Superpave^{TM} Asphalt Grading

Traditional Asphalt Grading

Penetration grading was based on the measured pen number at 77°F. That didn’t tell you much about how the asphalt cement would perform. It was based entirely on supposition: if an asphalt cement has a pen number of 40 at 77°F, I suppose it will be soft enough to resist fatigue cracking but hard enough to resist rutting and shoving in the summer. You don’t really know, though, do you?

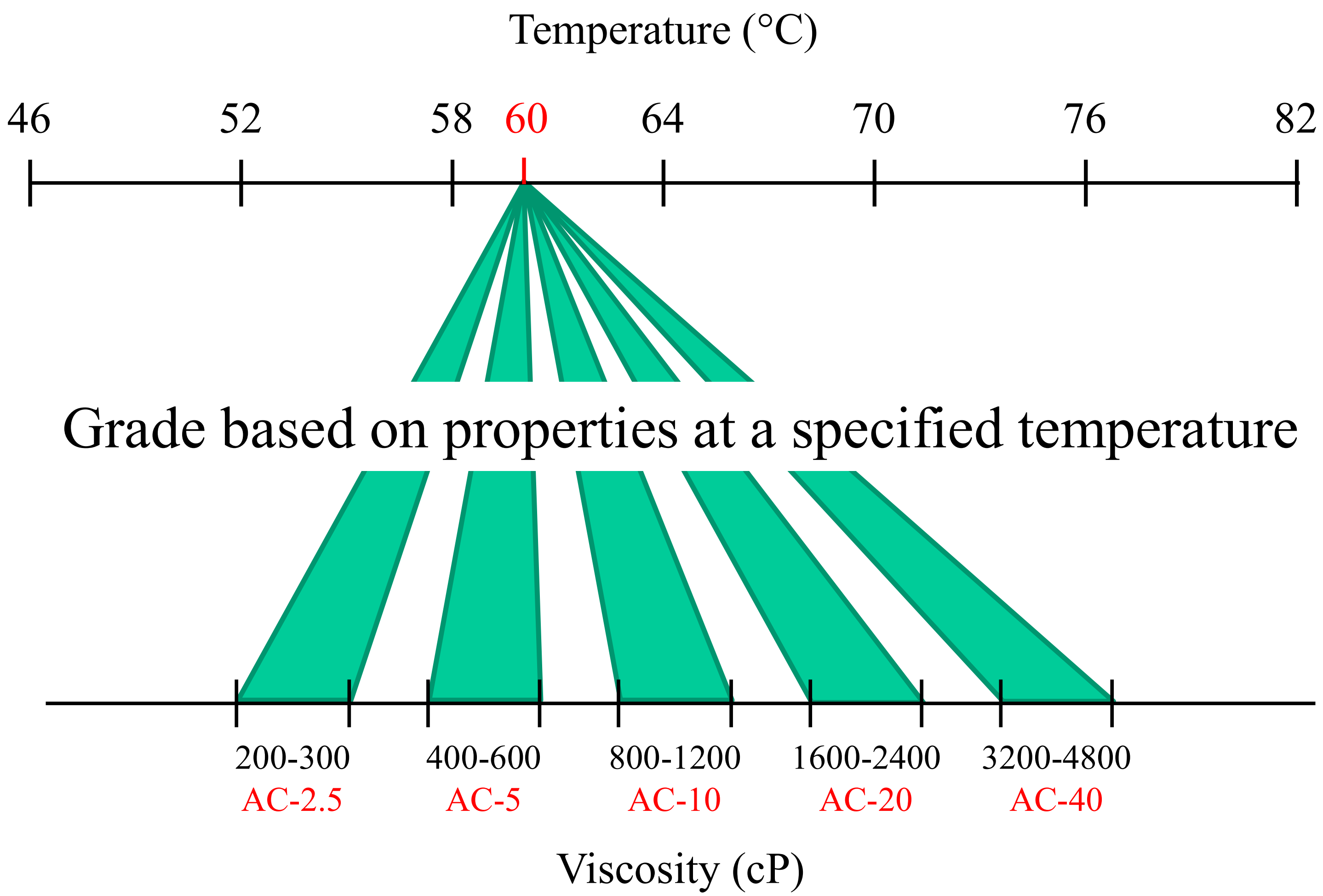
Traditional Asphalt Grading

Viscosity grading suffers from the same problem. It is based on the absolute viscosity at 140°F. Again, you suppose that a high viscosity asphalt cement will resist rutting and shoving in the summer and a low viscosity asphalt cement will resist fatigue cracking and thermal cracking, but you really don't know.

Traditional Asphalt Grading

Another problem with traditional asphalt cement grading is that it's done at one specific temperature that is supposed to represent a "typical" nationwide average or maximum service temperature. A typical summertime service temperature in Florida is quite a bit higher than it is in Minnesota!

Traditional Viscosity Grading



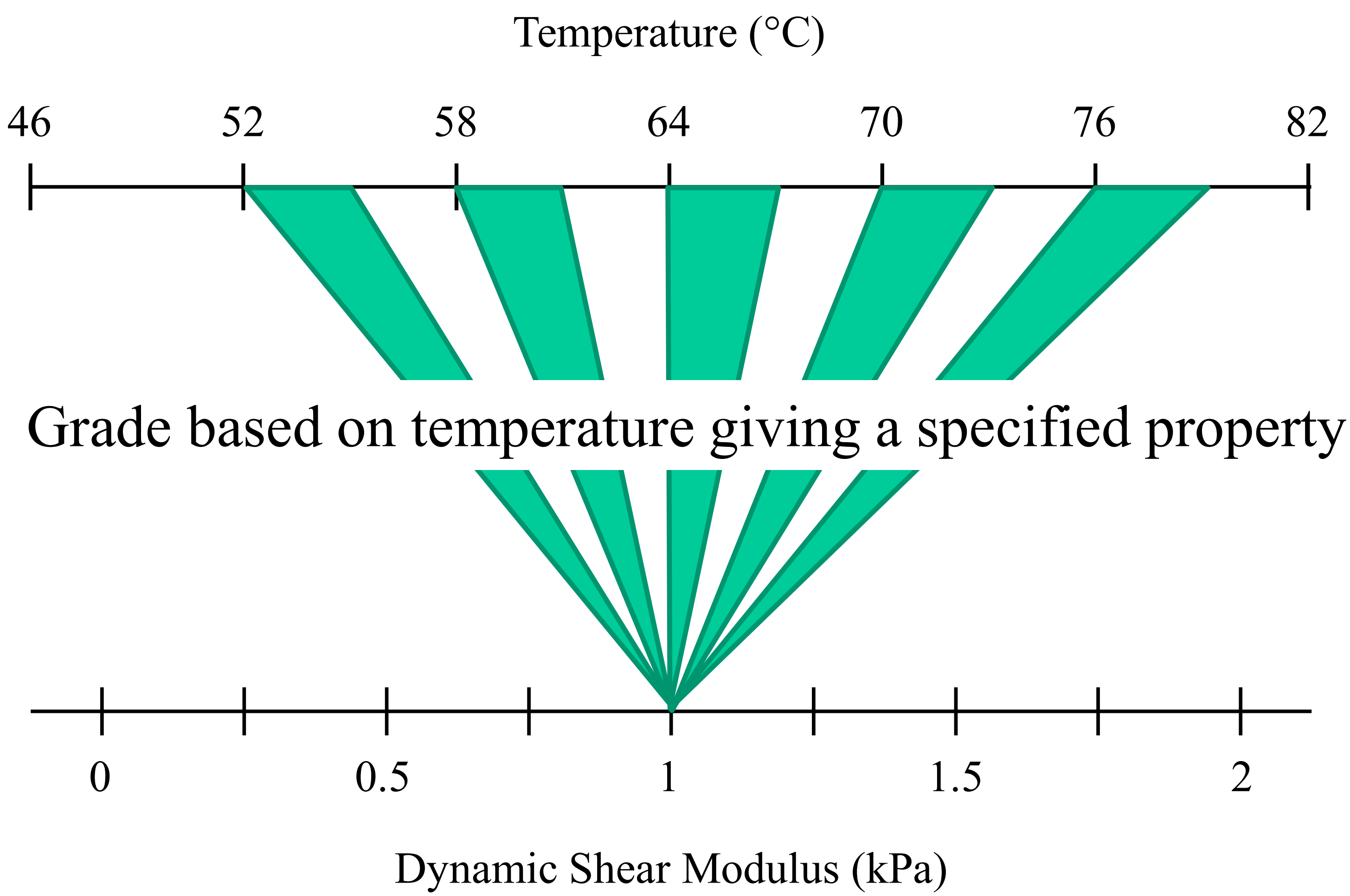
Superpave Asphalt Grading

In the late 1980s, the various state highway agencies banded together to create a brand new asphalt grading system under the auspices of the Strategic Highway Research Program (SHRP). The goal was to use only fundamental properties (not empirical tests like the pen number) and to specifically address the performance of the asphalt cement at maximum, minimum and average service temperatures and at mixing and placing temperatures.

Superpave Asphalt Grading

The new Superior Performing Pavements (SuperPave) system also adopted an entirely new philosophy for grading asphalt. Rather than base the grade on the value of some property (e.g., penetration, viscosity) at a specified temperature, the new system would be based on the temperature at which an asphalt cement exhibited a specific performance property (such as stiffness or ductility or strength).

Superpave Asphalt Grading



Superpave Asphalt Grading

- Uses fundamental physical and mechanical properties, not index properties
- Performance-based: performance criteria remain constant but the test temperature changes
- Includes performance requirements for the low, average, and high service temperatures plus the mixing temperature.
- Explicitly addresses short- and long-term aging

Superpave Asphalt Grading

Superpave uses a "Performance Grade" designation that consists of the letters PG followed by two values representing the maximum summertime high and minimum wintertime low temperatures at which the asphalt will exhibit all of the necessary performance properties. Temperatures of 6°C separate the various high and low temperature grades. This allows you to select a grade specific to your climate conditions.

Superpave Asphalt Grading

The low temperature grade corresponds to the lowest one-day pavement temperature expected at the project location. The high temperature grade corresponds to the highest 7-day average pavement temperature. Both are based on a statistical analysis of historical weather data plus models that predict the temperature inside the asphalt pavement layer as a function of the air temperature.

Superpave Asphalt Grading

PG 64 -22

- PG: "Performance Grade"
- 64: Maximum 7-day-avg. pavement temperature (°C)
- -22: Minimum 1-day pavement temperature (°C)

Superpave Asphalt Grading

High Grades	Low Grades
PG 46	–34, –40, –46
PG 52	–10, –16, –22, –28, –34, –40, –46
PG 58	–16, –22, –28, –34, –40
PG 64	–10, –16, –22, –28, –34, –40
PG 70	–10, –16, –22, –28, –34, –40
PG 76	–10, –16, –22, –28, –34
PG 82	–10, –16, –22, –28, –34

Typical Performance Grade

PG 64–22

Superpave Asphalt Grading

The assignment of temperature grades is based on the highest or lowest temperature at which the asphalt cement meets all of the performance measures. For example, one of the low temperature criteria is that an asphalt cement specimen must be able to stretch by at least 1% before failing in tension. If the asphalt cement achieves that goal at −16°C but not at −22°C it would be classified as a PG XX−16 (assuming it meets all the other requirements at −16°C).

Superpave Asphalt Grading

The next slide shows the various tests around which the Superpave grading system is based. There is at least one test each at mixing temperatures, high service temperatures, low service temperatures, and the average service temperature (which is assumed to be halfway between the high and low temperatures). Depending on the test, the performance is measured on unaged asphalts, short-term aged asphalts, and/or long-term aged asphalts.

Superpave Grading Tests

Equipment	Purpose
Rotational Viscometer	Properties at mixing temps
Dynamic Shear Rheometer	Properties at high service temps
Rolling Thin-Film Oven	Aging due to volatilization
Pressure Aging Vessel	Aging due to oxidation
Bending Beam Rheometer	Properties at low service temps
Direct Tension Tester	Properties at low service temps

Asphalt Aging

- Volatilization (short term)

  Lighter hydrocarbons evaporate (especially during mixing) leaving a harder (stiffer) asphalt cement behind

- Oxidation (long term)

  Hydrogen molecules react with oxygen to form water, leaving behind a stiffer, more-brittle asphalt cement

Superpave Asphalt Grading

Short-term aging due to volatilization is achieved in a ***rolling thin film oven*** (RTFO)—similar to the thin film oven used in viscosity grading—that heats the asphalt to mixing temperatures to evaporate lighter hydrocarbons.

Long-term aging due to oxidation is achieved in a ***pressure aging vessel*** (PAV) that applies air at high pressures to force oxygen into the asphalt samples.

Rotational Viscometer

The first performance measure is the viscosity of the asphalt cement at mixing and placing temperatures. Rather than use the old-style viscometers (which are prone to clogging, especially with modified asphalts) the viscosity is measured with a rotational viscometer.

