Dynamic Shear Rheometer

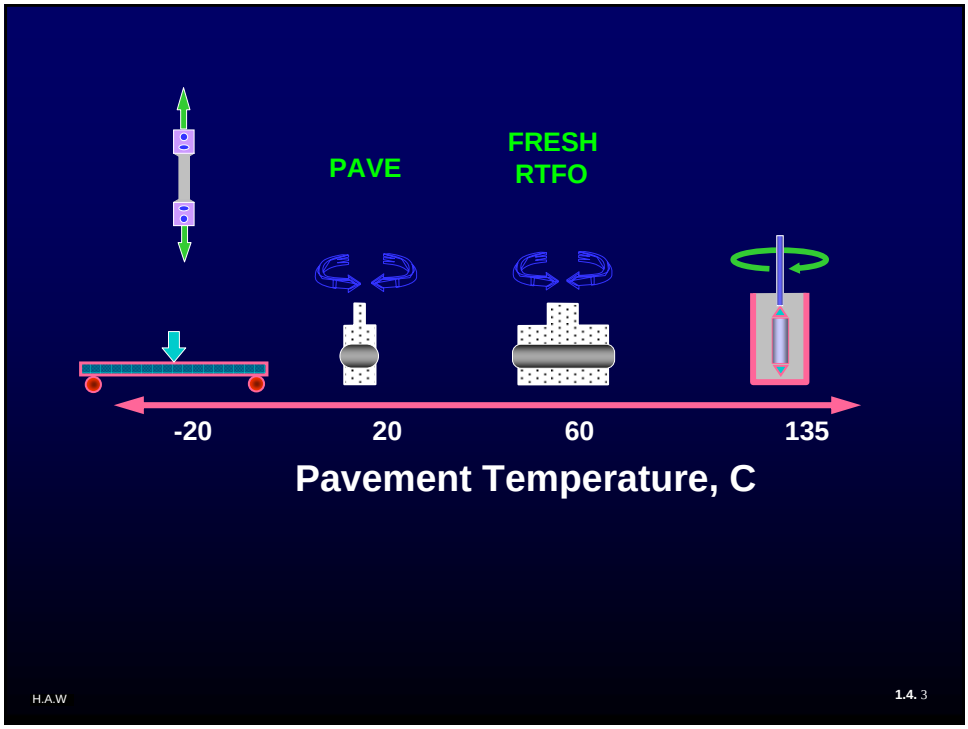
Presented by

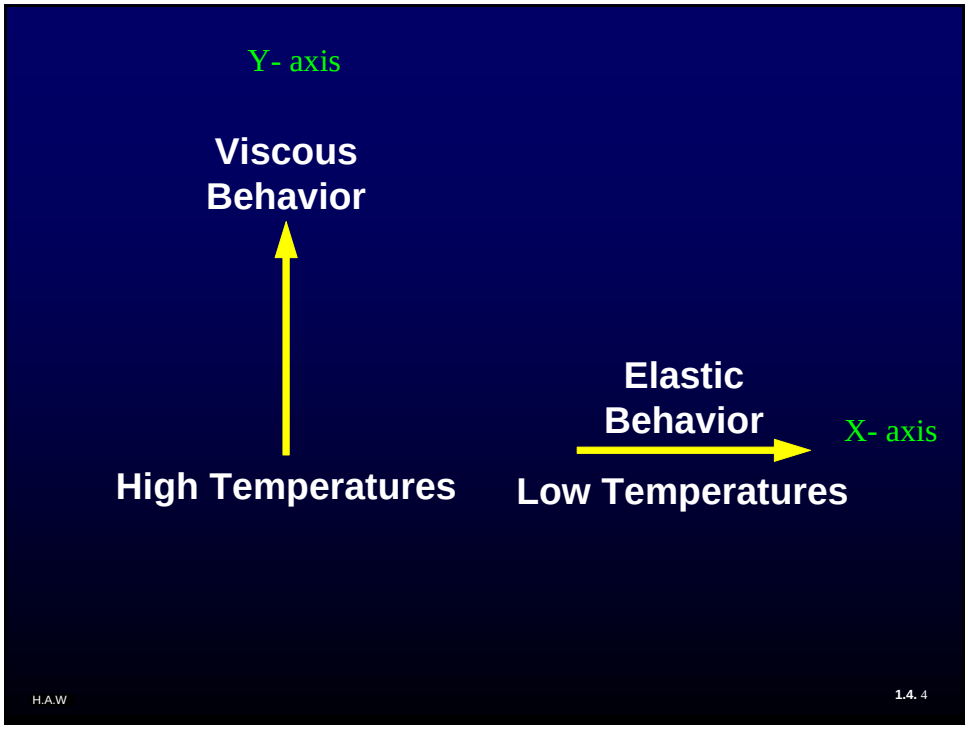
prof. Hamad I. Al-AbdulWahhab

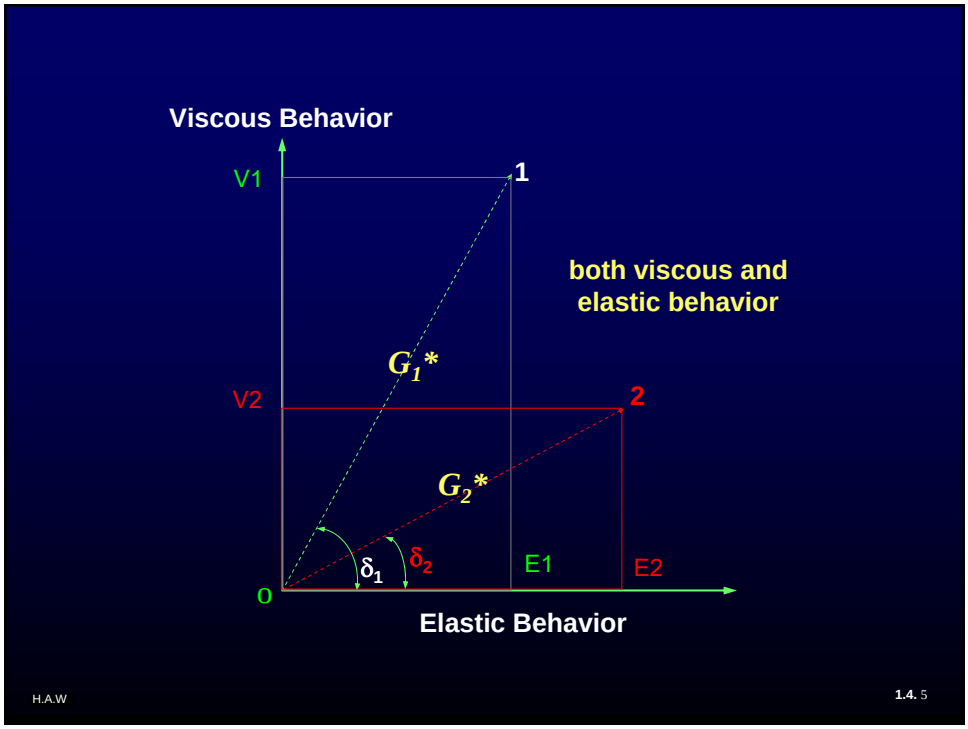
Civil Engineering Department
King Fahd University of Petroleum & Minerals
Dhahran, Saudi Arabia

