CRSI

Continuously Reinforced Concrete Pavement

Steel Bars and Concrete Provide Optimum Performance and Durability

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Definition

- Continuously Reinforced Concrete Pavement (CRCP) is
  - Steel bars placed in the longitudinal direction at a certain depth within within the concrete pavement

CRCP Description

- No formed (sawed) transverse joints
- Pavement cracks naturally at random intervals

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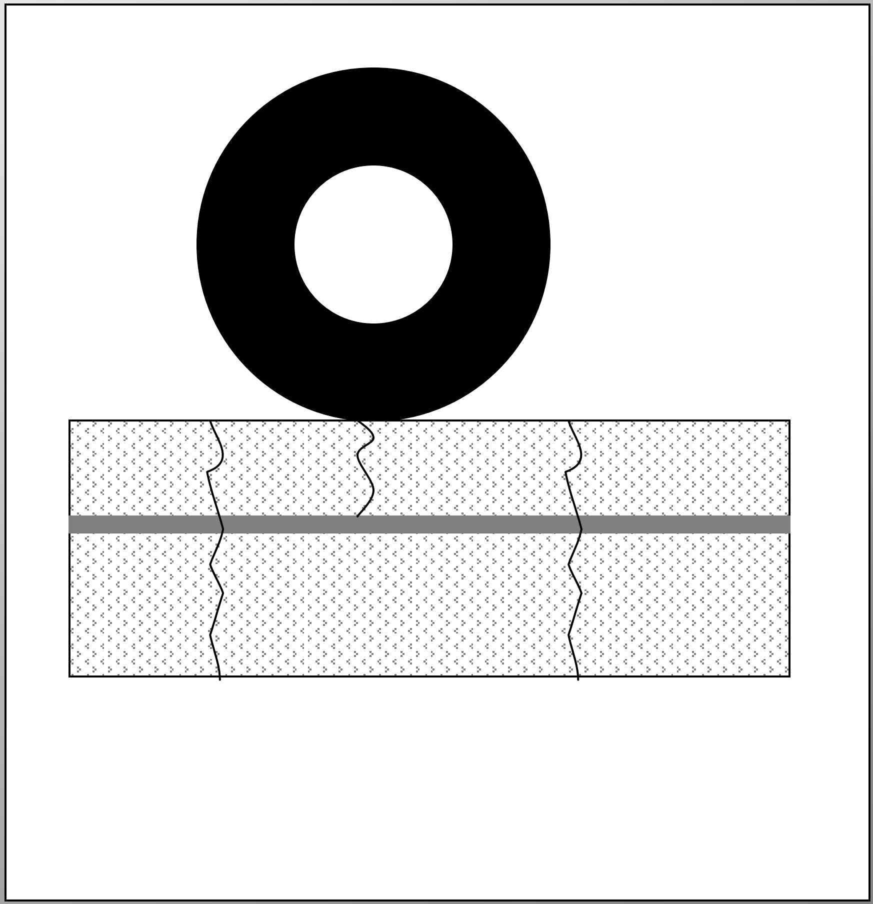
Why Is There Steel In CRCP?

- Concrete pavement develops shrinkage cracks
- Longitudinal steel holds cracks tight
- The aggregate interlock provides good load transfer



