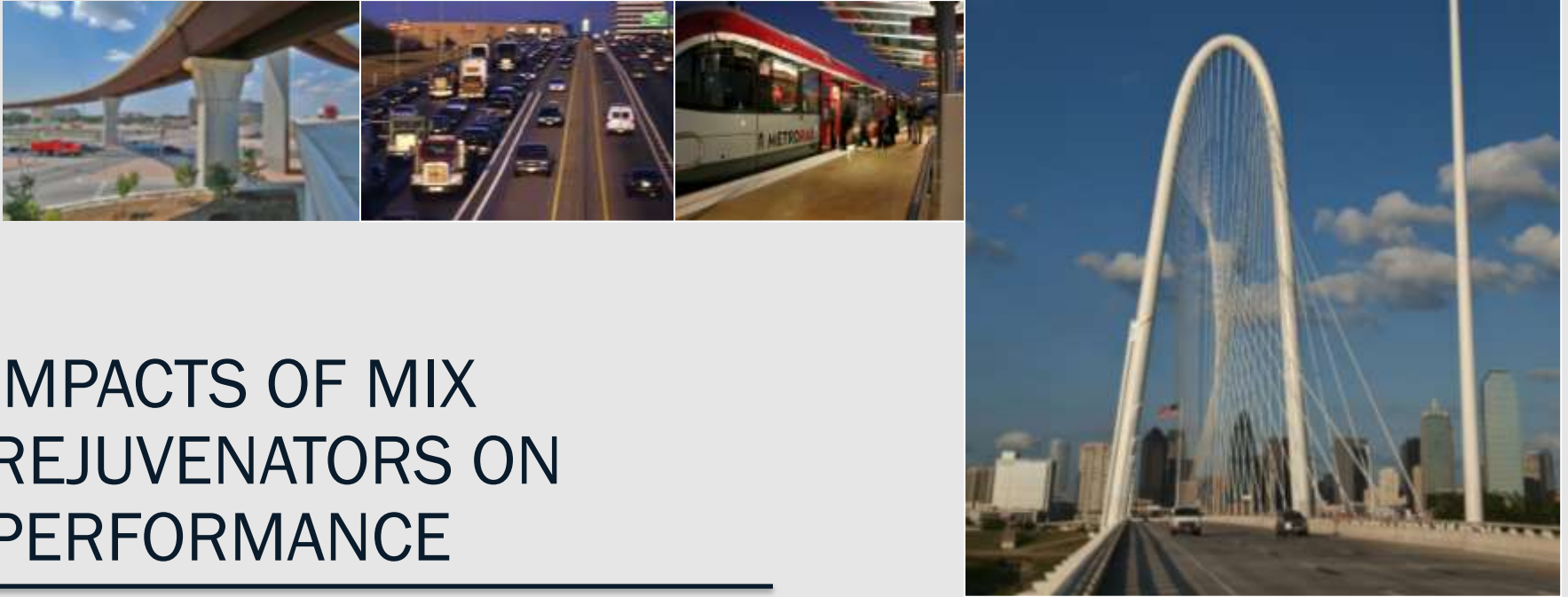




TEXAS DEPARTMENT OF TRANSPORTATION



IMPACTS OF MIX REJUVENATORS ON PERFORMANCE

Ryan Barborak, P.E.

Ohio Asphalt Paving 42nd Annual Conference

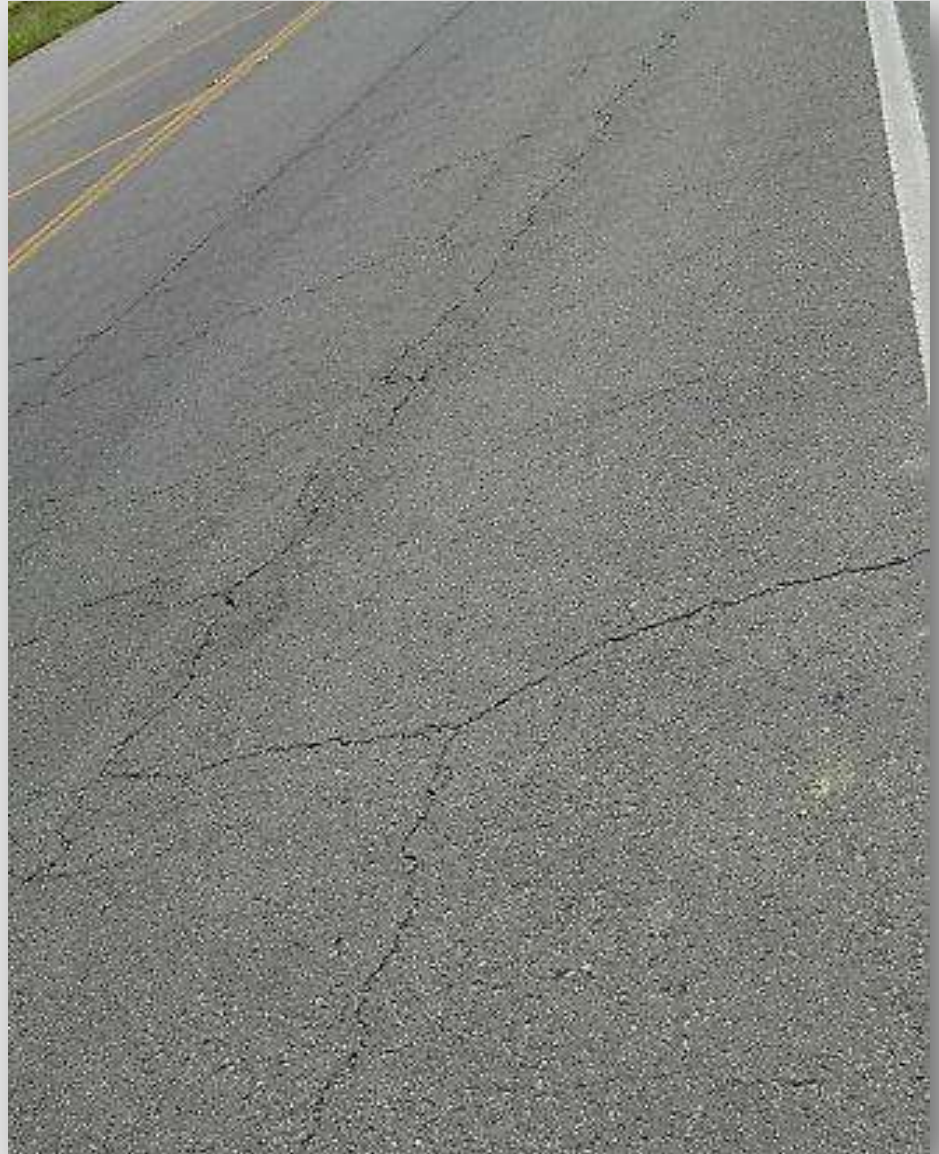
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The Problem is...