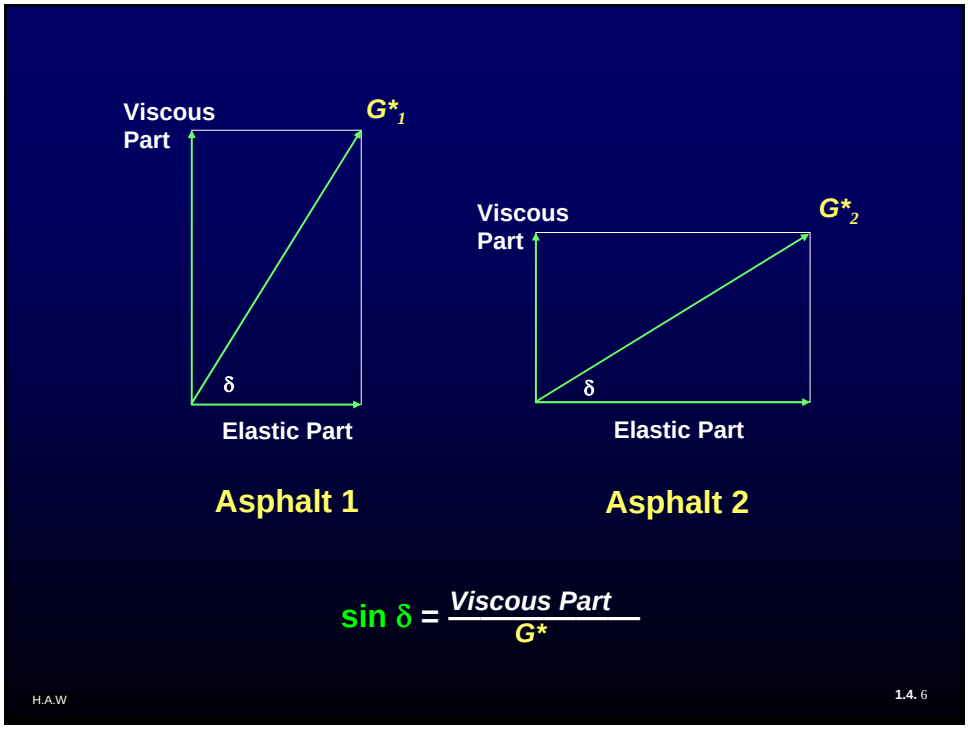
Dynamic Shear Rheometer

- **Purpose**
  - -- viscous and elastic properties
  - -- effect of temperature
- **Output**
  - -- Complex Shear Modulus (G*)
  - -- Phase Angle (δ)

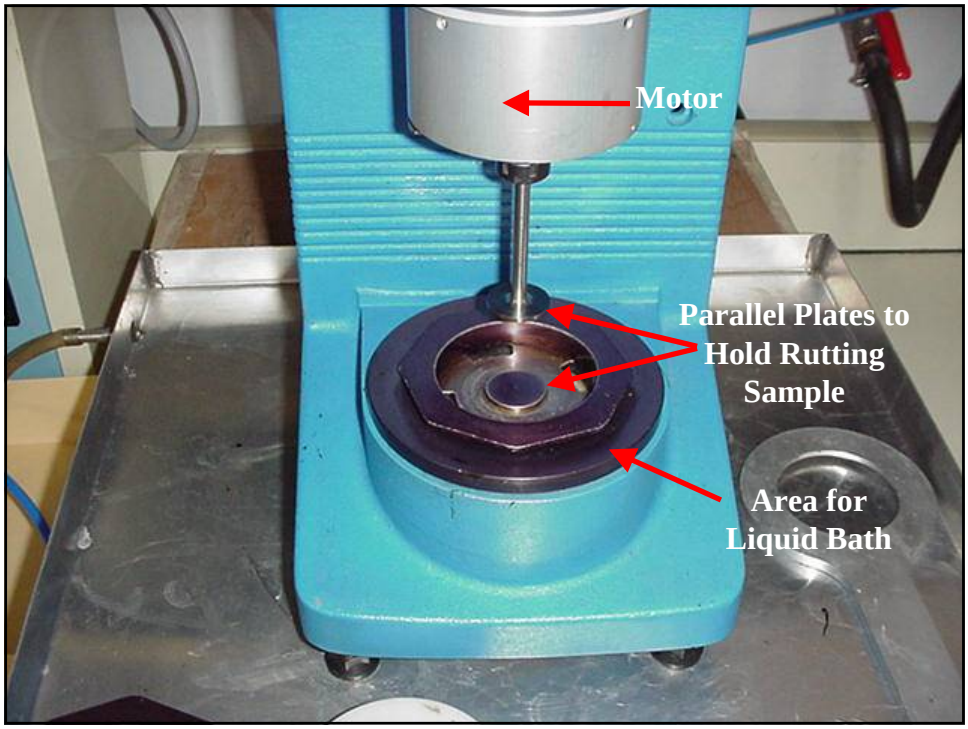

PAVE
FRESH
RTFO
-20
20
60
135
Pavement Temperature, C
H.A.W
1.4. 3


Y- axis
Viscous
Behavior
High Temperatures
Elastic
Behavior
X- axis
Low Temperatures
H.A.W
1.4. 4


