Continuously Reinforced Concrete Pavement

Steel Bars and Concrete Provide Optimum Performance and Durability
Definition

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

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

- Illinois, Texas become strong CRCP proponents
CRCP Today

- Dan Ryan Expressway reconstruction, Chicago
- Heavy volume
- Heavy loads
- 14 in. CRCP
- 0.7 percent steel
- 40-year design life
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
• The amount of steel in the CRCP affects pavement life
CRCP Design Life—LTE

Predicted Crack LTE

Pavement age, years
CRCP Design—1 Layer Steel

**PLAN**
- Edge of stabilized shoulder
- Transverse terminal joint
- Concrete pavement

**SECTION A-A**
- Transverse steel
- 3/8" dia., when t < 8"
- 3/4" dia., when t > 8"
- Concrete slab
- Concrete pavement

**SECTION B-B**
- Transverse terminal joint
- Concrete slab
- Reinforcement

**GENERAL NOTES**
1. Drawings show a typical 24'-0" wide pavement with 12'-0" wide lanes. Decksibrate modifications as per project design.
2. Grid梐rereinforcement shall be placed on opposite ends of adjacent steel bars.
3. See sheet 3 of 3 for steel details and sections 5-5 and A-A.
4. See sheet 3 of 3 for section F-F.
5. All dimensions are in inches unless otherwise shown.

**DETAIL 2:**
CRC Pavement - One Layer Steel with Lag Systems
Sheet 1 of 3
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
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
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
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
Placing Reinforcement

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

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

• Measure strength using test beams
• Example: TxDOT tests every 2000 m² or at beginning/end joints for the day
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)
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
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
Where Can You Find CRCP?

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

- Can design to minimize punchouts
• 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
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
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](http://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)
Get More CRCP Information

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