TRB Webinar:

Considerations for the Selection of Continuously Reinforced Concrete Pavement (CRCP) for Projects

March 30, 2015
2:00 PM – 3:30 PM ET

CRSI

U.S. Department of Transportation
Federal Highway Administration

Oregon Department of Transportation

Caltrans

Texas Department of Transportation

TRB
THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

Today's Panelists and Moderator

- **Justin Moderie**, *Oregon Department of Transportation*
  justin.g.moderie@odot.state.or.us
- **Deepak Maskey**, *California Department of Transportation*
  deepak.maskey@dot.ca.gov
- **Andy Naranjo**, *Texas Department of Transportation*
  andy.naranjo@txdot.gov
- **Sam Tyson**, *U.S. Federal Highway Administration*
  sam.tyson@dot.gov
- **Greg Halsted**, *Concrete Reinforcing Steel Institute*
  ghalsted@crsi.org

Selection and Use of CRCP in Oregon

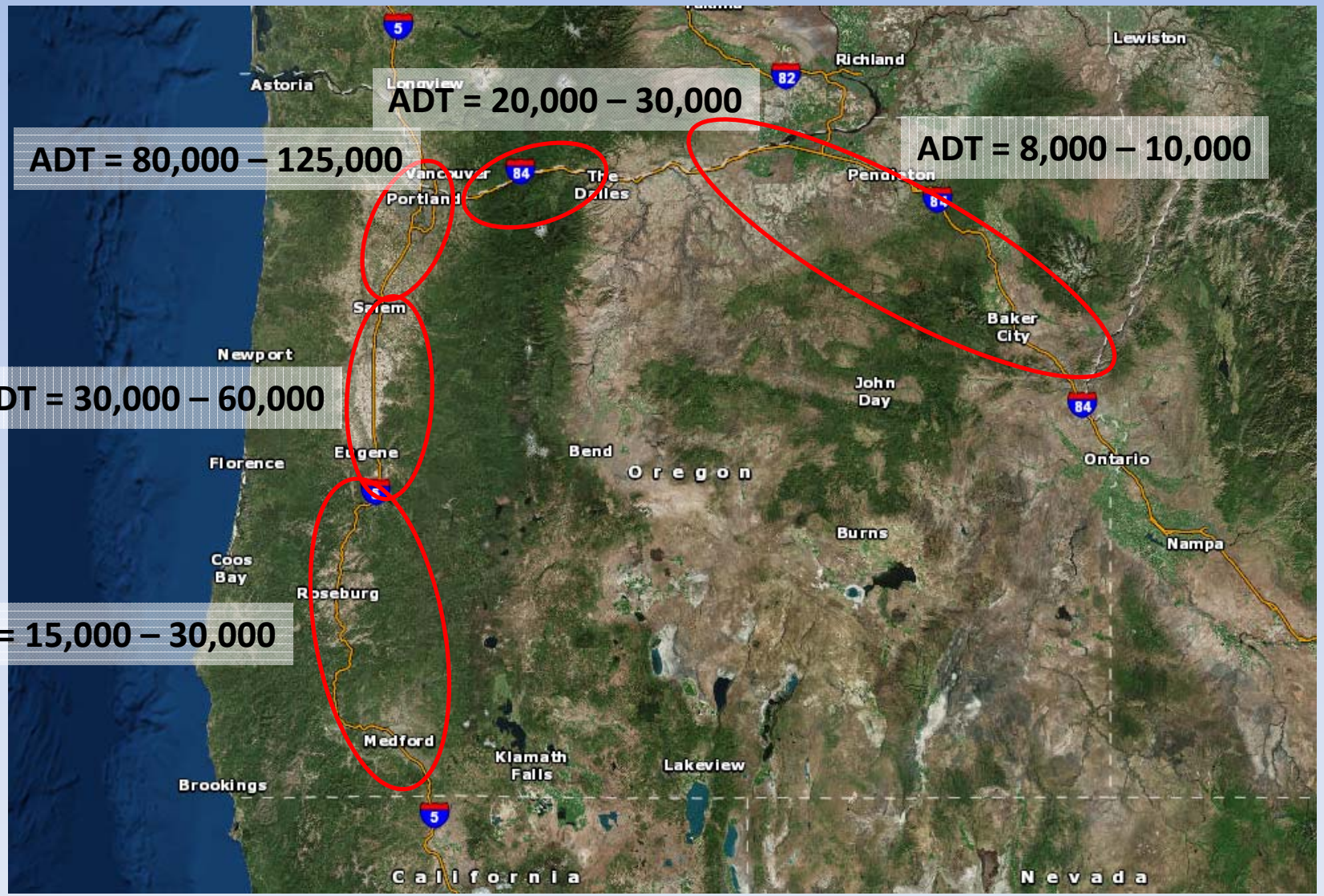
Justin Moderie, P.E., G.E.

ODOT Pavement Design Engineer

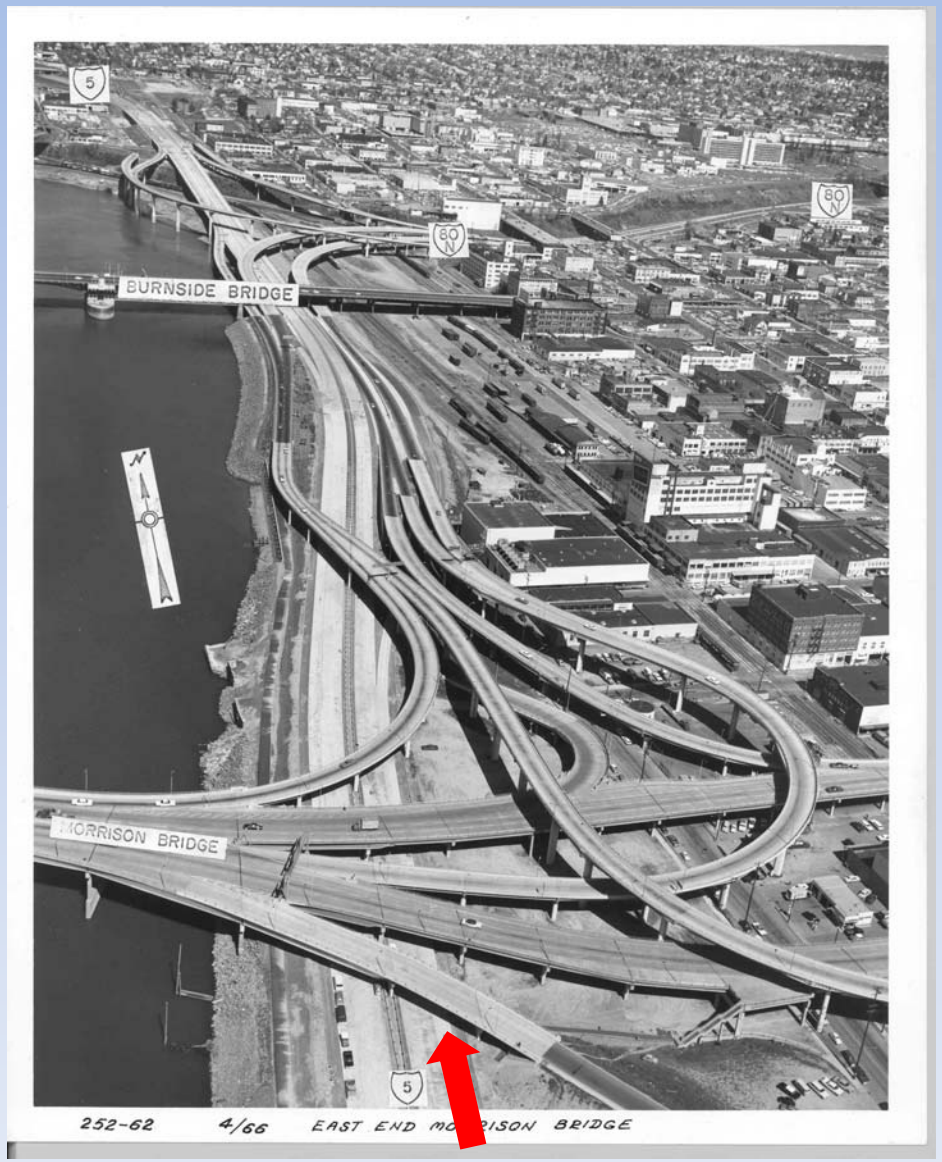
Overview

- Oregon's Climate and Traffic
- CRCP History in Oregon
- Long-Life and "30-year" life CRCP
- Current Strategy
- Design Solutions

Oregon's Climates and Traffic



CRCP History in Oregon



CRCP History in Oregon

CRCP History: 1962 to 2001

570 +/- Directional Miles Constructed	CRCP Age
Still in Service without Overlay ~ 59%	Age = 14 - 49 years. Average ~ 28 years.
Rut Repair (2" Overlay) ~ 22%	Age = 27 - 47 years. Average ~ 39 years. Overlays were placed at 17 to 44 years old due to rutting.
Structural Overlay (4" or more) ~ 16%	Overlays were placed at 30 - 42 years old due to punchout and cracking issues.
Rubblize/Reconstruct ~ 3%	30 - 37 years old or older.

Since 2009

- Price changes. Renewed use of CRCP.
- From 2009 to 2015: 90 directional miles (includes projects under construction)
- 11 and 12 inches thick
- One 9-inch thick unbonded concrete overlay of asphalt.

