

# **Balanced RAP/RAS Mix Design and Performance Evaluation for Project- Specific Service Conditions**




**Texas A&M Transportation Institute**

**Fujie Zhou**

**TxAPA, Buda, Texas; Jan. 8, 2013**

# Outline

- 
- Introduction
  - Accomplishments under Projects 0-6092/0-6614
    - ▣ Best practices
    - ▣ Field performance data of RAP/RAS test sections
  - Balanced RAP/RAS mix design for project-specific conditions
  - Approaches for improving RAP/RAS mix performance
  - Summary and conclusions

# Introduction

## □ RAP/RAS

### □ RAP

- Fresh/"young"/old pavements

### □ RAS

- Manufacture waste/Tear-off

## □ Why use RAP/RAS

### □ Save money

- Asphalt binder, aggregates, etc.

### □ Good for environment

## □ In most cases we **cannot avoid** RAP/RAS mixes!



# Introduction

## □ Concerns

- Variability
- Durability of RAP/RAS mixes
  - Stiffest virgin binder in Texas: **PG76-22**
  - RAP: **PG82** to **PG110**; RAS: **PG130** to **PG200**
- Workability and field compaction

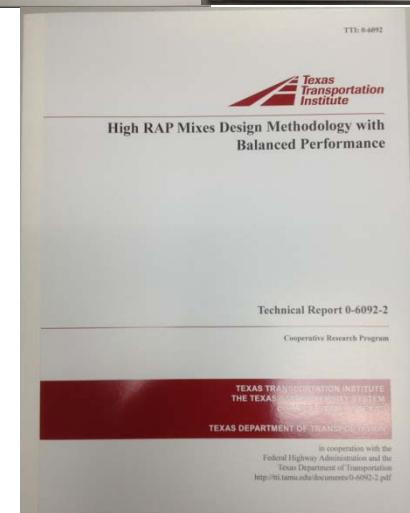
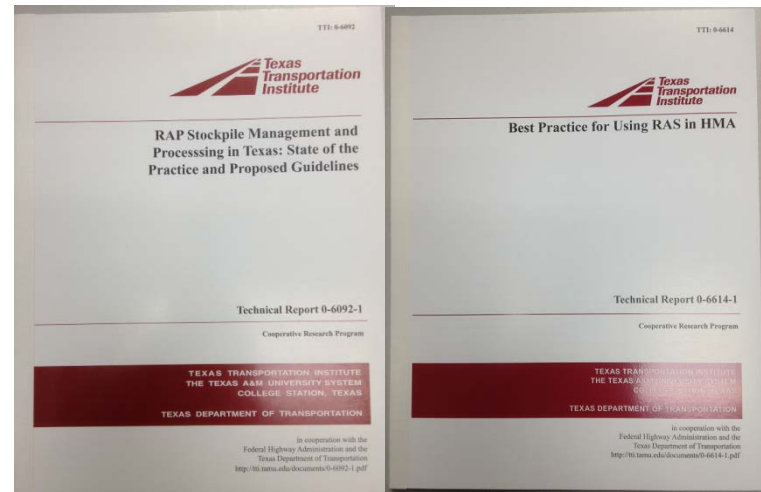


## □ Solutions

- Best practices for processing, produc., construc. QC/QA
- Balanced mix design for project-specific conditions

# Major Accomplishments under Projects 0-6092/0-6614

- Best practices for RAP/RAS
- **Field test sections and Performance data**
- Balanced mix design
  - ▣ Hamburg for rutting
  - ▣ Overlay test (OT) for cracking
    - **OT requirement???**



# Field Test Sections and Performance

## □ Amarillo-Overlay: (Aug 2009)

- IH40: Heavy traffic; Cold weather; Soft binder
- RAP: 0, 20, 35%

## □ Pharr district-New Const.: (April 2010)

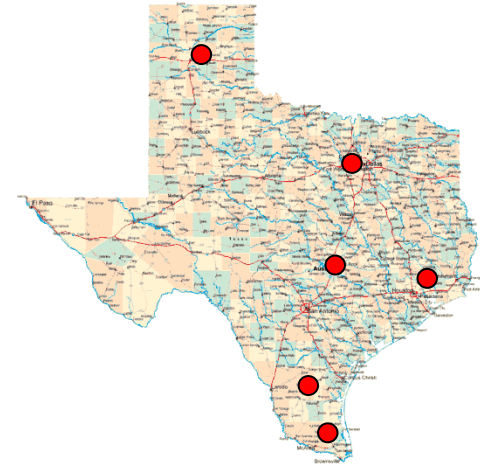
- FM1017: low traffic; Hot weather; stiff binder
- RAP: 0, 20, 35%

## □ Laredo-Overlay: SH359, 20%RAP (Mar. 2010)

## □ Houston-New Const.:SH146, 15%RAP/5%RAS (Oct. 2010)

## □ Austin-Overlay: FM973 (Jan. 2012)

## □ Fort Worth-AC/CRCR: Loop 820 (July 2012)



# Field Test Sections and Performance

## □ Performance of test sections

Test sections		Highway	Overlay/ new const.	Weather	Traffic MESAL	OT cycles	Performance
Amarillo	0%RAP	IH40 (severely cracked thick asphalt pavement)	4 inch/ overlay	Very 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	2.5 yrs: All in good condition
	20%RAP					6	
	35%RAP					7	
Laredo	20%RAP	SH359-regular support	3 inch/ overlay	Very hot	1.5	3	2.5 yrs: No cracking
Houston	15%RAP/ 5%RAS	SH146-Very good support	2 inch/new const.	hot	3.0	3	2 yrs: No cracking

