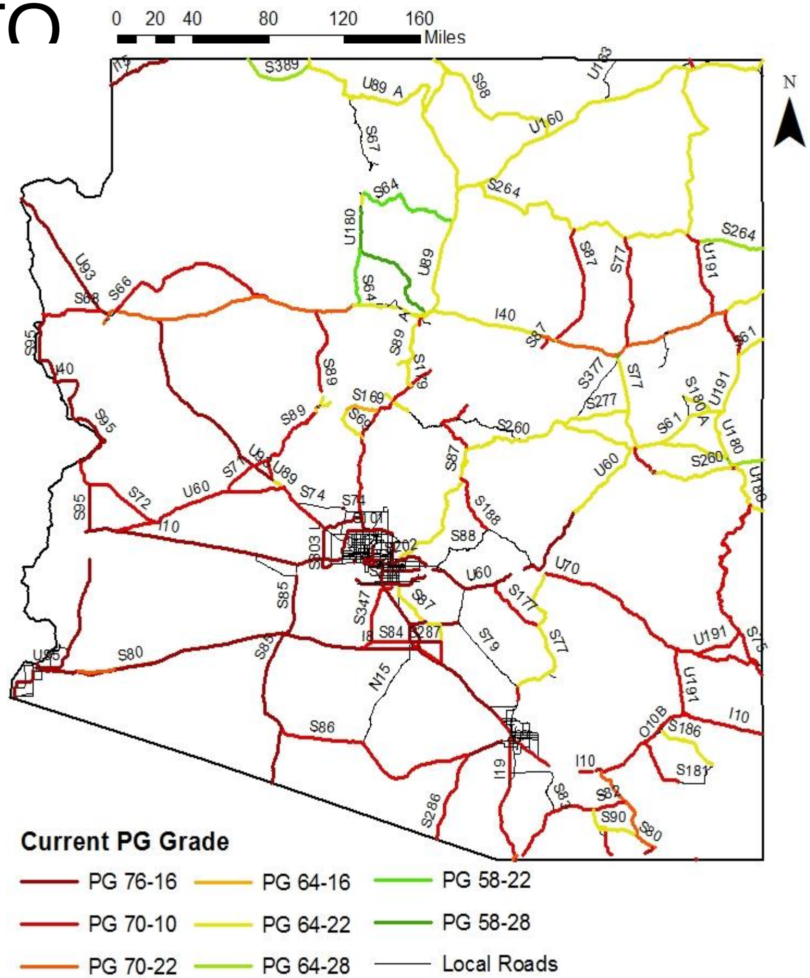
PG 70 - 10

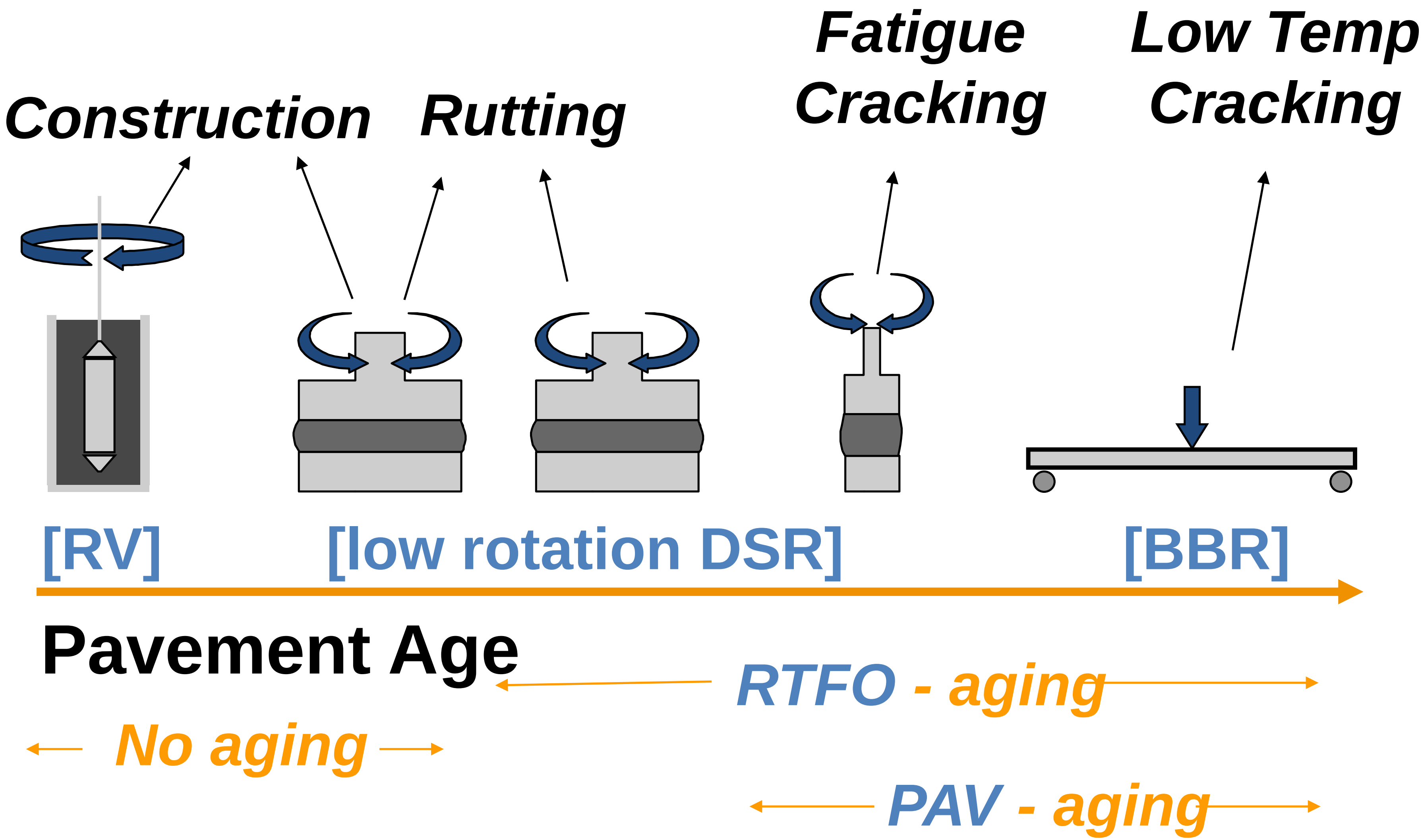
Performance Grade

Min pavement temperature (°C)

Average 7-day max pavement temperature (°C)

Embedded into this grade are assumptions of traffic speed (fast) and truck volume < 3 Million ESALs)

