Statewide Implementation of the SPG Specification for Chip Seal Binders in Service

TxDOT Implementation Project 5-6616

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WASHTO
Subcommittee on Materials & Construction

OUTLINE

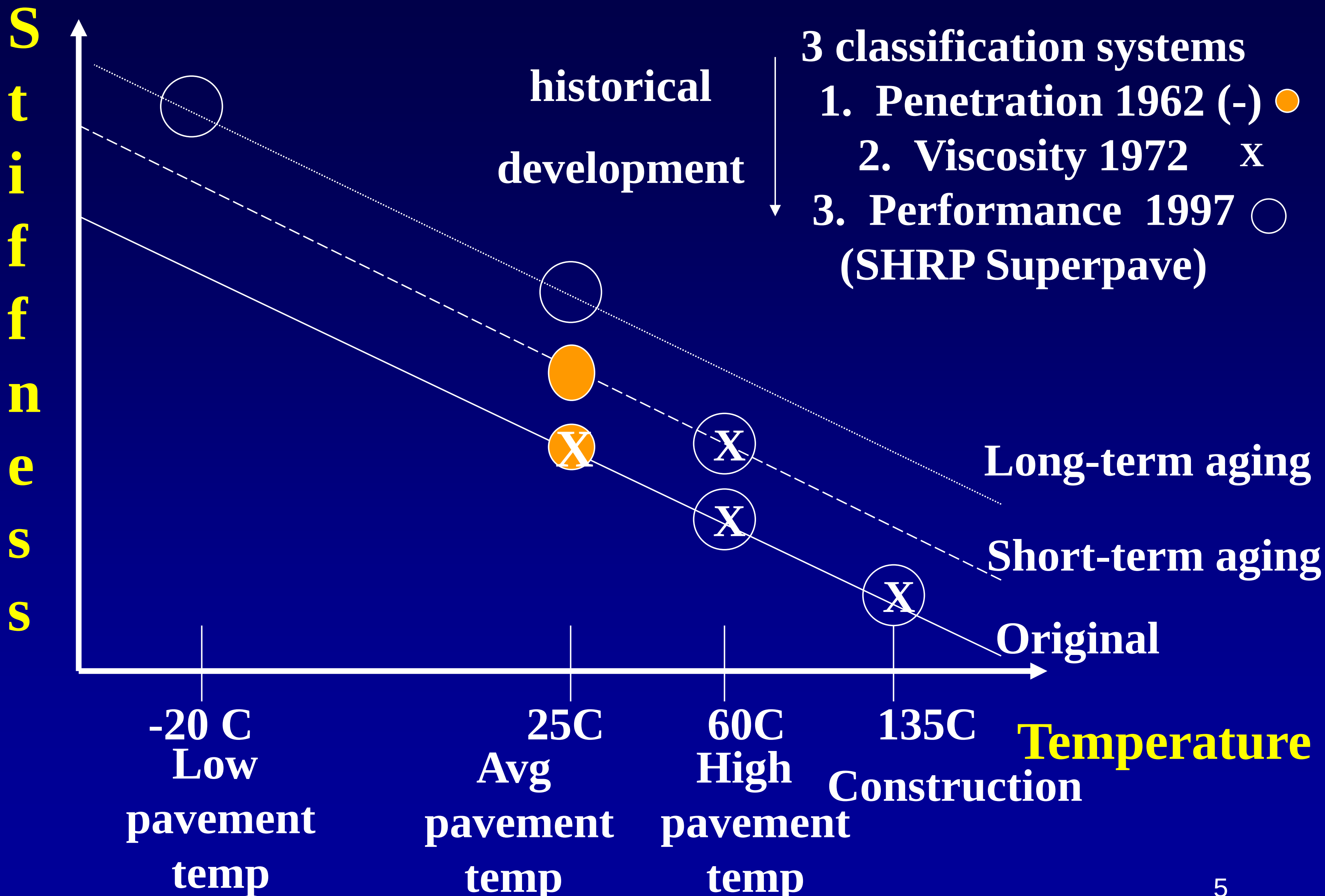
- Motivation & Objective
- Recommended SPG Specification
- Work Plan (Implementation Project Progress)
- The End of the World?

MOTIVATION & OBJECTIVE

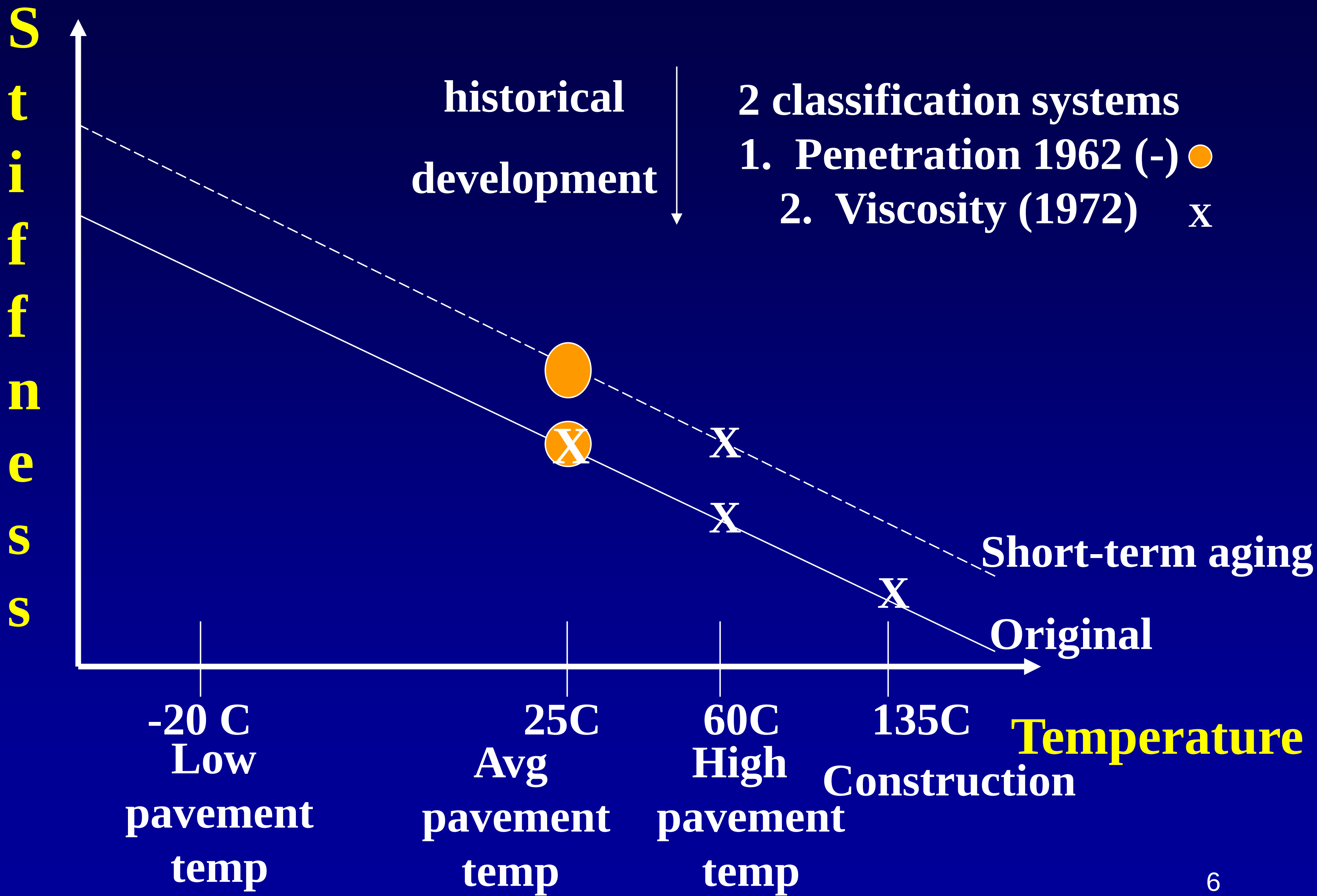
- Increase performance and reduce cost
- Improve chip seal binder spec & selection
  - performance-related tests
  - @ temperatures that cover entire ***in service*** range for specific climate
  - consider aging during critical 1st year
  - reduce variability in grades
  - possibly adjust due to traffic
- Implement SPG in TX in 4 year, staged effort
  - Replace Seal Coat Binder Tier Selection Table & Item 300 Seal Coat Binder Properties ***in service***

