Examining the use of ΔT_c to screen presence of high REOB

Binder Expert Task Group

Oklahoma City, Oklahoma

September 16th, 2015

Pavement Materials Team, TFHRC

Binders' and Mixtures' Engineering Properties

Two Modification Approaches

- **Softening an unmodified PG to another PG**

PG64-22

6% REOB*

PG58-28

**with a single REOB sample*

Two Modification Approaches

- Softening an unmodified PG to another PG

PG64-22

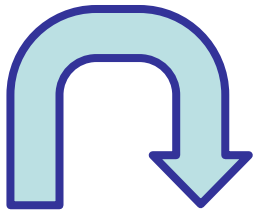
*6% REOB**

PG58-28

- **Diluting a unmodified PG**

PG69-24

+20% PG100-0



+15% REOB*

PG58-28 **PG58-28**

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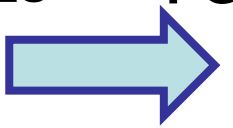
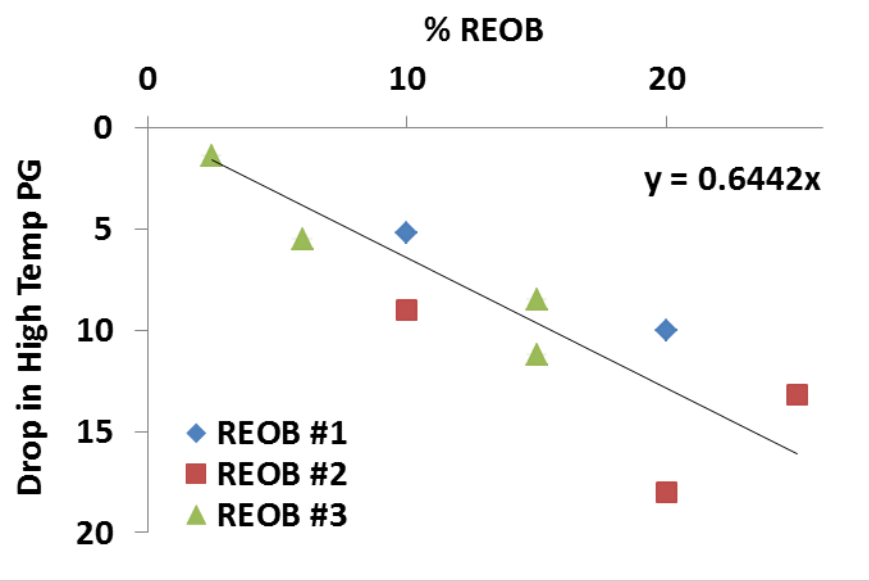
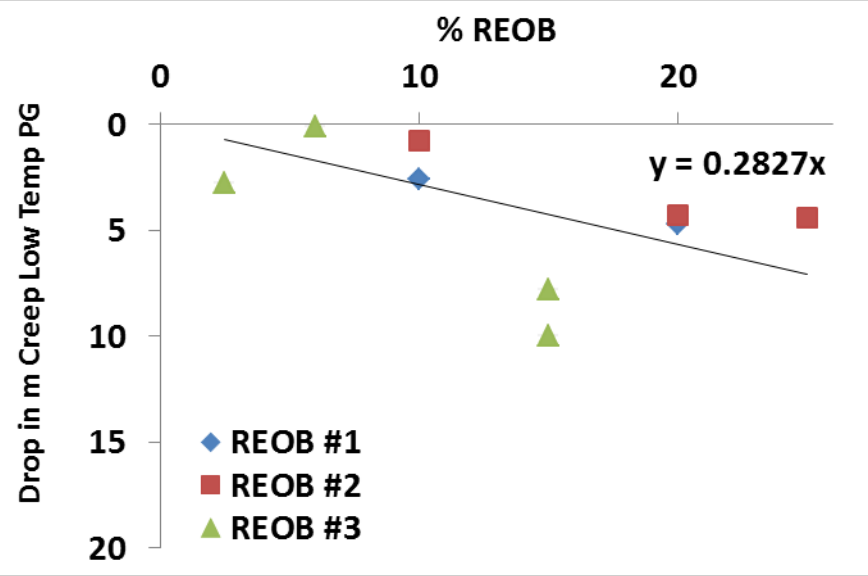


