2016 PAPA REGIONAL MEETINGS

Allentown - State College – Cranberry Township

"Balanced RAP/RAS Mix Design for Project- Specific Service Conditions"

Pennsylvania Asphalt Pavement Association
Pennsylvania Rides on Us.

Balanced RAP/RAS Mix Design for Project- Specific Service Conditions

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PAPA DIRECTOR OF TECHNICAL SERVICES

Original Presentation by:

Texas A&M Transportation Institute
Dave Newcomb

TXAPA, September 2014

Outline

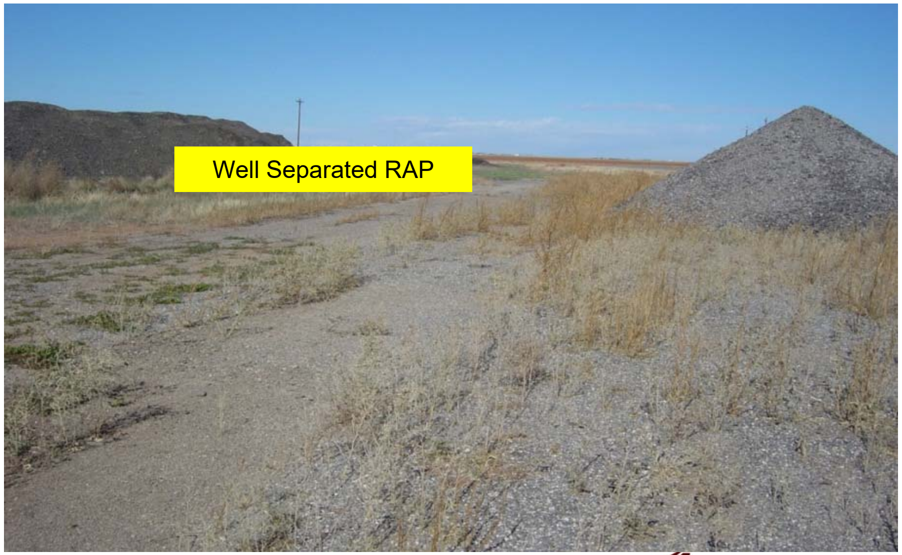
- Introduction
- Existing design methods and limitations
- Balanced RAP/RAS mix design for project-specific conditions
  - Need a mechanical test to assure rutting resistance
  - Need a mechanical test to assure cracking resistance
  - Need volumetric-air voids for quality control
  - Need project-specific rutting and cracking requirements
- Demonstration of project-specific OT requirement
- Summary and conclusions

Introduction

- Benefit of RAP/RAS
  - Economics
    - Saving aggregates
    - Saving asphalt binder
  - Reducing rutting
  - Environment
    - Reducing demands of non-renewable resources
    - Reducing landfill space demands
- RAP/RAS must be used!