Asphalt Binder Specification History

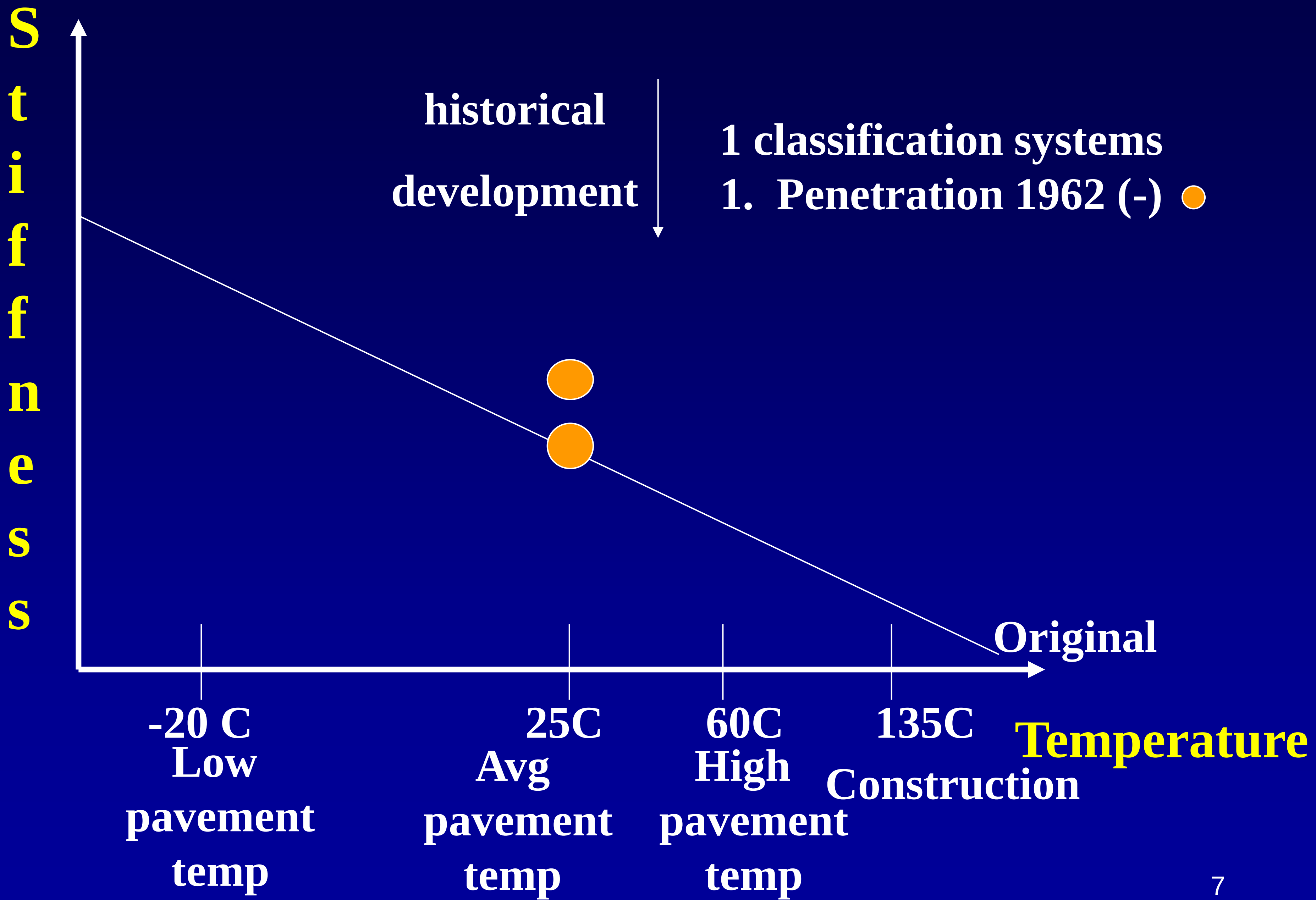
Classification of Asphalt Binders - HMA



Classification of Asphalt Binders – AC Chip Seal



Classification of Asphalt Binders – Chip Seal Emulsions

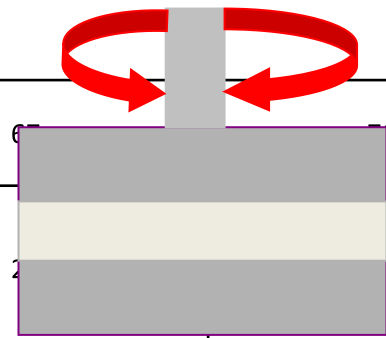


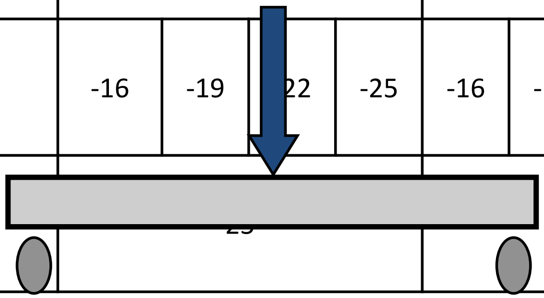
DEVELOPMENT OF SPG

- TxDOT Research Project 0-1710 (45 field sections)
- TxDOT Research Project 0-6616 (30 field sections)
- NCHRP Research Project 14-17 (3 field sections)
- SPG spec for chip seal binders ***in service***
  - Method B for emulsion residue recovery
  - + shear strain sweep with new threshold
  - X m-value
  - MSCR not added
- SPG specification part of system to be used ***with***
  - design guidelines
  - quality control procedures
  - construction techniques

RECOMMENDED SPG w/AASHTO Standards

with PP 72 Method B Recovery FP ≥ 230 by T 48 RV ≤ 0.15 Pa*s @ 205°C by T 316	**Performance Grade**											
	SPG 67				**SPG 70**				**SPG 73**			
	-16	**-19**	**-22**	**-25**	**-16**	**-19**	**-22**	**-25**	**-16**	**-19**	**-22**	**-25**
Average 7-day Maximum Surface Pavement Design Temperature, °C	<67				<70				<73			
Minimum Surface Pavement Design Temperature, °C	>-16	>-19	>-22	>-25	>-16	>-19	>-22	>-25	>-16	>-19	>-22	>-25
Original Binder												
Dynamic Shear, T315 G*/Sinδ Minimum: 0.65 kPa Test Temperature @10 rad/s, °C	6[illegible]				[illegible]0				[illegible]			
Shear Strain Sweep, T 315 % strain @ 0.8G_i*, Minimum: 17.5 Test Temperature @10 rad/s linear loading from 1-50% strain, 1 sec delay time with 20-30 measurements, °C	2[illegible]				[illegible]5				[illegible]			
Pressure Aging Vessel (PAV) Residue (AASHTO PP1)												
PAV Aging Temperature, °C	100				100				[illegible]			
Creep Stiffness, T 313 S, Maximum: 500 MPa Test Temperature @ 8s, °C	-16	-19	[illegible]22	-25	-16	-19	-22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dynamic Shear, T 315 G*, Maximum: 2.5 MPa Test Temperature @10 rad/s, °C	2[illegible]				25				[illegible]			





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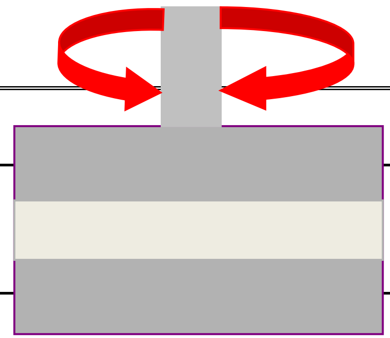
RECOMMENDED SPG w/AASHTO Stnds

with **AASHTO PP 72 Method B Recovery** FP ≥ 230 by T 48 RV ≤ 0.15 Pa*s @ 205°C by T 316	Performance Grade			
	SPG 70			
	-16	-19	-22	-25
Avg 7-day Max Surface Pavement T, °C	<70			
Min Surface Pavement T, °C	>-16	>-19	>-22	>-25

- Method B for Emulsion Residue Recovery
  - Thin Film on Silicone Mat
  - 60 °C for 6 hrs

Texas Department of Transportation

RECOMMENDED SPG w/AASHTO Stnds



	Performance Grade			
	SPG 70			
	-16	**-19**	**-22**	**-25**
	<70			
	>-16	>-19	>-22	>-25
Original Binder				
G*/Sinδ ≥ 0.65 kPa by T 315 **Test Temperature @ 10rad/s, °C**	70			
$0.8G_i^*$ ≥ 17.5% strain by T 315 **Test Temperature @ 10rad/s w/ 1-50%, °C**	25			

+ $\delta \leq 80$ where G*/sin $\delta = 0.65$ kPa for UTI ≥ 89

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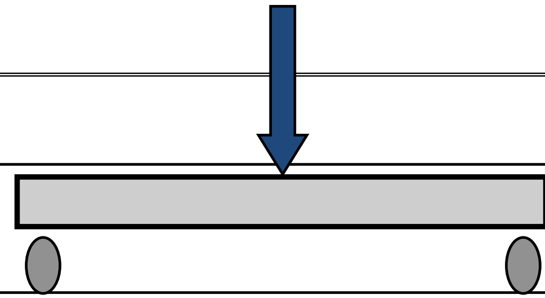
RECOMMENDED SPG w/AASHTO Stnds