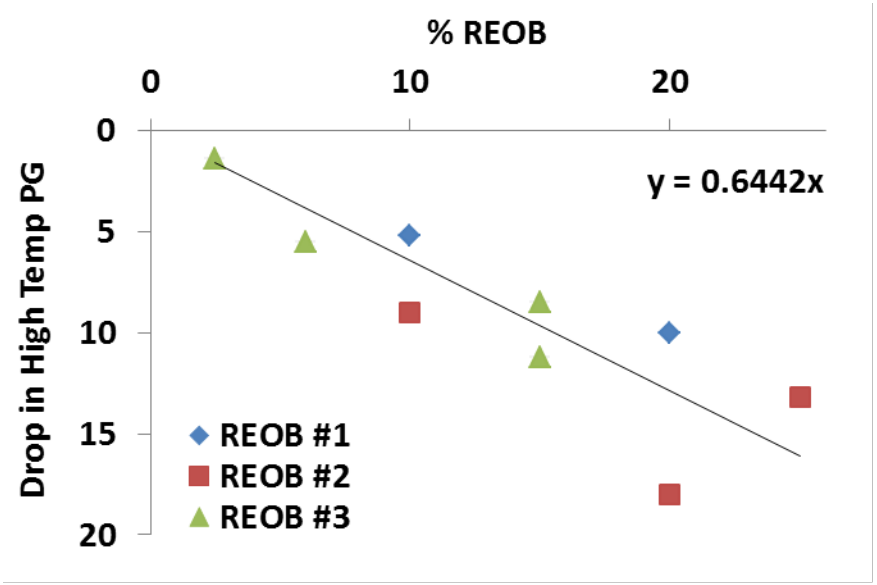
+2.5% REOB*

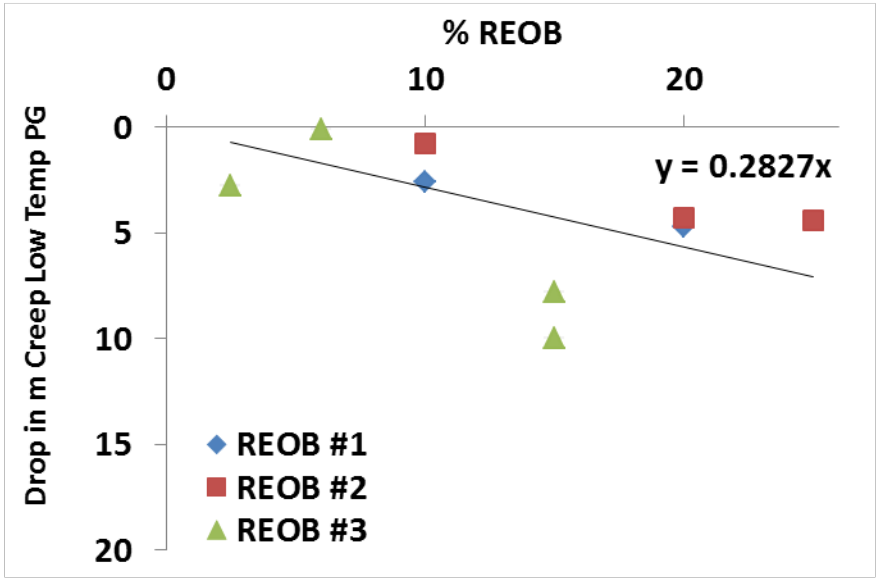
**with a single REOB sample*



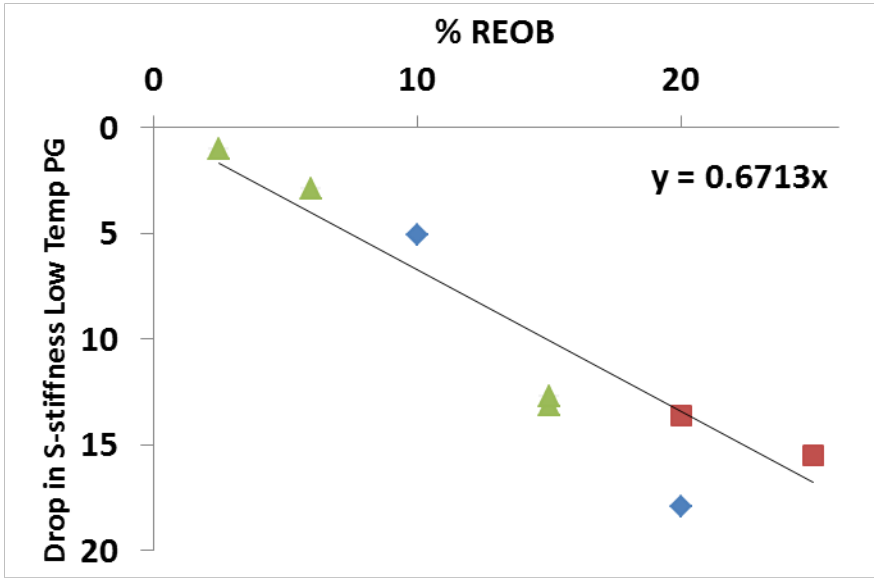


- **DSR High Temp**
  - **~9% REOB per PG Grade Drop**
- **BBR m-Value**
  - **~21% REOB per PG Grade Drop**





- **DSR High Temp**
  - **~9% REOB per PG Grade Drop**
- **BBR m-Value**
  - **~21% REOB per PG Grade Drop**
- **BBR Stiffness**
  - **~9% REOB per PG Grade Drop**



BBR $\Delta T_{critical}$ Spread: $PG_{(S)tiffness} - PG_{(m)\text{-}creep}$

	Base	*Exploratory Blends*			**Final Blends**
		+PG100-0	*+REOB Source 1*	*+REOB Source 2*	**+REOB Source 3**
	PAV				**PAV**
Holly 58-28	**-2.0°C** **60-30**				

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Holly 58-28	**-2.0°C** **60-30**	*-0.8°C* *0% / 20%* *69-24*			
		-1.6°C *0% / 30%* *72-20*			

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Holly 58-28	**-2.0°C** **60-30**	*-0.8°C* *0% / 20%* *69-24*	*-10°C* *20% / 20%* *59-28*	*-14°C* *20% / 20%* *51-28*	
		-1.6°C *0% / 30%* *72-20*	*-13°C* *25% / 30%* *59-25*		

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		-1.6°C *0% / 30%* *72-20*	*-13°C* *25% / 30%* *59-25*		*-5.1°C* *15% / 0%* *51-40*

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		-1.6°C *0% / 30%* *72-20*	*-13°C* *25% / 30%* *59-25*		*-5.1°C* *15% / 0%* *51-40*
					-0.2°C **2.5%** **59-33**