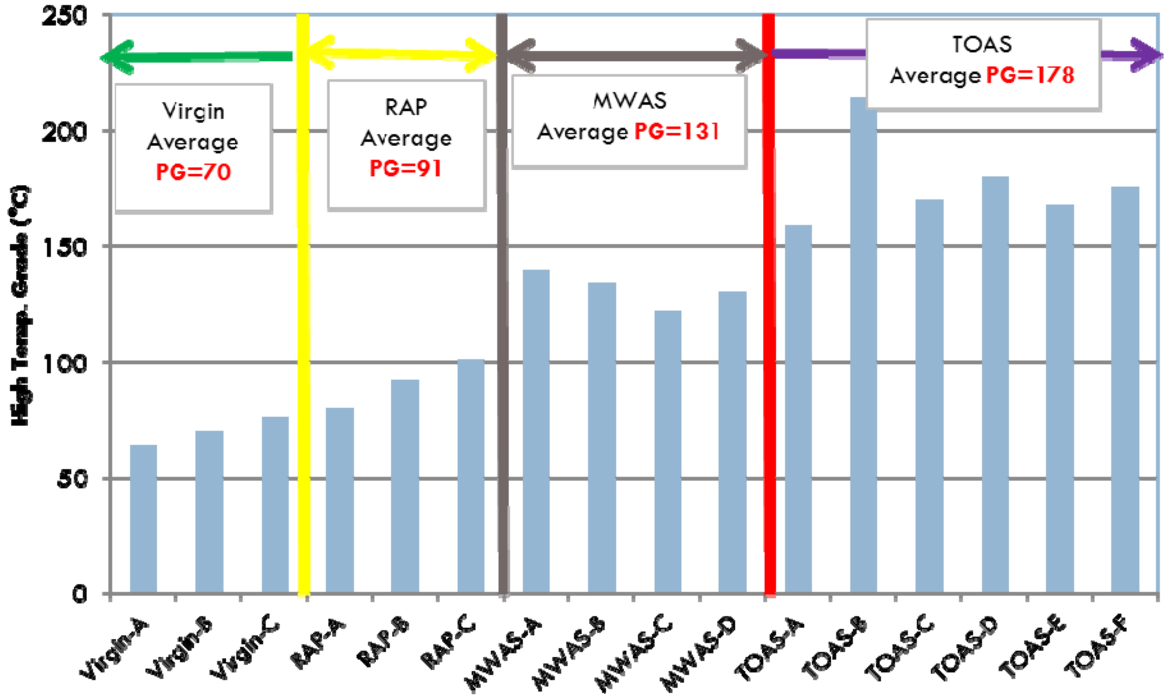
Introduction

- No.1 concern- variability
  - Binder grade variation
  - Binder content variation
  - Aggregate gradation
- Solution:
  - Best practices for RAP/RAS processing and stockpile management



Introduction

- No. 2 concern- cracking
  - RAP/RAS binder too stiff
- Solution:
  - Balanced mix design for project-specific conditions



Current mix design methods and limitations

- Current mix design methods
  - Volumetrics + Stability
    - Hveem
    - Marshall
  - Superpave method
    - Pure volumetrics; no mechanical testing
  - Superpave plus
    - Volumetrics+Hamburg/APA/…
- Control cracking in current methods
  - V_{BE} (=VMA-AV) to control cracking; OK for virgin mixes
  - No simple cracking test

Limitations of current design methods for RAP/RAS mixes

- Feature of RAP/RAS mixes: Unknown VMA (V_{BE})
  - Don't know how RAP/RAS blends with virgin binder.

- Need **a mechanical test** to assure cracking resistance.

One Benefit of Layered Pavement

- In a layered flexible pavement design, the material characteristics of each specific layer can be customized for optimum performance.

Plant Mix= AC + FA+ CA

- PLUS:
- WMA -Polymer -AS
- RAP -GTR -PPA
- RAS -Fibers -etc.

Balanced mix design for project specific condition

- Current mix designs not suitable for RAP/RAS design
  - Need to assure rutting resistance
  - Need to assure cracking resistance
  - Need volumetric-air voids for QC
  - Need project-specific rutting and cracking requirements
    - Traffic
    - Climate
    - Structure

Why project-specific design:

RAP/RAS field test sections and performance

Test sections		Highway	Overlay/ new const.	Weather	Traffic MESAL	OT cycles	Performance
Amarillo	0%RAP	IH40 (severely cracked thick asphalt pavement)	4 inch/ overlay	Cold	30	95	3 yrs: 100% refl. cracking
	20%RAP					103	
	35%RAP					200	3 yrs: 57% refl. cracking
Pharr	0%RAP	FM1017-Very good support	1.5 inch/ new const.	Very hot	0.8	28	3yrs: overall - good conditions
	20%RAP					6	
	35%RAP					7	
Laredo	20%RAP	SH359- regular support	3 inch/ overlay	Very hot	1.5	3	3yrs: No cracking
Houston	15%RAP/ 5%RAS	SH146-Very good support	2 inch/new const.	hot	3.0	3	2.5yrs: No cracking
Dalhart	5%RAS	US87	3 inch/ Overlay	Cold	3.0	48/96	96 cycles-20% RCR; 48 cycles-50%RCR

Why project-specific design:

RAP/RAS field test sections and performance

1. RAP/RAS mixes perform well at certain locations.
2. One OT requirement cannot fit for all.
3. Successful use of RAP/RAS mixes depends on
   - Weather/Traffic
   - AC overlay
     - Overlay thickness, Existing pavement structure (AC/AC; AC/PCC)
     - Existing pavement conditions
   - New construction
     - Pavement structure and which layer (surface, base, etc.)
4. Design the mix for project-specific conditions