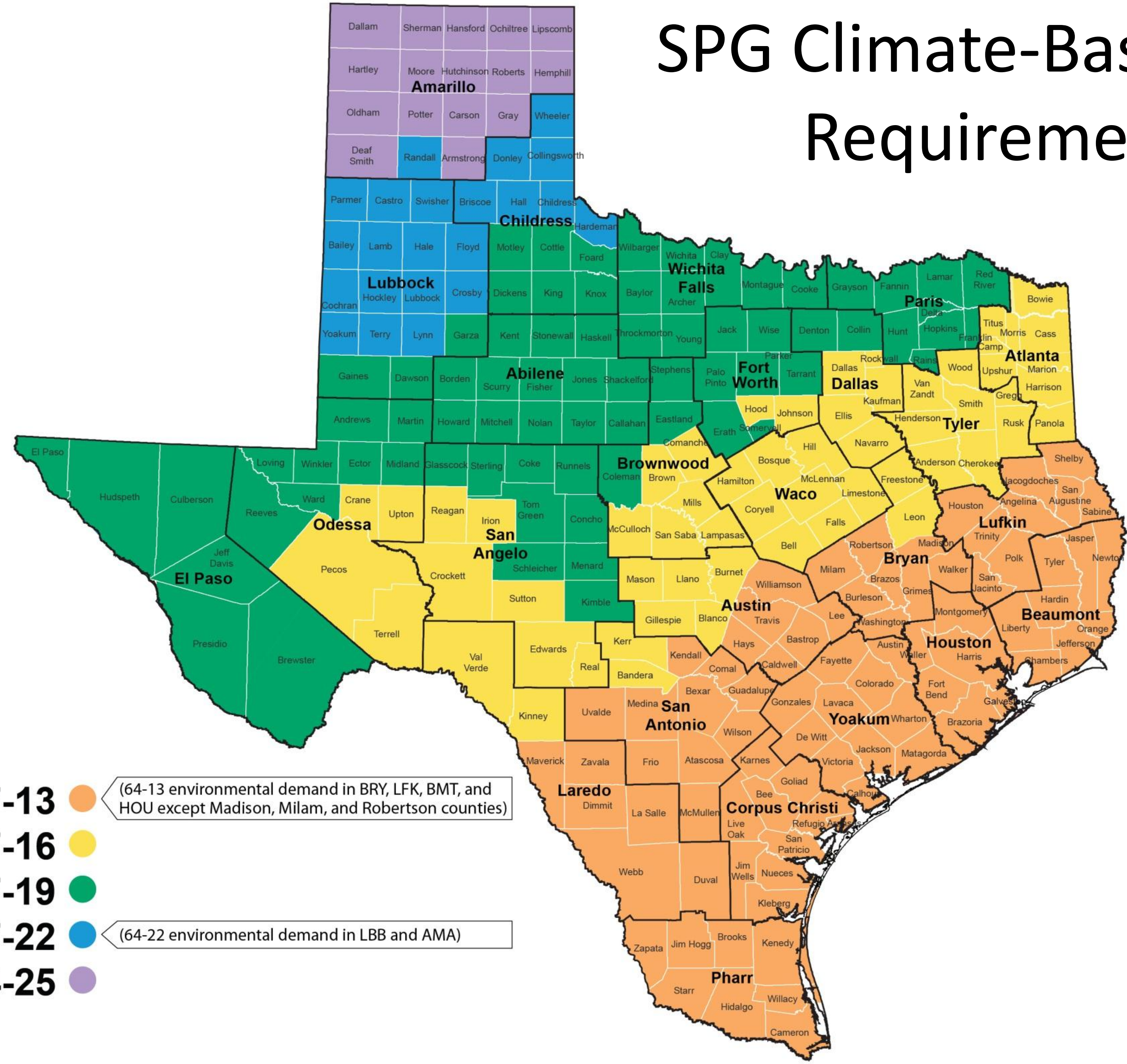


	Performance Grade			
	SPG 70			
	-16	**-19**	**-22**	**-25**
	<70			
	>-16	>-19	>-22	>-25
PAV Residue				
S ≤ 500 MPa by T 313 **Test Temperature @ *8s*, °C**	-16	-19	-22	-25
G* ≤ 2.5 MPa by T 315 **Test Temperature @10 rad/s, °C**	25			

WORK PLAN

- Conduct Technical Briefings w/TxDOT & Industry
  - User-Producer Group
  - Association of General Contractors (AGC) of TX
  - Texas Asphalt Pavement Association (TxAPA)
  - Industry
  - TxDOT
- Determine SPG Requirements in TX based on climate
  - Adjust based on traffic or service level (T_{high}) or other considerations (T_{low})

SPG Climate-Based Requirements



67-13 (64-13 environmental demand in BRY, LFK, BMT, and HOU except Madison, Milam, and Robertson counties)

67-16

67-19

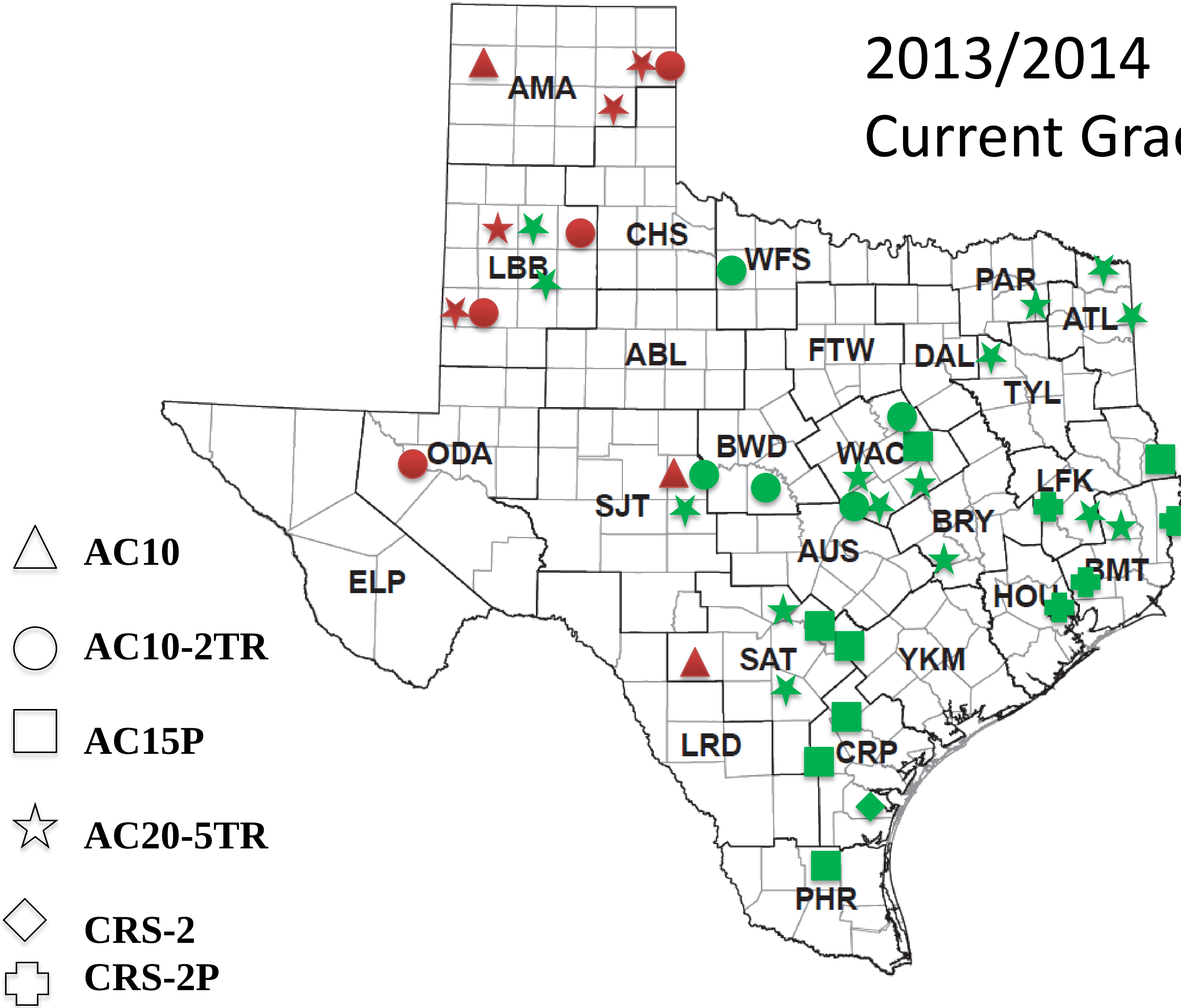
67-22 (64-22 environmental demand in LBB and AMA)