CRCP History

- Early CRCP construction in 1940s

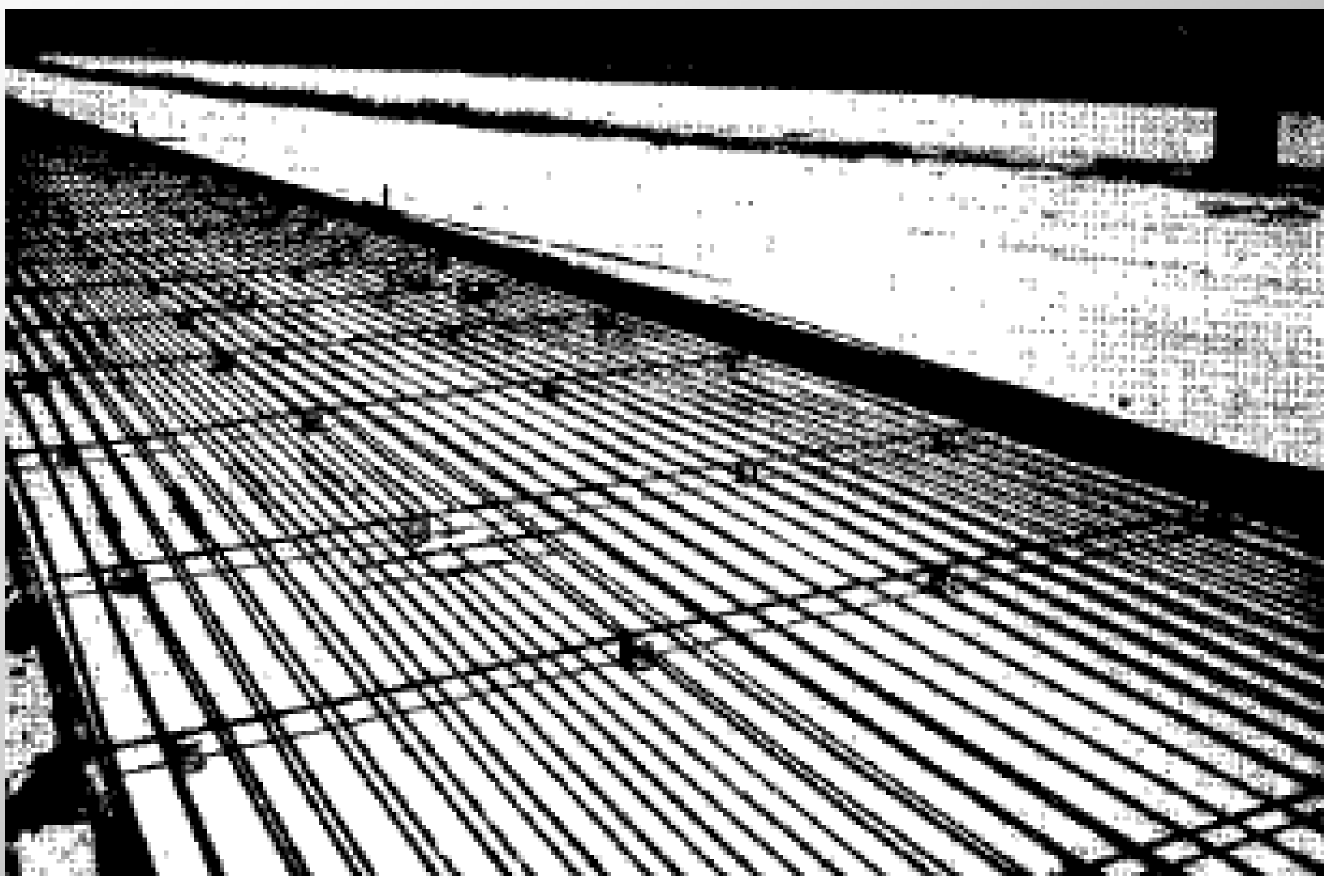


Photo Source: Caltrans 1951 Report

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CRCP History

- Illinois, Texas become strong CRCP proponents

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CRCP Today

- Dan Ryan Expressway reconstruction, Chicago
- Heavy volume
- Heavy loads
- 14 in. CRCP
- 0.7 percent steel
- 40-year design life

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CRCP Design

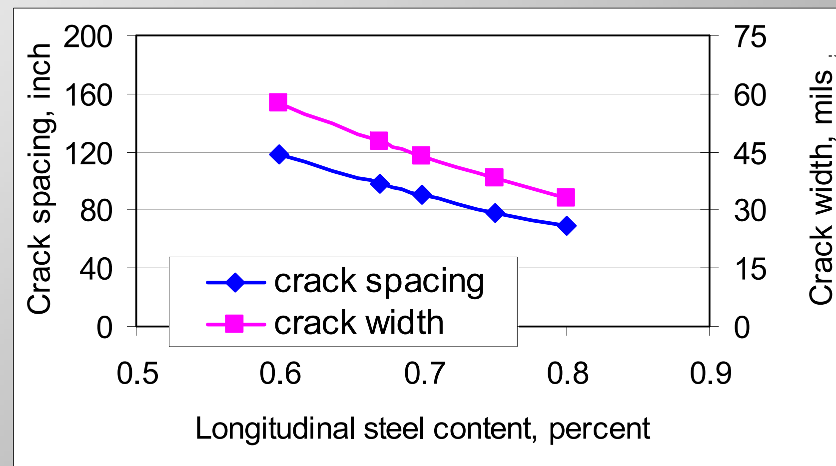
- CRCP design has improved
  - Engineers now know the steel percentage affects crack spacing and width (tightness)
- Knowledge gained from CRCP field performance has led to improved design
  - "CRCP is not a cure-all" *–Dr. Frank McCullough*
  - Varied underlayment of steel reinforcing

CRCP Design

- Steel Content (percent steel)
- Steel Depth
- Concrete Thickness
- Concrete Strength
- Base Materials and Base Friction
- Construction Issues