# Field Test Sections and Performance

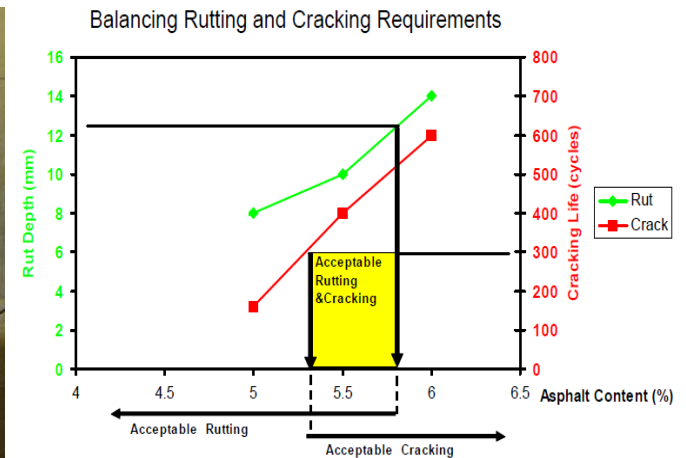
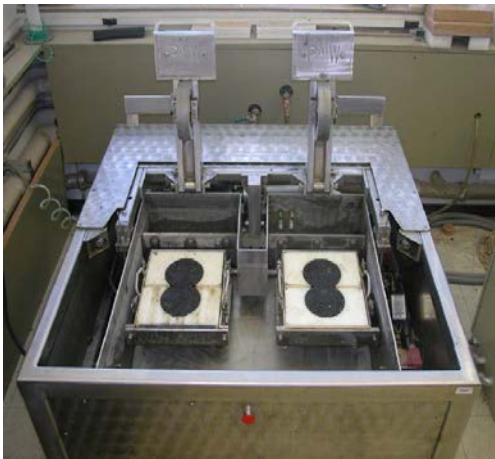
## - **Lessons** learned from field test sections

1. RAP/RAS mixes can 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 service conditions**



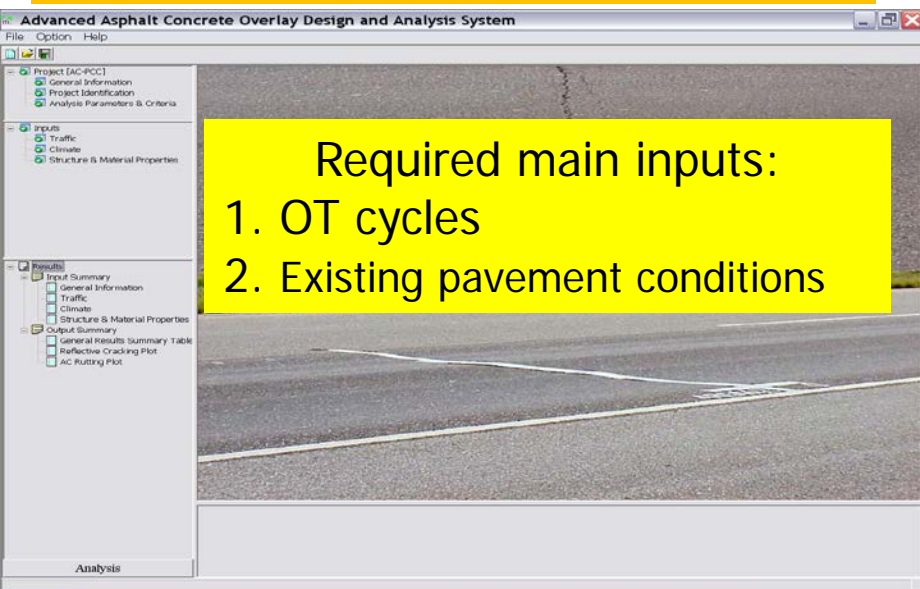
# Balanced RAP/RAS Mix Design for Project-Specific Service Conditions

- Hamburg test for rutting/moisture damage
- Overlay test for cracking
- OT requirement determined by Overlay program
- Max. density-98% for controlling potential bleeding



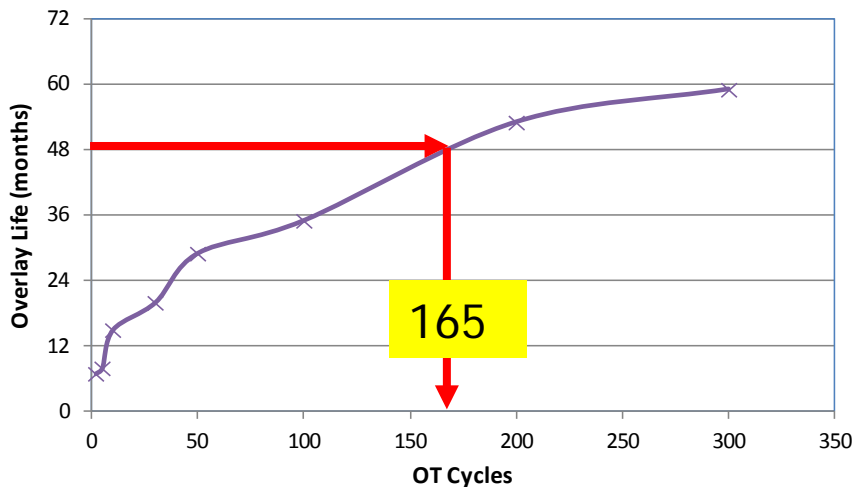
# Balanced RAP/RAS Mix Design for Project-Specific Service Conditions

## Simplified Overlay design system



## Determination of Min. OT cycles

2" Overlay over 10" JPCP  
under 3 MESALs/20 Years



# OT Cycles → A and n → Field Perform.

OT cycles	A	n	Overlay Cracking
1	4.3800E-03	2.0470	Depending on traffic, weather, existing pavement structure and conditions (LTE)
2	1.1655E-03	2.4102	
3	5.3725E-04	2.6227	
4	3.1013E-04	2.7734	
5	2.0251E-04	2.8903	
6	1.4296E-04	2.9859	
7	1.0650E-04	3.0667	
8	8.2522E-05	3.1366	
9	6.5898E-05	3.1983	
10	5.3886E-05	3.2536	
30	6.6096E-06	3.8292	
50	2.4914E-06	4.0969	
100	6.6294E-07	4.4601	
200	1.7640E-07	4.8233	
300	8.1315E-08	5.0358	
750	1.4129E-08	5.5159	
1000	8.1559E-09	5.6667	