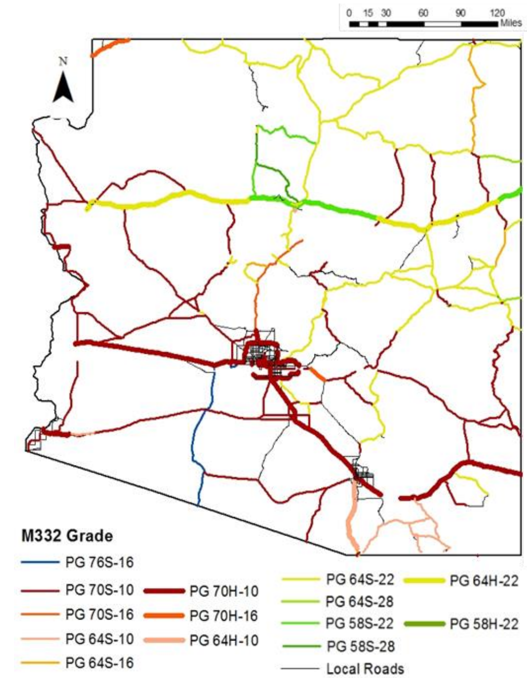




Embedded into this method are experiments that do not apply significant "stretch" to the asphalt system

Evolving Superpave Specifications

The Modified PG grading system (AASHTO M332) is based on climate and traffic conditions