Viscous Behavior
V1
1
both viscous and
elastic behavior
G1*
V2
2
G2*
δ1
δ2
E1
E2
0
Elastic Behavior
H.A.W
1.4. 5


Viscous
Part
G*1
δ
Elastic Part
Asphalt 1
Viscous
Part
G*2
δ
Elastic Part
Asphalt 2
sin δ = Viscous Part / G*
H.A.W
1.4. 6


DSR Equipment
Computer Control and Data Acquisition
DSR Equipment
BOHLIN RHEOMETER DSR


Motor
Parallel Plates to Hold Rutting Sample
Area for Liquid Bath

H.A.W

1.4. 9

Specimen Preparation

- **Set "Gap" Between Spindle Base**
  - -- gap controls specimen thickness
  - -- micrometer wheel adjusts gap
  - -- set at test temperature
  - -- high temperature gap = 1000 microns (1mm)
  - -- intermediate temperature gap = 2000 microns (2mm)
  - -- use extra 50 microns (0.05 mm)

H.A.W

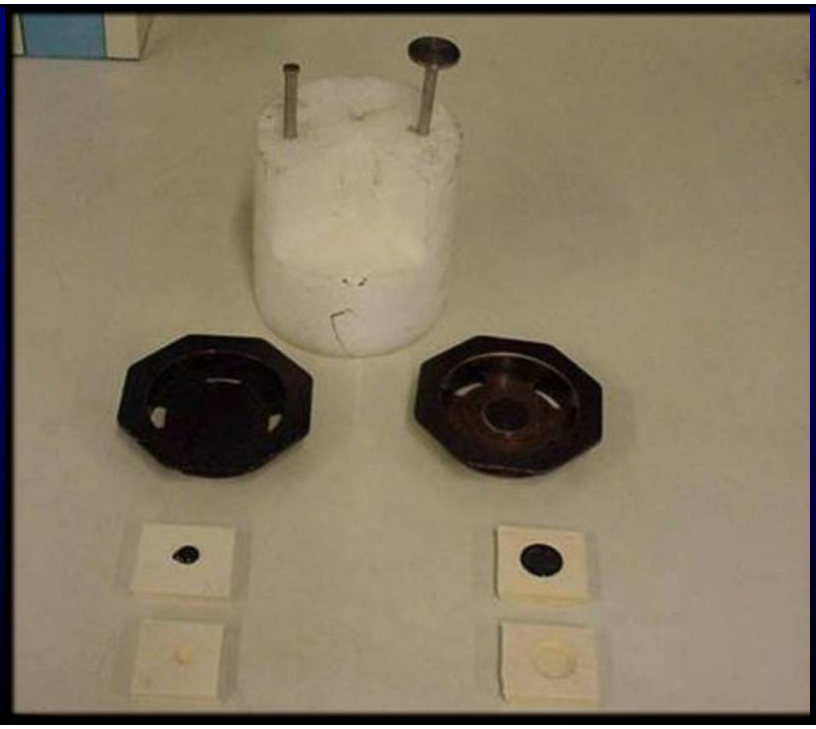
1.4. 10

Plate Geometry

- 25 mm plate diameter with 1 mm gap
  - -- original binder
  - -- RTFO residue
- 8 mm plate diameter with 2 mm gap
  - -- PAV residue