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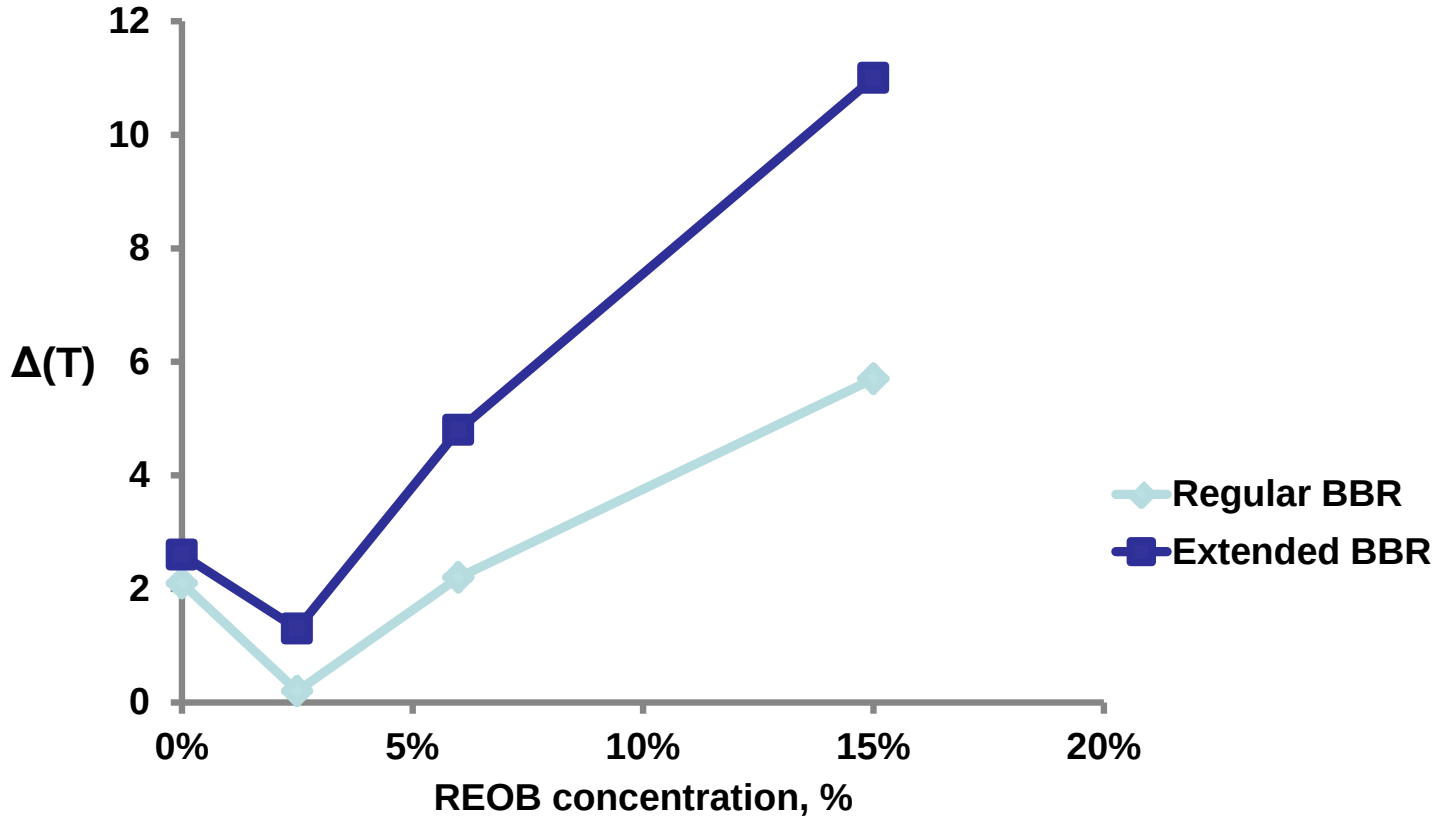
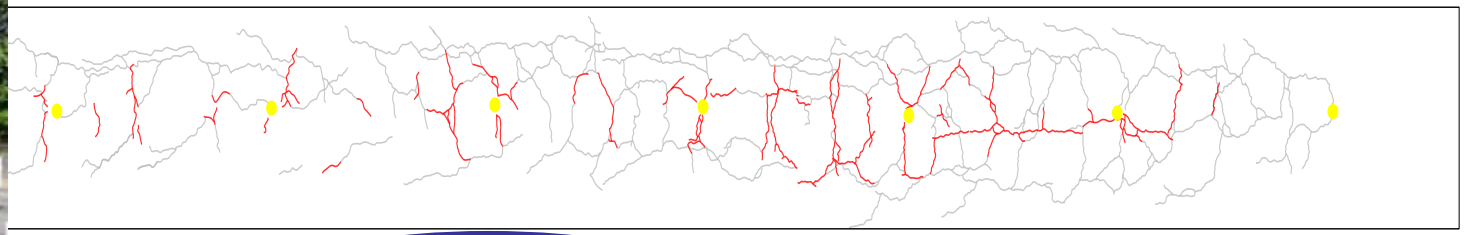
	Base	*Exploratory Blends*			**Final Blends**
		+PG100-0	*+REOB Source 1*	*+REOB Source 2*	**+REOB Source 3**
	PAV				**PAV**
Holly 58-28	**-2.0°C** **60-30**	*-0.8°C* *0% / 20%* *69-24*	*-10°C* *20% / 20%* *59-28*	*-14°C* *20% / 20%* *51-28*	**-5.7°C** **15% / 20%** **58-33**
		-1.6°C *0% / 30%* *72-20*	*-13°C* *25% / 30%* *59-25*		*-5.1°C* *15% / 0%* *51-40*
					-0.2°C **2.5%** **59-33**
BP 64-22	+0.8°C 67-27		*-1.7°C* *10%* *61-31*	*-4.0°C* *10%* *58-29*	**-2.2°C** **6%** **61-28**

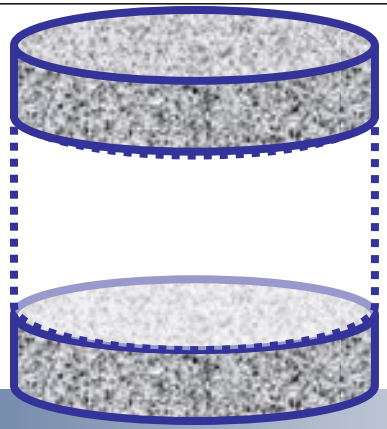
BBR $\Delta T_{critical}$ Spread: $PG_{(S)tiffness} - PG_{(m)\text{-}creep}$



Awareness of long-term performance

- Utility of PAV to approximate 5-years age
- Poor performance after 5-years ***anecdotally*** attributed to REOB
- Data from FHWA ALF test sections
  - Top and bottom 1-inch of core extracted & recovered binder