64-25

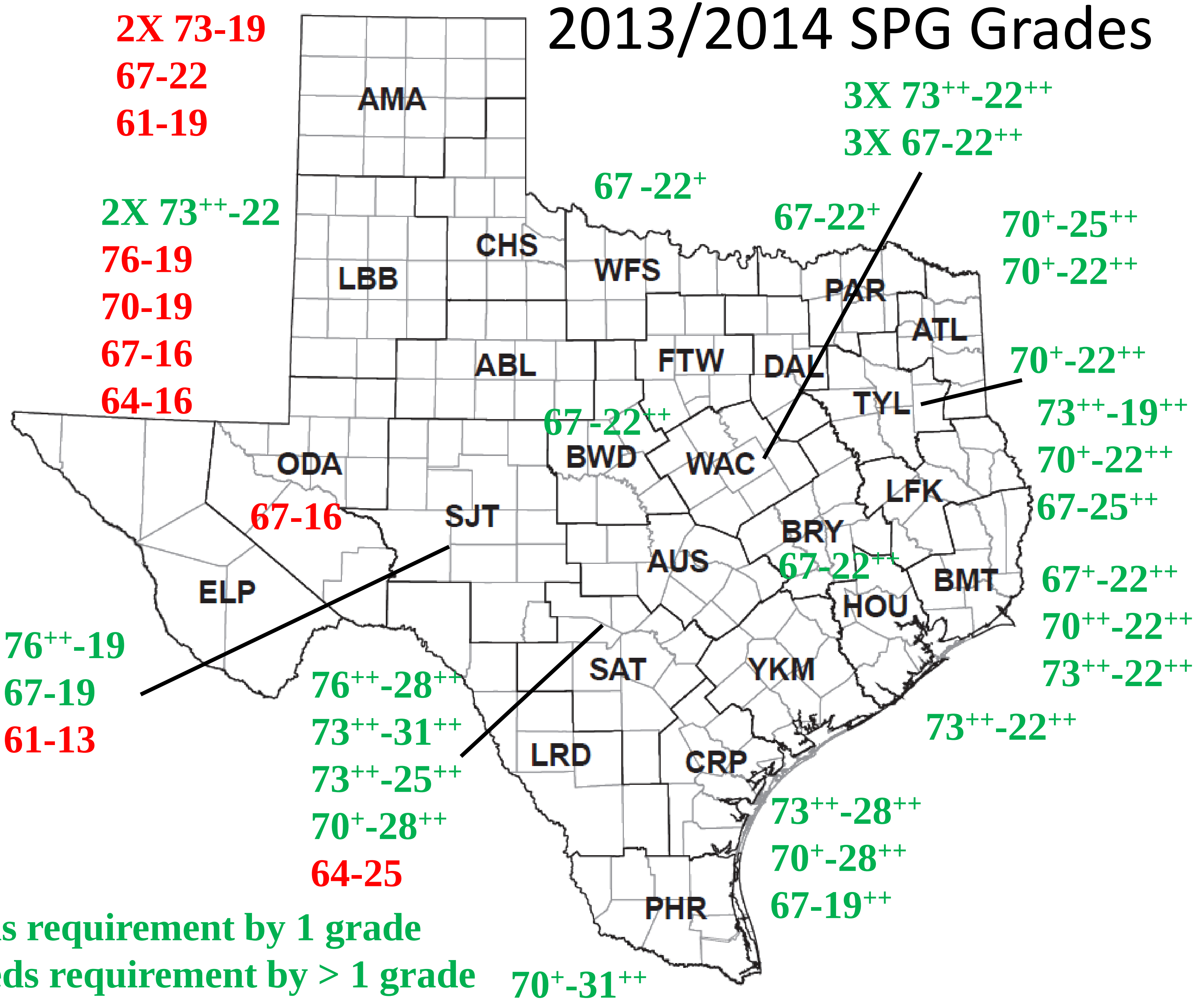
WORK PLAN

- Determine SPG Grades & Monitor Performance near construction & @ 1-year (including embedment depth)
  - 2013 - 29 binders & 19 sections
  - 2014 - 16 binders & 14 sections & Shadow Spec
  - 2015 - ~20 sections in ≥ 2 districts
  - 2016 - ~15 sections statewide

