TRB Webinar:

Mechanistic-Empirical Design and Details for Continuously Reinforced Concrete Pavement (CRCP)

June 3, 2015
2:00 PM – 3:30 PM ET

TEXAS A&M UNIVERSITY

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

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Today's Panelists and Moderator

- **Jeff Roesler**, *University of Illinois at Urbana-Champaign*
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- **Mike Darter**, *University of Illinois at Urbana-Champaign*
  midarter@gmail.com

- **Dan Zollinger**, *Texas A&M University*
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- **Dulce Rufino Feldman**, *Caltrans*
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Continuously Reinforced Concrete Pavement (CRCP)
Part 2 – Mechanistic-Empirical Design and Details

Transportation Research Board Webinar

Moderator: Dulce Rufino Feldman, Ph.D., P.E.
California Department of Transportation

June 3, 2015

CRCP 5-Year Cooperative Agreement

- **Agencies:**
  - Federal Highway Administration (FHWA)
  - Concrete Reinforcing Steel Institute (CRSI)
- **Goal:** expand the use of CRCP as a way to achieve long-life concrete pavement performance.
- **Webinars:**
  - CRCP Selection (March 2015)
  - CRCP Design (Today)
  - CRCP Construction (TBD)

Webinar Organizers

- Federal Highway Administration (FHWA)
- Concrete Reinforcing Steel Institute (CRSI)
- TRB Committees:
  - Rigid Pavement Design (AFD50)
  - Portland Cement Concrete Pavement Construction (AFH50)
  - Pavement Rehabilitation (AFD70)

Webinar Outline

- AASHTO ME Design for CRCP
  - **Jeff Roesler, University of Illinois at Urbana-Champaign**
- European Design Procedures for CRCP
  - **Mike Darter, Applied Research Associates, Inc.**
- End Treatments and Other Design Details
  - **Dan Zollinger, Texas A&M University**
- Questions and Answers

Professor Jeffery Roesler, P.E.

Dept. of Civil & Environmental Engineering

University of Illinois at Urbana-Champaign

TRB Webinar

Continuously Reinforced Concrete Pavement - Part 2: Mechanistic-Empirical Design and Details for CRCP

June 03, 2015

2:00-3:30 PM

AASHTO Pavement ME Design for CRCP

Presentation Overview

- CRCP Design Resources
- Introduction to Mechanistic-Empirical Design of CRCP
- AASHTO Pavement ME Design Principles and Inputs
- AASHTO ME Input Sensitivity
- Design Example with AASHTO Pavement ME

Key CRCP Design Questions to Answer

- **Consulting / Gov't pavement engineer**
  - Interested in M-E design of CRCP
- Why use AASHTO Pavement ME for CRCP?
- What are the basics of AASHTO Pavement ME?
- What are key inputs to gather?
- What are expected sensitive inputs/variables?
- Where can the CRCP design be optimized?
- Design examples and sensitivities
  - New CRCP and CRCP overlay

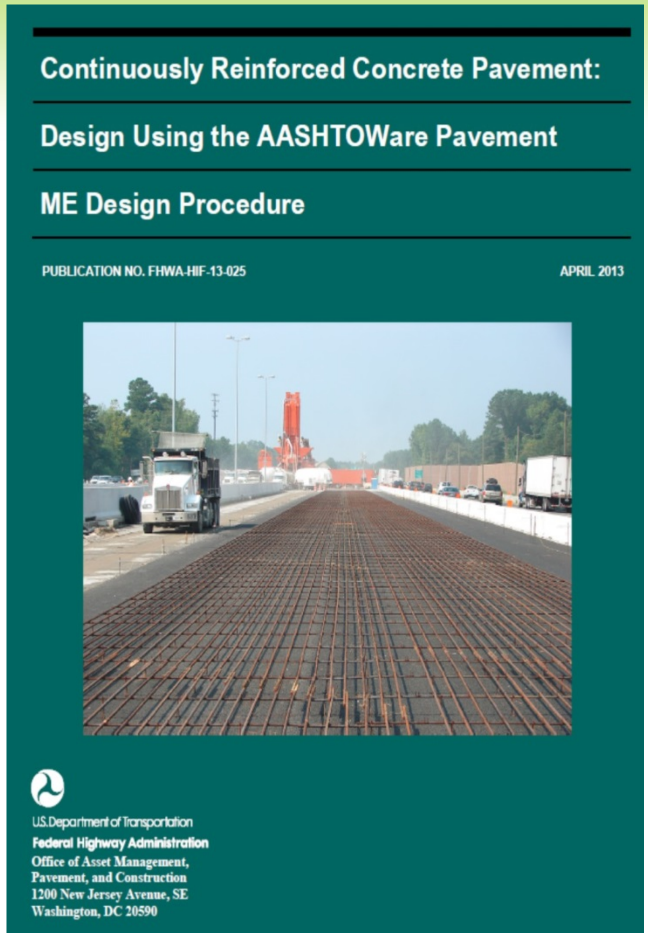
CRCP ME Design Resources

TechBrief
JUNE 2013 | FHWA-HIF-13-027

Continuously Reinforced Concrete Pavement: Design Using the AASHTO Pavement ME Design Program

INTRODUCTION TO MECHANISTIC–EMPIRICAL DESIGN OF CRCP

With the completion of the mechanistic–empirical pavement design guide (AASHTO 2008) and the recent availability of the AASHTO-Ware® Pavement ME Design software (http://www.darwinme.org/MEDesign/Index.html), design of continuously reinforced concrete pavement (CRCP) has undergone significant changes. The primary purpose of this TechBrief, based on a more comprehensive Technical Summary (Roesler and Hiller 2013), is to provide engineers with the basic mechanistic–empirical design background and criteria utilized in the new ME Design software for CRCP. This document describes the main CRCP design inputs and identifies the most sensitive design inputs and features. Also, examples are included to demonstrate the use of the new software for the design of both new CRCP and CRCP overlays.



Continuously Reinforced Concrete Pavement:

Design Using the AASHTOWare Pavement

ME Design Procedure

PUBLICATION NO. FHWA-HIF-13-025 APRIL 2013

U.S. Department of Transportation
Federal Highway Administration
Office of Asset Management, Pavement, and Construction
1200 New Jersey Avenue, SE
Washington, DC 20590

Roesler & Hiller (2013)

August 2011

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

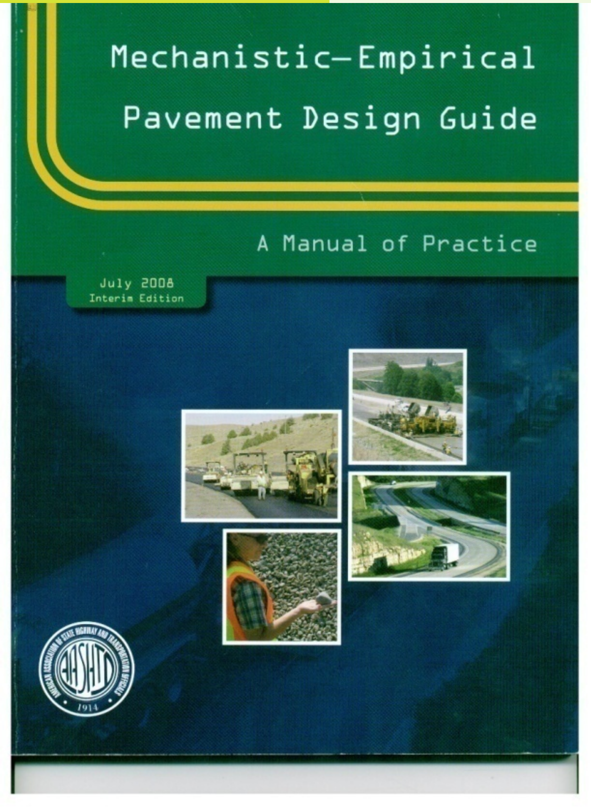
Design & Construction Guidelines

U.S. Department of Transportation
Federal Highway Administration

CRSI

Rasmussen et al. (2011)

AASHTO 2008
MEPDG CRCP Design



- New State-of-the-Art CRCP design procedure
- Development of mechanistic based models:
  - **Crack spacing—long term mean**
  - **Crack width—varies monthly & increases w/time**
  - **Crack load transfer efficiency—monthly**
  - **Punchout—repeated load edge failure**
- Development of empirical IRI model
  - **IRI = f(Initial IRI, future distress, site conditions)**

AASHTO (2008)

Introduction to Mechanistic-Empirical Design of CRCP

- Why the need for mechanistic-empirical design for CRCP?
  - AASHTO 1986/1993 - empirical
    - Higher traffic volumes
    - Extended-life designs
    - Sustainable design
  - Local climatic / site effects
  - Effect of design inputs on CRCP thickness
  - Material, support layer, construction effects
  - CRCP Overlay design

CRCP Failure Modes

- Too small crack spacing; Larger crack widths
- LTE deterioration of transverse cracks and spalling
- Punchouts & subbase erosion




Why Mechanistic-Empirical Design of CRCP?

- Benefits of mechanistic-empirical design
  - Rational method to compare with other pavement types M-E structural design
  - Designer has large control of inputs
  - Optimized designs possible (Level 1 -3)
  - Nationally calibrated models
  - More cost effective design than AASHTO 1993
  - Confident design extrapolations

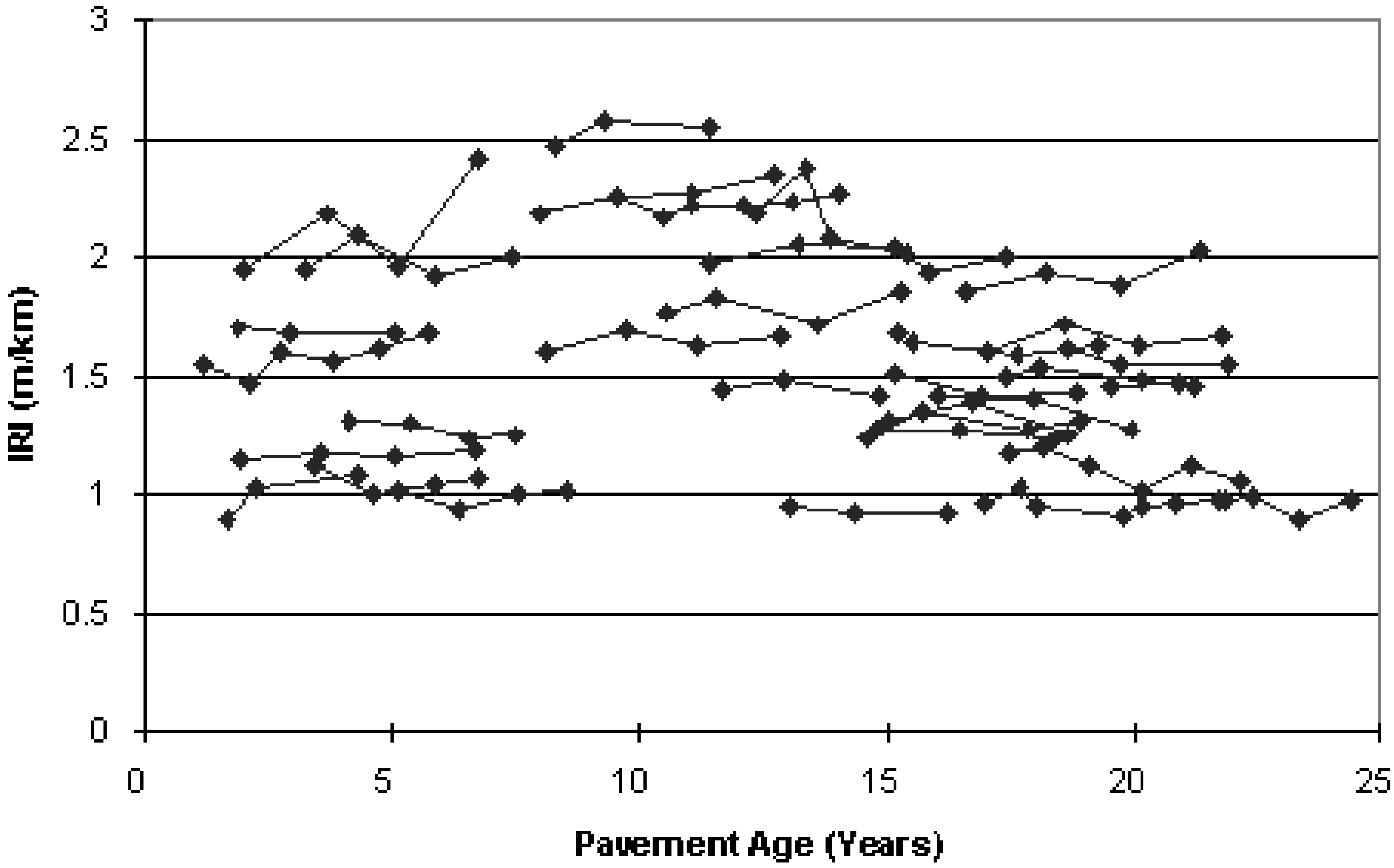
What can Engineer Control with ME Design of CRCP

- CRCP design inputs
  - Slab thickness
  - Layer type and properties
  - Concrete properties, i.e., strength, stiffness, CTE, shrinkage
  - Base type/friction/erodibility
  - Subgrade soil
  - Steel content; bar size and placement depth
  - Shoulder type / Edge support
  - Climate
  - Construction time
  - Traffic
  - Failure criteria limits
  - Reliability

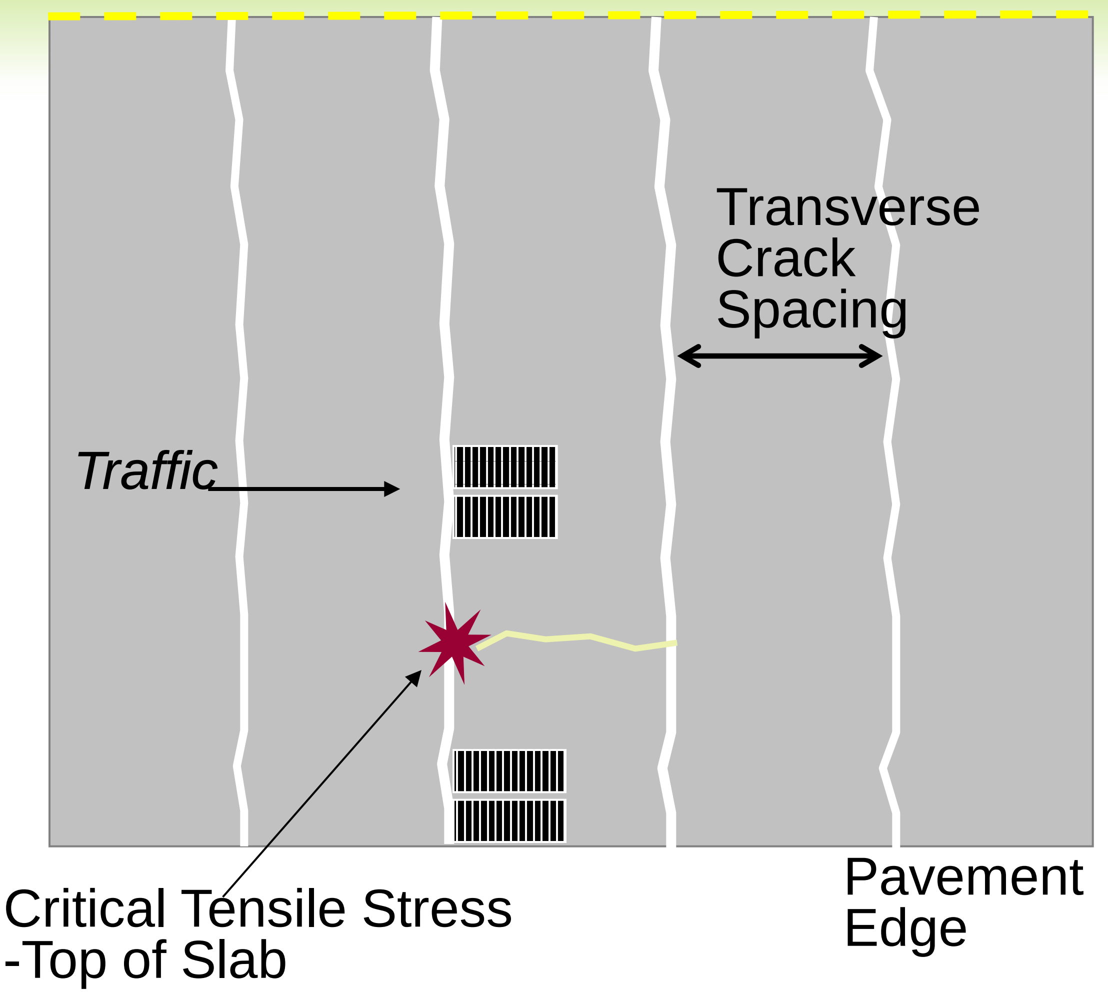
AASHTO Pavement ME CRCP Design Principles

- CRCP Design Objectives (New & Rehab)
  - Provide smooth, long-life pavement with minimal maintenance
  - Sustainable solution
- CRCP Design failure criteria
  - Classic punchout
    - Crack spacing
    - Crack width
  - Nonerodible subbase layer
  - IRI
    - Empirical model

Long Term Smoothness CRCP (LTPP GPS-5)



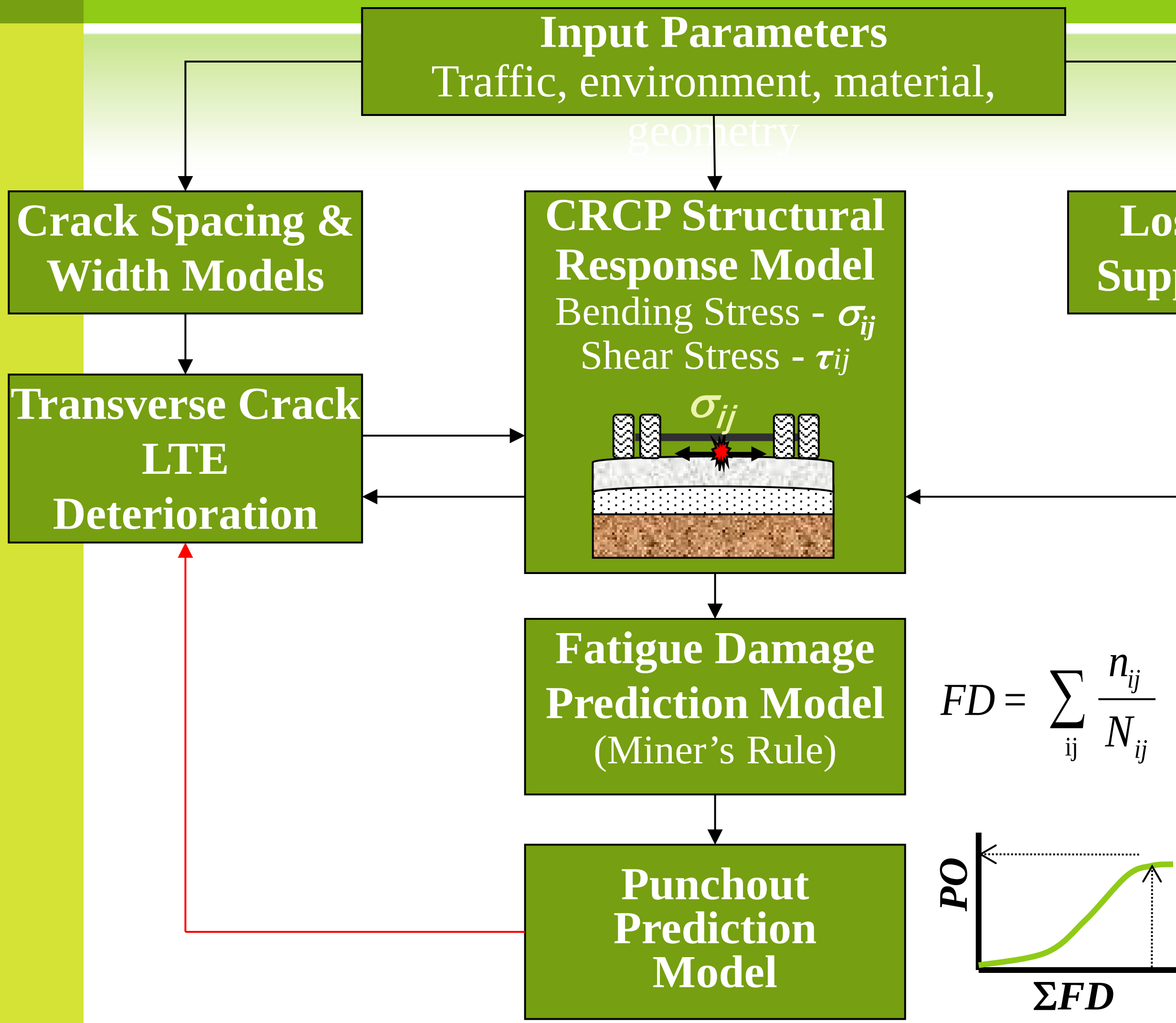
Punchout Mechanism: Top-Down Cracking



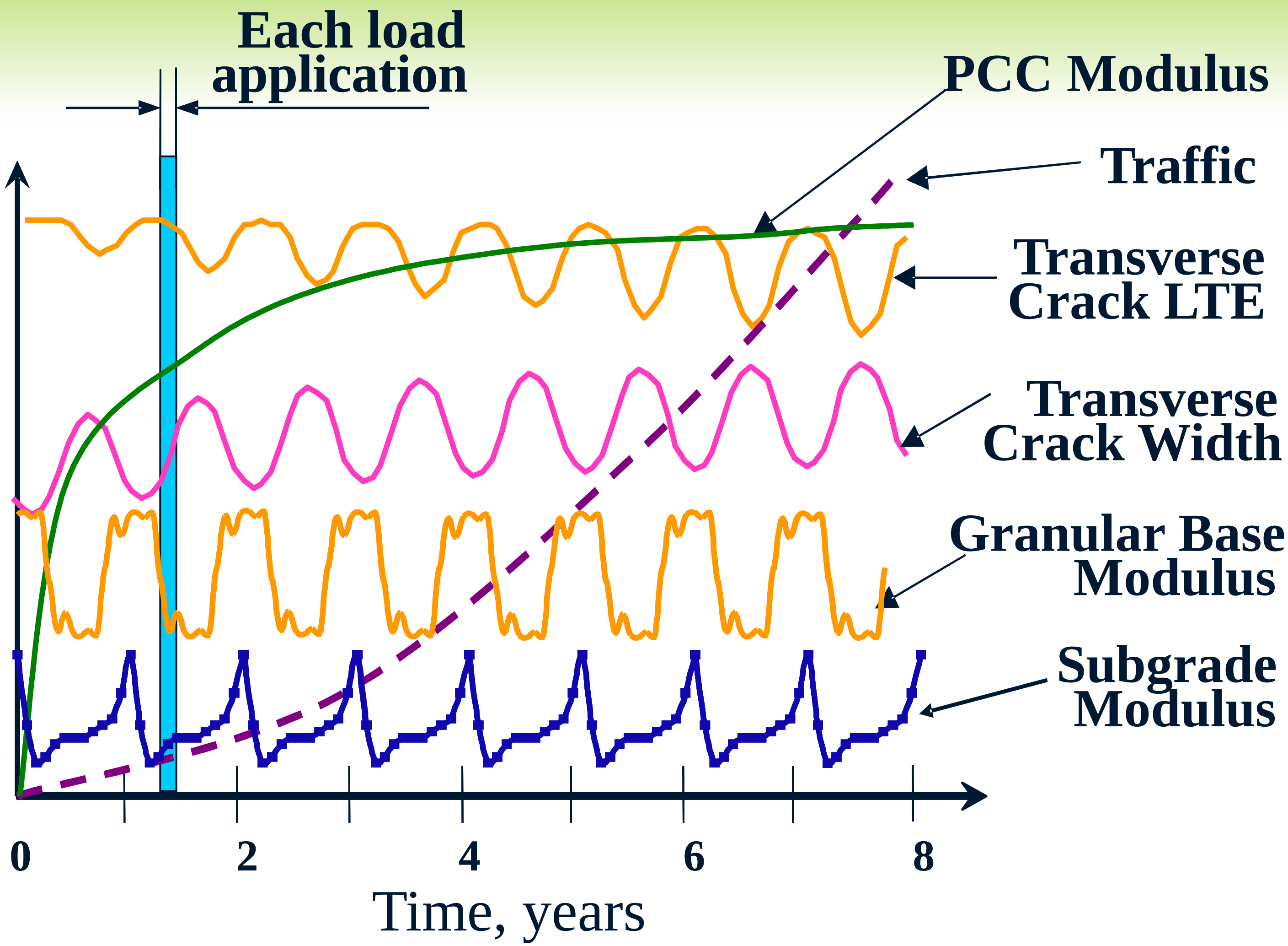
AASHTO Pavement ME Basic Design Process

- Mechanistic-empirical CRCP Design process
  - Design inputs
    - Pavement layers, materials, climate, traffic
  - Predict crack spacing and width
  - Cumulative damage analysis - incremental
    - Calculating slab tensile stresses
      - Climate and traffic
    - Monthly fatigue (punchout) damage
    - Crack deterioration model
  - Predicts punchouts and smoothness
  - Final CRCP thickness determined

