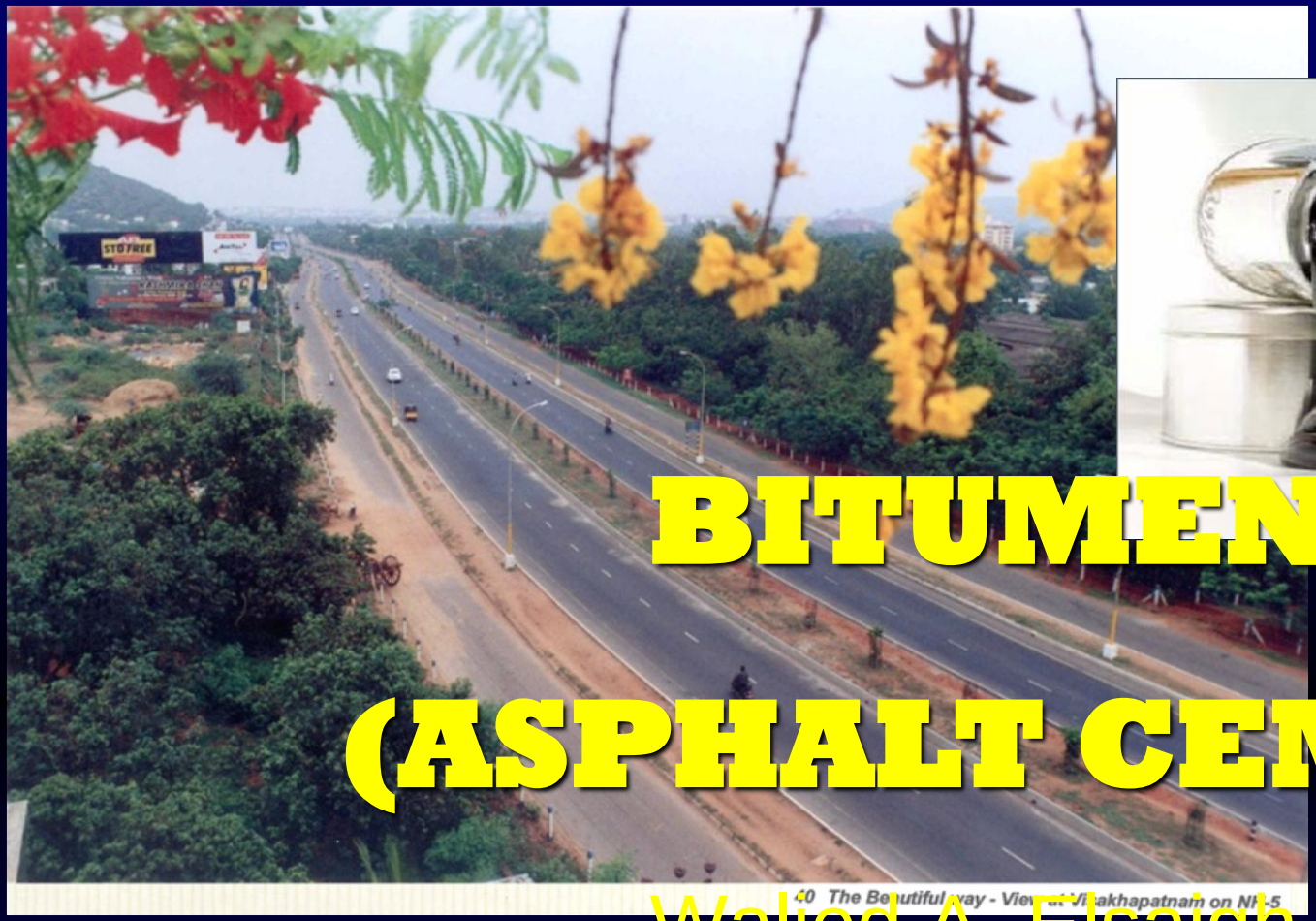

BITUMEN 1

(ASPHALT CEMENT)

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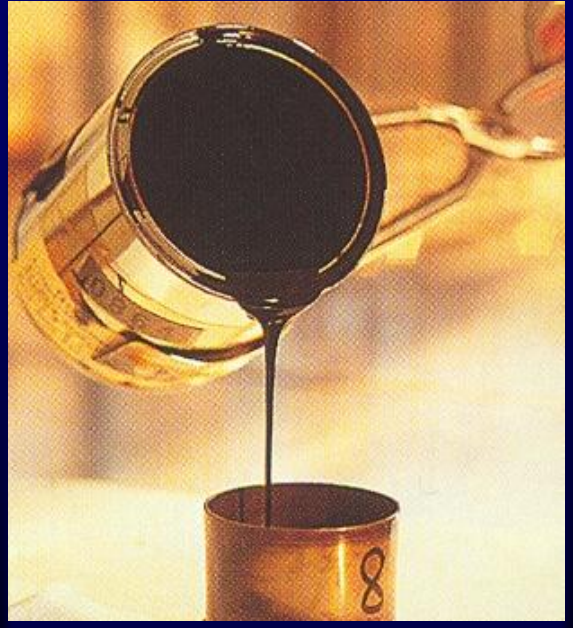
Definition



A black or dark brown non-crystalline solid or viscous material, composed principally of high molecular weight hydrocarbons, having **adhesive** properties, derived from petroleum either by **natural** or **refinery** processes and substantially soluble in carbon disulphide.

Adhesion (Cementing action)

Bituminous materials adhere to clean dry surfaces.

Origin of Bitumen

Asphalt materials have been utilized since 3500 B.C. (lining of water retaining structures) In building and road construction. Their main uses have been as adhesives, waterproofing agents, and as mortars for brick walls.

These early asphalt materials were natural asphalt. These asphalts were found in pools and asphalt lakes. For example Trinidad and Bermudez lake deposits (asphalt lake).

Historical Developments

- First US hot mix asphalt (HMA) constructed in 1870's
  - Pennsylvania Ave.
  - Used naturally occurring asphalt from surface of lake on Island of Trinidad
- Two sources
  - Island of Trinidad
  - Bermudez, Venezuela
- Demand for paved roads exceeded the supply of lake asphalts in late 1800, leading to use of petroleum asphalts

Lake Bitumen

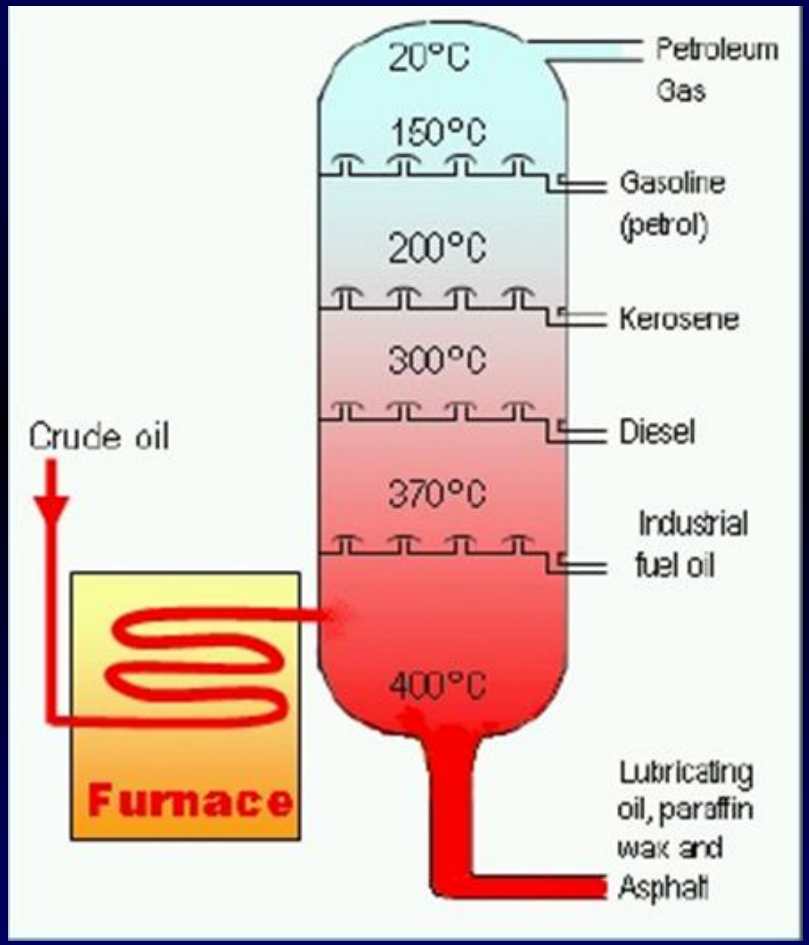
Petroleum Bitumen

- ✓ Petroleum bitumen is simply the residue left over from petroleum refining.

- ✓ Asphalt is waste product from refinery processing of crude oil
  - – Sometimes called the “bottom of the barrel”

- ✓ Properties depend on:
  - – Refinery operations
  - – Composition crude source-dependent

Refinery Operation



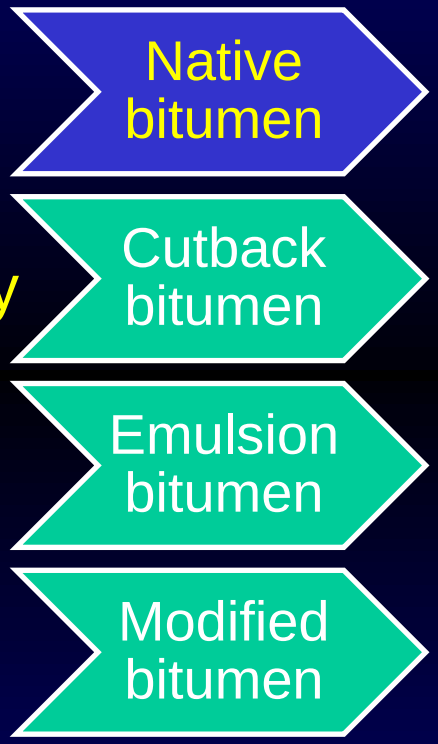
Bitumen Components

- ✓ Asphaltenes
- ✓ Resins
- ✓ Oils

Types of Bitumen / Classifications

Native bitumen

The primary asphalt product produced by the distillation of crude oil. They are produced in various **viscosity grades**.