Long-Life CRCP

- 8 to 12 inches thick
- 1-1/2-inch or 2-inch max aggregate. Later changed to max 1-1/2-inch crushed.
- Granular, CTB, lean concrete base
- Traffic level had moderate impact

Freeze-Thaw Climate – Low Traffic

“30-year” CRCP

- Workmanship
  - Construction joints
  - Unknowns
- Materials
  - Aggregate size/gradation
  - Mix design
- Design
  - Some bonding with CTB
  - 8-inch CRCP is too thin for current traffic
  - Subgrade drainage

Harsh Climate – Lower Traffic

Workmanship: Tube Feeders

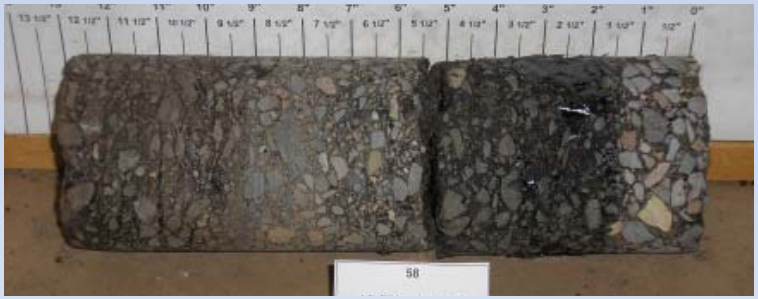
De-Icing: Magnesium Chloride

De-Icing: Magnesium Chloride

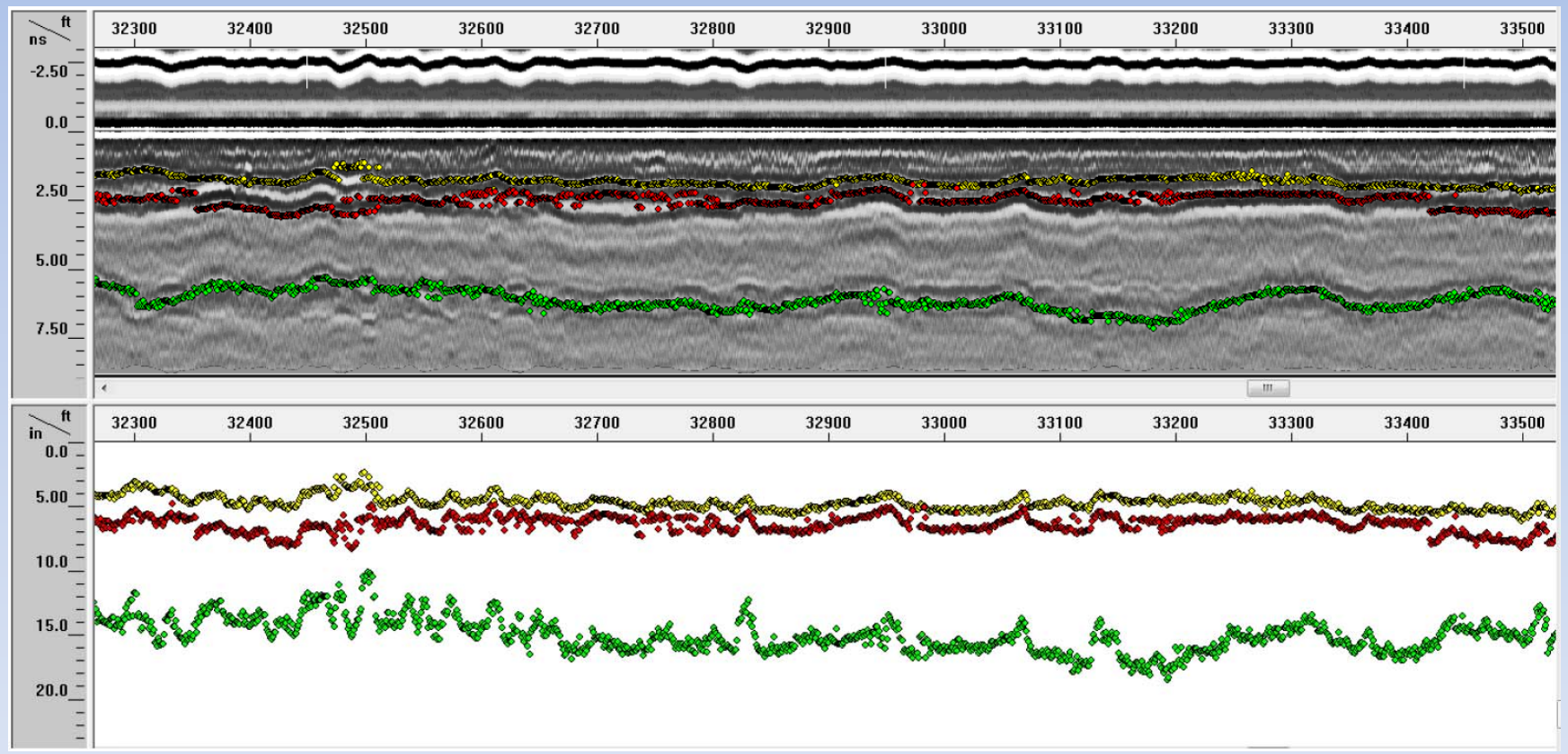
Current Strategy

- Project Timing
  - Close coordination between pavement management and design for major rehab timing
- Build it to last
  - MEPDG for design thickness and percent steel
  - Low shrinkage mix
    - Optimized gradation
    - Adequate coarse aggregate
  - Low permeability concrete
- Diamond grind 1 or 2 times for wear ruts (20-50 years)
- Place 2-inch overlay with asphalt (+/-50 years)

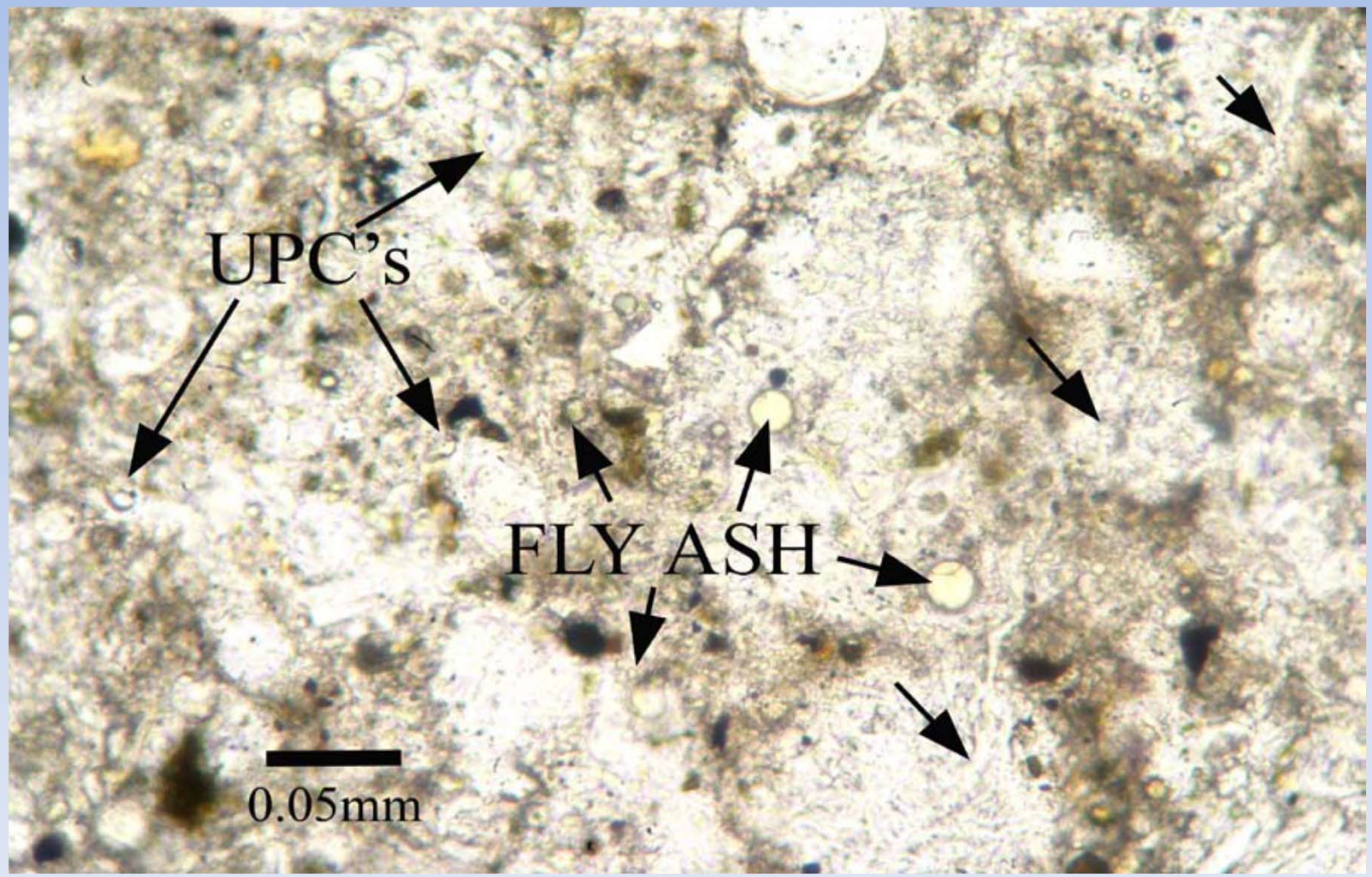
Project Timing



Project Timing



Build It to Last



CRCP Wear Rut Overlay

Design Solutions

- Placing CRCP on milled surface
- Using CRCP for only the truck lane
- Using FDR with cement for subbase

CRCP on Milled Surface

CRCP for Truck Lane Only

FDR for Subbase

Resources

Continuously Reinforced Concrete Pavement

California Practices

Deepak Maskey, Pavement Engineer
California Department of Transportation

California State Highway System

- 50,542 lane miles of pavement
- 13,063 bridges and other structures
- 205,000 Culverts
- 42,952 ITS/TMS Elements
- 5,782 traffic signals
- 30,000 acres of landscaping

History

- First used in 1921
- CA built test section in 1948 in Fairfield
- 2nd test section built on I-205 in 1970's
- Both sections were overlayed because surrounding jointed concrete pavement failed

CA CRCP after 60 years

Caltrans Mission

- Provide a safe, **sustainable**, integrated, and efficient transportation system to enhance California's economy and livability**.**

Why Continuously Reinforced Concrete Pavements (CRCP)?

- Smoother over time
- Low maintenance costs/exposure
  - No transverse joints
- Thinner slab thickness relative to jointed concrete pavement
- Higher capacity of truck loading and volumes

CRCP Sustainability

- Long lasting pavement solution
- Lower energy footprint
- Incorporates recycled materials
- Reduces noise
- Decreases life cycle cost
- Reduces cost to motorists

Factors to Consider for Selection of CRCP - 1

- Consideration of climate region.
- Preferred alternative for reconstruction for heavily truck trafficked freeways/highways.
- Preferred alternative for reconstruction with increasing traffic volume.

Factors to Consider for Selection of CRCP - 2

- Preferred alternative for new highways.
- Long-term performance pavement is desired.
- When long term consistency is desired (smooth pavement overtime since there are no transverse joints).

Factors to Consider for Selection of CRCP - 3

- Preferred alternative for isolated locations where pavement maintenance may not be easily accessible.
- Perform LCCA if CRCP alternative is cost benefit over other pavement types.