■ Cracking

- Although there are many causes...traffic conditions, pavement structure, poor drainage, climate
- Focus is on how recycled materials are used
 - Reclaimed asphalt pavement (RAP)
 - Recycled asphalt shingles (RAS)



RAP and RAS

■ Benefits

- Economics
- Reduced rutting
- Environment
- Source of aggregate

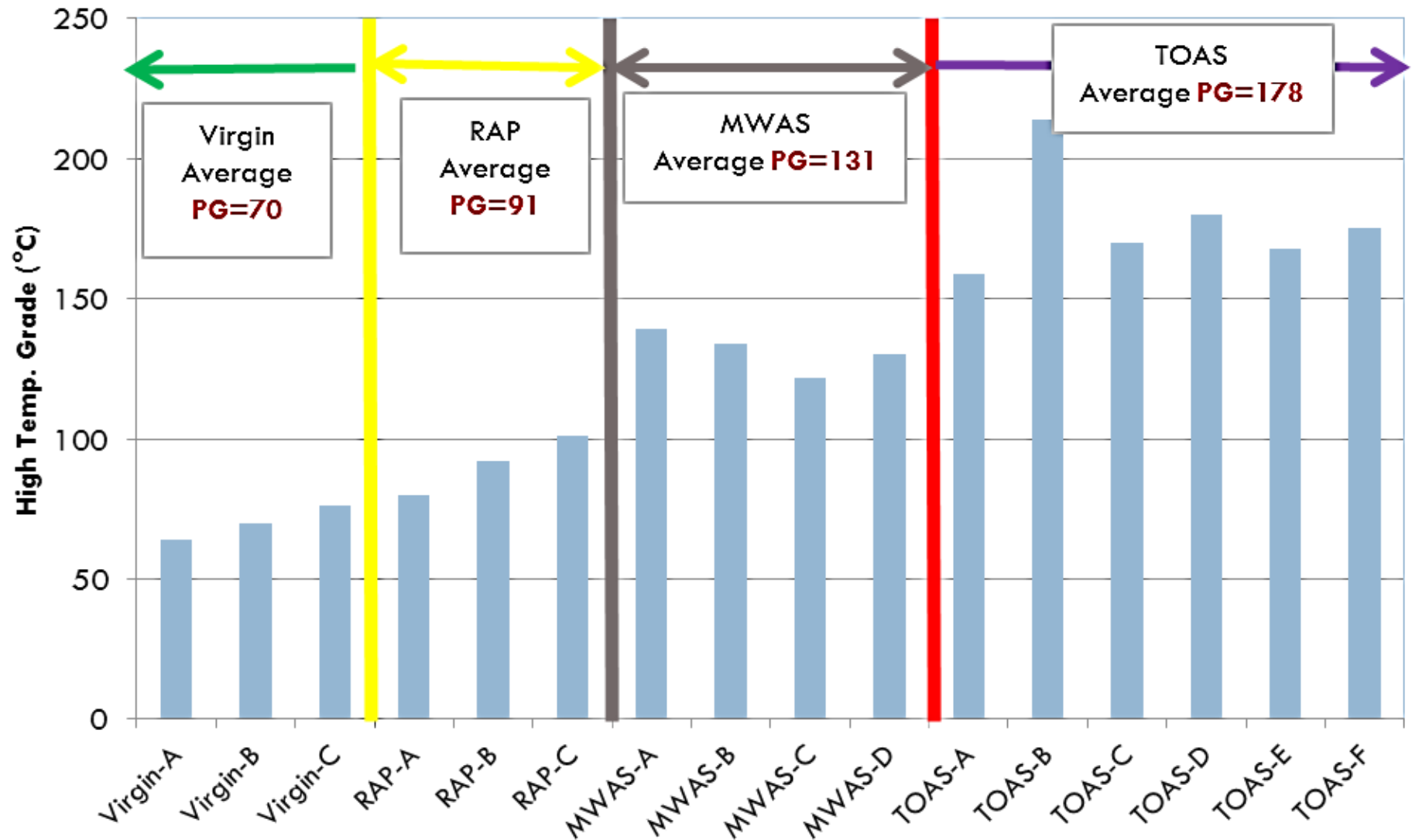


■ Disadvantages

- Stiffens mix
- Dry mixtures
- Mixes may be more prone to cracking



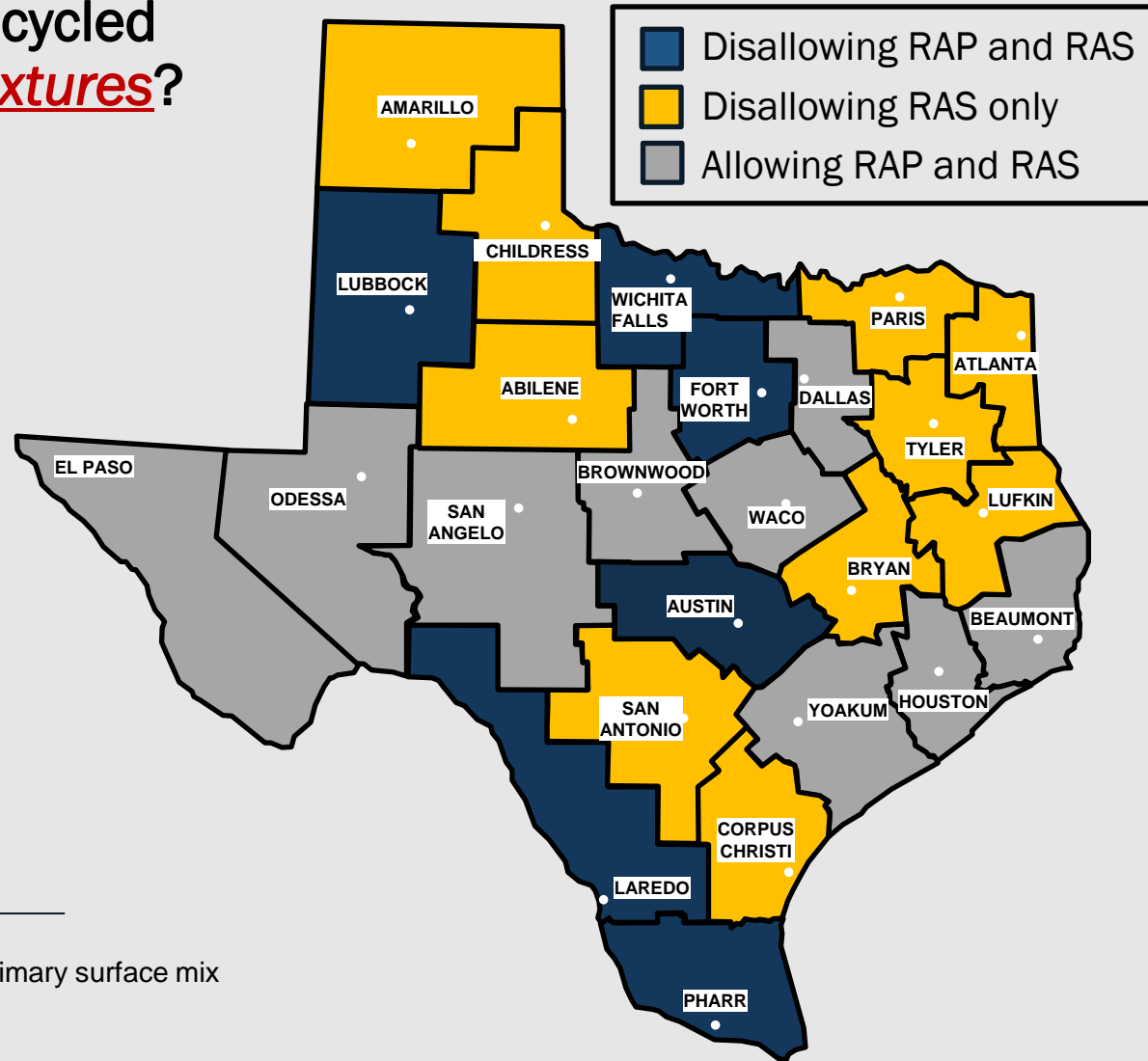
RAP and RAS PG Grade Determination



Recycled Materials Usage Statewide

■ What is the latest on recycled materials in surface mixtures?

- No recycle
 - 6 districts
- No RAS
 - 16 districts
 - Additional 2 districts without RAS producers, 1 only 1 contractor uses
- Allow RAP
 - 19 districts
- Allow RAP and RAS
 - 9 districts