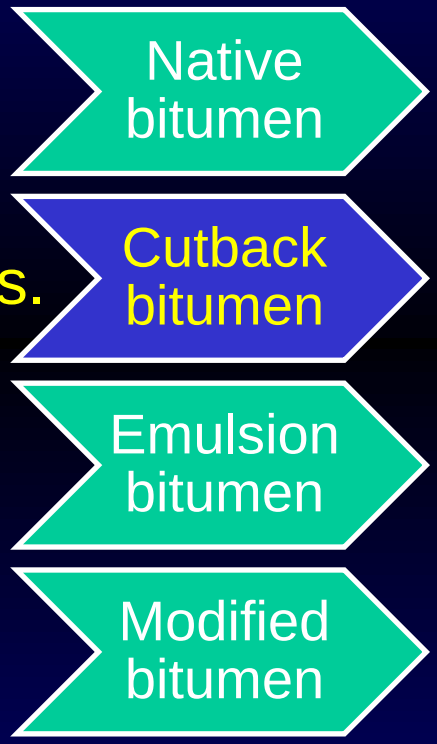
Cont. Types of Bitumen/ Classifications

Cutbacks

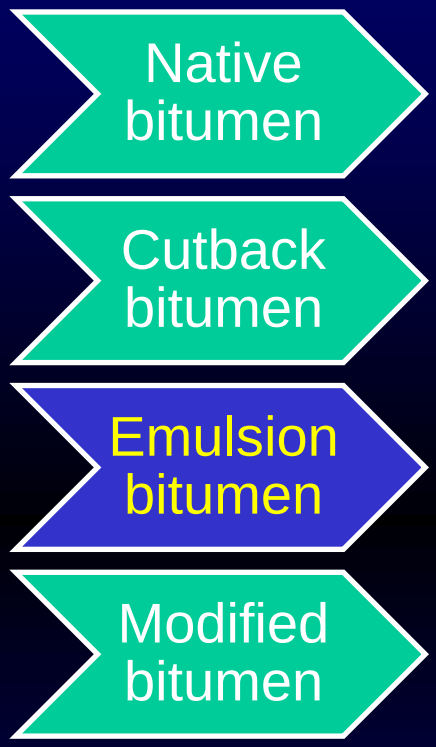
Describes a mixture of a binder and a light volatile oil. They are liquid at low temperatures until the volatile oil evaporates.

Environmental Aspect

Due to the release of solvents into the Atmosphere they are now rarely used.



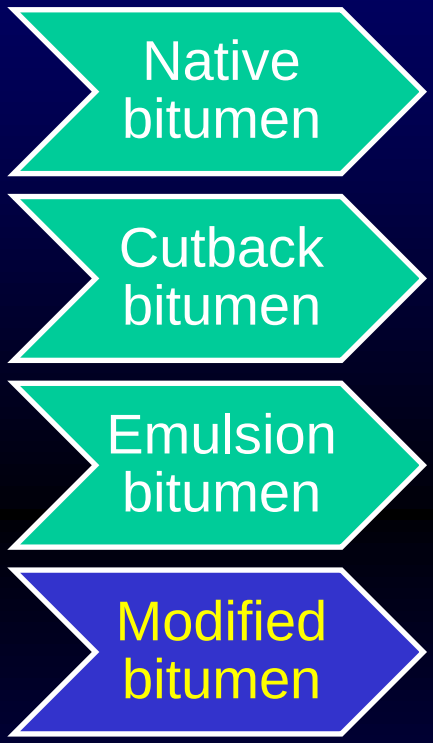
Cont. Types of Bitumen / Classifications



Emulsions

When mixed with water binders will generally settle out. An emulsifier must be added to give a stable solution. The water evaporates and the bitumen remains on the surface. The current types of cold rolled materials are based on emulsions.

Cont. Types of Bitumen / Classifications



Modified Bitumen

✓More stable under heavy loads, braking and accelerating forces;

✓ shows increased resistance to permanent deformation in hot weather.

✓It resists fatigue loads;

✓Better adhesion between aggregates and binders

Types of modifiers /Advantages [Google]
- Sulphur
- Rubber (natural and discarded tyres)
- Polymers (ethylene vinyle, polypropylene)

Other Types of Bitumen

Oxidised Bitumen

- Bitumen, the properties of which are modified by blowing air through it at a comparatively high temperature and pressure.

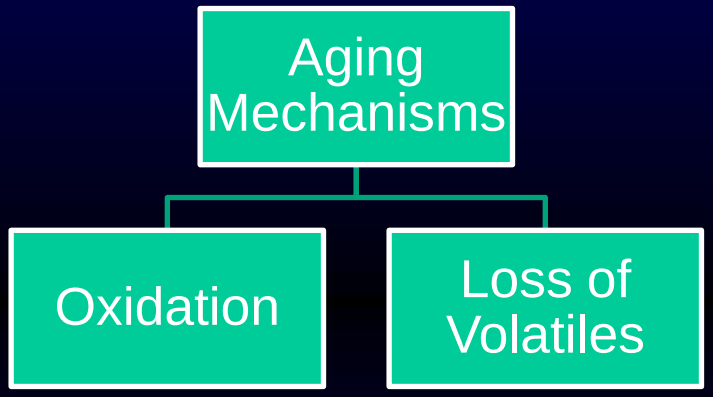
- Used in wide variety of industrial application including roofing, flooring, pipe coating, etc

Foamed Bitumen

created by injection of a pre-determined amount of cold water(usually around 2.5%) into hot bitumen in the mixing chamber of a pavement recycling unit. [Google search]

Aging (Ageing) of Bitumen

- Results due to exposure of bitumen to atmosphere.



Consequence

Aging = hardening

= becoming brittle

BUT

✓what is wrong of being **brittle**?!

Oxidation: Oxygen molecules from the air combine with the resins forming asphaltenes (high weight molecules)

Loss of Volatiles: Low weight molecules evaporates due to increase in temperature during production of asphalt concrete and thereafter.

Bitumen Behavior

- Bitumen is **visco-elastic** meaning that it can exhibit both elastic and viscous properties in the same time

- Behaviour of bitumen depends on:
  - Temperature (discuss latter)
  - Time (duration) of loading (rate of loading)
  - Aging properties

- Bitumen is **thermoplastic** material meaning that it soften as temperature rises but become hard again when temperature fall.

Temperature susceptibility = change in viscosity with temperature

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BITUMEN 2

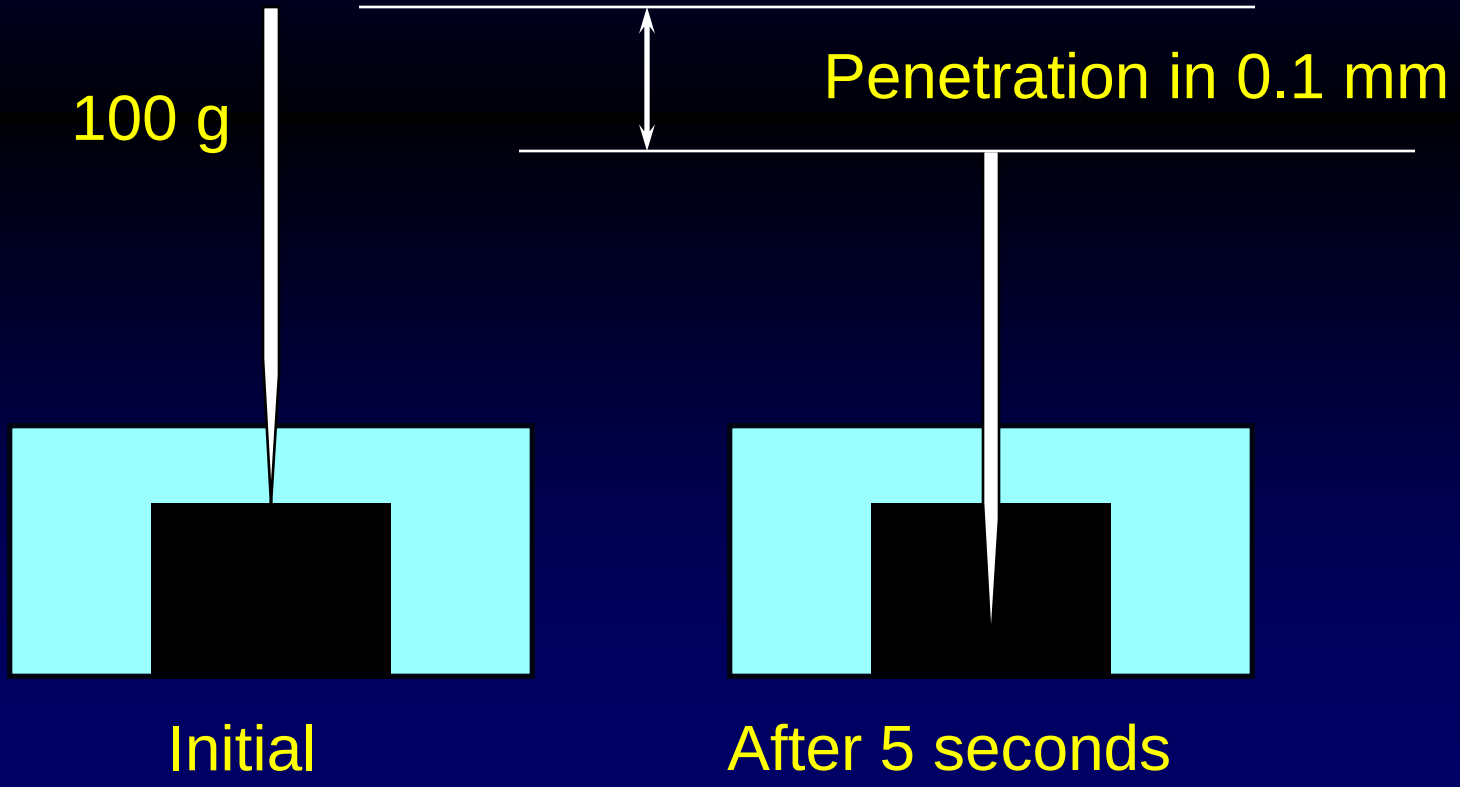
Testing

Penetration grade Specifications

- Flash point test
- Ductility
- Solubility
- Penetration
- Ductility
- Softening