2013/2014 Current Grades



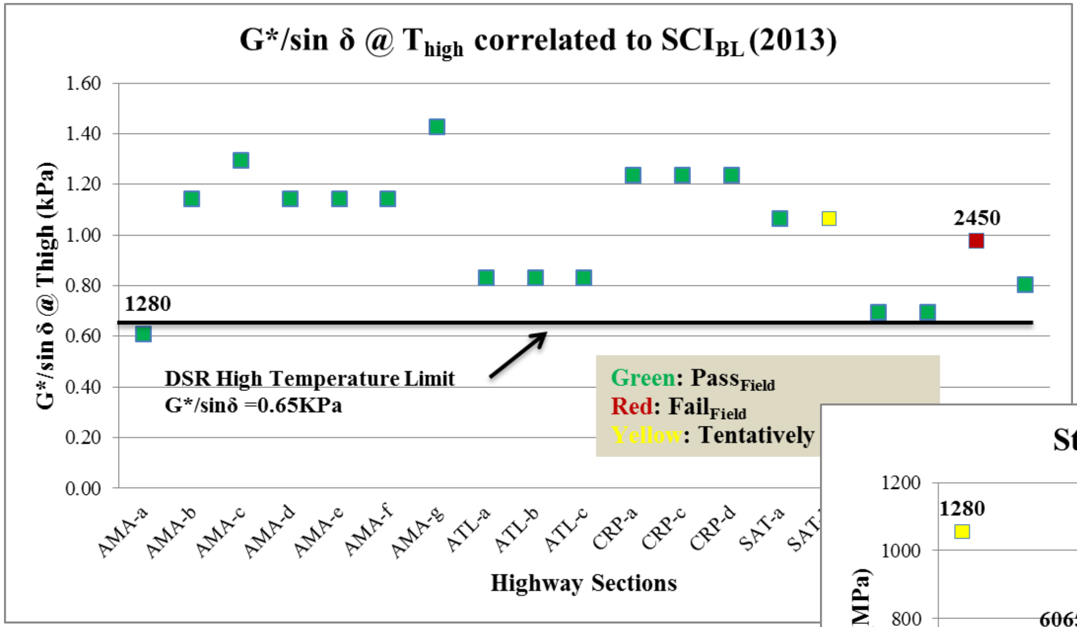
2013/2014 SPG Grades

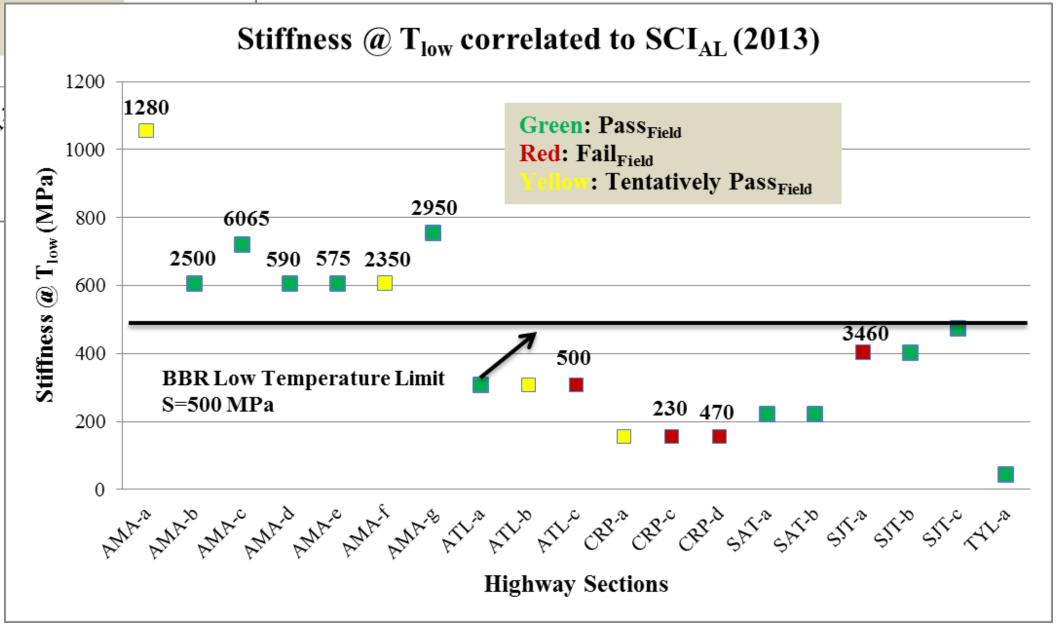


+: exceeds requirement by 1 grade

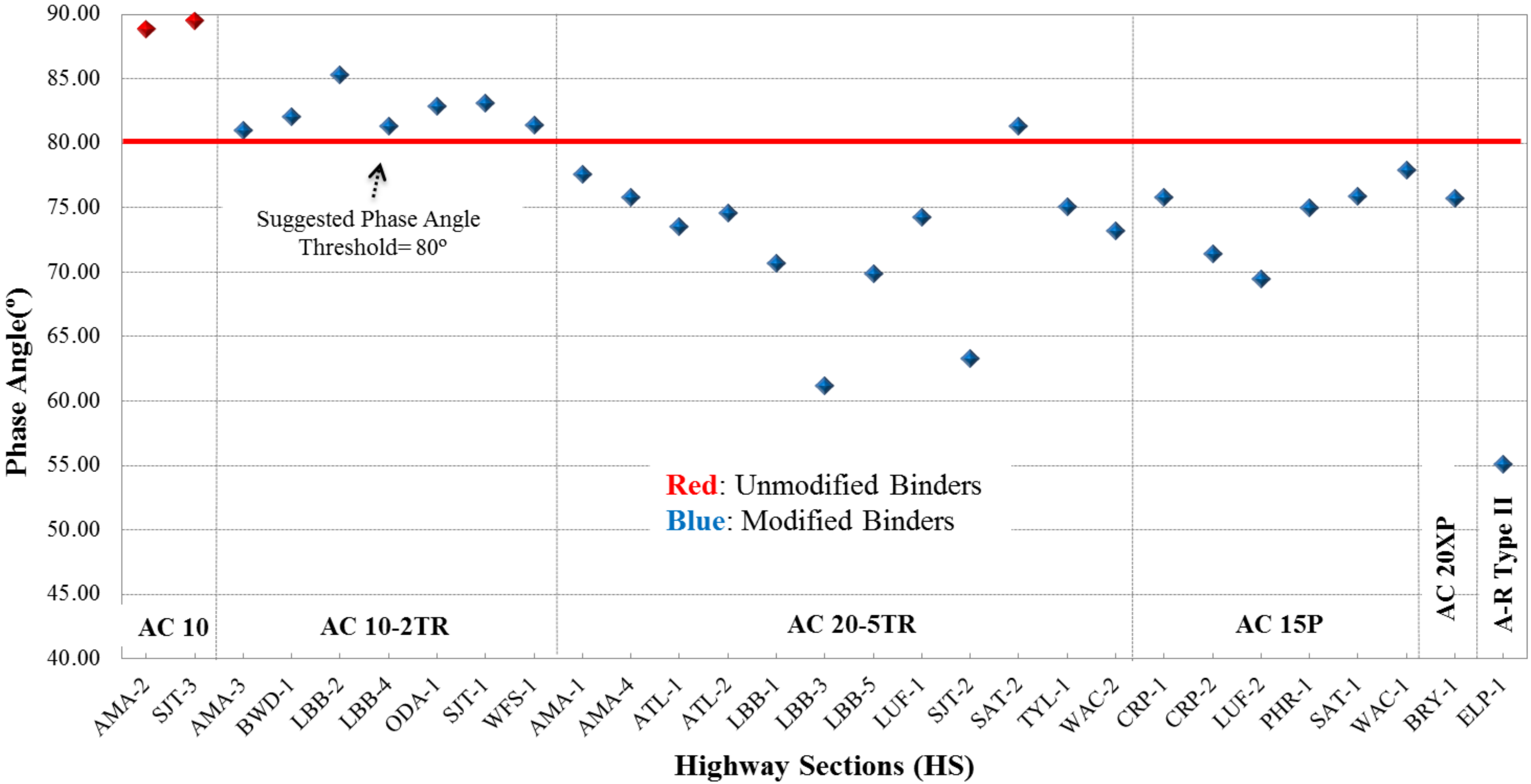
++: exceeds requirement by > 1 grade

SPG Parameters Correlated to SCI Score (2013)





δ @ Interpolated Continuous SPG Grade



WORK PLAN

- Verify SPG
  - Validate that PAV simulates critical 1st year
  - Review 10 uncorrelated (lab ≠ field) 0-6616 sections
    - Validated critical 1st year field performance

- Revise SPG
  - Consider 3°C vs 6°C increments, single maximum surface temperature, & ***traffic effects***
  - Further explore exclusive use of DSR w/predicted low temperature property & LAS for intermediate temperature
  - Add high temperature property & threshold to ensure modification = ***$\delta \leq 80$ @ continuous T_H for UTI $\geq$ 89***
  - Verify thresholds

Project Research and Project Samples Tested as SPG (< summer 2013)

Curent Grade	Surface Performance Grade of Multiple Project Samples							
AC-20-5TR	67-16	70-13	70-16	70-19	73-16	73-19	76-16	79-19
CRS-2	64-10	67-13						
CRS-2P	70-10	76-16	79-16					
AC-10	61-19	64-16	64-19					
AC-15P	70-19	73-13	73-19	73-22				

Current specifications allow a significantly wide variation in properties, enough for multiple proposed SPG grade binders.

Data from Research Project and Implementation Efforts

AC-SPG Summary 2013 Samples

AC Grade	SPG
AC-10	61-13, 61-19
AC-10-2TR	64-16, 67-16, 67-19, 67-22, 70-28
AC-15P	67-25, 70-28, 70-31, 73-25
AC-20-5TR	70-22, 70-25, 73-19, 73-22, 73-25, 76-19
AC-20XP	73-19
AR	79-25

WORK PLAN

- Modify SPG based on feedback from TxDOT districts & briefings

- Document effort including estimated economic impact of implementation

How am I going to get my polymer?

- Rule of 89
  - If Temperature Spread > 89C
  - Phase Angle (δ) < 80 º

    (at the temperature where $G^*/\sin\delta = 0.65$)

How would I call for a material using the Spec?

Possible SPG Grades

- SPG 73-25
- SPG 70-19
- SPG 67-16
- SPG 64-25

- CRS-2(SPG 73-25)
- CRS-2(SPG 70-19)
- HFRS-2(SPG 67-16)
- CHFRS-2(SPG 64-25)

Effects of SPG Specification

Like the REM song says, is it:

"The End of the World as We Know It?"

Effects of SPG Specification

NO!

- Select Binders based on Climate
- Modify Climate Grade based on traffic or other considerations
- Can select hot applied or emulsion (both would have to meet the same binder or emulsion residue properties)

Effects of SPG Specification

- Every material will meet some grade.
- SPG is a tighter spec and we will get less variability.
- Current higher performing binders will still be higher performing binders – we will have a way to say they are higher performing.
- Current Tier Table is replaced by a better system based on performance.

Effects of SPG Specification

- Remember the rest of that REM verse:

It's the End of the World As We Know It, AND I FEEL FINE.

THANK YOU

BACKUP

SPG Binder Specification
2004---300-054
2014---300-001

Table 17A
Surface Performance Grade (SPG) Specification

Surface Performance Grade	SPG 64	SPG 67					SPG 70					SPG 73				
	-25	-13	-16	-19	-22	-25	-13	-16	-19	-22	-25	-13	-16	-19	-22	-25
Average 7-day Max pavement surface design temperature[1], °C	<64	<67					<70					<73				
Min pavement surface design temperature[1], °C	>-25	>-13	>-16	>-19	>-22	>-25	>-13	>-16	>-19	>-22	>-25	>-13	>-16	>-19	>-22	>-25
Original Binder																
Flash point temp, T 48, Min, °C	230															
Viscosity, T 316: Max 0.15 Pa*s, test temp., °C	205															
Original Performance Properties																
Dynamic Shear, T 315: G*/sind, Min 0.65 kPa, Test temp @ 10 rad/s, °C	64	67					70					73				
Shear Strain Sweep, T 315: % strain @ 0.8 G_i*, Min: 17.5 MPa Test temp. @ 10 rad/s linear loading from 1–50% strain, 1 sec. delay time with measurement of 20–30 increments, °C	25	25					25					25				
Phase angle[3] (d), Max, @ temp. where G*/sind = 0.65 kPa	80	–	–	–	80	80	–	–	80	80	80	–	80	80	80	80
Pressure Aging Vessel (PAV) Residue (R 28)																
PAV aging temperature, °C	100	100					100					100				
Creep stiffness, T 313: S, Max 500 MPa, Test temp. @ 8 sec., °C	-25	-13	-16	-19	-22	-25	-13	-16	-19	-22	-25	-13	-16	-19	-22	-25
Shear Strain Sweep, T 315 G_i*, Max: 2.5 MPa Test temp. @ 10 rad/s linear loading at 1% strain, 1 sec. delay time, °C	25	25					25					25				

1. Temperatures are at the surface of the pavement structure. These may be determined from experience or may be estimated using equations developed by SHRP or LTPP, but modified to represent surface temperatures. Surface-grade high temperatures are generally 3°C to 4°C greater than those determined for Superpave PG binders.
2. The referee method will be AASHTO T 316 using a #21 spindle at 50 r/min, however alternate methods may be used for routine testing and quality assurance.
3. Phase angle is determined at the temperature where G*/sind = 0.65 kPa. For routine testing and quality assurance, the phase angle can be interpolated from testing at two temperatures, one above and one below where G*/sind = 0.65 kPa.

Table 7A
Surface Performance-Grade Emulsified Asphalt

Grade	Test Procedure	HFRS-2(SPG xy[1])		CRS-2(SPG xy)		CHFRS-2(SPG xy)	
		Min	Max	Min	Max	Min	Max
Tests on emulsions:							
Viscosity, Saybolt Furol at 50°C, SFs[2]	T 72	150	400	150	400	150	400
Storage stability test, 24 h., %[2]	T 59		1		1		1
Demulsibility, 35 mL, 0.02 N $CaCl_2$, %	T 59	60					
Demulsibility, 35 mL, 0.8% dioctyl sodium sulfosuccinate, %	T 59			60		60	
Particle charge test	T 59			positive		positive	
Sieve test, %[2]	T 59		0.10		0.10		0.10
Residue recovery	PP 72, Procedure B						
Residue, %		65		65		65	
Tests on recovered residue:							
Residue properties		Meet the specified SPG in Table 17A[3]					
Solubility in trichloroethylene, %	T 44	97.5		97.5			
Float test, 60°C, sec.[4]	T 50	1,200				1,200	

1. **X is the average 7-day maximum pavement surface design temperature, and y is the minimum pavement surface design temperature used in Table 17A.**
2. **This test requirement on representative samples is waived if successful application of the material has been achieved in the field.**
3. **Meet original performance properties and PAV residue requirements only**
4. **If Float test is less than 1,200 sec. using PP 72, Procedure B, for residue recovery, then use T 59 for residue recovery.**

