

# SHRP Asphalt Binder Specification

Presented by

Prof. Hamad I. Al-Abdul Wahhab

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

H.A.W

1.7.1

## Superpave Asphalt Binder Specification

The grading system is based on Climate

**PG 70 - 10**

Performance  
Grade

Min pavement  
temperature

Average 7-day max  
pavement temperature

H.A.W

1.7.2

## PG Specifications

- Based on rheological testing (study of flow and deformation)
  - ◆ Asphalt cement is a viscoelastic material
- Behavior depends on:
  - ◆ Temperature
  - ◆ Time of loading
  - ◆ Aging (properties change with time)

H.A.W

1.7.3

## SHRP Asphalt Binder Spec

- **Performance Based**
  - permanent deformation
  - fatigue cracking
  - low temperature cracking
- **Physical Properties**
  - criteria remain the same
  - temperature at which criteria achieved varies
  - measured on aged binder

H.A.W

1.7.4

**ASPHALT GRADING SUMMARY SHEET -  
SHRP BINDER PERFORMANCE SPECIFICATION**

Asphalt ID

Grade	Original	RTFOT	RTFOT + PAV residue					
	Flash Pt. °C (Min: 230 °C) Max: 125 °C (Max: 3000 cP)	Loss % (Max: 1.0%)	Time Temp after PAV 20 HRS @ 110°C					
	Dynamic Shear 10 rads (1.6Hz)	Dynamic Shear 10 rads (1.6Hz)	Dynamic Shear 10 rads (1.6Hz)		Flexural Creep (at 60 sec)		DT* (1mm/min)	
	G* sin δ (kPa) ≥ 1 kPa	G* sin δ (kPa) ≥ 2.2 kPa	Temp °C	G* sin δ (MPa) ≤ 5 MPa	Temp °C	Stiffness, S ≤ 300 MPa	Slope, m ≥ 0.30	F. Strain ≥ 1.0%
PG 58			25		-6			
			22		-12			
			19		-18			
			16		-24			
			13		-30			
PG 64			28		-6			
	✓	✓	25	✓	-12	✓		
			22	✓	-18	x		
			19	x	-24			
			16		-30			
PG 70			24		0			
			31		-6			
	✓	x	28		-12			
			25		-18			
			22		-24			
PG 76			37		0			
	x	x	34		-6			
			31		-12			
			28		-18			
			25		-24			
PG 82			40		0			
			37		-6			
			34		-12			
			31		-18			
			28		-24			

H.A.W

\* Required only if Creep Stiffness(S) is between 300 and 600 Mpa, and m > 0.30

Asphalt Grade : PG

1.7.5

## Miscellaneous Spec Requirements

	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82
<b>ORIGINAL</b>							
(Flash Point) FP							
(Rotational Viscosity) RV							
(Dynamic Shear Rheometer) DSR							
	52	58	58	58	58	58	82
<b>(ROLLING THIN FILM OVEN) RTFO</b>							
(Dynamic Shear Rheometer) DSR							
$G^* \sin \delta \geq 2.20 \text{ kPa}$	52	58	58	58	58	58	82
<b>(PRESSURE AGING VESSEL) PAV</b>							
20 Hours, 2.07 MPa							
	90	100	100	100 (110)	100	100	100
(Dynamic Shear Rheometer) DSR $G^* \sin \delta$							
$\leq 5000 \text{ kPa}$	10	7	4	25	22	22	38
$S \leq 300 \text{ MPa}$ $m \geq 0.300$	10	7	4	25	22	22	38
(Bending Beam Rheometer) BBR "S" Stiffness & "m"-value							
	-24	-30	-34	0	-6	-12	-18
Report Value (Bending Beam Rheometer) BBR Physical Hardening							
$\geq 1.00 \%$							
(Direct Tension) DT							
	-24	-30	-34	0	-6	-12	-18

H.A.W

1.7.6







# Miscellaneous Spec Requirements

- **Pumping and Handling**
  - rotational viscometer
  - controlled by unaged binder vis. @ 135 C  $\leq 3$  Pa-s
- **Safety**
  - flash point COC
  - controlled by flash point  $\geq 230$  C
- **Aging During Hot Mixing/Construction**
  - RTFO
  - controlled by mass loss  $\leq 1.00$  %