Balanced RAP/RAS mix design for project specific condition

Cracking

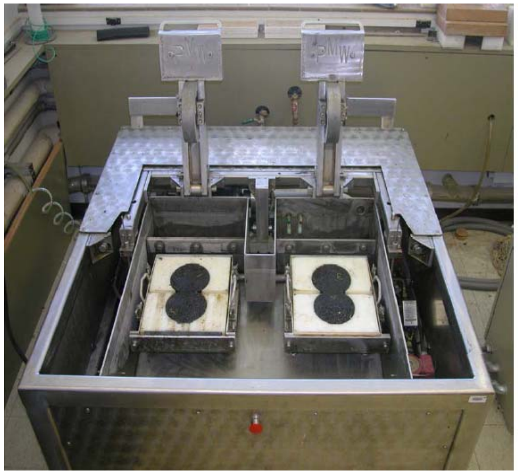
Rutting

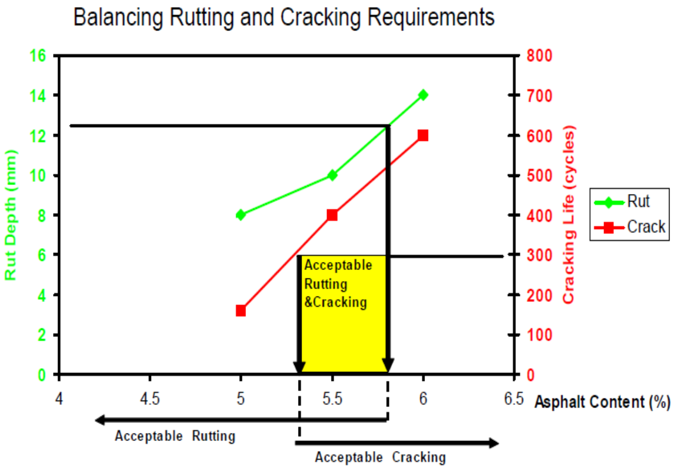
Mix Design

Balanced RAP/RAS Mix Design for Project-Specific Service Conditions

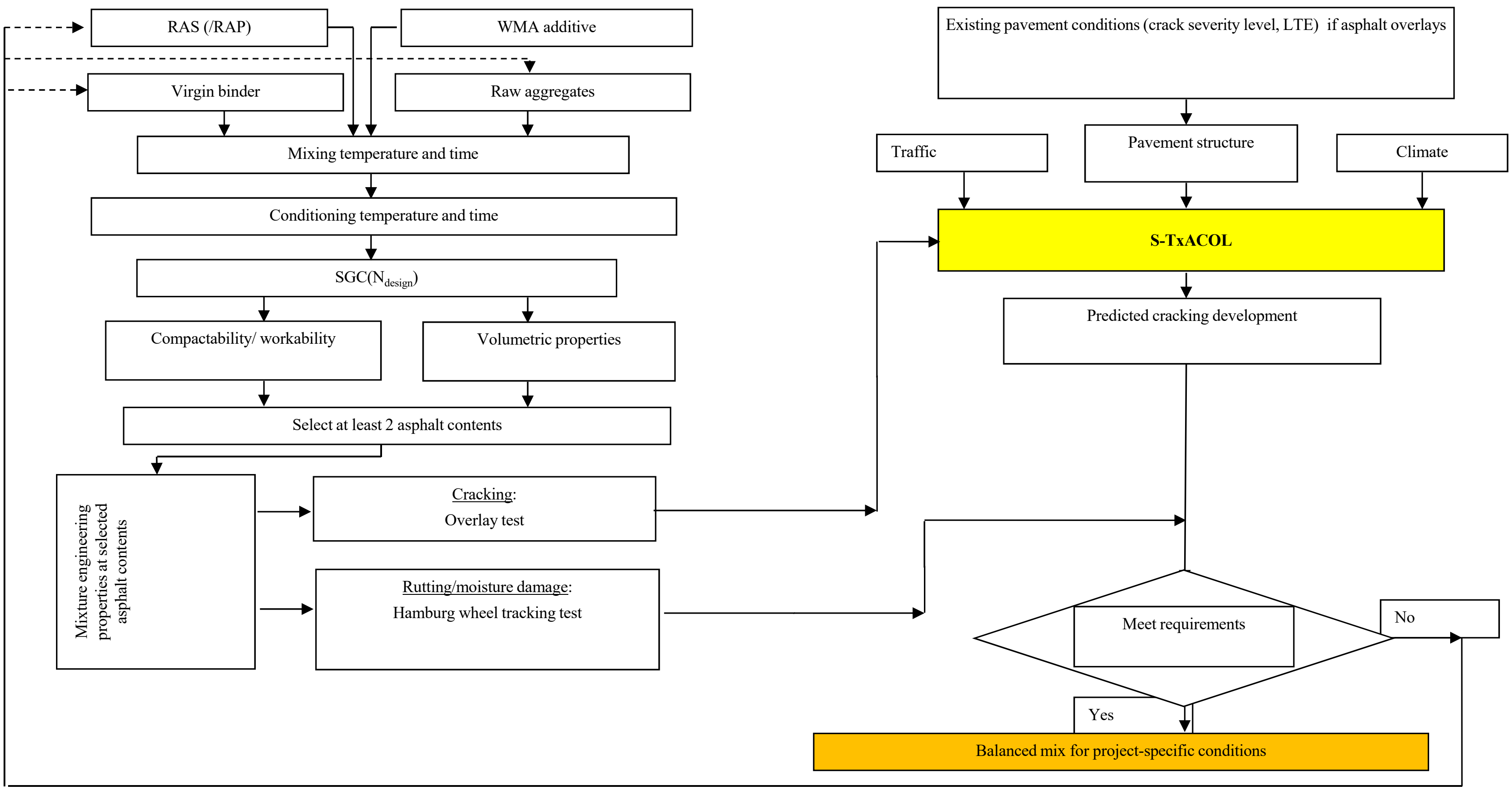
- Hamburg test for rutting/moisture damage
- Overlay test for cracking