MECHANISTIC-EMPIRICAL PUNCHOUT MODELING APPROACH



Design Parameters Over CRCP Life



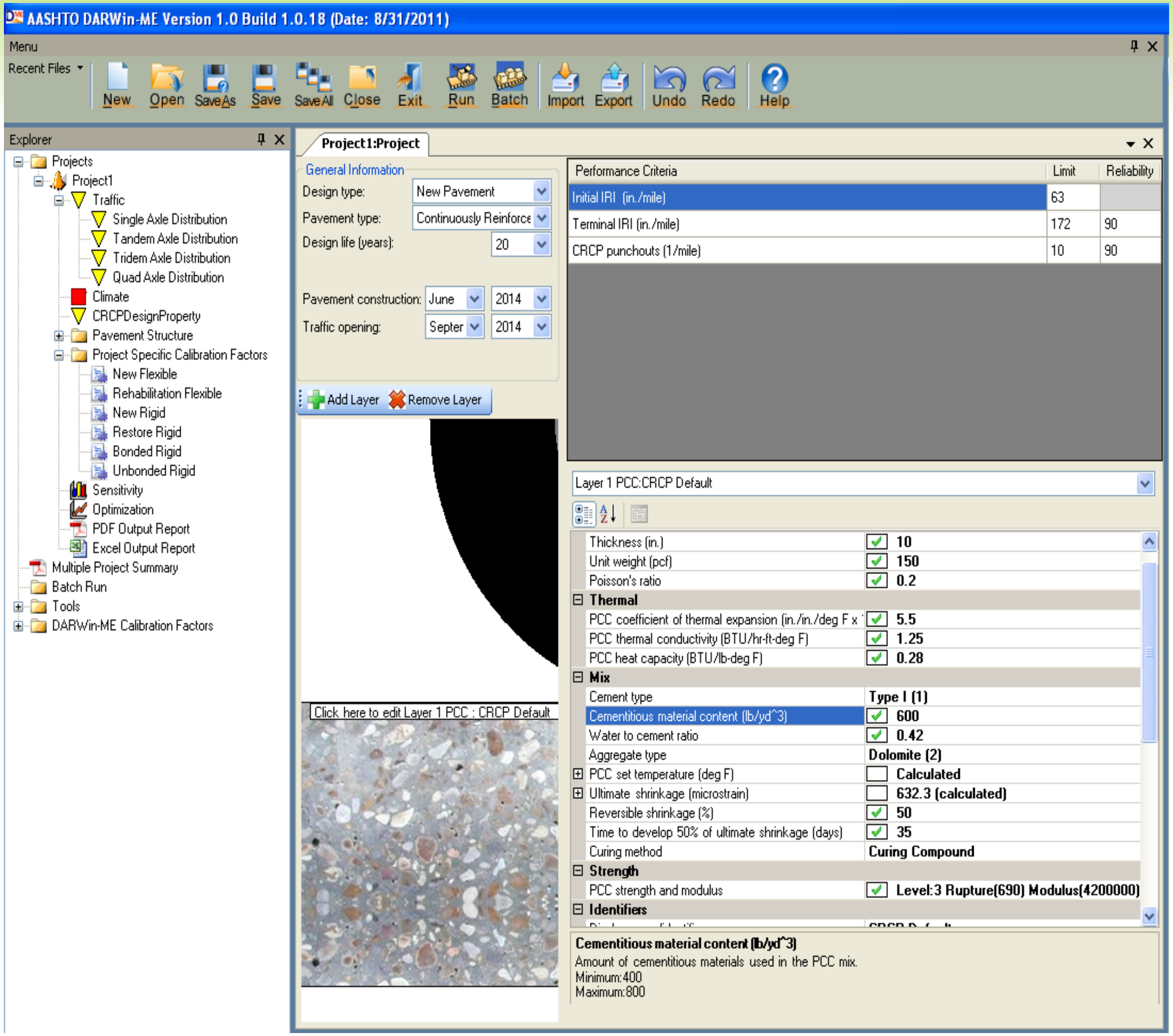
Models in AASHTO Pavement ME Unique to CRCP

- Transverse Crack Spacing Model
  - e.g., mean of 48 inches
- Transverse Crack Width Model
  - Varies monthly and increases over time
- Crack Deterioration Model
  - Load Transfer Efficiency
- Edge support erosion model
  - Empirical based on base type
- Edge Punchout Model
- IRI Model

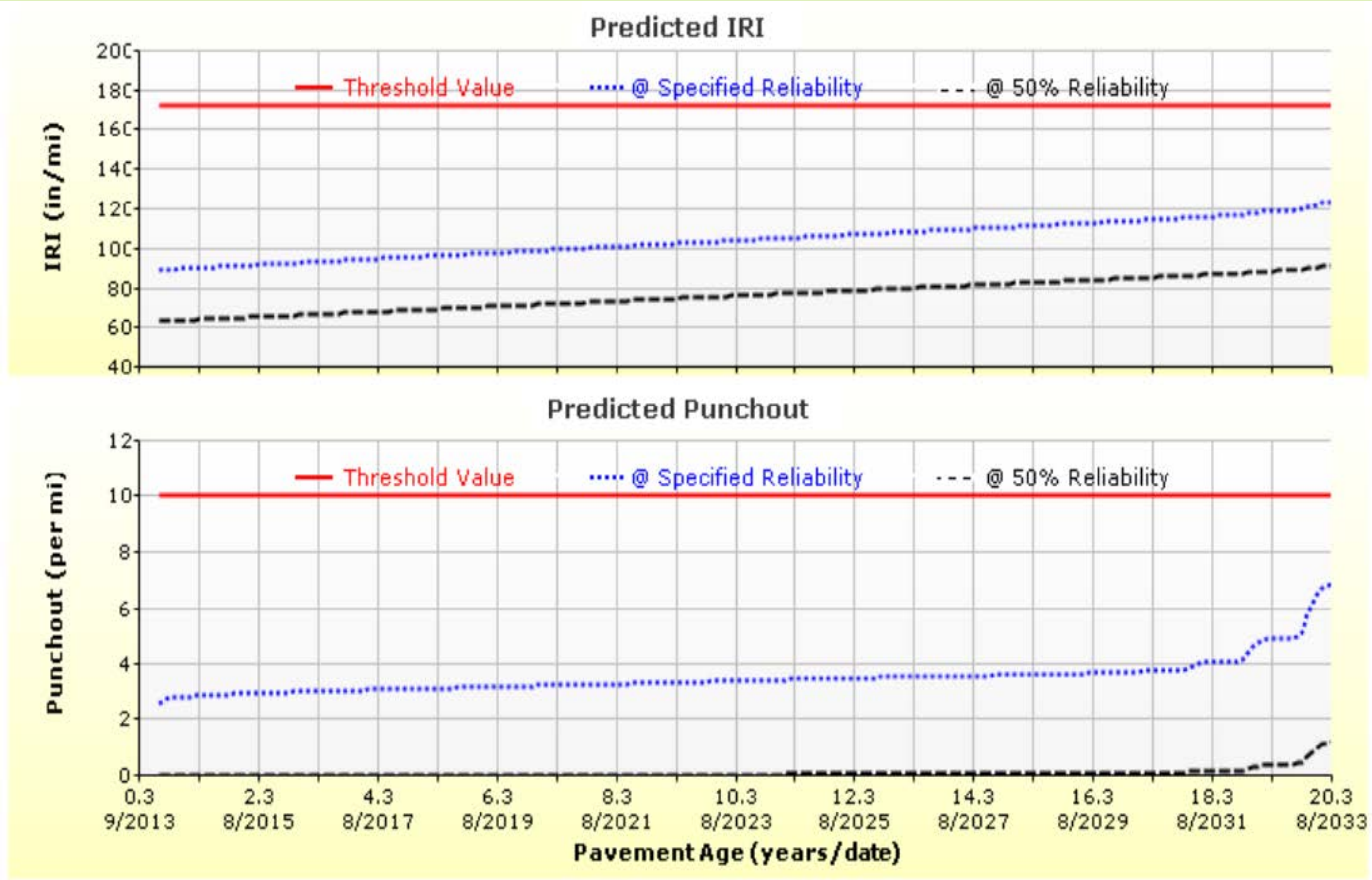
Main CRCP Design Elements for Pavement Engineer

- Longitudinal steel design (e.g., #6 @ ρ=0.75%)
- Base / subbase design (friction, erodibility)
- Shoulder / edge support design
- Concrete properties design
- Construction timing & climate effects
- Slab thickness determination (90-95% reliability)
  - Punchout limit ≤ 10/mile
  - IRI limit ≤ 172 in./mile

AASHTO Pavement ME Input Screen



AASHTO Pavement ME CRCP Output Screen



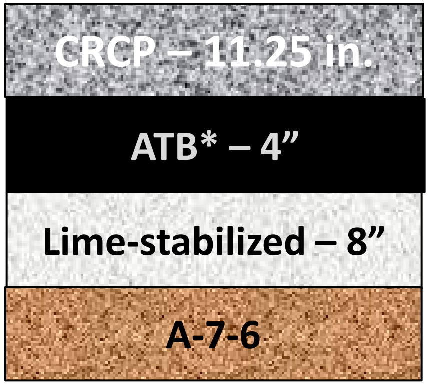
CRCP Performance Sensitivity in AASHTO Pavement ME

- Most sensitive design inputs:
  - Slab thickness
  - Concrete -strength, CTE, shrinkage
  - Steel content and depth
  - Shoulder type
  - Base type/ Friction / Erodibility
  - Heavy truck volume
  - Other sensitive variables
    - Construction Month, surface absorptivity, built-in curling

**From past sensitivity studies

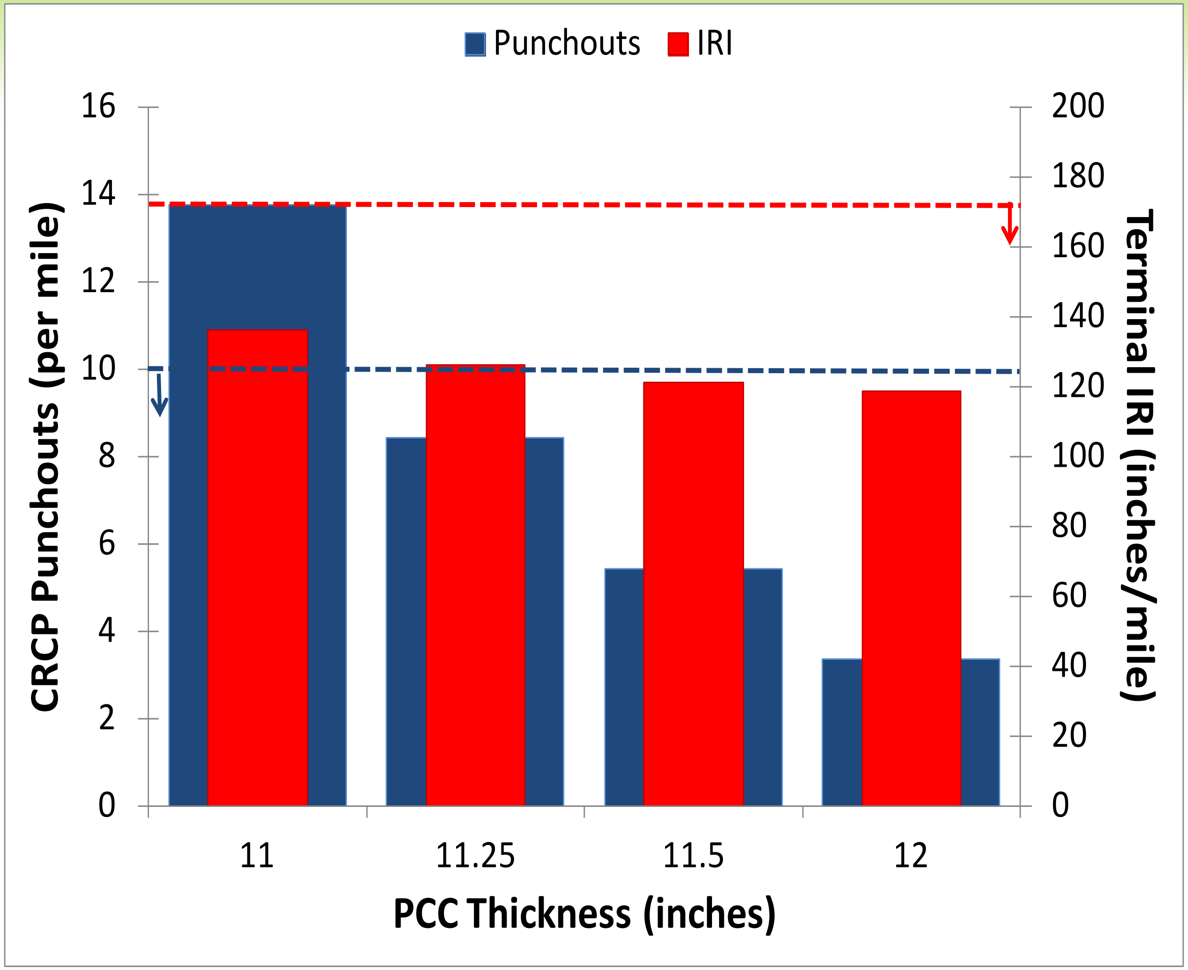
Chicago, IL Sensitivity Example

- High volume highway in Chicago, IL
- AADTT = 20,000
  - 103 million design ESALs
- Asphalt shoulder
- MOR = 650 psi, w/c = 0.42
- Base/slab friction coefficient =7.50
- Steel content = 0.7% @ 3.5 inches
- *AASHTO Pav't ME Level 3 defaults*
- *AASHTO 1993 = 14 in.*



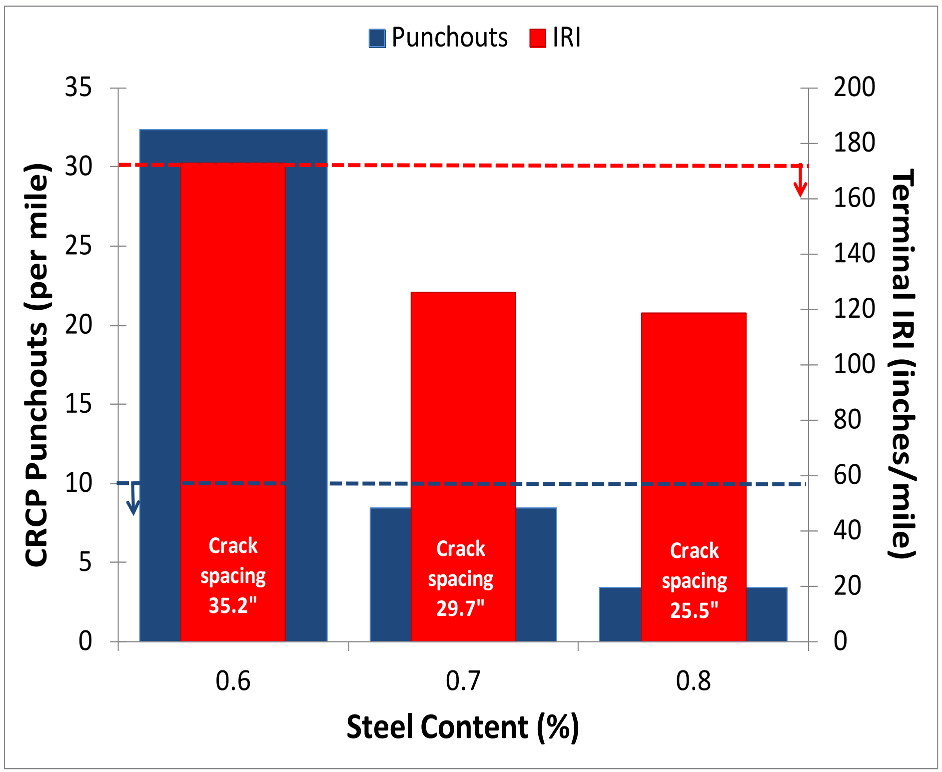
**ATB=asphalt treated bas*

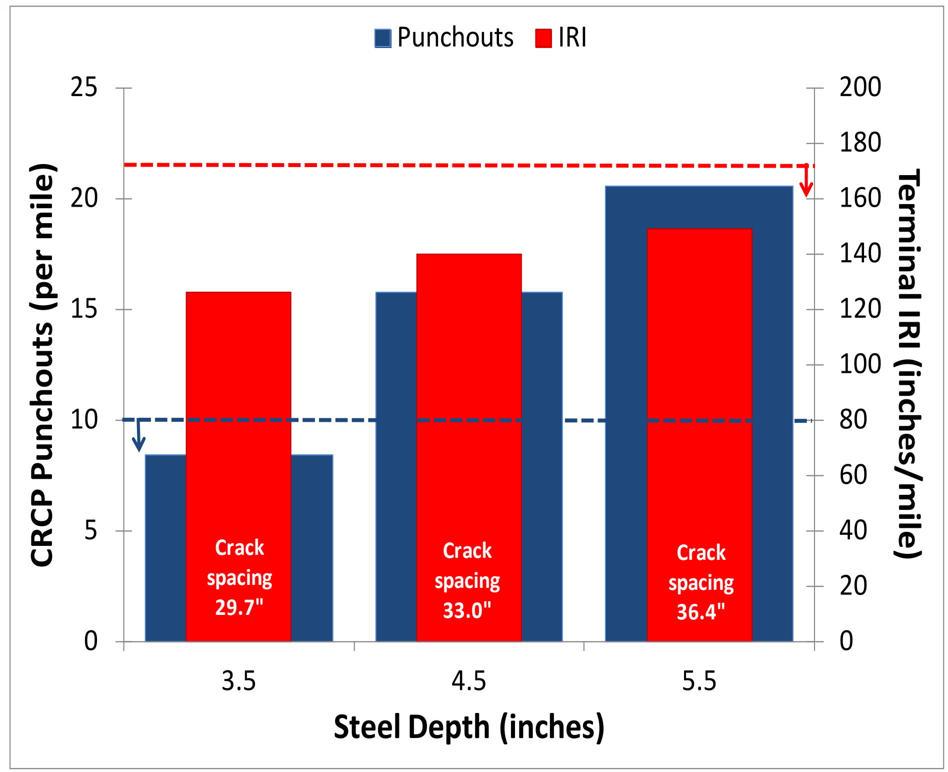
PCC Thickness Sensitivity Chicago, IL



Punchouts → control design (11.25")