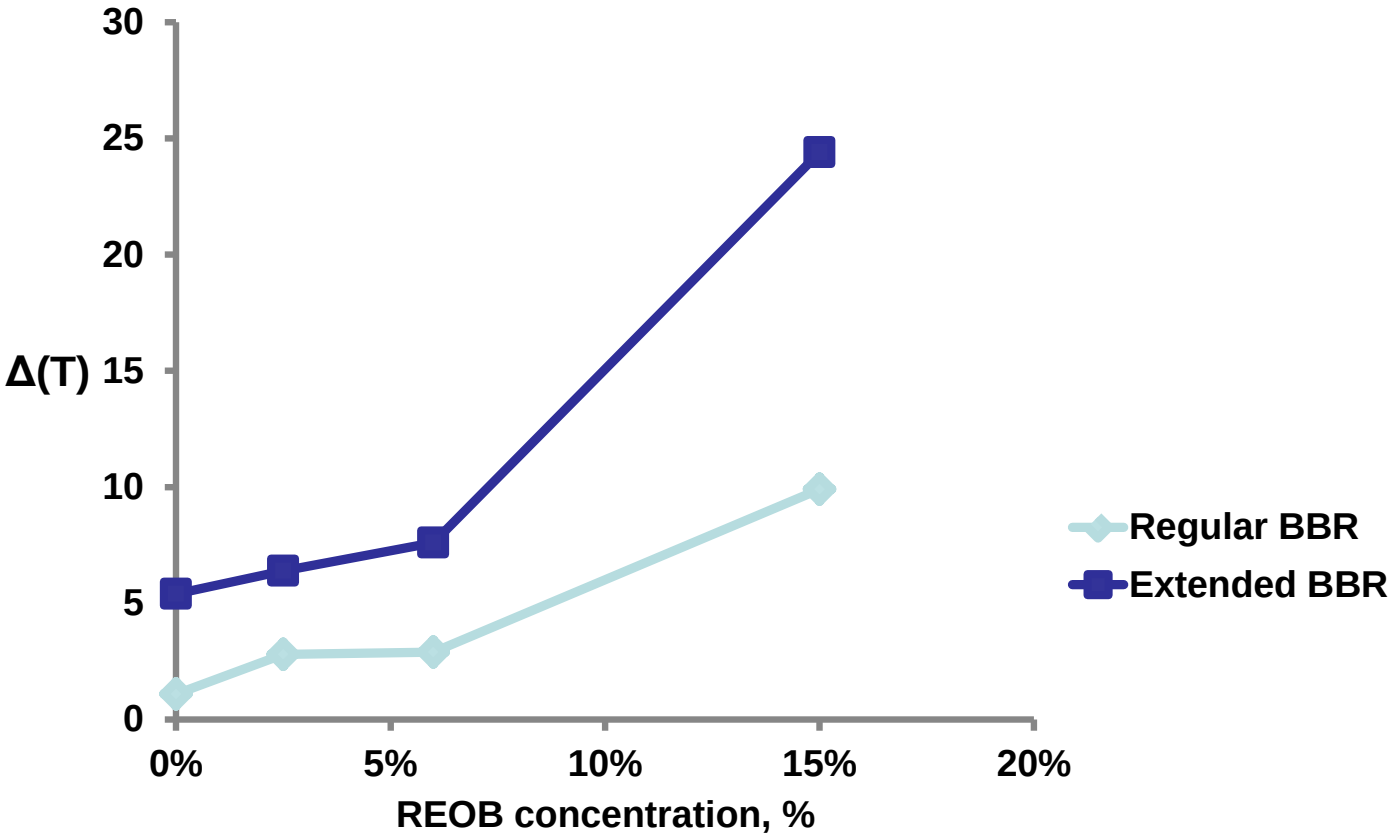




BBR $\Delta T_{critical}$ Spread: $PG_{(S)tiffness} - PG_{(m)\text{-}creep}$

	Base		*Exploratory Blends*			**Final Blends**	
			+PG100-0	*+REOB Source 1*	*+REOB Source 2*	**+REOB Source 3**	
	PAV	**2 X PAV**				**PAV**	**2 X PAV**
Holly 58-28	**-2.0°C** **60-30**	**-1.1°C** **□-29**	*-0.8°C* *0% / 20%* *69-24*	*-10°C* *20% / 20%* *59-28*	*-14°C* *20% / 20%* *51-28*	**-5.7°C** **15% / 20%** **58-33**	**-10°C** **15% / 20%** **□-26**
			-1.6°C *0% / 30%* *72-20*	*-13°C* *25% / 30%* *59-25*		*-5.1°C* *15% / 0%* *51-40*	*-10°C* *15% / 0%* *□-34*
						-0.2°C **2.5%** **59-33**	**-2.8°C** **2.5%** **□-29**
BP 64-22	+0.8°C 67-27	-1.9°C □-23		*-1.7°C* *10%* *61-31*	*-4.0°C* *10%* *58-29*	**-2.2°C** **6%** **61-28**	**-2.9°C** **6%** **□-23**

BBR $\Delta T_{critical}$ Spread: $PG_{(S)tiffness}$ – $PG_{(m)\text{-}creep,}$ 2X PAV



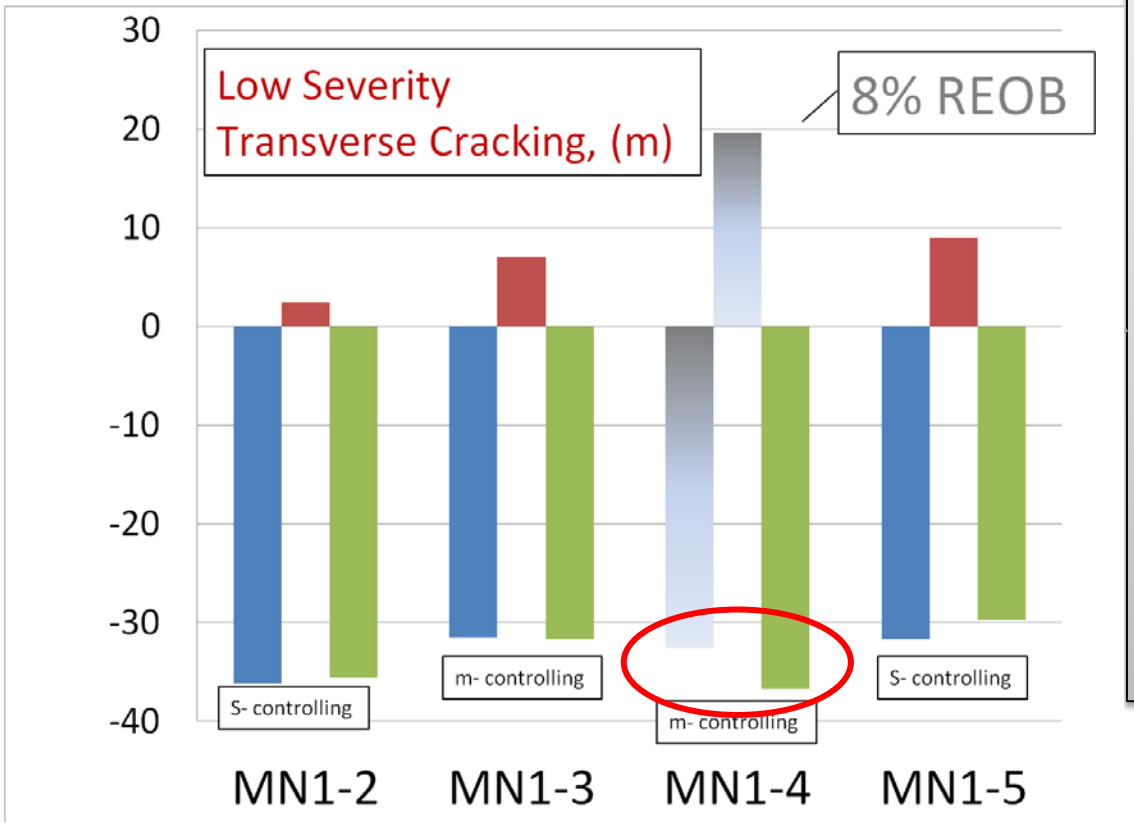
STOA & LTOA Extracted PG Grades

* * Mix Contained 22% RAP * *

Recovered Binder/Major Rheological Properties	HTPG (°C)		ITPG (°C)		LTPG, ΔT (°C)			
	STOA	LTOA	STOA	LTOA	STOA	STOA ΔT	LTOA	LTOA ΔT
B6598 (0% REOB)	75.3	82	15.7	21.8	-25.2	-2.5	-26.0	-1.4
B6538 (2.5% REOB)	72.7	79.5	17.7	18.5	-28.4	-2.7	-28.3	-2.5
B6537 (6% REOB)	74.4	80.4	19.7	22.2	-23.8	-5.4	-24.9	-3.3
B6536 (15% REOB)	76.1	82.5	20.4	20.3	-24.0	-8.2	-24.9	-8.2