Penetration Testing

- Sewing machine needle
- Specified load, time, temperature



Penetration Grades

Five Grades

- 40 - 50
- 60 - 70
- 85 - 100
- 120 - 150
- 200 - 300

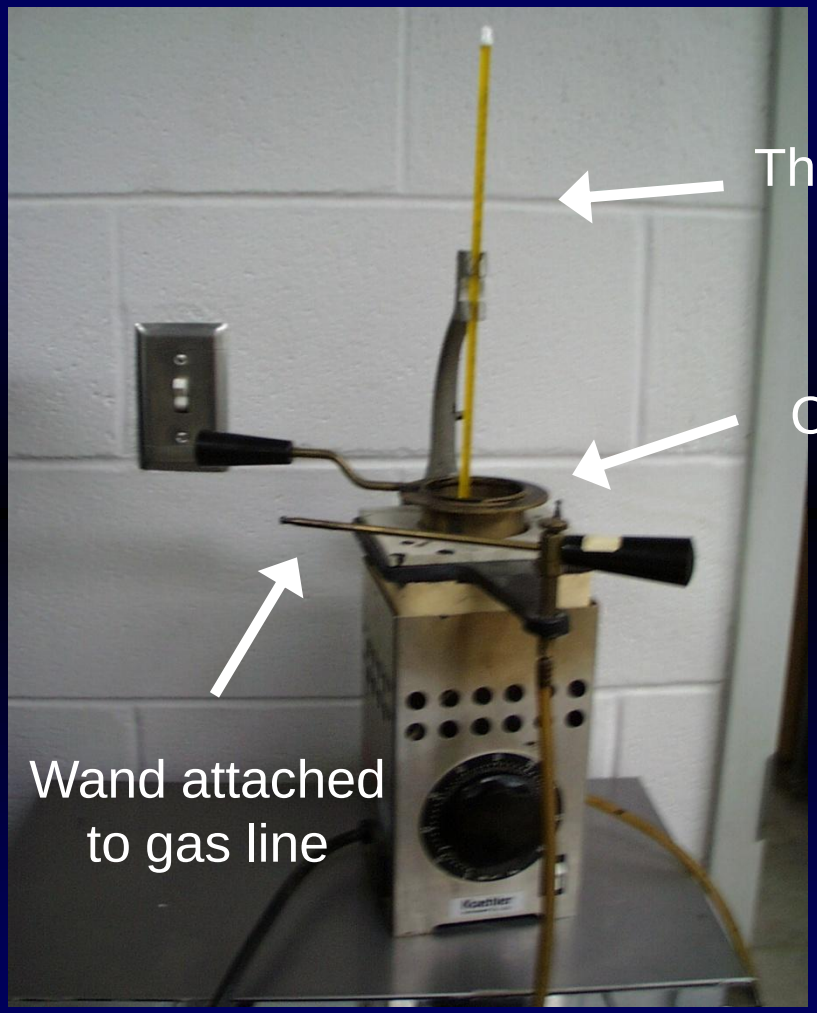
Penetration test is a 1mm diameter needle is loaded with a weight of 100g and the distance it drops into a bitumen sample in 5 seconds is measured **(at 25ºC)**. A bitumen is referred to as 70 pen if the penetration is 7mm.

Flash & Fire Points (Safety)

Flash point
Temperature at which Vapour starts.

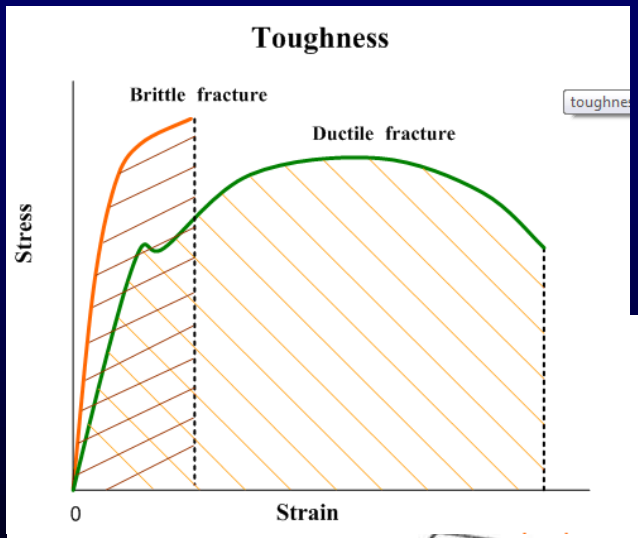
Bitumen vapour
Carcinogenic!

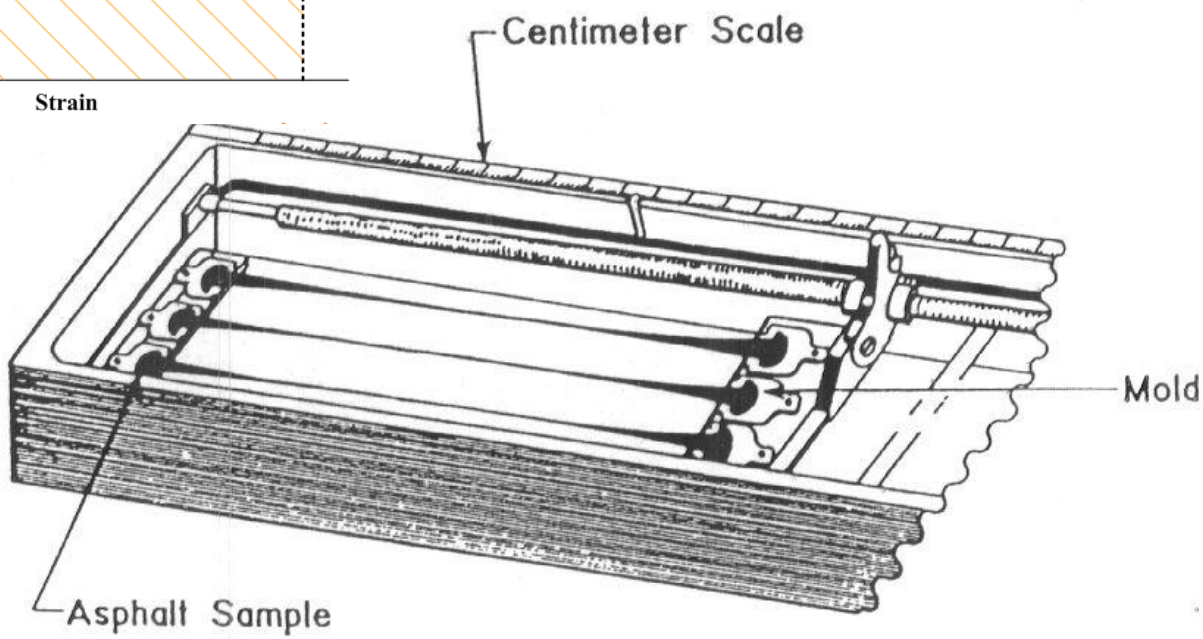
Fire point
Temperature at which Bitumen starts to burn



Ductility

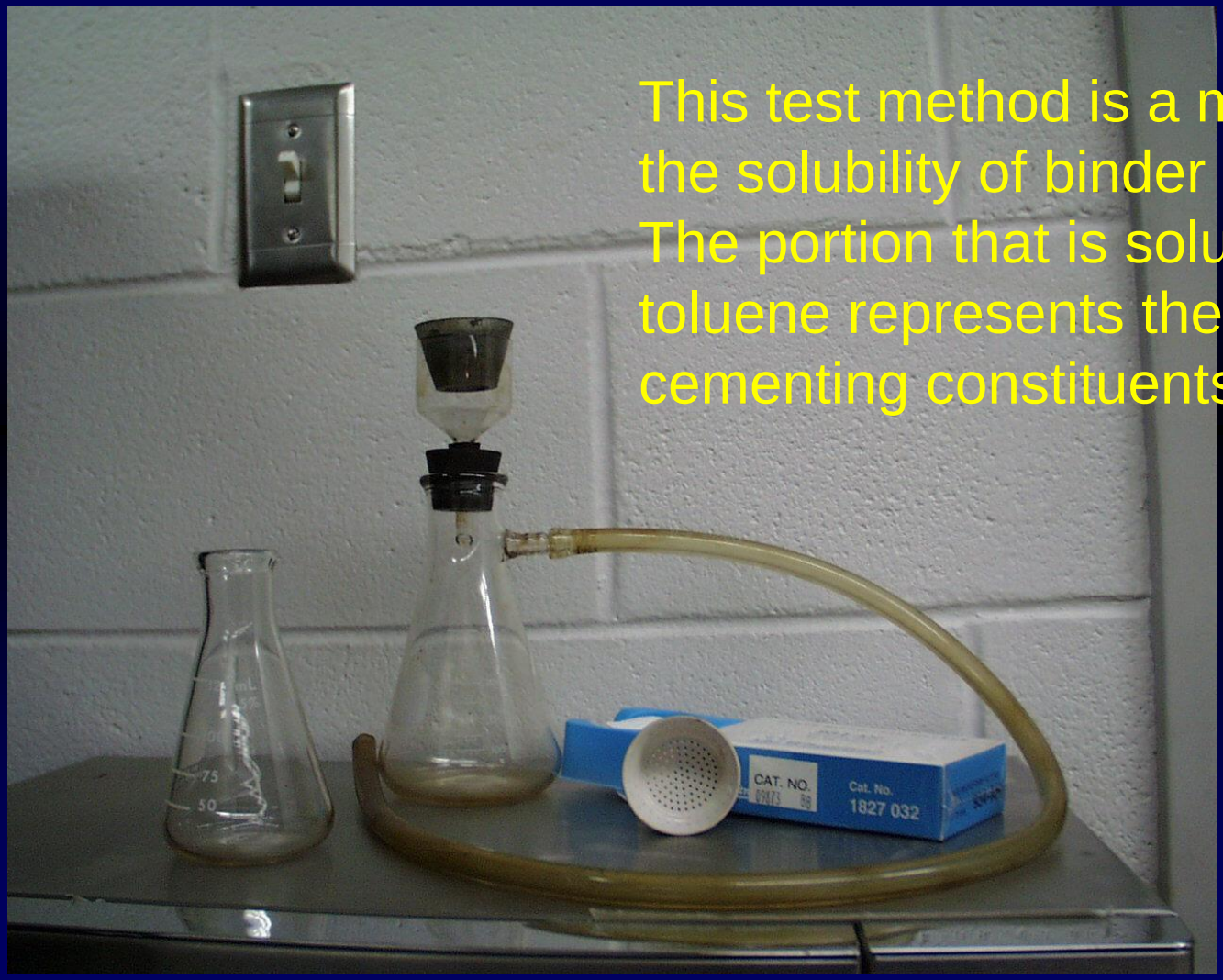
✓Ability to stretch without breaking





Distance in cm to which a standard specimen will elongate before breaking is pulled apart at a specified speed and a specified temperature.

Solubility



This test method is a measure of the solubility of binder in toluene. The portion that is soluble in toluene represents the active cementing constituents.

Softening Point

The softening-point is reported as the mean of the temperatures at which two disks of bitumen soften enough to allow each ball to fall a distance of 25 mm.

Why the softening temp. is so important in KSA?

Advantages of Pen. Spec.

- Grades asphalt near average in-service temp.
- Fast
- Can be used in field labs
- Low capital costs
- But can Temp. susceptibility be determined?

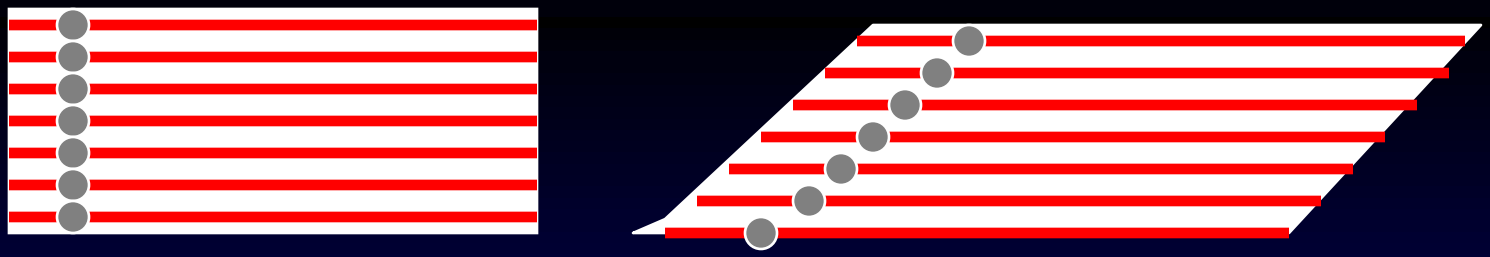
Disadvantages of Pen. Spec.