H.A.W

1.7.7

# 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	-11	-2	-8	-14	-10	-6	-2	28	34	-10	-16	-22	-28	-34	-40	-46	-14	-10	-6	-2	28	34	-10	-16	-22	-28	-34	-40	-46	-14	-10	-6	-2	28	34
<b>ORIGINAL</b>																																						
 $\geq 230$ °C	(Flash Point) <b>FP</b>																																					
 $\leq 3$ Pa·s @ 135 °C	(Rotational Viscosity) <b>RV</b>																																					
 $\geq 1.00$ kPa	(Dynamic Shear Rheometer) <b>DSR G'/sin δ</b>																																					
	46	52	58	64	70	76	82																															
(ROLLING THIN FILM OVEN) <b>RTFO</b> Mass Loss $\leq 1.00$ %																																						
 $\geq 2.20$ kPa	(Dynamic Shear Rheometer) <b>DSR G'/sin δ</b>																																					
	46	52	58	64	70	76	82																															
(PRESSURE AGING VESSEL) <b>PAV</b>																																						
20 Hours, 2.07 MPa	90	90	100	100	100 (110)	100 (110)	110 (110)																															
 $\leq 5000$ kPa	(Dynamic Shear Rheometer) <b>DSR G' sin δ</b>																																					
	10	7	4	25	22	15	14	11	10	7	2	2	9	6	13	31	28	25	22	19	16	34	31	28	25	22	19	16	37	34	11	28	25	0	17	328		
$S \leq 300$ MPa $m \geq 0.300$	(Bending Beam Rheometer) <b>BBR "S" Stiffness &amp; "m"-value</b>																																					
	-24	-30	-34	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90	-96	-102	-108	-114	-120	-126	-132	-138	-144	-150	-156	-162	-168	-174	-180	-186	-192		
Report Value	(Bending Beam Rheometer) <b>BBR</b> Physical Hardening																																					
 $\geq 1.00$ %	(Direct Tension) <b>DT</b>																																					
	-24	-30	-34	0	-6	-12	-18	-24	-30	-36	-42	-48	-54	-60	-66	-72	-78	-84	-90	-96	-102	-108	-114	-120	-126	-132	-138	-144	-150	-156	-162	-168	-174	-180	-186	-192		

H.A.W

1.7.8

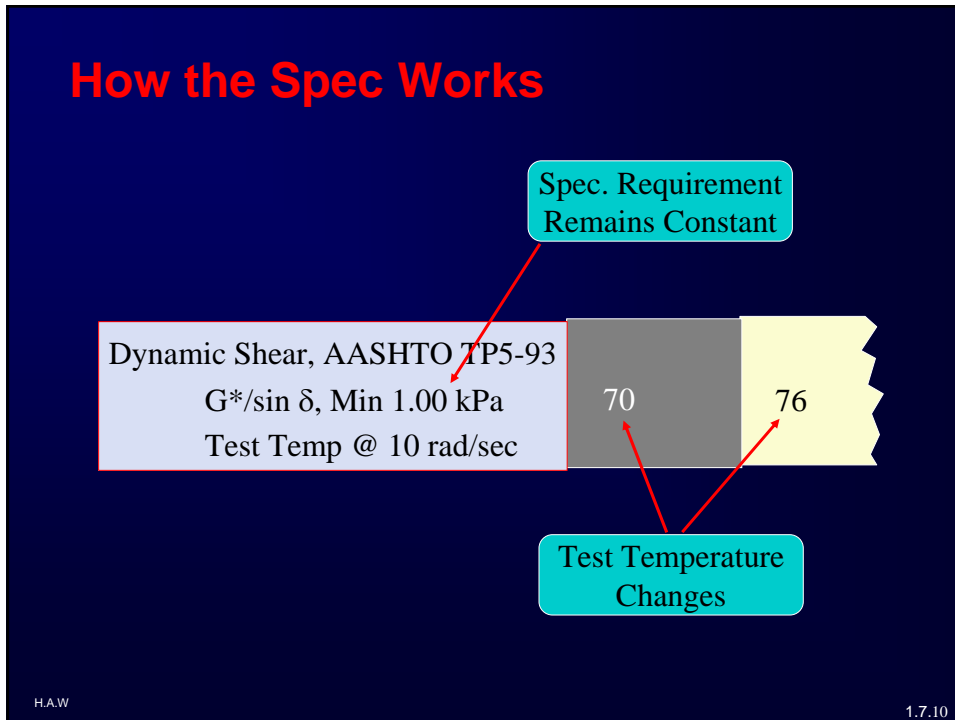
## How the PG Spec Works

**Spec Requirement Remains Constant**

**Test Temperature Changes**

Avg	PG 58	PG 64	PG 70	PG 76	PG 82
1-	0	0	0	0	0
$\geq 230^\circ\text{C}$					
$\leq 3 \text{ Pa}\cdot\text{s @ } 135^\circ\text{C}$					
$\geq 1.00 \text{ kPa}$	46	52	70	76	82
$\geq 2.20 \text{ kPa}$	46	52	70	76	82
20 Hours, 2.07			100 (110)	100 (110)	110 (110)
$\leq 5000$					
$S \leq 300 \text{ MPa}$ $m \geq 0.300$					
Report Value					
$\geq 1.00 \%$					