Field Study - Rochester, MN
Comparative Test sites

❑BBR vs. transverse cracking

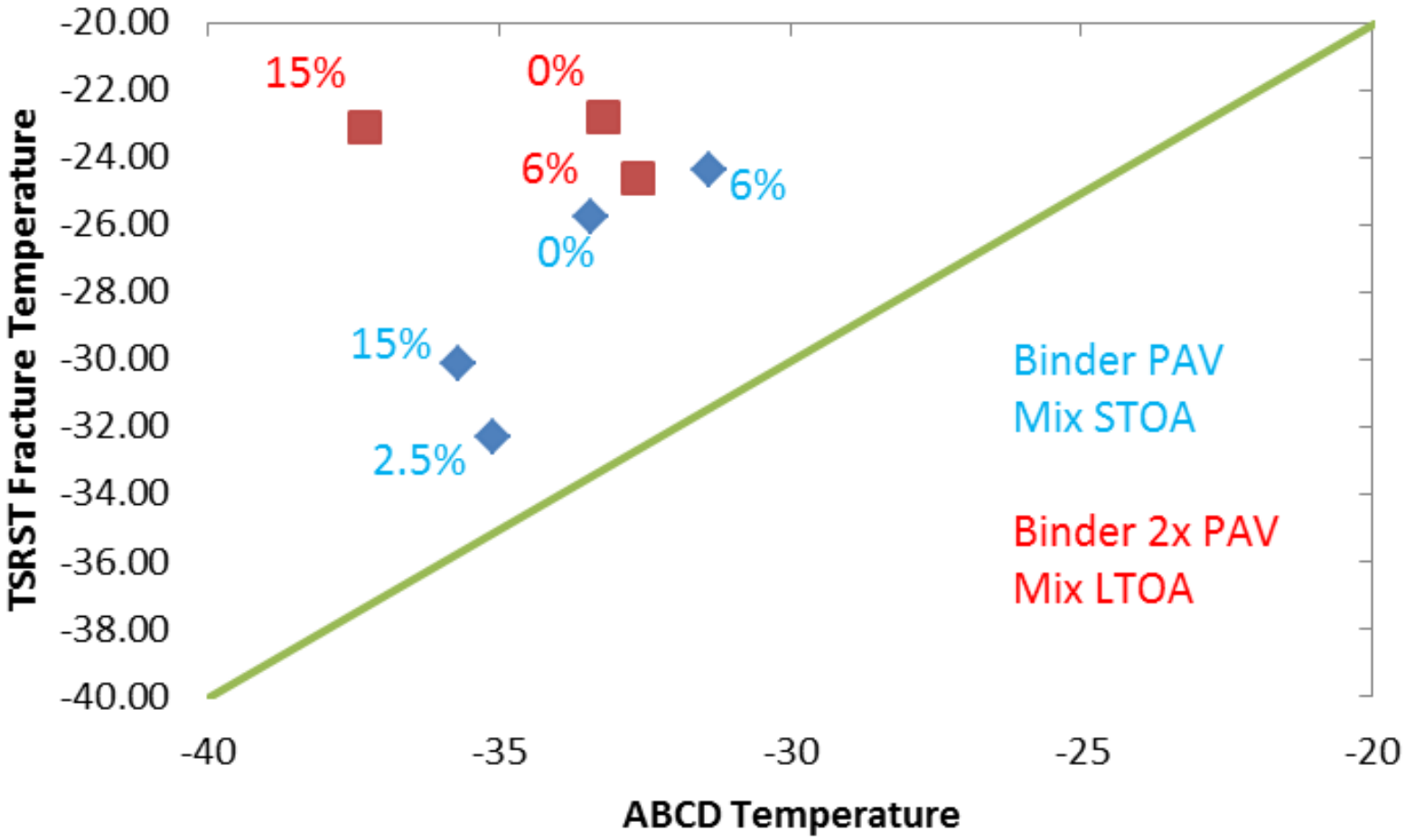


- **BBR limited T grading did not predict** the transverse cracking issue on the MN1-4 test section