Rotational Viscometer

Rotational Viscometer

Recall that viscosity is shear stress divided by shear strain rate.

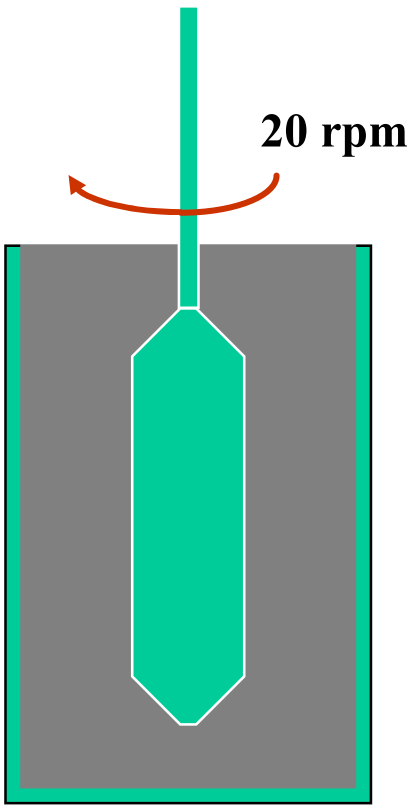
In a rotational viscometer, a specific shear strain rate is applied by rotating a steel spindle in a steel test tube filled with liquid asphalt cement. So instead of sliding one plate relative to another (as in our earlier definition of viscosity) we rotate a spindle relative to the fixed walls of the test tube.

Rotational Viscometer

As the device rotates the spindle, it also measures the torque needed to maintain the specified rotation rate. That torque is directly proportional to the shear stress experienced by the liquid asphalt cement.

The device automatically converts the rotation speed and measured torque into a viscosity reading (usually in units of centipoise, or hundreds of poise).

Rotational Viscometer



$$\text{viscosity} = \frac{\text{shear stress}}{\text{shear strain rate}}$$

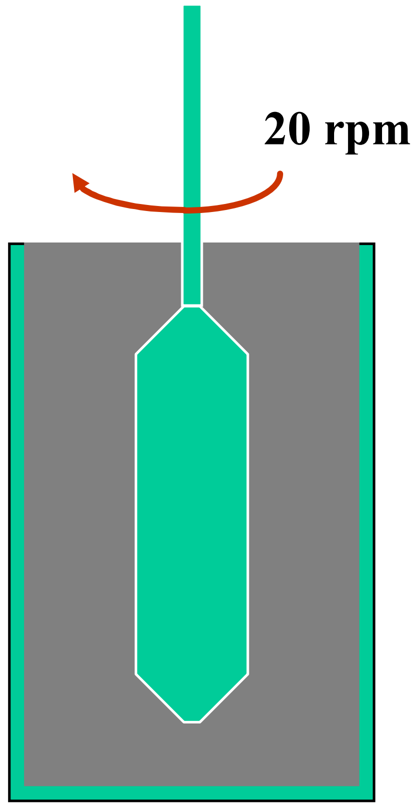
Constant rotation of the spindle produces a constant shear strain rate; torque required to maintain that rate is proportional to the shear stress.

Rotational Viscometer

At typical mixing temperatures of 135°C (275°F) the asphalt must have a viscosity of less than 3000 cP (roughly the viscosity of honey at room temperature) to ensure it can be adequately mixed with aggregate to create hot-mix asphalt.

Rotational Viscometer

Can be used with modified or unmodified binders w/out clogging



The viscosity of the unaged binder must be less than 3000 cP at 135ºC to ensure good mixing with the aggregate

Viscosity of Common Liquids

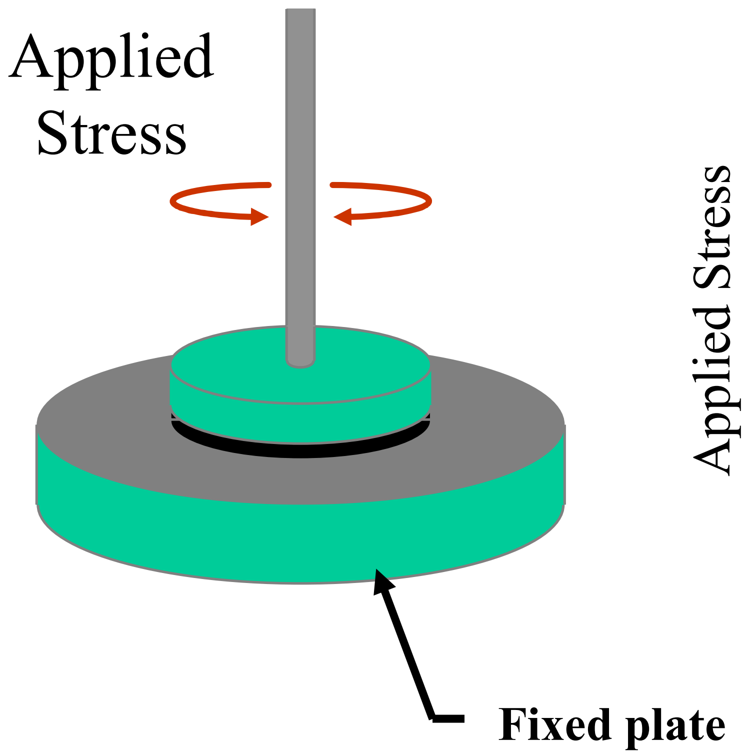
Water	1 centipoise
Cream	20 centipoise
Vegetable Oil	100 centipoise
Tomato Juice	200 centipoise
Honey	2000 centipoise
Chocolate Syrup	10000 centipoise
Sour Cream	20000 centipoise
Ketchup	50000 centipoise
Peanut Butter	150000 centipoise
Vegetable Shortening	1000000 centipoise

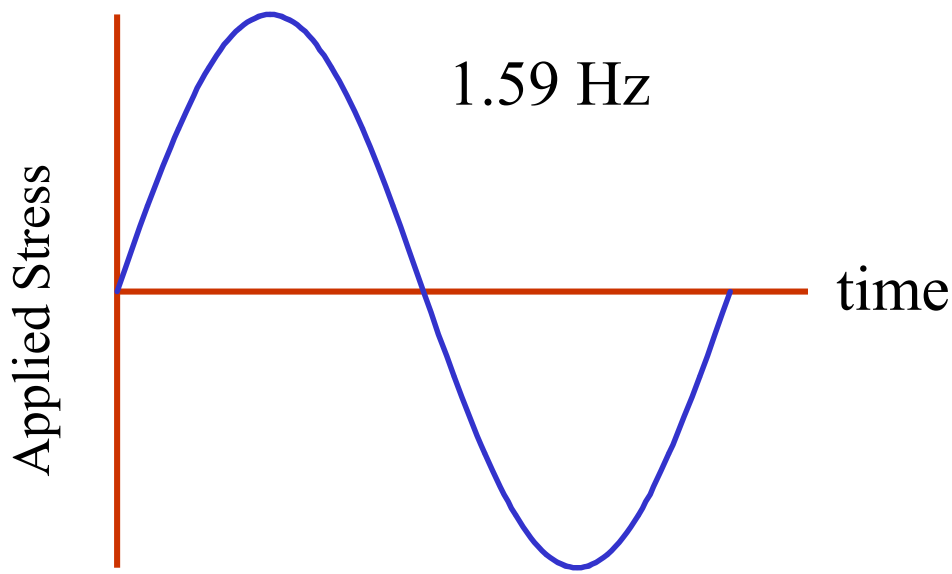
Dynamic Shear Rheometer

The next performance test is based on a device called the dynamic shear rheometer. In this test, a cyclical shear stress is applied to a quarter-sized specimen of asphalt cement at typical summertime temperatures and the resulting shear strain is measured along with the lag time between the application of stress and the resulting strain response.

Dynamic Shear Rheometer

Dynamic Shear Rheometer



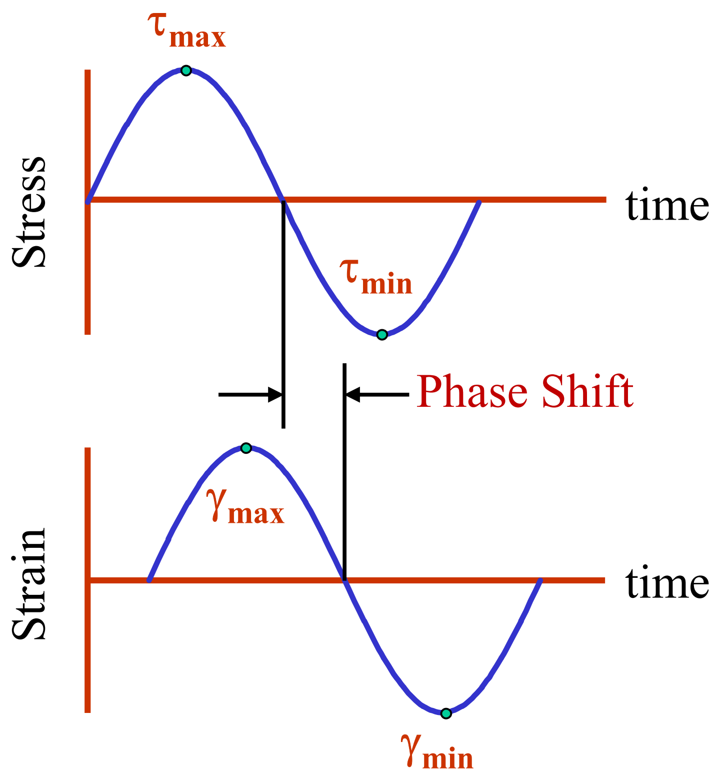


46°C to 82°C

Dynamic Shear Rheometer

The magnitudes of the oscillating shear stresses and shear strains are used to define a ***dynamic shear modulus*** (G*) and the phase shift (time lag) between the shear stress and shear strain are used to define a ***phase angle*** (δ).

Dynamic Shear Rheometer



Dynamic Modulus

$$G^* = \frac{\tau_{max} - \tau_{min}}{\gamma_{max} - \gamma_{min}}$$

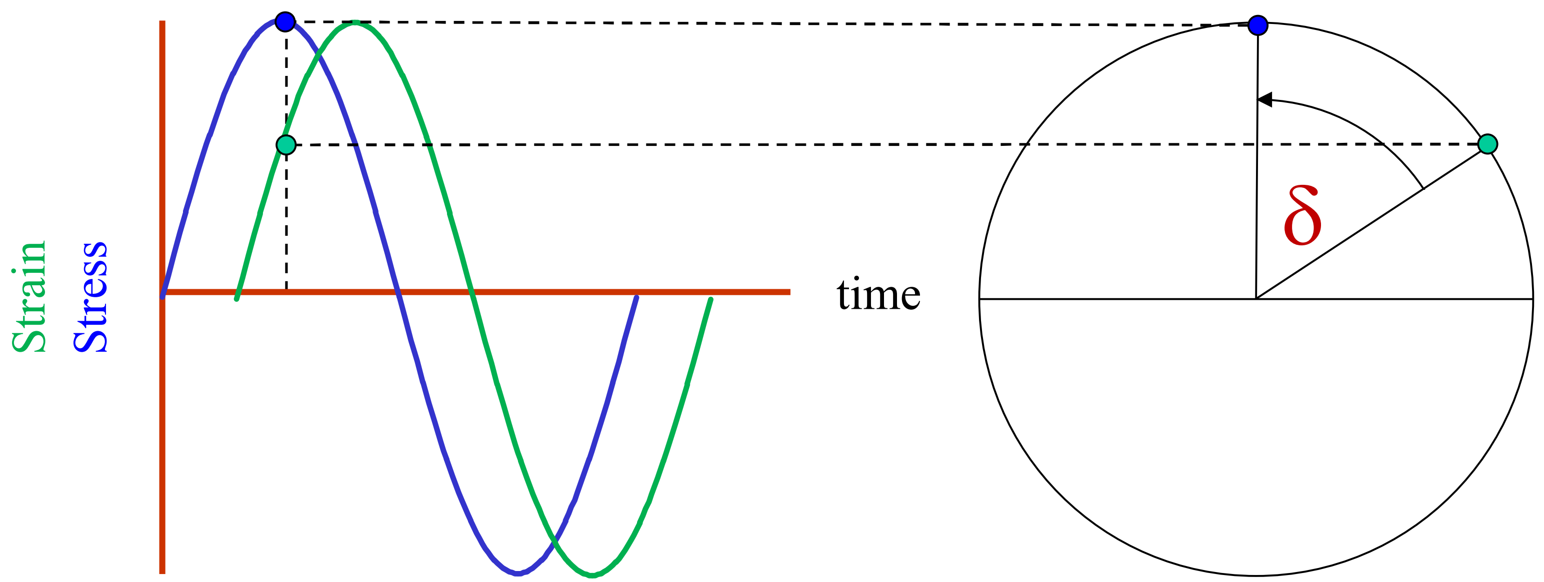
Phase Angle

$$\delta = f(\text{Phase Shift})$$

Dynamic Shear Rheometer

To explain the phase angle, let's superimpose a dial on the plots of oscillating shear stress and shear strain. A stress or strain of zero corresponds to an angle on the dial of zero degrees. A stress or strain at the maximum value corresponds to an angle of 90° on the dial. If we simultaneously plot the relative magnitudes of the stress and strain on the same dial, the angular distance between the two points is the phase angle.