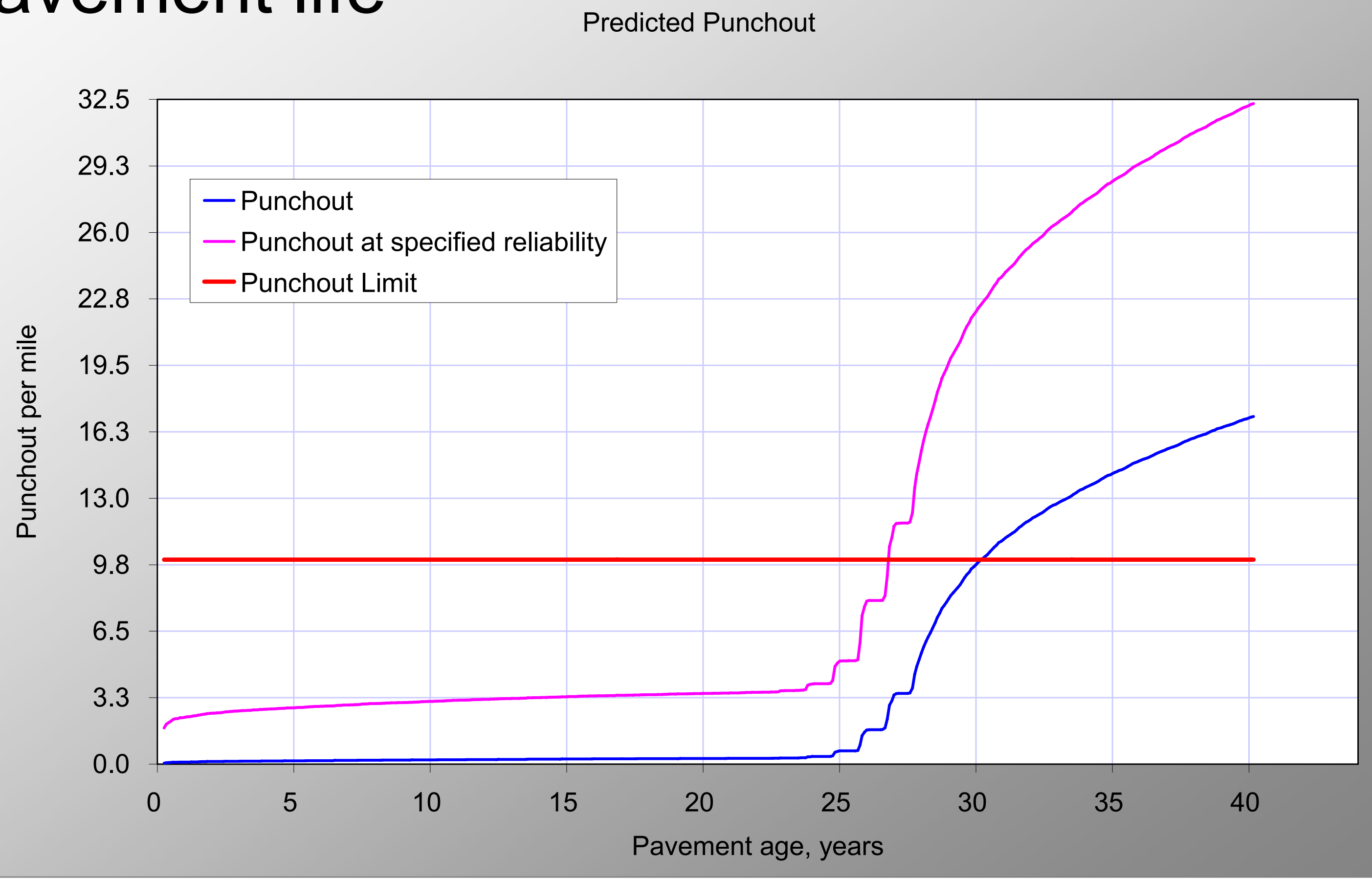
CRCP Design—Steel Content

- Design will determine the spacing and width of transverse cracks in the pavement