Notes:

LBB does not allow RAP in SMA which is their primary surface mix

YKM most producers don't use RAS

ELP no RAS producers

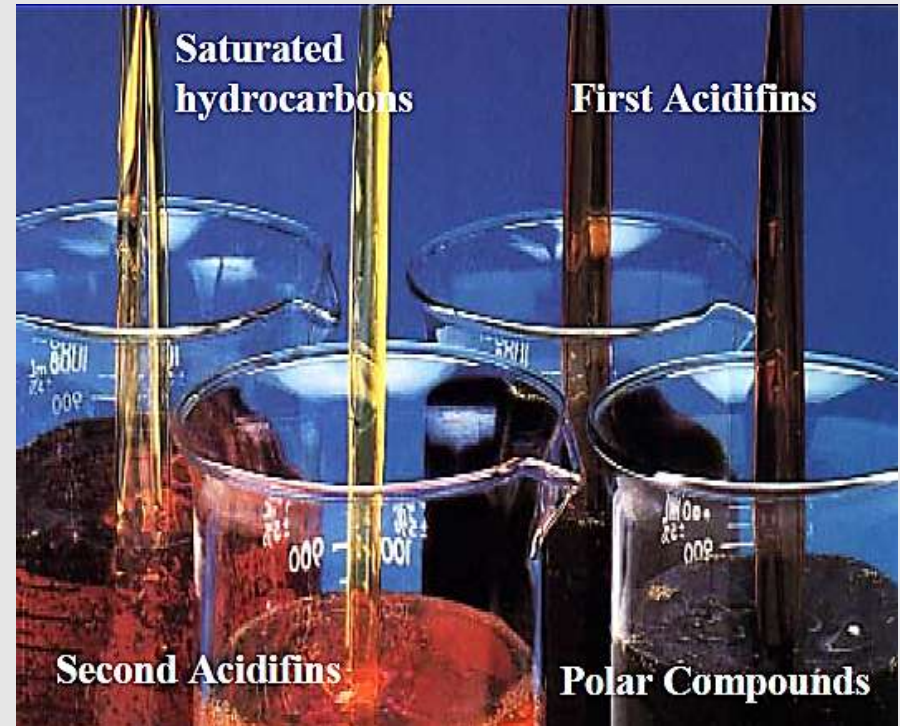
ODA no RAS producers

Methods to Address Cracking

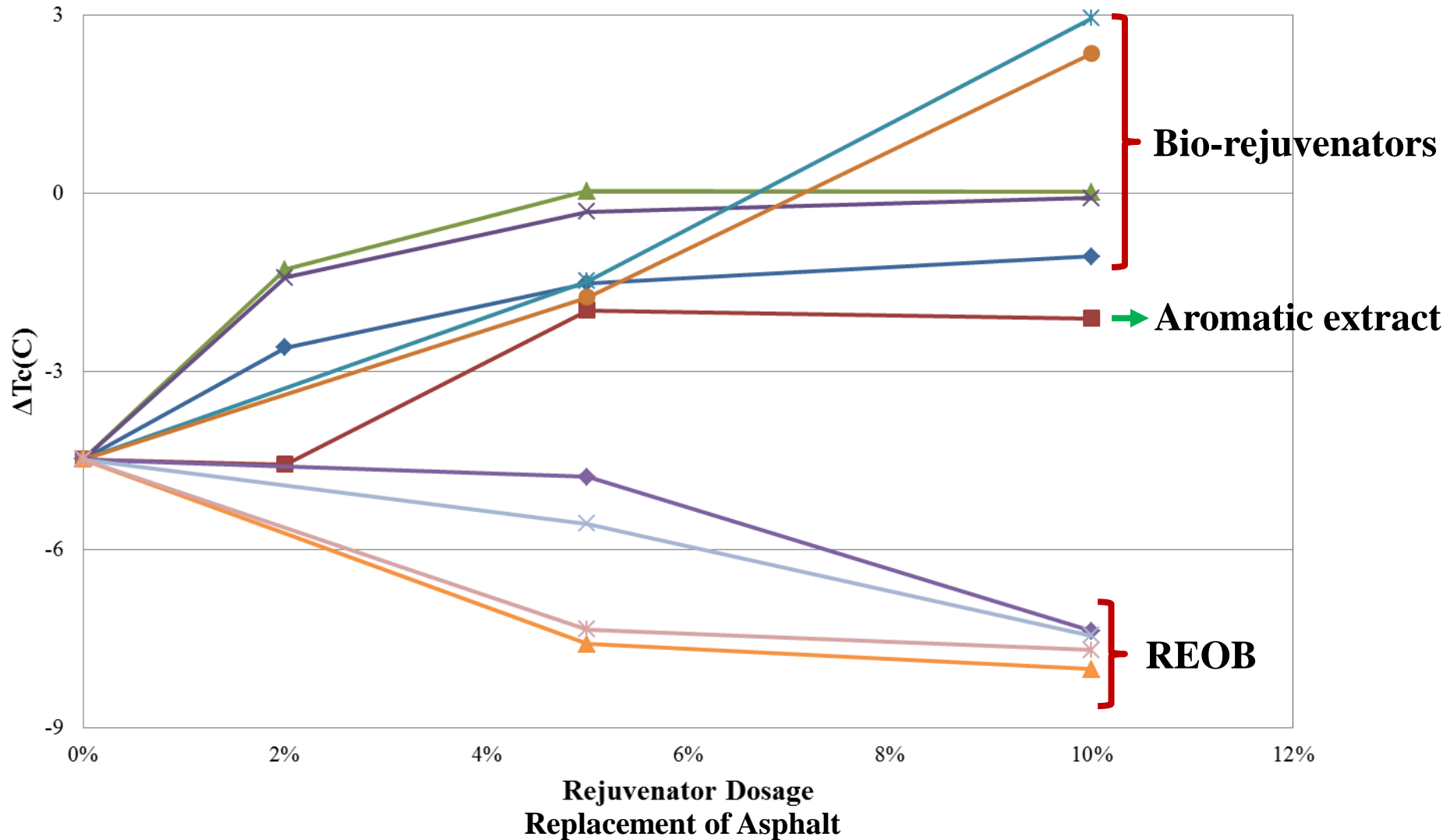
- Limit the quantity of RAP/RAS
 - Maximum recycled binder ratio
- Discount the effective asphalt content of RAP/RAS
 - TxDOT currently uses 100% effective for designing with RAP and RAS
- Use Superpave mix design procedure to allow more asphalt
 - TxDOT shift is towards using Superpave gyratory compactor
- Use softer virgin binders
 - PG 58-28
 - Consider lower temperature grade binders (e.g. PG XX-28, PG XX-34)
- Use a balanced mix design approach
 - Overlay test (cracking)
 - Hamburg wheel tracking test (rutting)
- Add rejuvenators to the mix