- Empirical test
- Shear rate
  - High
  - Variable
- Mixing and compaction temp. information not available
- Similar penetrations at 25C (77F) do not reflect wide differences in asphalts

Viscosity Graded Specifications

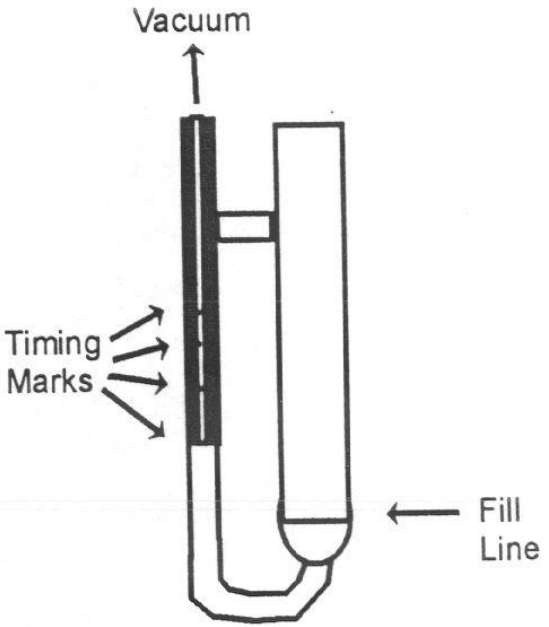
Viscosity: the ratio between the applied shear stress and the rate of shear.

$$\eta = \tau / \dot{\gamma}$$

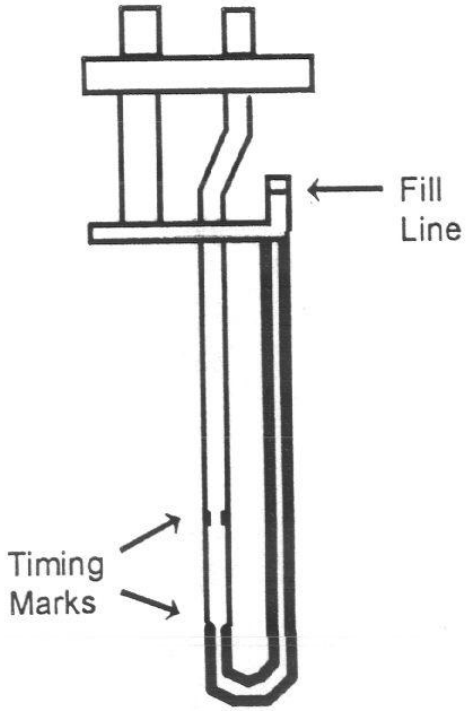


- The viscosity of a liquid is the property that retards flow so that, when a force is applied to liquid, the higher the viscosity, the slower will be the movement.

Types of Viscosity Tubes



Asphalt Institute Tube



Zietfuchs Cross-Arm Tube

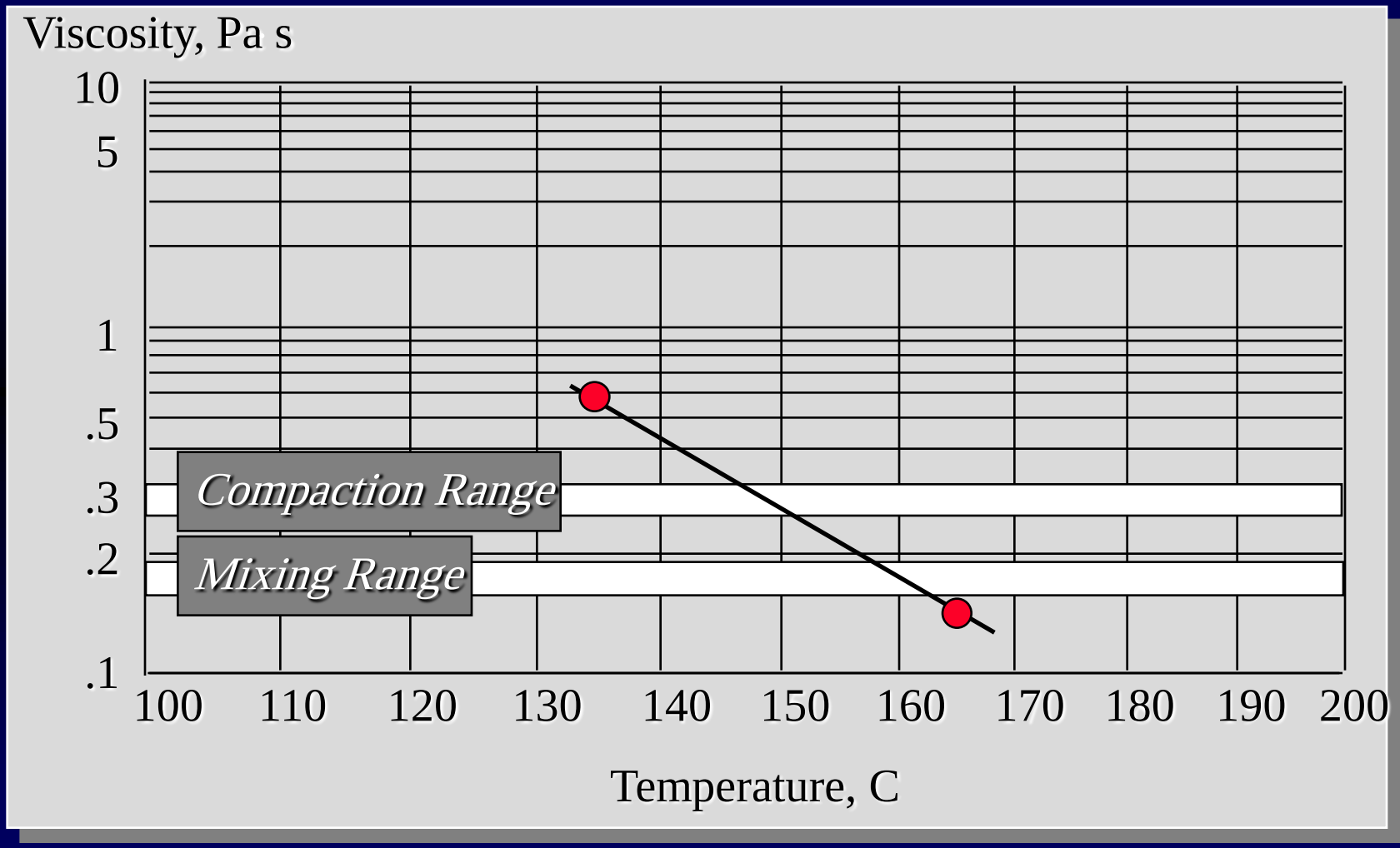
Viscosity Testing- Absolute

- Absolute viscosity
  - U-shaped tube with timing marks & filled with asphalt
  - Placed in 60^0C bath
  - Vacuum used to pull asphalt through tube
  - Time to pass marks
  - Viscosity in Pa s (Poise)

Viscosity Testing - Kinematic

- ✓ Cross arm tube with timing marks & filled with asphalt.
- ✓ Placed in 135C bath
- ✓ Once started gravity moves asphalt through tube
- ✓ Time to pass marks .
- ✓ Viscosity in mm^2 / s (centistoke)

Mixing/Compaction Temps



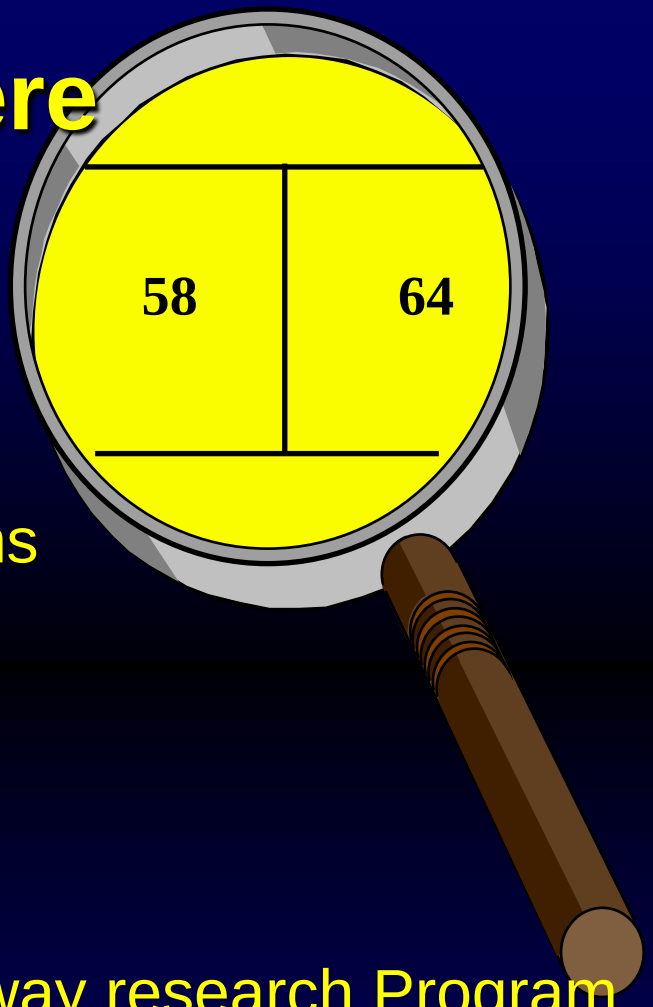
Advantages of Viscosity Grade Spec.

- Fundamental property
- Wide range of temperatures
- Based on max. pavement surface temp.
- Wide range of instruments
- Test method precision established
- Temperature susceptibility is controlled
- Information on mixing & compaction temps.

Disadvantages of Viscosity Grade Spec.