Dynamic Shear Rheometer

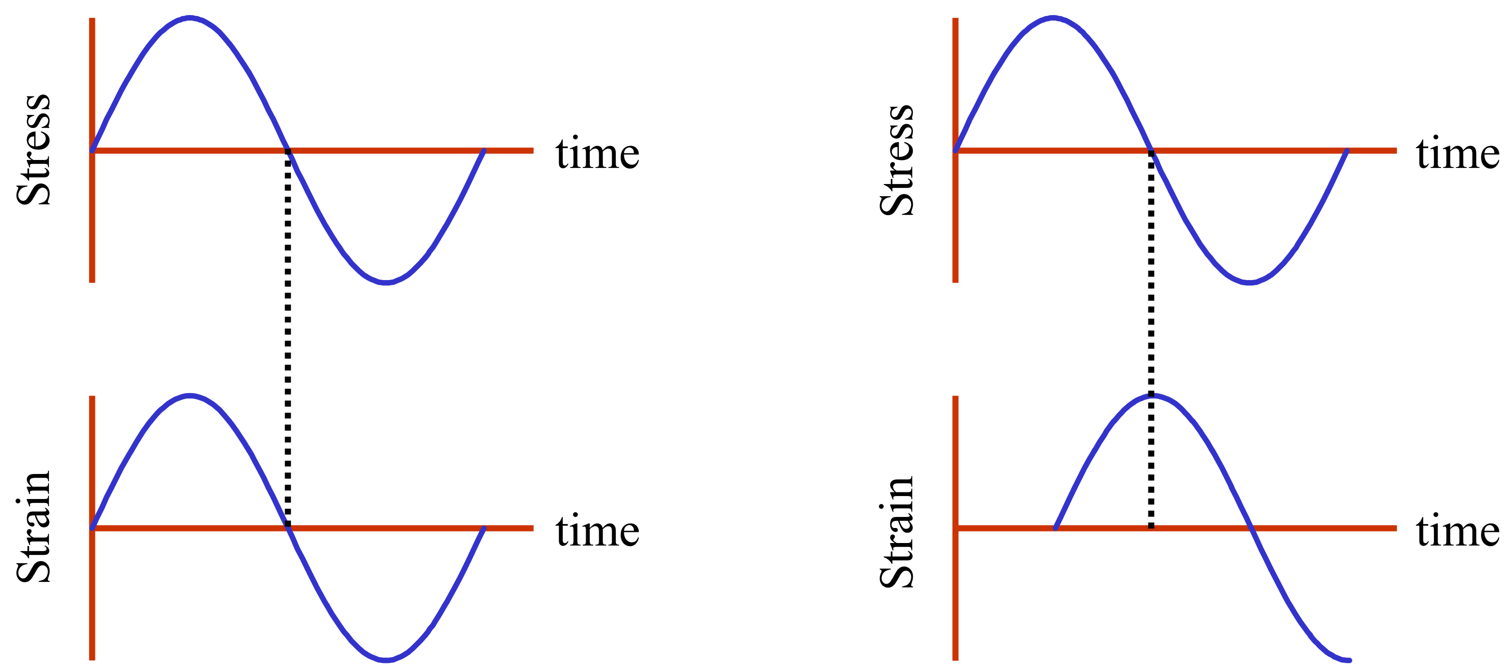


Dynamic Shear Rheometer

In a perfectly elastic material, the instant you apply a shear stress, the specimen strains in response, so plots of the oscillating shear stress and shear strain are in perfect sync. The phase angle is 0°.

In a viscous liquid, the two plots are 90° out of sync; the peak shear stress occurs at zero shear strain and the peak shear strain occurs at zero shear stress.

Dynamic Shear Rheometer



Elastic Solid
δ = 0 deg

Viscous Liquid
δ = 90 deg

Dynamic Shear Rheometer

Since asphalt cement is viscoelastic (it has properties of both an elastic solid and a viscous liquid) the two plots are typically somewhere in between.

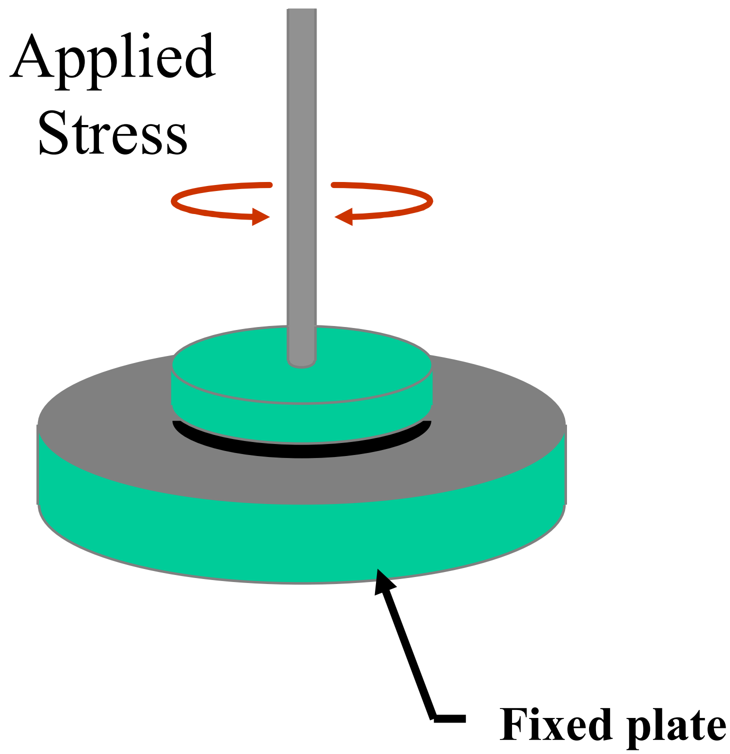
The ***dynamic modulus*** (G*) tells you how stiff the asphalt cement is at the current test temperature and the ***phase angle*** (δ) tells you whether its behaving more like an elastic solid or a viscous liquid.

Dynamic Shear Rheometer

G* and δ are used as predictors of HMA rutting and fatigue cracking. Early in the pavement life rutting is the main concern. Later on, fatigue cracking becomes the major concern.

In order to resist rutting at high service temperatures early in a pavement's life, the asphalt binder should be stiff (high G*) and elastic (low δ). The parameter $G^*/\sin\delta$ captures this.

Dynamic Shear Rheometer



G*/sin δ of unaged binder must exceed 1.00 kPa at the high service temperature to prevent rutting

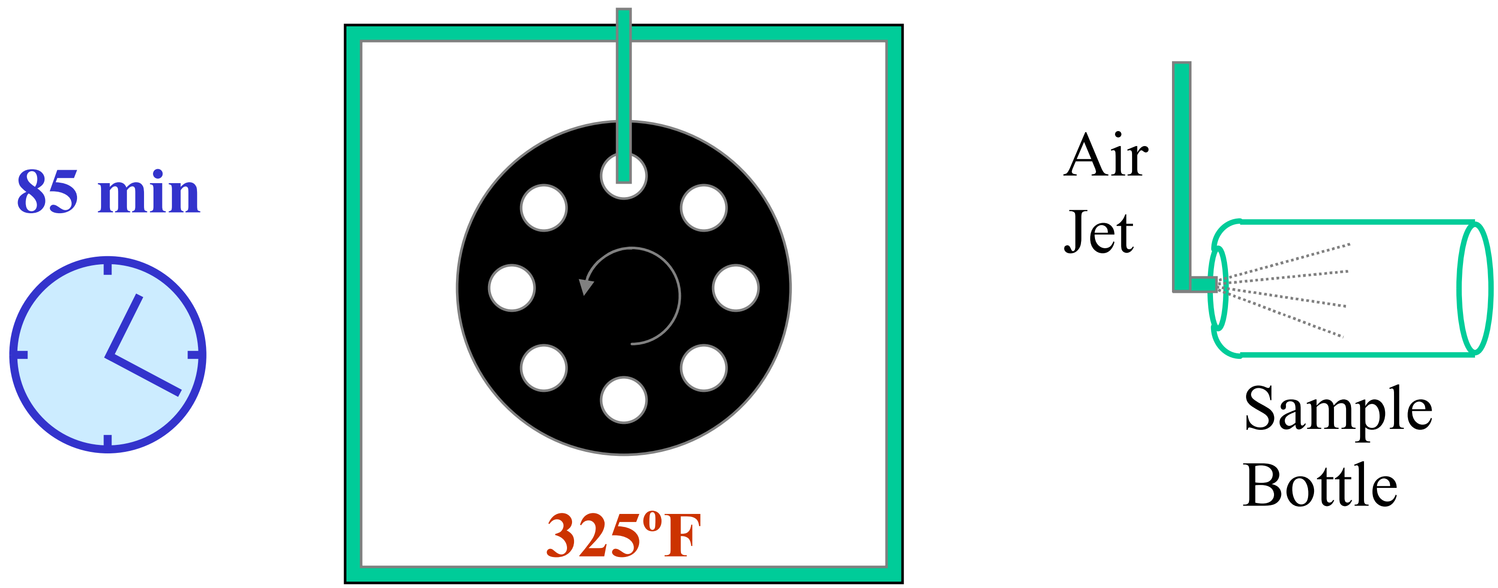
Rolling Thin-Film Oven

To account for the short-term aging that the asphalt cement undergoes while being mixed with aggregate in the hot-mix asphalt plant, the unaged binder is put in a ***rolling thin film oven*** (RTFO) for 85 minutes at 325°F. This causes some of the lighter hydrocarbons in the asphalt cement to volatilize, leaving behind a stiffer material.

Rolling Thin-Film Oven

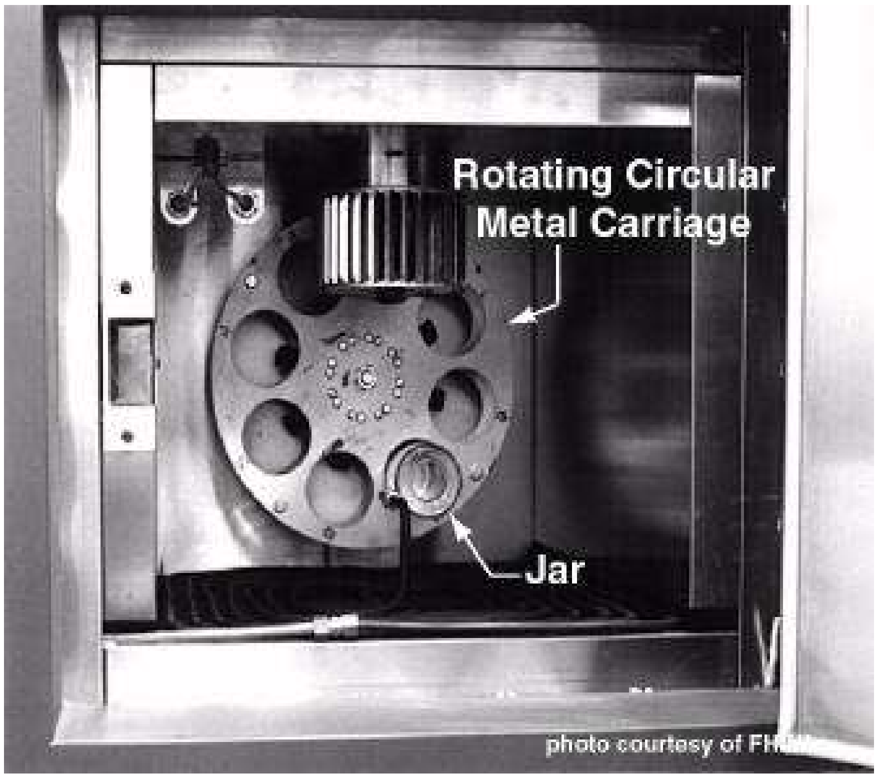
Recall that the ***thin film oven*** required 5 hours to age the asphalt cement. In the ***rolling thin film oven***, the aging is accomplished in 1/3 the time. The liquid asphalt is poured into a glass bottle that is mounted in a rotating carousel. Every time a bottle reaches the top position, a jet of air pushes out the hydrocarbon saturated air, allowing additional volatiles to outgas. This speeds up the process.