CRCP Design Life--Punchouts

- The amount of steel in the CRCP affects pavement life



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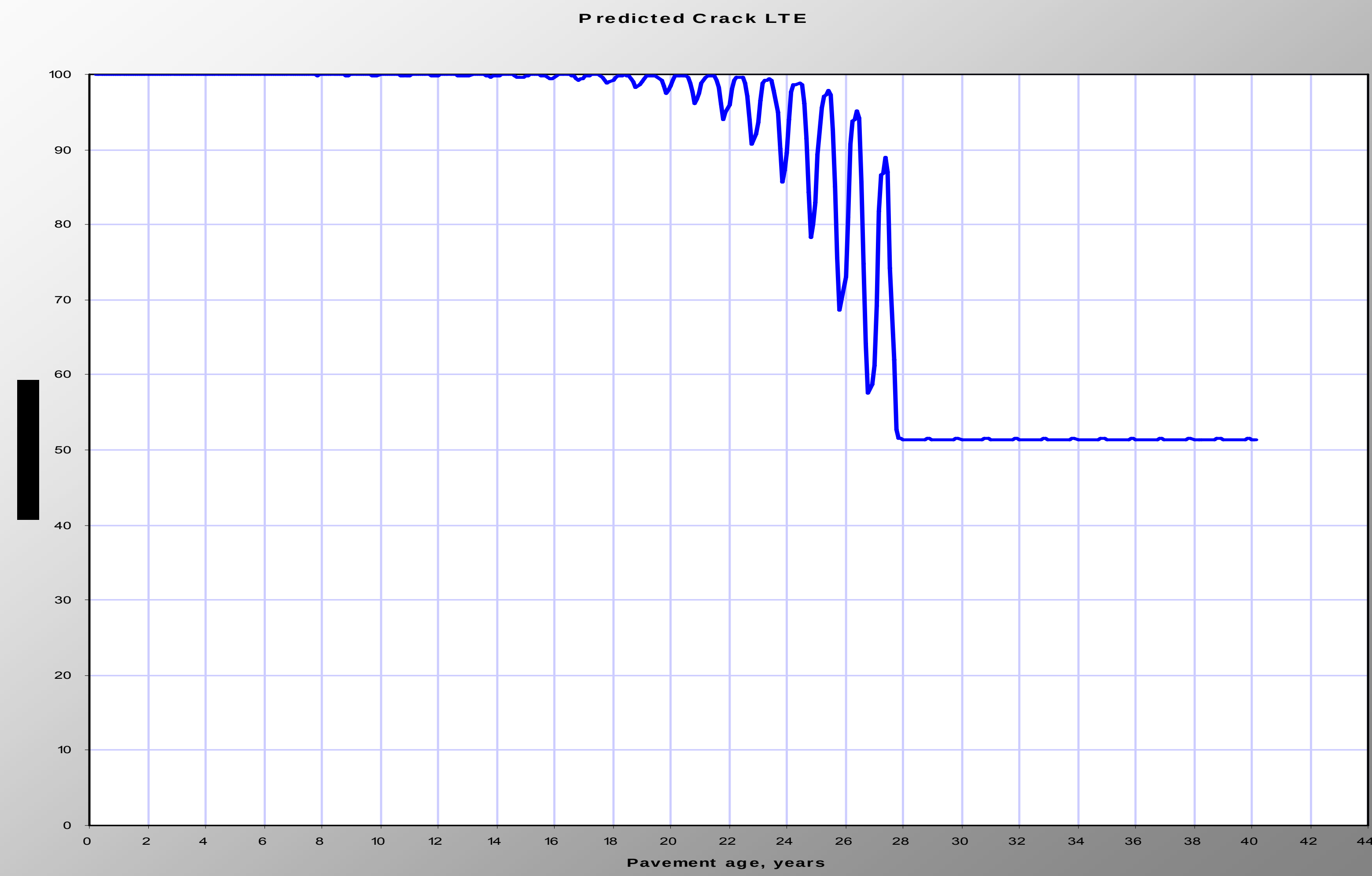
CRCP Design Life—LTE



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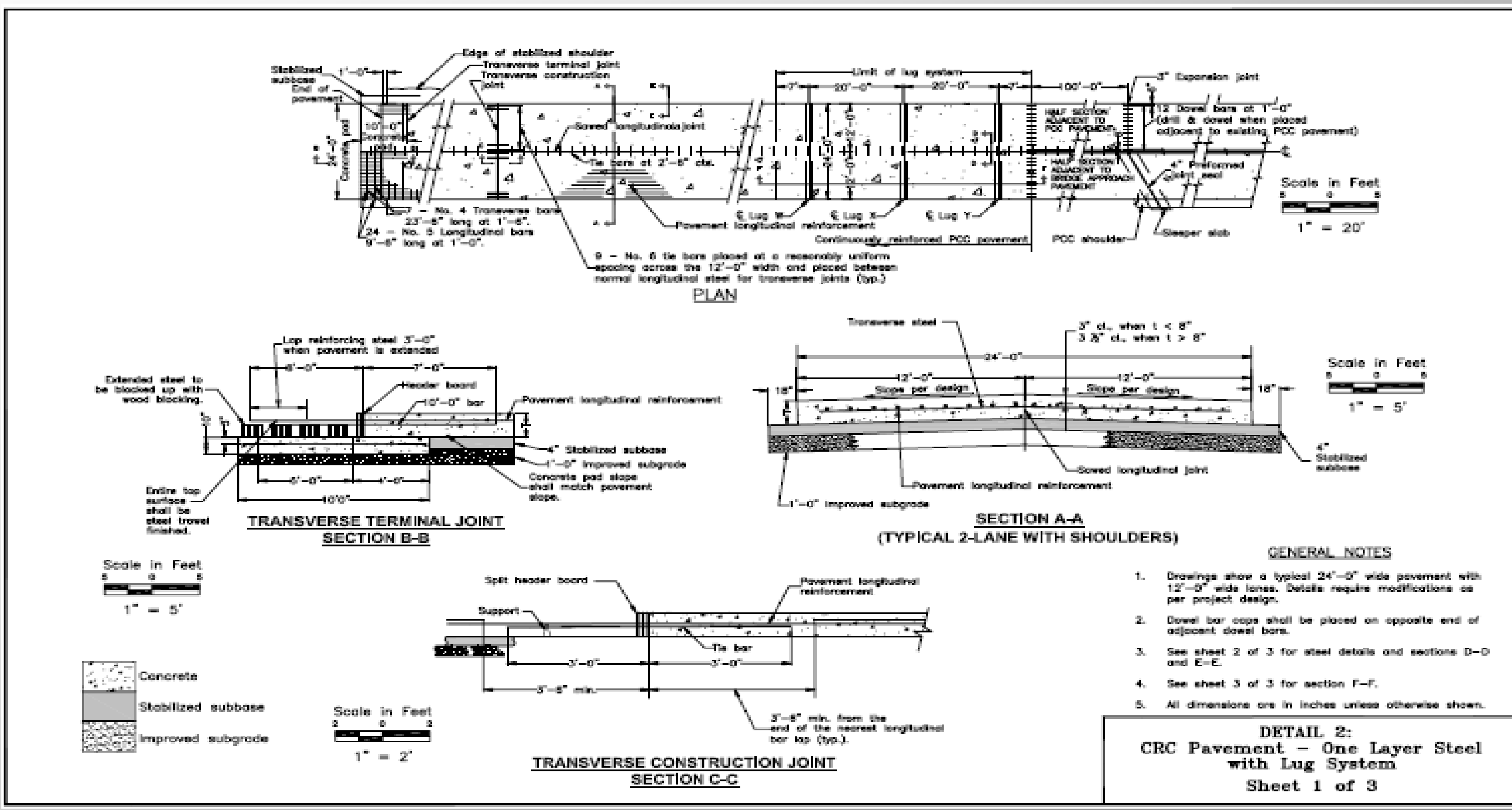
CRCP Design—1 Layer Steel