Rejuvenator Types

- **Bio-based (vegetation based)**
 - Arizona Chemical, Green Asphalt Technologies, Ingevity, Cargil, Collabortive Aggregates, Sonneborn, Roadscience
- **Aromatic extracts**
 - HollyFrontier, Reclamite
- **Re-refined waste materials**
 - Re-refined engine oil bottoms (REOB)
 - Re-refined waste fast food vegetable oil

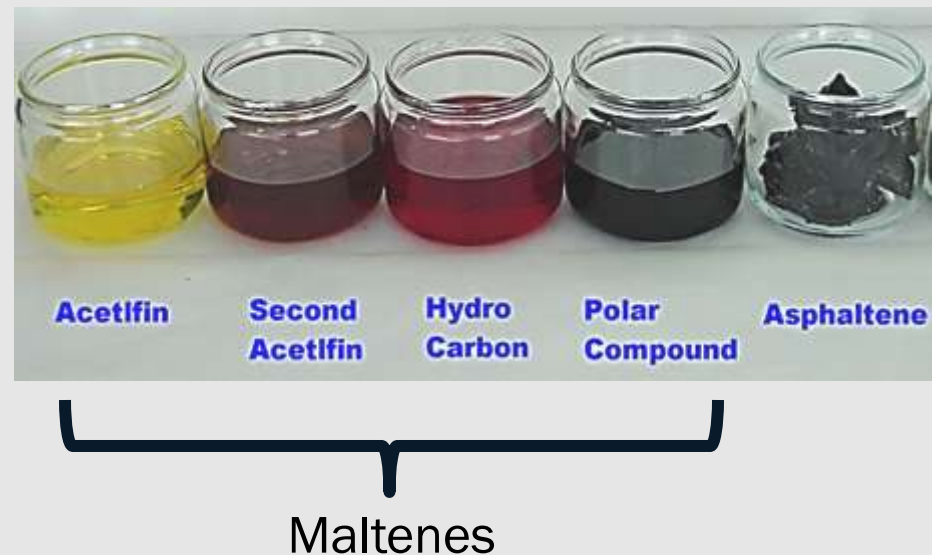


Bio-Based and Aromatic Extract Vs. REOB



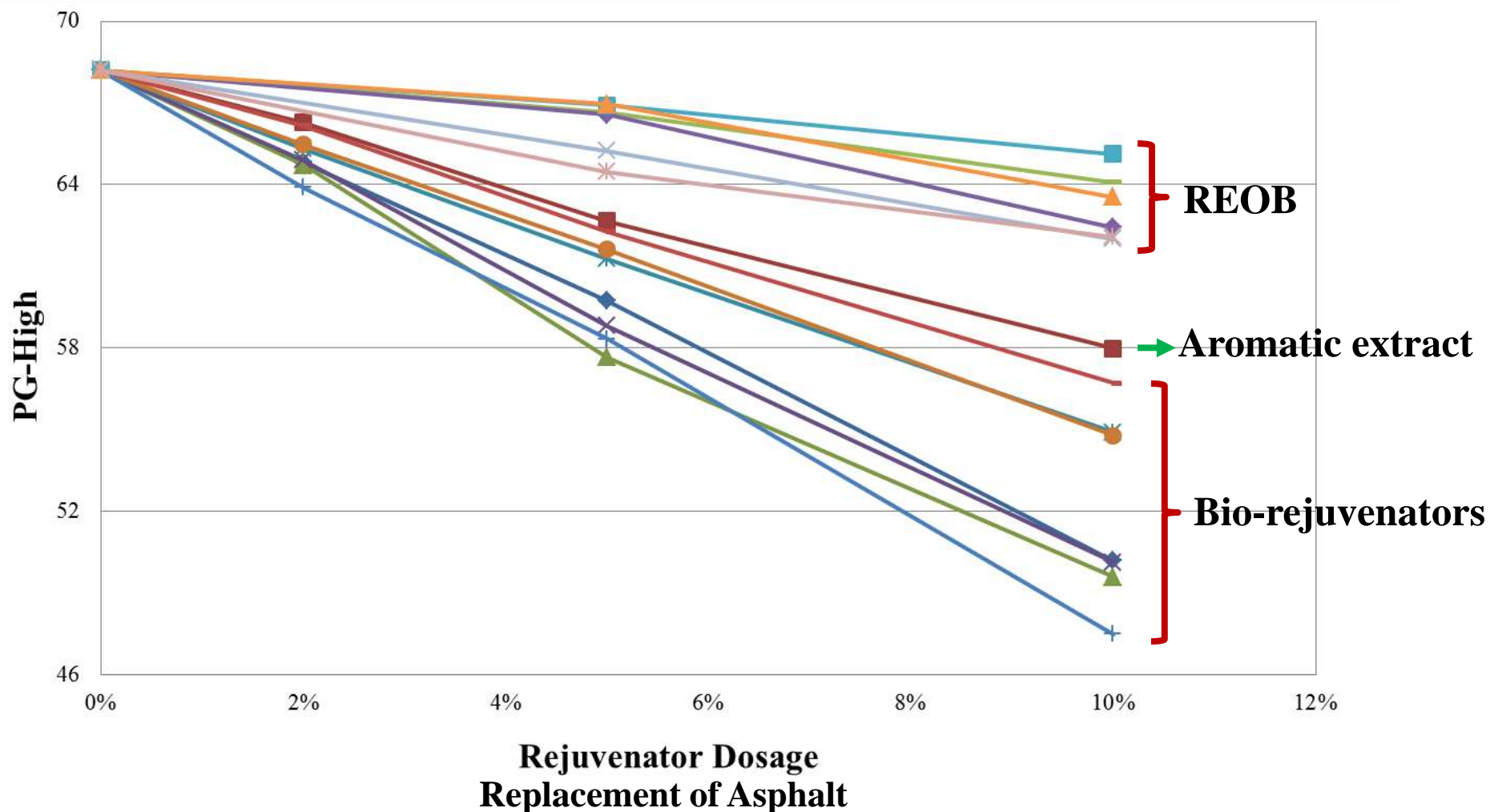
Rejuvenator Function

- Asphalt composition
 - Asphaltenes (insoluble, brittle, not affected by oxidation)
 - Maltenes (oily, flexible, affected by oxidation)
- Role of rejuvenators