Steel Content & Depth Sensitivity Chicago, IL

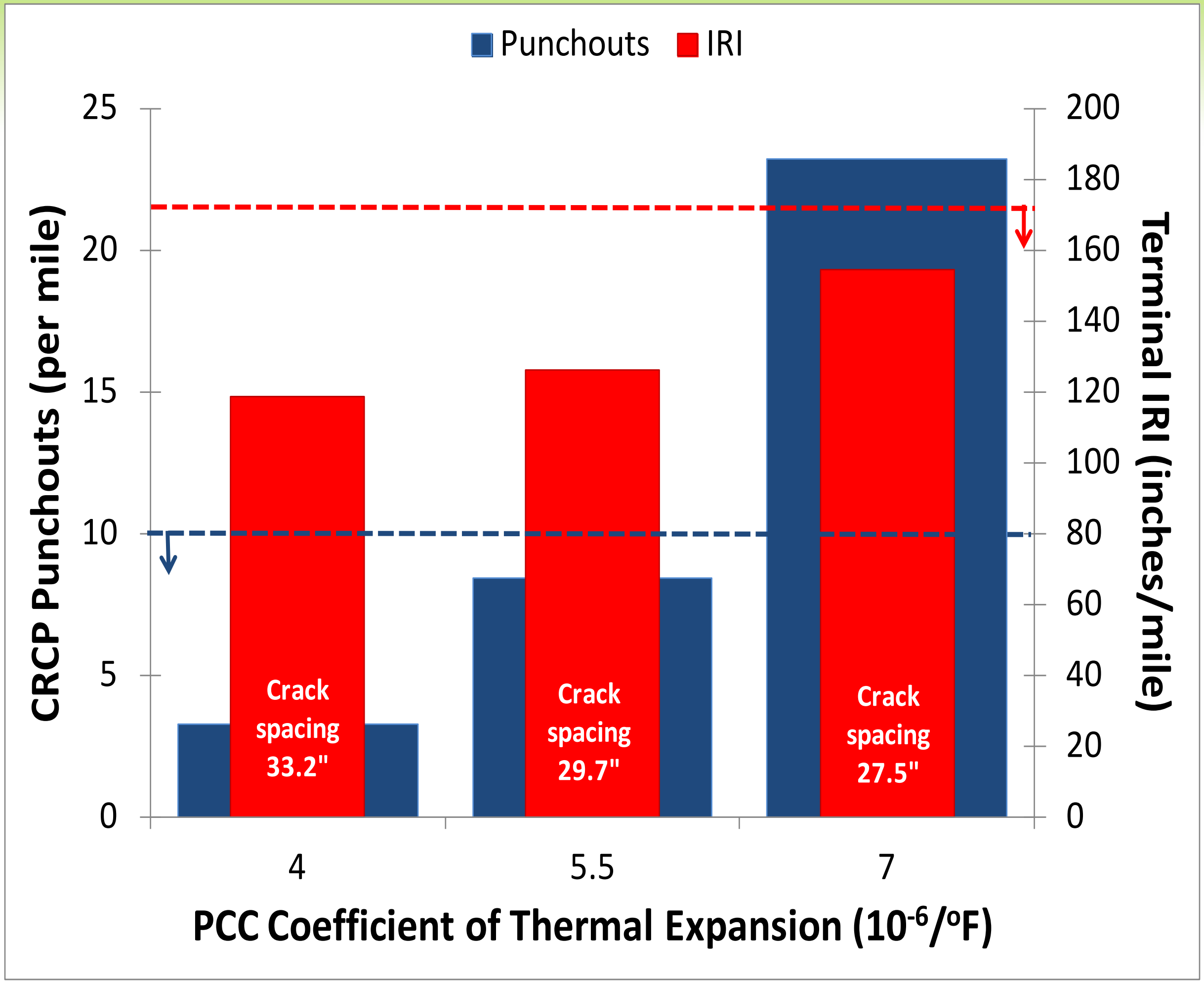




Punchouts → control design (≥0.7%)

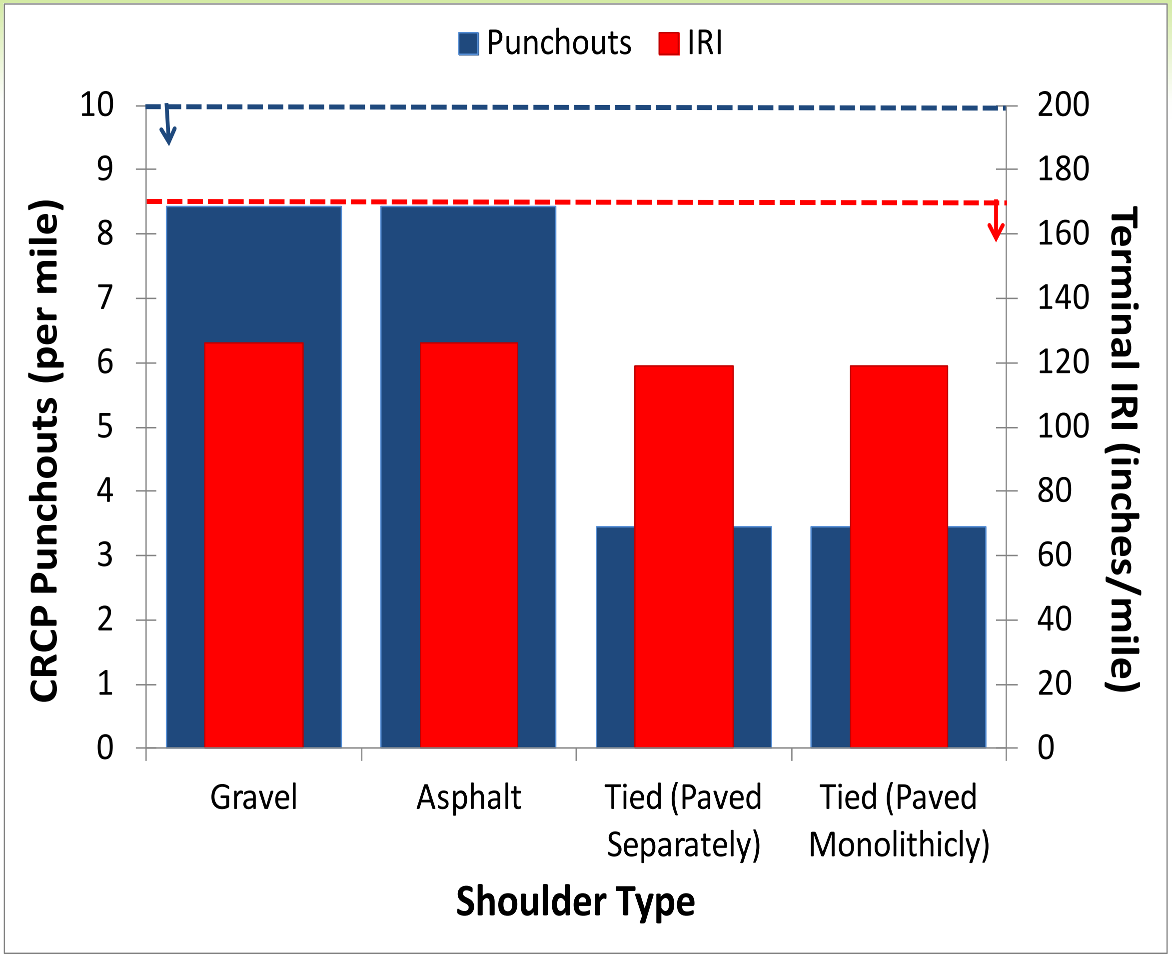
Punchouts → control design (3.5”)

CTE SENSITIVITY CHICAGO, IL



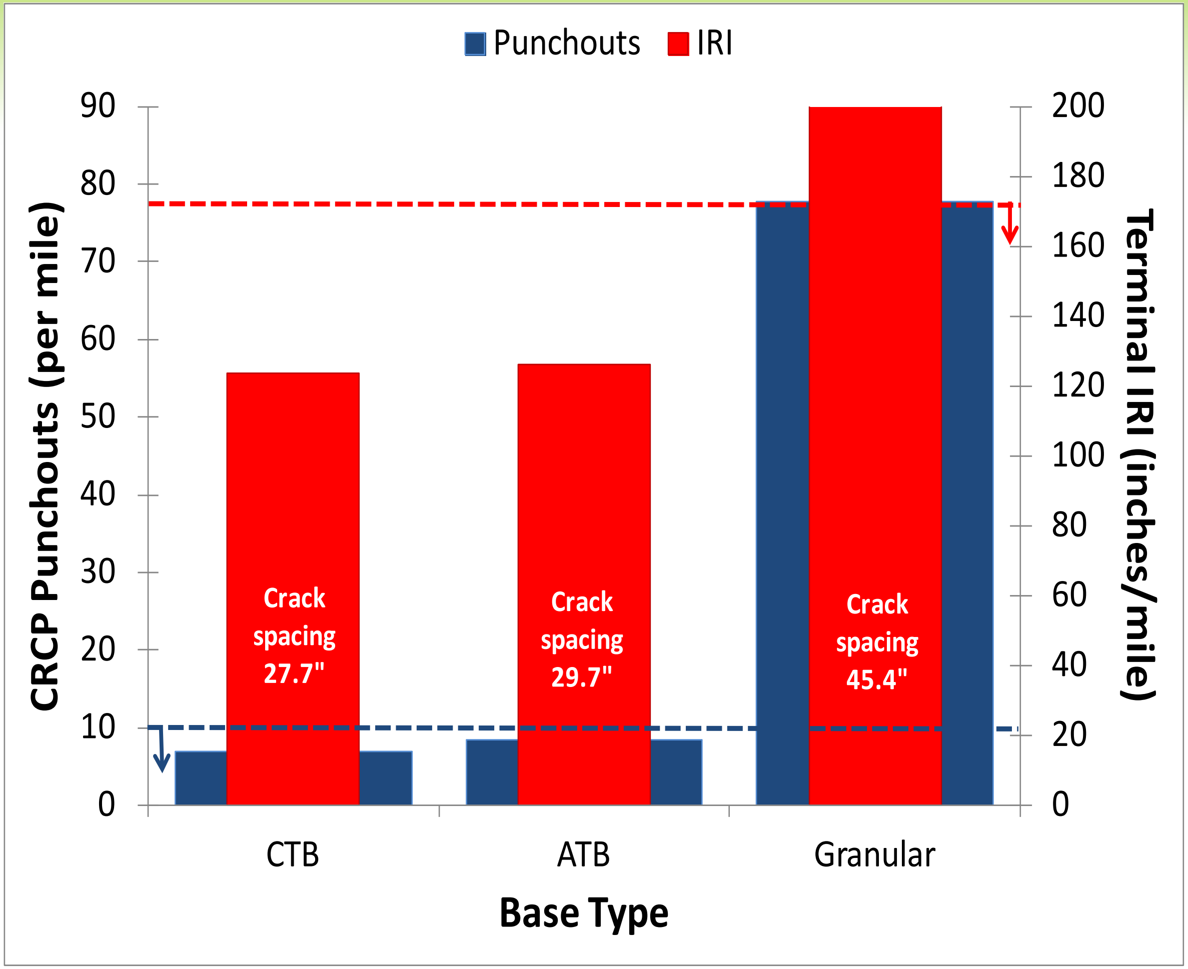
Higher CTE concrete leads to significant increases in punchouts and IRI

Impact of Shoulder Type Chicago, IL



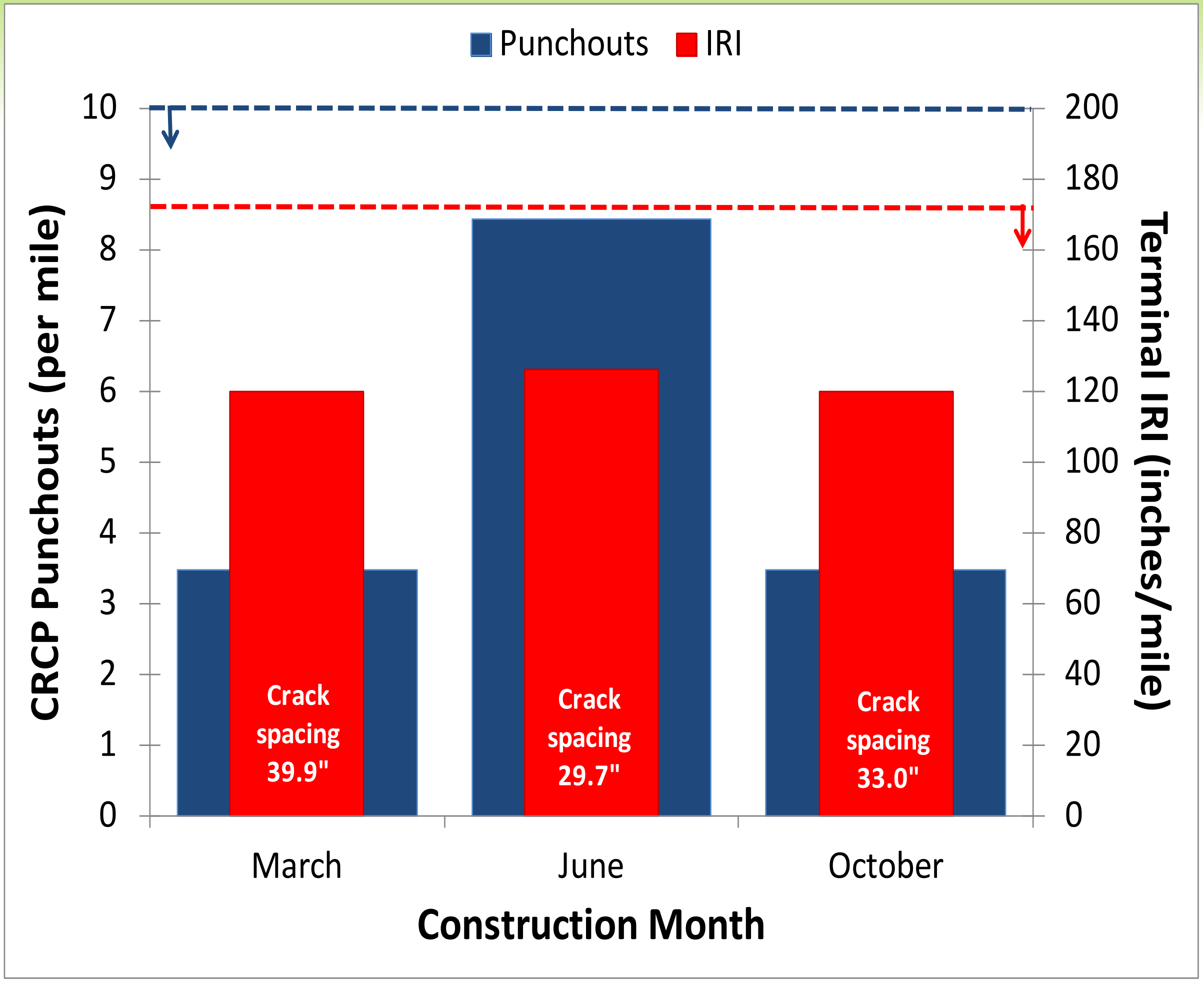
Concrete shoulder reduces distress development

Base Type / Friction / Erosion Chicago, IL



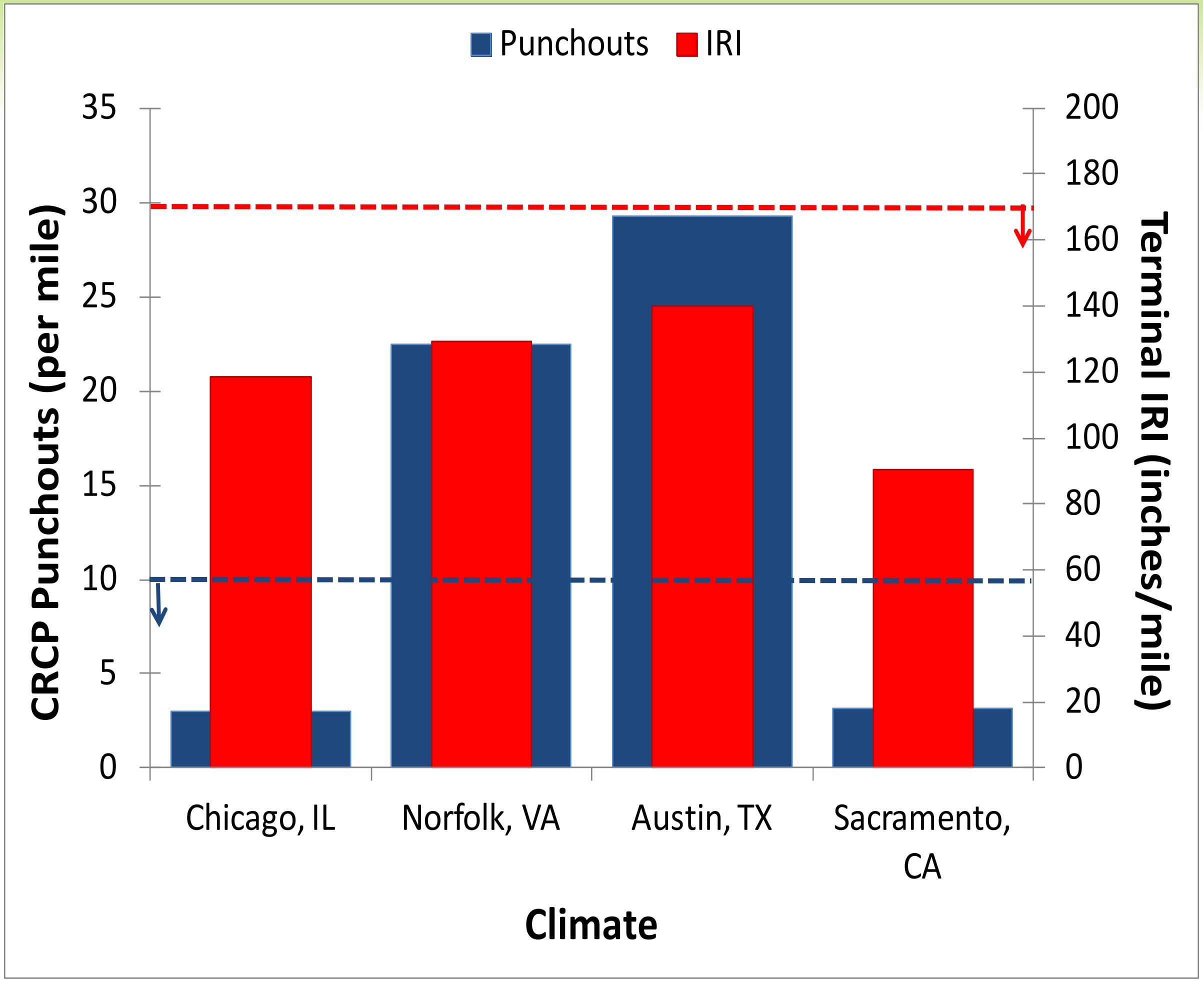
Stabilized bases show significantly better CRCP performance

Construction Month Sensitivity Chicago, IL



Summer season shows highest level of distress → wider crack openings

Climatic Effects on CRCP Design

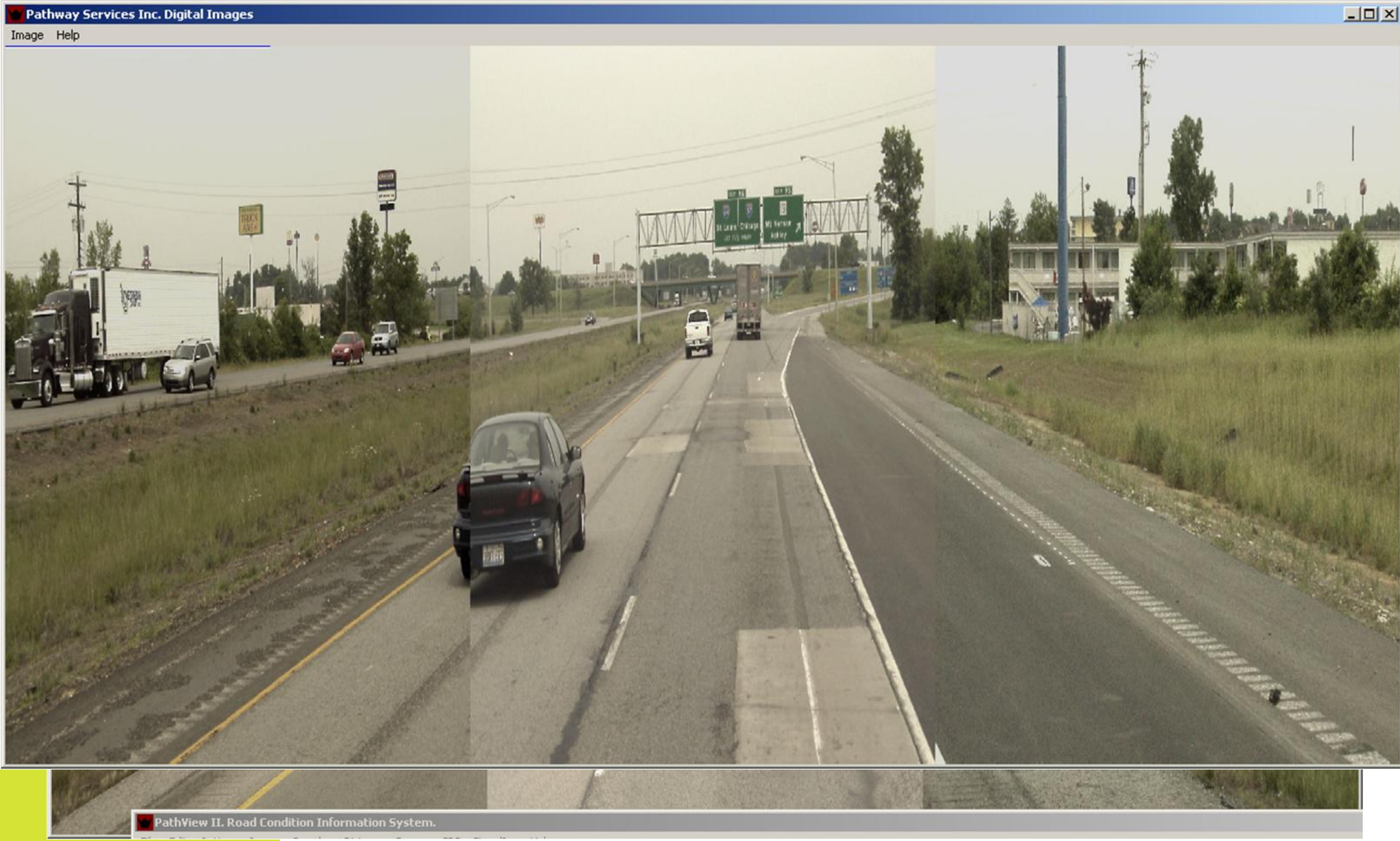


Climate has impact crack spacing/width and punchout development

I-57/I-64 Overlay Case Study

- 9.4 centerline miles of existing CRCP
- AADTT = 17,391
- 3 - 12 ft lanes each direction
- 10 ft & 12 ft concrete shoulders
- Investigate CRCP unbonded overlay of existing CRCP
  - Milling options vs. rubblization
  - JPCP & HMA alternative

Poor Section I-57/I-64 NB



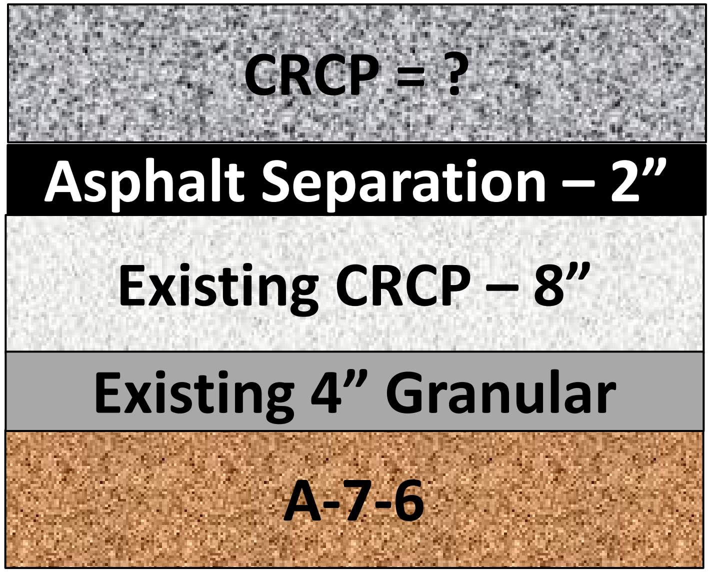
Good Section I-57 NB

CRCP Unbonded Overlay AASHTO Pavement ME Inputs

- 20-year design life
  - Charleston-Mattoon, IL Climate
- ESALs
  - $80x10^6$ approx. (AADTT=17,400)
- A-7-6 soil type
  - k=200 psi/in
- Tied concrete shoulder
  - 50% LTE
- CRCP Steel properties
  - 3.5-inch depth, #6, 0.70%

CRCP Overlay Designs using AASHTO Pavement ME

- Reconstruct project with CRCP = 11 in.
- Unbonded CRCP w/ existing CRCP = 9 in.
- *Unbonded CRCP w/ rubblized existing CRCP = 10.5 in.*
- *Unbounded JPCP w/ existing CRCP = 9 to 10 in.*



I-57 / I-64 Mt. Vernon (2011-2012)

- Mill existing HMA overlay
- Primarily RUBBLIZE existing 8-inch CRCP
- Place 3-inch HMA interlayer
- **10.5-in. CRCP overlay w/ 0.7% steel**
  - #6 bars @ 5¼ inch spacing

CRCP ME Design Summary

- AASHTO Pavement ME is significant advance for design of economical, long-life CRCP
  - New CRCP and CRCP Overlays
- Designer has input control for pavement layer and materials, traffic, and local climate
- Failure criteria:
  - Punchouts and IRI
  - Subbase erosion
- CRCP Design thickness sensitive to:
  - climate, shoulder type, strength, base type, steel content and position, and construction month.