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CRCP 1 Layer Steel

Photo: South Dakota DOT

CRCP Design—1 Layer Steel

- Most common design
- Pavement depth between 6-15″
- Concrete forms contact with deformed rebar
- Steel percentage usually 0.6-0.8%
  – Rebar size determines percentage and spacing
  – Rebar sizes determined as per ASTM specification, e.g. #6

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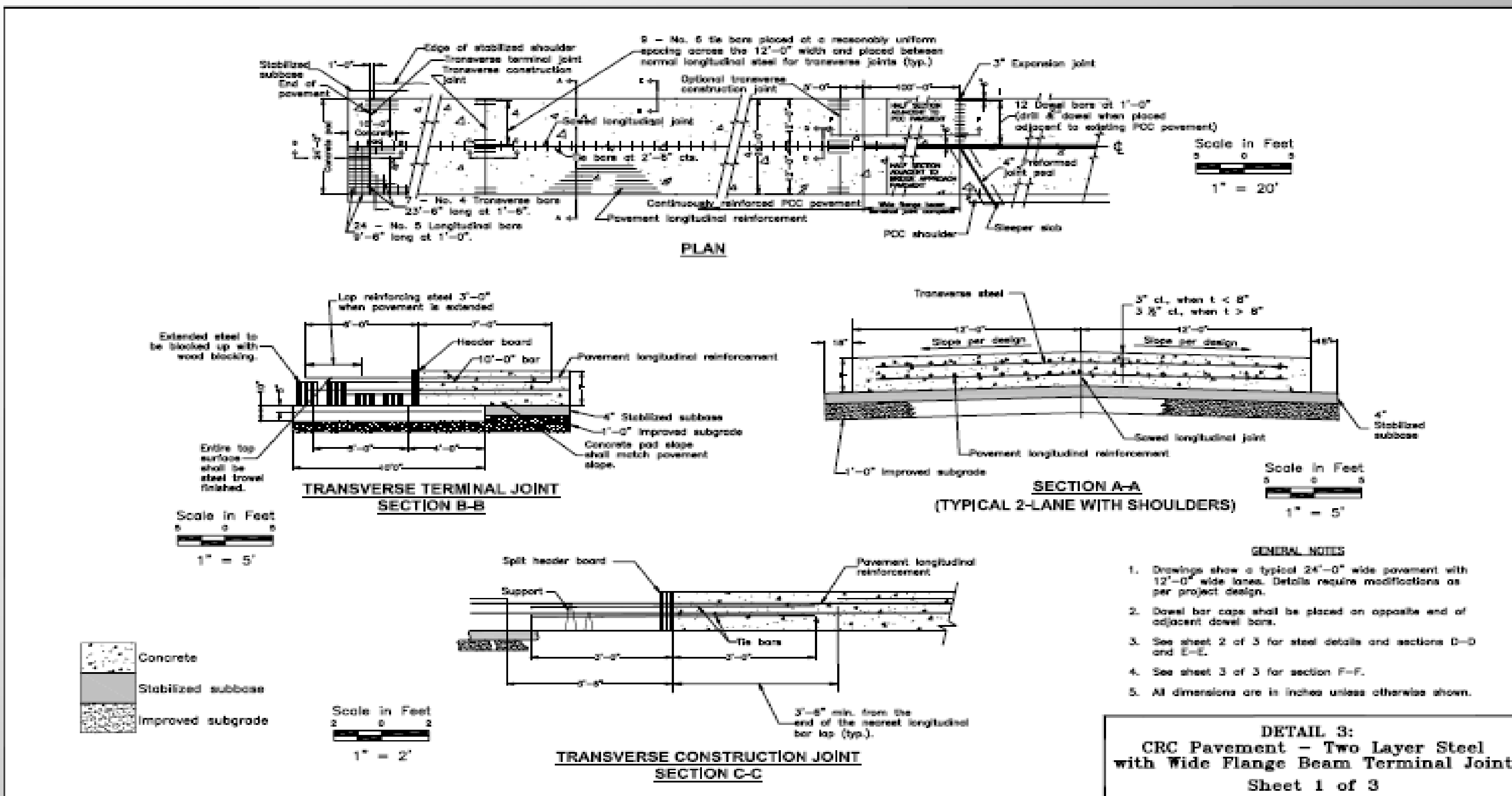
CRCP Design—2 Layer Steel