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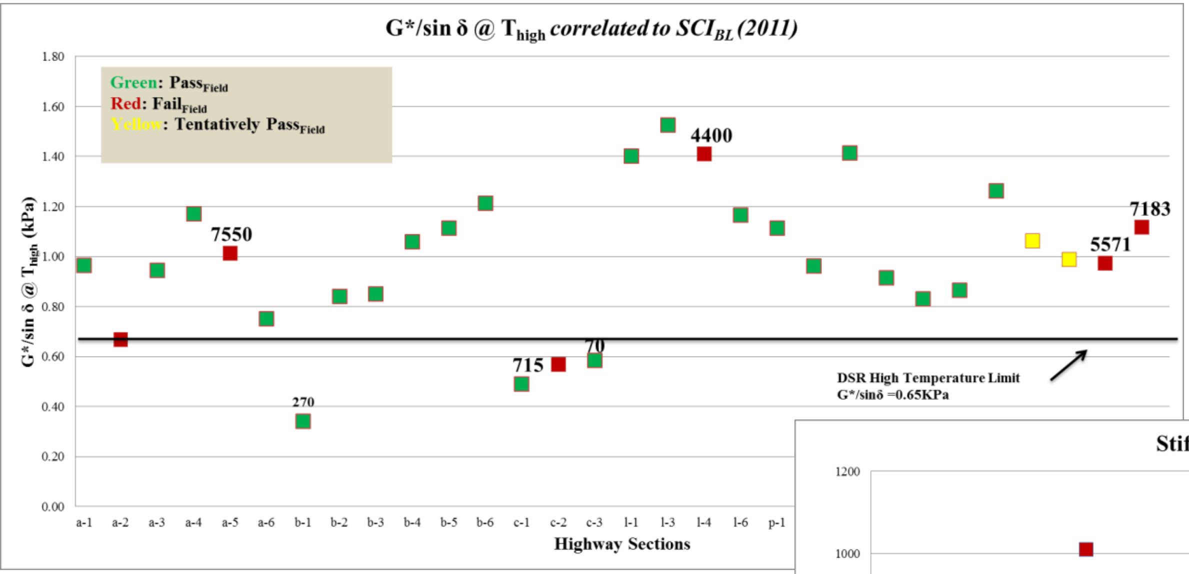
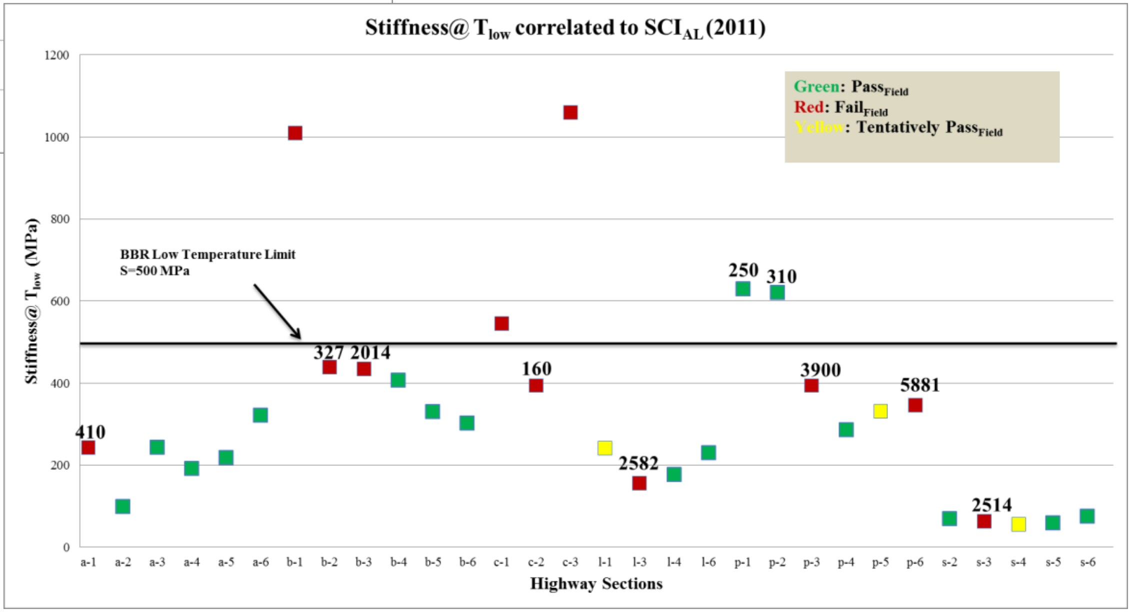
TxDOT 0-6747

- WFS 2012
- SPG 67-19 required by climate
- δ @ T_{high} ~90 for AC10s

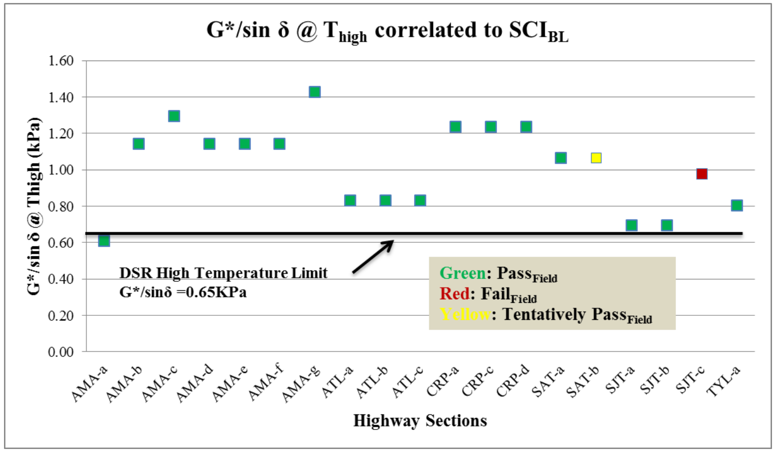
Binder	Field Performance	SPG High Temperature Grade	AADT
AC10	Good	64	270
AC10	Bleeding	64	460
AC10	Bleeding	64	690
AC10-2TR	Good	64	840
AC10-2TR	Bleeding	64	1350
AC10-2TR	Bleeding	64	2300
AC10-2TR	Bleeding	64	3300

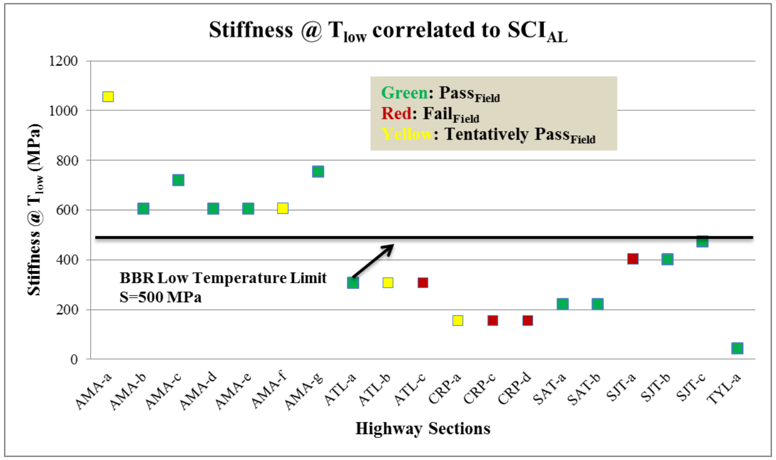
SPG Parameters Correlated to SCI Score (2011)

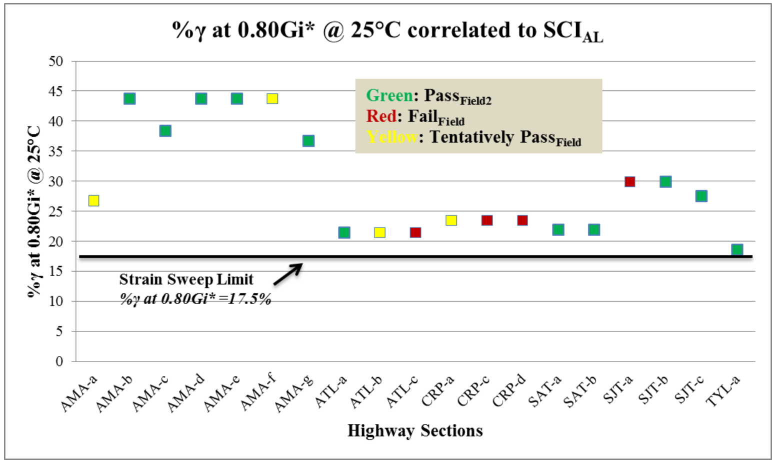


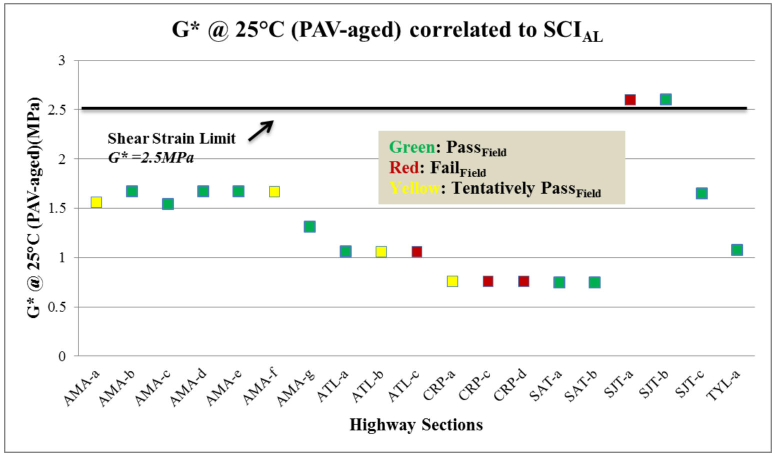


SPG Parameters Correlated to SCI Score (2013)