Typical CRCP Design Features

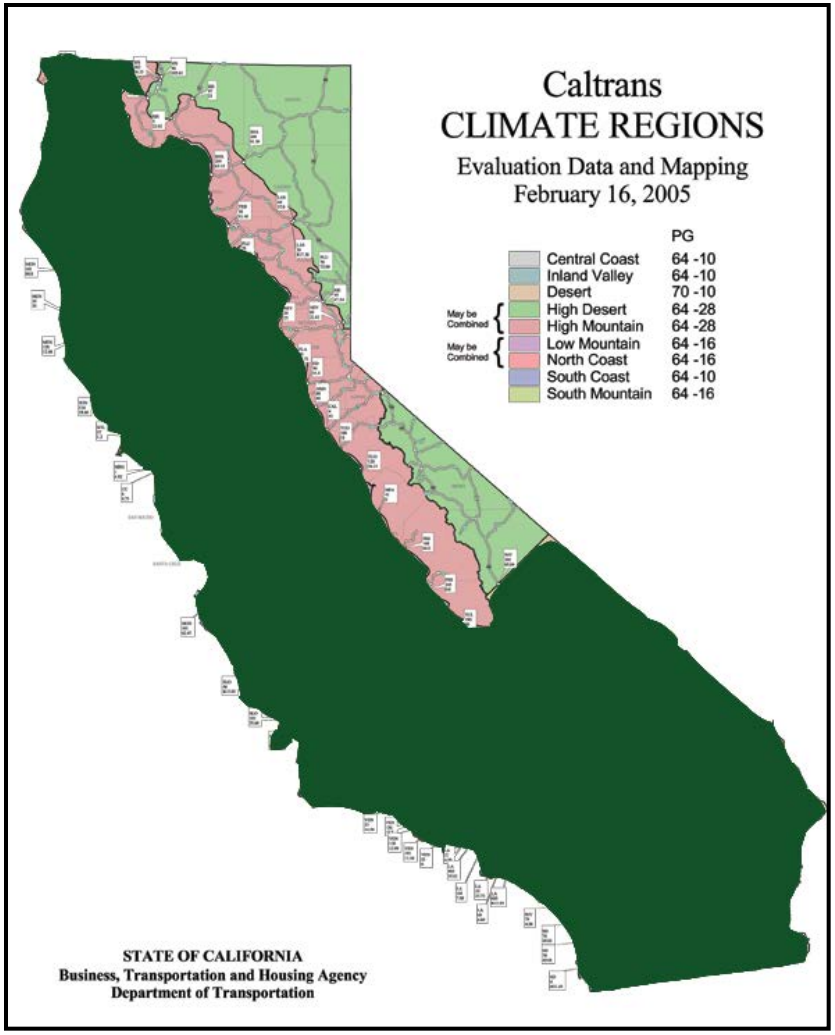
- Long life
  - 40 years minimum
  - Preferred 60+ years
- Concrete thickness
  - 9 to 13 inches
- Steel content
  - 0.7 to 0.8 percent
- Lap spliced
  - Continuous longitudinal reinforcement
- Depth to steel:
  - 4.0” to 6.0”
- Asphalt concrete base used

Least Suited For

- Areas of frequent underground work
- Variable width widening
- Space constraint
- Location
- Low truck volumes
  - Not cost effective
  - No designs TI<11.5
  - (6.6 million ESALs)

No Approved Designs for High Mountain and High Desert Regions

- Mountain areas are sparsely populated
- Focus standard details and work in the more populated/travelled areas.
- Two routes where CRCP would even apply, I-80 and I-5
- Just needs some changes to fit the climate.



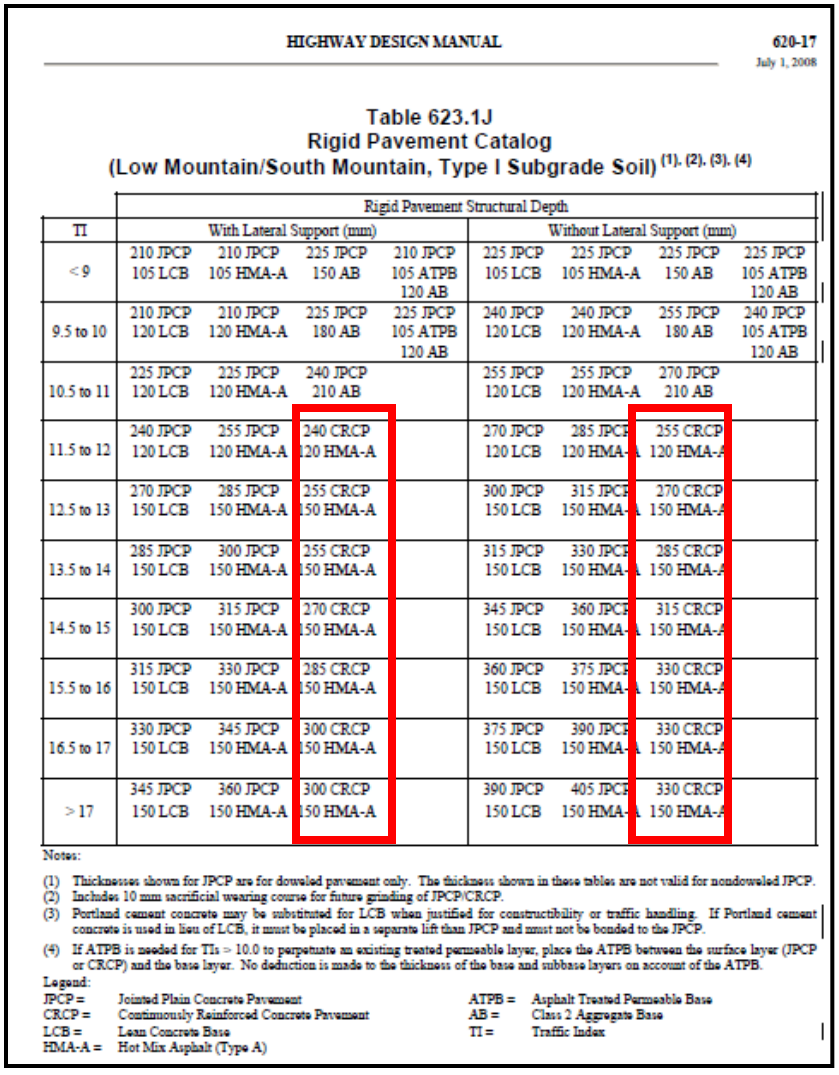
HDM Chapter 620 – Rigid Pavement

HDM Index 621.2 – Continuously Reinforced Concrete Pavement (CRCP)

http://www.dot.ca.gov/hq/oppd/hdm/pdf/english/chp0620.pdf

Similarities to JPCP

- Use same design tables in HDM
- Choose CRCP option from tables
- Use same Std Spec Section 40
- Use same mix design process
- Pay for by CY



HIGHWAY DESIGN MANUAL 620-17
July 1, 2008

Table 623.1J
Rigid Pavement Catalog
(Low Mountain/South Mountain, Type I Subgrade Soil) (1), (2), (3), (4)

TI	Rigid Pavement Structural Depth							
	With Lateral Support (mm)				Without Lateral Support (mm)			
< 9	210 JPCP 105 LCB	210 JPCP 105 HMA-A	225 JPCP 150 AB	210 JPCP 105 ATPB 120 AB	225 JPCP 105 LCB	225 JPCP 105 HMA-A	225 JPCP 150 AB	225 JPCP 105 ATPB 120 AB
9.5 to 10	210 JPCP 120 LCB	210 JPCP 120 HMA-A	225 JPCP 180 AB	225 JPCP 105 ATPB 120 AB	240 JPCP 120 LCB	240 JPCP 120 HMA-A	255 JPCP 180 AB	240 JPCP 105 ATPB 120 AB
10.5 to 11	225 JPCP 120 LCB	225 JPCP 120 HMA-A	240 JPCP 210 AB		255 JPCP 120 LCB	255 JPCP 120 HMA-A	270 JPCP 210 AB	
11.5 to 12	240 JPCP 120 LCB	255 JPCP 120 HMA-A	240 CRCP 120 HMA-A		270 JPCP 120 LCB	285 JPCP 120 HMA-A	255 CRCP 120 HMA-A	
12.5 to 13	270 JPCP 150 LCB	285 JPCP 150 HMA-A	255 CRCP 150 HMA-A		300 JPCP 150 LCB	315 JPCP 150 HMA-A	270 CRCP 150 HMA-A	
13.5 to 14	285 JPCP 150 LCB	300 JPCP 150 HMA-A	255 CRCP 150 HMA-A		315 JPCP 150 LCB	330 JPCP 150 HMA-A	285 CRCP 150 HMA-A	
14.5 to 15	300 JPCP 150 LCB	315 JPCP 150 HMA-A	270 CRCP 150 HMA-A		345 JPCP 150 LCB	360 JPCP 150 HMA-A	315 CRCP 150 HMA-A	
15.5 to 16	315 JPCP 150 LCB	330 JPCP 150 HMA-A	285 CRCP 150 HMA-A		360 JPCP 150 LCB	375 JPCP 150 HMA-A	330 CRCP 150 HMA-A	
16.5 to 17	330 JPCP 150 LCB	345 JPCP 150 HMA-A	300 CRCP 150 HMA-A		375 JPCP 150 LCB	390 JPCP 150 HMA-A	330 CRCP 150 HMA-A	
> 17	345 JPCP 150 LCB	360 JPCP 150 HMA-A	300 CRCP 150 HMA-A		390 JPCP 150 LCB	405 JPCP 150 HMA-A	330 CRCP 150 HMA-A	

Notes:

(1) Thicknesses shown for JPCP are for doweled pavement only. The thickness shown in these tables are not valid for nondoweled JPCP.
(2) Includes 10 mm sacrificial wearing course for future grinding of JPCP/CRCP.
(3) Portland cement concrete may be substituted for LCB when justified for constructibility or traffic handling. If Portland cement concrete is used in lieu of LCB, it must be placed in a separate lift than JPCP and must not be bonded to the JPCP.
(4) If ATPB is needed for TIs > 10.0 to perpetuate an existing treated permeable layer, place the ATPB between the surface layer (JPCP or CRCP) and the base layer. No deduction is made to the thickness of the base and subbase layers on account of the ATPB.