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CRCP Design—2-Layer Steel

- Conservative design
- Used for thicker pavement (14”-16” depth)
- Favored by some DOTs for roads with heavy traffic
- Holds cracks tight from both top and bottom of slab

CRCP Materials—Concrete

- Early pavement was just sand, cement and water
- Pavement mix today is more complex
  - Admixtures
  - High Performance Concrete

CRCP Materials—Reinforcement

- Uncoated Steel Reinforcing Bars
- Epoxy-coated Rebar (ECR)
  - Coating protects rebar from corrosive agents
- Stainless Steel Rebar
  - Ideal for locations requiring absolute corrosion resistance

CRCP Construction-Subgrade/Base

- Important to have consistent sub layers to prevent performance problems
  - Friction
  - Drainage
  - Good construction platform

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CRCP Construction—Subgrade

- Below the base layer, the subgrade should have good drainage and support
  - Compacted soil plus gravel layer
  - Can mix soil with lime or cementitious material to reduce moisture/increase strength

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CRCP Construction—Base

- Base should offer consistency
  - Asphalt
  - Concrete
- Some DOTs prefer gravel base for its drainage capabilities
- Recycle existing pavement as a base

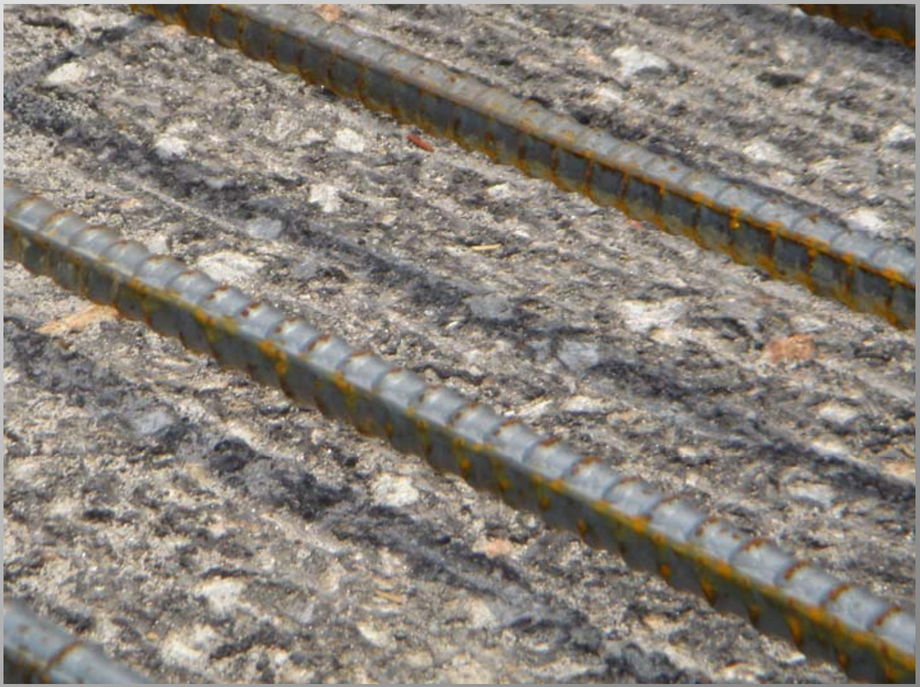

Photo: Georgia State Road 6

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Placing Reinforcement

- Longitudinal bars are set upon transverse bars
- Longitudinal bars overlap at irregular intervals to keep reinforcement continuous

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Placing Concrete

- Paver places well-mixed concrete over the rebar
- Vibrators and hand tools make sure the concrete is compacted without air voids

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Finishing CRCP

- Hand or machine finishing to add texture to the pavement surface
  - Carpet drag
  - Tining
- NO transverse joints are sawed
- Curing compound is sometimes added