## How the Spec Works



## Permanent Deformation



Function of warm weather and traffic

H.A.W

1.7.11

## High Temperature Behavior

- High in-service temperature
    - ◆ Desert climates
    - ◆ Summer temperatures
  - Sustained loads
    - ◆ Slow moving trucks
    - ◆ Intersections
- ➡ *Viscous Liquid*

H.A.W

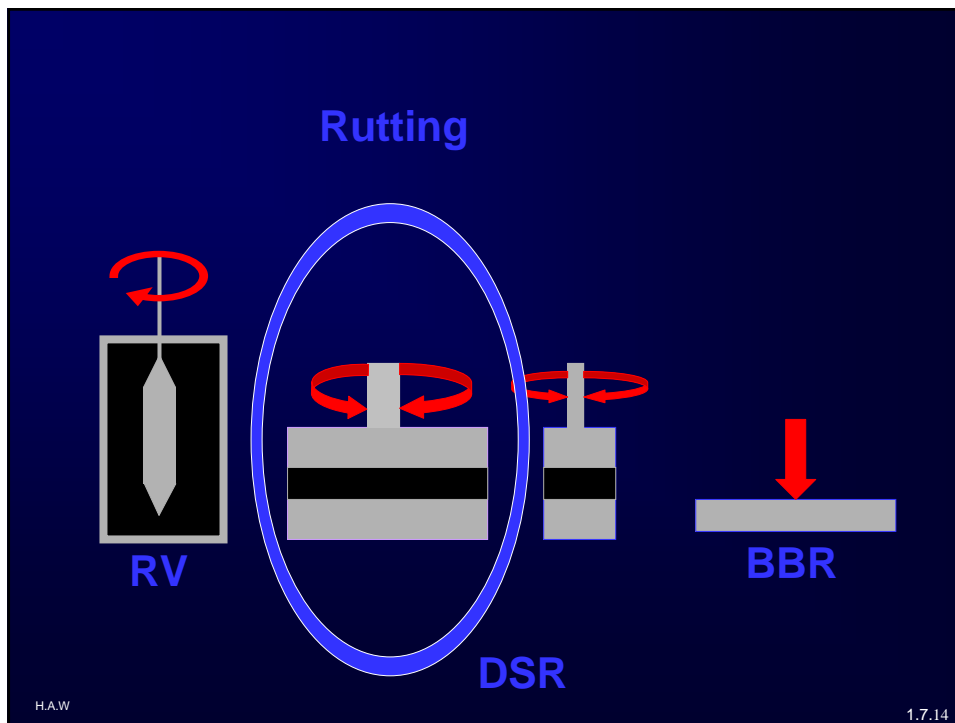
1.7.12

## Pavement Behavior (Warm Temperatures)

- Permanent deformation (rutting)
- Mixture is plastic
- Depends on asphalt source, additives, and aggregate properties

H.A.W

1.7.13



H.A.W

1.7.14





## Permanent Deformation

- Addressed by high temp stiffness
  - ◆  $G^*/\sin \delta$  on unaged binder  $\geq 1.00$  kPa
  - ◆  $G^*/\sin \delta$  on RTFO aged binder  $\geq 2.20$  kPa



**For the early part  
of the service life**

H.A.W

1.7.17

## Permanent Deformation

Question: Why a minimum  $G^*/\sin \delta$  to address rutting

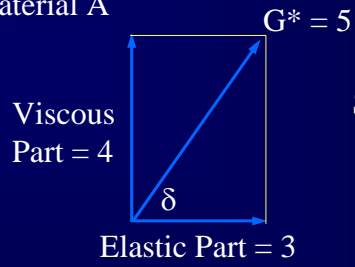
Answer: We want a *stiff, elastic* binder to contribute to mix rutting resistance