- More expensive
- Longer testing time
- More technician skill needed
- Wide range of properties for same grade

Where Must I Go from Here



Should look for a binder specifications
That addresses:

- ❖Permanent deformation
- ❖Low temperature cracking
- ❖Fatigue cracking

SHRP = Strategic Highway research Program

Superior **Per**forming Asphalt **Pave**ments

SUPERPAVE

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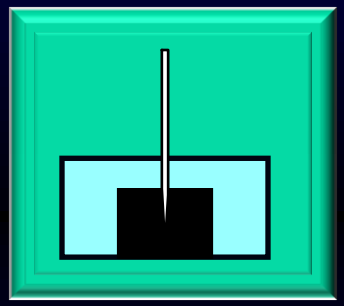
BITUMEN 3

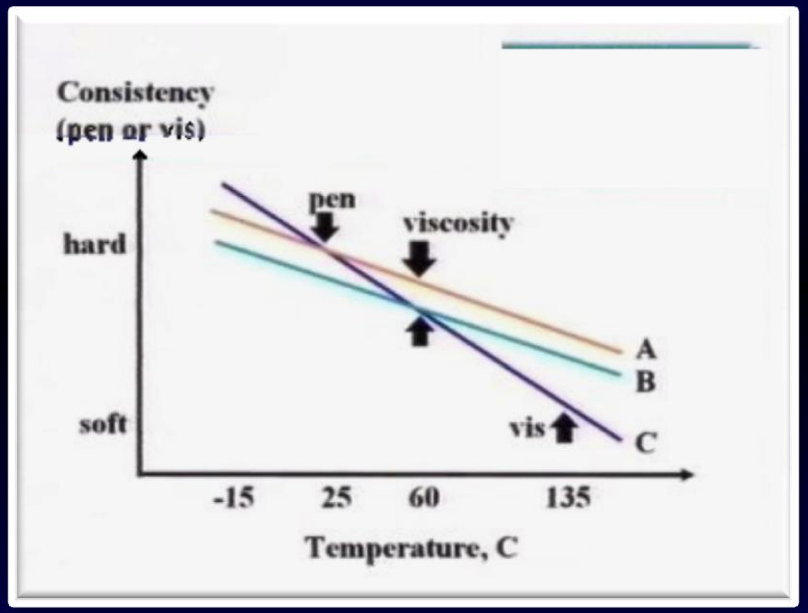
SUPERPAVE BINDER SPECIFICATIONS

Background

Superpave Performance Graded Specifications was developed to address the shortcoming seen in traditional bitumen specifications

@25 degree Celsius!
Fits both conditions in Canada and KSA??





Same specification grade, but might be different behavior with respect to temperature?

- Relationship between performance And Pen. / Visc. Spec. is missing OR has to be gained from experience!

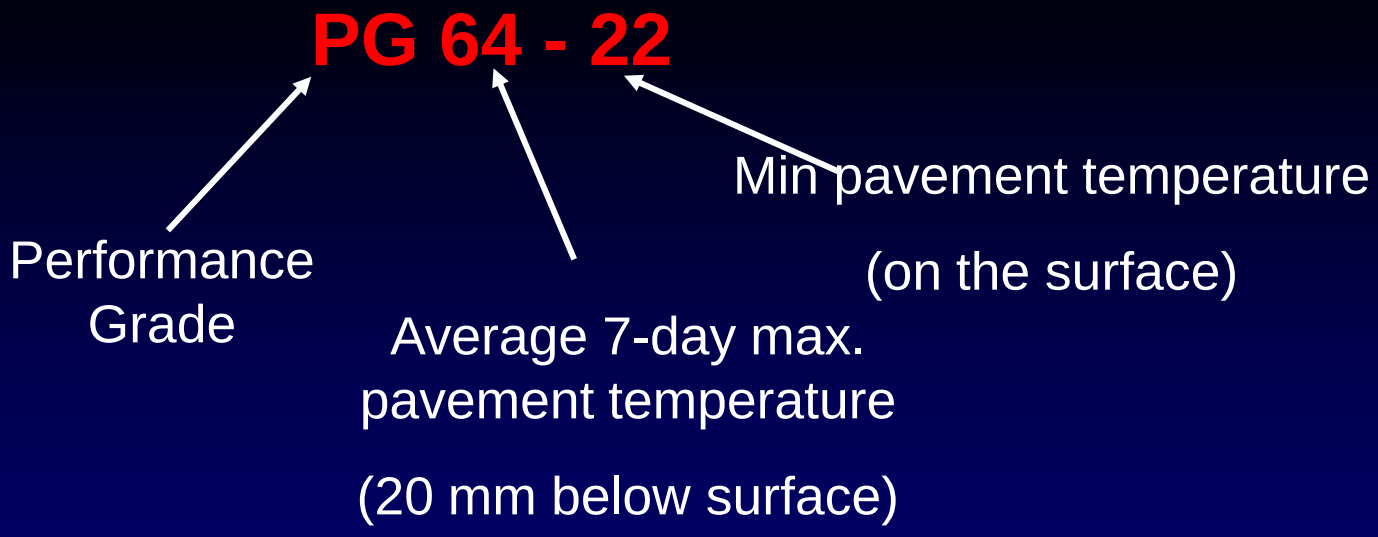
- Long-term **aging** not considered in Both Pen. and viscosity specifications

- Entire range of temperature was not Included in the Pen (only at 25^{o}C)/ Visc (only at 60 & 135^{o} C) Spec. !!

Superpave – Performance Grade (PG) Specifications

Advantages:

- ✓ Fundamental properties related to pavement performance.
- ✓ Environmental factors included.
- ✓ In-service & construction temp. are taken into account.
- ✓ Short and long term aging is considered.

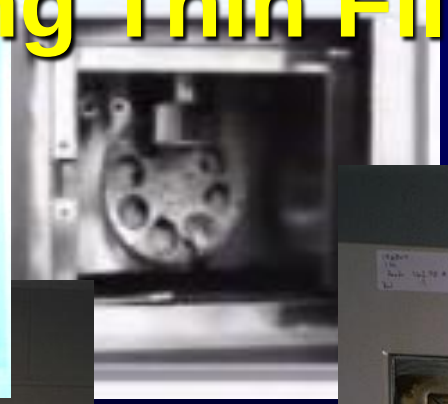


Pavement temp = f (air temp, depth, latitude)

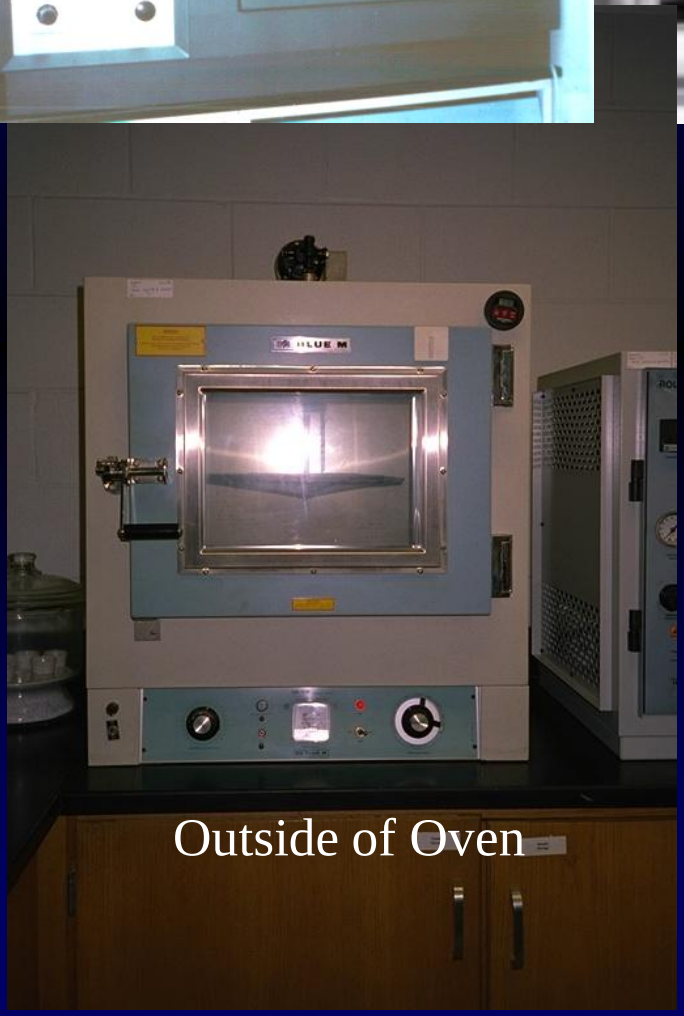
SUPERPAVE Binder Tests

Test	Purpose
Rolling Thin Film Oven (RTFO)	simulates short-term aging (aging from hot mixing and construction)
Pressure Aging Vessel (PAV)	simulates long-term aging (aging of 7 to 10 years)
Dynamic Shear Rheometer (DSR)	measure binder properties at high and intermediate temp.
Rational Viscometer (RV)	measure binder properties at high temp.
Bending Beam Rheometer (BBR)	measures binder properties at low temp.
Direct tension Tester (DTT)	measures binder properties at low temp.