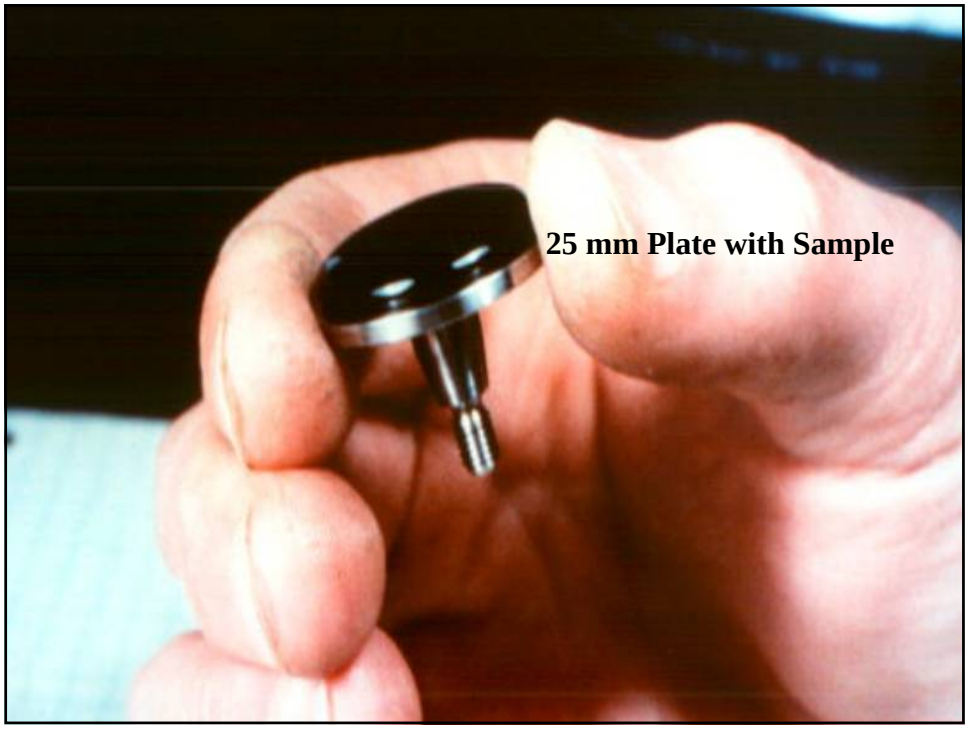
H.A.W

1.4. 11

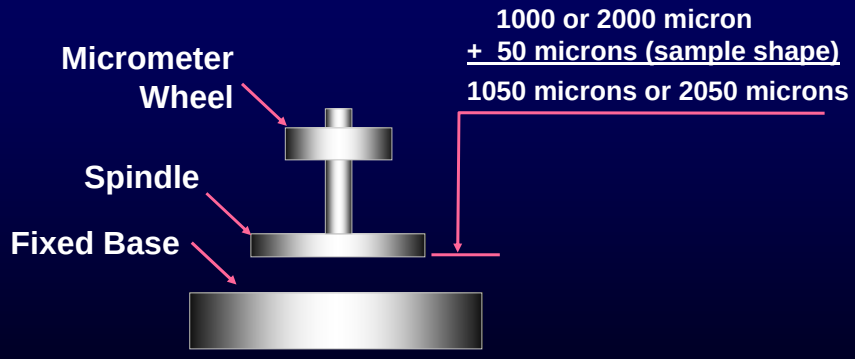


H.A.W

1.4. 12

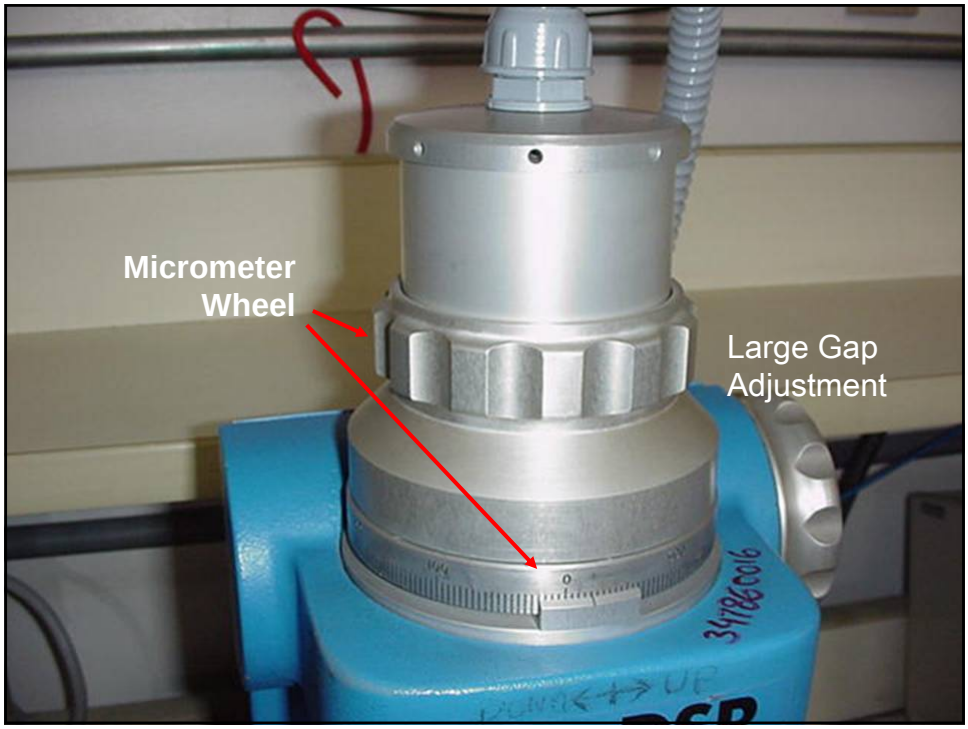


Initial Gap Setting



H.A.W

1.4. 14

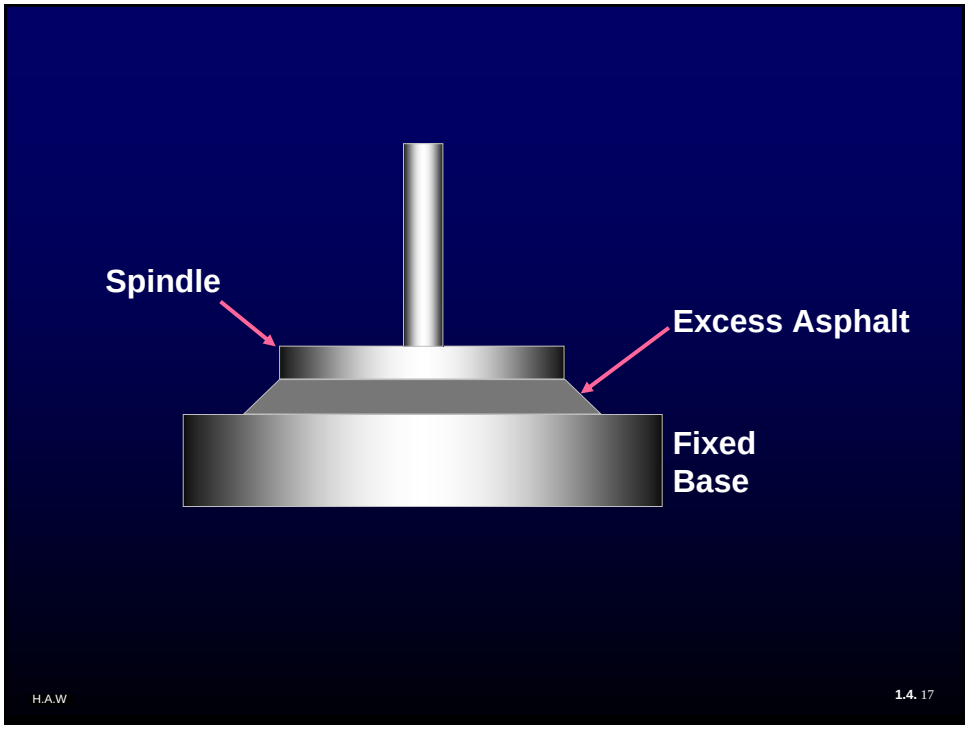


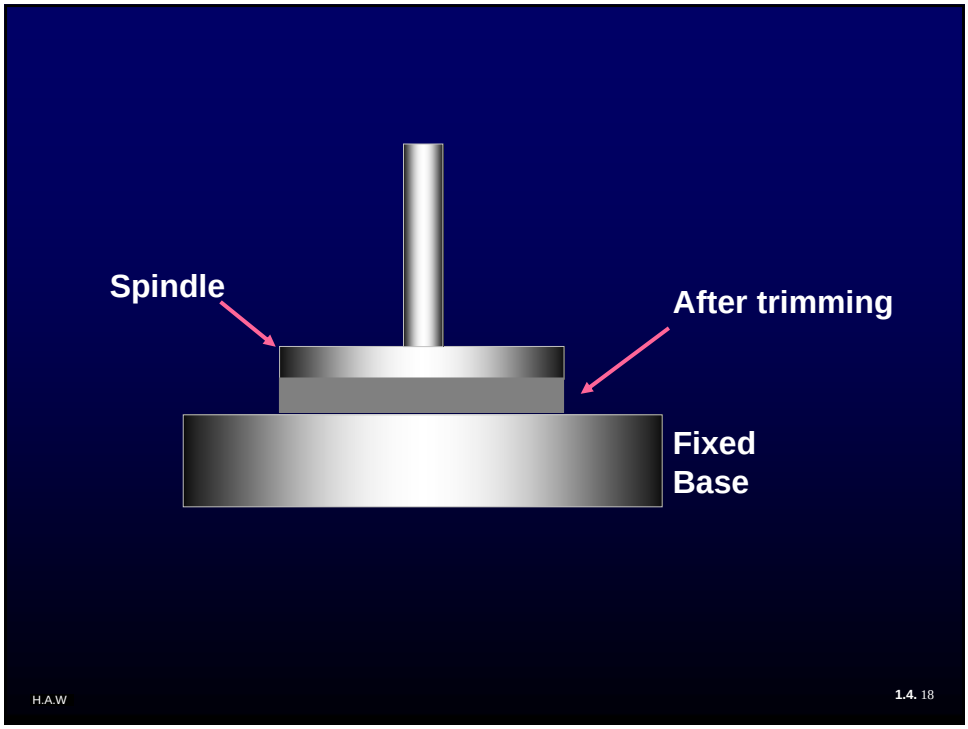
Specimen Preparation

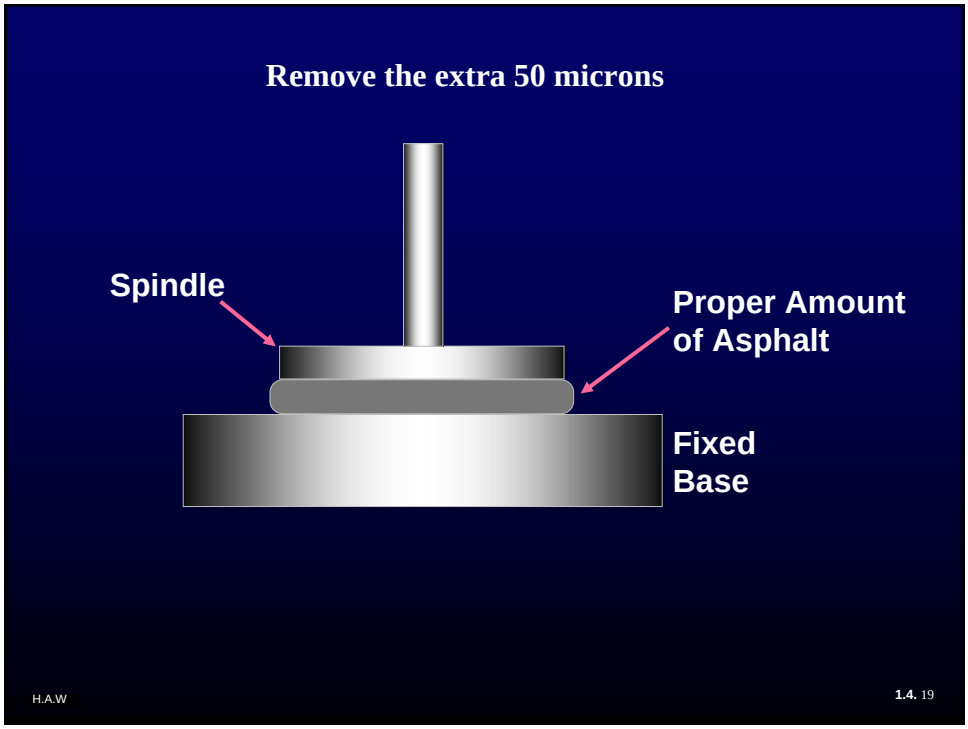