How: By increasing  $G^*$  or decreasing  $\delta$

H.A.W

1.7.18

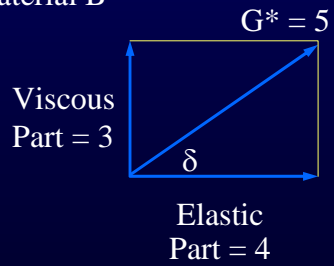
Material A



$$\sin \delta = \frac{\text{Viscous Part}}{G^*} = \frac{4}{5}$$

$$\frac{G^*}{\sin \delta} = \frac{5}{4/5} = 6.25$$

Material B



$$\sin \delta = \frac{\text{Viscous Part}}{G^*} = \frac{3}{5}$$

$$\frac{G^*}{\sin \delta} = \frac{5}{3/5} = 8.33$$

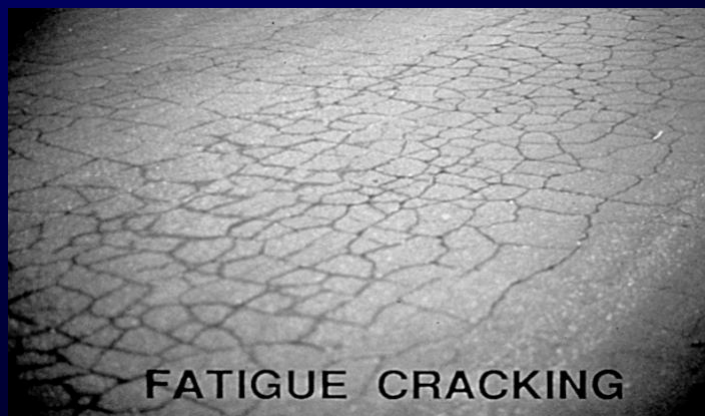
Large value means behaves more like elastic solid

H.A.W

1.7.19

## Fatigue Cracking

Function of repeated traffic loads over time  
(in wheel paths)

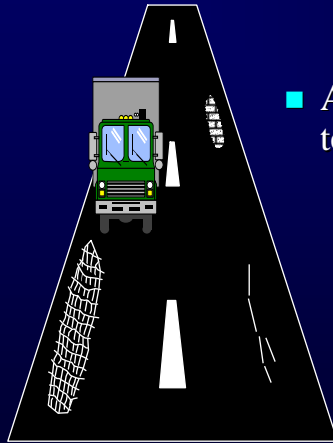


FATIGUE CRACKING

H.A.W

1.7.20

# Fatigue Cracking



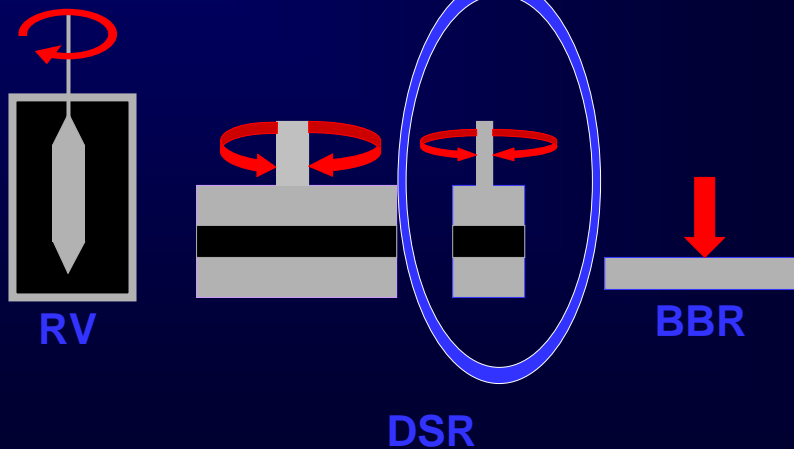
- Addressed by intermediate temperature stiffness
- ◆  $G^* \sin \delta$  on RTFO + PAV aged binder  $\leq 5000$  kPa

> *Later part of pavement service life*

H.A.W

1.7.21




## Fatigue

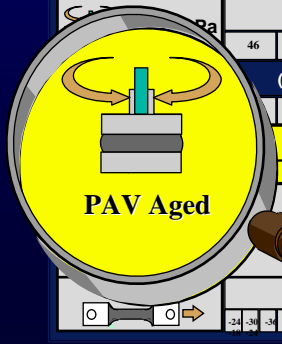


H.A.W

1.7.22

# Fatigue Cracking

Avg 7-day Max, °C	PG 46	PG 52	PG 58	PG 64	PG 70	PG 76	PG 82																					
1-day Min, °C	-34 -28	-40 -34	-46 -40	-52 -46	-58 -52	-64 -58	-70 -64	-76 -70	-82 -76																			
<b>ORIGINAL</b>																												
 ≥ 230 °C	(Flash Point) <b>FP</b>																											
 ≤ 3 Pa·s @ 135 °C	(Rotational Viscosity) <b>RV</b>																											
 ≥ 1.00 kPa	(Dynamic Shear Rheometer) <b>DSR</b> G'/sin δ																											
	46	52	58	64	70	76	82																					
<b>(ROLLING THIN FILM OVEN) RTFO</b> Mass Loss ≤ 1.00 %																												
	(Dynamic Shear Rheometer) <b>DSR</b> G'/sin δ																											
	46	52	58	64	70	76	82																					
<b>(PRESSURE AGING VESSEL) PAV</b>																												
	90	100	100	100 (110)	100 (110)	110 (110)																						
	(Dynamic Shear Rheometer) <b>DSR</b> G' sin δ																											
	25	25	19	14	11	11	7	6	3	31	28	25	22	19	16	34	31	28	25	21	17	5	7	38				
	(Bending Beam Rheometer) <b>BBR</b> "S" Stiffness & "m"-value																											
	12	12	8	5	2	2	8	24	30	6	12	18	24	30	0	6	12	18	24	30	0	6	12	18	24	0	6	12
	(Bending Beam Rheometer) <b>BBR</b> Physical Hardening																											
	(Direct Tension) <b>DT</b>																											
	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	0	6	12