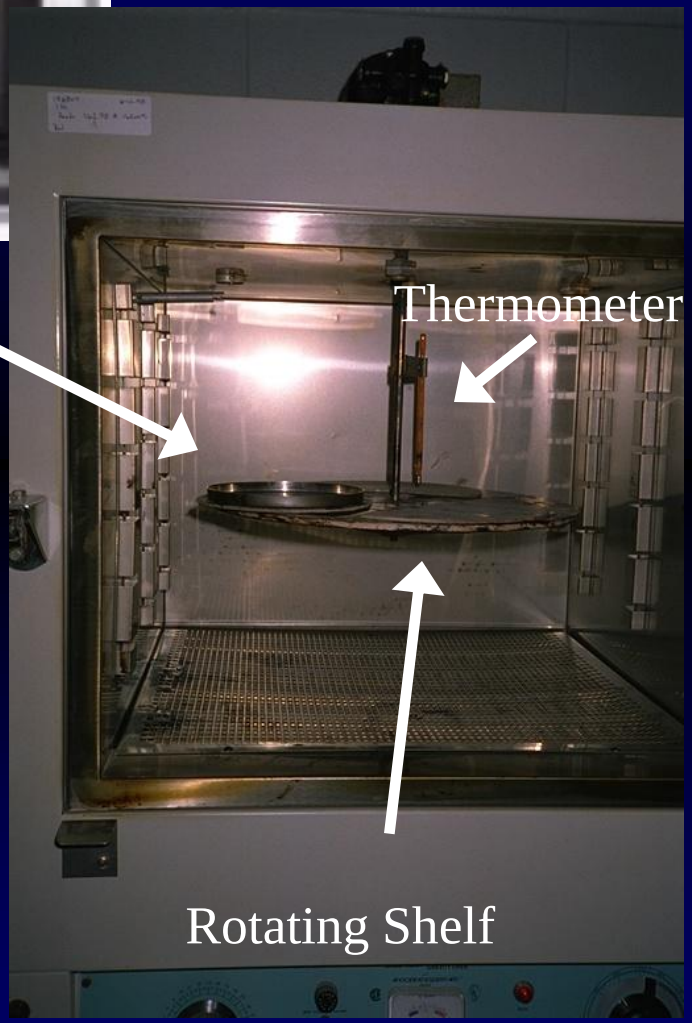
Rolling Thin Film Oven



Pan

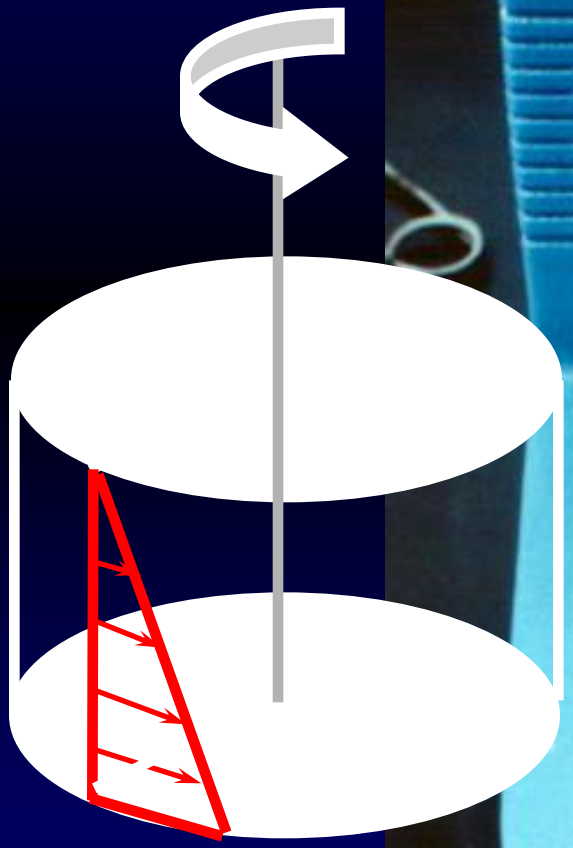


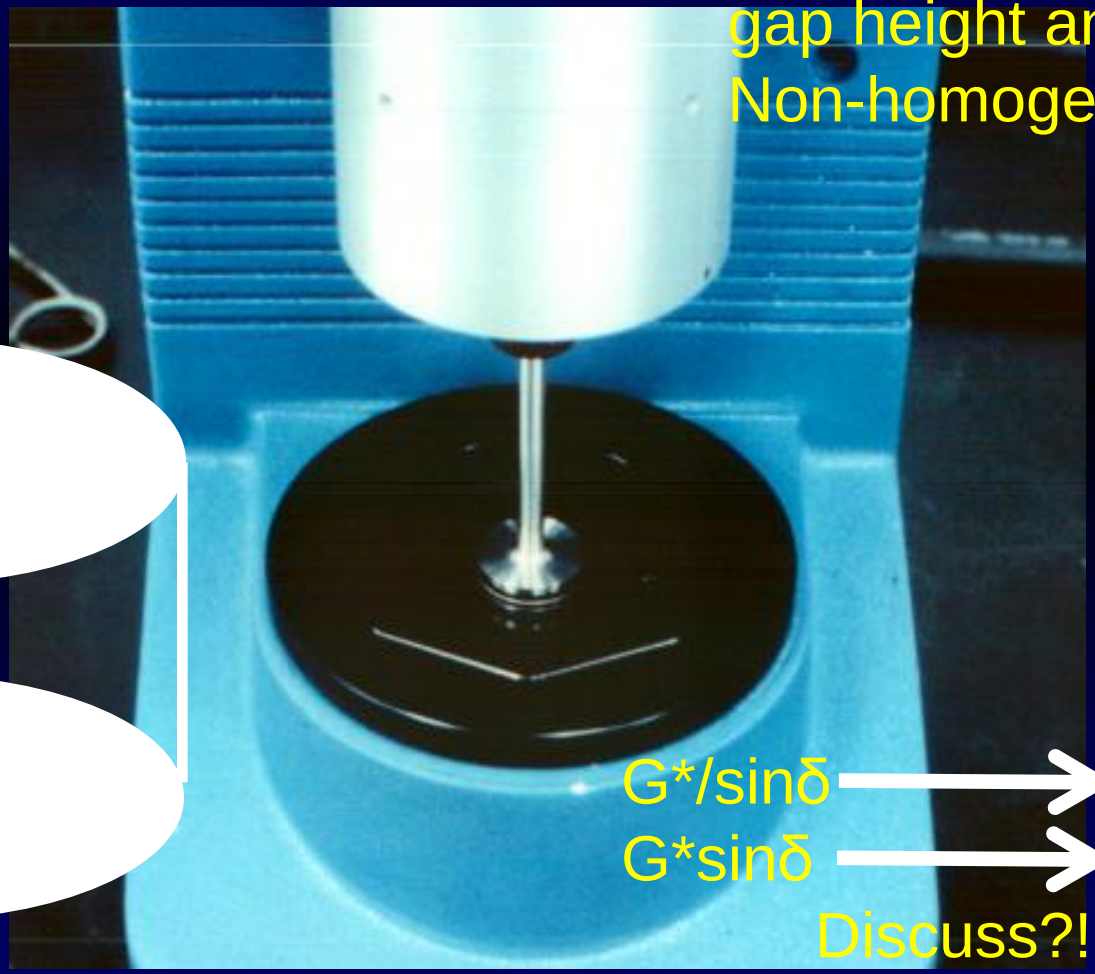
Outside of Oven



Dynamic Shear Rheometer (DSR)

Shear flow varies with
gap height and radius
Non-homogeneous flow





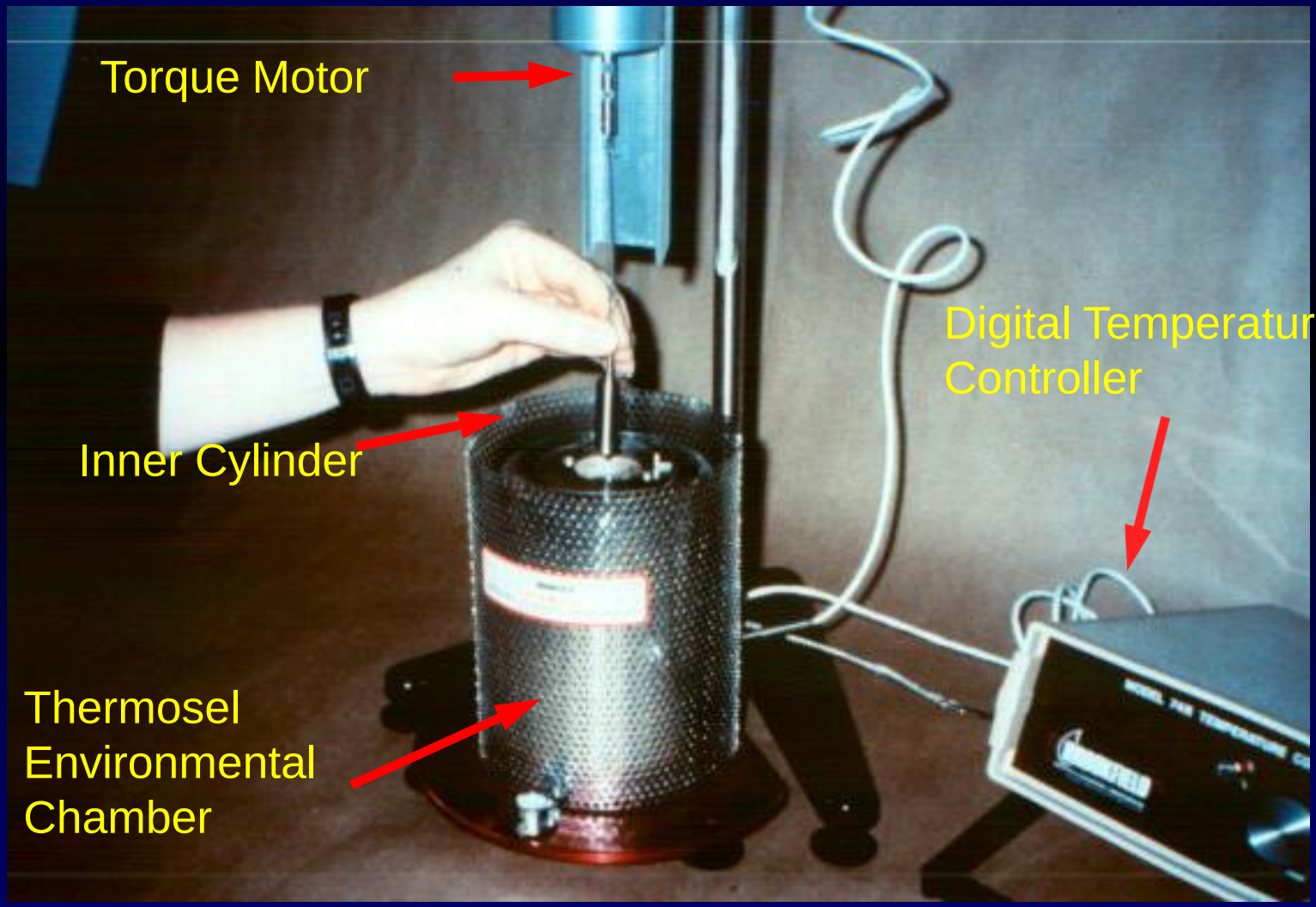
$G^*/\sin\delta$ → Rutting

$G^*\sin\delta$ → Fatigue

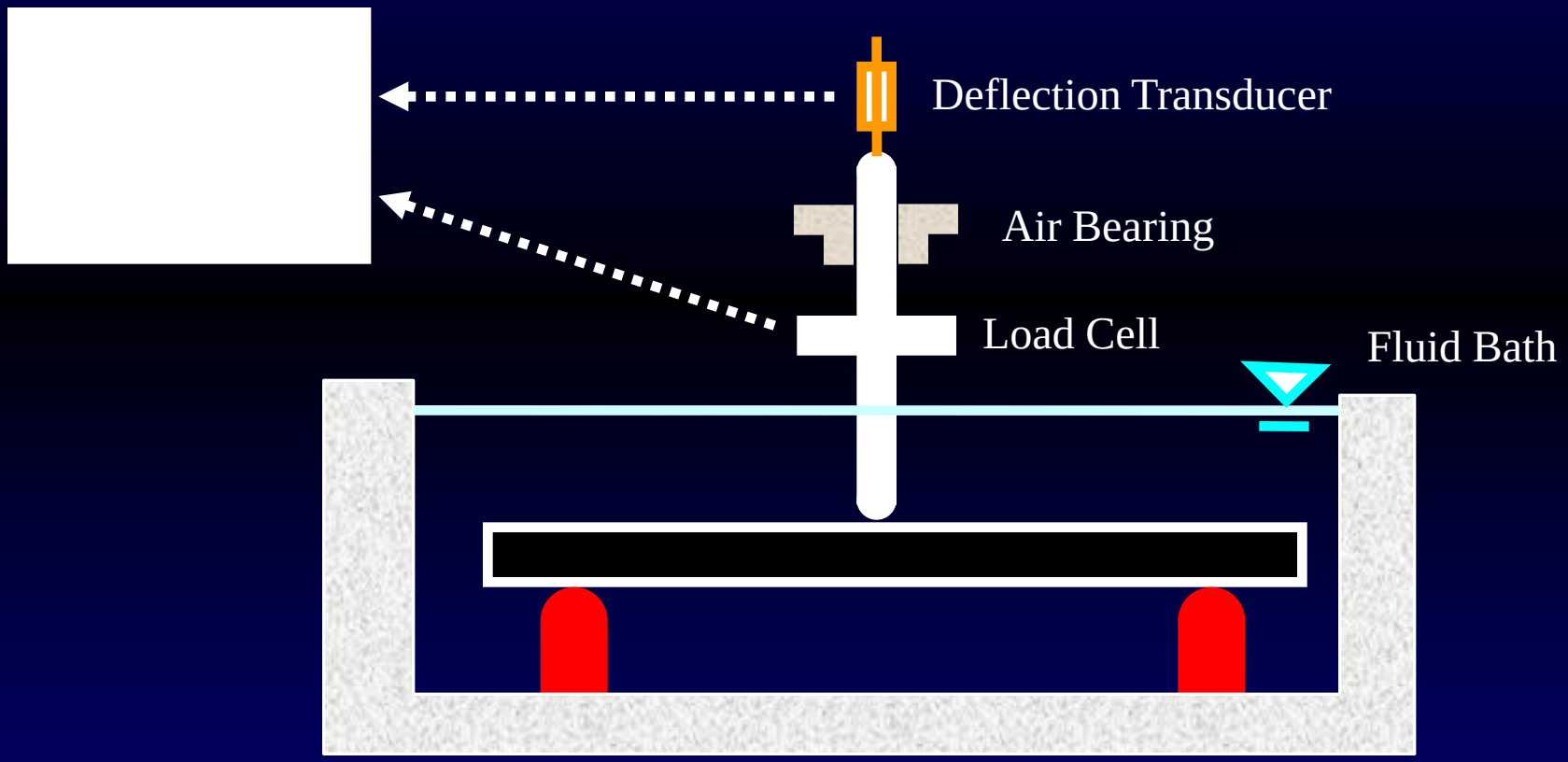
Discuss?!