- **Use mold**

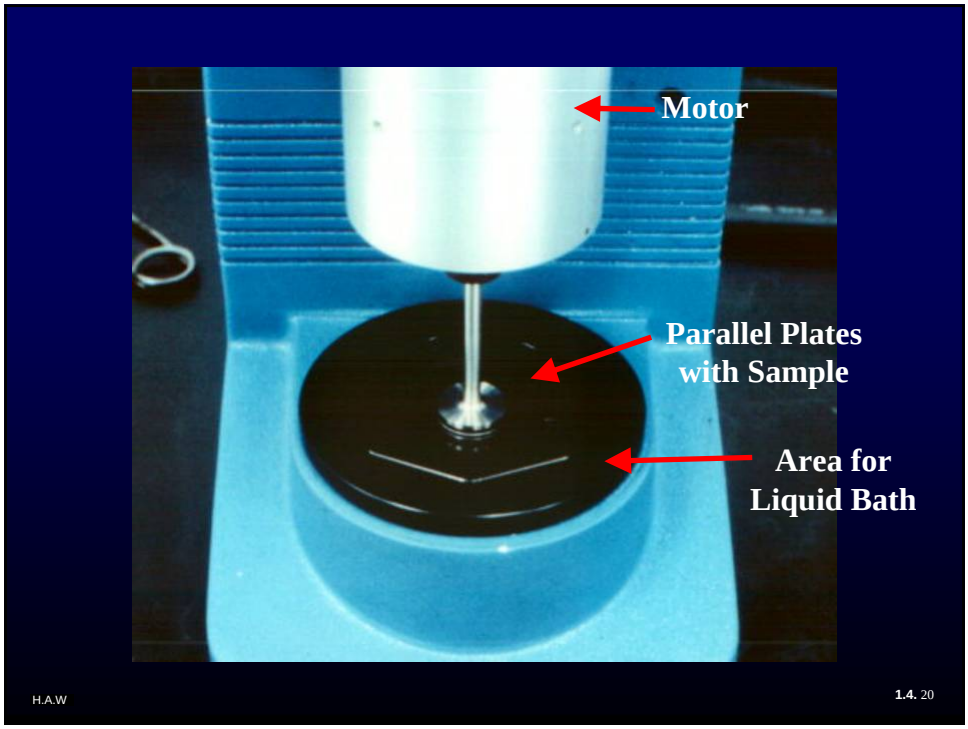
H.A.W

1.4. 16


Spindle
Excess Asphalt
Fixed
Base
H.A.W
1.4. 17

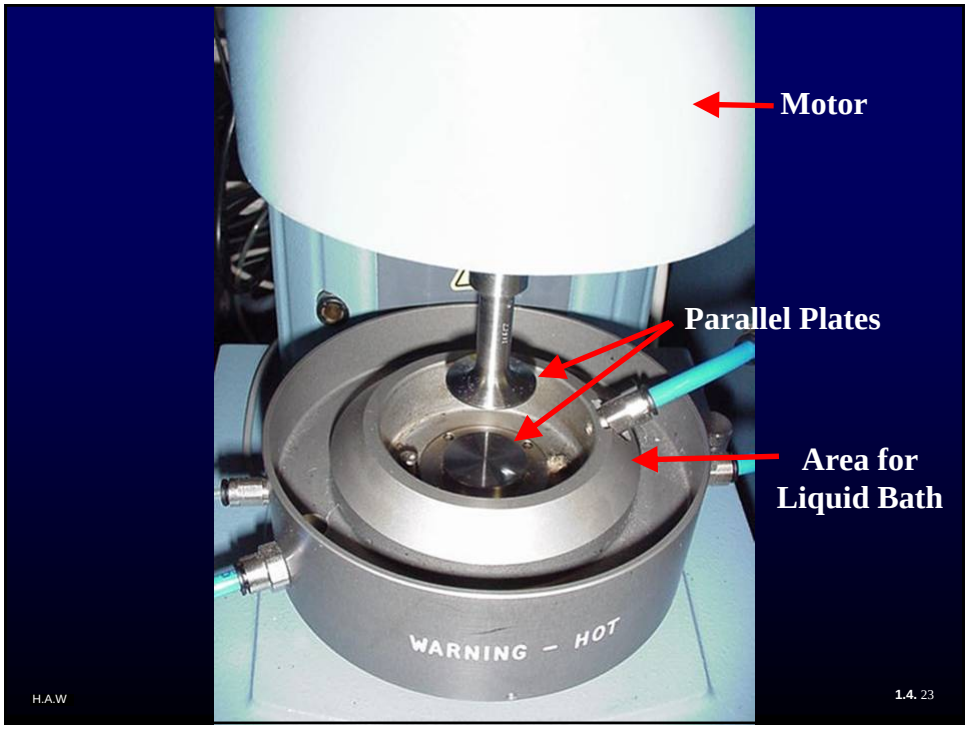

Spindle
After trimming
Fixed
Base
H.A.W
1.4. 18

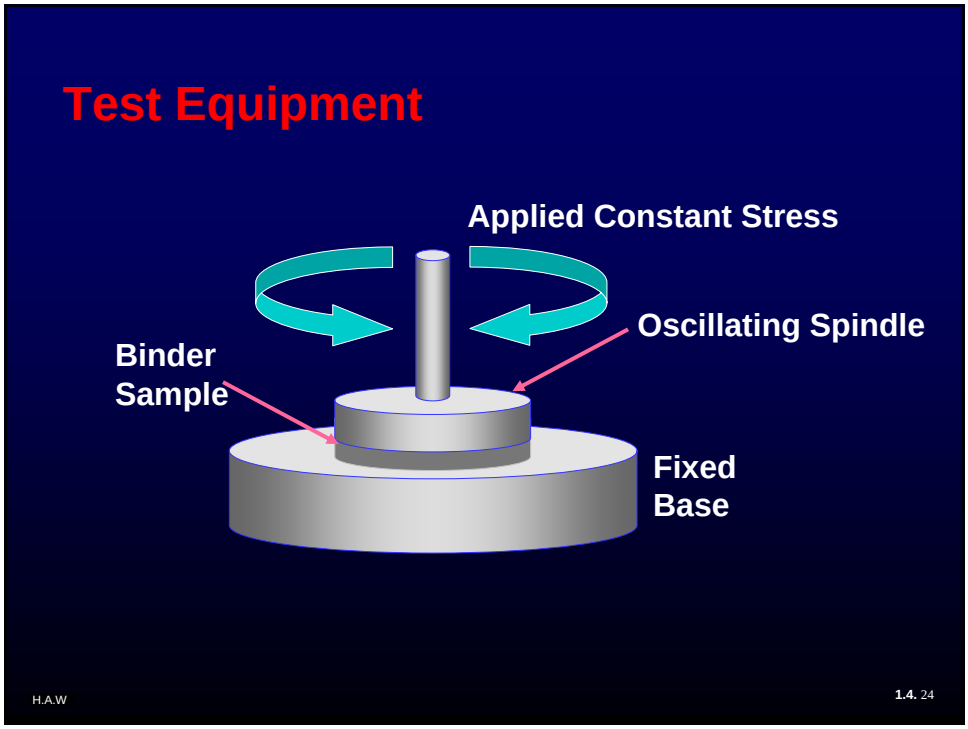

Remove the extra 50 microns
Spindle
Proper Amount of Asphalt
Fixed Base
H.A.W
1.4. 19


Motor