Rolling Thin-Film Oven



Simulates aging of asphalt cement during mixing and laydown due to volatilization

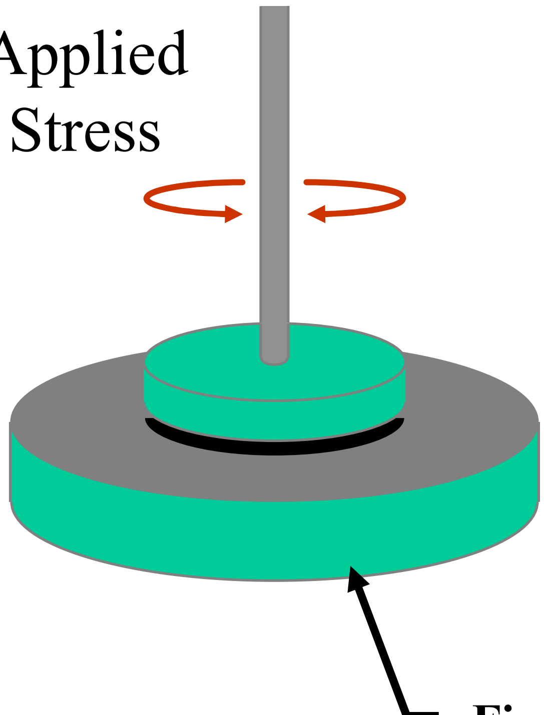
Rolling Thin-Film Oven



Dynamic Shear Rheometer

After the asphalt cement has been short-term aged in the RTFO, it is tested again in the dynamic shear rheometer. In order to resist rutting, $G^*/\sin\delta$ must exceed a somewhat higher threshold (because the aged binder is stiffer than the unaged binder).

Dynamic Shear Rheometer

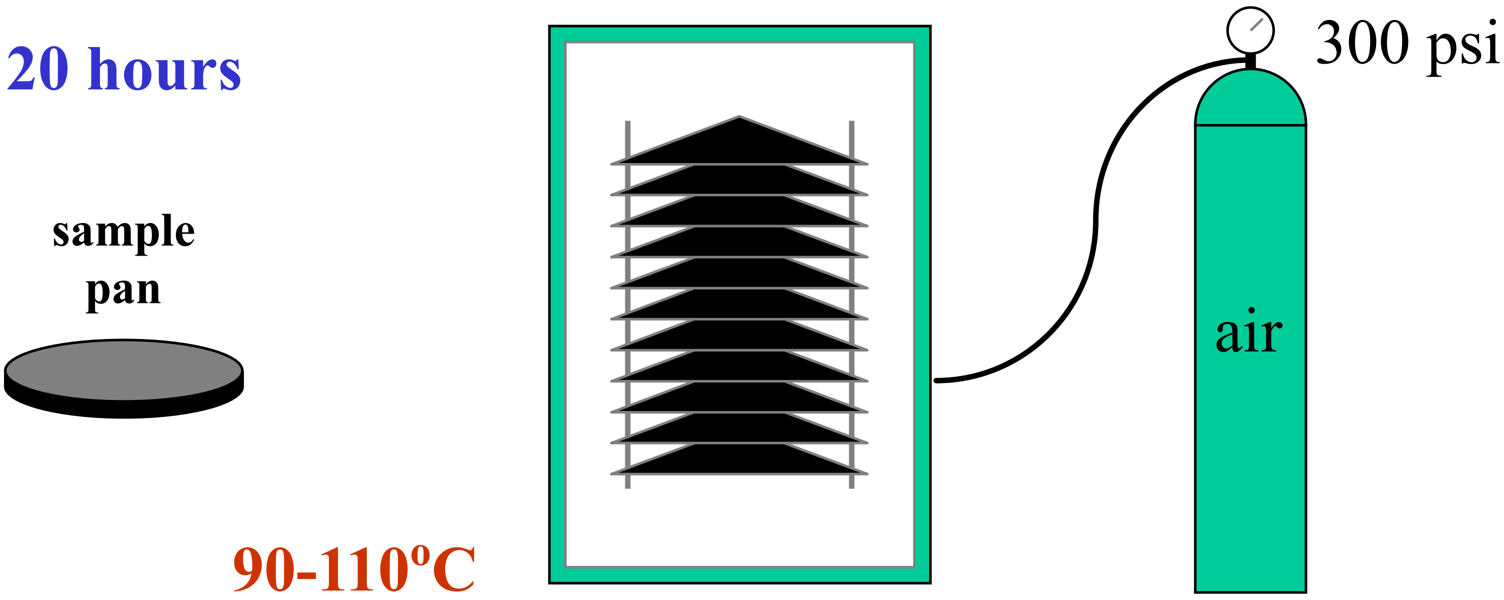


G*/sin δ of the stiffer RTFO-aged binder must exceed 2.2 kPa at the high service temp to prevent rutting

Pressure Aging Vessel

After the asphalt cement has been short-term aged in the RTFO, it is long-term aged in a ***pressure aging vessel*** (PAV) to simulate the oxidation the asphalt will experience over time due to the oxygen in the atmosphere. The PAV forces air into the asphalt under pressure to speed up the process from years to hours.

Pressure Aging Vessel



Simulates aging of asphalt cement over years of use due to oxidation

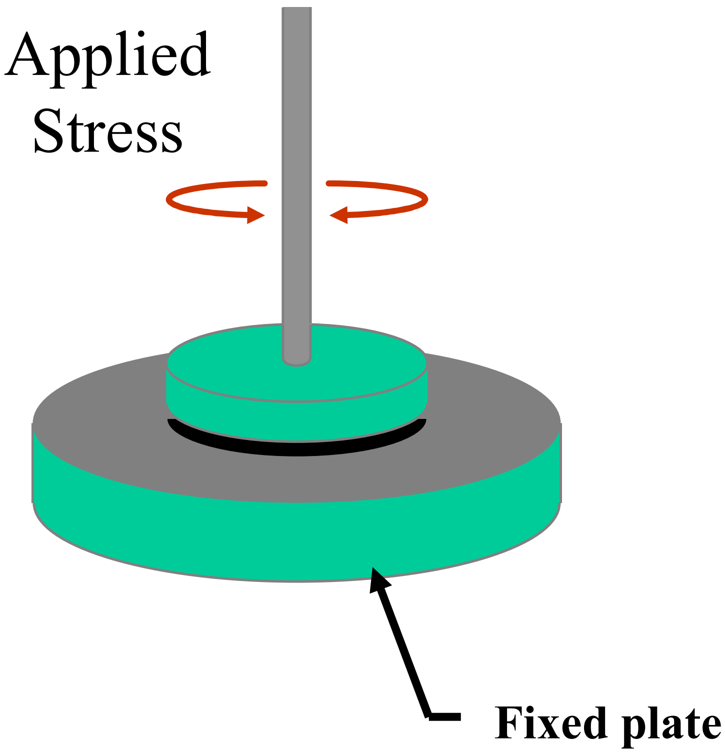
Dynamic Shear Rheometer

After the asphalt cement has been long-term aged in the PAV, it is tested again in the dynamic shear rheometer.

In order to resist fatigue cracking at the ***average*** service temperature (defined as the mean of the low and high temperatures for the PG grade) the asphalt should be elastic (low δ) but not too stiff (low G^*). A maximum value for $G^* \times \sin\delta$ captures this.

•

Dynamic Shear Rheometer



G* sin δ of the stiffer PAV-aged binder must be less than 5000 kPa at the mean of the high and low service temperatures to prevent fatigue cracking

Bending Beam Rheometer

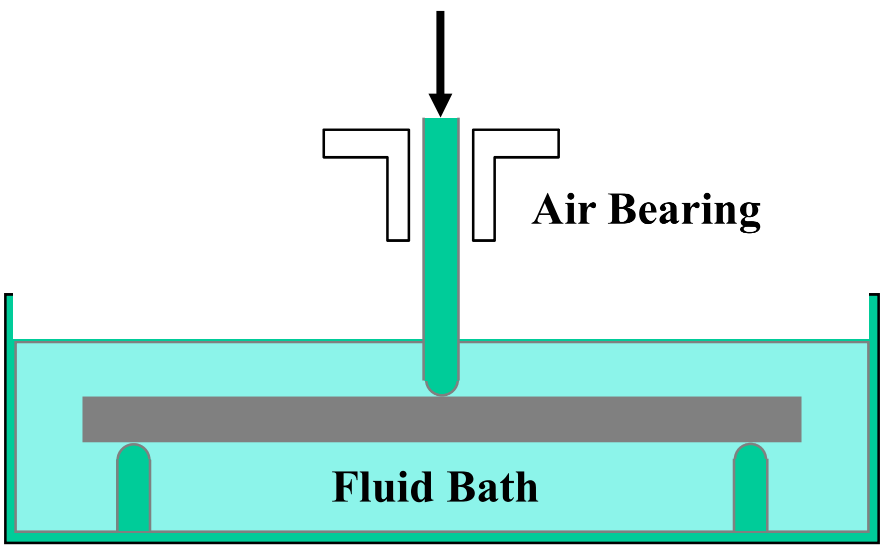
The next test is the ***bending beam rheometer***. It is used to test the asphalt cement's resistance to thermal cracking at low service temperatures.

In this test, a small beam (1/2" × 1/4" × 5") is made from the asphalt cement and it is submerged in an antifreeze solution at the low service temperature. A small (100 g) load is applied at the midpoint for a specified length of time then released.

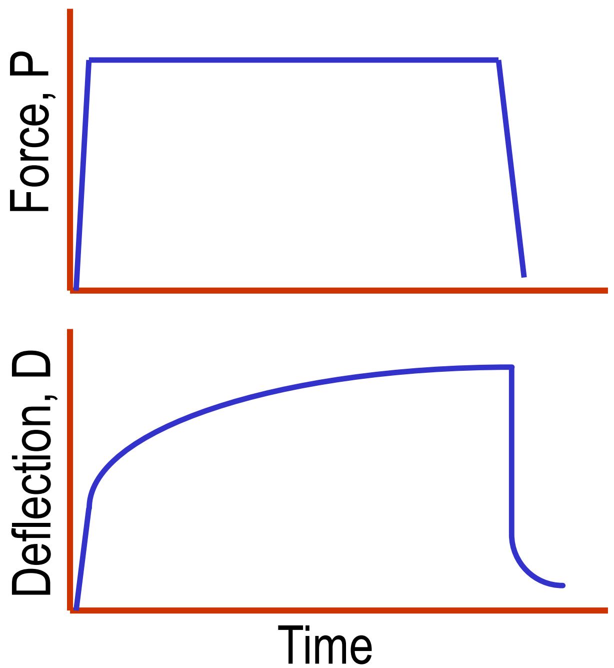
Bending Beam Rheometer

Bending Beam Rheometer

Bending Beam Rheometer



0°C to -36°C



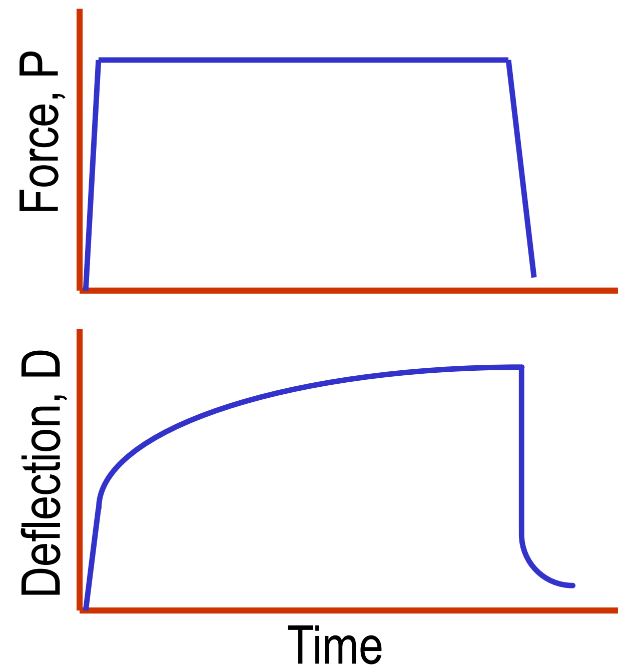
Bending Beam Rheometer

The load-vs-time and deformation-vs-time results are used to calculate a ***creep stiffness***, which is similar to an elastic modulus.