Acknowledgments

- CRSI / FHWA
- Drs. M.I. Darter and C. Rao

- AASHTO. (2008). *Mechanistic-Empirical Pavement Design Guide, A Manual of Practice*, Washington DC.
- Applied Research Associates (2003*). Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures, Appendix LL: Punchouts in Continuously Reinforced Concrete Pavements,* NCHRP 1-37A.
- Roesler, J.R. and Hiller, J. (2013), *Continuously Reinforced Concrete Pavement: Design Using the AASHTO Pavement ME Design Program*, ACPT TechBrief, USDOT/FHWA, FHWA-HIF-13-027, 11 pp.
- Roesler, J.R. and Hiller, J. (2013), *Continuously Reinforced Concrete Pavement: Design Using the AASHTOWare Pavement ME Design Procedure*, USDOT/FHWA, FHWA-HIF-13-025, 34 pp.

European Design Procedures for CRCP

Michael Darter PE, PhD
Emeritus Professor, University of Illinois
Applied Research Associates, Inc.

Transportation Research Board
May 2015

European CRCP

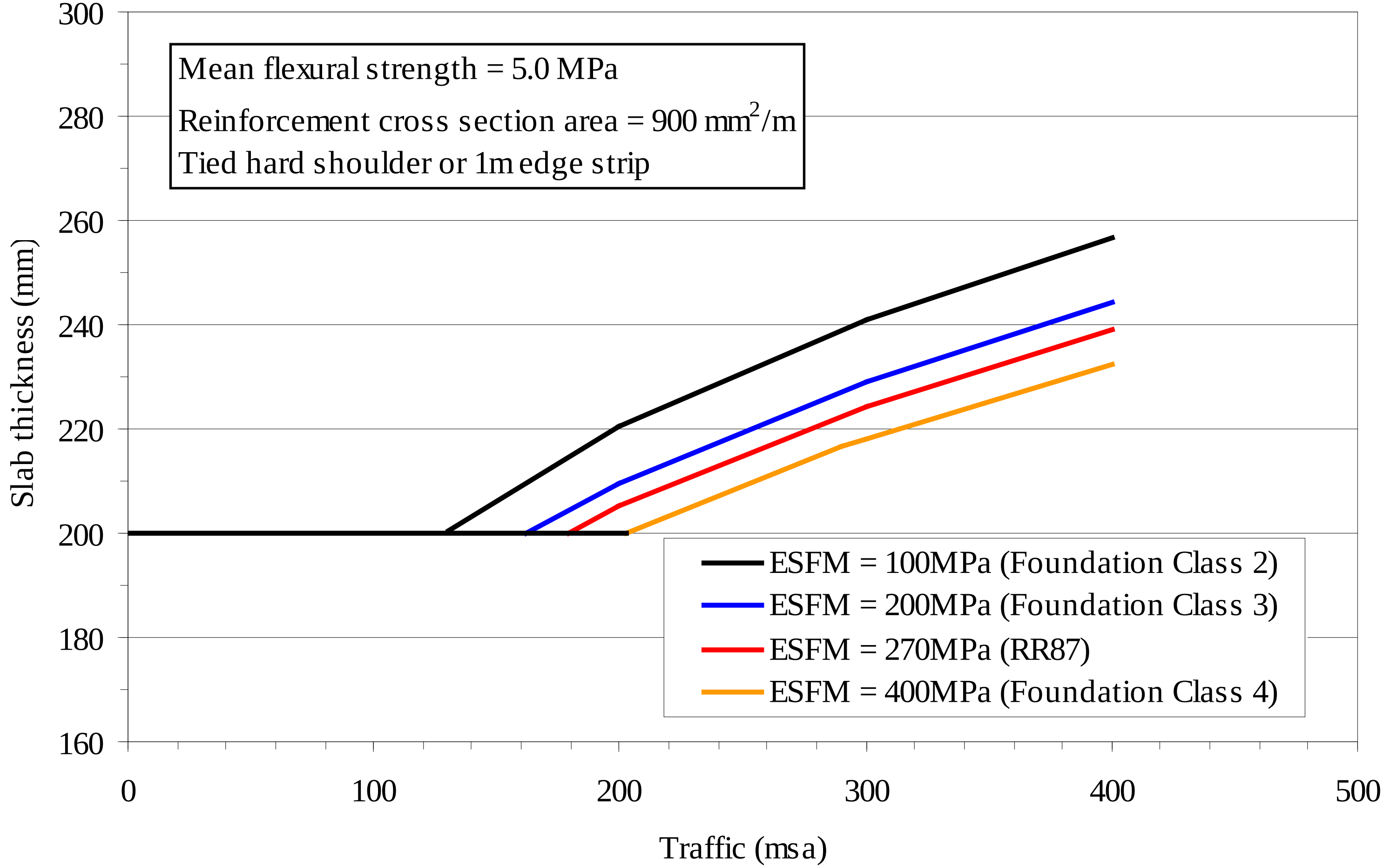
- Belgium: Has constructed the most CRCP of all countries. CRCP been routine since 1960’s
- Netherlands has built over a dozen large projects (Porous Asphalt/CRCP)
- France has built numerous projects from 1980’s onward, both bare and PA
- Other countries building from a few to over a dozen projects: UK (Bare, PA), Germany, Italy (PA 1988), Spain (1975), others

European CRCP Design

- Catalogs: Most countries use design catalogs
  - Given traffic and subgrade support, provides CRCP thickness, % reinforcement, base, PCC strength, etc.
  - Based on experience and calculations.
- Calculations: Critical stresses & deformations using elastic layered theory, Westergaard, and finite element models plus flexural strength to calculate fatigue damage.
- Reinforcement: Field experiments, Vetter, AASHTO

CRCP Design Chart UK

Hassan, et al



Field Results: UK (Hassan, et al)

Percentage Wide & Spalled Transverse Cracks

Large Aggregate	Reinforcement Mid-Depth	Reinforcement Above Mid-Depth
Siliceous Gravel	63%	31%
Limestone	21%	10%

Wide crack > 0.5 mm, 0.020 inch

Belgium CRCP Design

- Design Catalogue in Belgium; the structures have been determined by calculation (same way as JPCP, based on fatigue cracking, but with a higher load transfer across the transverse cracks. Does not model typical CRCP distresses such as a punchout.
- Reinforcement is mainly based upon experience. In the 1960’s, the Vetter formula with a result of 0.85% (used on early CRCP); later reduced to 0.67% (reduced cost CRCP), and again increased to 0.75% which is standard practice today.

Belgium CRCP

- Belgium has constructed CRCP since the late 1960’s on a fairly large scale. About 100-km of the original CRCP design was constructed from the late 1960’s through 1976.
- Approximately 18 million square meters, including 3.5 m2 of CRCP overlay on old concrete and bituminous pavements were constructed between 1968 and 1990 (700 miles 4-lane).
- These pavements were placed primarily on heavily trafficked highways.

Original Belgium CRCP Design

- 8-in (20-cm) CRCP.
- Concrete strength (674 lbs/cy cement, 90-day compressive strength minimum of 55 MPa (7,860 psi).
- 0.85% longitudinal steel, deformed reinforcing bars, diameter 18-mm, BE 500, 15-cm spacing.
- The longitudinal steel was placed 6-cm (2.4-in) from the top of the slab
- Transverse reinforcement is placed at an angle.
- 2.4-in (6-cm) HMA (dense) base course
- 7-8-in (18-20-cm lean concrete subbase
- Granular layer

Brussels E-40 CRCP 1970-2010

Over 100-km built, excellent performance!
MEPDG runs for this design showed 98% reliability over 30-years

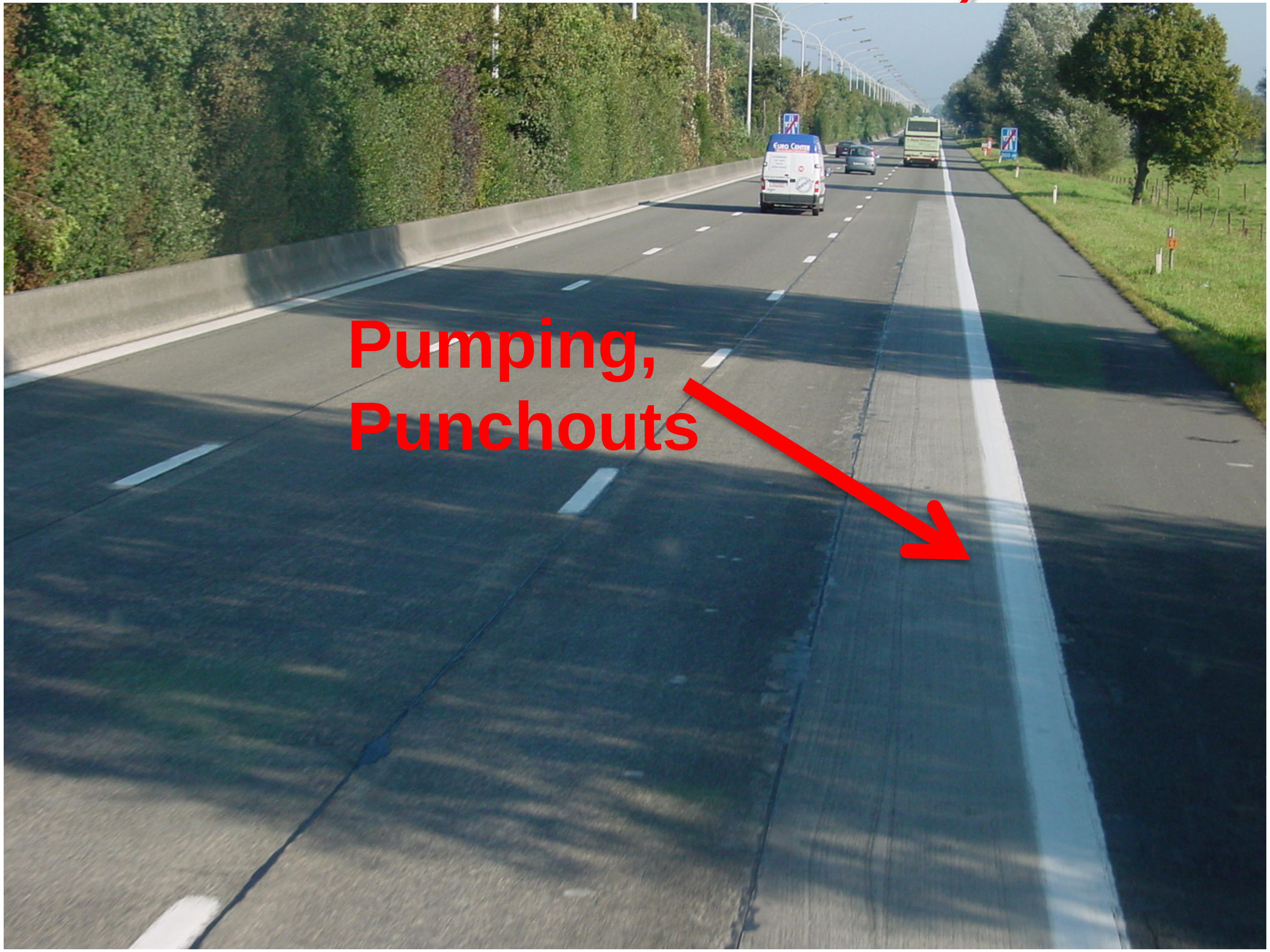
Modified Belgium CRCP Design
(1980's - 90's)

- 0.85% (0.67%) longitudinal steel, deformed bars.
- Longitudinal steel 2.4-in (6-cm) (9-cm, 3.5-in) from top of slab.
- 2.4-in (6-cm bituminous base course (REMOVED)

RESULT: This design resulted in much erosion of the lean concrete base, much longer crack spacing, and ultimately punchouts. Debonding!

Modified CRCP Design 1990s

(HMA removed, Reinforcement Reduced: Erosion & Punchouts)

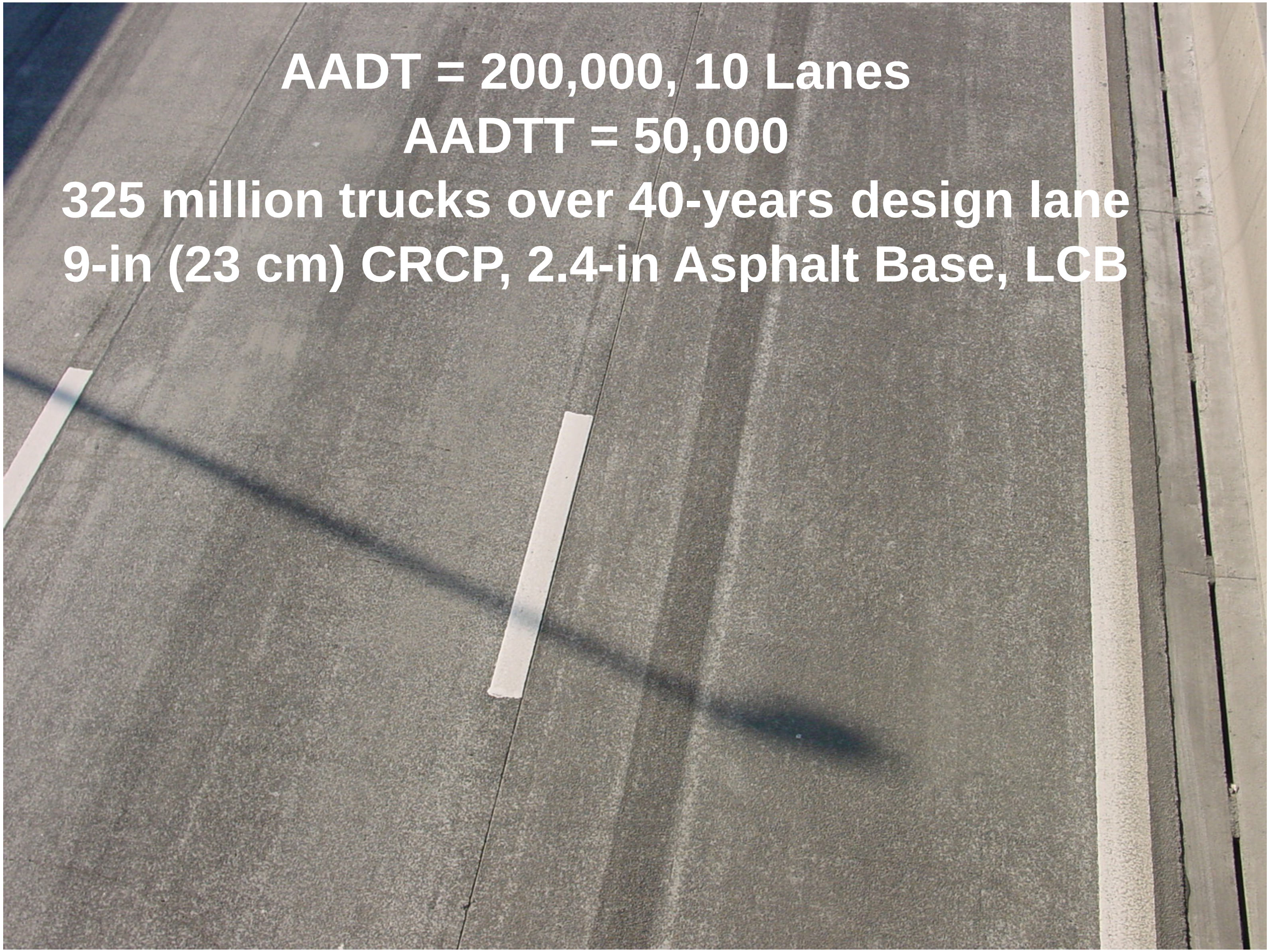


Current Belgium CRCP Design

- Width of truck lane: 3.75 m (12.3-ft, paint stripe shifted)
- **9-10 in (23-25 cm) CRCP**.
- Concrete strength (674 lbs/cy cement, 90-day compressive strength minimum of 55 MPa (7,860 psi)
- **0.75% Longitudinal steel, deformed bars.**
- Depth of reinforcement: 8-cm (3.2-in) from top of slab.
- Transverse reinforcement is placed at an angle.
- **2.4-in (6-cm HMA base course**
- 7-8 in (18-20-cm) lean concrete subbase

Antwerp Ring Road R1, 2005

Antwerp R1 CRCP



Widened Slab CRCP

CRCP Lower Volume Highway

CRCP Roundabout

Belgium CRCP

Netherlands Major Composite Pavement Projects

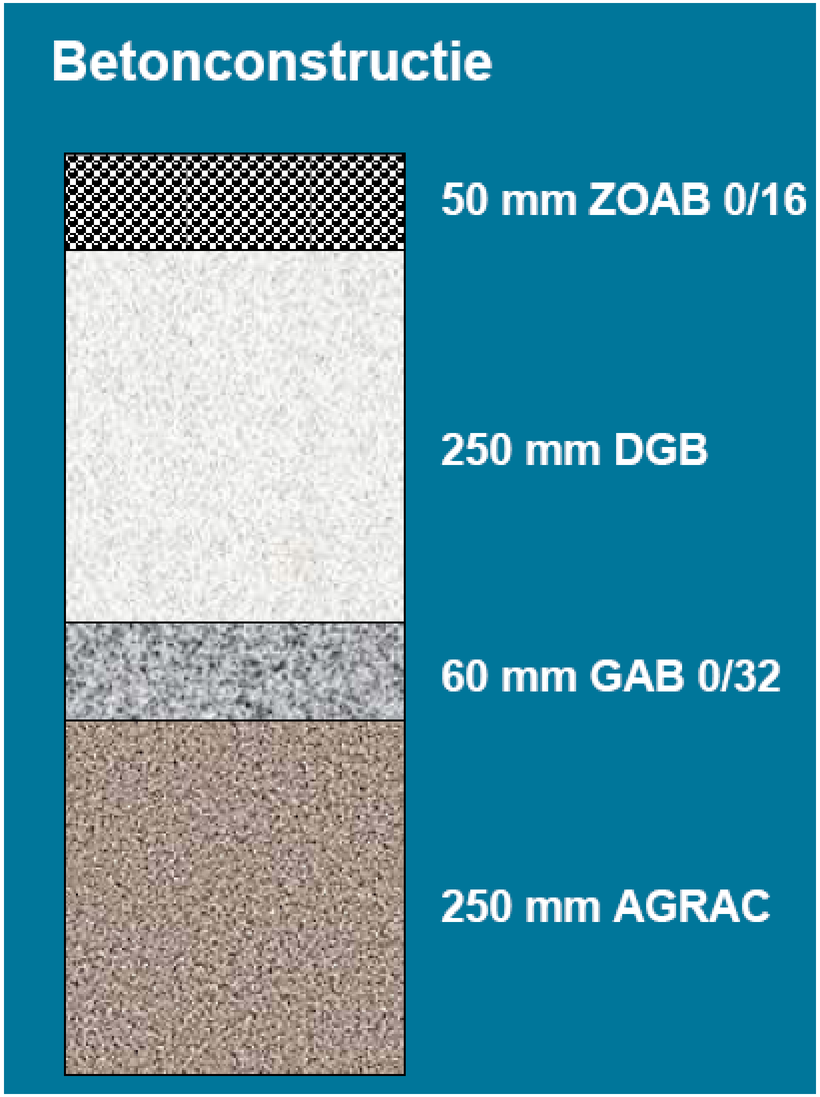
- Netherlands has built several major projects in past 17 years using porous asphalt surfacing over CRCP and have considerable confidence in this design.
  - A12 West of Utrecht, 1998
  - A76, Near Schopol Airport
  - A5, Am Sk
  - A50, Einhoven
  - A73, Venlo to Echt-Susteren, 42 lane-km, 2007
  - Others

Netherlands AC Surfaced Composite CRCP

- **Porous AC/CRCP provides significant advantages:**
  - Noise reduction.
  - Reduced splash and spray.
  - Smooth surface.
  - Rapid removal and replacement of AC surface.
  - Little or no reflection cracking.