1.7.23

**Specification requirement  
To control fatigue cracking**

**Dynamic Shear, TP5:  
G\* sin δ, Max 5000 kPa  
Test Temp @ 10 rad/sec, C**

H.A.W

1.7.24

# Fatigue Cracking

- Question: Why a **maximum**  $G^* \sin \delta$  to address fatigue?

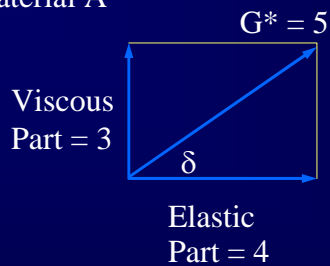
Answer: We want a *soft elastic* binder (to sustain many loads without cracking)

How: By decreasing  $G^*$  or decreasing  $\delta$

H.A.W

1.7.25

Material A

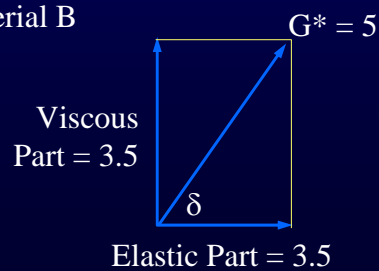


$$\sin \delta = \frac{\text{Viscous Part}}{G^*} = \frac{3}{5}$$

$$G^* \sin \delta = 5 \times 3/5 = 3$$

Smaller value means Better at dissipating stress

Material B



$$\sin \delta = \frac{\text{Viscous Part}}{G^*} = \frac{3.5}{5}$$

$$G^* \sin \delta = 5 \times 3.5/5 = 3.5$$

H.A.W

1.7.26

## Low Temperature Behavior

- Low Temperature

- ◆ Cold climates
- ◆ Winter



*Elastic Solid*

H.A.W

1.7.27

## Pavement Behavior (Low Temperatures)

- Thermal cracks

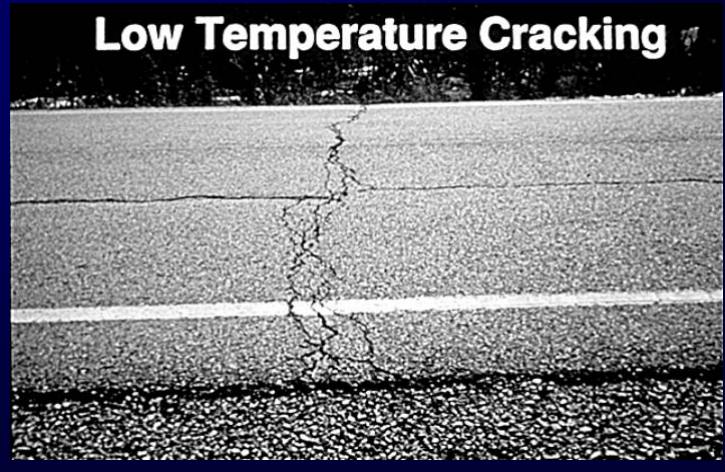
- ◆ Stress generated by contraction due to drop in temperature
- ◆ Crack forms when thermal stresses exceed ability of material to relieve stress through deformation
  - ◆ Material is brittle