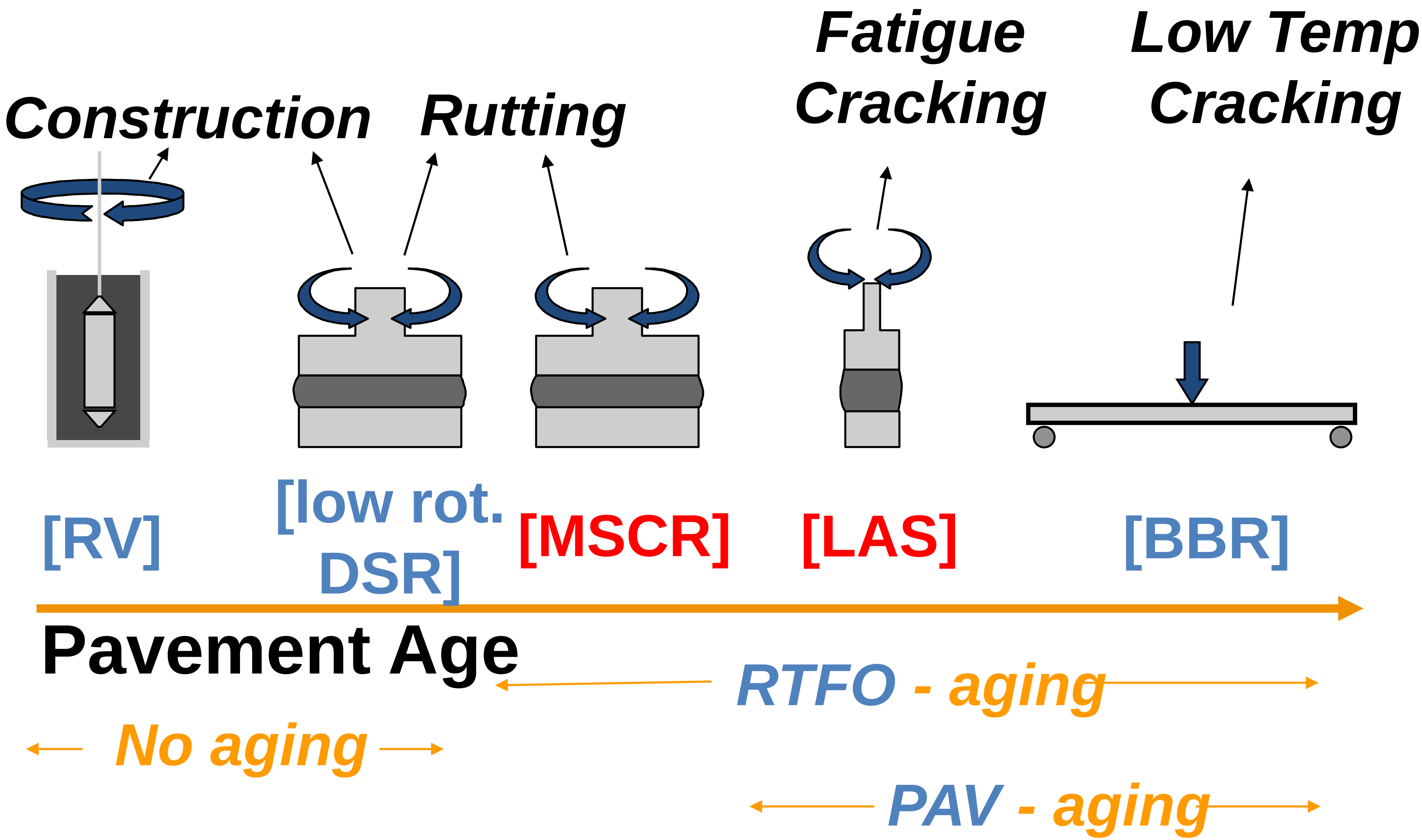
PG 70H - 10

Average 7-day max pavement temperature (°C)

Min pavement temperature (°C)