A12
A main highway between Netherlands & Germany 1998

A12 Composite Pavement Design



2-in (5 cm) Porous AC Friction Course

10-in (25 cm) CRCP, 0.7% steel; Above mid-depth

2.5-in (6 cm) AC Interlayer, Dense

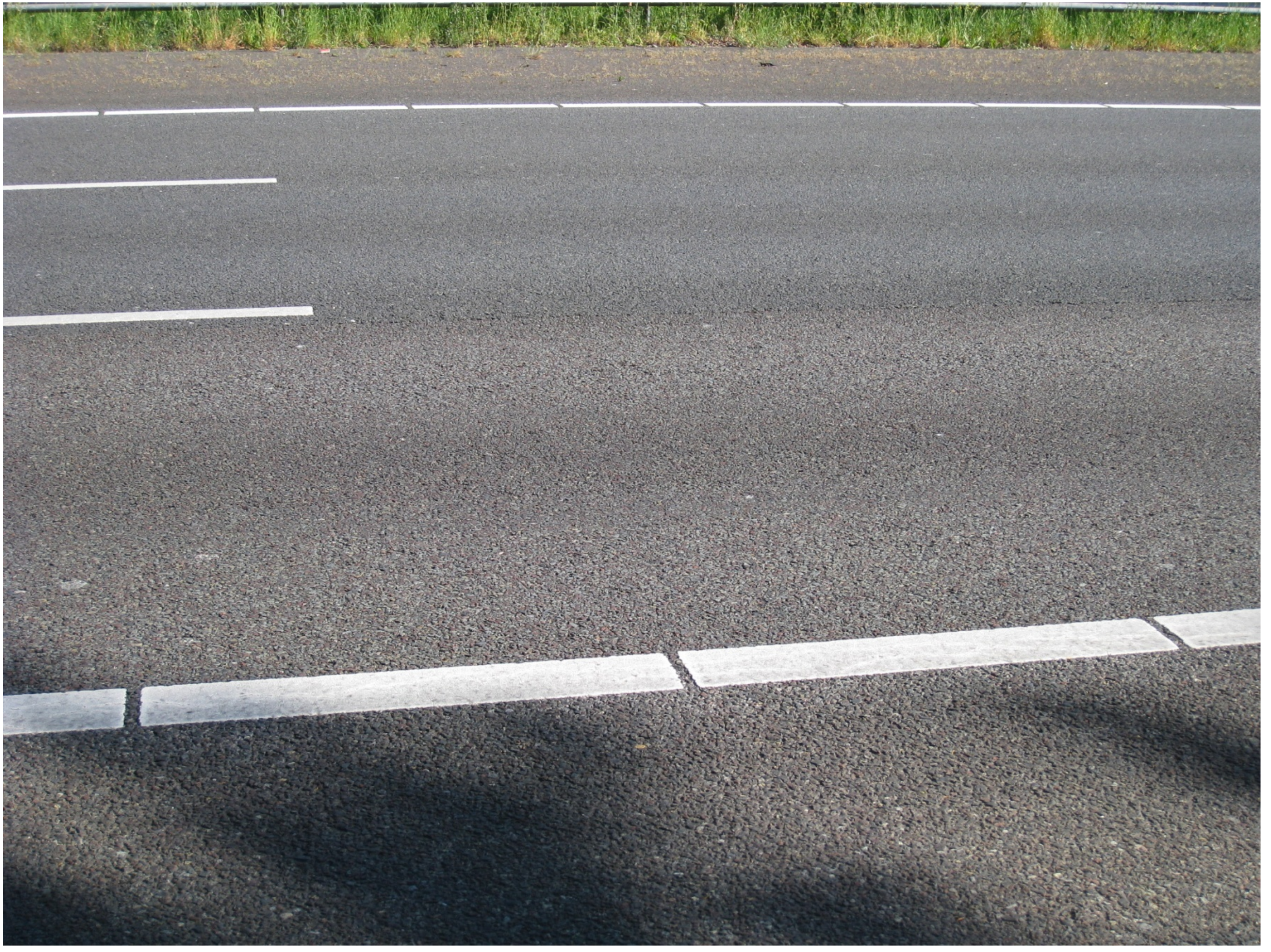
10-in (25 cm) Cement Bound Recycled Asphalt

A12 Motorway Porous Asphalt / CRCP

- 40-year design, 100,000 ADT
- 2.2 km long, 6 lanes wide
- CRCP crack spacing: 0.8 – 3 m

A12 Netherlands – 10 Years

(No Reflection Cracks)



A12 Netherlands

Porous Asphalt/CRCP: Voids Filled

A73 Motorway, Netherlands
Porous Asphalt Over CRCP

- Located in south Netherlands, 4-Lanes.
- Two directional daily truck traffic: 14,000
- Constructed in 2007 with a **double porous asphalt surfacing over a CRCP**.
- Structure
  - 1-in (2.5 cm) porous asphalt 4/8 surface layer
  - 1.8-in (4.5 cm) porous asphalt 11/16 layer
  - 10-in (25 cm) CRCP, 0.7% reinforcement
  - 2.4-in (6 cm) asphalt base

A73 Netherlands
Porous Two Lift AC/CRCP

A73 Netherlands (Porous Asphalt Surface 4/8 (few months old)

A73 CRCP Reinforcement

A73 Netherlands

Off Ramp Bare CRCP Meeting Porous AC/CRCP

Constructing CRCP Roundabout

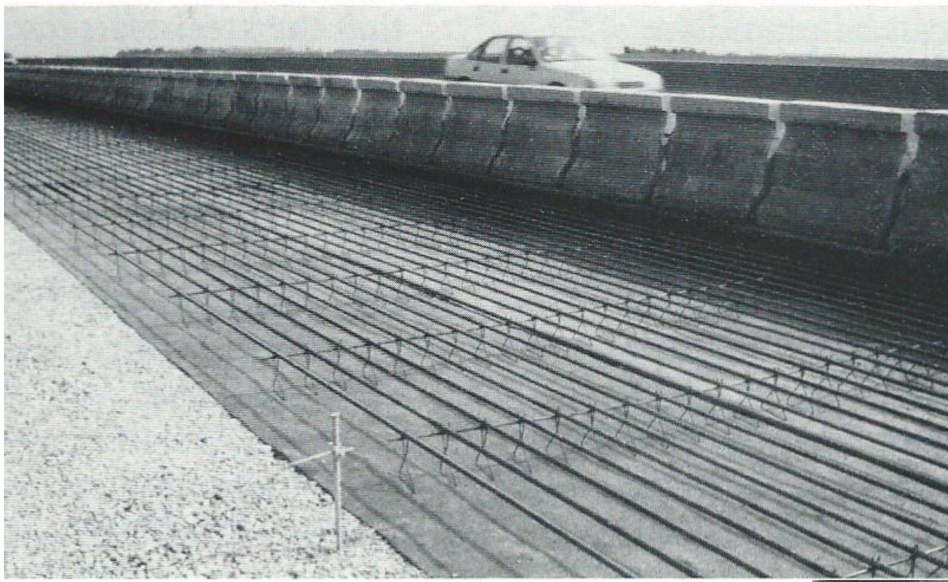
CRCP Roundabout

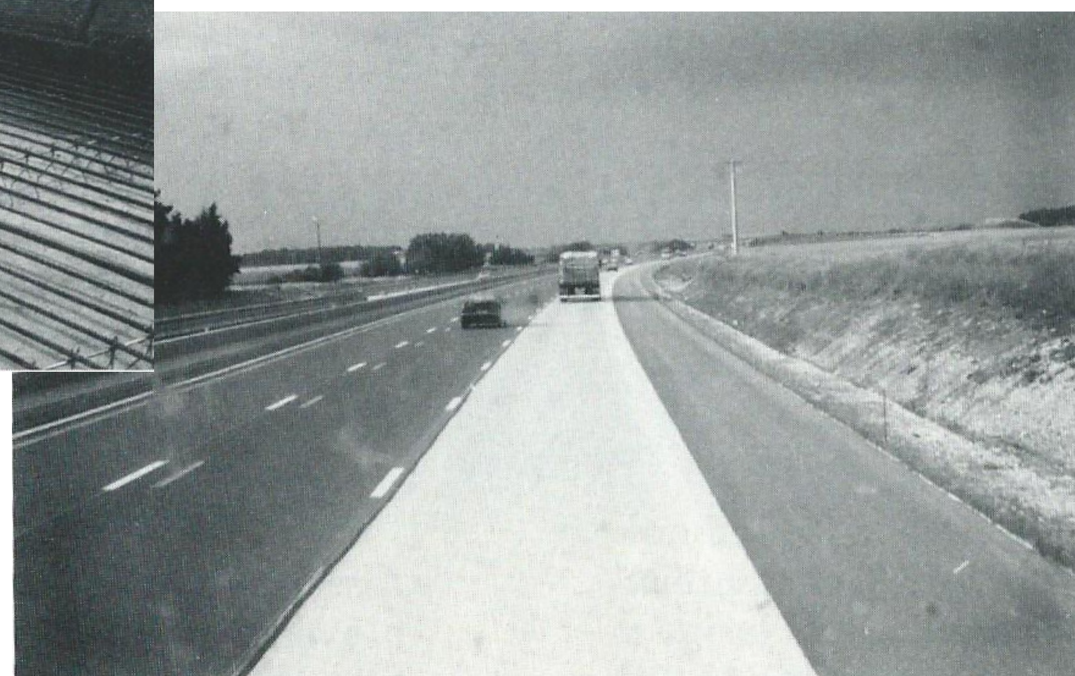
French CRCP

- **France has built significant amount of CRCP**
  - First project 1983
  - >342 Lane-Miles as of 1992, including Overlays
  - >62 Miles of Truck lanes reconstructed on existing highways, two-layer exposed aggregate
  - Much built by French Tollroad companies.
- **Typical design:**
  - 7.5 to 10-in CRCP, 0.67% Reinf., 3-in Depth in slab
  - Lane widening 12.5-in
  - 2-in HMA
  - 6-in Lean concrete base, over granular material

French A-10 CRCP

- CRCP Truck Lane Added to Flexible Pavement, South of Paris

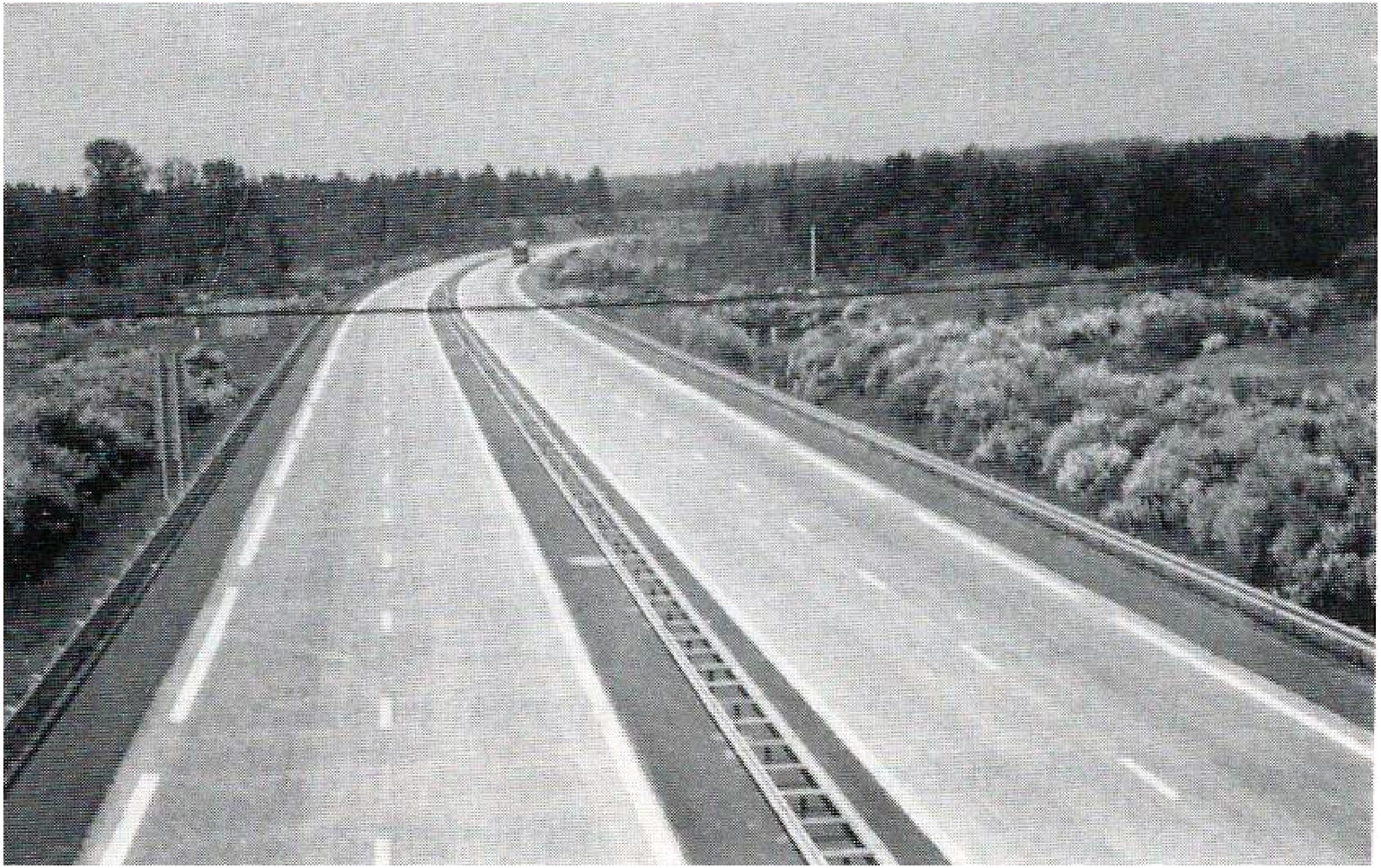




French A-6 CRCP Overlay

7-in CRCP; 0.67% Reinf.; Thin asphalt interlayer; Existing JPCP fractured; Widened lane, Tied PCC Shoulders

French A-10 CRCP



Two-Layer CRCP; 7-8 in Trapezoidal; 0.67% Reinf; 2-in HMA; 14-in cement sand; Widened Slab 12-in.

French Composite CRCP

- Recently: Composite design for CRCP in France (Laurent)
- Two experimental composite CRCP constructed in 1998 and 2001.
- Design: Thickness calculations performed using French pavement design rational method, Technical Guide Conception.
  - 1.0-in (254-mm)Special asphalt surface
  - Thickness Varied 4 to 9-in (100-240-mm) CRCP
  - 3.5-in (90-mm) HMA (good bonding w/PCC)
  - Subgrade
- Projects reported no failures at about 5 years life.

Other Countries CRCP

- UK: Bare and recently Composite CRCP. Over a dozen CRCP projects built in UK, newer with low noise asphalt surfacing.
- Italy: Composite CRCP several projects Rome Ring Road. First 1988: 1.6 in porous asphalt; 8.7 in CRCP; 7.9 in CTB; 7.9 in granular.
- Germany: Have constructed two or more projects in recent years.
- Spain: First CRCP in 1975. 9-in with 0.85% reinf. has performed very well over many years. Few others built since.

Summary European CRCP

- Design: Catalogs predominantly, experience
- Surface:
  - CRCP: 8-10 in; 0.67-0.85% (0.75% today); higher strength PCC; 12-in widened slab.
  - Surface: Textured concrete, or 1-3-in Porous Asphalt surfacing; few Two-layer exposed aggregate
- Base Course: 2-3-in HMA dense graded, bonded
- Subbase Course: LCB or CTB

Summary European CRCP

- Performance: Excellent!
  - Tight cracks, some clusters, little to no punchouts
  - Smooth
  - Low noise (porous asphalt, exposed aggregate)
- Design for 40+ years service on heavy truck highways.
- Substantial research on CRCP has been conducted over the years in Europe.

Design Details – Reinforcement & End Treatments

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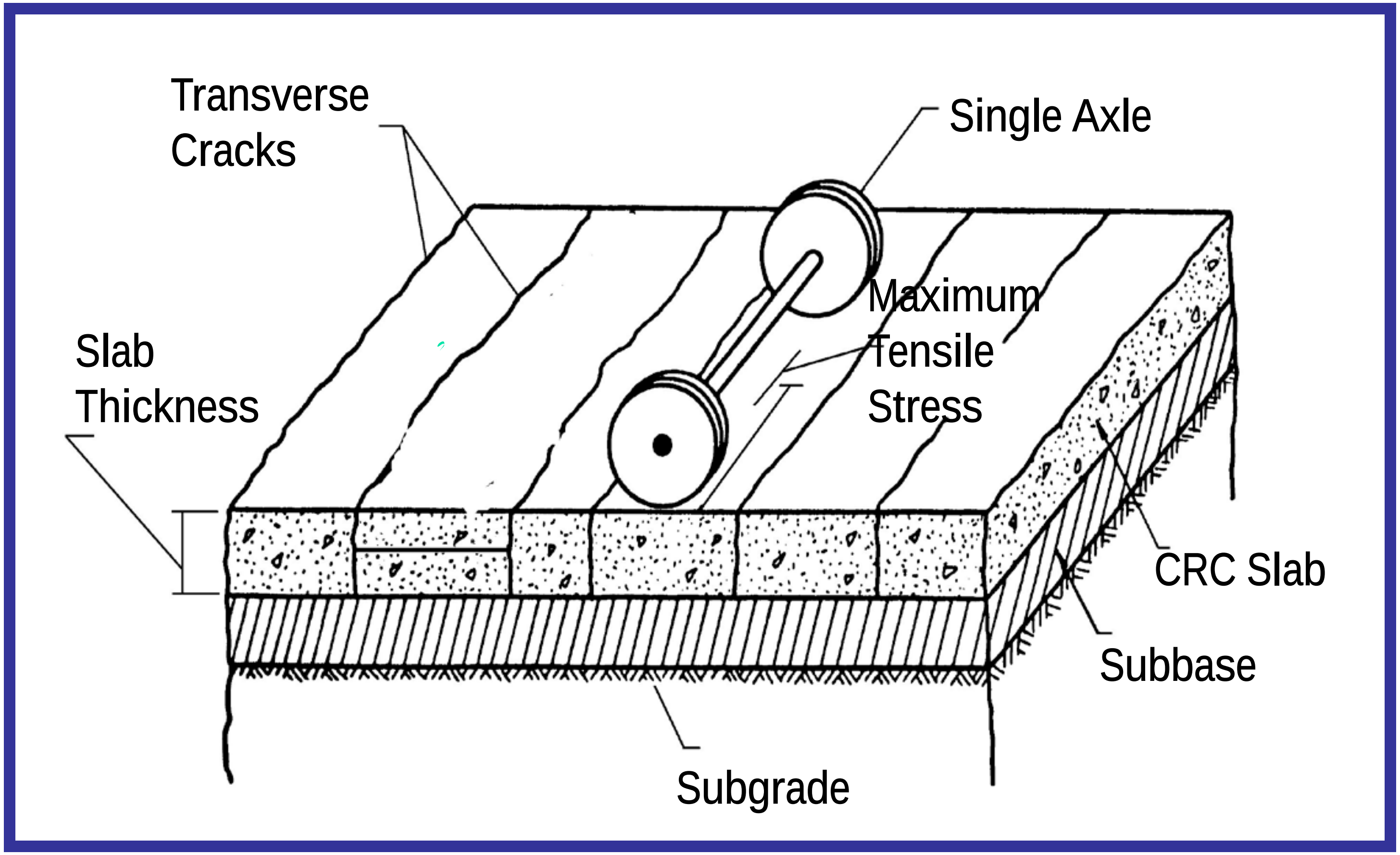
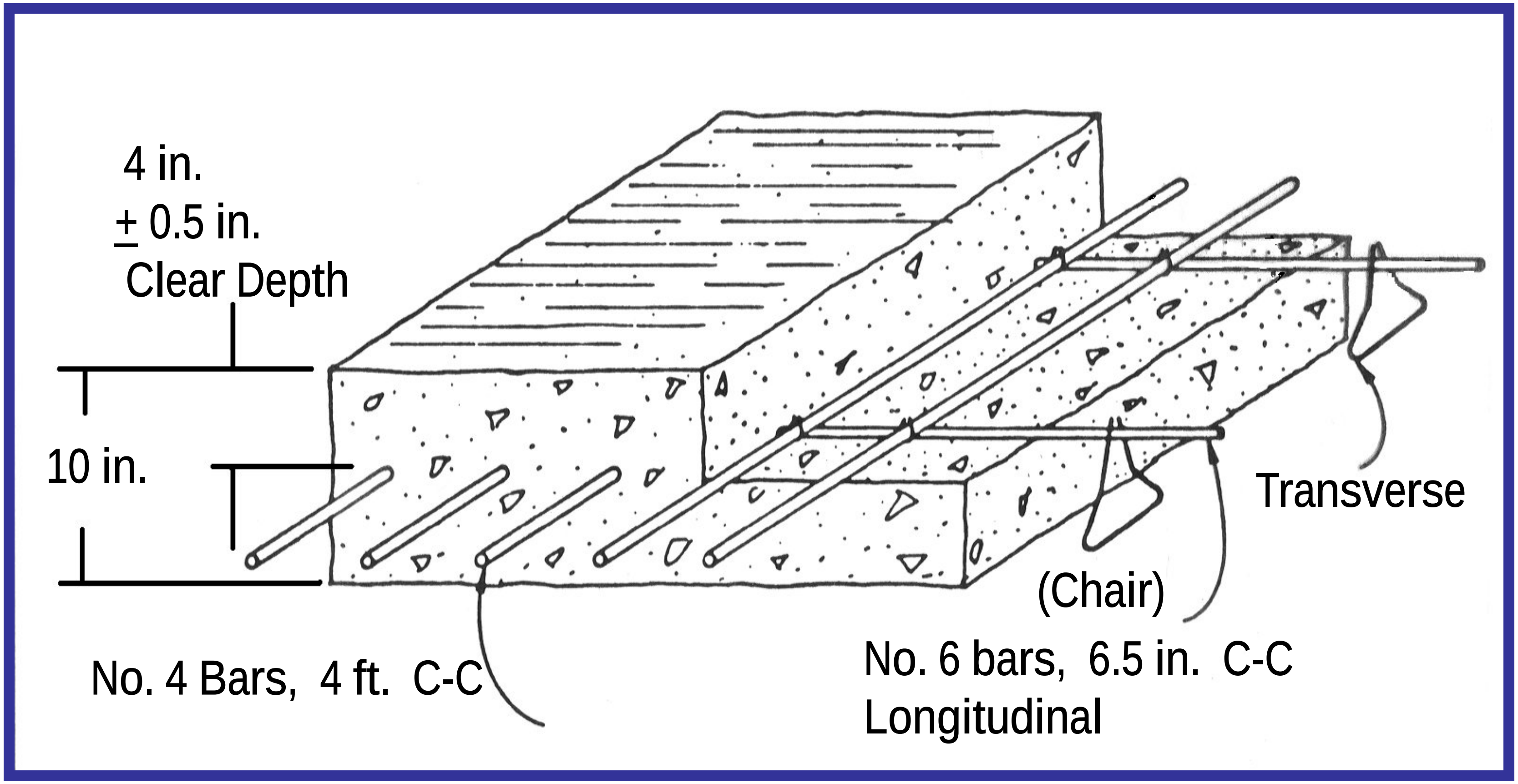
CRC Pavement