 - Re-balance maltene fraction of asphalt
- Dynamic Shear Rheometer (DSR)
 - Lowers high temperature PG grade
- Bending Beam Rheometer (BBR)
 - Softens aged binders (creep stiffness, S)
 - Improves relaxation (m-value)



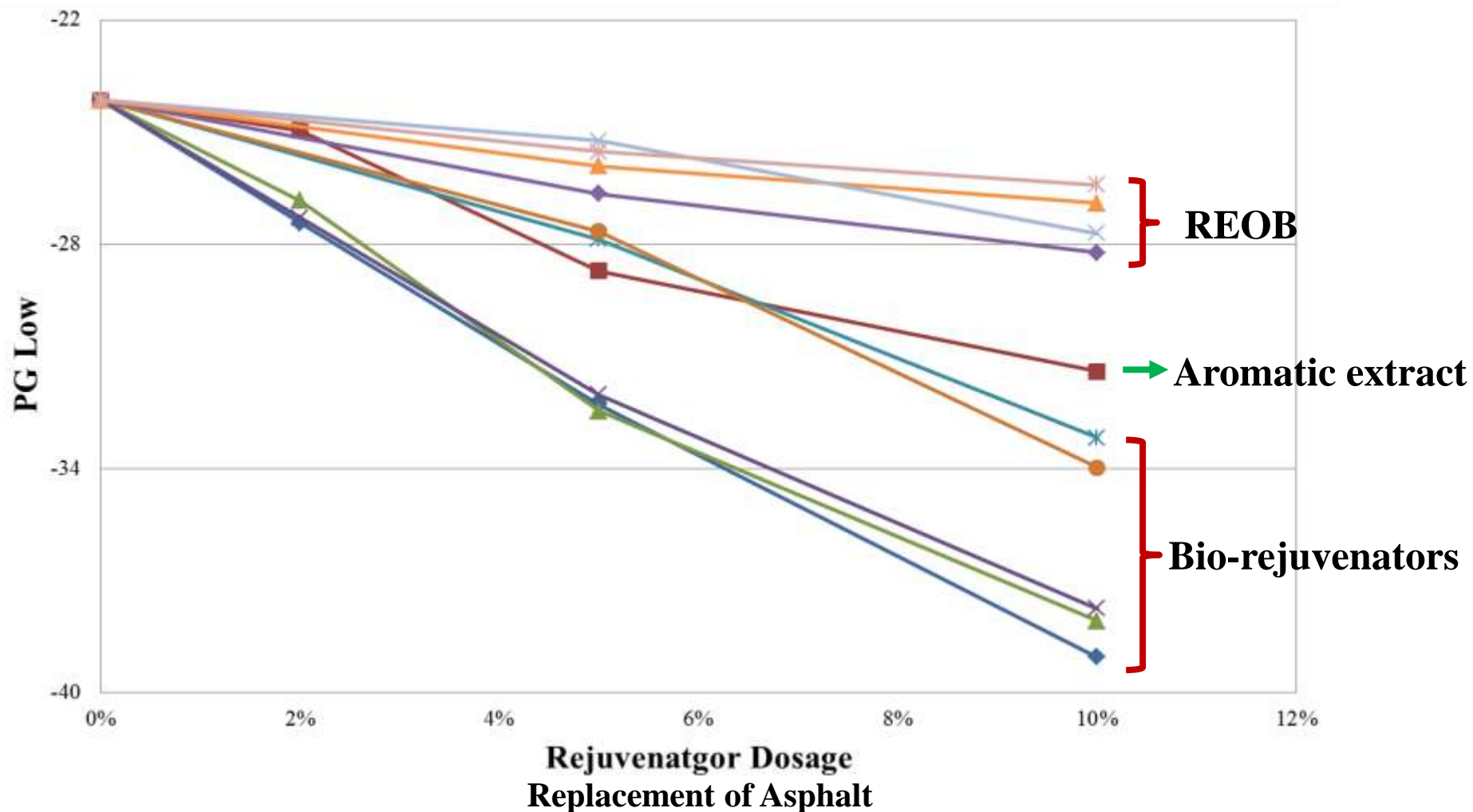
Rejuvenator Effectiveness

■ Virgin Binder PG 64-22



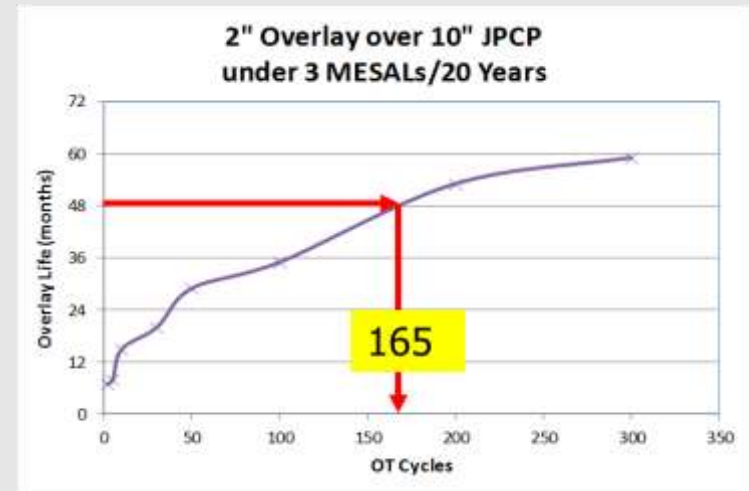
Rejuvenator Effectiveness

■ Virgin Binder PG 64-22



Four Step Design Process

- Step 1 – Select rejuvenator
- Step 2 – Select rejuvenator dosage range (binder testing)
- Step 3 – Obtain balanced mix design data (mix testing)
- Step 4 – Select dosage based on engineering judgement