  OT requirement determined by Overlay program
- Max. density-98% for controlling potential bleeding





Balanced RAP/RAS mix design for project specific condition

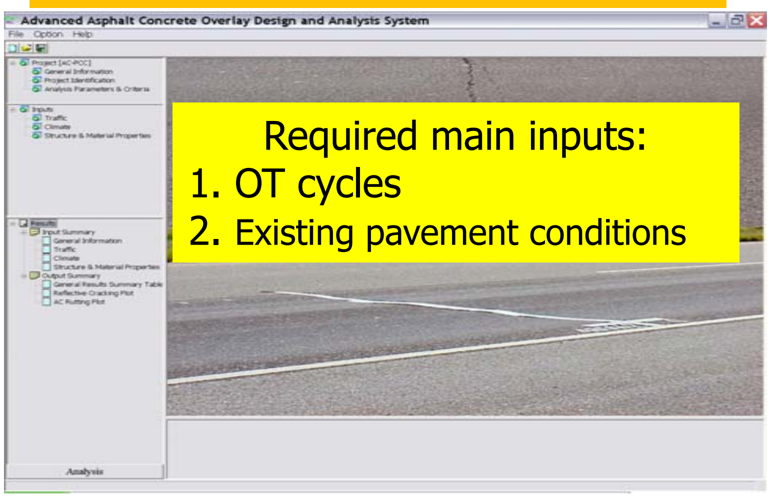


Cracking in Mixes

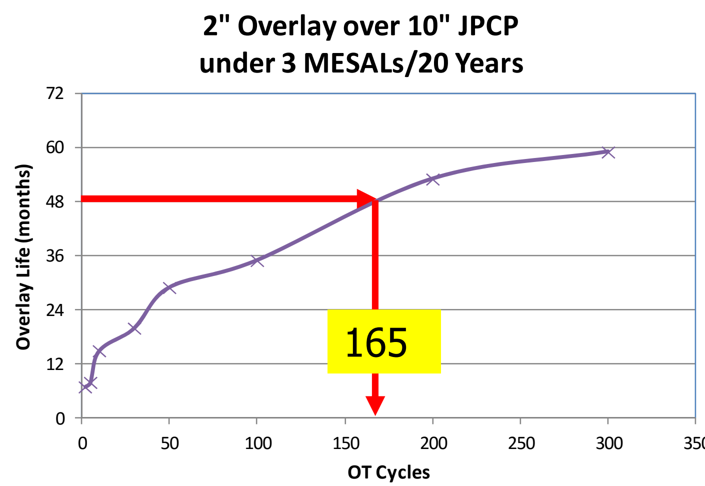
- How rapidly cracks occur:
  - $Rate = A(\Delta SIF)^n$
- Stress Intensity Factor (SIF) depends upon:
  - How wide the crack opens
  - How stiff the material is
  - How long the crack is

Balanced RAP/RAS Mix Design for Project-Specific Conditions

Simplified Overlay design system



Determination of Min. OT cycles



Approaches for Improving RAP/RAS Mix Cracking Performance

- **Available approaches**
  - **Increase virgin AC (**higher density**) minimum Vbe**
  - **Soft, modified binders:** PG64-28, PG64-34, PG58-34
  - Rejuvenators

What Performance Tests Have Been Adopted by Other States?