Traffic Dependent Designation

S = Standard (< 10 Million ESALs at > 45 mph)
H = Heavy (10-30 Million ESALs at > 45 mph or < 10 Millon ESALs at 15-45 mph)
V = Very Heavy (> 30 Million ESALs at > 45 mph or 10-30 Million ESALs at 15-45 mph or < 10 Million ESALs < 15 mph)
E = Extreme = > 30 Million ESALs at < 15 mph

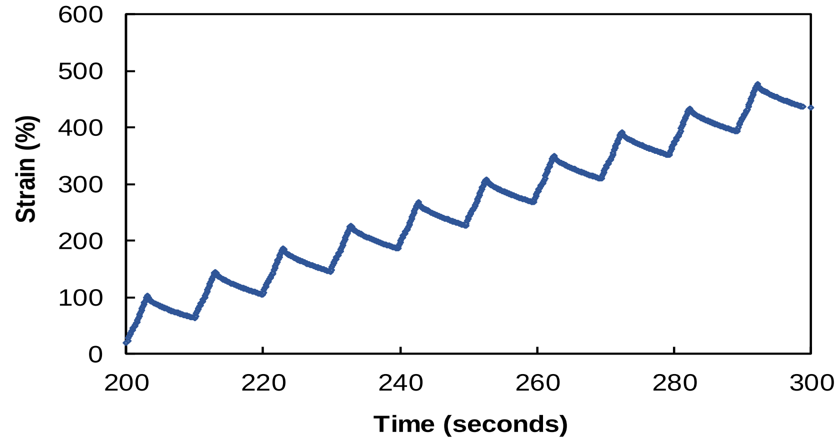


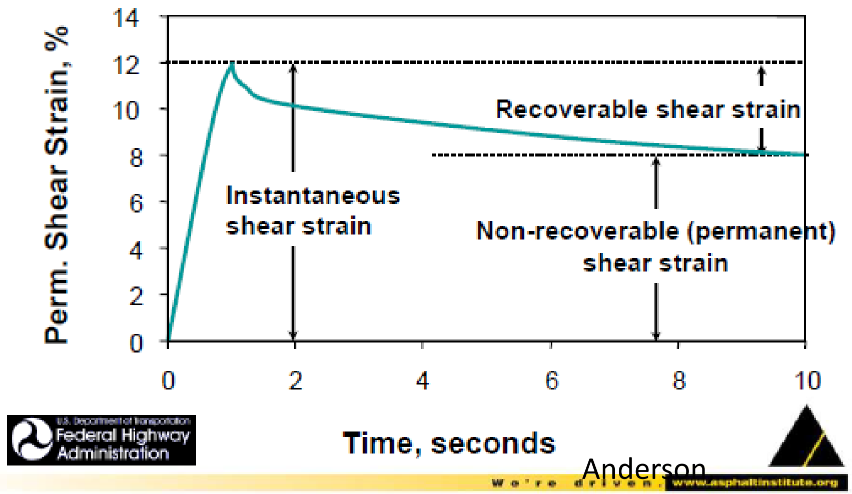
New experiments subject materials to higher rotations to activate the polymer network as it would be in service.

MSCR of Asphalt Binder

AASHTO T350

- **M**ultiple **S**tress **C**reep **R**ecovery test
  - Evaluate resistance to rutting at stress levels “more similar” to pavements.
  - 25 mm DSR sample subjected to pulse of load followed by a recovery period.
  - Response is J_{nr} and a smaller J_{nr} = better performance