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Quality Assurance and Testing

- Measure strength using test beams
- Example: TxDOT tests every 2000 m^2 or at beginning/end joints for the day

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CRCP Performance

- CRCP designed for smooth, strong and durable surface for transportation
- Performance measured by structural and functional factors
  - Crack width
  - Punchouts and spalling
  - Smoothness (IRI)

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Cracking and Smoothness

- Transverse cracks must remain tight
  - Steel and aggregate work together to transfer load
  - Traffic and environmental loads, loss of support and incompressible fines contribute to crack widening
  - Pavement surface will provide a smooth ride if cracks are tight (<0.02in)
  - Load transfer efficiency remains high (>95)
- Closely spaced cracks are desirable

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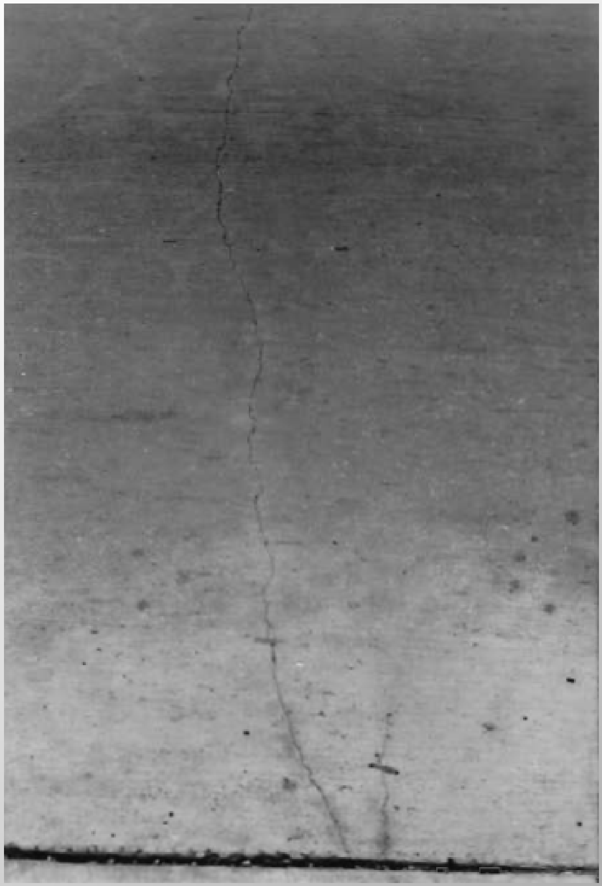
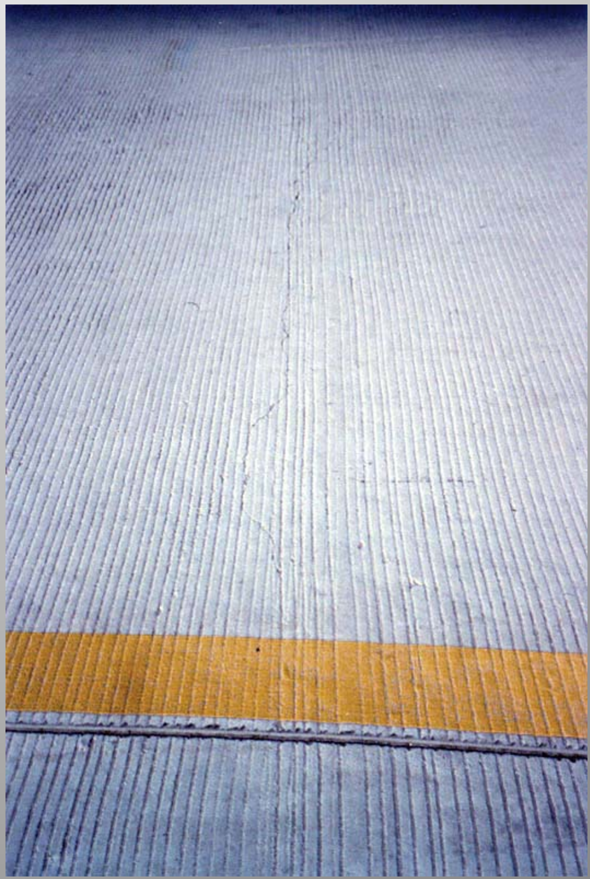
Typical CRCP Cracking Pattern





Load Transfer Efficiency (LTE)

- CRCP cracks diffuse the pressure from dynamic forces
- Widened cracks lower the LTE
- Steel reinforcement restrains pavement from curling and warping
- High LTE is good

Low LTE Leads to Punchouts

- Repeated loadings of joints with low LTE leads to punchouts

Punchout

Where Can You Find CRCP?

- Interstate Roads: high traffic volume, heavy vehicle loads
- Airports: runways and taxiways

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Where Can You Find CRCP?