Bending Beam Rheometer

$$S(t) = \frac{P(t)L^3}{4bh^3D(t)}$$

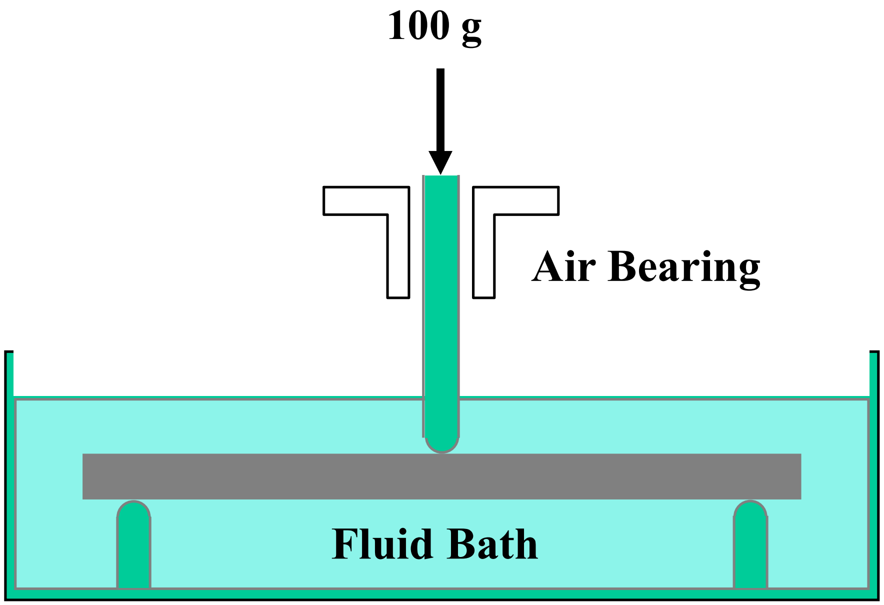
Creep Stiffness



Bending Beam Rheometer

A drop in temperature produces thermal strain that is resisted by friction with the underlying base course. Since stress and strain are related through stiffness, a stiff binder will react to that strain with stresses that could be high enough to crack the asphalt. So the asphalt must not have too high of a creep stiffness, or it could crack. Since thermal cracking is more prevalent later in the pavement's life, this test is performed on PAV-aged binder.

Bending Beam Rheometer



0^oC to -36^oC

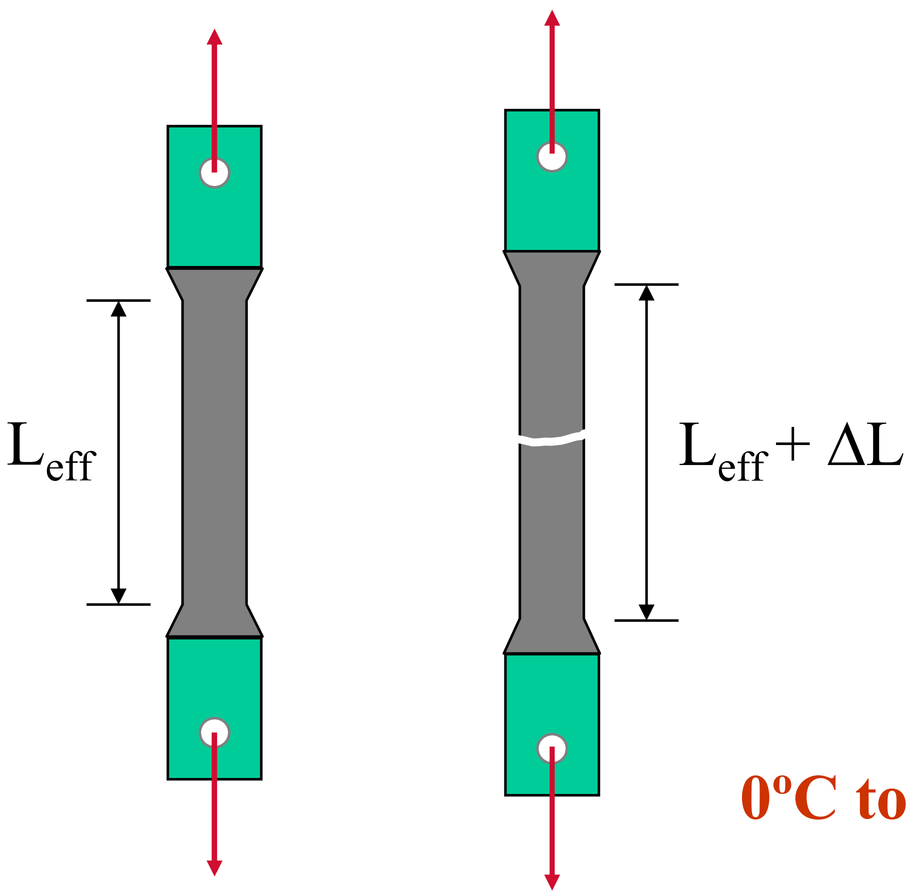
S(t) of the PAV-aged binder must not exceed 300 MPa after 2 hours at low service temperature to prevent thermal cracking

Direct Tension Test

The final test is the ***direct tension test***, which is also used to assess the low-temperature performance of the asphalt cement. The test applies a constant rate of strain to an asphalt binder specimen until it fails due to brittle cracking. The greater the strain at failure, the more ductile the asphalt and the better the asphalt can resist cracking. Since thermal cracking is more prevalent later in the pavement's life, this test is performed on PAV-aged binder.

Direct Tension Test

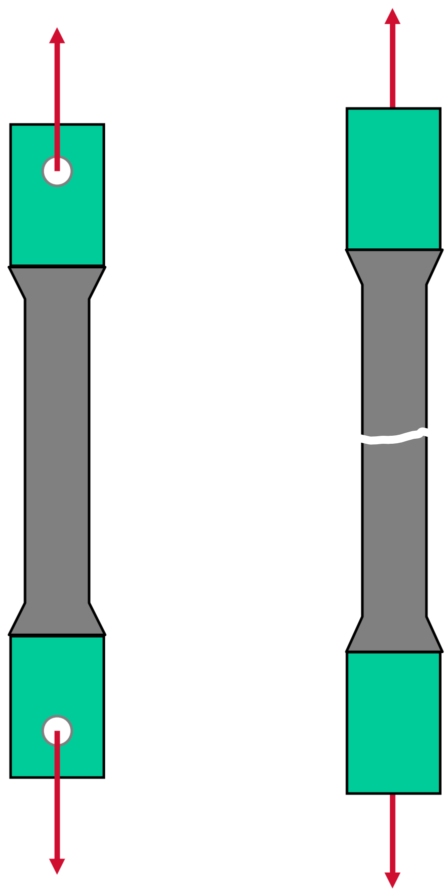
Direct Tension Tester



$$\varepsilon_f = \frac{\Delta L}{L_{eff}}$$

0°C to -36°C

Direct Tension Tester



ε_f of the PAV-aged binder must exceed 1% at the low service temperature to prevent thermal cracking

Superpave Asphalt Grading

The next slide summarizes all of the performance testing requirements used in the Superpave system. It includes all of the tests on unaged binder, short-term aged binder, and long-term aged binder at the low, high, and average service temperatures.

Un-aged Binder

Kinematic Viscosity $\leq$ 3 Pa·s @ 135°C

$G^*/\sin \delta \geq$ 1.00 kPa @ Design High Temperature

RTFO-aged Binder

$G^*/\sin \delta \geq$ 2.20 kPa @ Design High Temperature

PAV-aged Binder

$G^* \sin \delta \leq$ 5000 kPa @ Average Design Temperature

$S \leq$ 300 MPa @ Design Low Temperature + 10°C

$\varepsilon_f \geq$ 1.00% @ Design Low Temperature + 10°C

Superpave Grading

The next three slides are taken from the NCEES *Supplied Reference Handbook* that you will use for the FE exam. They summarize the performance test requirements for a small subset of the Superpave Performance Grades (namely, PG 52-XX, PG 58-XX, and PG 64-XX).

Superpave Grading

PERFORMANCE-GRADED (PG) BINDER GRADING SYSTEM

PERFORMANCE GRADE	PG 52							PG 58					PG 64				
	−10	−16	−22	−28	−34	−40	−46	−16	−22	−28	−34	−40	−16	−22	−28	−34	−40
AVERAGE 7-DAY MAXIMUM PAVEMENT DESIGN TEMPERATURE, °C[a]	<52							<58					<64				
MINIMUM PAVEMENT DESIGN TEMPERATURE, °C[a]	>−10	>−16	>−22	>−28	>−34	>−40	>−46	>−16	>−22	>−28	>−34	>−40	>−16	>−22	>−28	>−34	>−40
ORIGINAL BINDER																	
FLASH POINT TEMP, T48: MINIMUM °C	230																
VISCOSITY, ASTM D 4402:[b] MAXIMUM, 3 Pa-s (3,000 cP), TEST TEMP, °C	135																
DYNAMIC SHEAR, TP5:[c] G*/sin δ, MINIMUM, 1.00 kPa TEST TEMPERATURE @ 10 rad/sec., °C	52							58					64				

Source: NCEES *FE Reference Handbook*

Superpave Grading

PERFORMANCE-GRADED (PG) BINDER GRADING SYSTEM

PERFORMANCE GRADE	PG 52							PG 58					PG 64				
	−10	−16	−22	−28	−34	−40	−46	−16	−22	−28	−34	−40	−16	−22	−28	−34	−40
ROLLING THIN FILM OVEN (T240) OR THIN FILM OVEN (T179) RESIDUE																	
MASS LOSS, MAXIMUM, %	1.00																
DYNAMIC SHEAR, TP5: G*/sin δ , MINIMUM, 2.20 kPa TEST TEMP @ 10 rad/sec. °C	52							58					64				

Source: NCEES *FE Reference Handbook*

Superpave Grading

PERFORMANCE-GRADED (PG) BINDER GRADING SYSTEM

PERFORMANCE GRADE	PG 52							PG 58					PG 64				
	−10	−16	−22	−28	−34	−40	−46	−16	−22	−28	−34	−40	−16	−22	−28	−34	−40
PRESSURE AGING VESSEL RESIDUE (PP1)																	
PAV AGING TEMPERATURE, °C[d]	90							100					100				
DYNAMIC SHEAR, TP5: G*/sin δ , MAXIMUM, 5,000 kPa TEST TEMP @ 10 rad/sec. °C	25	22	19	16	13	10	7	25	22	19	16	13	28	25	22	19	16
PHYSICAL HARDENING [e]	REPORT																
CREEP STIFFNESS, TP1: [f] S, MAXIMUM, 300 MPa M-VALUE, MINIMUM, 0.300 TEST TEMP, @ 60 sec., °C	0	−6	−12	−18	−24	−30	−36	−6	−12	−18	−24	−30	−6	−12	−18	−24	−30
DIRECT TENSION, TP3: [f] FAILURE STRAIN, MINIMUM, 1.0% TEST TEMP @ 1.0 mm/min, °C	0	−6	−12	−18	−24	−30	−36	−6	−12	−18	−24	−30	−6	−12	−18	−24	−30