Rheology = study of flow and deformation

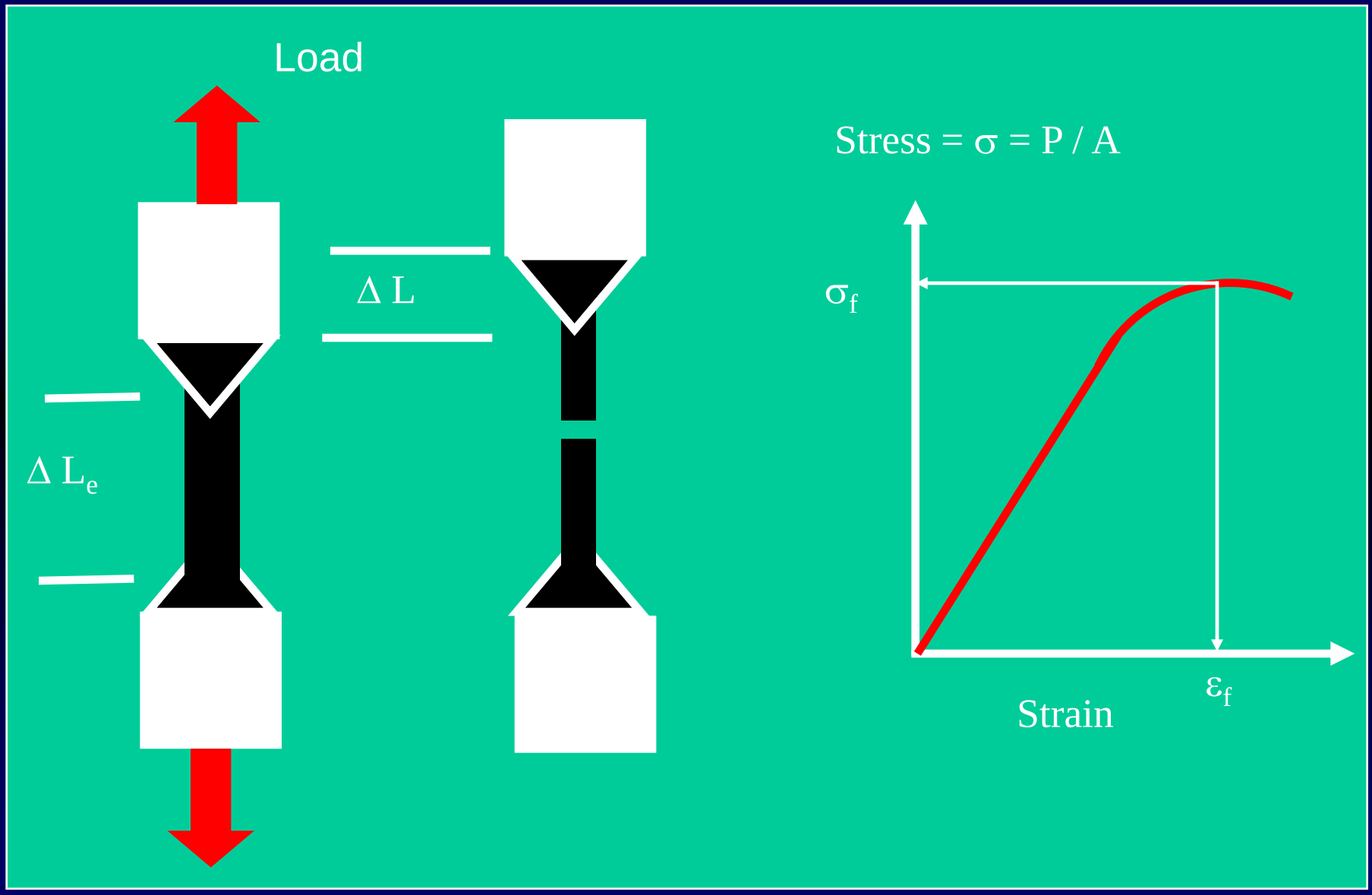
Rational Viscometer



Bending Beam Rheometer



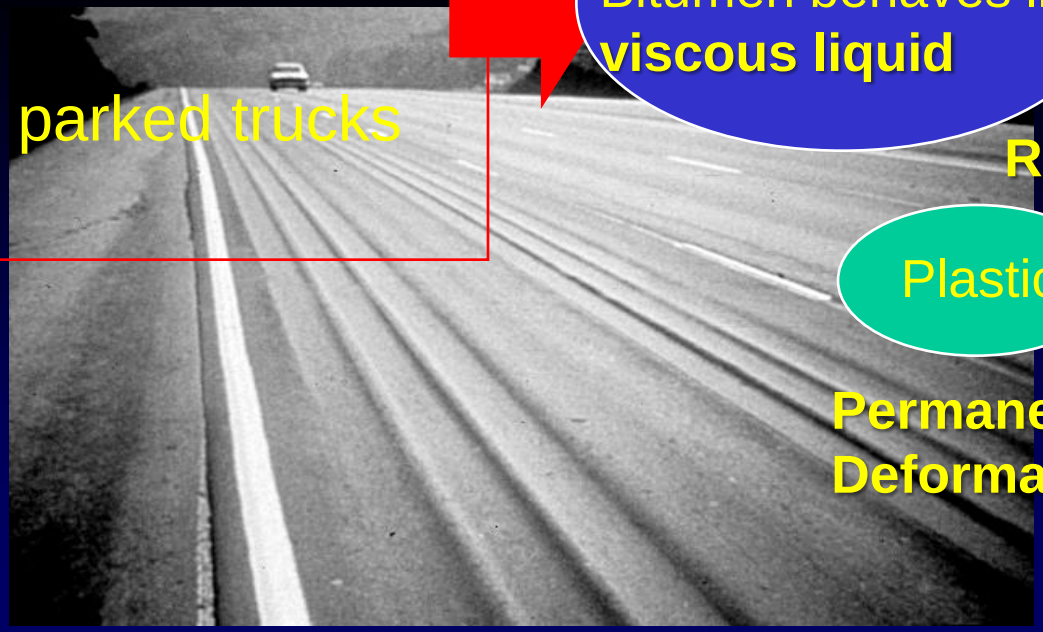
Direct Tension Test

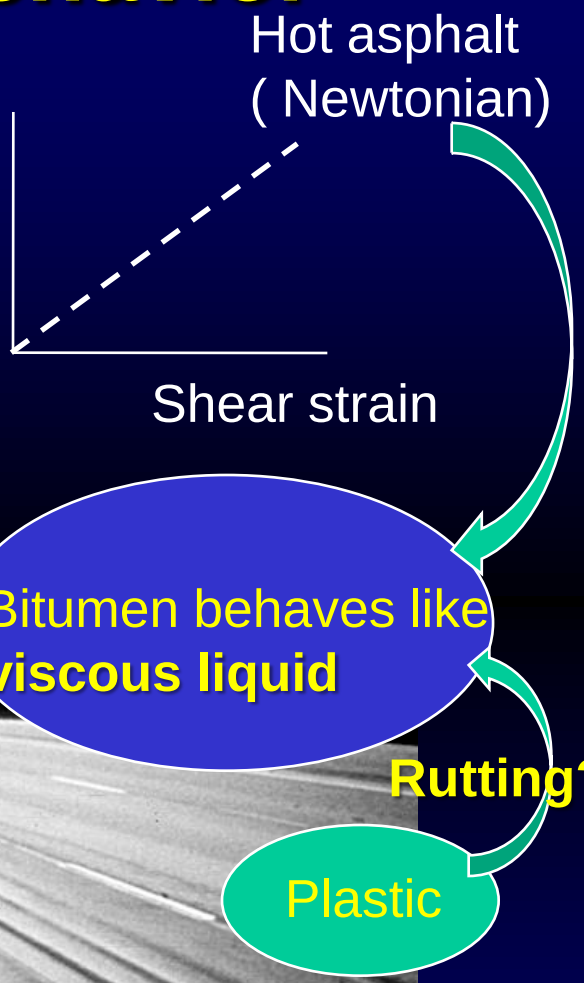


High Temperature Behavior

- ✓ High in-service temperature (KSA)
  - – Desert climates
  - – Summer temperatures
- ✓ Sustained loads
  - – Slow moving or parked trucks
  - – Intersections

Can **additives** reduce / alleviate such effect?