- Seaports: staging for heavy static and dynamic loads
- Industrial Slabs
- Railbeds: stable support for high-speed trains

CRCP Aesthetics

- Concrete reflects light from its surface
- Absence of joints removes “thump-thump” noise
- Transportation electronics
  - Toll readers
  - Temperature sensors
  - Traffic sensors

Maintenance

- Prolongs pavement life
- Keeps surface smooth
- Do:
  - Surface grind
  - Repair punchouts and spalling
- Don't repair the transverse cracks!
  - Train maintenance teams to expect cracks

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Deterioration

- Punchouts
  - Pavement no longer has support: AKA "punchout"
- Spalling caused by poor mix design, or excessive crack widths or corroded rebar
- Irregular cracking
  - Many causes, but usually leads to punchouts or spalling
- Concrete-related durability deterioration

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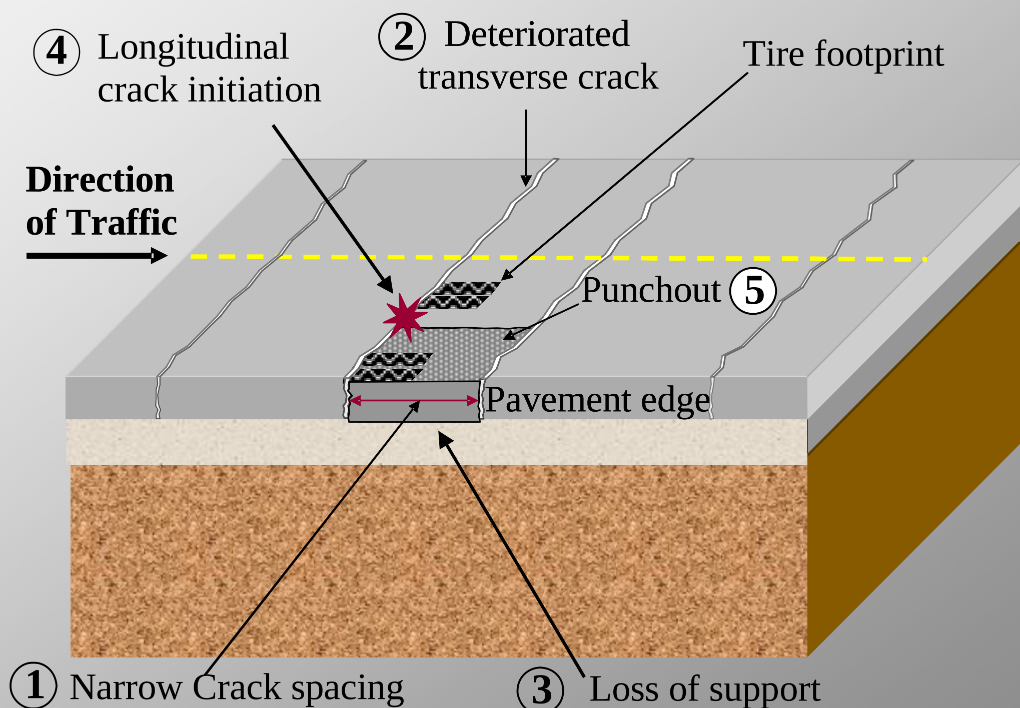
Punchouts

- Can design to minimize punchouts



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Repair

- Patching
  - Usually asphalt
  - Usually short-term
- Full-depth repair
  - Saw-cut to the steel or to the base
  - Replace (or don't) the reinforcement
  - New concrete mixes for fast/strong curing

Overlays

- Covers deteriorated pavement surface if reinforcing steel is still serviceable
- CRCP is good underlay for concrete or asphalt because it does not propagate cracks through the pavement overlay

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Long-Life CRCP

- CRCP is often specified when the pavement must have an extended service life
  - I-70 was designed for a 40 year service life by utilizing CRCP containing epoxy-coated rebar
- Use the M-E Design Guide to analyze and predict performance over service life

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CRCP Minimal Maintenance

- Corrosion protection for the reinforcing steel where deicing chemicals are used extensively
- Continual evolution of pavement design to find ideal for each climate
  - Pavement thickness
  - Percentage of steel in the pavement

Example: CRCP 50+ Years Old

- Constructed in 1949 near Fairfield, CA as an experiment by Caltrans
- Original pavement is now part of I-80 Westbound
- Exceptional performance: pavement has only needed one surface grinding to maintain smoothness
- No damage from Loma Prieta earthquake

Fairfield, CA CRCP

CRSI Aids for CRCP

- Manual of Standard Practice
- Placing Reinforcing Bars
- Epoxy Coated Reinforcement CD
- Transportation CD
- CRCP drawings
- www.crsi.org
- Look through your packet for research series and case studies

Industry Aids for CRCP

- M-E Pavement Design Guide
- HIPERPAV II
- Guidelines for CRCP (coming)

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Get More CRCP Information

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- Many thanks to ACPA, IDOT, TxDOT, SDDOT, ARA, Caltrans and Walsh Construction