Parallel Plates with Sample
Area for Liquid Bath
H.A.W
1.4. 20

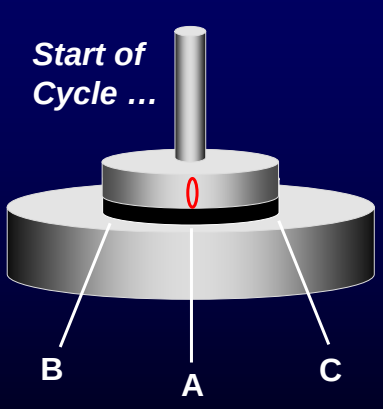

TA Instruments

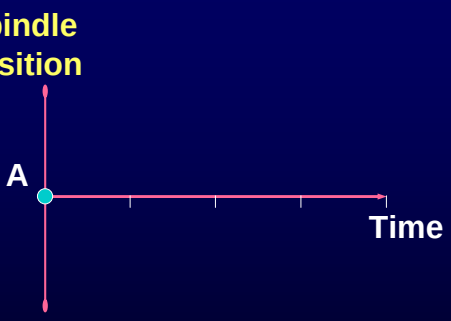

H.A.W
1.4. 22


Motor
Parallel Plates
Area for
Liquid Bath
WARNING – HOT
H.A.W
1.4. 23


Test Equipment
Applied Constant Stress
Oscillating Spindle
Binder
Sample
Fixed
Base
H.A.W
1.4. 24