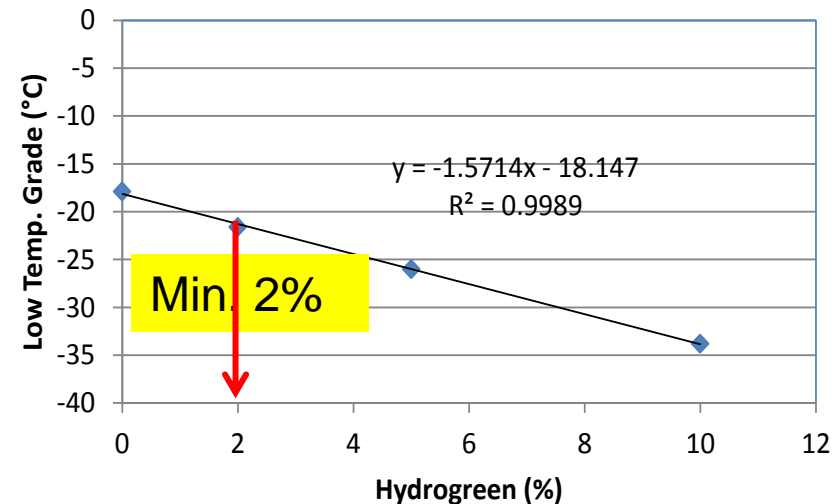
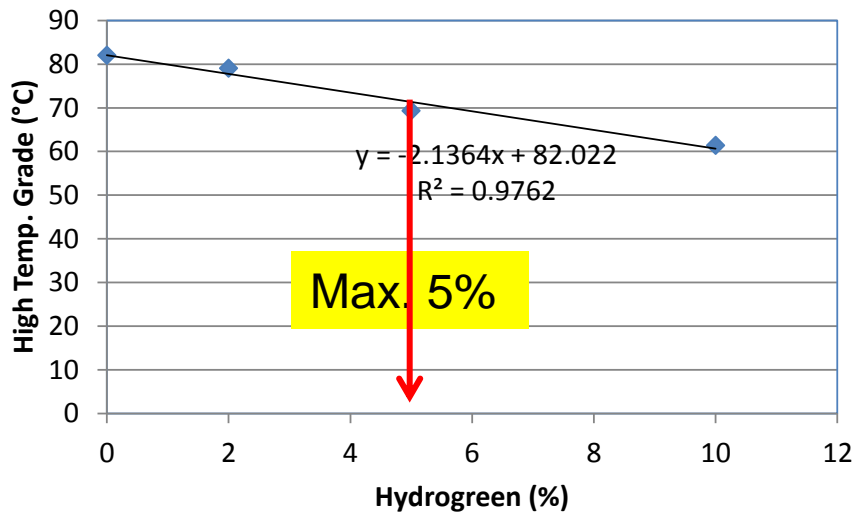


Step 1 – Select Rejuvenator

- Arizona Chemical/Kraton
- Green Asphalt Technologies
- Ingevity
- Cargil
- Collabortive Aggregates
- Sonneborn
- Roadscience
- Texas Road Recyclers
- HollyFrontier

Step 2 – Select Rejuvenator Dosage Range

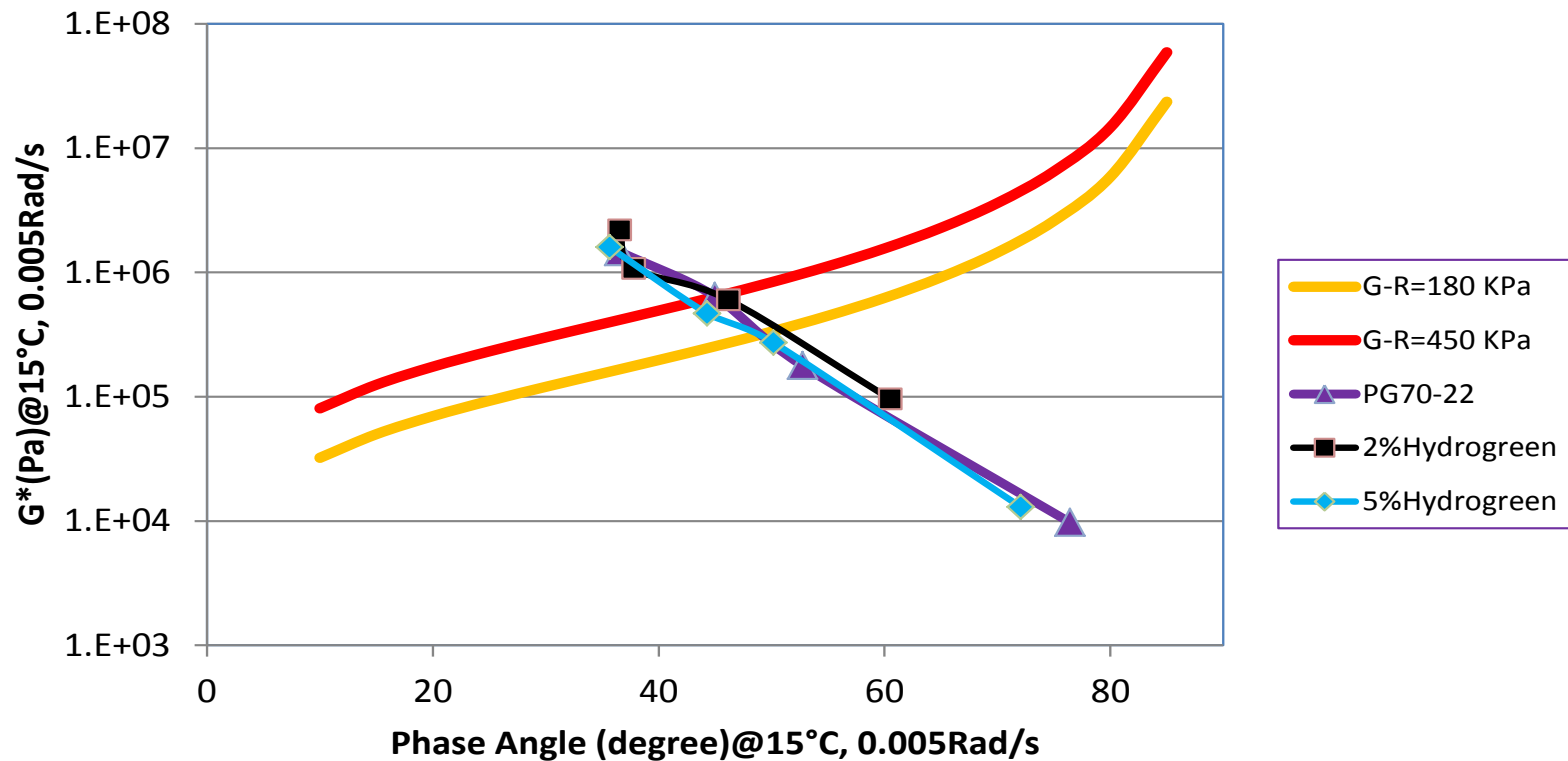
- Example : Original Binder Specified = PG 70-22
- Proposed: 10% RAP, 5% RAS, PG 64-22
 - Extract and combine asphalt from RAP and RAS with virgin binder at proposed binder ratios according to the mix design (e.g. PG 82-16)
- Add rejuvenator until DSR high temperature grade and BBR low temperature grade match original specified binder (PG 70-22)
 - Dosage range = 2% – 5%