- Depends on source of asphalt and aggregate properties

H.A.W

1.7.28

# Thermal Cracking



H.A.W

1.7.29

## Low Temperature Cracking

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	-52	-58	-64	-70
	-28	-34	-40	-46	-52	-58	-64
	-22	-28	-34	-40	-46	-52	-58
	-16	-22	-28	-34	-40	-46	-52
	-10	-16	-22	-28	-34	-40	-46
	-4	-10	-16	-22	-28	-34	-40
	2	-4	-10	-16	-22	-28	-34
	8	2	-4	-10	-16	-22	-28
	14	8	2	-4	-10	-16	-22
	20	14	8	2	-4	-10	-16
	26	20	14	8	2	-4	-10
	32	26	20	14	8	2	-4
	38	32	26	20	14	8	2
	44	38	32	26	20	14	8
	50	44	38	32	26	20	14
	56	50	44	38	32	26	20
	62	56	50	44	38	32	26
	68	62	56	50	44	38	32
	74	68	62	56	50	44	38
	80	74	68	62	56	50	44
	86	80	74	68	62	56	50
	92	86	80	74	68	62	56
	98	92	86	80	74	68	62
	104	98	92	86	80	74	68
	110	104	98	92	86	80	74
	116	110	104	98	92	86	80
	122	116	110	104	98	92	86
	128	122	116	110	104	98	92
	134	128	122	116	110	104	98
	140	134	128	122	116	110	104
	146	140	134	128	122	116	110
	152	146	140	134	128	122	116
	158	152	146	140	134	128	122
	164	158	152	146	140	134	128
	170	164	158	152	146	140	134
	176	170	164	158	152	146	140
	182	176	170	164	158	152	146
	188	182	176	170	164	158	152
	194	188	182	176	170	164	158
	200	194	188	182	176	170	164
	206	200	194	188	182	176	170
	212	206	200	194	188	182	176
	218	212	206	200	194	188	182
	224	218	212	206	200	194	188
	230	224	218	212	206	200	194
	236	230	224	218	212	206	200
	242	236	230	224	218	212	206
	248	242	236	230	224	218	212
	254	248	242	236	230	224	218
	260	254	248	242	236	230	224
	266	260	254	248	242	236	230
	272	266	260	254	248	242	236
	278	272	266	260	254	248	242
	284	278	272	266	260	254	248
	290	284	278	272	266	260	254
	296	290	284	278	272	266	260
	302	296	290	284	278	272	266
	308	302	296	290	284	278	272
	314	308	302	296	290	284	278
	320	314	308	302	296	290	278
	326	320	314	308	302	296	290
	332	326	320	314	308	302	296
	338	332	326	320	314	308	302
	344	338	332	326	314	308	302
	350	344	338	332	314	308	302
	356	350	344	338	314	308	302
	362	356	350	344	314	308	302
	368	362	356	350	314	308	302
	374	368	362	356	314	308	302
	380	374	368	362	314	308	302
	386	380	374	368	314	308	302
	392	386	380	374	314	308	302
	398	392	386	380	314	308	302
	404	398	392	386	314	308	302
	410	404	398	392	314	308	302
	416	410	404	398	314	308	302
	422	416	410	404	314	308	302
	428	422	416	410	314	308	302
	434	428	422	416	314	308	302
	440	434	428	416	314	308	302
	446	440	434	416	314	308	302
	452	446	440	416	314	308	302
	458	452	446	416	314	308	302
	464	458	452	416	314	308	302
	470	464	458	416	314	308	302
	476	470	464	416	314	308	302
	482	476	470	416	314	308	302
	488	482	476	416	314	308	302
	494	488	482	416	314	308	302
	500	494	488	416	314	308	302
	506	500	494	416	314	308	302
	512	506	500	416	314	308	302
	518	512	506	416	314	308	302
	524	518	512	416	314	308	302
	530	524	518	416	314	308	302
	536	530	524	416	314	308	302
	542	536	530	416	314	308	302
	548	542	536	416	314	308	302
	554	548	542	416	314	308	302
	560	554	548	416	314	308	302
	566	560	554	416	314	308	302
	572	566	560	416	314	308	302
	578	572	566	416	314	308	302
	584	578	572	416	314	308	302
	590	584	578	416	314	308	302
	596	590	584	416	314	308	302
	602	596	590	416	314	308	302
	608	602	596	416	314	308	302
	614	608	602	416	314	308	302
	620	614	608	416	314	308	302
	626	620	614	416	314	308	302
	632	626	620	416	314	308	302
	638	632	626	416	314	308	302
	644	638	632	416	314	308	302
	650	644	638	416	314	308	302
	656	650	644	416	314	308	302
	662	656	650	416	314	308	302
	668	662	656	416	314	308	302
	674	668	662	416	314	308	302
	680	674	668	416	314	308	302
	686	680	674	416	314	308	302
	692	686	680	416	314	308	302
	698	692	686	416	314	308	302
	704	698	692	416	314	308	302
	710	704	698	416	314	308	302
	716	710	704	416	314	308	302
	722	716	710	416	314	308	302
	728	722	716	416	314	308	302
	734	728	722	416	314	308	302
	740	734	728	416	314	308	302
	746	740	734	416	314	308	302
	752	746	740	416	314	308	302
	758	752	746	416	314	308	302
	764	758	752	416	314	308	302
	770	764	758	416	314	308	302
	776	770	764	416	314	308	302
	782	776	770	416	314	308	302
	788	782	776	416	314	308	302
	794	788	782	416	314	308	302
	800	794	788	416	314	308	302
	806	800	794	416	314	308	302
	812	806	800	416	314	308	302
	818	812	806	416	314	308	302
	824	818	812	416	314	308	302
	830	824	818	416	314	308	302
	836	830	824	416	314	308	302
	842	836	830	416	314	308	302
	848	842	836	416	314	308	302
	854	848	842	416	314	308	302
	860	854	848	416	314	308	302
	866	860	854	416	314	308	302
	872	866	860	416	314	308	302
	878	872	866	416	314	308	302
	884	878	872	416	314	308	302
	890	884	878	416	314	308	302
	896	890	884	416	314	308	302
	902	896	890	416	314	308	302
	908	902	896	416	314	308	302
	914	908	902	416	314	308	302
	920	914	908	416	314	308	302
	926	920	914	416	314	308	302
	932	926	920	416	314	308	302
	938	932	926	416	314		