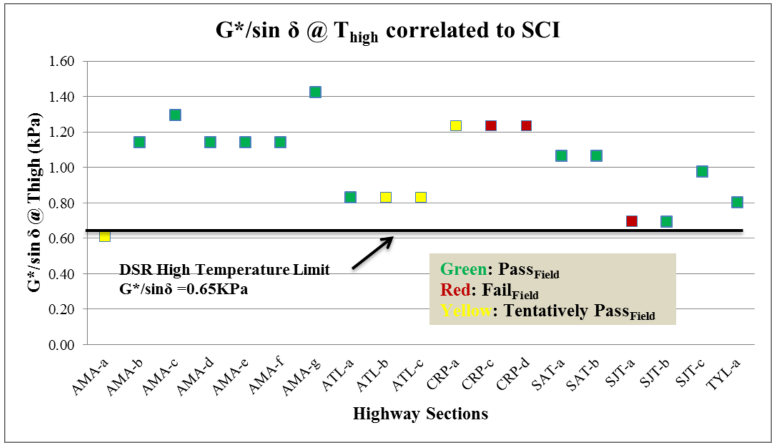


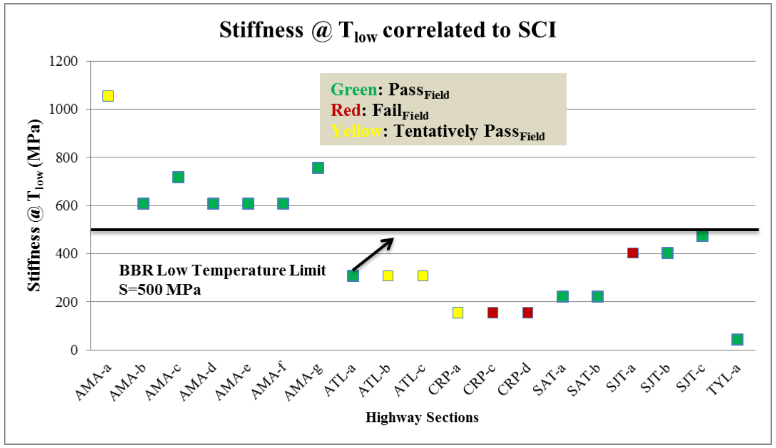


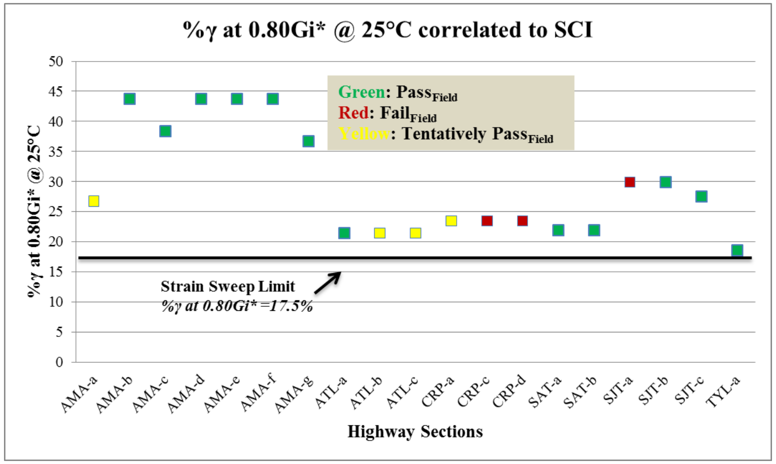


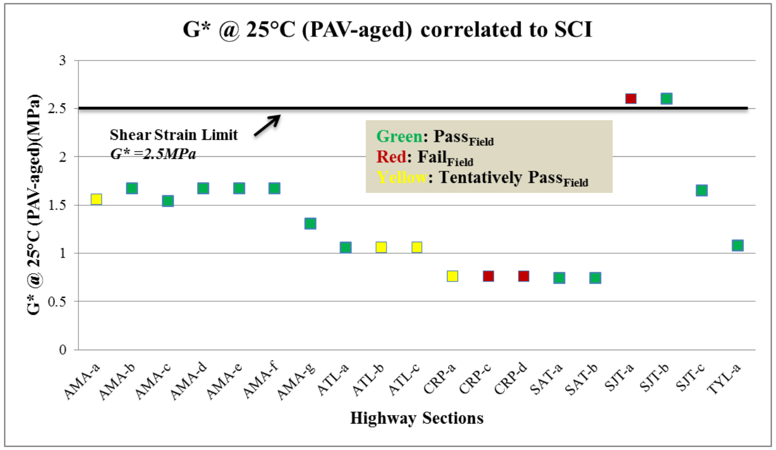


SPG Parameters Correlated to SCI Score



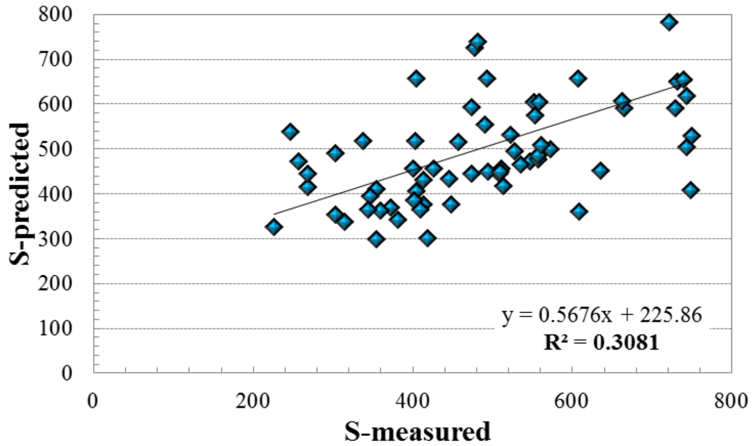




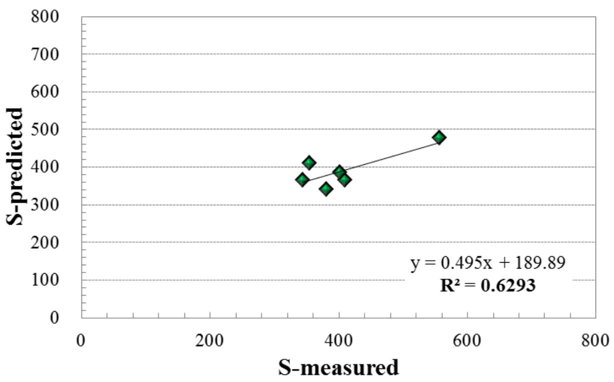


Exclusive Use of DSR - Prediction of BBR Stiffness

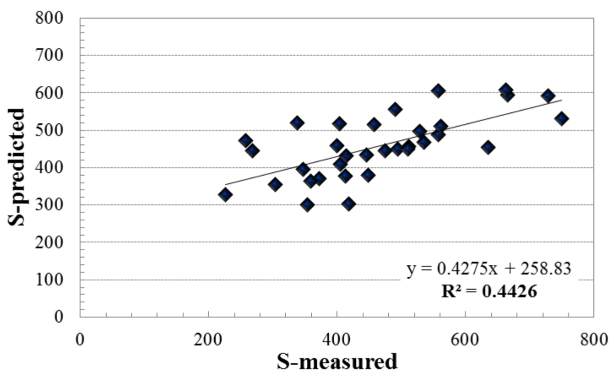
stiffness comparison @ 8s loading time



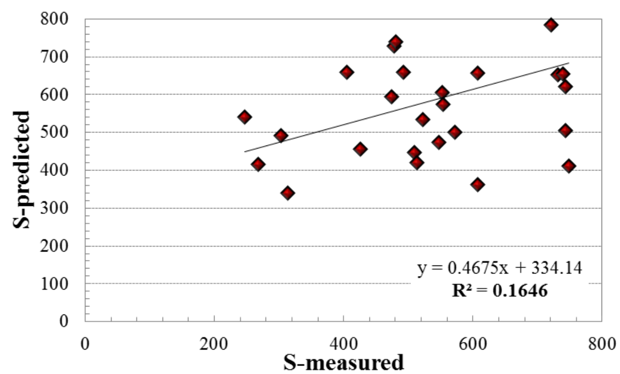
stiffness comparison @ -13°C and -16°C



stiffness comparison @ -19°C and -22°C



stiffness comparison @ -25°C and -28°C



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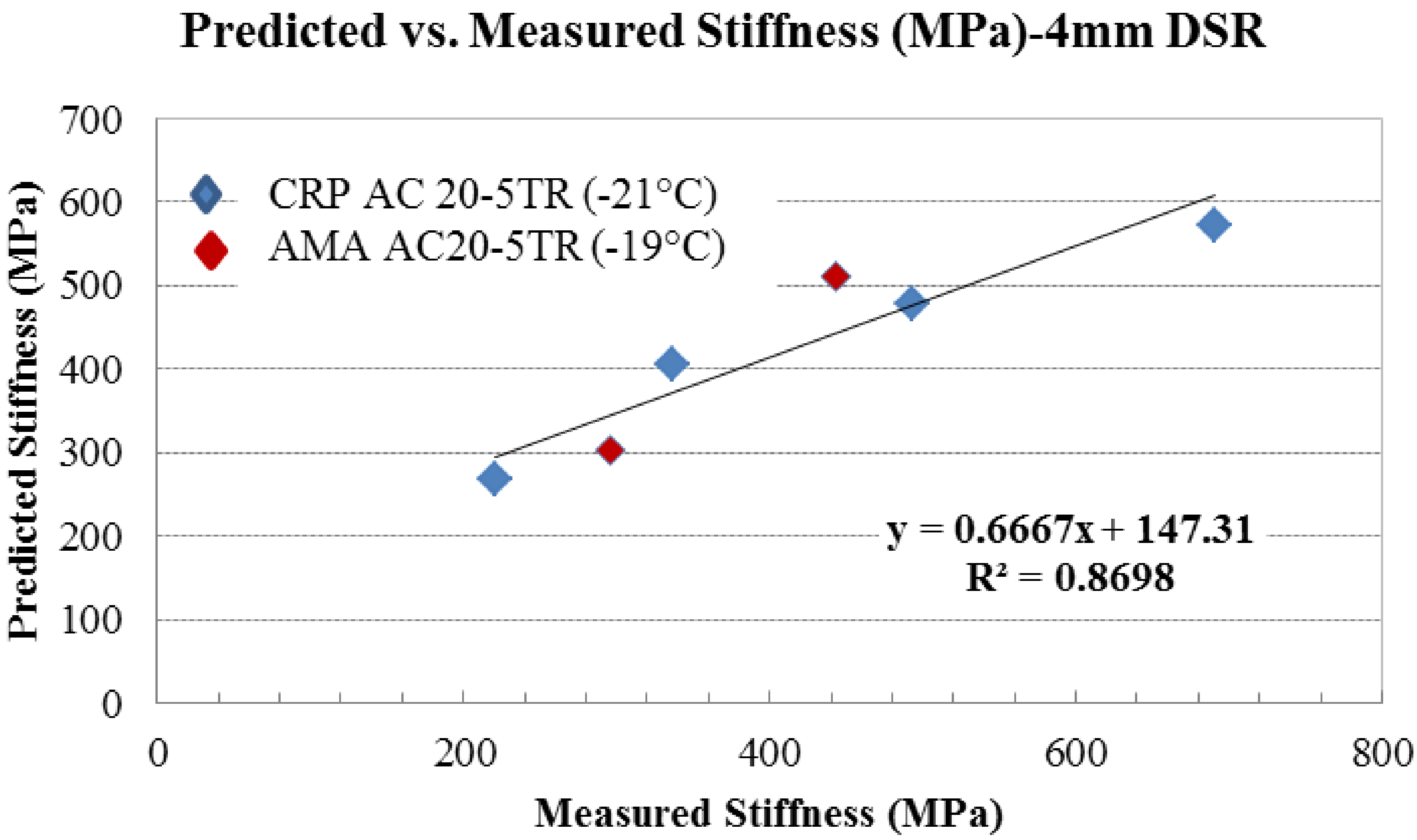
4-mm DSR

RESULTS

AMA AC20-5TR(73-19)	BBR-measured stiffness(Mpa)	SHRP Back-calculation	
		-19°C	-9°C
-19°C	303	296	148
-22°C	511	443	240

CRP AC20-5TR(70-31)	BBR-measured stiffness(Mpa)	SHRP Back-calculation		
		-31°C	-21°C	-11°C
-25°C	268	38	221	111
-28°C	405	64	337	166
-31°C	478	106	494	243
-34°C	573	173	691	348

4-mm DSR



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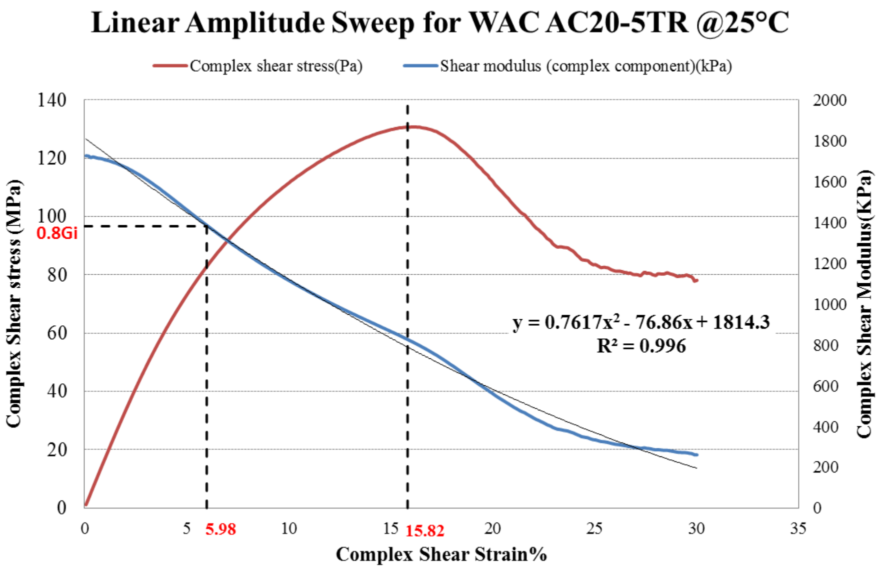
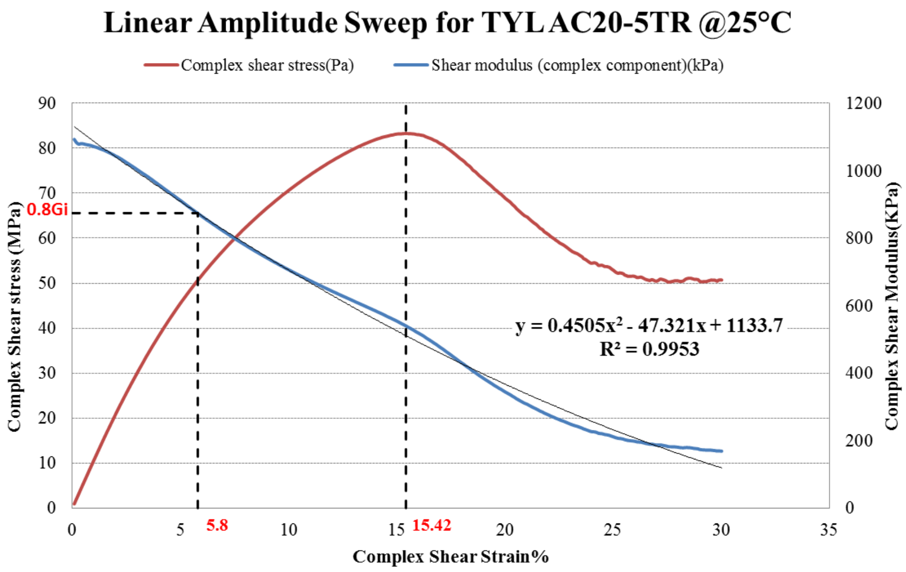
LAS Test Results

	Shear Strain Sweep	Linear Amplitude Sweep	
	%strain@0.8G_i	%strain@peak stress	%strain@0.8G_i
WAC AC20-5TR	18.44	15.82	5.98
TYL AC20-5TR	18.58	15.42	5.8





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MOTIVATION & OBJECTIVE

- Need to improve seal coat binder specs
  - replace empirical tests (penetration, ductility) with performance-related tests applicable to both unmodified and modified binders
  - consider temperatures that cover entire ***in service*** range that are tied to specific climate
  - consider aging during critical 1st year
  - reduce variability in grades

- Developed Surface Performance-Grade (SPG) spec for seal coat binders ***in service***
- Validated with 75 TX highway sections

TxDOT 0-1710 (3.5 yr+ project, 9/99 – 3/03) Superpave Binder Tests for Surface Treatment Binders

Traditional Specification for Surface Treatment Binder RESIDUE Inadequate

- **Develop Performance-Based Specification & Grade Selection Process for Surface Treatment Binder RESIDUE**