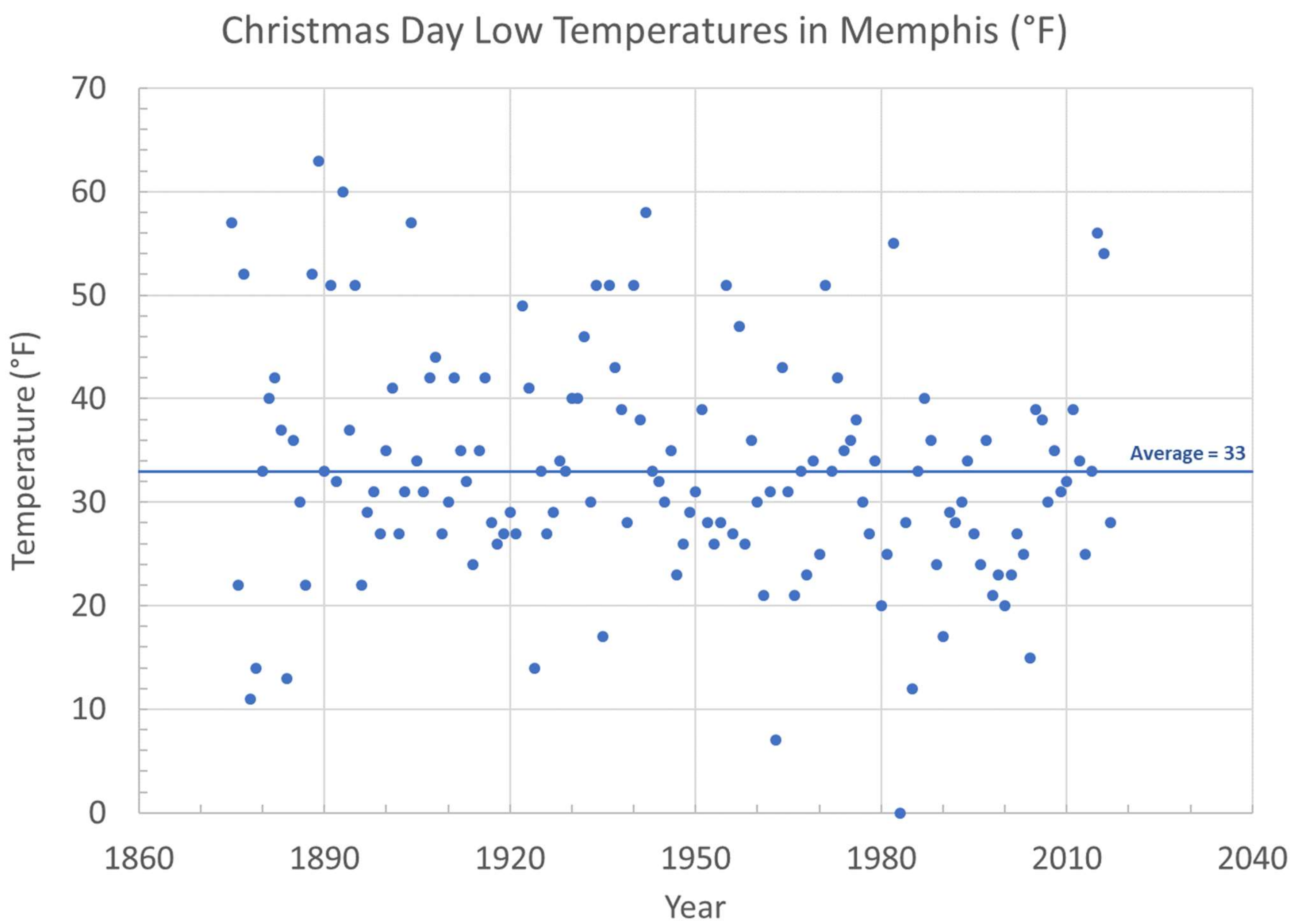
Source: NCEES *FE Reference Handbook*

Superpave Grading

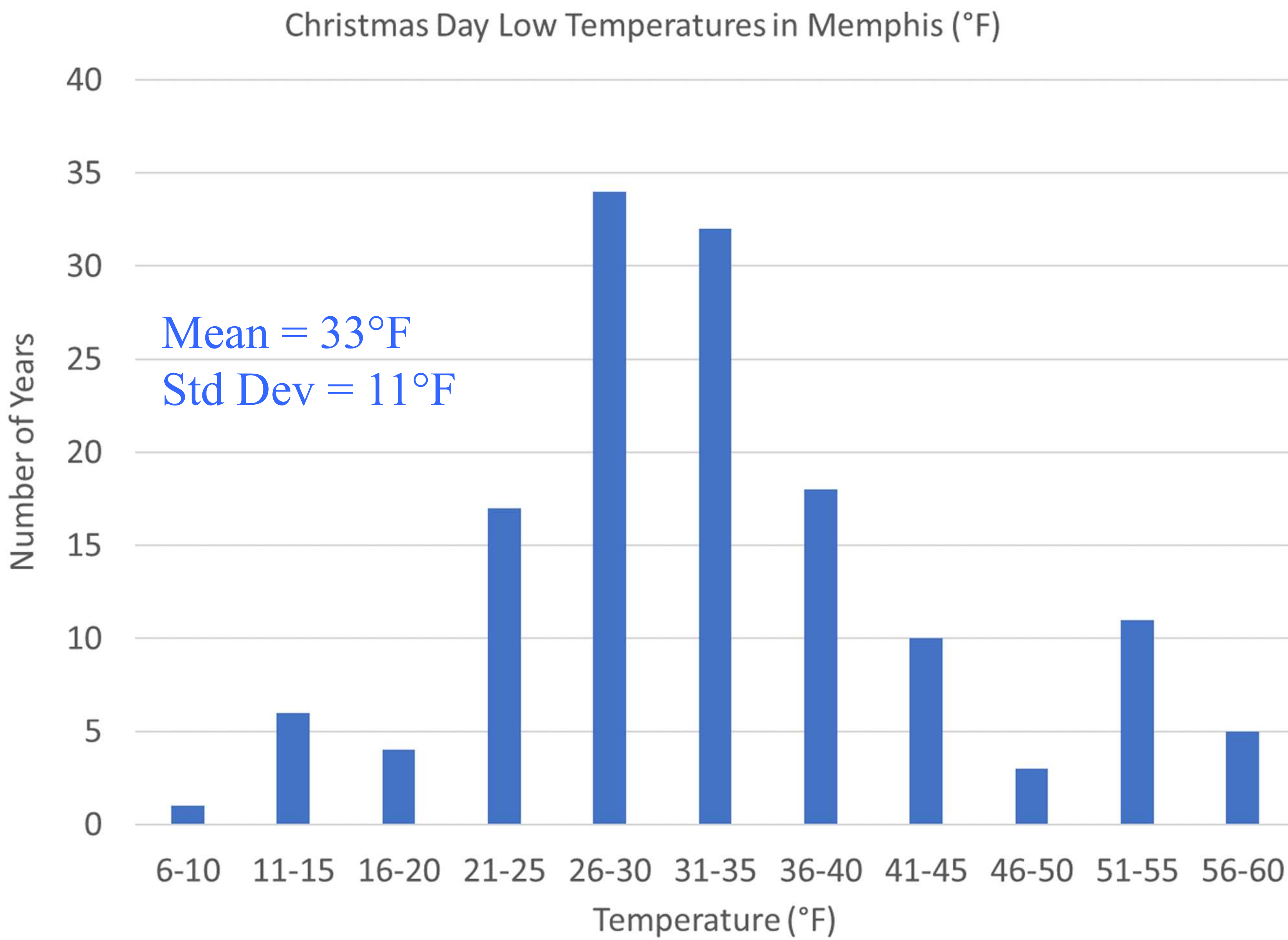
So how do we use all of this information?

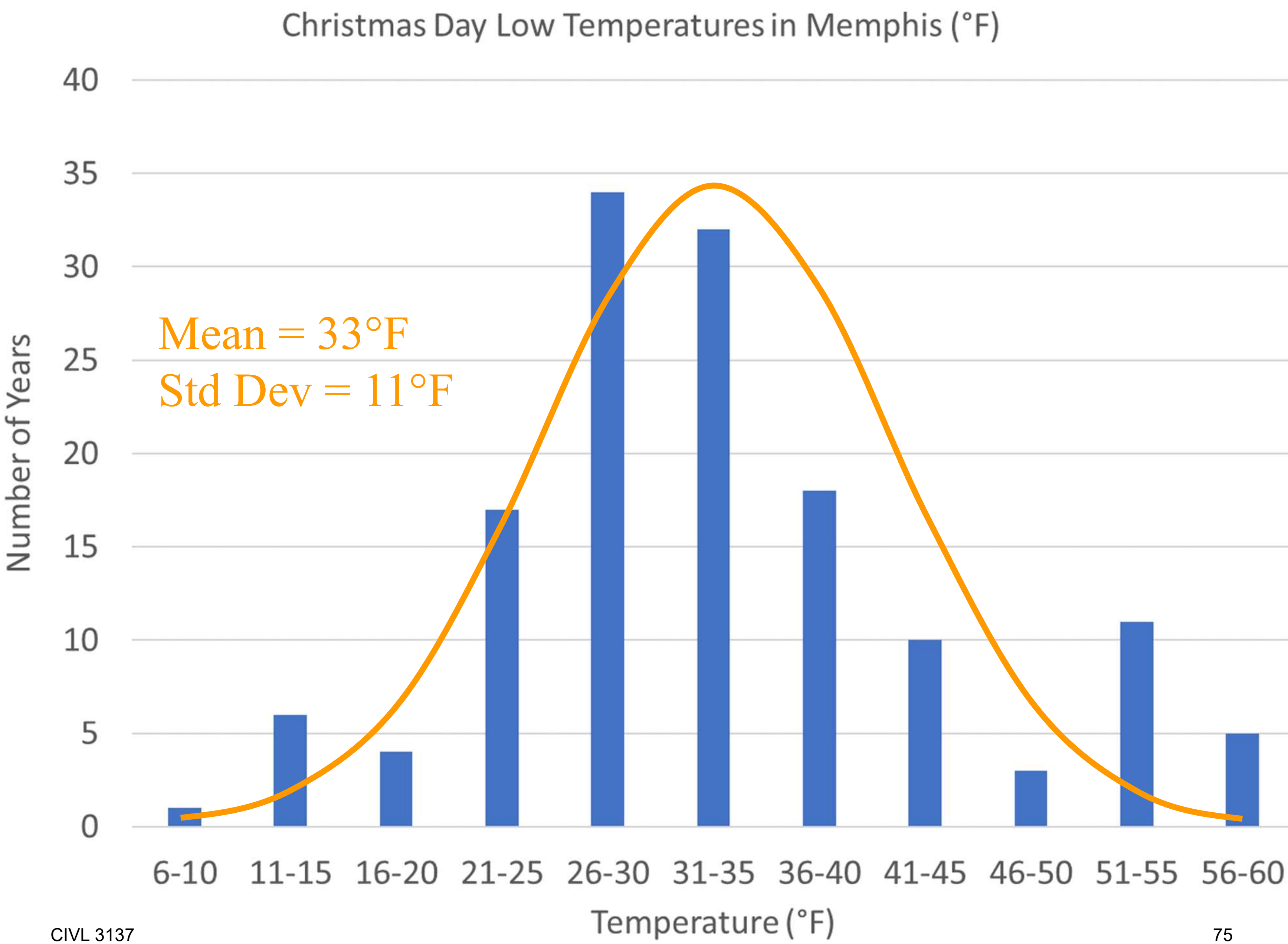
To start, let's look at a plot of the Christmas Day low air temperatures in Memphis, TN from 1875 to 2015.

We can create a histogram of these temperatures. We can also fit a normal distribution to the data. It shows that the mean 1-day low air temperature is 33°F with a standard deviation of 11°F.



Christmas Day Low Temperatures in Memphis (°F)
Temperature (°F)
70
60
50
40
30
20
10
0
1860
1890
1920
1950
1980
2010
2040
Year
Average = 33


Christmas Day Low Temperatures in Memphis (°F)
Mean = 33°F
Std Dev = 11°F
40
35
30
25
20
15
10
5
0
Number of Years
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
Temperature (°F)

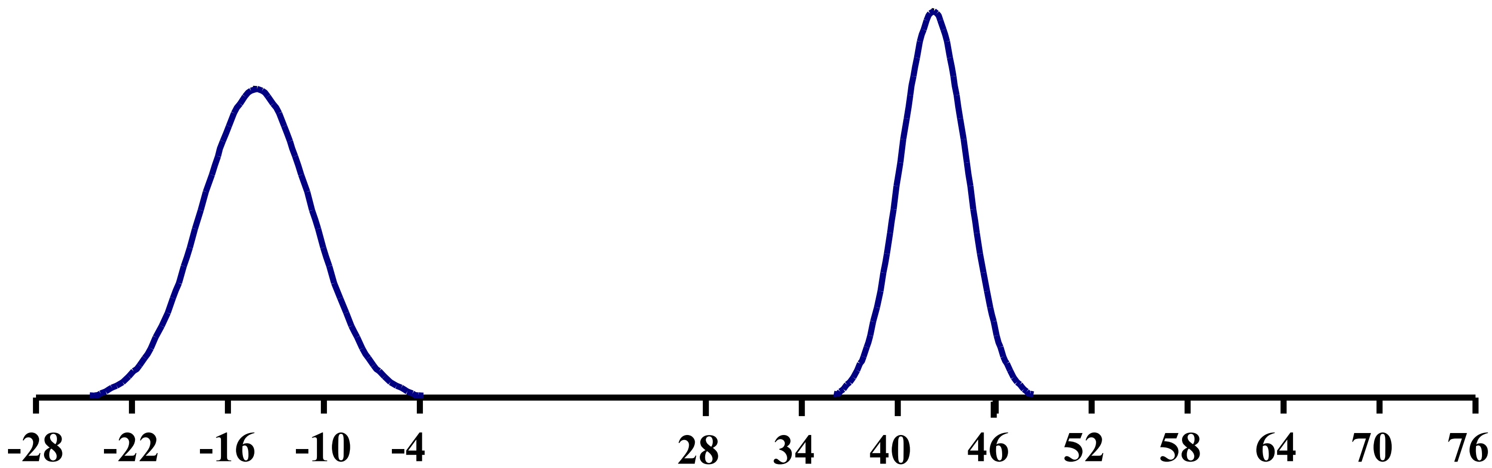

Christmas Day Low Temperatures in Memphis (°F)
Mean = 33°F
Std Dev = 11°F
Number of Years
40
35
30
25
20
15
10
5
0
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
Temperature (°F)

Superpave Grading

When we get ready to pave a roadway, we can do the same sort of thing by looking in the historical record for the ***lowest 1-day*** air temperature of each year (not just on Christmas Day) and the ***highest 7-day average*** air temperature of each year. We can then fit a normal distribution to those data.