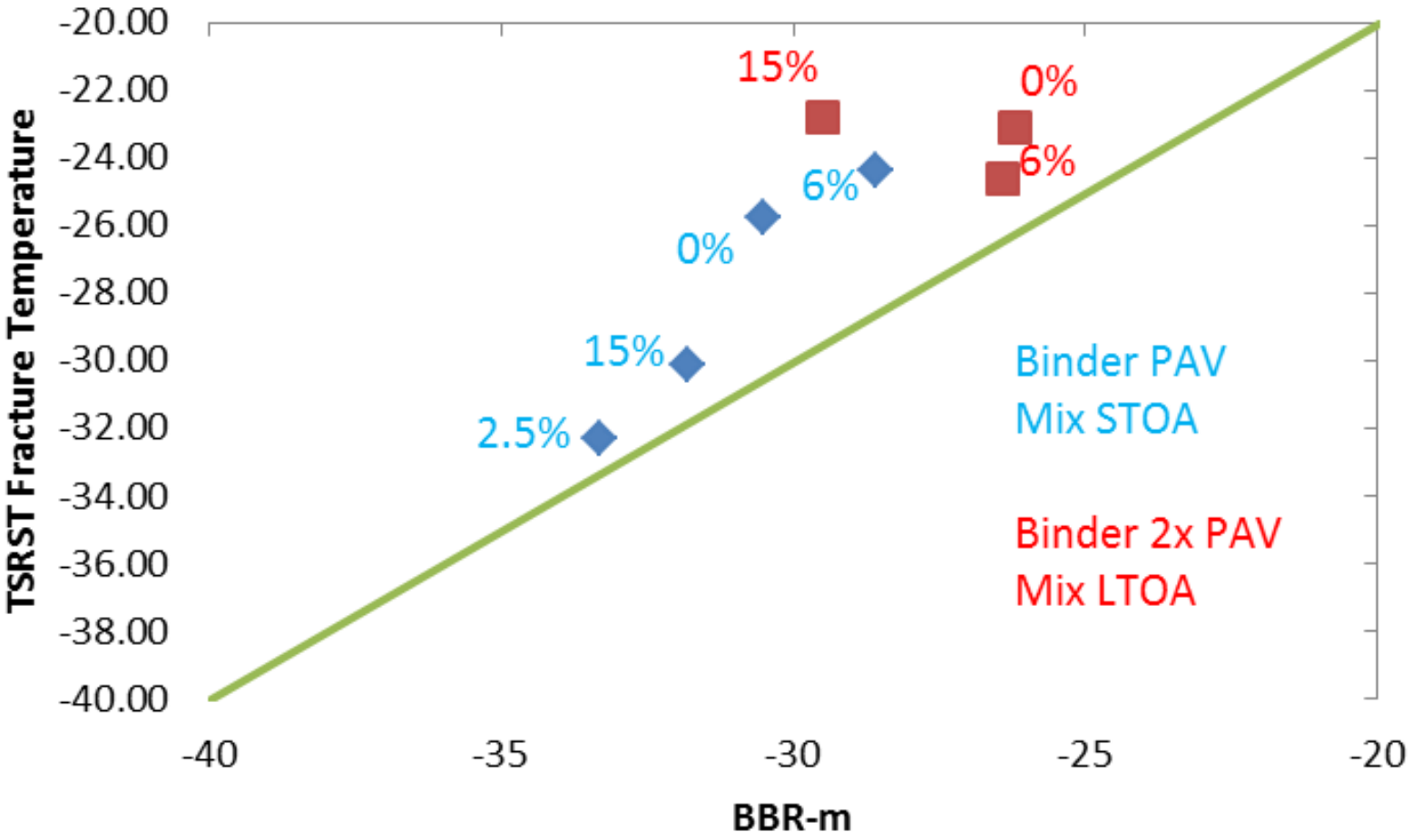
- **Neither did ABCD**

- **But the BBR m-value 5°C temperature control is a warning**

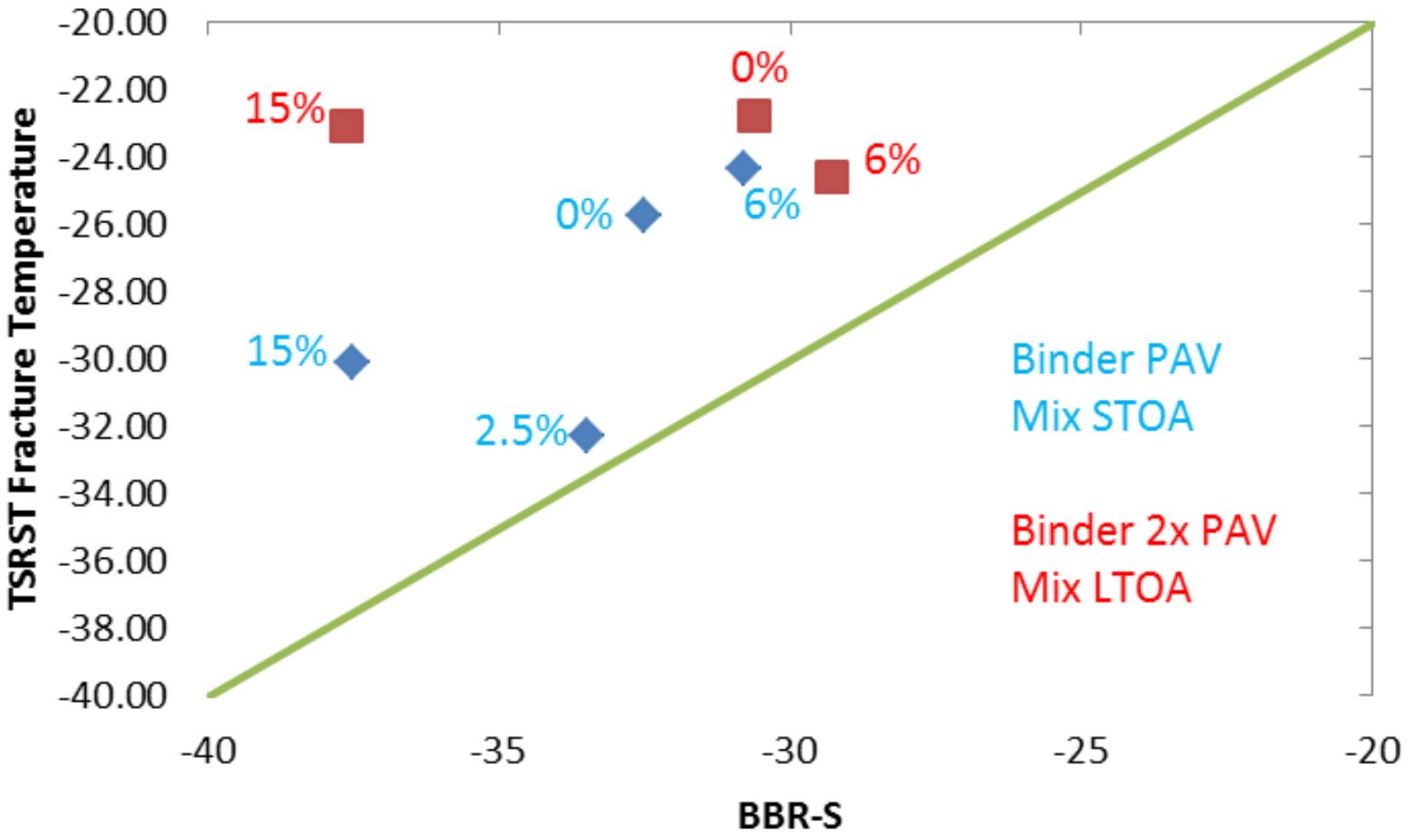
Thermal Cracking



Thermal Cracking



Thermal Cracking



Findings (1 of 4)

1. **You can readily detect REOB presence**
2. **You can tell that it is there; but you *cannot* tell *exactly* how much is there.**
   - **Round Robin XRF results may shed more light on this.**
3. **Effect of REOB depends on base binder (like PPA)**
4. **Variation between REOB suppliers & their samples**
   - **Same concentration can produce different PG grades**

Findings (2 of 4)

5. **2 X PAV is a reasonable approximation of 5 years - *where anecdotal concerns lie* (ALF Data)**

6. **REOB softens and reduces tensile strength**
   - **Binder notched tension (DENT)**
   - **Decreases mix wet and dry IDT strength**
   - **Also seen in TSRST**