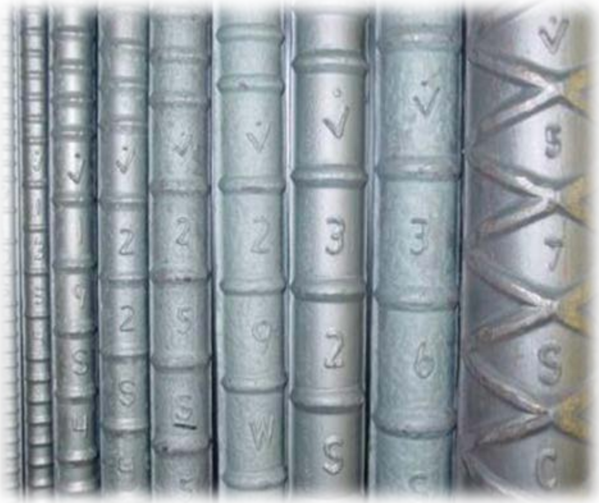


Steel Reinforcement



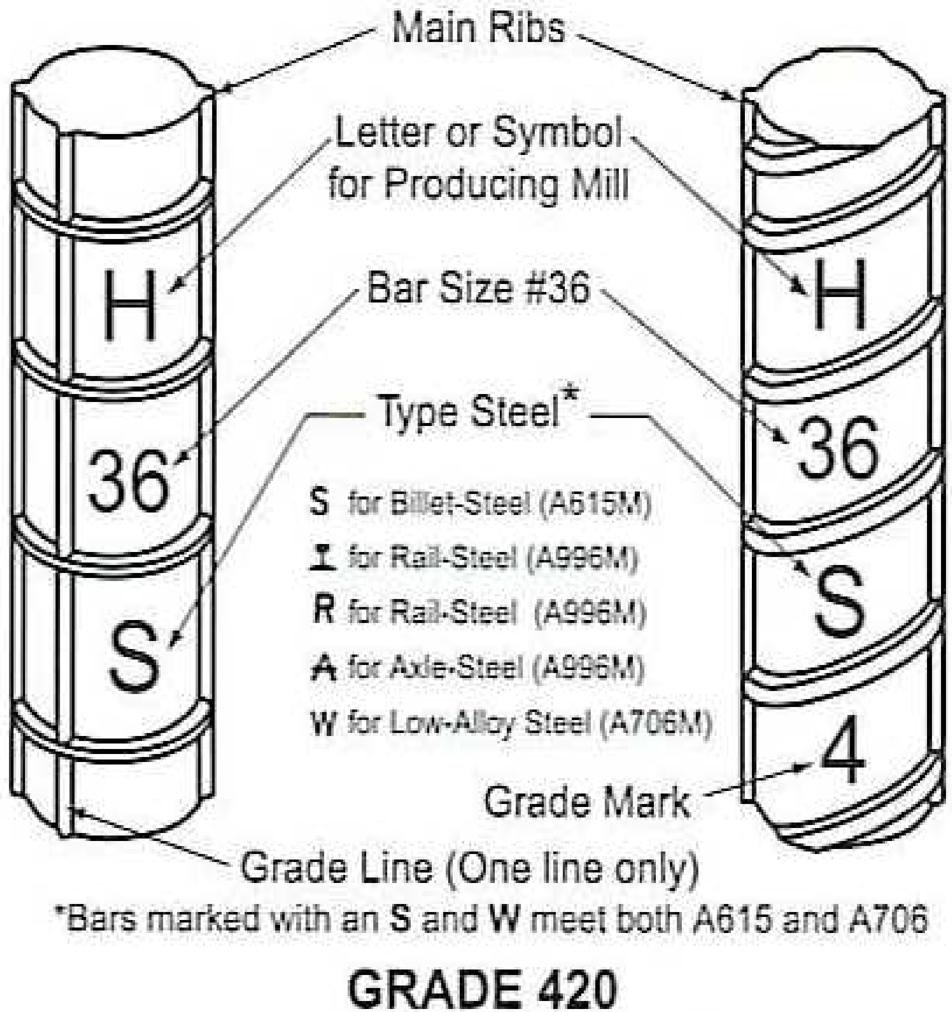
Steel Reinforcement Material

- Deformed steel reinforcing bars conforming to
  - ASTM A615
  - AASHTO M31
- Grade 60 (Metric Grade 420), yield strength 60,000 psi



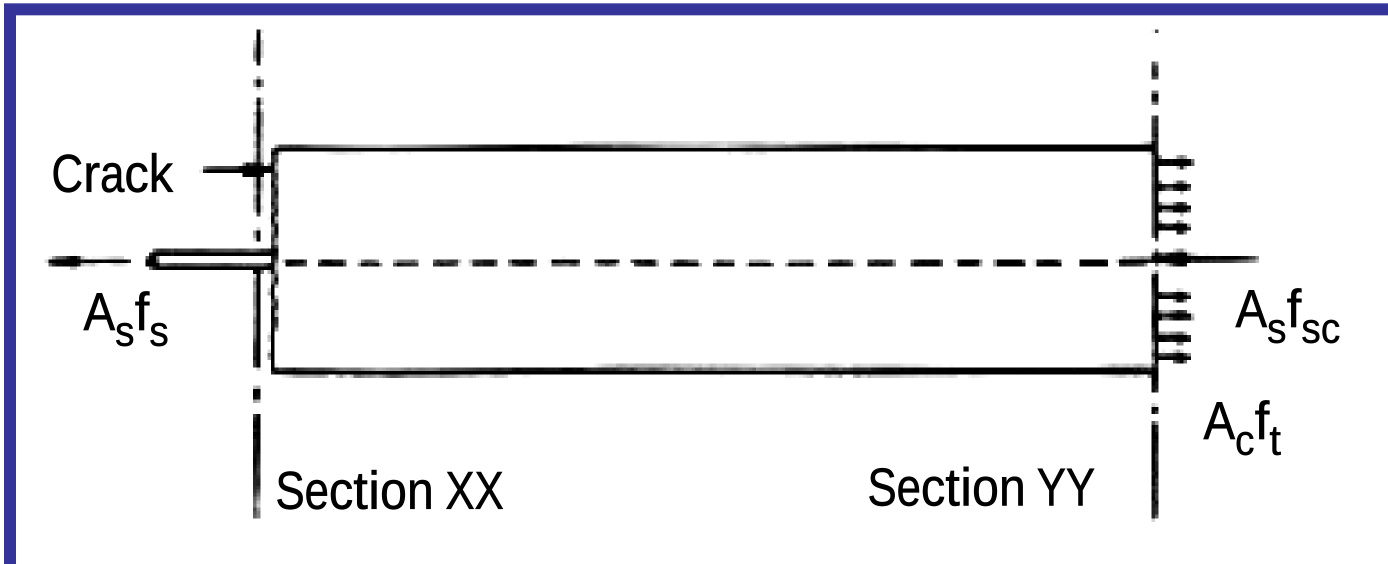
Steel Reinforcement Material

Industry Standard Identification



Longitudinal Bars

- Quantity of bars based on ratio of steel/concrete area, shown as percentage
  - Typical range from 0.55 to 0.70%
  - 11-inch-thick slab with #6 bars & 0.60% steel spaced at 6.7” o.c. = 39 bars (in 22 ft)



Longitudinal Bars

- Standard mill lengths are 60’
- Brought to jobsite in bundles
- Bars should not have kinks or bends that may prevent proper assembly, placement or performance

Longitudinal & Transverse Bars

- Longitudinal Bars
  - Vertical placement affects performance: crack spacing and crack width (load transfer, resistance to corrosion)
  - Must be placed within vertical tolerances
    - To prevent fractures/corrosion from too high rebar
    - To prevent continuity loss from too low rebar
  - Horizontal placement important for radiuses >30°
- Transverse bars
  - Most often placed first to support longitudinal bars
  - Sometimes placed on top of longitudinal bars

Tie Bars

- Placed between lanes or on longitudinal shoulder joints
- Prevent separation
- Normal to joint line
- 1 piece or 2-piece assembly
- Avoid bending
- Placement tolerances
  - Vertical: middepth +/-1/2”
  - Horizontal: +/-2”

Rebar Placement

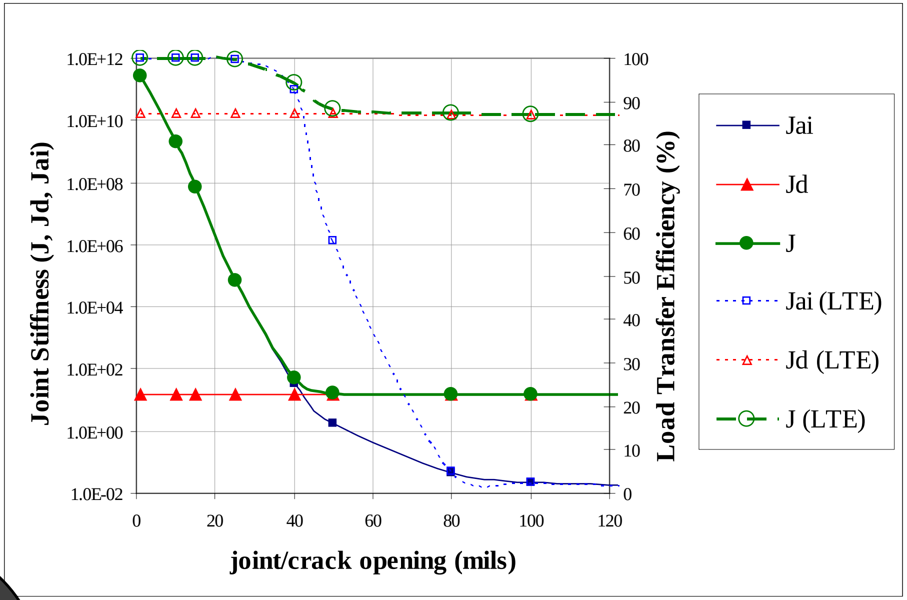
- **Manual Method:** seat bars on bar supports prior to concrete slip-forming
- **Mechanical Method (tube placement):** vibrate into concrete during concrete slip-forming

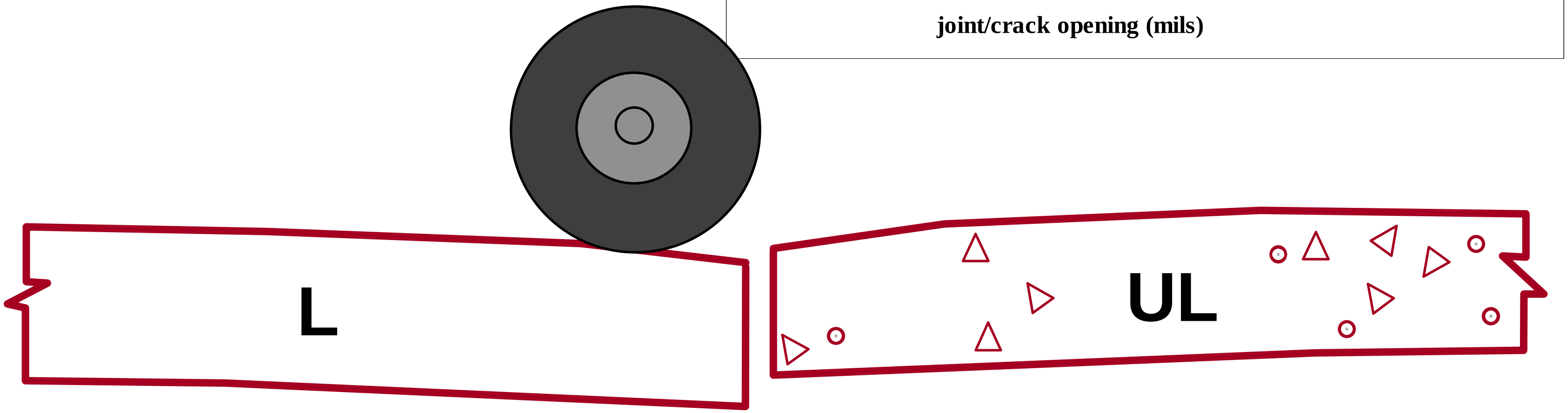
Pavement Transition Functions

- Maintain rideability
- Allow a gradual transition in geometry (profile and cross-slope)
- Allow a gradual transition in structural capacity of the pavement cross-section
- Accommodate slab end movements, as necessary

Design Considerations

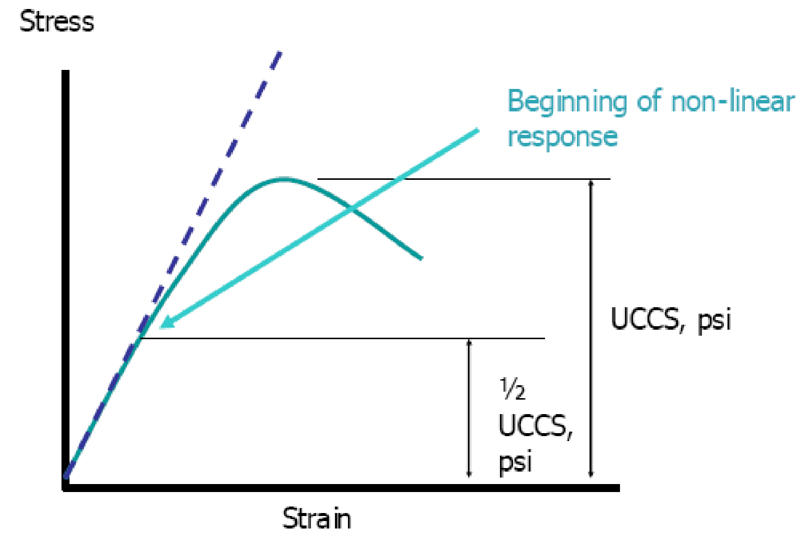
- **Load Transfer Factors:**
  - ❖ Crack width
  - ❖ Slab thickness
  - ❖ Dowel bar size and spacing

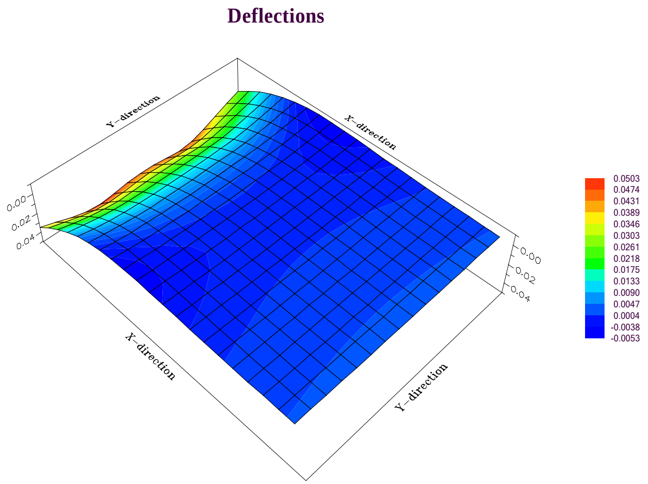




Design Considerations (Cont.)

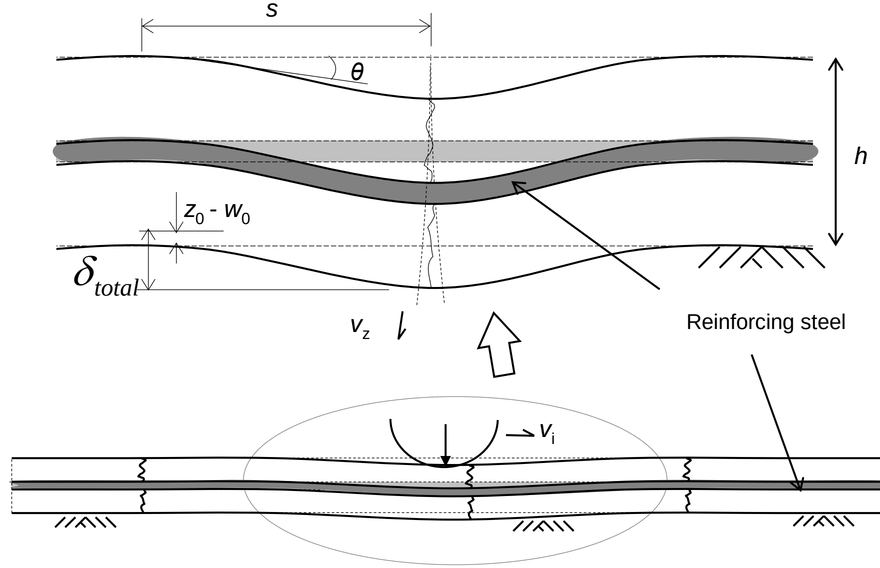
- **Slab Deflection Factors:**
  - Subgrade strength and interlayer friction
  - Subbase thickness and stiffness

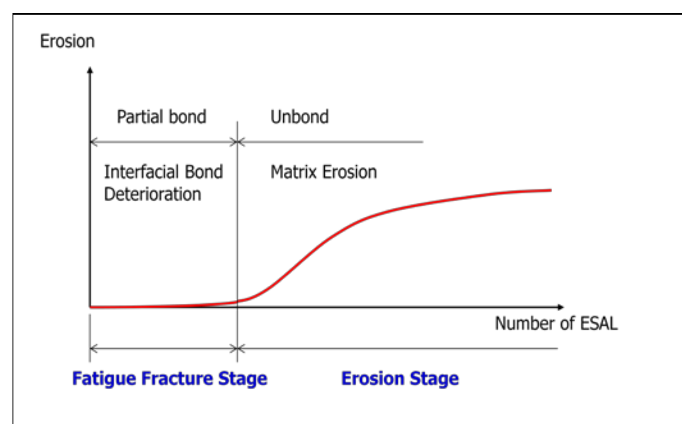




Design Considerations (Cont.)