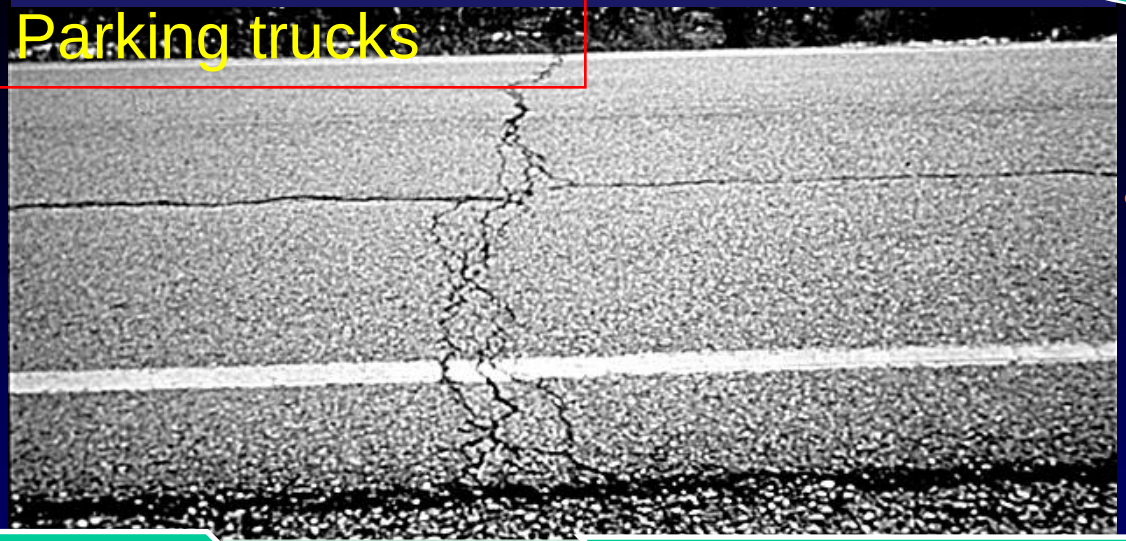
Low Temperature Behavior

- Low Temperature
  - Cold climates
  - Winter
- Rapid Loads
  - Fast moving trucks
  - Parking trucks

Too **brittle**
cracks at excessive load

Elastic Solid

Like rubber band?



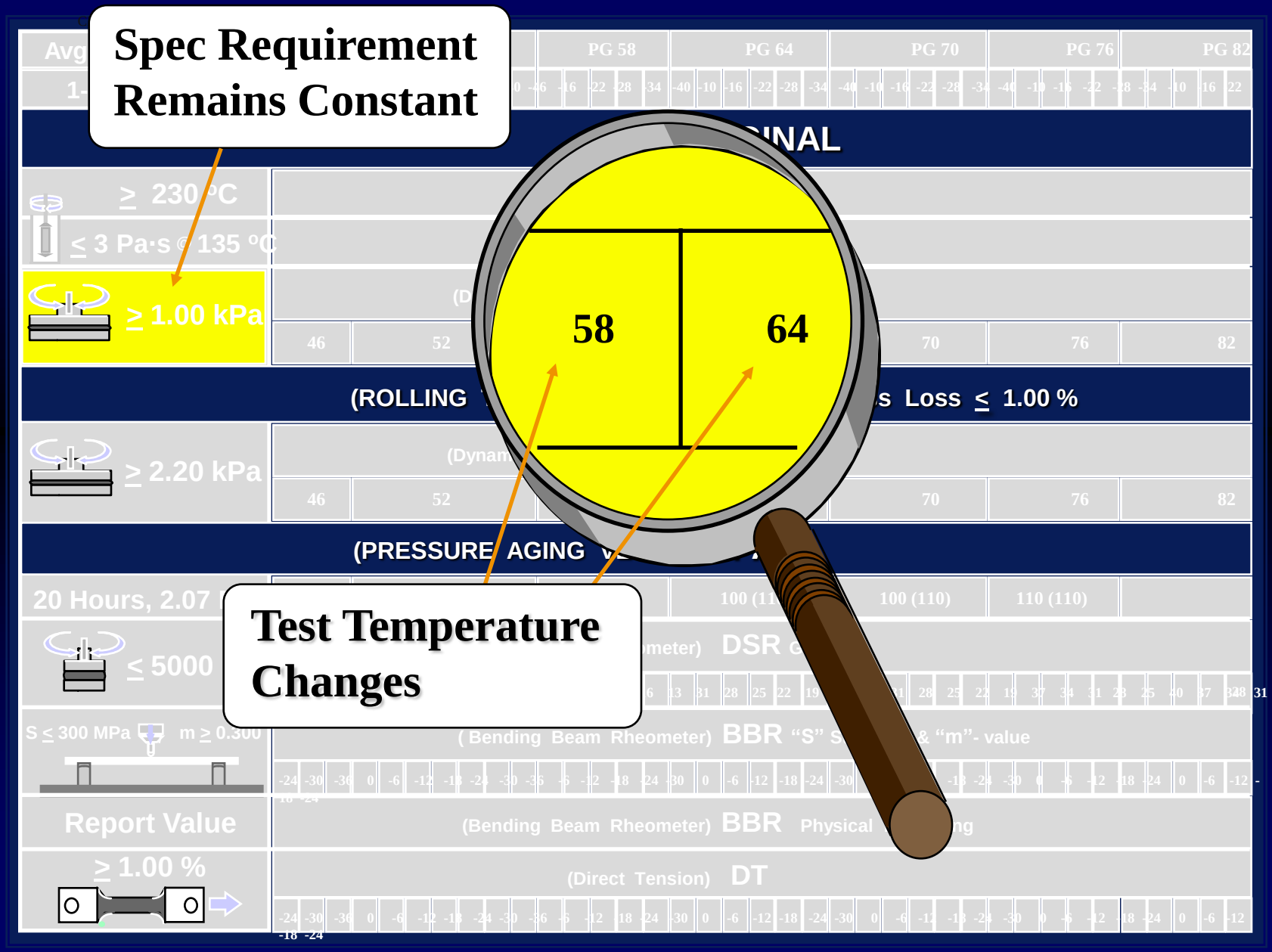
Hooke's Law applies

Drop in temp. → contraction → Tensile stress >>> material strength → Thermal Cracks

Performance Grades

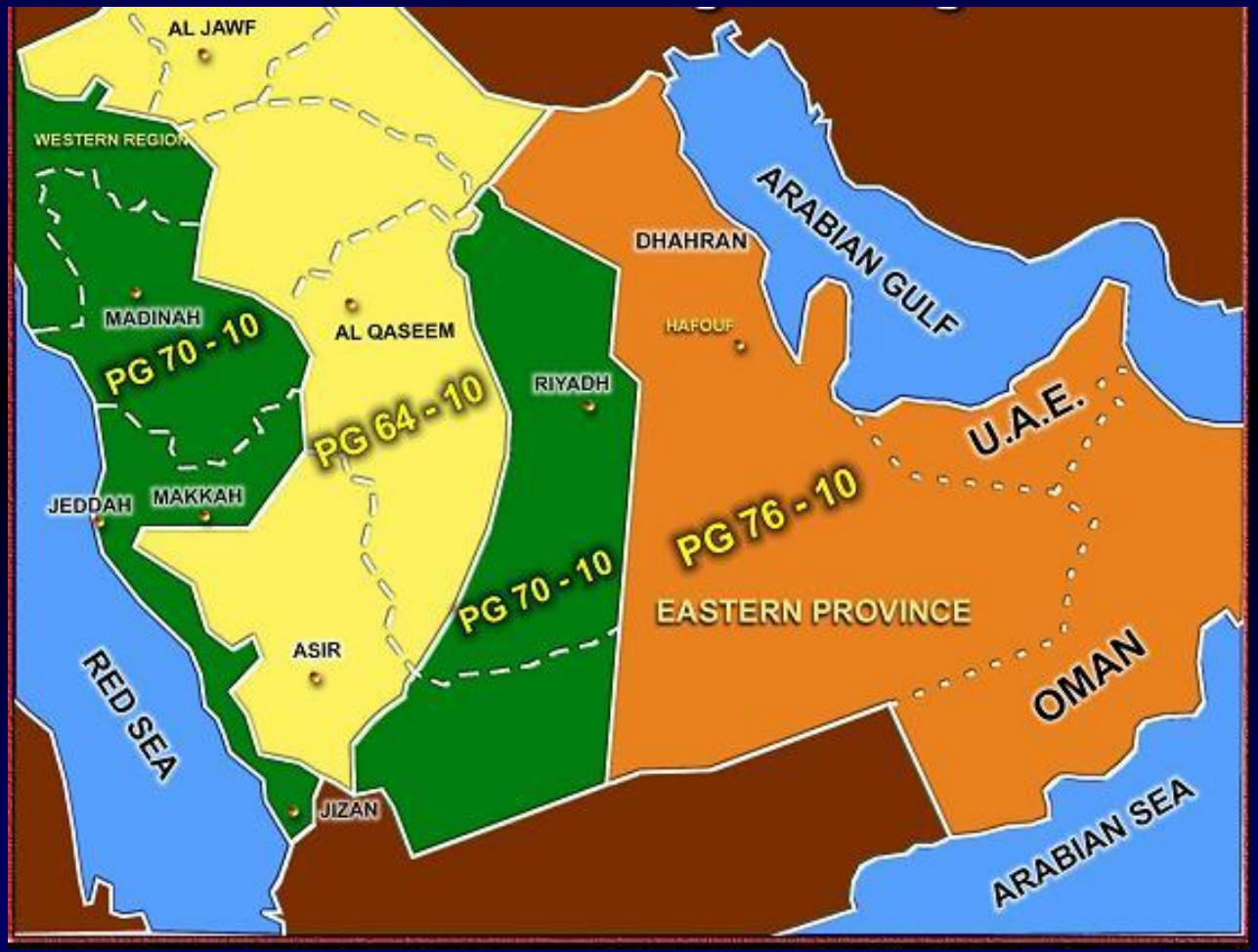
Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
1-day Min, °C	-34 -40 -46	-10 -16 -22 -28 -34 -40	-16 -22 -28 -34	-10 -16 -22 -28 -34	-10 -16 -22 -28 -34	-10 -16 -22 -28 -34	-10 16 22
ORIGINAL							
≥ 230 °C	(Flash Point) FP						
≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) RV						
≥ 1.00 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ						
	46	52	58	64	70	76	82
(ROLLING THIN FILM OVEN) RTFO Mass Loss ≤ 1.00 %							
≥ 2.20 kPa	(Dynamic Shear Rheometer) DSR G*/sin δ						
	46	52	58	64	70	76	82
(PRESSURE AGING VESSEL) PAV							
20 Hours, 2.07 MPa	90	90 100	100	100 (110)	100 (110)	110 (110)	
≤ 5000 kPa	(Dynamic Shear Rheometer) DSR G* sin δ						
	10 7 4	25 22 19 16 13 10 7	25 22 19 16 13	31 28 25 22 19 16	34 31 28 25 22 19	37 34 31 28 25 22	40 37 34 31
S ≤ 300 MPa m ≥ 0.300	(Bending Beam Rheometer) BBR "S" Stiffness & "m"- value						
	-24 -30 -36	0 -6 -12 -18 -24 -30 -36	-6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24
Report Value	(Bending Beam Rheometer) BBR Physical Hardening						
≥ 1.00 %	(Direct Tension) DT						
	-24 -30 -36	0 -6 -12 -18 -24 -30 -36	-6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24 -30	0 -6 -12 -18 -24

How the PG Spec Works



PG Binder Selection

KSA Ministry of Transport has established PG zones



Ras -Tanura produces PG64 - 22

How can we get PG70 -10 for Riyadh Roads?!?!

Questions