7. **In 2 of 3 cases, REOB improved ***binder*** intermediate temperature parameters for fatigue / strain tolerance**
   - **6% and 2.5% REOB blends**
   - **CTOD and LAST**

Findings (3 of 4)

8. **Rheological "disruption" occurred w/ highest %REOB**
   - **Differences in Low Temperature m&S**
   - **Did Not occur in blend with PG100-0 by itself**
   - **Did occur in blends with high-REOB + PG100-0**
   - **Made worse by continued aging**
   - **Alludes to performance deterioration**
   - **Corroborated by DENT CTOD & LAST & Stripping**
   - **Forces the issue of compatibility** (extenders, rejuvenators, RAP / RAS, WMA…)

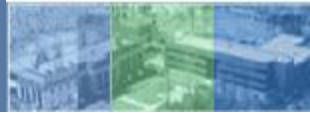
Findings (4 of 4)

10. Conclusions

- Low concentrations of REOB did not appear to adversely affect binder and mixture properties
- High concentration of REOB consistent with loss of strength in different binder and mix test methods

11. Recommendations

- Further examination of m & S as “flag” is warranted.
- Minimum value for S should be reexamined

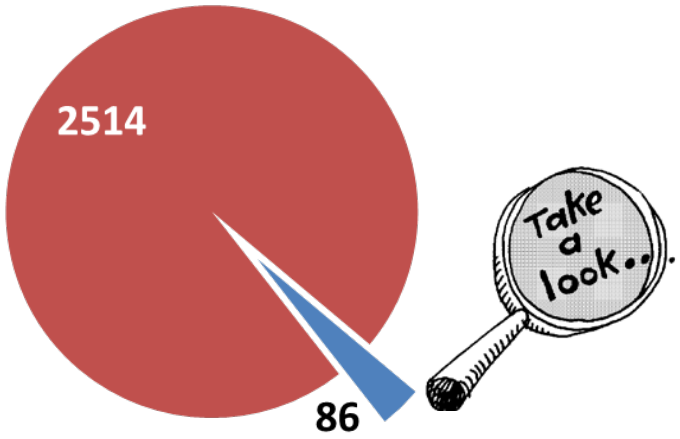


Thank You.

Questions?

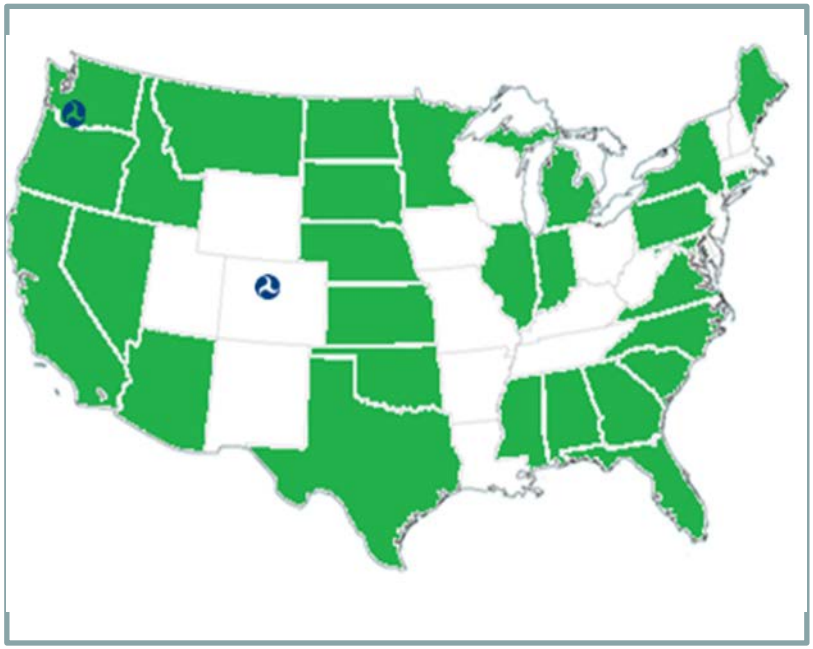
TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