    - **Surface Treatment Distresses & Conditions**
    - **Superpave Equipment**
    - **Qualitative Performance Rankings & Corresponding Environmental Conditions**

- **Validate Specification**
    - **Laboratory Measured Binder SPG Grade**
    - **Observed Field Performance on 45 Highway Sections**

NCHRP 14-17
(2.5 yr+ project @ A&M, 4/08 – 12/09)
Manual for Emulsion-Based Chip Seals for Pavement Preservation

- Provide technology-based ***tools*** that promote sound engineering decisions and reduce the subjectivity in chip seal design and construction processes
- Create a ***manual*** which describes how to design and construct chip seals with a very high confidence level in the success of the resulting project

- A&M: Emulsion residue recovery, chemical & rheological binder characterization for 5 emulsions + 3 Highway Sections

TxDOT 0-6616 (2 year project, 9/10-8/12) Validate Surface Performance-Graded (SPG) Specification for Surface Treatment Binders

Improve SPG Specification

- **Standardize Emulsion Residue Recovery Method**
- **Explore Exclusive Use of DSR – Predict S, m-value**
- **Evaluate Additional Performance Parameters**
- **Further Field Validate SPG Thresholds on 30 Highway Sections**

Emulsion Task Force (ETF) of FHWA Pavement Preservation ETG (formed 08, ~30 members, 2 X per year)

- **Review Ongoing Research & Integrate Work**
- **Recommend / Propose / Evaluate Research Needs**
- **Advance Development of Performance-Based Methods & Specifications**
- **Facilitate Implementation / Adoption of Standards through AASHTO/ASTM**
- **Share Info w/Other ETGs**

Presentations & Publications

Presentations	Publications
ASTM Subcommittee D04.41 – 2001	TRR – 2002, 2004, 2010, 2013
Transportation Short Course – 2002, 2012, 2013, 2014	NCHRP 680 – 2011
TxAPA – 2013, 2014	TTI Reports – 2001, 2005, 2013
TRB – 2002, 2004, 2010, 2013, 2013	Journal of Applied Asphalt Binder Technology – 2002
3rd Symposium on Binder Rheology & Pavement Performance - 2002	TRR Catalog of Practical Papers - 2002
Transportation Systems Workshop - 2012	
FHWA Pavement Preservation ETG Emulsion Task Force – 2009, 2009, 2010, 2013, 2014	

δ @ interpolated continuous SPG grade