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

# OT Cycles → A and n → Field Perform.

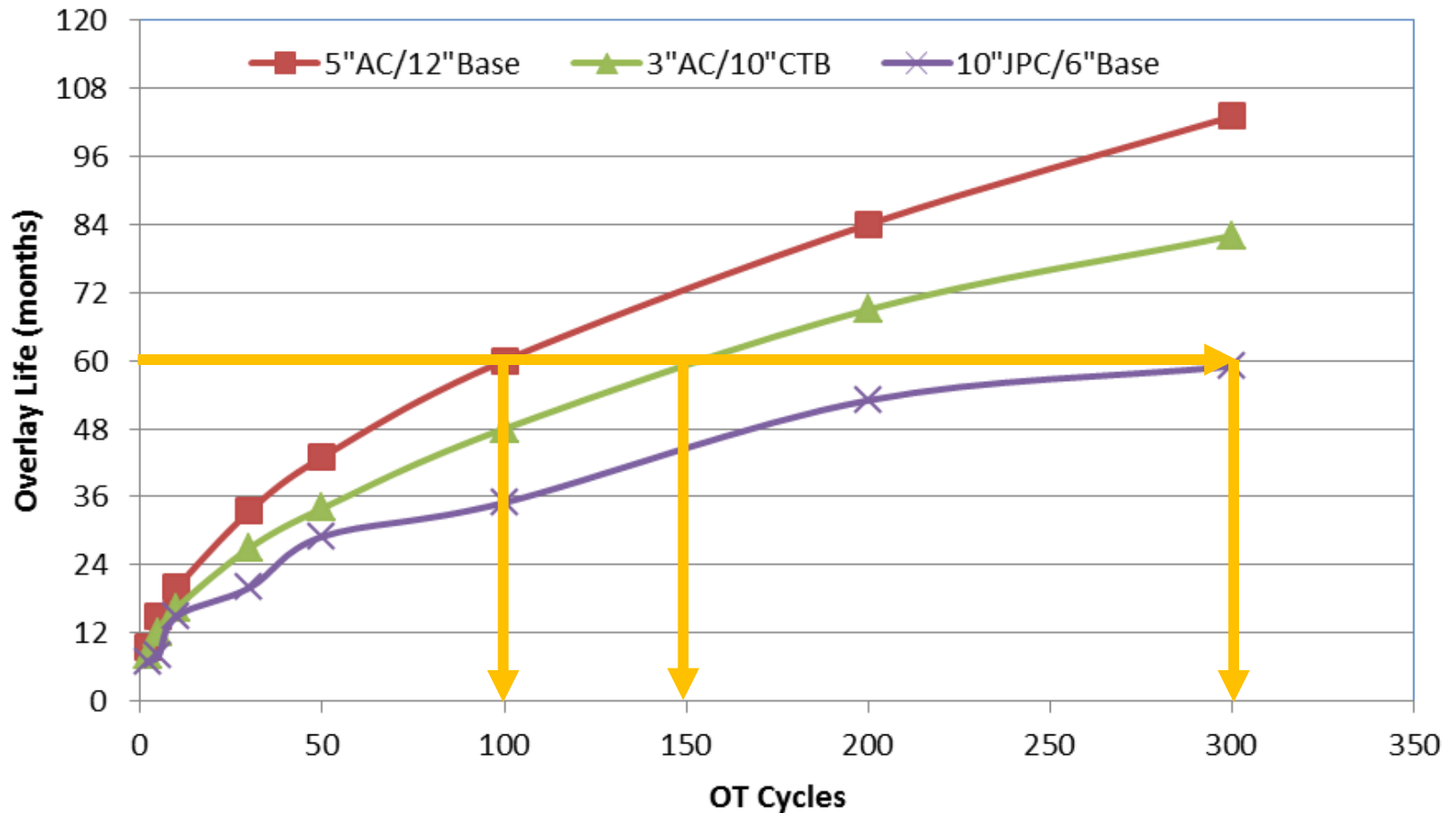
- 2" AC overlay scenarios: 3 MESAL/Austin
  - AC/PCC
    - 10" PCC/6" base, LTE=70%
  - AC/CRCP
    - 10" CRCP/6" base, LTE=90%
  - AC/AC/CTB
    - 3" AC/10" CTB, LTE=70%
  - AC/AC/granular base
    - 5" AC/12" Base, cracking severity=medium
  - FM973: 8" AC/10" stiff base, low severity cracking