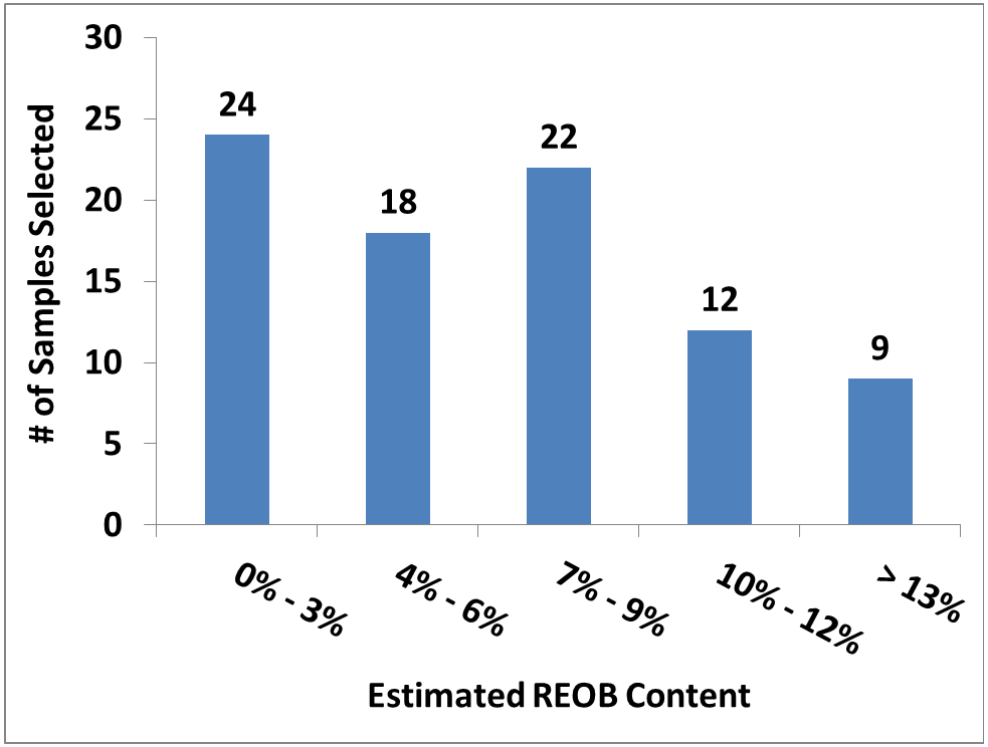
FHWA has tested 2,600 samples in XRF

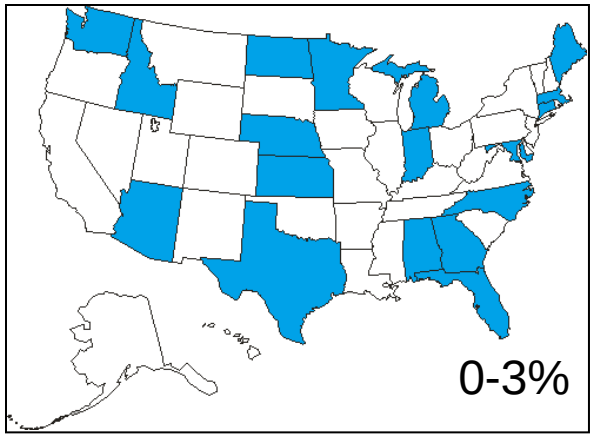


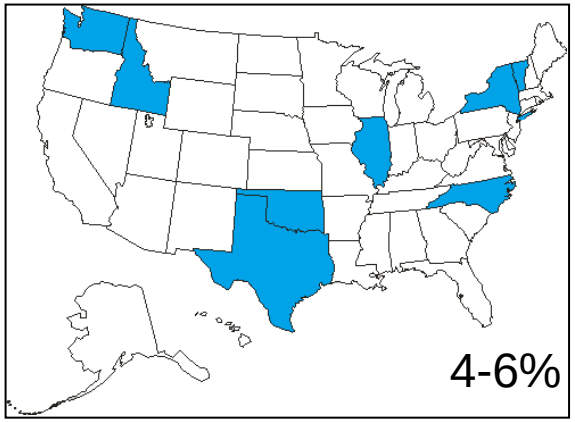
FHWA has tested 2,600 XRF samples

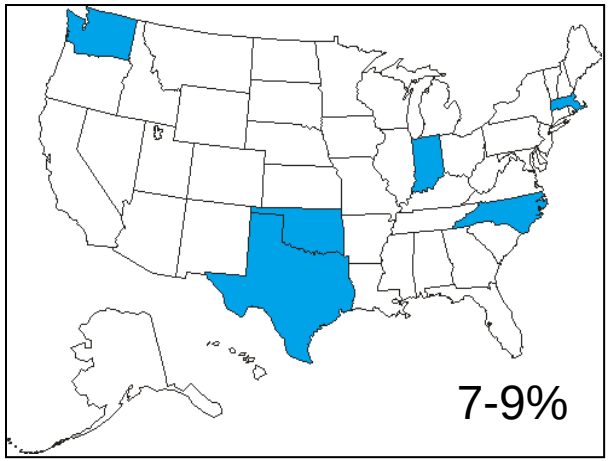
Select ~3% of the data set for further study…

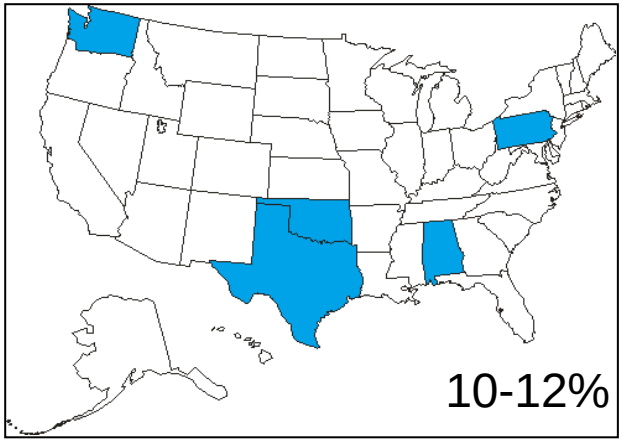


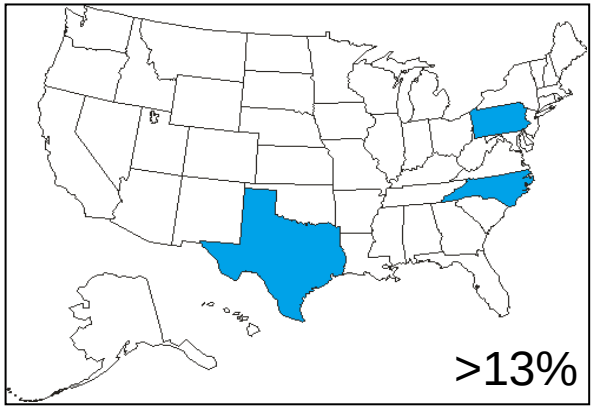



0-3%


4-6%


7-9%


10-12%


>13%

of Binders and their Grades Selected Data Set

	52	58	64	70	76
-16			**1**		
-22		**2**	**19**	**2**	**2**
-28		**8**	**15**	**4**	**4**
-34	**2**	**2**	**2**	**1**	

AC 0.6	AC 3	AC 5	AC 10	AC 15	AC 20
3	**1**	**2**	**2**	**2**	**1**

of Binders and their Grades
0-3%

	52	58	64	70	76
-16			**1**		
-22		**1**	**8**	**1**	**2**
-28		**1**	**2**		
-34	**1**	**1**	**1**	**1**	

AC 0.6	AC 3	AC 5	AC 10	AC 15	AC 20

of Binders and their Grades 4-6%

	52	58	64	70	76
-16					
-22			**4**	**1**	
-28			**3**	**1**	**2**
-34	**1**	**1**	**1**		

AC 0.6	AC 3	AC 5	AC 10	AC 15	AC 20

of Binders and their Grades 7-9%

	52	58	64	70	76
-16					
-22		**1**	**3**		
-28		**3**	**7**	**2**	**2**
-34					

AC 0.6	AC 3	AC 5	AC 10	AC 15	AC 20
			2	**1**	**1**

of Binders and their Grades 10-12%

	52	58	64	70	76
-16					
-22			**4**		
-28		**1**	**3**	**3**	
-34					

AC 0.6	AC 3	AC 5	AC 10	AC 15	AC 20
				1	

of Binders and their Grades > 13%

	52	58	64	70	76
-16					
-22					
-28		**3**			
-34					

AC 0.6	AC 3	AC 5	AC 10	AC 15	AC 20
3	**1**	**2**			

Work Plan

- **Verify Effect of Additives on High, Intermediate and Low PG Grades**
- **BBR m & S continuous grade**
  - **Standard 20 hr. PAV**
  - **2x PAV *if sufficient binder quantity was provided***
- **<u>Mix Testing??? Insufficient binder quantities ☹</u>**
- **Separate evaluations for binders which contain:**
  - **Ground Tire Rubber**
  - **Hydrolene**
  - **Used motor oil (unrefined)**
  - **Vegetable oil**
  - **etc.**