-Overlay Test (OT)
-Disk-Shaped Compact Tension (DCt)
-Semi-Circular Bend (SCB)

	Mix Design	Acceptance Quality Characteristics	Initial Verification Go / No Go	Ongoing Go / No Go	Information Only
Superpave M323	Volumetric	Volumetric Field Compaction			
California	Volumetric Beam Fatigue Repeated Shear Hamburg	Volumetric Field Compaction			Beam Fatigue Repeated Shear Hamburg
Texas	Volumetric Overlay Tester Hamburg	Volumetric Field Compaction	Overlay Tester Hamburg	Overlay Tester Hamburg	
Wisconsin	Volumetric SCB, DC(t) Overlay Tester	Volumetric Field Compaction	DC(t) Overlay Tester	DC(t) Overlay Tester	SCB
Illinois	Volumetric IL-SCB* Hamburg	Volumetric Field Compaction	IL-SCB* Hamburg	IL-SCB* Hamburg	DC(t)
New Jersey	Volumetric APA Beam Fatigue Overlay Tester	Field Compaction	APA Beam Fatigue Overlay Tester	APA Beam Fatigue Overlay Tester	
Louisiana	Volumetric SCB Hamburg	Field Compaction	SCB Hamburg	SCB Hamburg	

Overlay Test

-Developed at Texas Transportation Institute

-Cyclical Direct Tension

-Primarily for Overlay Layers

-Texas and New Jersey

Overlay Test:
VIDEOS FOR POWERPOINTS\Overlay Test.mp4

https://www.youtube.com/watch?v=tLGVK_mHX_I

Disk-Shaped Compact Tension

- DCt (ASTM D 7313-13)
- Direct tension at low temps. (PG + 2C)
- Minnesota & Wisconsin

DCT Test:

VIDEOS FOR POWERPOINTS\DCT Test.mp4

https://www.youtube.com/watch?v=r7y-0AziaP8

Semi-Circular Bend

- SCB   (AASHTO TP 105)
- Bending Fatigue Test
- Illinois & Louisiana

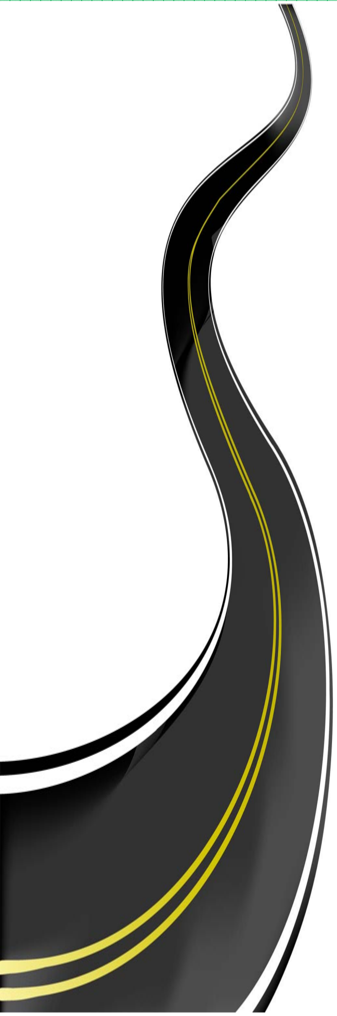
SCB at Low Temperature:

VIDEOS FOR POWERPOINTS\SCB at Low Temperature.mp4

https://www.youtube.com/watch?v=mWKXZhEHot0

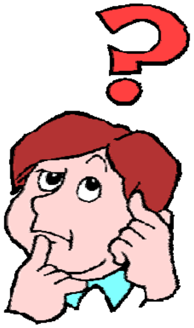
Summary and Conclusions

- RAP/RAS and other modified binder mixes can have same or better performance with proper design.
- Balanced or optimized mix design using laboratory performance tests for project-specific conditions is recommended for use.
  - Hamburg test for rutting/moisture damage
  - OT, DCt, SCB for cracking; Project-specific requirements or thresholds
  - Max. density to control potential bleeding



QUESTIONS?