Superpave Grade Selection

Based on Historical Weather Records
at the Project Location



Lowest Annual
1-day Air
Temperature (°C)

Highest Annual
7-day avg. Air
Temperature (°C)

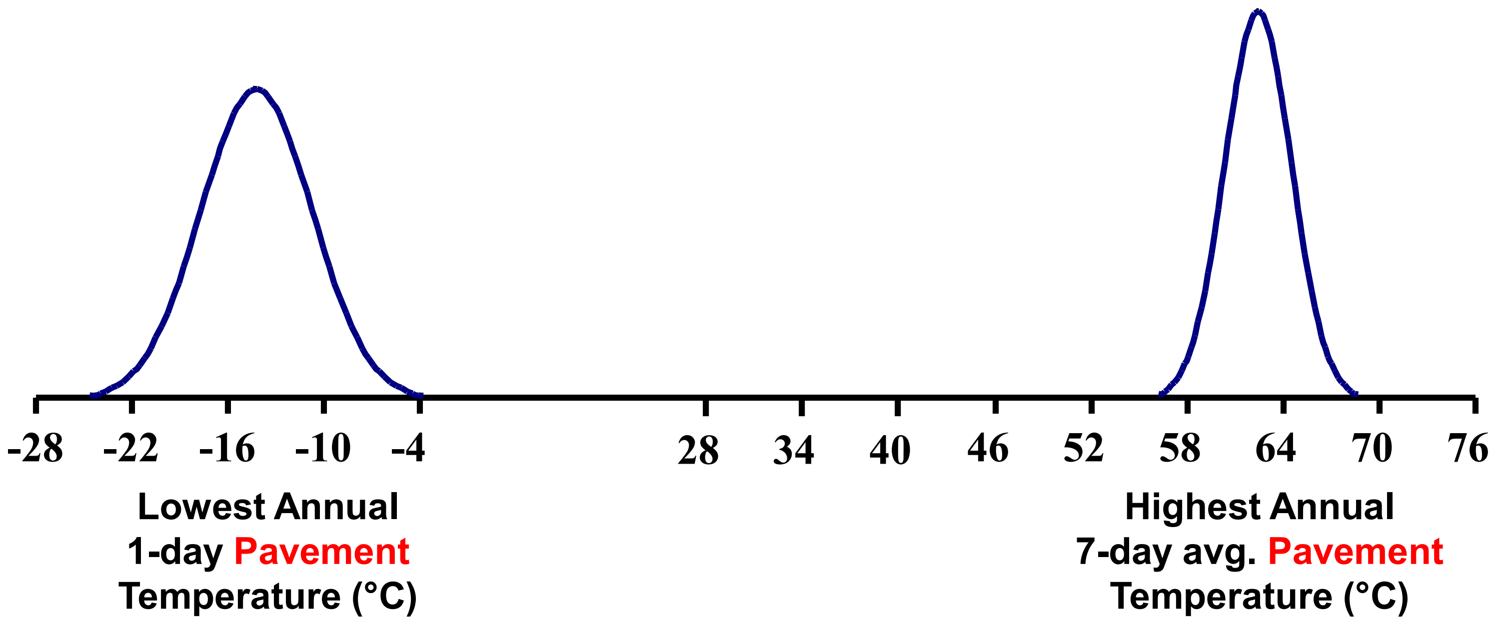
Superpave Grading

The lowest pavement temperature usually occurs in the middle of the night and is equal to the lowest air temperature.

The highest pavement temperature usually occurs in the middle of the day and is higher than the highest air temperature due to solar radiation (i.e., sunlight beating down on the pavement). A model converts the air temperature into pavement temperatures.

Superpave Grade Selection

Based on Empirical Relationships
Between Air and Pavement Temperature



Superpave Grading

Now that we know, historically, what the pavement temperatures look like, we can choose a PG grade that will span the most likely temperatures we will encounter in the years ahead.

In the example below, a PG 70-22 grade will span almost all of the temperatures we're likely to see, so it should perform well at our job site. But it will be expensive!

Superpave Grading

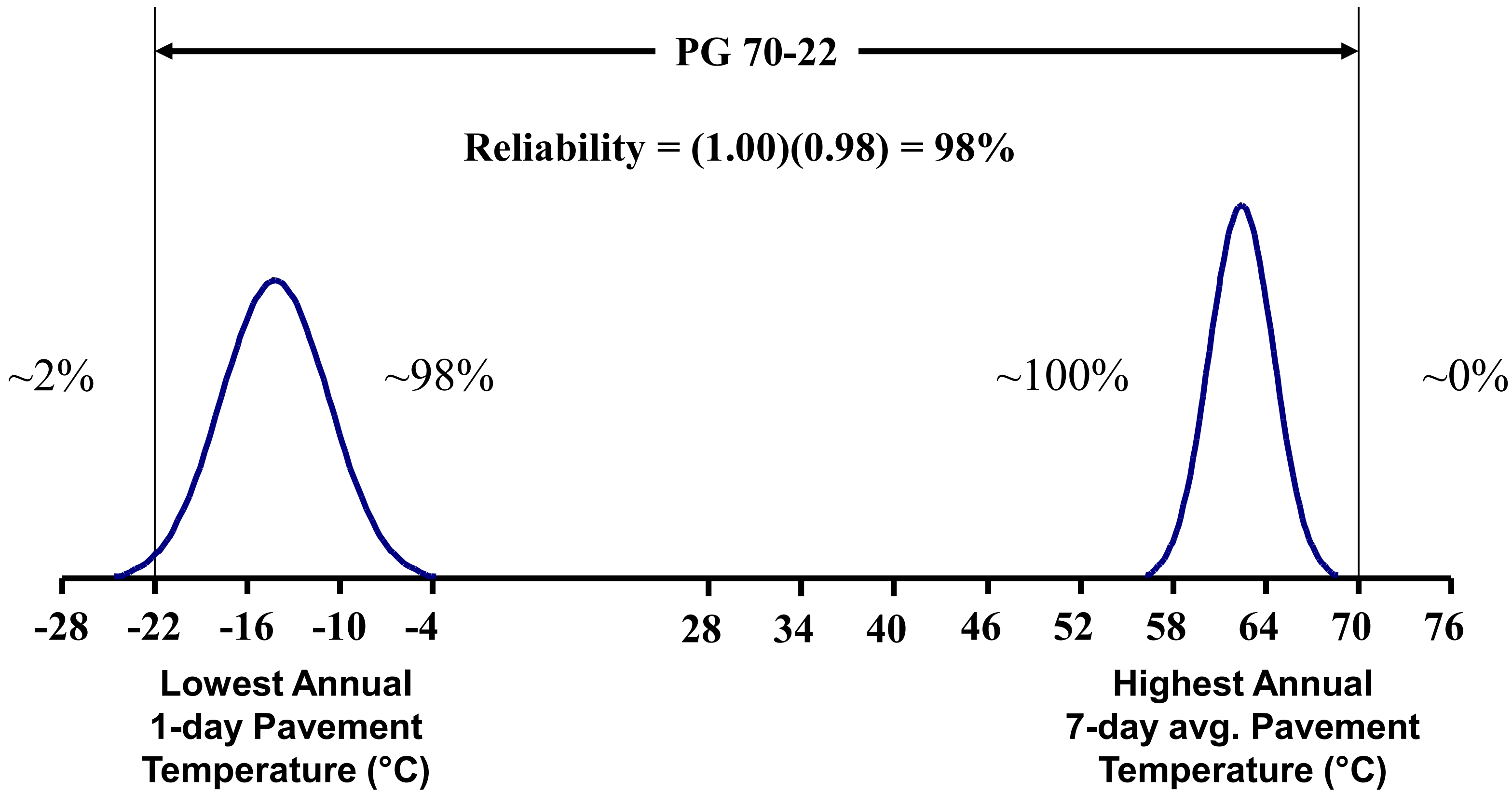
The goal is to find an asphalt grade that will perform well <u>most</u> years while keeping the costs reasonable.

If this is an important road like an Interstate highway we probably don't want to mess around. But if we are paving a residential street, it doesn't matter if we accumulate a bit of cracking or rutting, so we could save a lot of money by using a PG 64-16 instead.

Superpave Grading

Using statistics, we can calculate that the PG 70-22 binder will have 98% reliability. The wintertime low temperature should be higher than -22°C in 98 out of 100 years and the summertime high temperature will be lower than 70°C in 100 out of 100 years, so the temperatures should fall within the range for that PG grade 98% of the time.

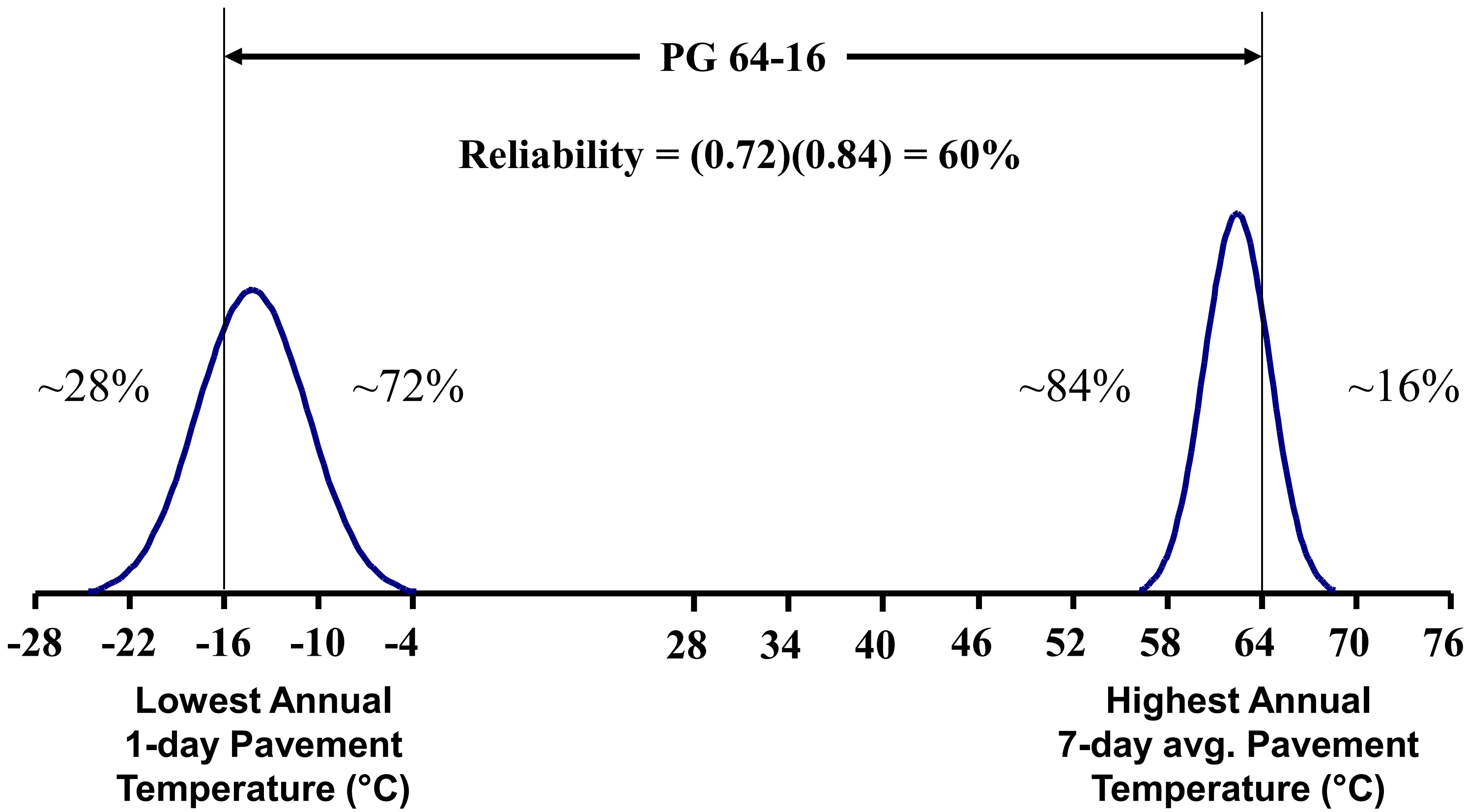
Superpave Grade Selection



Superpave Grading

If we choose to save money by using a PG 64-16, instead, the wintertime low temperature should be higher than -16°C in 72 out of 100 years and the summertime high temperature will be lower than 64°C in 84 out of 100 years, so the temperatures should fall within the range corresponding to that PG grade 60% of the time.