Step 2 – Select Rejuvenator Dosage Range

- Check aging characteristics
 - Glover-Rowe parameter
 - Goal is to match aging characteristics of virgin binder

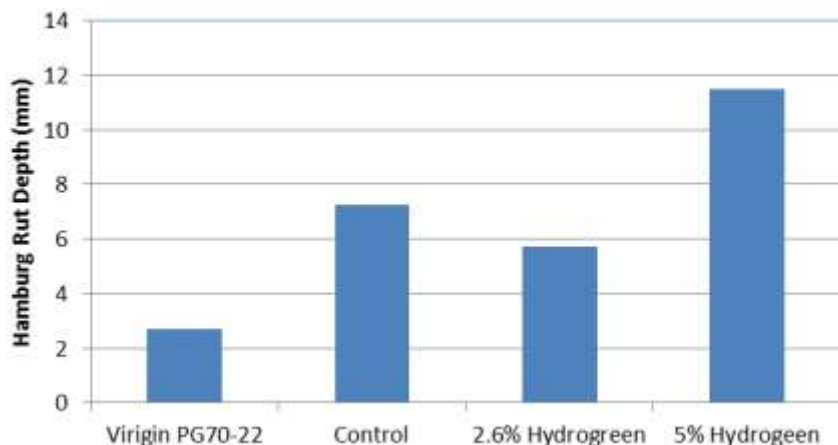
Aging Characteristics: PG70-22 Vs. Hydrogreen Rejuvenated Binder



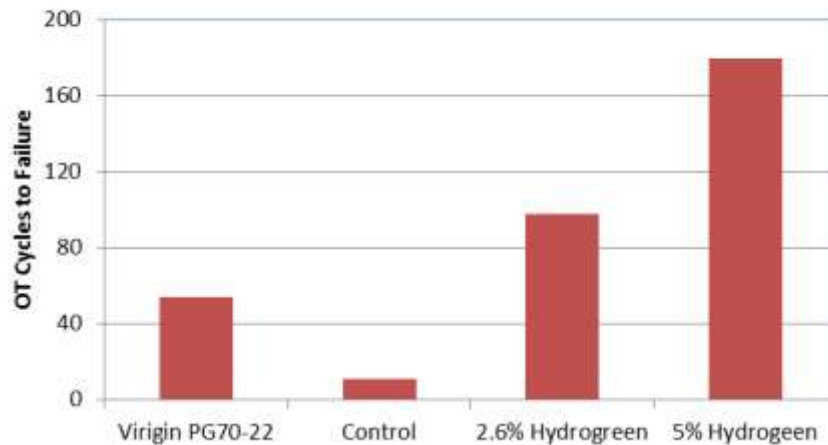
Step 3 – Obtain Data from Balanced Mix Design

- Perform Hamburg wheel tracking tests and Overlay tests on mix produced in the laboratory
 - Overlay requirements are determined by Overlay program (TxACOL)
 - Number of cycles are project specific (traffic, climate, pavement structure, etc.)

Hamburg Wheel Tracking Test Results



OT Test Results



Step 4 – Select Rejuvenator Dosage

- Use data gathered from Steps 1-3 to select rejuvenator dosage
 - Use engineering judgement to decide actual dosage
 - Higher rejuvenator dosage in areas more prone to cracking
 - Lower rejuvenator dosage in areas less prone to cracking
 - Factors include:
 - Traffic conditions
 - Interstate/high traffic levels
 - May consider lower rejuvenator dosage
 - FM roads with less traffic levels
 - May consider higher rejuvenator dosage
 - Pavement structure
 - Climate

Test Sections

- Test sections
 - Tyler District, SH31, included 5 test sections, 6/14/2014
 - Laredo District, FM468, included 5 test sections, 9/15/2015
 - Houston District, FM1463, included 4 test sections, 7/16/2016
 - San Angelo (coming soon)



- Dense Grade Type C Mix Designs:
 - Virgin mix, PG 70-22, AC = 4.5%
 - 10% RAP, 5% RAS, PG 64-22, AC = 4.6%
 - 10% RAP, 5% RAS, PG 64-22, 2.6% Hydrogreen, AC = 4.5%
 - 10% RAP, 5% RAS, PG 64-22, 3.7% Evoflex, AC = 4.7%
 - 10% RAP, 5% RAS, PG 64-22, 2.0% ERA-1, AC = 4.9%
- Reflective cracking was observed on all sections
- After 2.5 years, cracking was similar with all sections



- Lessons learned
 - Dosage of rejuvenators may have been too conservative
 - Two lift overlay was constructed over jointed concrete pavement
 - Crack attenuating mix (CAM) was placed before winter and had previously cracked prior to placing test sections
 - Solution – Construct both sections at the same time

Laredo District – FM468

■ Superpave Type C Mix Designs

- Virgin mix, PG 70-22, AC = 6.1%
- 30% RAP, PG 64-22, AC = 6.3%
- 30% RAP, PG 64-22, 2.2% Road Science, AC = 6.3%
- 30% RAP, PG 64-22, 3.0% Arizona Chemical, AC = 6.3%
- 30% RAP, PG 64-22, 3.2% Hydrogreen, AC = 6.3%