# OT Cycles $\rightarrow$ A and n $\rightarrow$ Field Perform.



## 2" Overlay under 3 MESALs/20 Years

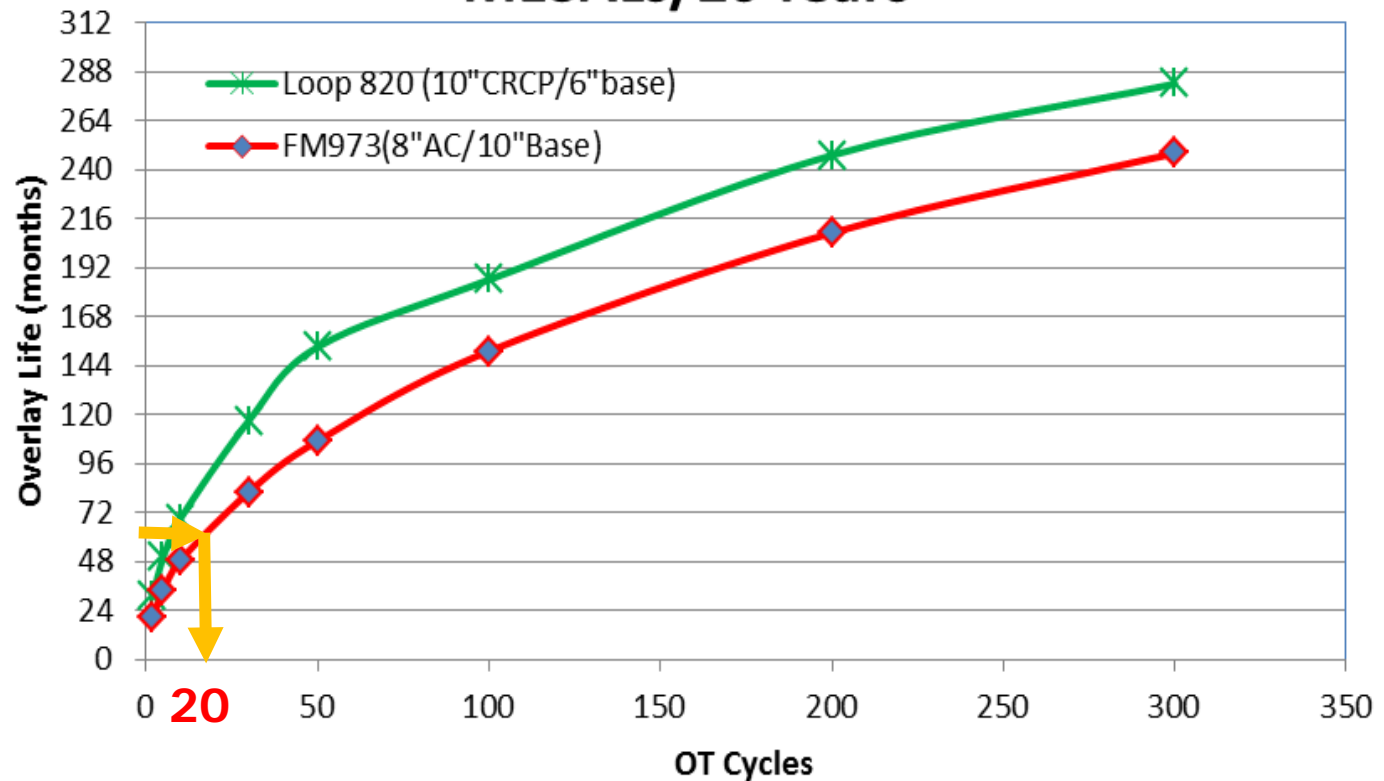


# OT Cycles → A and n → Field Perform.



Very good support:  
20 cycles=5 years

## 2" Overlay with Good Support under 3 MESALs/20 Years



# Use of RAP/RAS Mixes with Low Risk

- Overlay
  - CRCP
  - JPCP with good  $LTE \geq 90$
  - Thick AC with low severity cracking (FM973)
  
- New construction
  - Bond breaker layer between PCC and subbase
  - Thick pavement, like NCAT test track
    - Sandwich pavement: virgin AC/RAP-RAS AC/virgin AC

# OT Cycles → A and n → Field Perform.

- 2" AC overlay scenarios: 3 MESAL/Amarillo
  - AC/AC/CTB
    - 3" AC/10" CTB, LTE=70%
  - AC/AC/granular base
    - 5" AC/12" Base, medium severity cracking