Legend:

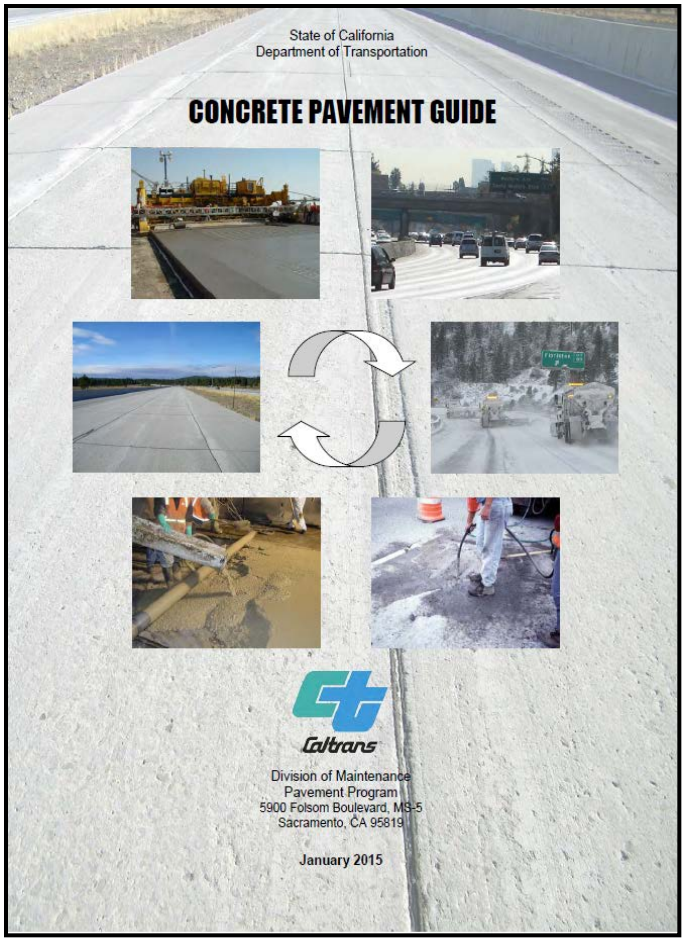
JPCP =	Jointed Plain Concrete Pavement	ATPB =	Asphalt Treated Permeable Base
CRCP =	Continuously Reinforced Concrete Pavement	AB =	Class 2 Aggregate Base
LCB =	Lean Concrete Base	TI =	Traffic Index
HMA-A =	Hot Mix Asphalt (Type A)		

Caveats

- Need min 16-ft horizontal clearance
- Only concrete shoulder or widened lane options
- Show on plans and pay for as CRCP
- Coefficient of thermal expansion must be 6.0×10^{-6} in/in/^{o}F max
- Requires end joint details at terminus

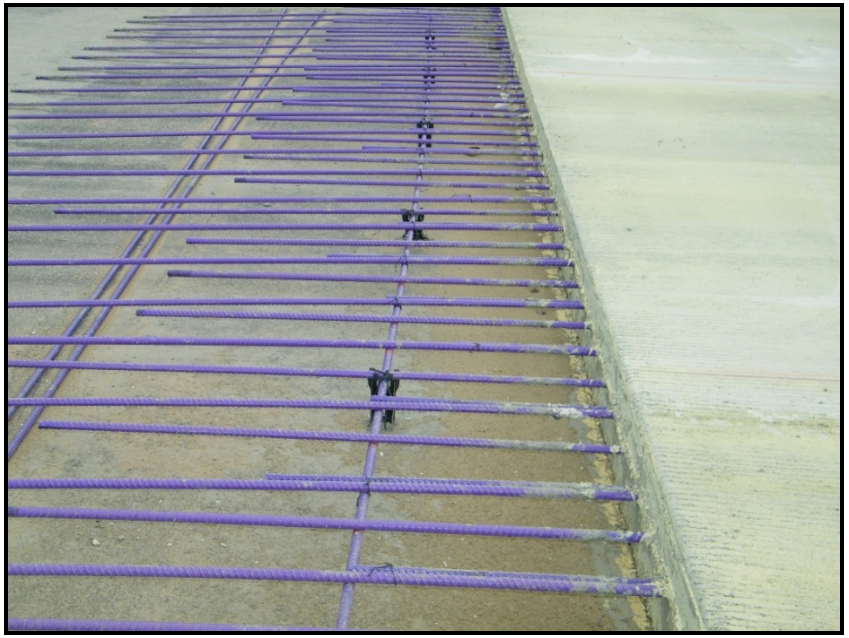
CHAPTER 200 – CONTINUOUSLY REINFORCED CONCRETE PAVEMENT (CRCP)

http://www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/CPG/CPG_Ch200_CRCP.pdf



CRCP Projects

- 300 lane miles have been constructed
- 50 lane miles under construction
- 200 lane miles in design phase



CRCP Under Construction Projects

Where to Search

Caltrans Resource sites

http://www.dot.ca.gov/hq/esc

http://www.dot.ca.gov/hq/maint

http://www.dot.ca.gov/hq/maint/Pavement/Pavement_Program/index.htm

http://www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_Engineering/index.html

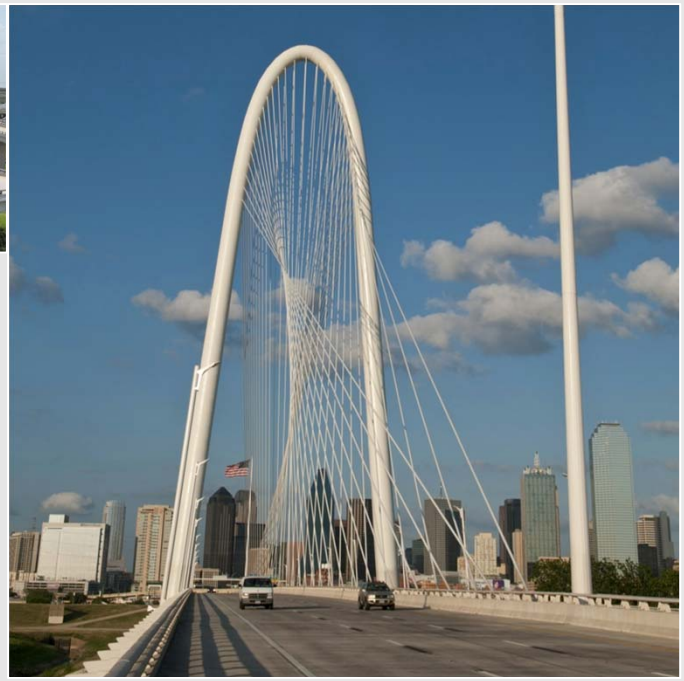
http://www.dot.ca.gov/hq/maint/Pavement/Offices/Pavement_EngineeringRigid_Pavement.html

http://www.dot.ca.gov/hq/esc/oe/project_plans/highway_plans/2010-RSP-and-NSP/Entire-2010-rsp-and-nsp.pdf

Thank you

Deepak Maskey, P. E.
Pavement Engineer
Phone: 916-227-5842
Email: deepak_maskey@dot.ca.gov



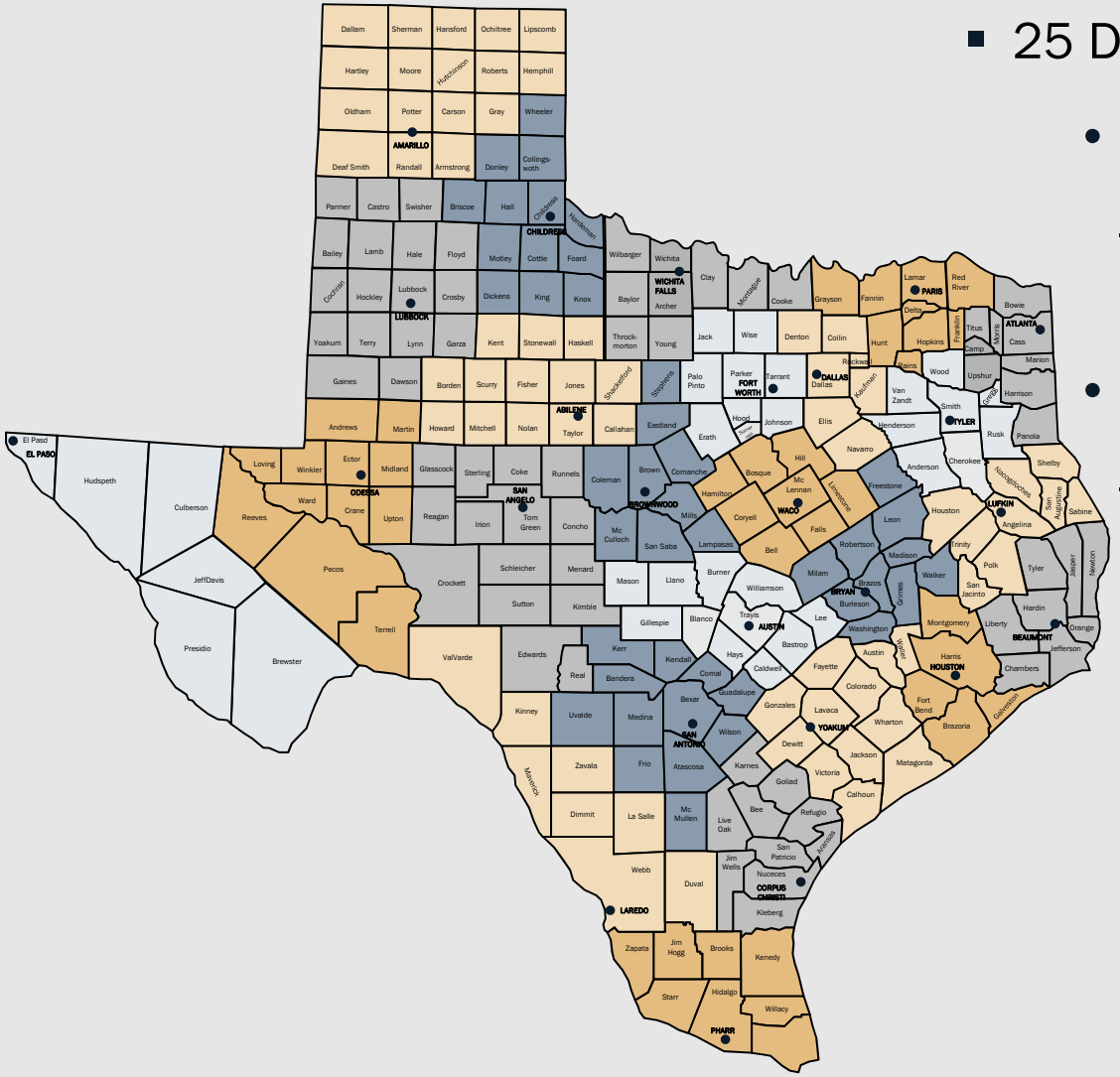
SELECTION AND USE OF CRCP IN TEXAS

Andy Naranjo, P.E.