- **Subbase Erosion Factors:**
  - Traffic levels
  - Subbase type
  - Climate (#wet days)





Concrete Pavement Transition Categories

- **Transverse Construction Joints**
  - Terminals at Bridge Abutments
  - PCC Pavement and PCC/AC Pavement
  - Partial Restraint/Inclusion Type Joints
- **Longitudinal Construction Joints**
  - Lane/Shoulder Joints
  - Ramps/Gore Area Transition
  - Intersections
- **Thickness Transition**
  - PCC Pavements Thickness Transition
  - Overlays – Unbonded, Bonded, AC Transitions

Classification and Notation of Joint Types

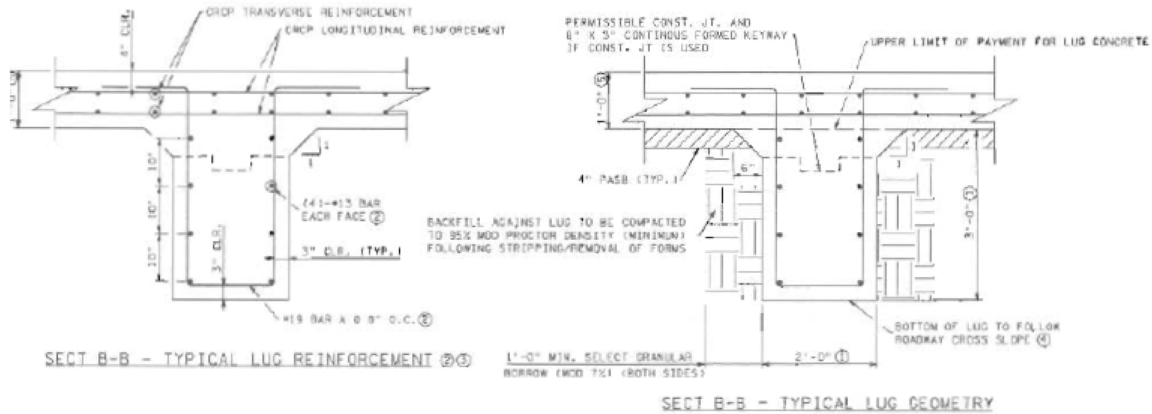
Type	Joint Description
A	Contraction joint
B	Construction joint
C	Isolation joint

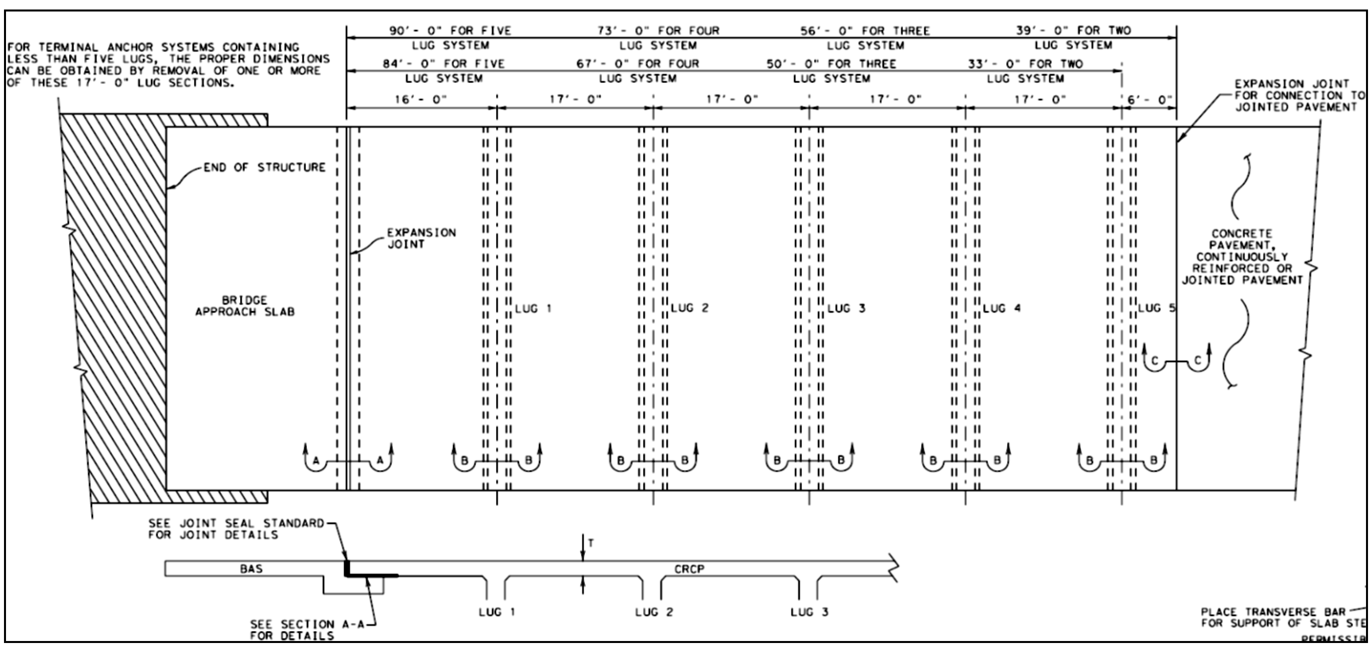
Feature	Abbreviation
W / Smooth dowel	SD
W / Deformed bar	DB
Thickened Edge	TE
Wide Flange	WF
Sleeper Slab	SS

Examples:

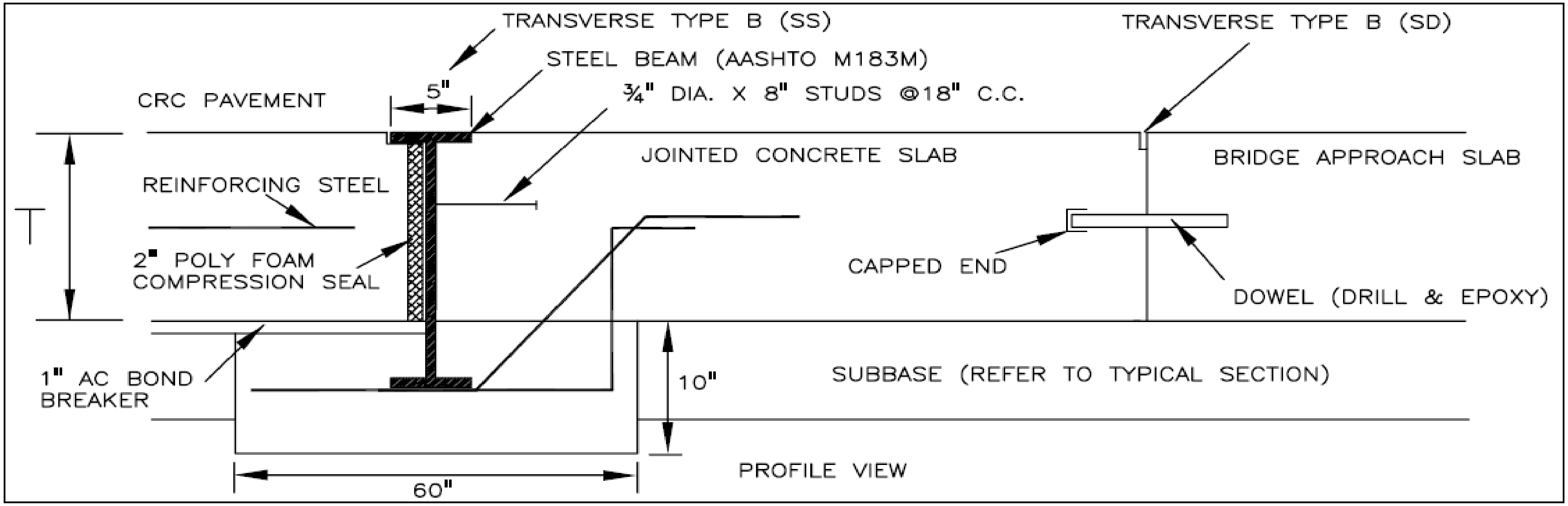
- **Longitudinal Type A (DB)**
  - Longitudinal contraction joint with deformed bar
- **Transverse Type B (SD)**
  - Transverse construction joint with dowel bar
- **Transverse Type C (WF)**
  - Transverse isolation joint with wide flange

Terminals at Bridge Abutments





Terminals at Bridge Abutments (Cont.)



Terminals at Bridge Abutments (Cont.)

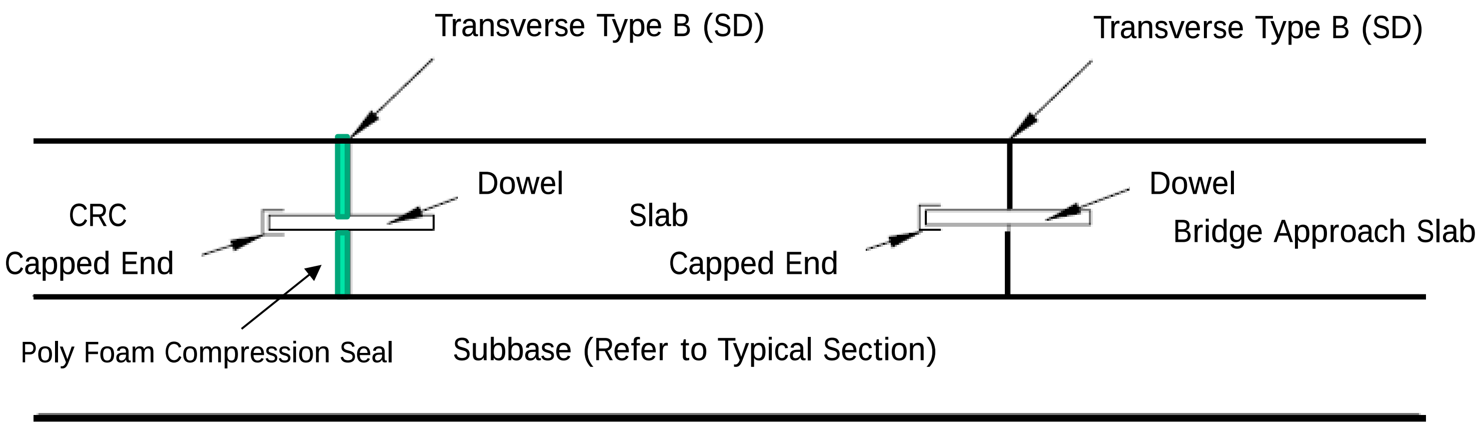
"Seamless" Design

- Improved restraint
- Increased simplicity in design and construction
- Reduced maintenance and improved rideability
- Possibly reduced load-induced stressing on the bridge substructure
- Simplification of the bridge deck drainage design

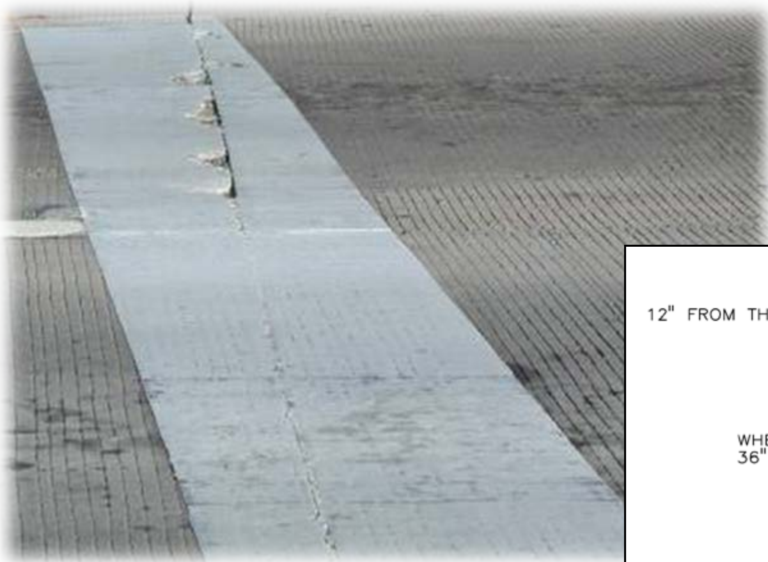
Approach slab tied into deck slab.

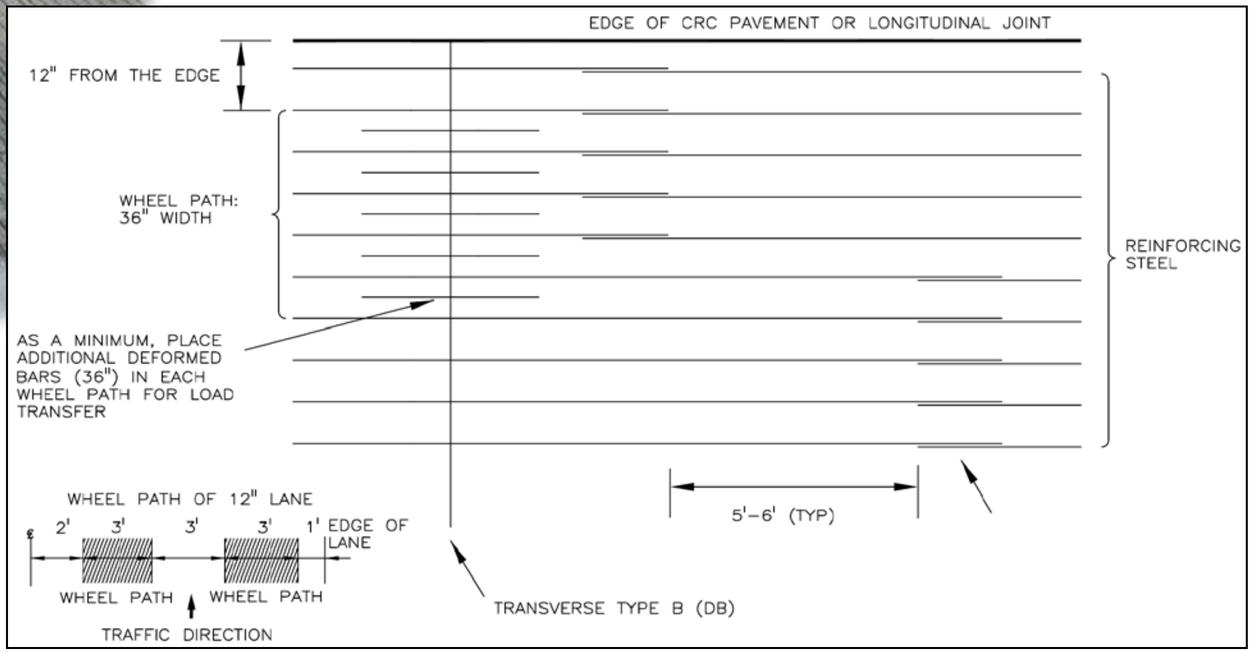
Closure joint between approach slab and CRC pavement.

Terminals at Bridge Abutments (Cont.)

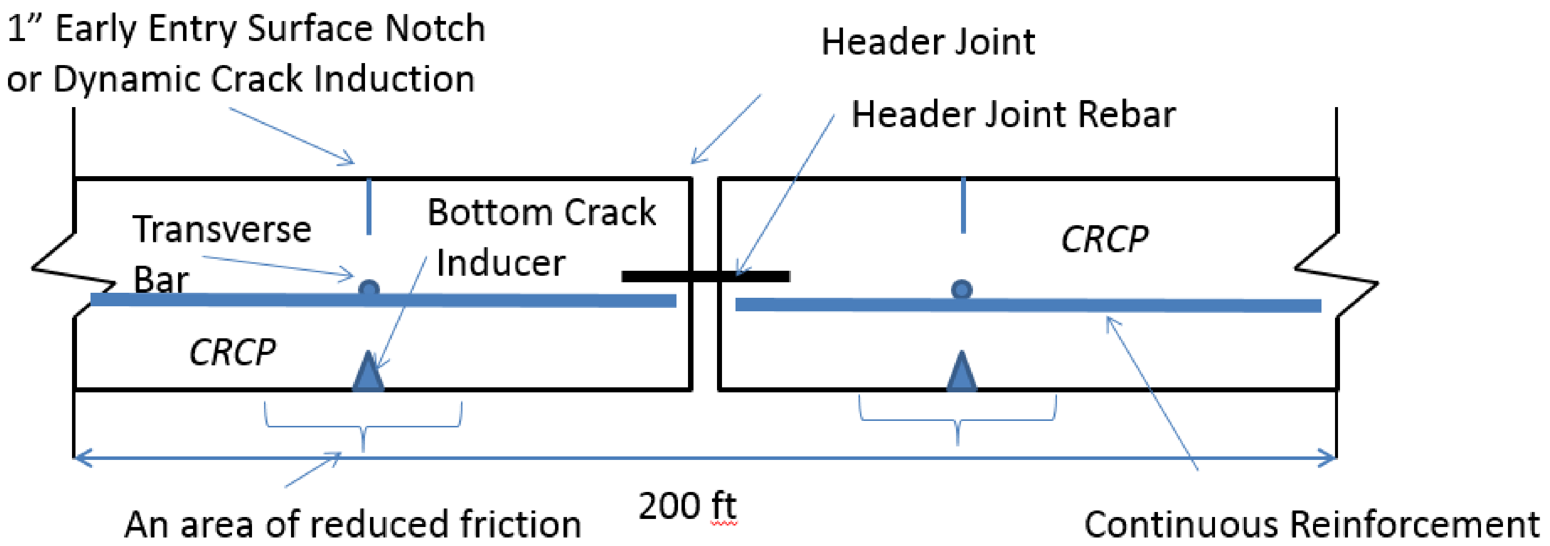


CRC Pavement and CRC Pavement

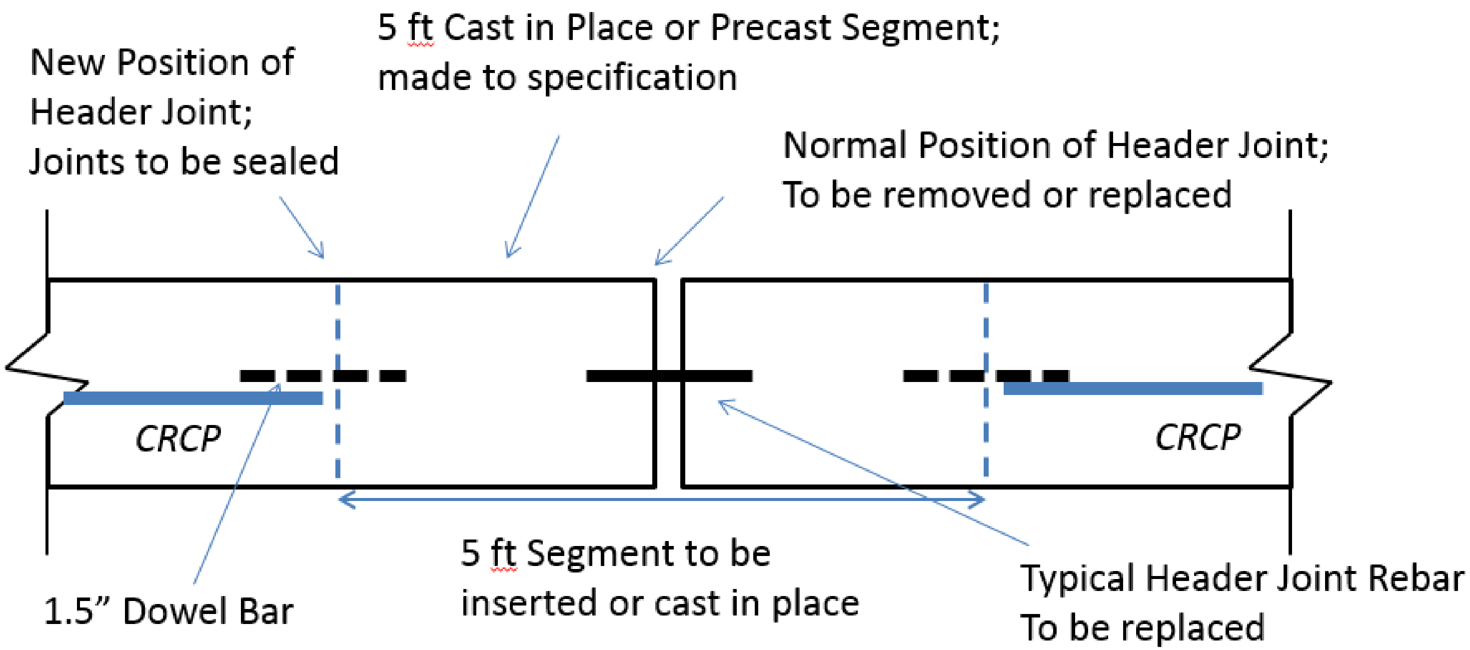




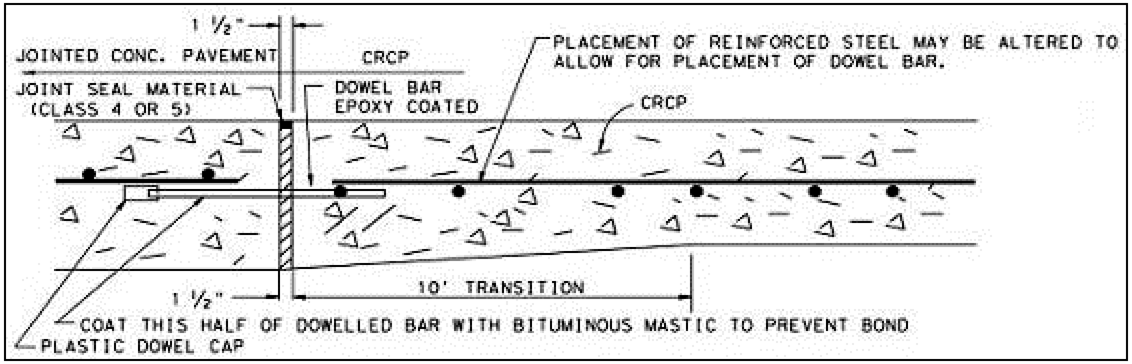
Header Joint Transition (Option #1)

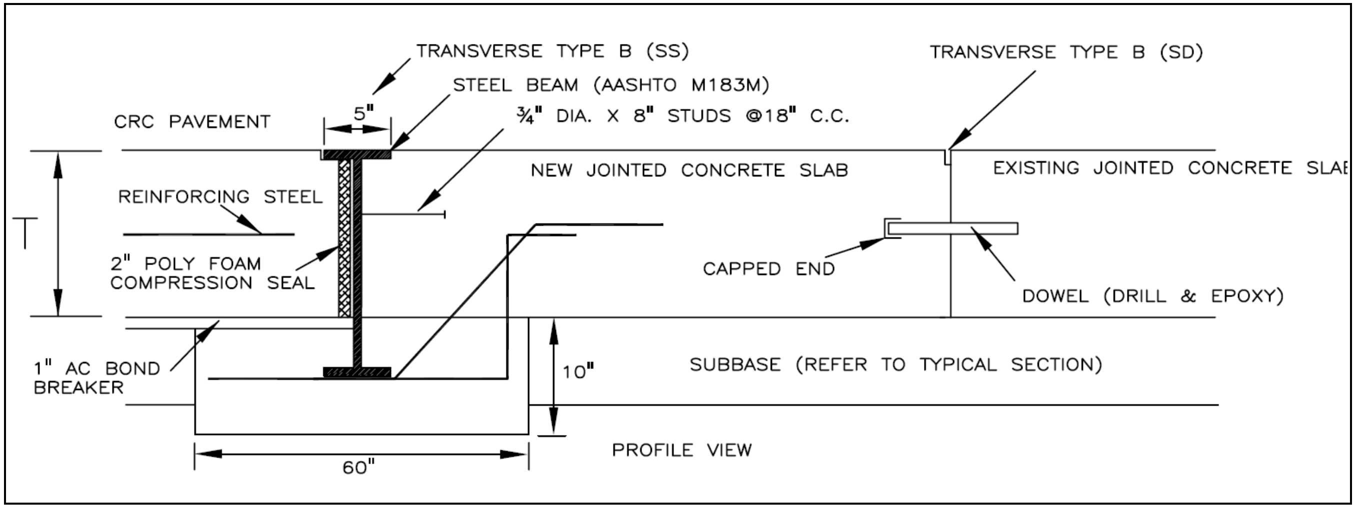


Header Joint Transition (Option #2)