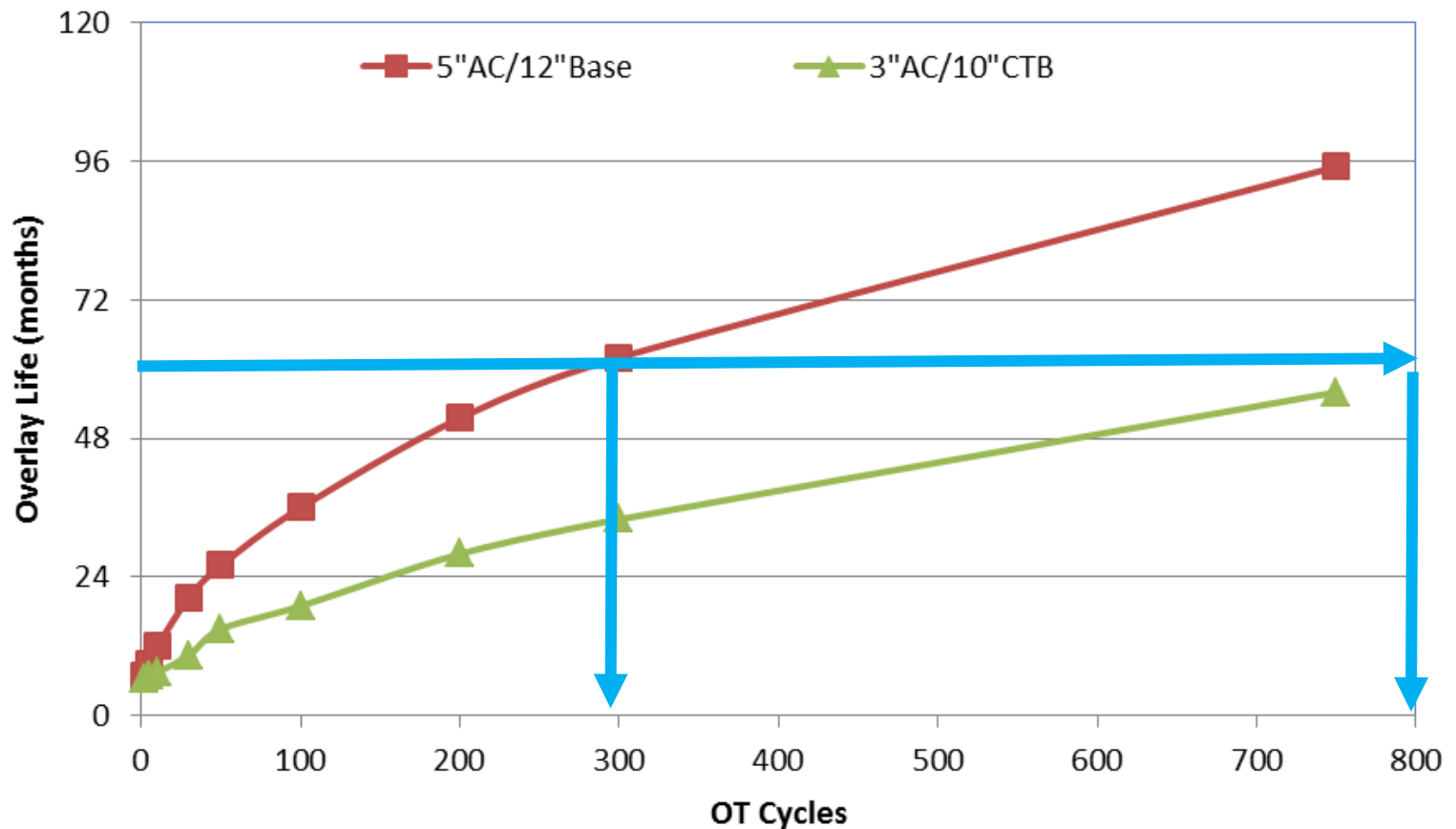




# OT Cycles $\rightarrow$ A and n $\rightarrow$ Field Perform.

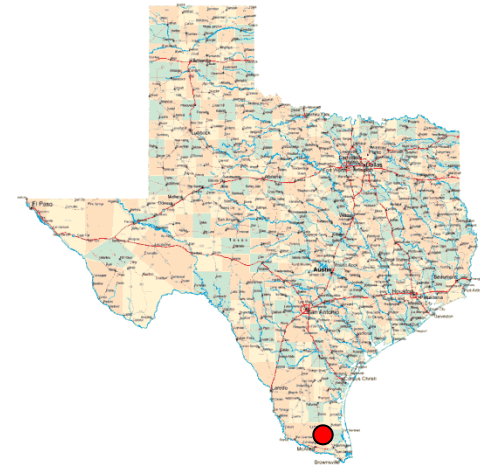
## □ Amarillo

### 2" Overlay under 3 MESALs/20 Years



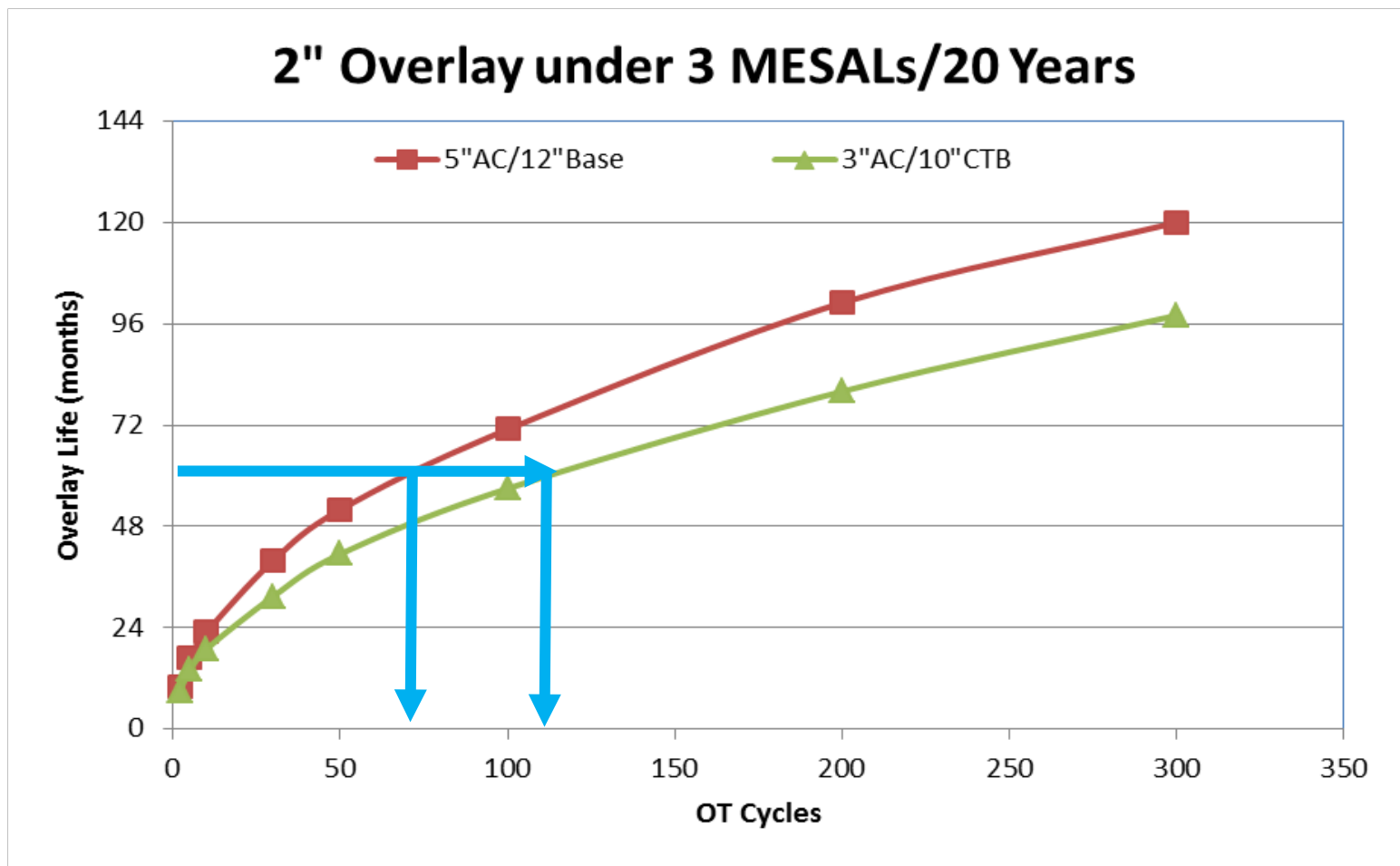
# OT Cycles → A and n → Field Perform.

- 2" AC overlay scenarios: 3 MESAL/McAllen
  - AC/AC/CTB
    - 3" AC/10" CTB, LTE=70%
  - AC/AC/granular base
    - 5" AC/12" Base, medium severity cracking



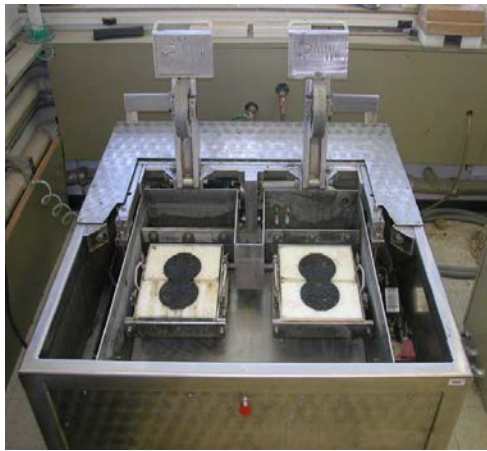
# OT Cycles $\rightarrow$ A and n $\rightarrow$ Field Perform.