Construction Division

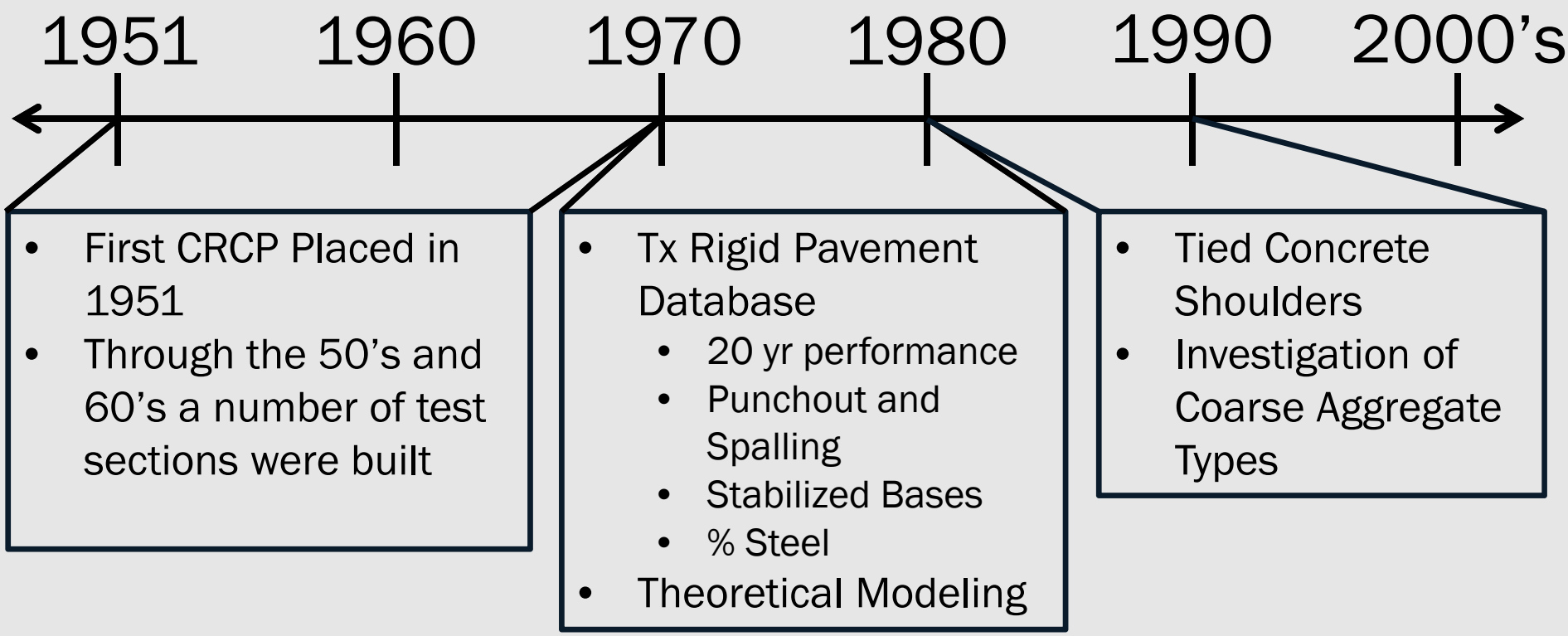
Table of Contents

Texas is a Big State!

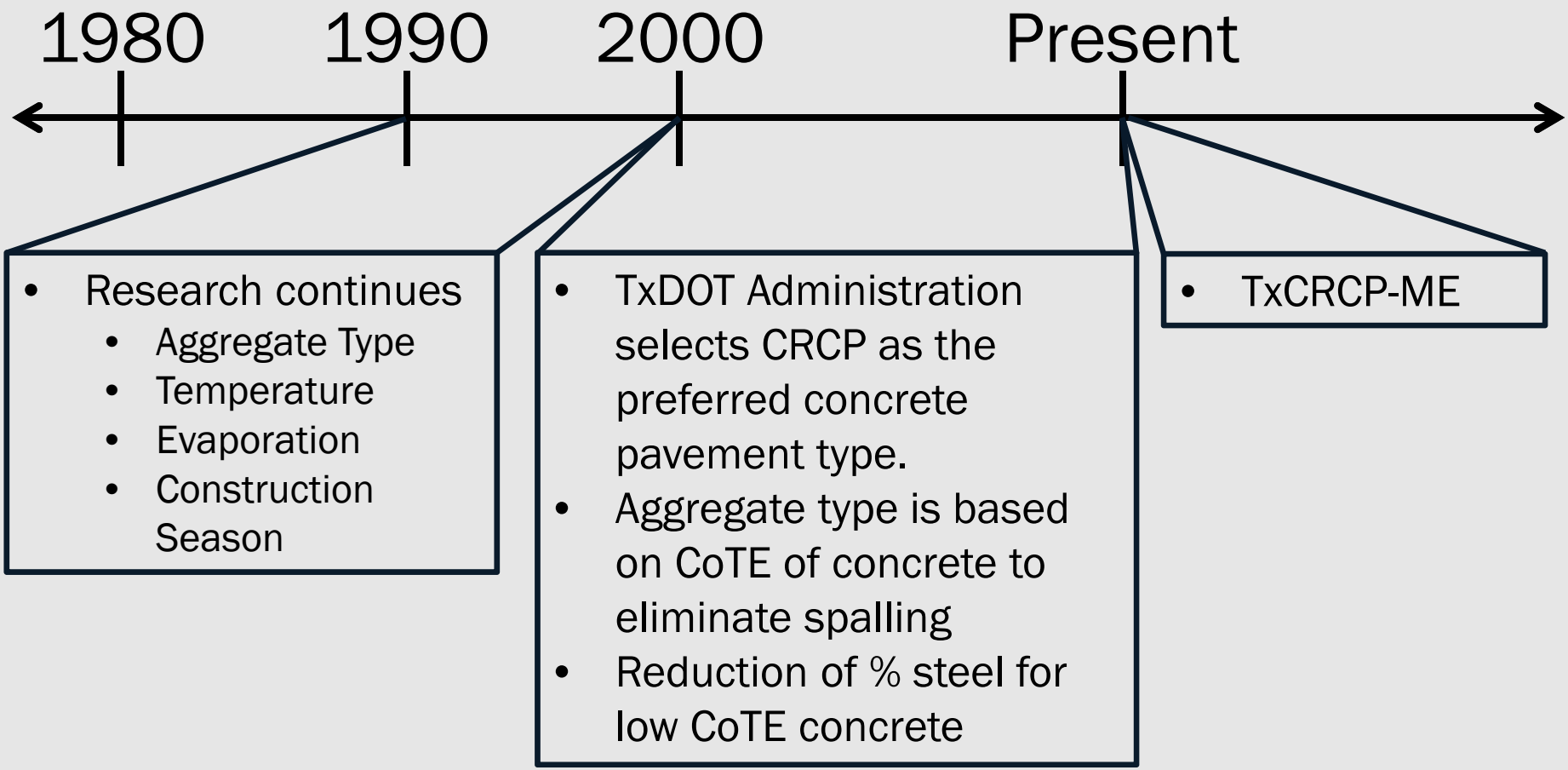


- 25 Districts
  - 5 Metro Districts
    - Austin, Dallas, Fort Worth, Houston, and San Antonio
  - 20 Urban Districts
    - Abilene, Amarillo, Atlanta, Beaumont, Brownwood, Bryan, Childress, Corpus, El Paso, Laredo, Lubbock, Lufkin, Odessa, Paris, Pharr, San Angelo, Tyler, Waco, Wichita Falls, and Yoakum