Spindle Begins at A

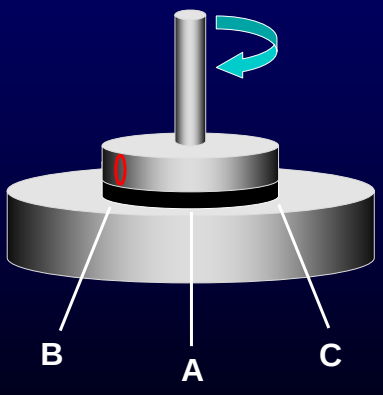


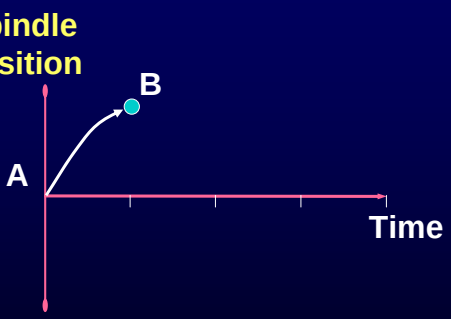


H.A.W

1.4. 25

Spindle Moves From A to B

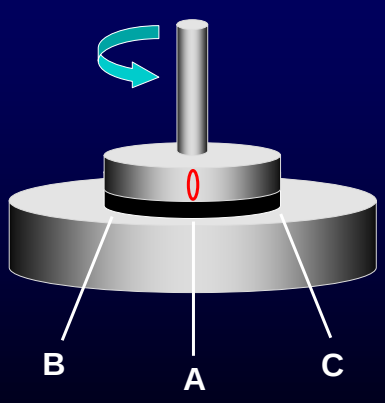


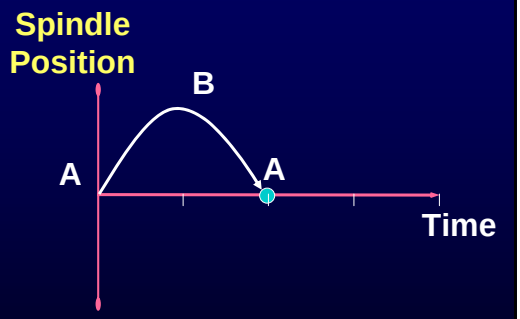


H.A.W

1.4. 26

Spindle Moves From B to A

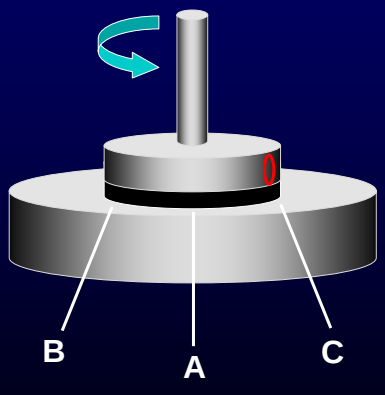


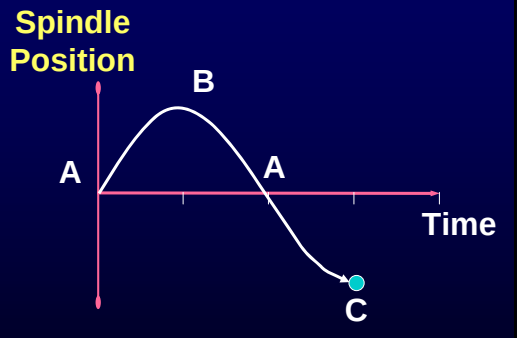


H.A.W

1.4. 27

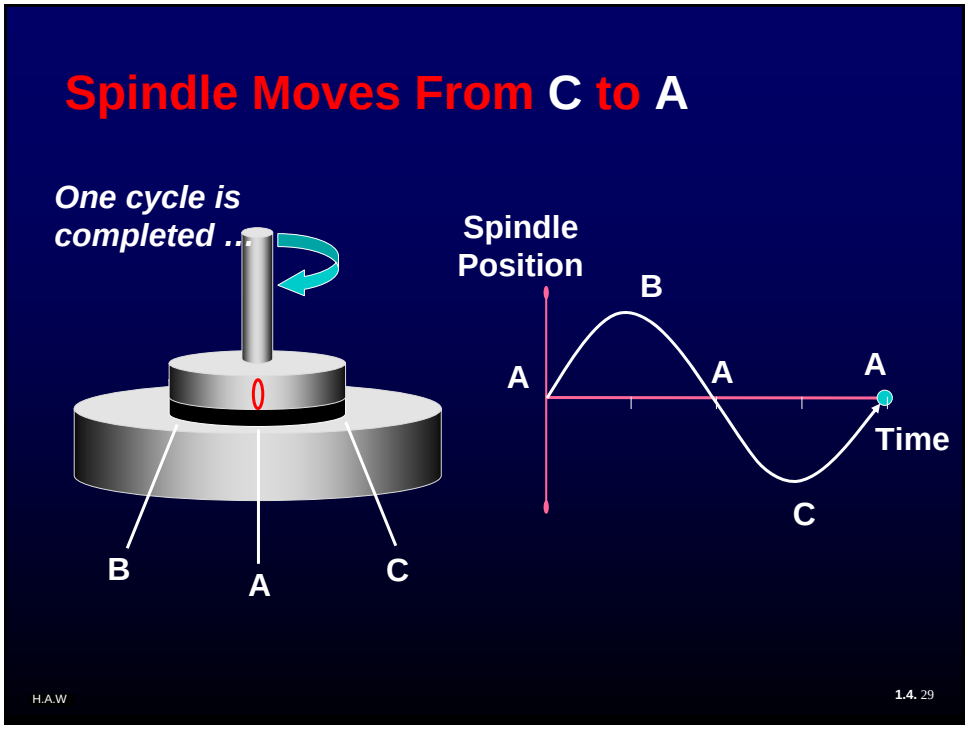
Spindle Moves From A to C

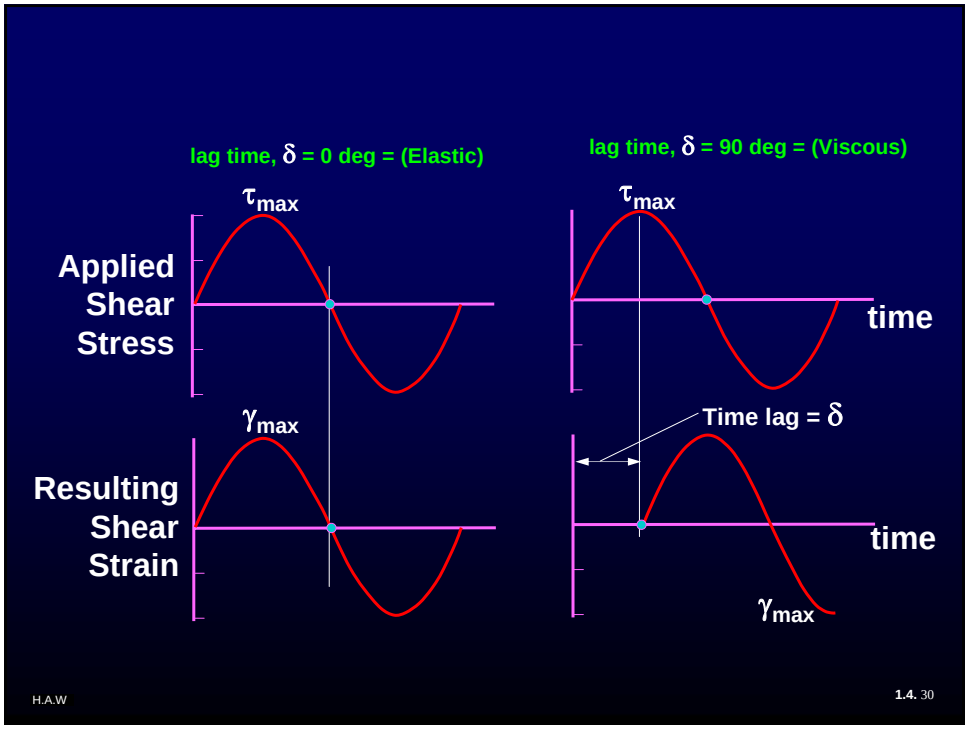




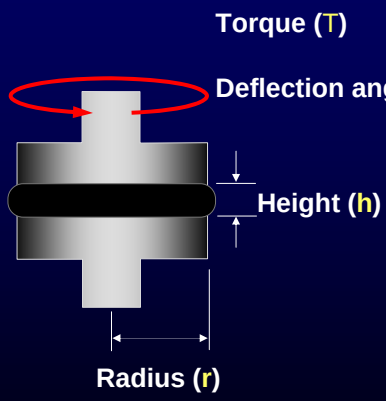
H.A.W

1.4. 28


Spindle Moves From C to A
One cycle is completed …
B
A
C
Spindle Position
B
A
A
A
Time
C
H.A.W
1.4. 29


lag time, δ = 0 deg = (Elastic)
τmax
Applied Shear Stress
γmax
Resulting Shear Strain
lag time, δ = 90 deg = (Viscous)
τmax
time
Time lag = δ
time
γmax
H.A.W
1.4. 30

Shear Stress (τ) and Shear Strain (γ)



$$\tau = \frac{2\,T}{\pi\, r^{3}}$$

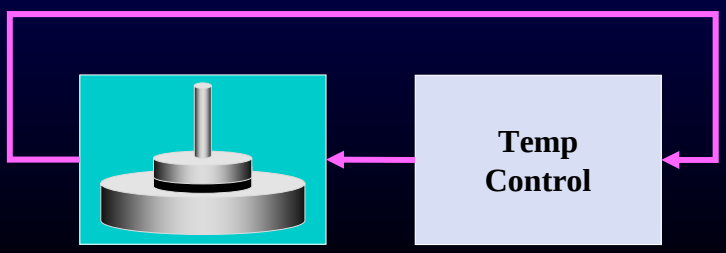
$$\gamma = \frac{\Theta\, r}{h}$$

H.A.W

1.4. 31

Tester Equipment

- **Temperature Control**