## □ McAllen

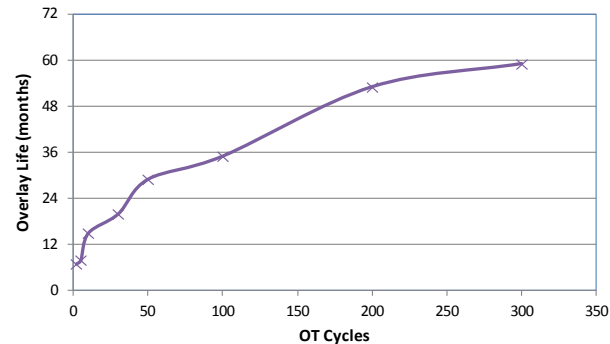


# Balanced RAP/RAS Mix Design for Project-Specific Service Conditions

- **Design your mix for project-specific condition!**



2" Overlay over 10" JPCP  
under 3 MESALs/20 Years



# Outline



- Introduction
- Accomplishments under Projects 0-6092/0-6614
  - ▣ Best practices
  - ▣ Field performance data of RAP/RAS test sections
  - ▣ ....
- Balanced RAP/RAS mix design for project-specific conditions
- Approaches for improving RAP/RAS mix performance
- Summary and conclusions

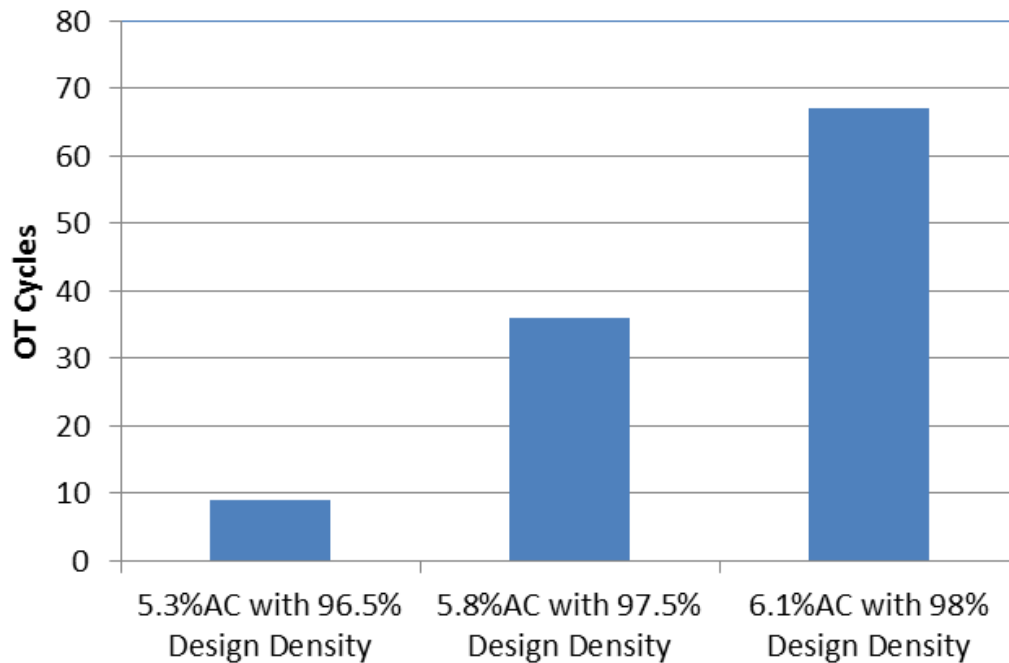
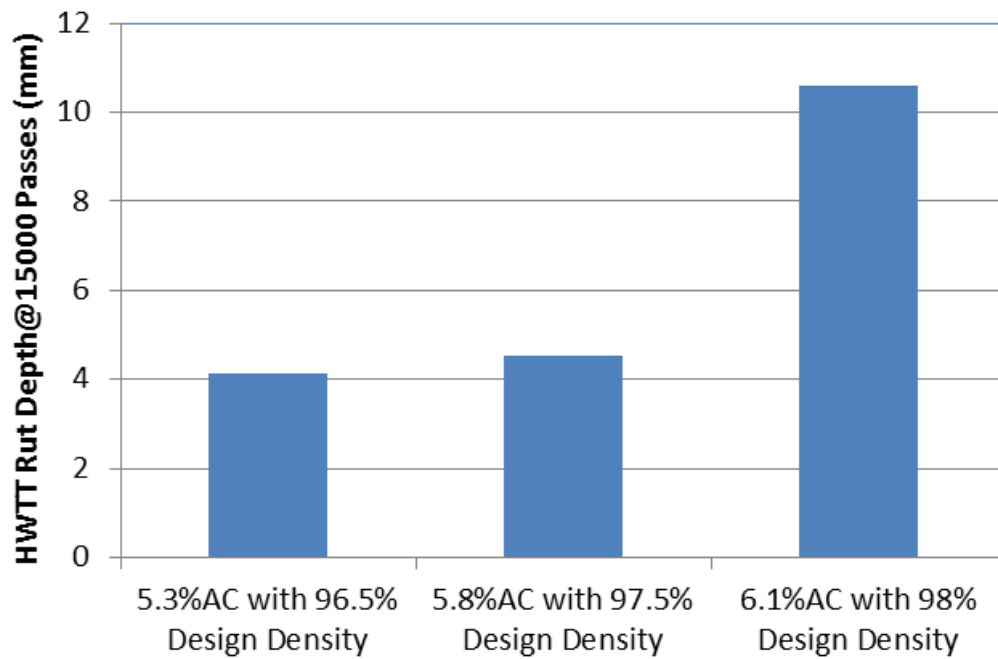


# Approaches for Improving RAP/RAS Mix Performance



## □ Available approaches

- Reduce RAP/RAS usage
- **Increase virgin AC** (higher density)
- **Soft, modified binders: PG64-28, PG64-34, PG58-34**
- Rejuvenators
- WMA