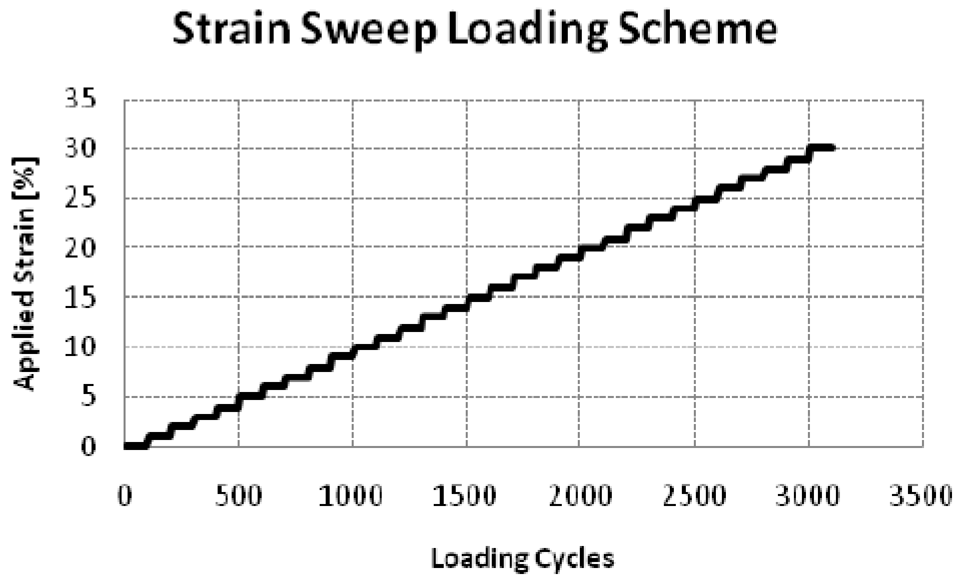


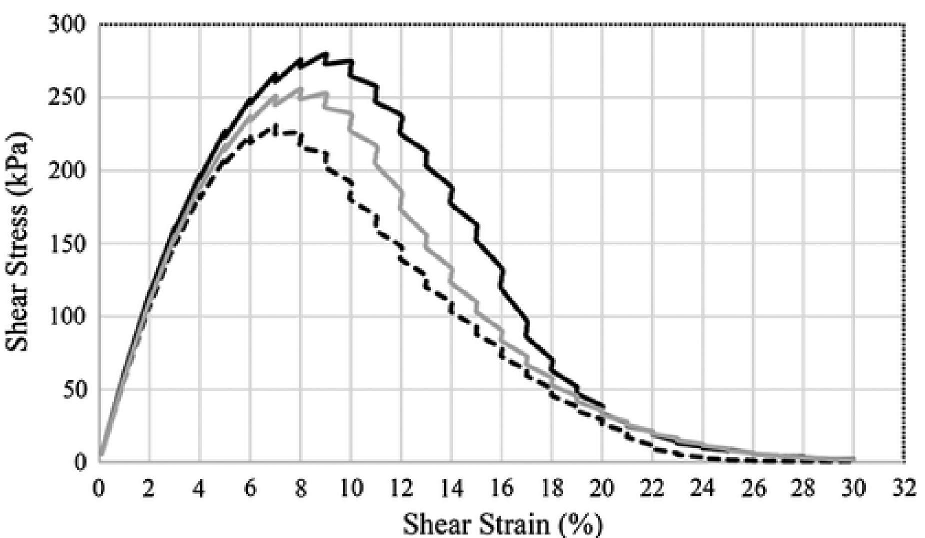
Anderson 2011

LAS Test of Asphalt Binder

AASHTO TP101

- **L**inear **A**mplitude **S**weep
  - Evaluate fatigue performance of asphalt binder
  - 8 mm DSR sample subjected to stepped increase loading pattern





Evolving Specification, M332

Performance Grade	PG 64						PG 70					
	10	16	22	28	34	40	10	16	22	28	34	40
Average 7-day max pavement design temp, °C[b]	<64						<70					
Min pavement design temp, °C[b]	>–10	>–16	>–22	>–28	>–34	>–40	>–10	>–16	>–22	>–28	>–34	>–40

MSCR, T 350: Standard Traffic "S" $J_{nr3.2}$, max 4.5 kPa^{-1} J_{nrdiff}, max 75% test temp, °C	64	70
MSCR, T 350: Heavy Traffic "H" $J_{nr3.2}$, max 2.0 kPa^{-1} J_{nrdiff}, max 75% test temp, °C	64	70
MSCR, T 350: Very Heavy Traffic "V" $J_{nr3.2}$, max 1.0 kPa^{-1} J_{nrdiff}, max 75% test temp, °C	64	70
MSCR, T 350: Extremely Heavy Traffic "E" $J_{nr3.2}$, max 0.5 kPa^{-1} J_{nrdiff}, max 75% test temp, °C	64	70