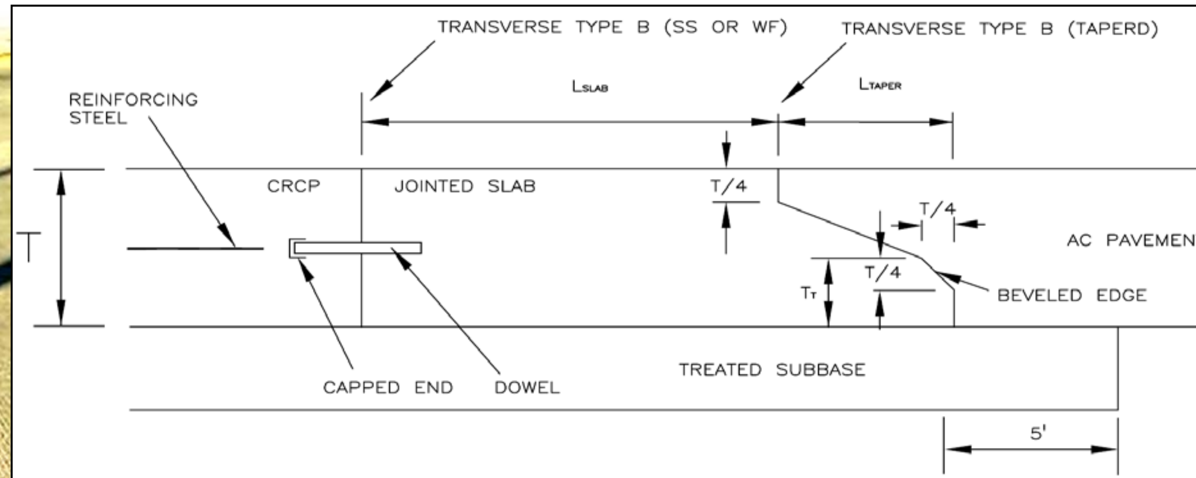


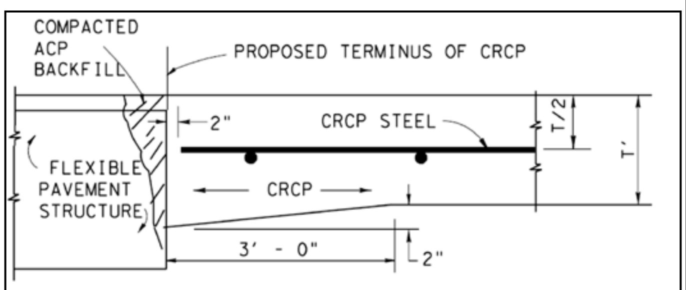
CRC Pavement and JC Pavement

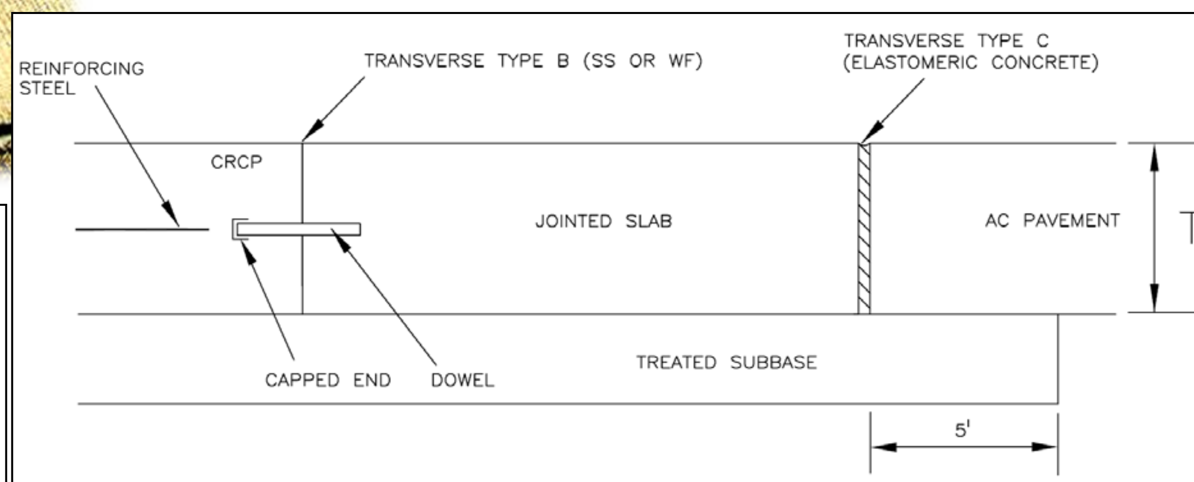




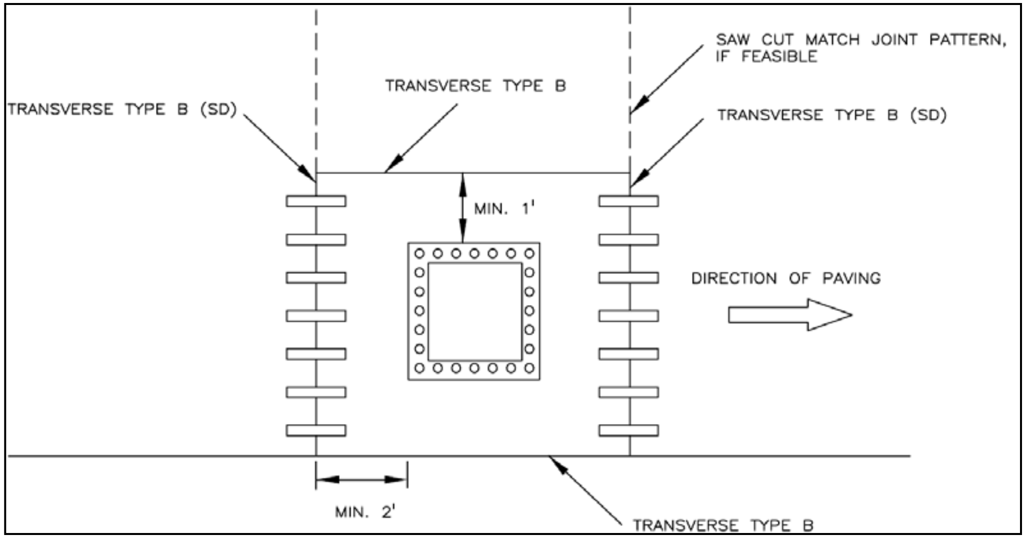
CRC/JC Pavement and AC Pavement



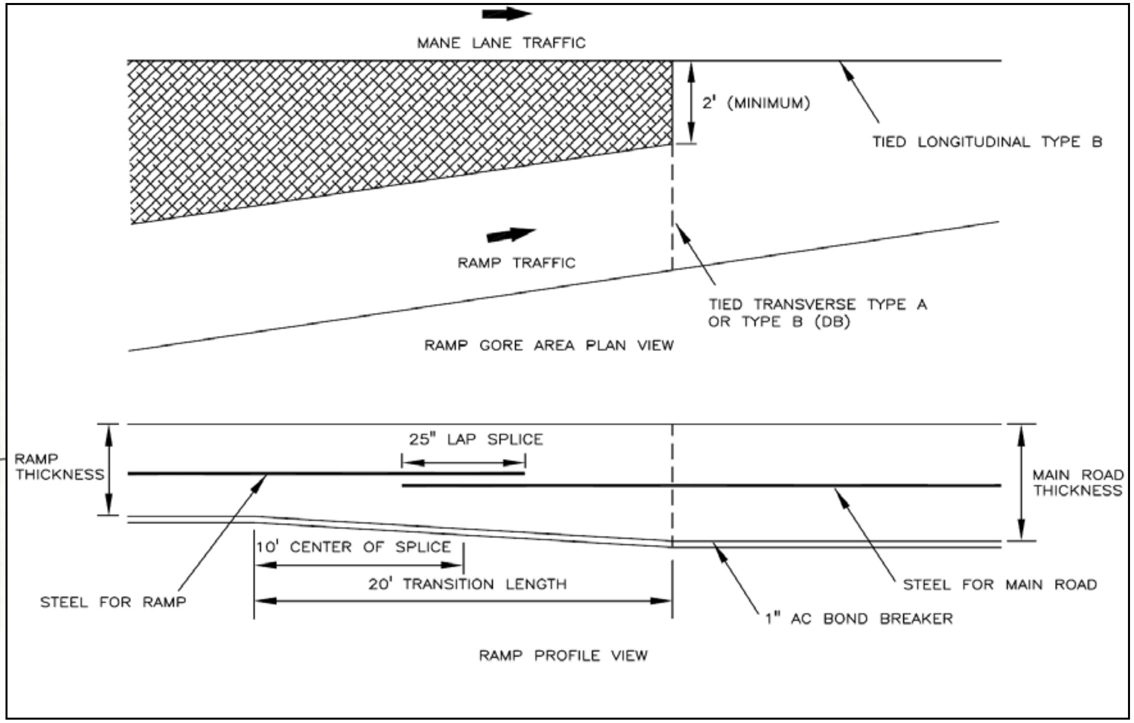




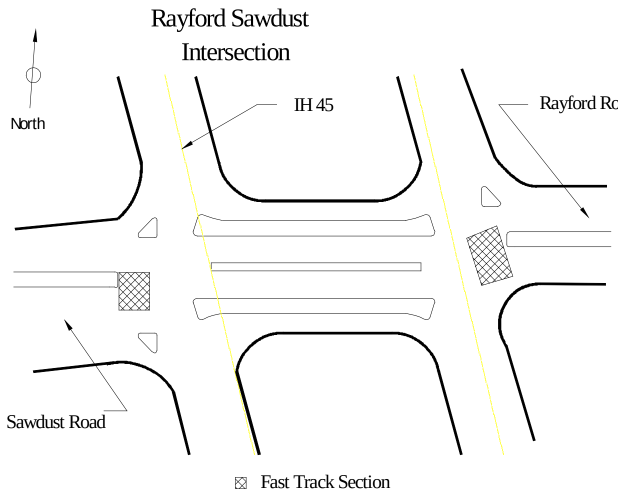
Partial Restraint/Inclusion Type Joints



Ramps/Gore Area Transition

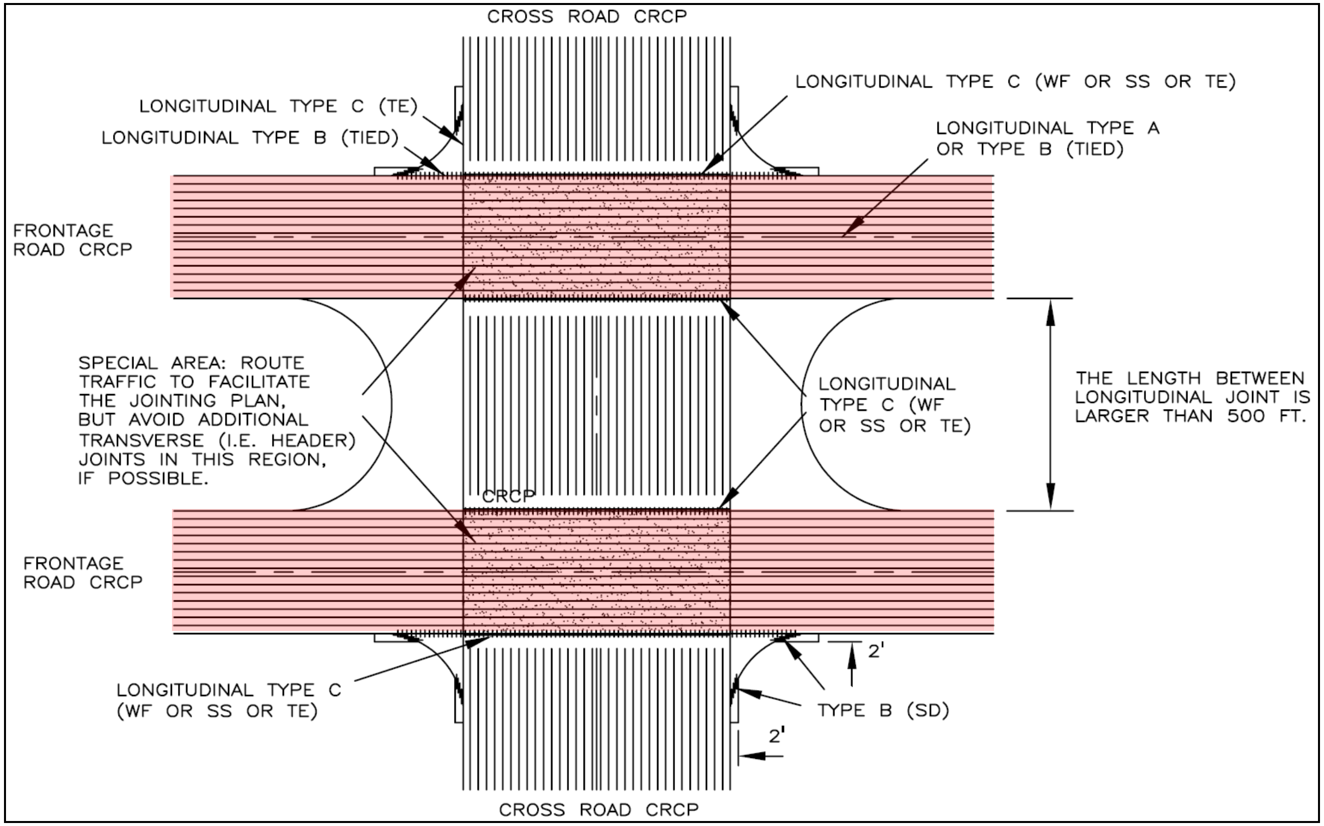


Intersections



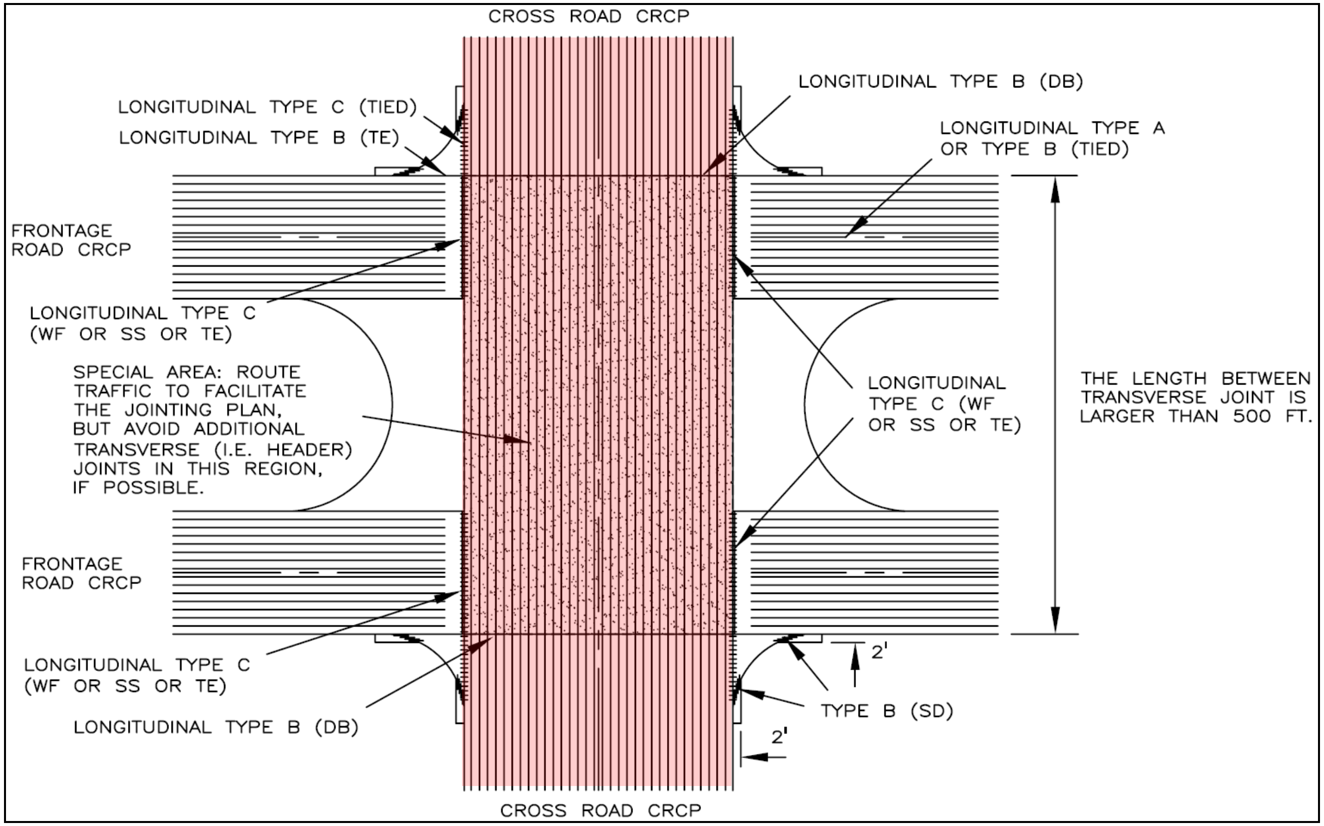
Intersections (Cont.)

Isolated Frontage Road CRC Pavement Design

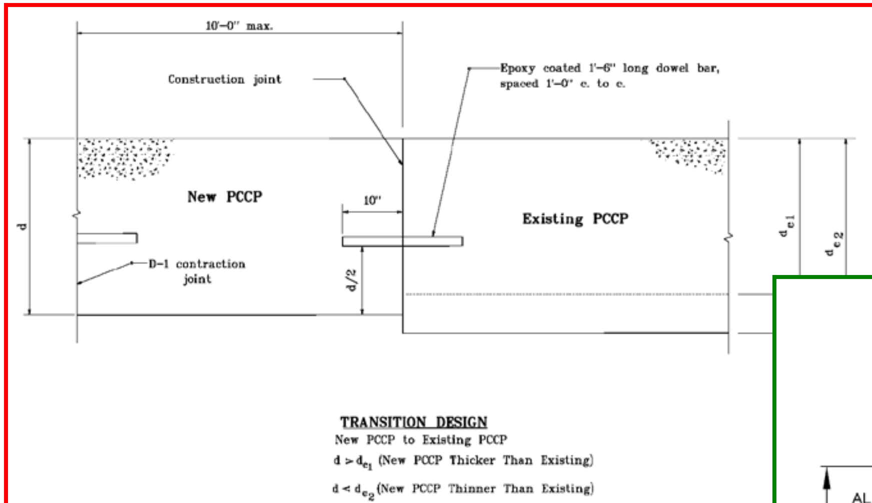


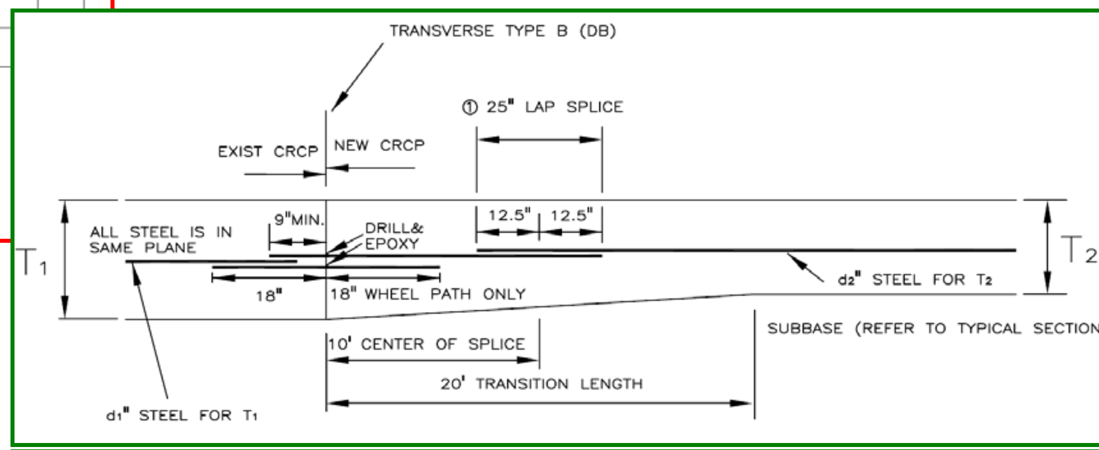
Intersections (Cont.)

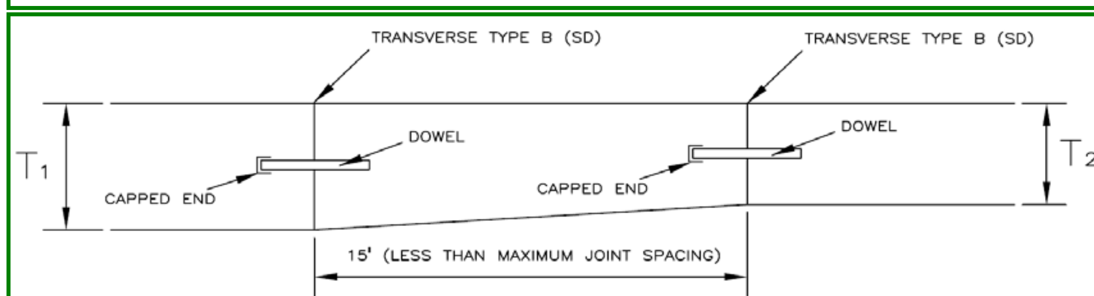
Isolated Cross Road CRC Pavement Design



PCC Pavement Thickness Transition







In Summary: Proper Transition Design

- **Enhanced Constructability Details**
  - Sleeper slabs, tapered slab joints, use of dowel bars and sawcuts, etc.
- **Reduced Restraint**
  - Prevent restraint cracking by isolation of adjoining/intersecting pavements
- **Maximized Joint Stiffness**
  - Improve transition performances by higher load transfer

TTI/TxDOT Reports (http://tti.tamu.edu/)

- **P1 – Survey of Best Practices for Concrete Pavement Transitions**
  - Reconsider current practices
  - Survey current transition conditions in the field
  - Suggest design improvements
- **P2 – Design Detail Standard Sheets**
  - Develop transition detail drawings for design improvements

TTI/TxDOT Reports (Cont.)

- **P3 – Design and Construction Transition Guidelines**
  - Provide mechanistic based transition design spread sheet
  - Present guidelines for transition design and construction issues
- **R1 – Best Practices of Concrete Pavement Transition Design and Construction**
  - Summarize products to report with comprehensive understanding