History of CRCP in Texas

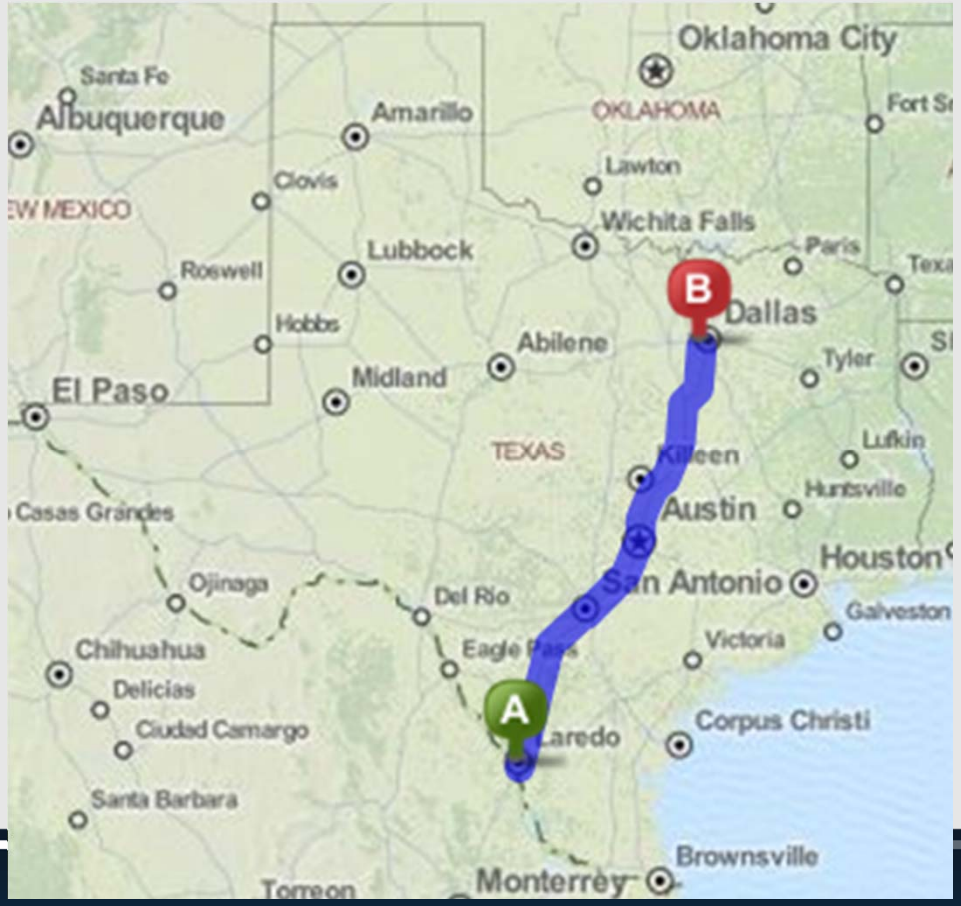


History of CRCP in Texas



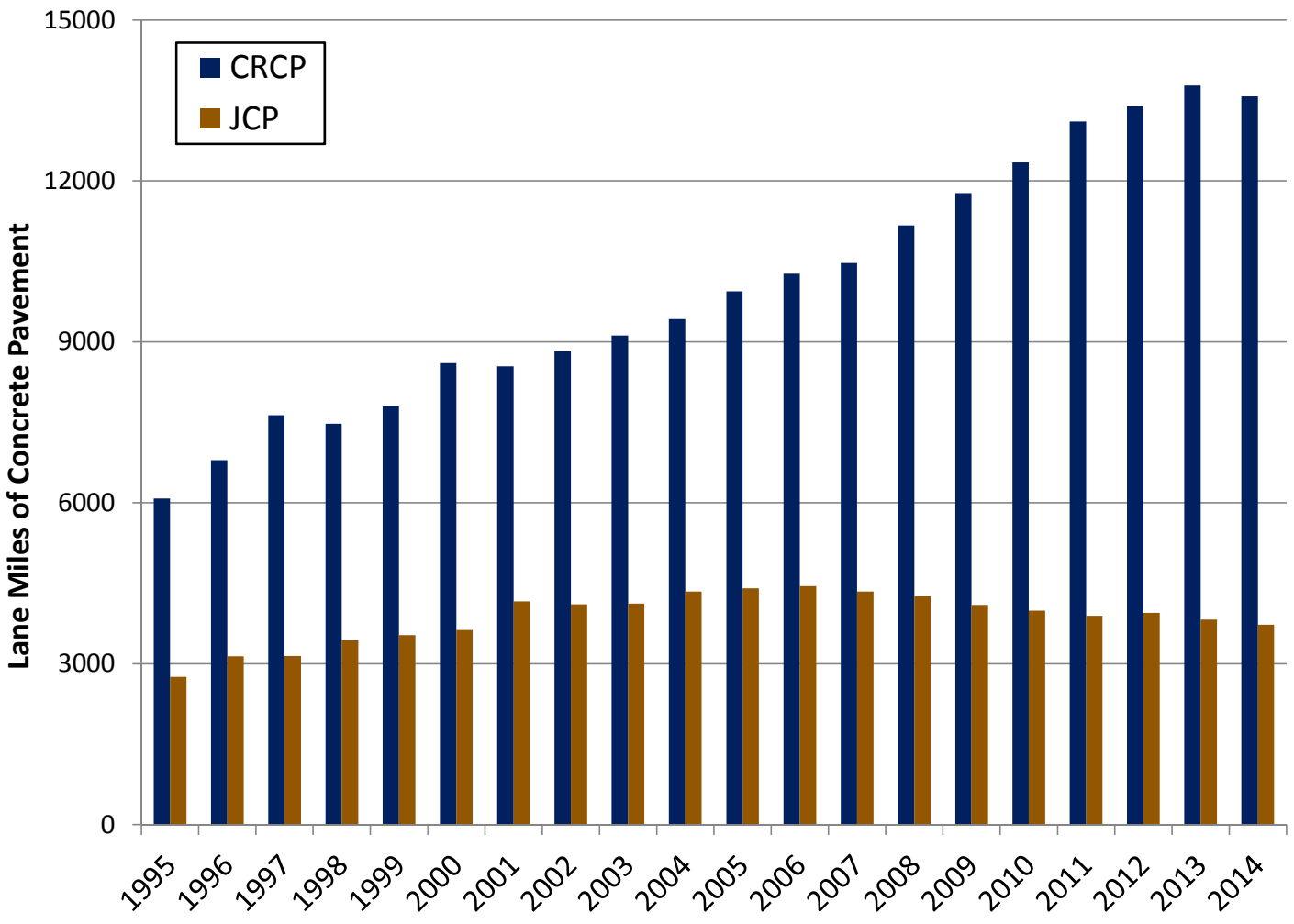
CRCP Stats

- Average 2.1 million CY of pavement concrete placed annually
- Average about 450 lane miles per year added to system
  - Pave one lane from Laredo, TX to Dallas, TX along IH-35