Thanks for your attention!



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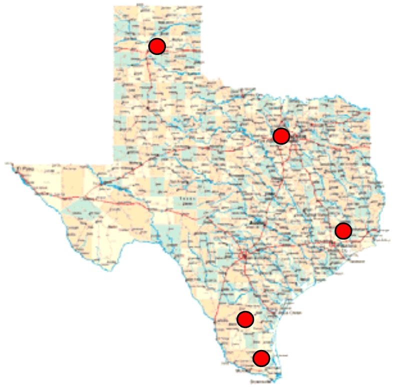
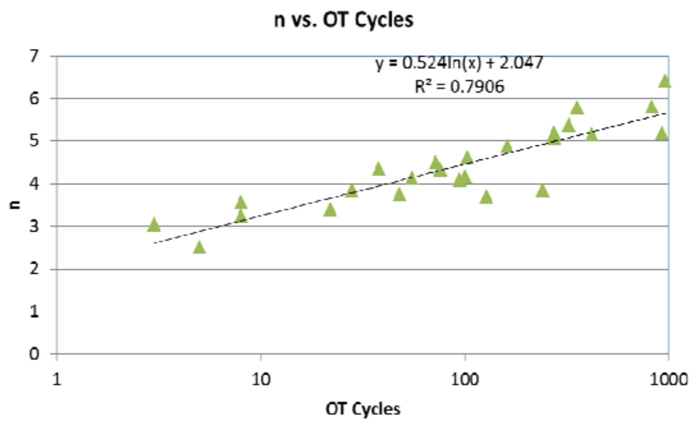
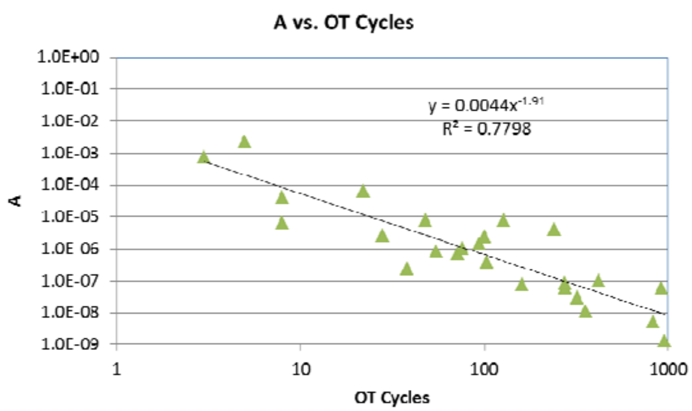


- Amarillo-Overlay: (Aug 2009)
  - IH40: Heavy traffic; Cold weather; Soft binder
  - RAP: 0, 20, 35%
- Pharr district-New Const.: (April 2010)
  - FM1017: low traffic; Hot weather; stiff binder
  - RAP: 0, 20, 35%
- Laredo-Overlay: SH359, 20%RAP (Mar. 2010)
- Houston-New Const.:SH146, 15%RAP/5%RAS (Oct. 2010)
- Fort Worth-AC/CRCP: Loop 820 (July 2012)