Traffic grade is dependent on the compliance of the asphalt from MSCR test

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	10	16	22	28	34	40	10	16	22	28	34	40
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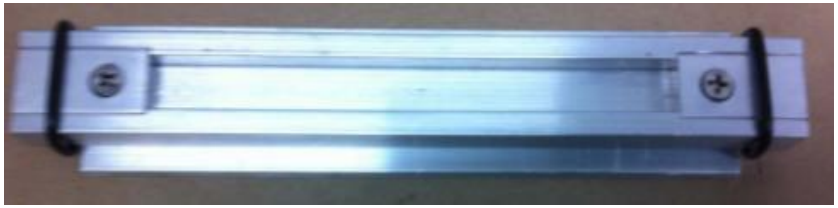
LAS, TP101 Grade "S" N_f at 2.5 and 5% > 15,000 Test temp, °C	31	28	25	22	19	16	34	31	28	25	22	19
LAS, TP101 Grade "H" N_f at 2.5 and 5% > 19,000 Test temp, °C	31	28	25	22	19	16	34	31	28	25	22	19
LAS, TP101 Grade "V" and "E" N_f at 2.5 and 5% > 31,000 Test temp, °C	31	28	25	22	19	16	34	31	28	25	22	19

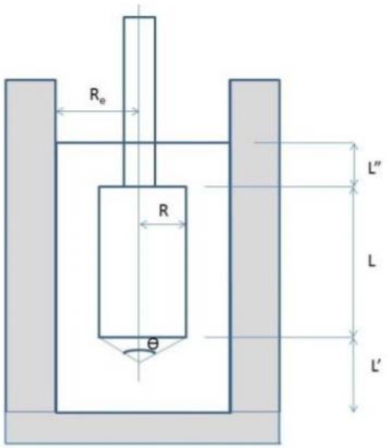
Traffic grade is dependent on the fatigue life of the asphalt binder

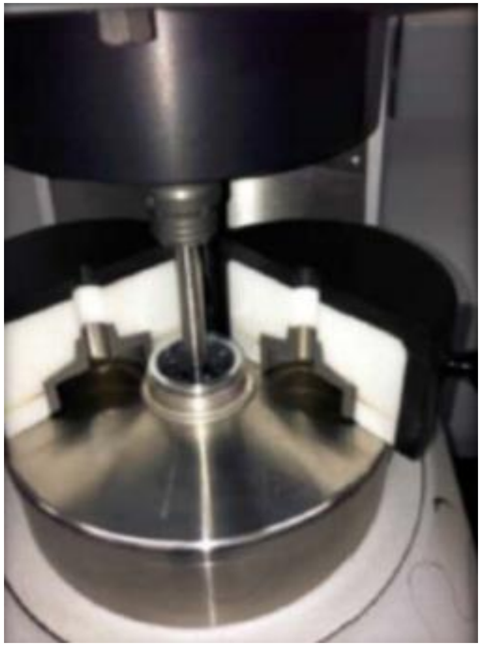
Tested at the same temperature as the existing Superpave system

Asphalt Rubber Specifications

- Similar high strain evaluations have been proposed for AR.
- Primary modifications involves experimental methods incorporating concentric cylinders.







Summary

- Identify the factors affecting the sustainability of asphalt binder.
  - Energy and emissions
  - Finite resource
  - Durability
  - Appropriate use of long-life binders
- Name two classes of long-lasting asphalt binder systems.
  - Polymer modified
  - Rubber modified

Summary

- Explain the properties of binder systems that are measured to estimate their longevity.
  - Viscosity/Stiffness as a function of temperature
  - Elasticity as a function of temperature
- Describe the distinguishing characteristic of evolving tests and specifications in asphalt.
  - Explicit consideration of traffic loads and speed in specification grade
  - Testing at high strains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