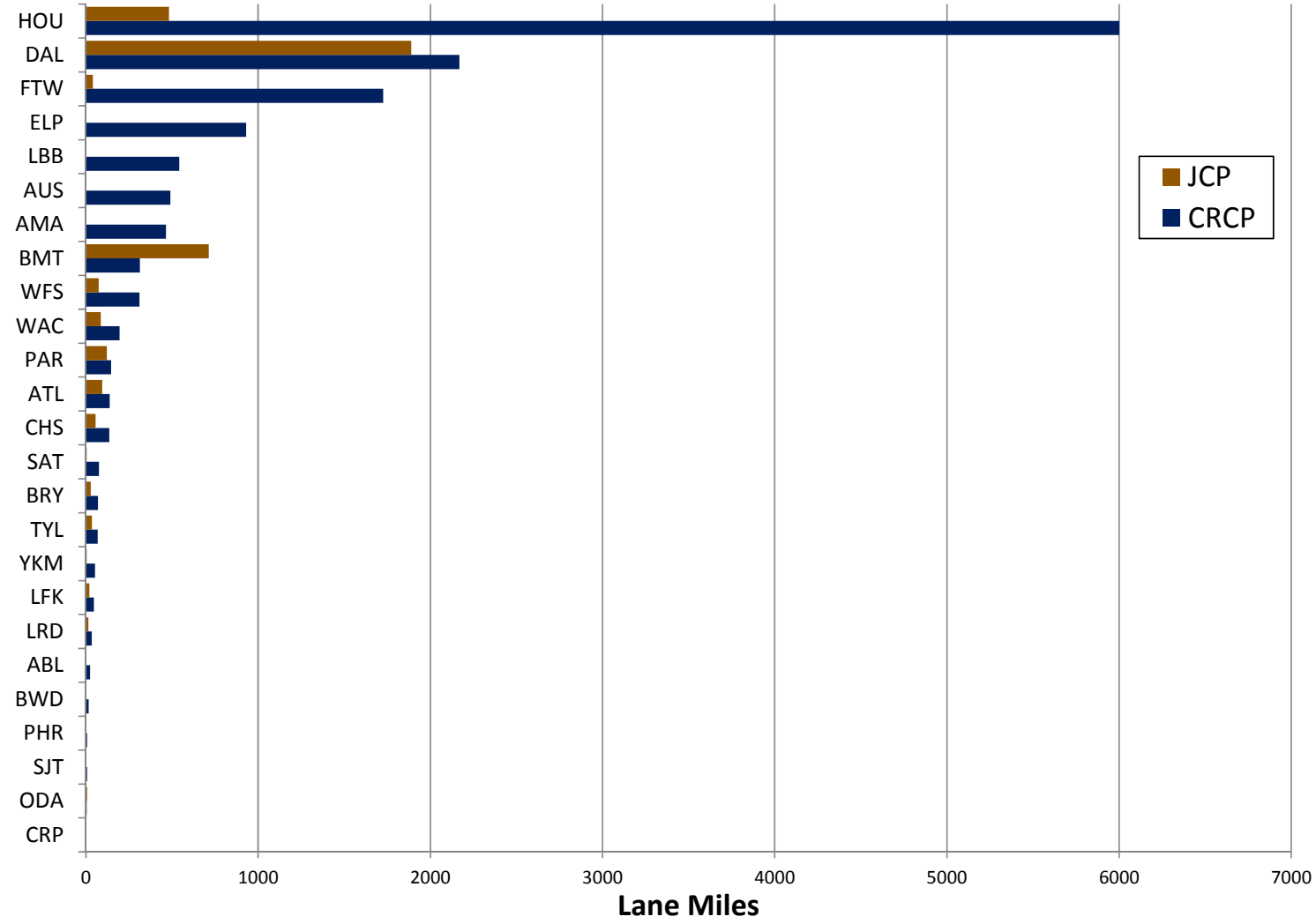
CRCP Stats

Lane Miles of Concrete Pavement Per Year

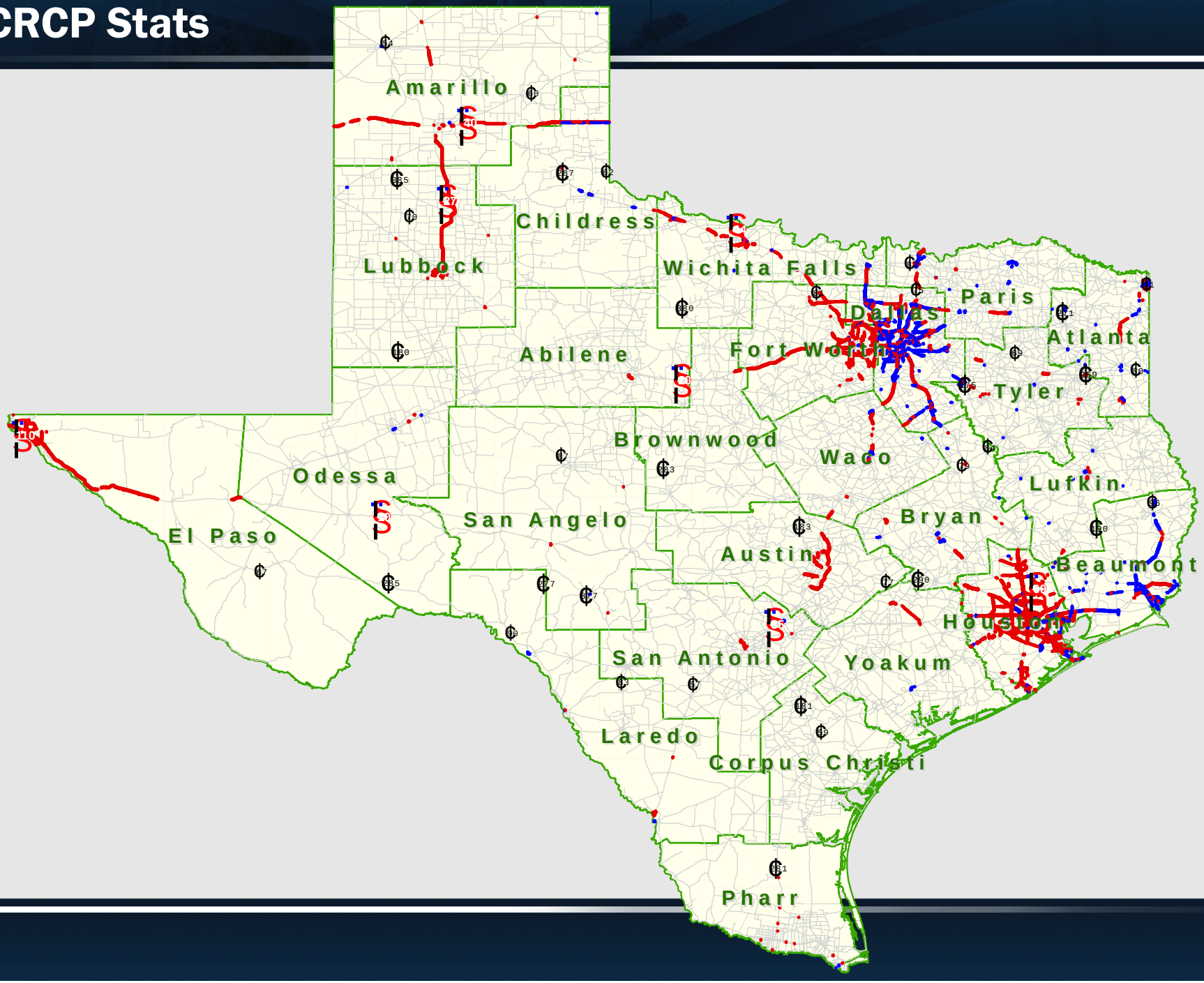


CRCP Stats

Lane Miles per District



CRCP Stats


Amarillo
Childress
Lubbock
Wichita Falls
Paris
Dallas
Atlanta
Fort Worth
Abilene
Tyler
Brownwood
Waco
Odessa
Lufkin
San Angelo
Bryan
El Paso
Austin
Beaumont
Houston
San Antonio
Yoakum
Laredo
Corpus Christi
Pharr

Standard Details

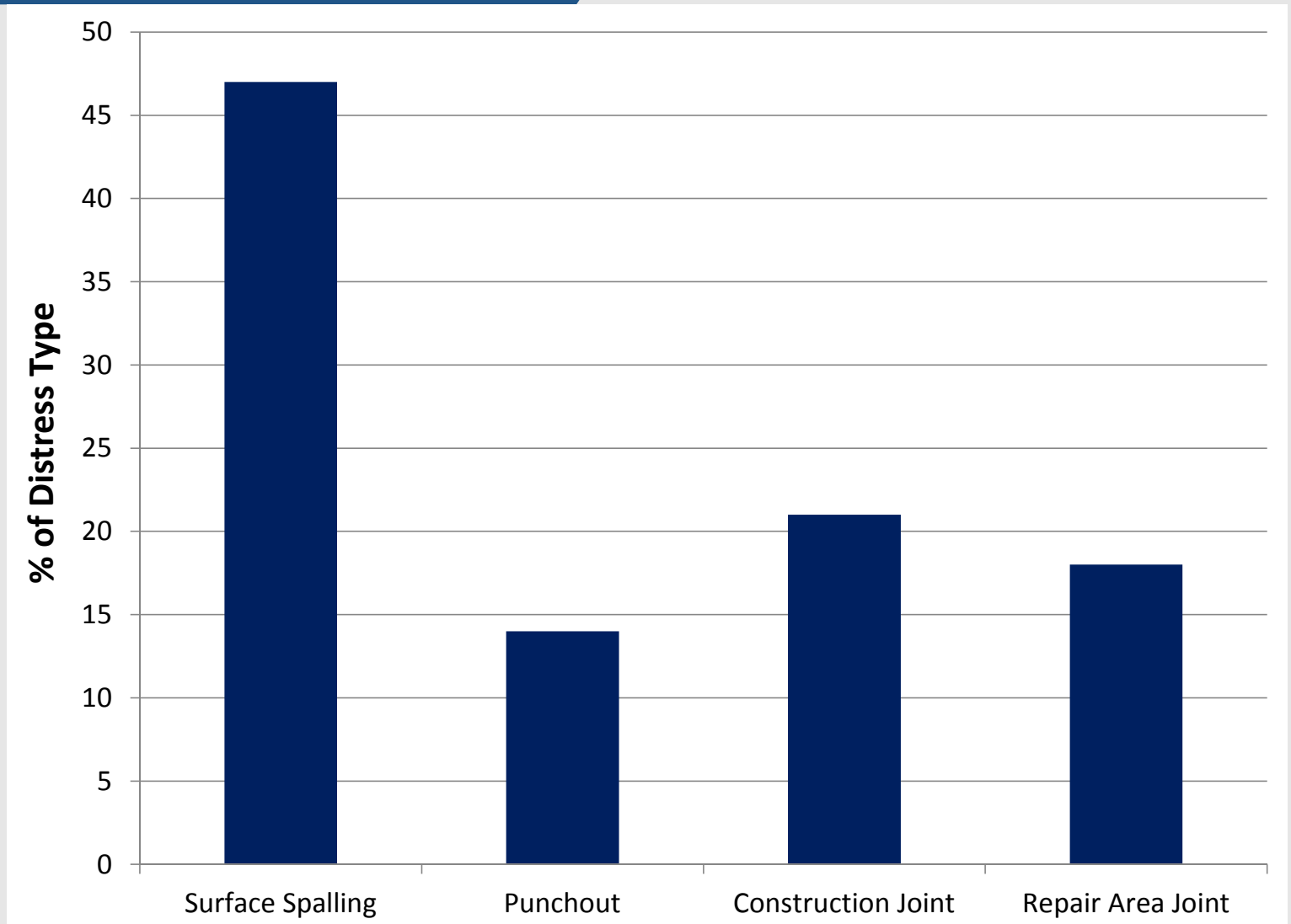
- Standard Thickness – 7” to 13”
  - Single mat of steel
- 14 and 15 inch thick sections allowed with District Engineer approval
  - Double mat of steel
- Steel % - 0.56% to 0.68%
- CTE limit – 5.5 µstrain/°F
  - 10% steel reduction for CTE 4.0 µstrain/°F or less
- Maximum cement content – 520 lb/CY
- Steel located at mid depth
- Stabilized Bases
  - 6” cement treated base and 1” ACP bond breaker
  - 4” ACP or ASB
- Tied concrete shoulder
- 30 year Design Life

Performance History

2014 PMIS DATA								
Utility	Overall Utility Average	Substandard Utility (<0.7) Lane Miles	Highway System Utility Average					
			IH	US	SH	BR	FM	PA
CRCP Ride	69.1	1050.7	75.05	70.58	61.34	55.88	61.32	58.81
CRCP PCC Patching	77.62	771.4	69.31	77.96	89.35	91.68	82.82	100.00
CRCP Punchouts	94.17	139.3	93.03	92.52	95.95	97.14	97.08	100.00
CRCP Spalled Cracks	98.78	16.9	98.98	99.33	97.69	100.00	99.53	100.00
CRCP ACP Patching	99.26	17.6	98.90	99.10	99.78	100.00	99.73	100.00