OT Cycles vs. A and n

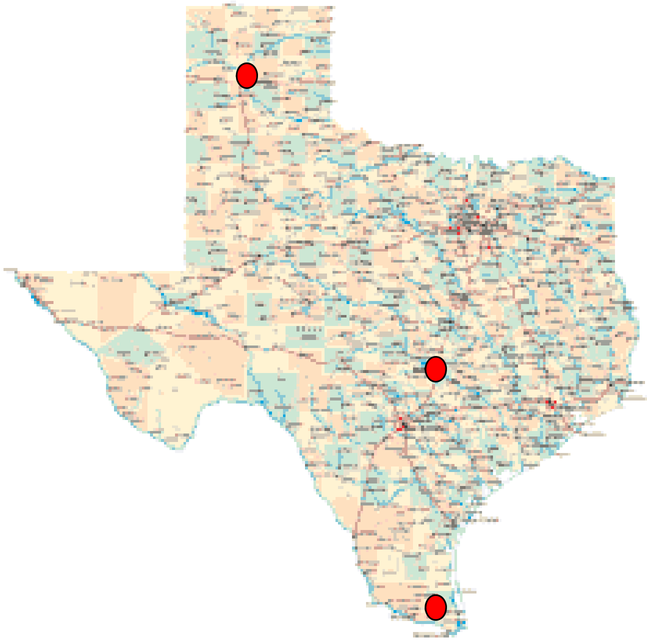




No.	Mixes	OT Cycles	A	n
1	US87 S1-RAS mix (dense-graded mix)	94	1.3677E-06	4.0833
2	US87 S2-RAS mix (dense-graded mix)	48	7.8997E-06	3.7445
3	SH143-RAP mix (dense-graded mix)	5	2.2461E-03	2.5136
4	SH359-RAP mix (dense-graded mix)	3	7.6451E-04	3.0370
5	Loop820-RAP/RAS/WMA (dense-graded mix)	8	3.9572E-05	3.2465
6	Dallas-Ty B mix (dense-graded mix)	22	6.2163E-05	3.3900
7	Dallas-Ty C mix (dense-graded mix)	128	7.9056E-06	3.7014
8	MnRoad Cell2 (Superpave mix)	356	1.1148E-08	5.7841
9	MnRoad Cell16 (Superpave mix)	100	2.4601E-06	4.1542
10	PG64-34 TamKo RAS-5.2AC	322	2.9004E-08	5.3648
11	PG58-34 TamKo RAS-5.2AC	420	1.0015E-07	5.1560
12	Odessa P. Mix S4 (dense-graded mix)	161	7.3597E-08	4.8755
13	Buda PG64-34-5% RAS mix (dense-graded mix)	72	6.6989E-07	4.4910
14	Buda PG58-34-5% RAS mix (dense-graded mix)	274	6.1648E-08	5.0803
15	NCAT N9-1 (Superpave mix)	55	8.1553E-07	4.1200
16	NCAT N9-2 (Superpave mix)	8	6.4143E-06	3.5650
17	PG64-22 15%RAP (dense-graded mix)	76	1.0020E-06	4.3220
18	PG64-28 15%RAP (dense-graded mix)	240	3.9073E-06	3.8385
19	PG64-34 15%RAP(dense-graded mix)	926	5.8813E-08	5.1721
20	Paris-PG58-34 15%RAP (dense-graded mix)	274	8.3199E-08	5.1880
21	Amarillo-20%RAP-I40 (dense-graded mix)	103	3.8371E-07	4.6076
22	SMA PG70-28 0RAP AC 6.6	827	5.1984E-09	5.7962
23	SMA PG70-28 0RAP AC 6.0	957	1.2871E-09	6.4071
24	NCAT S6-1 (Superpave mix)	28	2.6396E-06	3.8433
25	NCAT N10-1 (Superpave mix)	38	2.4574E-07	4.3536

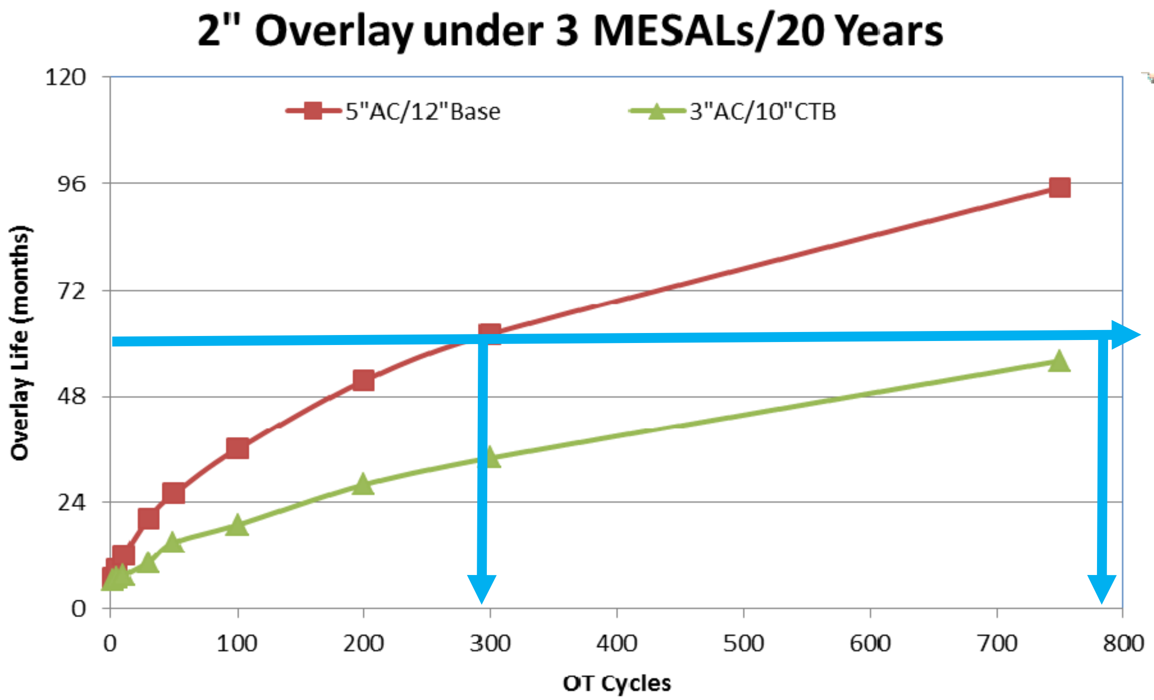
Demonstration of project-specific OT requirement