Superpave Grade Selection

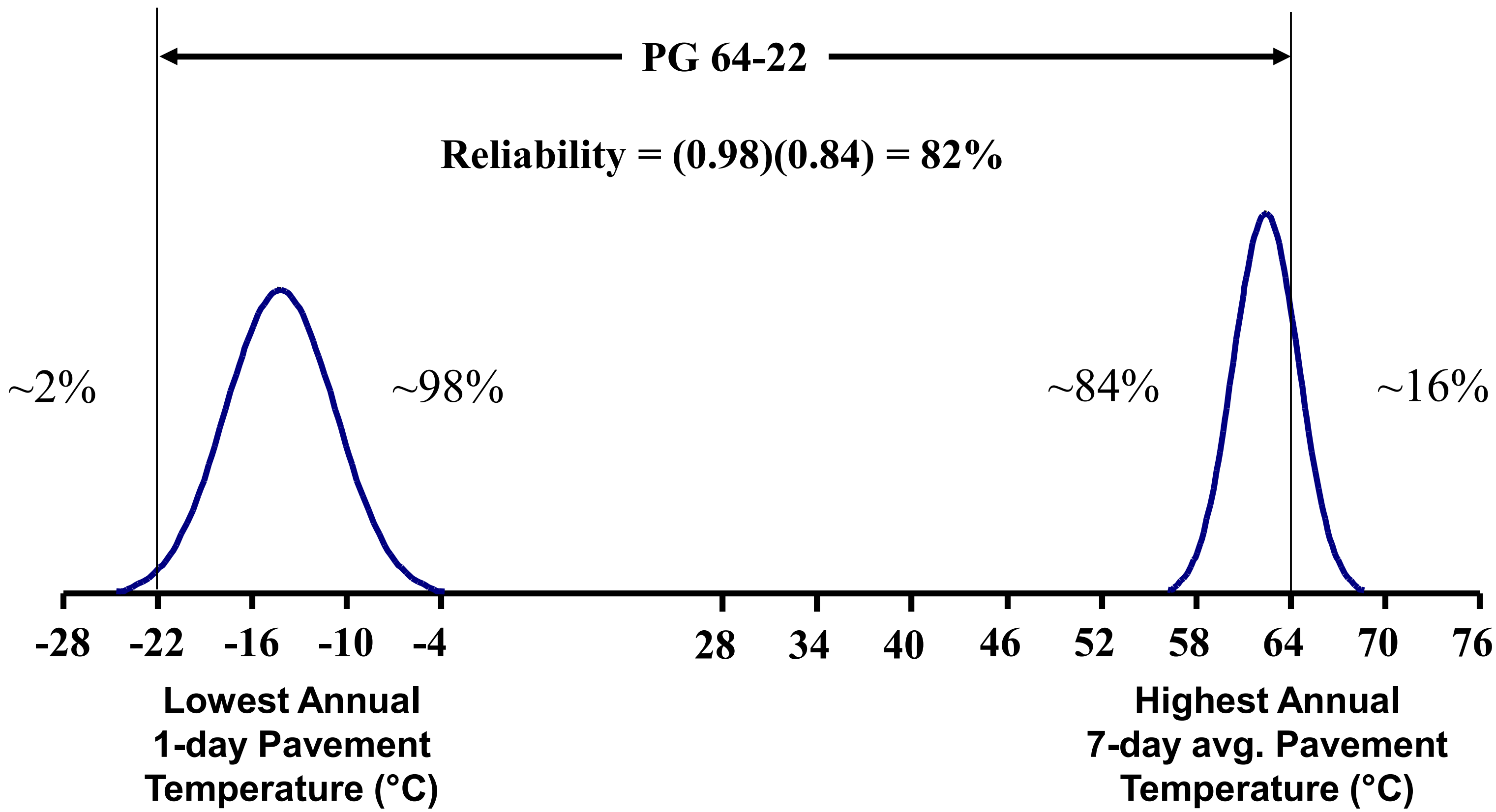


Superpave Grading

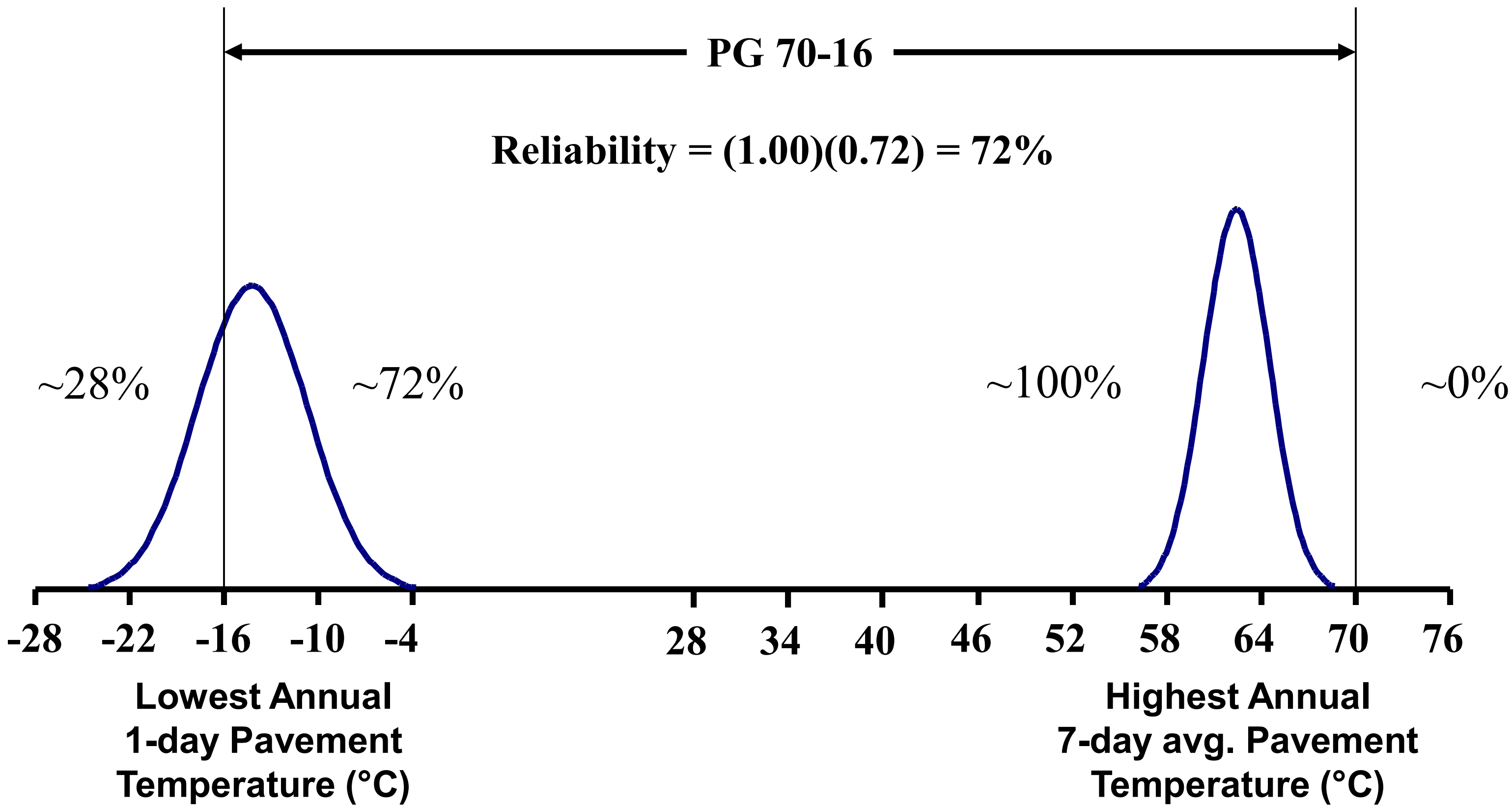
If we use a PG 64-22 or PG 70-16, the temperatures should fall within the ranges for those grades 82% of the time and 72% of the time, respectively.

A pavement can withstand <u>some</u> damage in several bad years and still be perfectly usable. We may have to repave it a year or two earlier, but it's not going to suffer a sudden, catastrophic failure. It will just wear out faster. So you can trade economy for reliability.

Superpave Grade Selection



Superpave Grade Selection



Superpave Grading

The reason we might not want to design for 100% reliability is because many of the PG grades cannot be achieved with regular asphalt cement. If the high and low temperatures are more than 86°F apart, you have to use asphalt cement derived from high-quality crude oil. If they are more than 92°F apart, you have to use asphalt cement that has been modified with the addition of polymers or elastomers or rubber.

Superpave Binder Grades

High Temperature, °C

Low Temperature, °C	52	58	64	70	76	82
-16	52-16	58-16	64-16	70-16	76-16	82-16
-22	52-22	58-22	64-22	70-22	76-22	82-22
-28	52-28	58-28	64-28	70-28	76-28	82-28
-34	52-34	58-34	64-34	70-34	76-34	82-34
-40	52-40	58-40	64-40	70-40	76-40	82-40

= Crude Oil

= High Quality Crude Oil

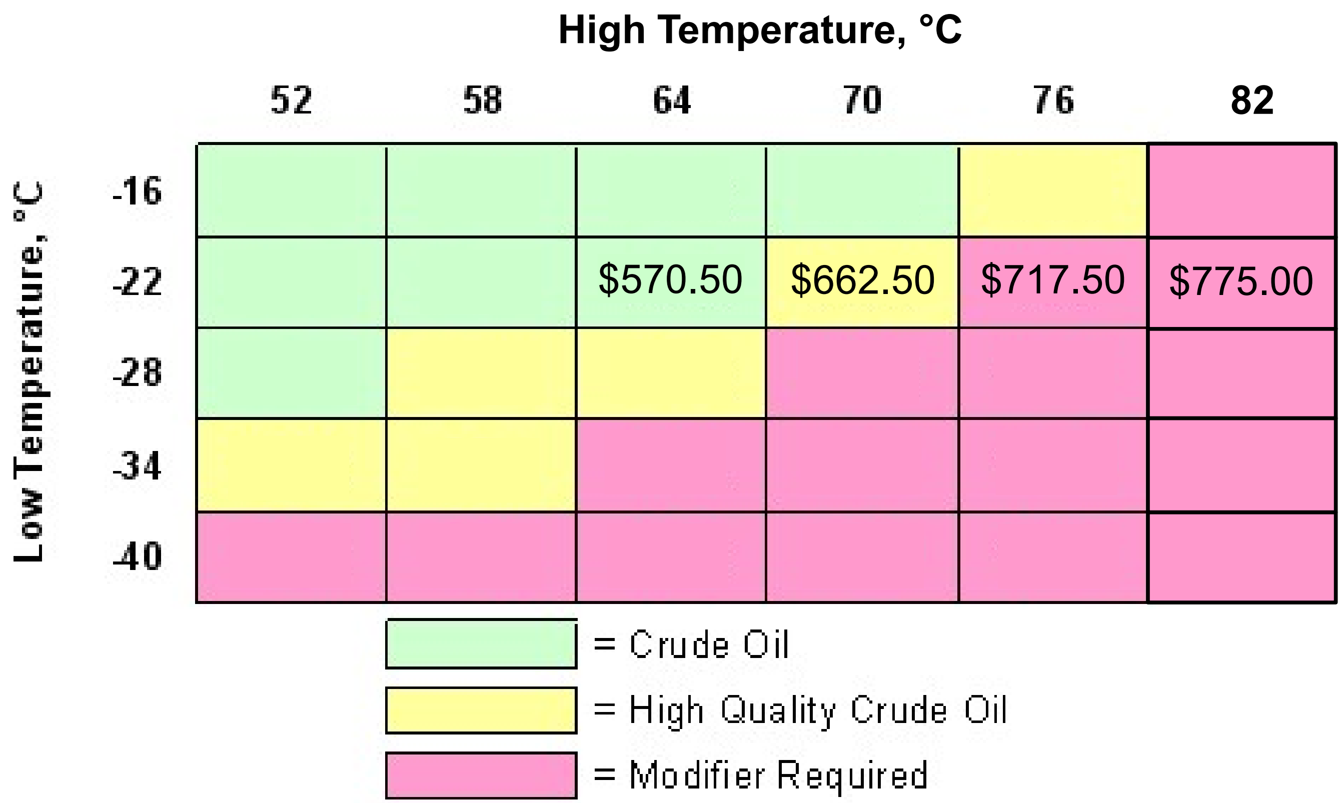
= Modifier Required

Superpave Grading

In Tennessee, back in 2012, a PG 64-22, which is a typical grade used around Memphis, cost $570.50 per ton. A PG 70-22 cost $662.50 (16% more) and a modified PG 76-22 cost $717.50 (26% more). The highest grade, PG 82-22 cost $775.00 per ton, which is 35% more than the plain-vanilla PG 64-22 grade.

(For reference, PG 76-22 was $995 per ton in 2019, so prices have gone up 40% since 2012.)

Binder Cost



Cost per ton based on TDOT reimbursement rates for October 2012

Superpave Grading

Our asphalt temperatures don't get much above 70°C (158°F) in the summer, but there are other reasons to use a higher grade. If the road will see more than 30 million ESALs over the next 20 years, you should bump the high-temperature end up one grade. If the road will see a lot of slow-moving heavy vehicles, you should also bump it up one grade. If there will frequently be stationary loads, you should bump it up two grades.

Grade Bumping

Original Grade	Grade for Slow Transient Loads	Grade for Stationary Loads	20-yr ESALs > 30 million
PG 58-22	PG 64-22	PG 70-22	PG 64-22
PG 64-22	PG 70-22	PG 76-22	PG 70-22
PG 70-22*	PG 76-22	PG 82-22	PG 76-22

*the highest possible pavement temperature in North America is about 70°C but two more high temperature grades were necessary to accommodate transient and stationary loads.

Superpave Grading

So even in Tennessee, it is not uncommon to find paving jobs that use PG 70-22 and PG 76-22 asphalt grades. You will also occasionally see a PG 82-22, though they are infrequent.

Superpave Grading

In summary, Superpave grading corrects many of the problems cited in the last lecture for penetration and viscosity grading. It covers all of the relevant asphalt temperatures and accounts for both short-term and long-term aging of the asphalt cement. And it gives the pavement designer the ability to tailor the asphalt grade to the specific job site and balance cost against performance.