## Low Temperature Cracking

- **Controlled by**

- **S** on RTFO/PAV aged materials  $\leq 300$  kPa
- **m-value** on RTFO/PAV aged materials  $\geq 0.300$

- **Alternate Control**

- **S** on RTFO/PAV aged materials **300 – 600 MPa**
- **m-value** on RTFO/PAV aged materials  $\geq 0.300$
- **tensile failure strain** on RTFO/PAV aged materials  $\geq 1.0\%$

H.A.W

1.7.33

## Effect of Loading Rate on Binder Selection



- **Dilemma**

- ◆ specified DSR loading rate is 10 rad/sec (90kph)
- ◆ what about longer loading times ?

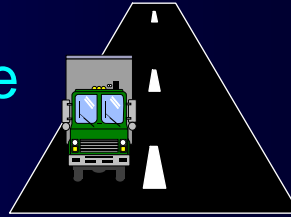
- **Use binder with more stiffness at higher temps**

- ◆ slow - - increase one high temp grade
- ◆ stationary - - increase two high temp grades
- ◆ *no effect on low temp grade*

H.A.W

1.7.34

## Effect of Loading Rate on Binder Selection



- Example
  - ◆ for toll road
  - ◆ for toll booth
  - ◆ for weigh stations

PG 64-22

PG 70-22

PG 76-22

90 kph

Slow

Stopping

H.A.W

1.7.35

## Effect of Traffic Amount on Binder Selection



- 10 - 30 x 10<sup>6</sup> ESAL
  - ◆ Consider increasing - - one high temp grade
- 30 x 10<sup>6</sup> + ESAL
  - ◆ Recommend increasing - - one high temp grade

**Equivalent Single Axle Loads**

H.A.W

1.7.36

*New Binder Selection Adjustments for Traffic Level and Speed MP2*

Design ESAL's <sup>(1)</sup> (Millions)	Adjustment to Binder PG Grade <sup>(2)</sup>		
	Traffic Load Rate		
	Standing (Avg. Speed < 20 km/hr)	Slow (Avg. Speed 20 to 70 km/hr)	Avg. Speed > 70 km/hr
< 0.3	- <sup>(3)</sup>	-	-
0.3 to < 3	2	1	-
3 to < 10	2	1	-
10 to < 30	2	1	- <sup>(3)</sup>
≥ 30	2	1	1

- (1) Design ESAL's are anticipated project traffic level expected on the design lane over a 20 years period. Regardless of the actual design life of the roadway, determine the design ESAL's for 20 years and choose appropriate  $N_{design}$  level.
- (2) Increases the high temperature grade by the number of grade equivalents indicate (1 grade equivalent to 6°C).
- (3) Consideration should be given to increasing the high temperature grade by 1 grade equivalent.