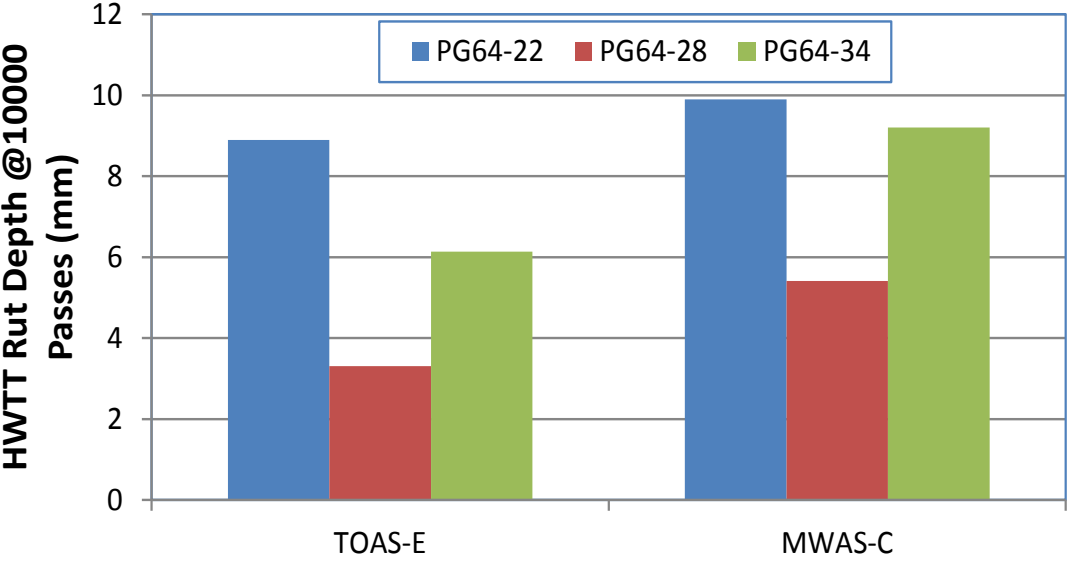


RAP

Effect of increasing  
virgin AC  
FM1017 Mix/PG64-22

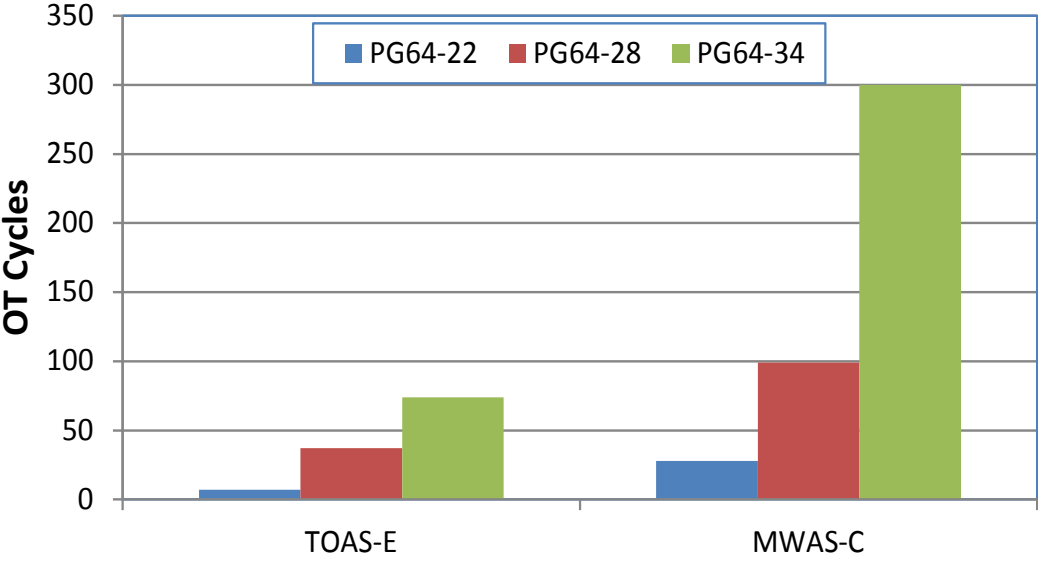
**RAS**

### Impact of Soft Binder on Rutting

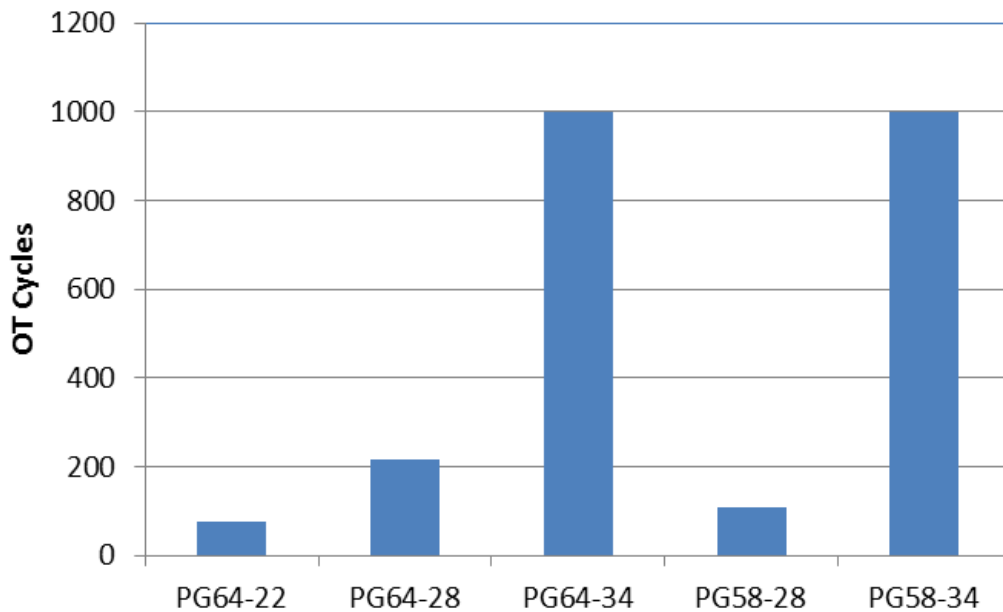
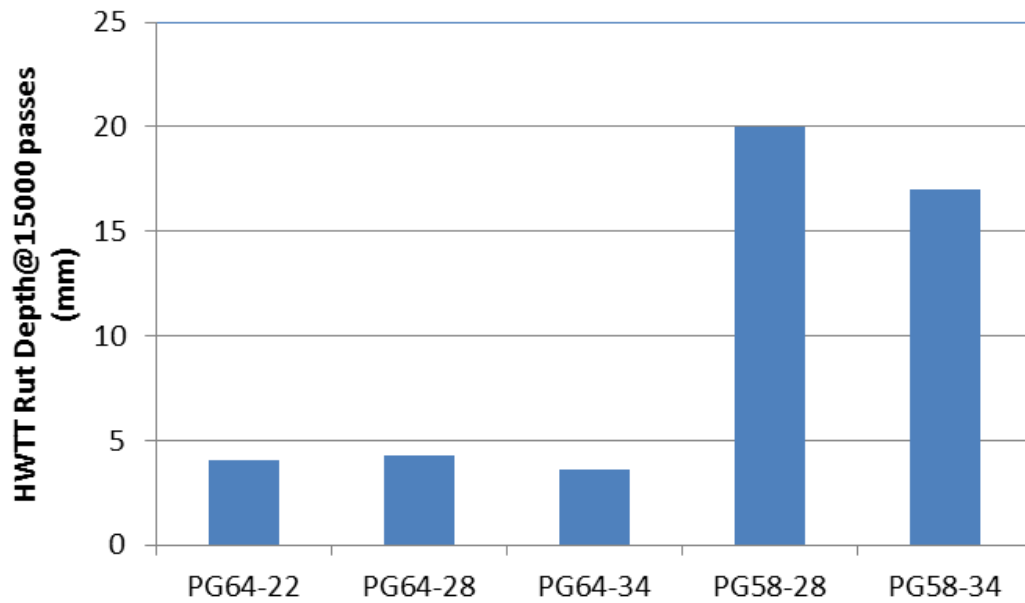