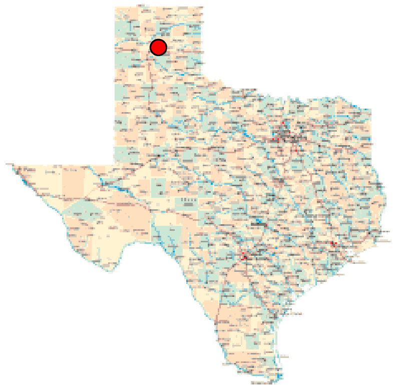
- AC overlay scenarios
  - AC/PCC
  - AC/AC/CTB
  - AC/AC/granular base
- Traffic level: 3 MESAL
  - **SH/US: 3-5 MESAL**
- Weather:
  - Amarillo
  - Austin
  - McAllen



Demonstration of project-specific OT requirement

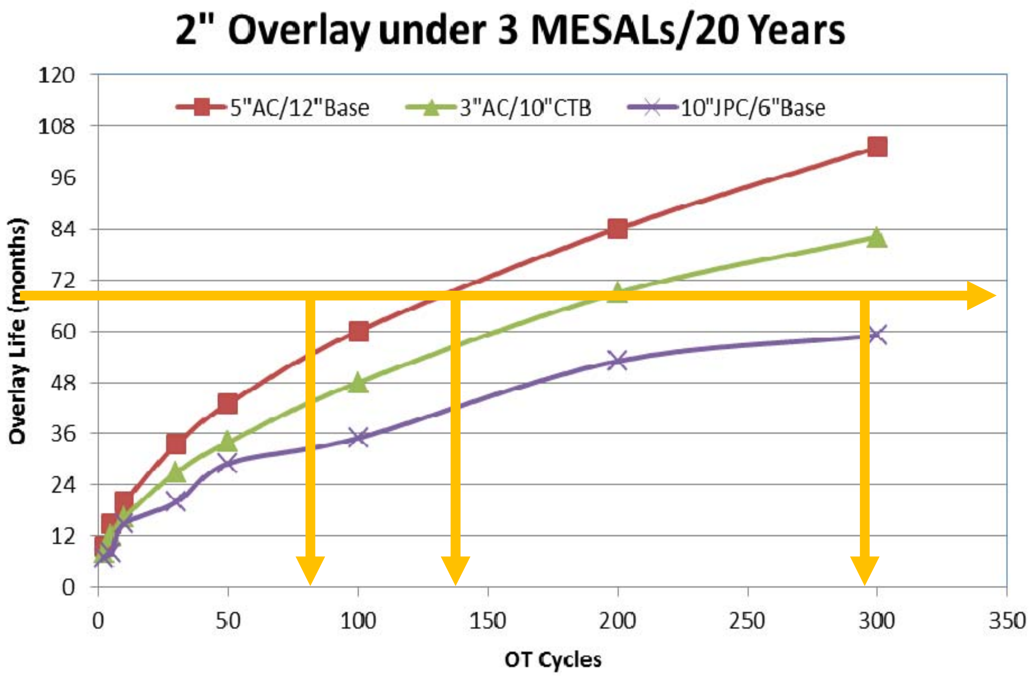
- Amarillo





Demonstration of project-specific OT requirement

- Austin



Demonstration of project-specific OT requirement

- McAllen