April 8, 2016



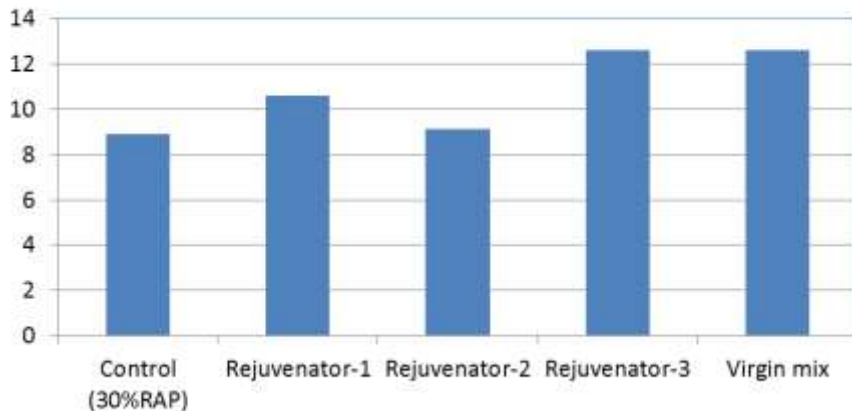
November 16, 2016



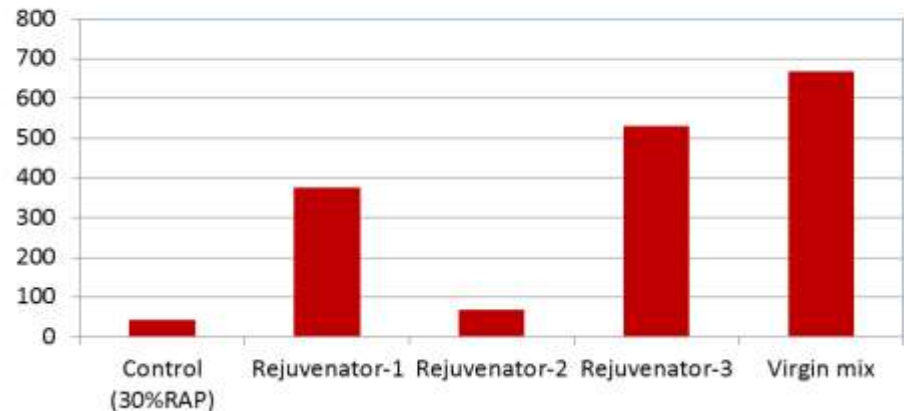
Laredo District – FM468

- After 15 months, all sections performed well
- Laboratory molded densities did approach 98.0%
 - No rutting observed to date (~15 months)
 - FM468 is in the energy sector
 - High truck traffic due to the Eagle Ford Shale oil production

Hamburg Rut depth (mm)



OT Cycles



Houston District – FM1463

■ Dense Grade Type D Mix Designs

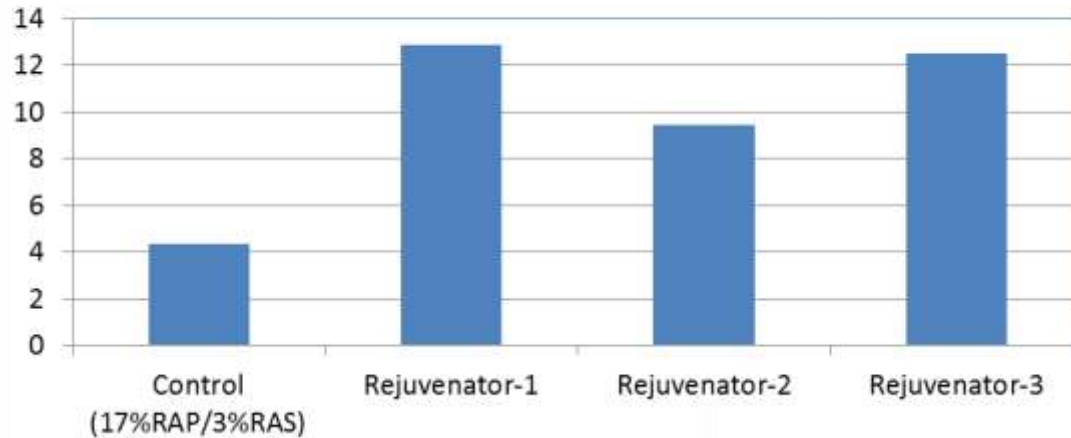
- 17% RAP, 3% RAS, PG 64-22, AC = 5.2%
- 17% RAP, 3% RAS, PG 64-22, 3.5% Arizona Chemical, AC = 5.2%
- 17% RAP, 3% RAS, PG 64-22, 4.0% Sonneborn, AC = 5.2%
- 17% RAP, 3% RAS, PG 64-22, 7.5% Evoflex, AC = 5.2%



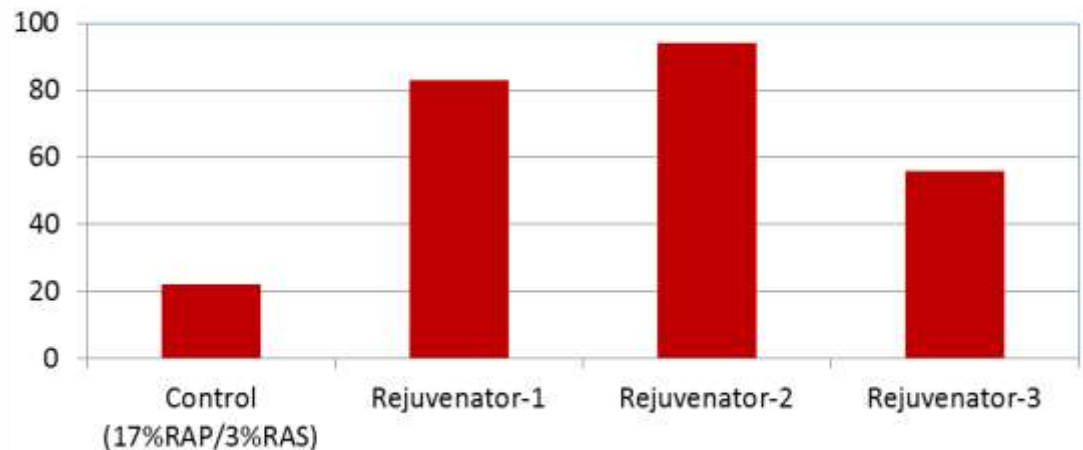
Houston District – FM1463

- Too early to tell, but laboratory results look promising...

Hamburg Rut Depth (mm)



OT Cycles



Conclusions

- Rejuvenators have been shown to improve cracking resistance of RAP/RAS mixes in the laboratory
- Use of rejuvenators may impact lab molded density and compaction effort in the field
 - Consider changing lab molded density requirements/decrease number of gyrations
 - Roller patterns will need to be adjusted (less compaction effort)
- Too early to determine their effectiveness in the field
 - No problems were encountered with meeting air void requirements
 - Difficult to know cost savings
 - Performance based (more service life)
 - Will allow use of more recycled materials
- Continuation of monitoring field test sections is needed

- Special thanks to the Texas Transportation Institute (TTI) and Dr. Fujie Zhou for the information presented in this presentation

Questions