H.A.W

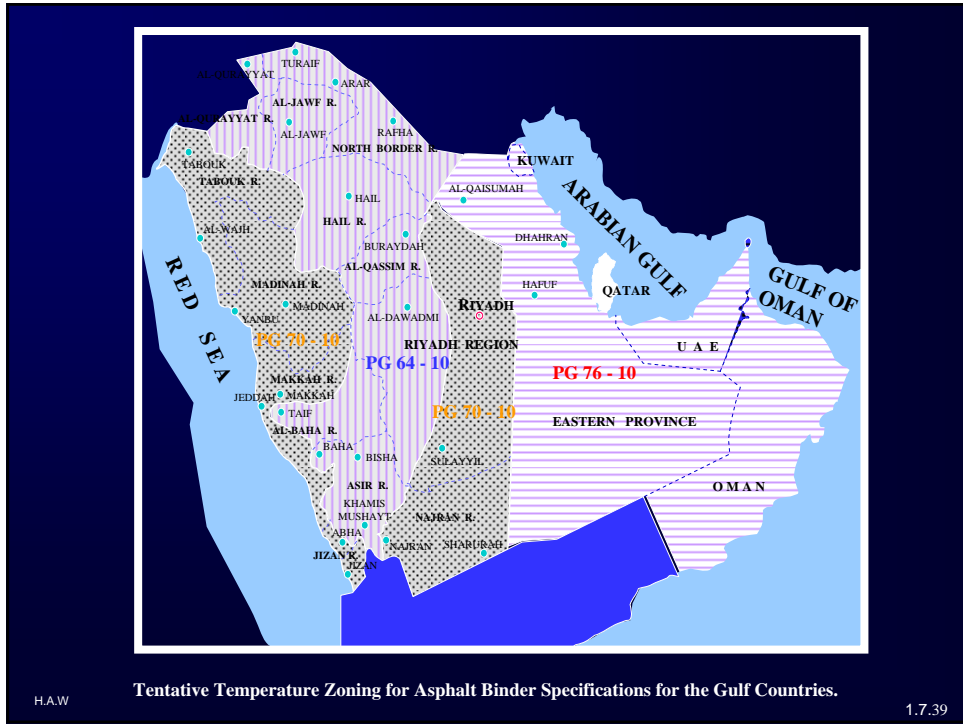
1.7.37

## Summary of How to Use PG Specification

- Determine
  - ◆ 7-day max pavement temperatures
  - ◆ 1-day minimum pavement temperature
- Use specification tables to select test temperatures
- Determine asphalt cement properties and compare to specification limits

H.A.W

1.7.38



**ASPHALT GRADING SUMMARY SHEET - SHRP BINDER PERFORMANCE SPECIFICATION**

Asphalt ID

Grade	Original	RTFOT	RTFOT + PAV residue					
	Flash Pt. (Min: 230 °C) (Max: 125 °C) (Max: 3000 cP)	Loss % (Max: 1.0%)	Time Temp after PAV 20 HRS @ 110°C					
	Dynamic Shear 10(rads (1.6Hz))	Dynamic Shear 10(rads (1.6Hz))	Dynamic Shear 10(rads (1.6Hz))		Flexural Creep (at 60 sec)		DT* (1mm/min)	
G* sinδ (kPa) > 1.4 kPa	G* sinδ (kPa) > 2.2 kPa	Temp °C	G* sinδ (MPa) < 5 MPa	Temp °C	Stiffness, S < 300 MPa	Slope, m > 0.30	F. Strain > 1.0%	
PG 58	2.7		25		-6			
			22		-12			
			19		-18			
			16		-24			
			13		-30			
PG 64	1.6	3.1	28	3.55	-6	193.5	0.308	
			25	4.64	-12	256.1	0.602	
			22	5.12	-18	Failed	Failed	
			19		-24			
			16		-30			
PG 70	0.82		34		0			
			31		-6			
			28		-12			
			25		-18			
			22		-24			
PG 76			37		0			
			34		-6			
			31		-12			
			28		-18			
PG 82			40		0			
			37		-6			
			34		-12			
			31		-18			

Required only if Creep Stiffness(S) is between 300 and 600 Mpa, and m>0.30

Asphalt Grade : PG 64-16

H.A.W 1.7.40

**ASPHALT GRADING SUMMARY SHEET -  
SHRP BINDER PERFORMANCE SPECIFICATION**

Asphalt ID

Grade	Original	RTFOT	RTFOT + PAV residue					
	Flash Pt. °C (Min: 230 °C) Max: 125 °C (Max: 3000 cP)	Loss % (Max: 1.0%)	Time Temp after PAV 20 HRS @ 110°C					
	Dynamic Shear 10 rads (1.6Hz)	Dynamic Shear 10 rads (1.6Hz)	Dynamic Shear 10 rads (1.6Hz)		Flexural Creep (at 60 sec)		DT * (mm/min)	
	G* sinδ (kPa) > 1 kPa	G* sinδ (kPa) > 2.2 kPa	Temp °C	G* sinδ (MPa) < 5 MPa	Temp °C	Stiffness, S < 300 MPa	Slope, m > 0.30	F. Strain > 1.0%
PG 58			25		-6			
			22		-12			
			19		-18			
			16		-24			
			13		-30			
PG 64	3.4		28		-6			
			25		-12			
			22		-18			
			19		-24			
			16		-30			
PG 70	2.3		24		0			
			31		-6			
			28		-12			
			25		-18			
			22		-24			
PG 76	1.5	2.4	37	3.62	0	95.18	0.312	
			34	4.18	-6	170.8	0.270	
			31	5.2	-12	Failed	Failed	
			28		-18			
			25		-24			
PG 82	0.9		40		0			
			37		-6			
			34		-12			
			31		-18			
			28		-24			

H.A.W

Required only if Creep Stiffness(S) is between 300 and 600 Mpa, and m>0.30

Asphalt Grade : PG 76-10

1.7.41

# THANK YOU

H.A.W

1.7.42