Effect of soft binder  
FM973 Mix with  
5%RAS

### Impact of Soft Binder on Cracking







RAP

Effect of soft binders  
Paris Sandstone Mix  
with 15%RAP

# Summary and Conclusions



- Best practices for best use of RAP/RAS are available.
- RAP/RAS mixes can have similar or even better performance with proper design.
- Balanced RAP/RAS mix design for project-specific service conditions is highly recommended for use.
- Different approaches are available for improving RAP/RAS mix performance.



# Thank You All!

Questions???

# Field test sections to validate approaches for improving perfor.

- US87
  - Increase design density: 96.5% vs. 97.5%
- FM973
  - PG64-22 vs. PG58-28
  - HMA vs. WMA
- Loop820
  - Increase design density: 97% vs. 97.5%
  - Soft binder: PG64-22 vs. PG64-28
  - WMA

# Field test sections to validate approaches for improving perf.

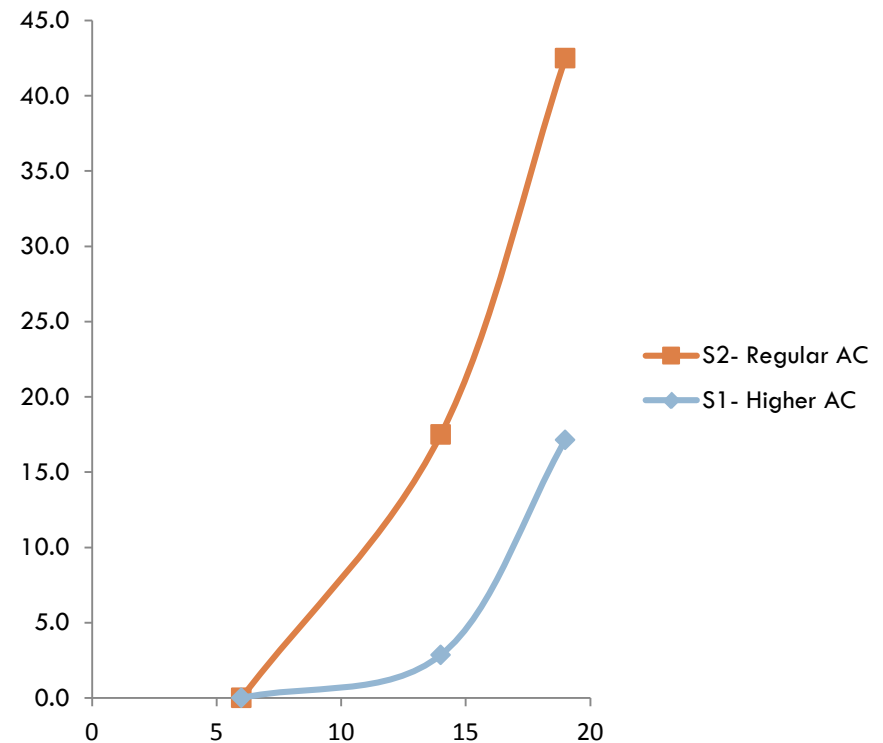
## US 87 Reflective Cracking Rate (%)

	Months since construction	S1- Higher AC	S2- Regular AC
4/5/2011	6	0.0	0.0
12/15/2011	14	2.9	17.5
5/30/2012	19	17.1	42.5

### US87 Overlay Material and Thickness



## US 87 RCR %



# Field Test Sections

## □ FM973: Overlay, Austin Airport

### 7 Overlay Test Sections

Section	Type	Binder	RAP	RAS
1	HMA	70-22	0	0
2	HMA	64-22	30	0
3	HMA	64-22	15	3
4	HMA	64-22	0	5
5	HMA	58-28	30	0
6	HMA	58-28	15	3
9	WMA	64-22	15	3

□ So far all sections are good.



# Field test sections

- Loop 820: 4 test sections/2" AC/CRCP

Section	Type	Binder	AC (%)	RAP (%)	Manufacture waste RAS (%)
1	WMA-Advera	64-22	5.1	13	5
2	WMA-Advera in the RAS	64-22	5.1	13	5
3	WMA-Advera	64-28	5.1	13	5
4	WMA-Advera	64-22	5.5	13	5