  - -- ± 0.1 degrees C
  - -- circulating water bath



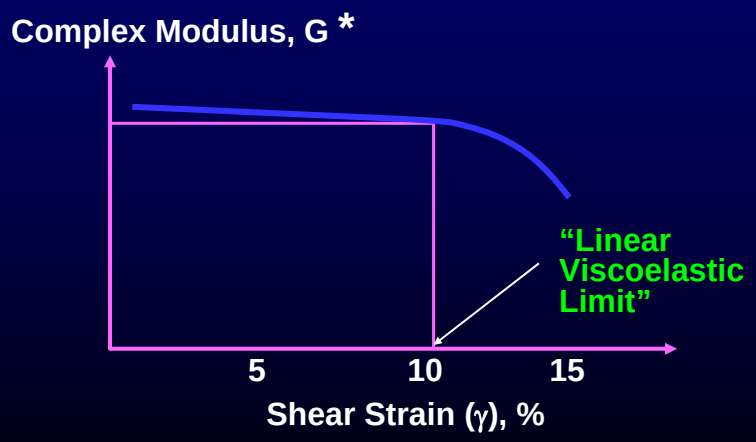
H.A.W

1.4. 32

Overview of Procedure

- **Specimen Temperature**
  - -- stabilize temperature
  - -- equilibrate temperature (5+ minutes)
- **Initialize Software**
- **Set / Verify Software Settings**
  - -- set stain
  - -- strain rate = 10 rad/sec (1.59 Hz ≅ 90 kph)

Set Strain



Overview of Procedure

- **Run Test**
  - -- condition specimen for 10 cycles
  - -- obtain data from 10 addition cycles
- **Print Results**
  - -- G* and δ

Data Analysis and Presentation

- **Calculate G*/sin δ**
  - -- stiffness at high service temp.
  - -- $\geq$ 1.00 kPa for unaged binders
  - -- $\geq$ 2.20 kPa for RTFO aged binders
- **Calculate G*sin δ**
  - -- viscous part at intermediate temps
  - -- $\leq$ 5000 kPa for PAV aged binders

Calibration and Standardization

- **Temperature**
  - -- dummy specimen
- **Load and Strain Transducers**
  - -- manufacturer
- **Overall Calibration**
  - -- reference Asphalt

THANK YOU