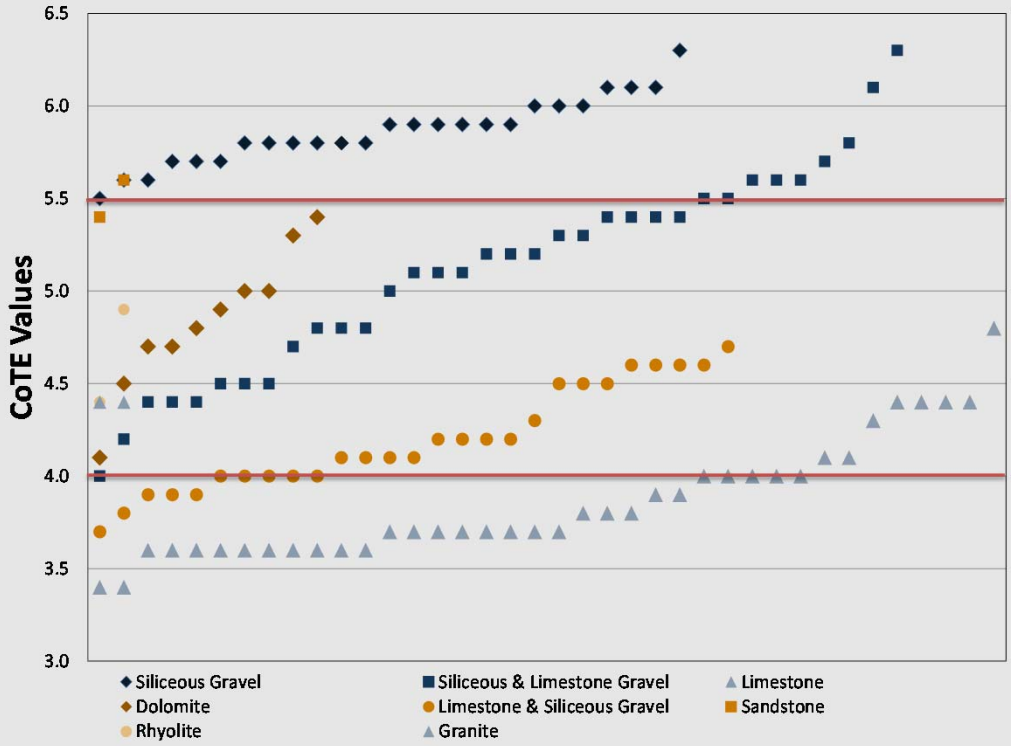
Performance History

Types of Distress



Shallow Spalling

CoTE by Aggregate Classification

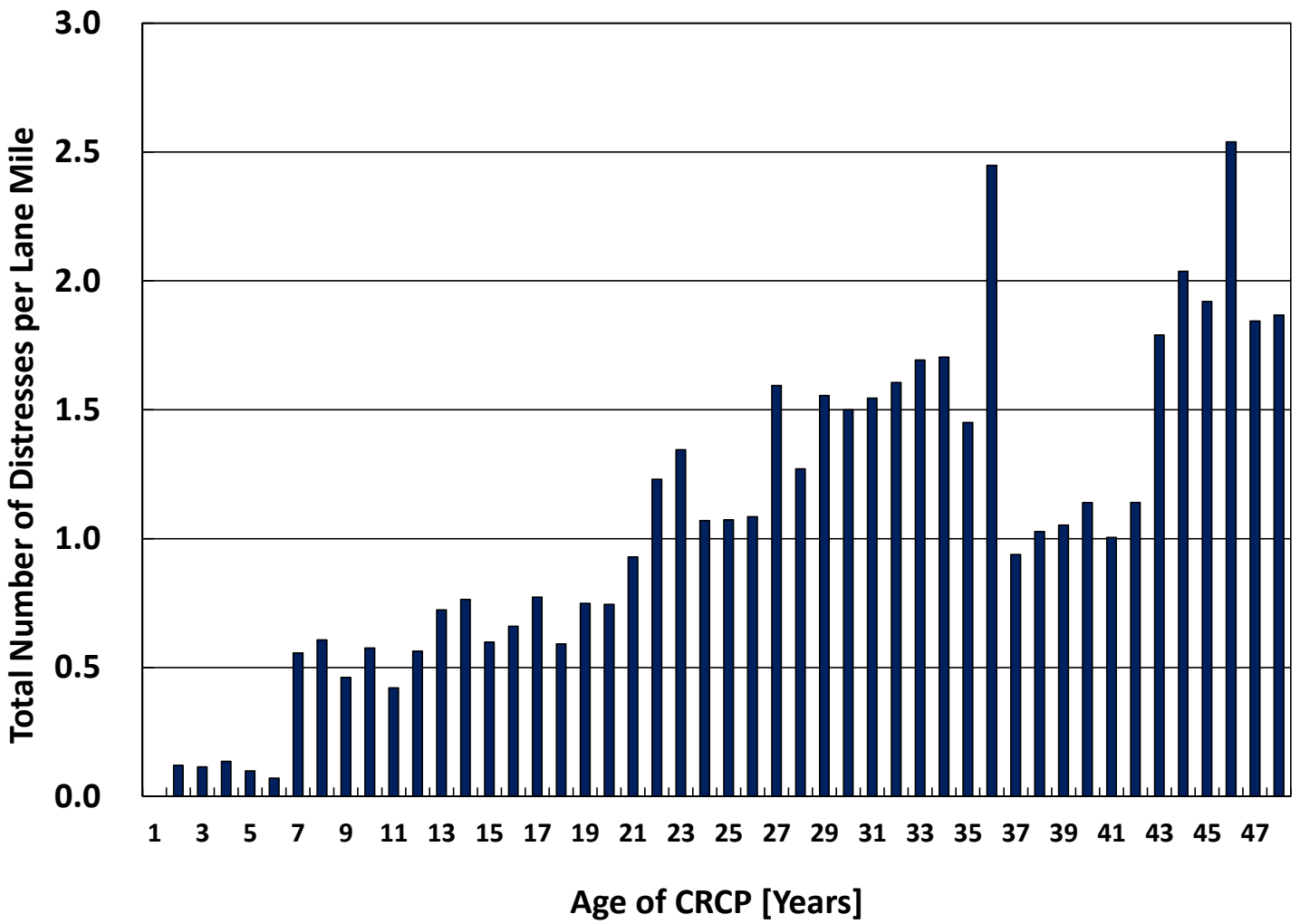


Distress at Joints

Punchouts

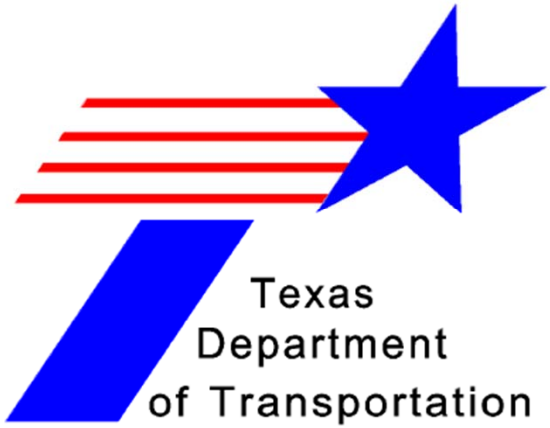
Performance History

Distribution of Distress



Selection Process

Pavement Design Guide



Revised January 2011

TxDOT – Houston District
Pavement Design
Standard Operating Procedure

Approval Authority: District Engineer **Effective:** September 1, 2009

Review Authority: Director of Transportation Planning and Development

Department Policy & Procedure Manuals:

- Pavement Design Guide (November 2008)
- Wet Weather Accident Reduction Program (WWARP) Guidelines and Form 2088
- Guidelines for Modification and Stabilization of Soils and Base for Use in Pavement Structures, September 2005
- Guidelines for Treatment of Sulfate-Rich Soils and Bases in Pavement Structures, September 2005
- Memoranda from:
  - John A. Barton, P.E., Guidelines for Alternate Pavement Designs (Design-Bid-Build Process), dated October 22, 2008
  - Thomas Bohuslav, P.E., Item 247, Grade 5 and Base Selection Guidance, dated February 11, 2009
  - John A. Barton, P.E., Cost Control Ideas Update, dated February 12, 2009
  - Thomas Bohuslav, P.E., Alternate Pavement Rehabilitation Options, Revised Attachments, March 16, 2009 Memorandum is Rescinded, April 1, 2009
  - John A. Barton, P.E., Guidance on Potential Vertical Rise (PVR) for design, dated July 6, 2009
  - John A. Barton, P.E., Flexible Pavement Design Guidance, dated August 10, 2009
  - John A. Barton, P.E., Use of Grade 1 Flex Base, dated August 25, 2009

  Note all memoranda are available at:
  http://crossroads/org/cst/default.asp?p=Memos_Emails
- District Specific Guidelines

Purpose: To provide guidance to Houston's design engineers and design personnel on pavement design considerations and the pavement design process.

Standard Operating Procedures

- Factors to be considered
  - Existing Structure
  - Traffic
  - Project Scope and Budget
  - Pavement History
  - Type of Facility
  - Material Considerations
  - Constructability
  - Maintenance Activities
  - Local Preference

Contact Information

Andy Naranjo, P.E.

Andy.naranjo@txdot.gov

512-505-5858

Or

Hua Chen, P.E.

Hua.Chen@txdot.gov

512-506-5846

Selection of Continuously Reinforced Concrete for Projects – Focus on Long-Life Pavement Performance

Webinar – March 30, 2015

Sam Tyson, P.E.

Concrete Pavement Engineer

Federal Highway Administration

Office of Asset Management, Pavements, and Construction

Long-Life Concrete Pavement

FHWA Conferences in 2006 & 2012

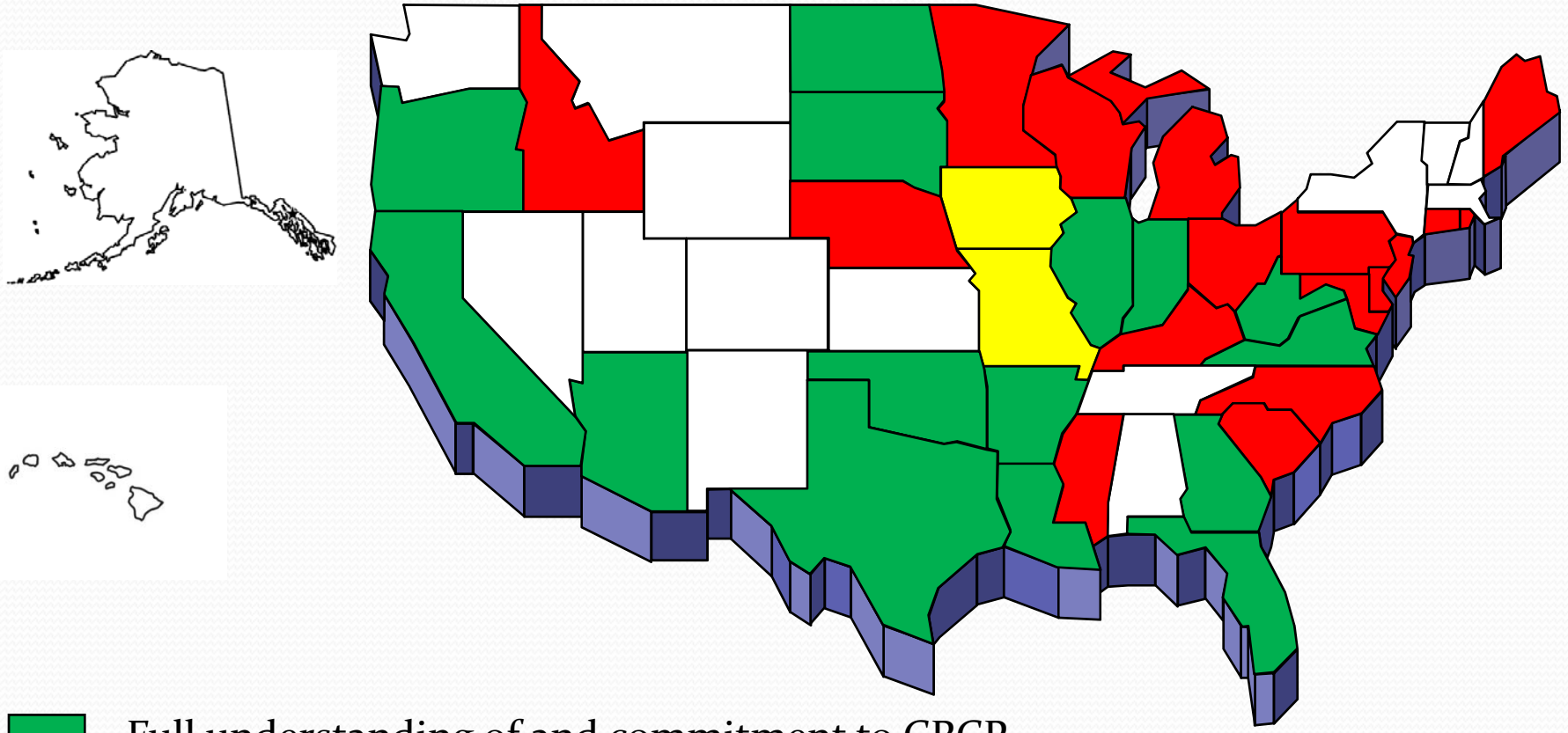
Long-Life Pavement Characteristics

- **Original service 40+ years.**
- **No premature construction defects or material-related distress.**
- **Reduced potential for cracking faulting & spalling.**
- **Smoothness and surface texture easily maintained.**

CRCP Resources

- Design and Construction Guidelines
- Technical Briefs on Key Topics
- Peer-to-Peer Assistance
- Webinars
- Workshops

CRCP Use by Highway Agencies



Full understanding of and commitment to CRCP.
Considering the use of CRCP.
Built CRCP in the past but have since discontinued.
Never built CRCP or have no current experience.

As determined by FHWA-CRSI CRCP ETG on 06.04.14.

CRCP for New Alignment

CRCP for Rehabilitation

Thank You

Sam Tyson, P.E.

Concrete Pavement Engineer

Phone: 202-366-1326

E-mail: sam.tyson@dot.gov